



U.S. Department of Transportation
Federal Aviation Administration
Washington, DC

Master Minimum Equipment List (MMEL)

Revision: 0
Date: XX/XX/XXXX

Boeing 777
B777-9

Flight Operations Evaluation Board (FOEB)

Federal Aviation Administration (FAA)
Aircraft Evaluation Division (AFS-100)
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Feb 26, 2026

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Revision Record

Revision Transmittal Letter

To: All holders of Federal Aviation Administration Master Minimum Equipment List, Boeing Document Number D639W201-01.

Subject: Master Minimum Equipment List (MMEL) Revision 0.

MMEL Revision 0 is a complete revision. MMEL Revision 0 incorporates changes to apply restrictions, adjust format and nomenclature and increase dispatch flexibility.

Revision Record

No.	Revision Date	Date Filed	No.	Revision Date	Date Filed

General

This 777X Master Minimum Equipment List (MMEL) is approved by the Federal Aviation Administration (FAA) Flight Operations Evaluation Board (FOEB).

Revisions include a Transmittal Letter, a new Revision Record, Revision Highlights, and a List of Effective Pages. The Revision Record should be completed by the person incorporating the revision into the Master Minimum Equipment List.

Filing Instructions

Consult the List of Effective Pages. The List of Effective Pages determines the correct content of the manual. Pages identified with an asterisk (*) are either replacement pages or new (original) issue pages.

Pages may be re-dated without revision bars. This is due to repagination of content. The List of Effected Pages will reflect the date change, but there will not be a corresponding revision highlight.

Revision Highlights

Specific changes in this revision are noted in the following highlights.

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Highlights

No revision highlights.

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* 2.26-21-02.2	XX/XX/XXXX	* 2.27-51-06.1	XX/XX/XXXX
* 2.26-22-01.1	XX/XX/XXXX	* 2.27-51-06.2	XX/XX/XXXX
* 2.26-22-02.1	XX/XX/XXXX	* 2.27-51-07.1	XX/XX/XXXX
* 2.26-22-02.2	XX/XX/XXXX	* 2.27-51-08.1	XX/XX/XXXX
* 2.26-23-01.1	XX/XX/XXXX	* 2.27-58-01.1	XX/XX/XXXX
* 2.26-23-01.2	XX/XX/XXXX	* 2.27-58-01.2	XX/XX/XXXX
* 2.26-23-01.3	XX/XX/XXXX	* 2.27-61-01.1	XX/XX/XXXX
* 2.26-23-02.1	XX/XX/XXXX	* 2.27-61-01.2	XX/XX/XXXX
* 2.26-23-02.2	XX/XX/XXXX	* 2.27-61-02.1	XX/XX/XXXX
* 2.26-24-01.1	XX/XX/XXXX	* 2.27-61-02.2	XX/XX/XXXX
* 2.26-24-01.2	XX/XX/XXXX	* 2.27-61-02.3	XX/XX/XXXX
* 2.26-26-01.1	XX/XX/XXXX	* 2.27-61-03.1	XX/XX/XXXX
Section 2 - ATA 27 (tab)		* 2.27-61-03.2	XX/XX/XXXX
* 2.27.TOC.1-2	XX/XX/XXXX	* 2.27-61-04.1	XX/XX/XXXX
* 2.27-00-01.1	XX/XX/XXXX	* 2.27-81-01.1	XX/XX/XXXX
* 2.27-02-01.1	XX/XX/XXXX	* 2.27-81-01.2	XX/XX/XXXX
		* 2.27-81-02.1	XX/XX/XXXX

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* 2.27-81-03.2	XX/XX/XXXX	* 2.28-41-01.2	XX/XX/XXXX
* 2.27-88-01.1	XX/XX/XXXX	* 2.28-41-01.3	XX/XX/XXXX
* 2.27-88-01.2	XX/XX/XXXX	* 2.28-41-01.4	XX/XX/XXXX
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* 2.28.TOC.1-4	XX/XX/XXXX	* 2.28-41-02.1	XX/XX/XXXX
* 2.28-11-01.1	XX/XX/XXXX	* 2.28-41-02.2	XX/XX/XXXX
* 2.28-11-01.2	XX/XX/XXXX	* 2.28-41-03.1	XX/XX/XXXX
* 2.28-21-01.1	XX/XX/XXXX	* 2.28-41-03.2	XX/XX/XXXX
* 2.28-21-01.2	XX/XX/XXXX	* 2.28-41-04.1	XX/XX/XXXX
* 2.28-21-01.3	XX/XX/XXXX	* 2.28-41-04.2	XX/XX/XXXX
* 2.28-21-01.4	XX/XX/XXXX	* 2.28-41-05.1	XX/XX/XXXX
* 2.28-21-01.5	XX/XX/XXXX	* 2.28-41-05.2	XX/XX/XXXX
* 2.28-21-01.6	XX/XX/XXXX	* 2.28-43-01.1	XX/XX/XXXX
* 2.28-21-02.1	XX/XX/XXXX	* 2.28-43-01.2	XX/XX/XXXX
* 2.28-21-02.2	XX/XX/XXXX	Section 2 - ATA 29 (tab)	
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* 2.28-22-01.2	XX/XX/XXXX	* 2.29-11-01.1	XX/XX/XXXX
* 2.28-22-01.3	XX/XX/XXXX	* 2.29-11-01.2	XX/XX/XXXX
* 2.28-22-02.1	XX/XX/XXXX	* 2.29-11-01.3	XX/XX/XXXX
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* 2.28-22-02.4	XX/XX/XXXX	* 2.29-11-03.1	XX/XX/XXXX
* 2.28-22-02.5	XX/XX/XXXX	* 2.29-11-03.2	XX/XX/XXXX
* 2.28-22-03.1	XX/XX/XXXX	* 2.29-11-03.3	XX/XX/XXXX
* 2.28-22-03.2	XX/XX/XXXX	* 2.29-11-03.4	XX/XX/XXXX
* 2.28-22-04.1	XX/XX/XXXX	* 2.29-11-03.5	XX/XX/XXXX
* 2.28-22-04.2	XX/XX/XXXX	* 2.29-11-04.1	XX/XX/XXXX
* 2.28-22-04.3	XX/XX/XXXX	* 2.29-11-05.1	XX/XX/XXXX
* 2.28-22-05.1	XX/XX/XXXX	* 2.29-11-05.2	XX/XX/XXXX
* 2.28-22-05.2	XX/XX/XXXX	* 2.29-11-06.1	XX/XX/XXXX
* 2.28-25-01.1	XX/XX/XXXX	* 2.29-11-06.2	XX/XX/XXXX
* 2.28-25-02.1	XX/XX/XXXX	* 2.29-11-07.1	XX/XX/XXXX
* 2.28-25-02.2	XX/XX/XXXX	* 2.29-11-08.1	XX/XX/XXXX
* 2.28-25-02.3	XX/XX/XXXX	* 2.29-18-01.1	XX/XX/XXXX
* 2.28-26-01.1	XX/XX/XXXX	* 2.29-18-02.1	XX/XX/XXXX
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* 2.28-31-01.2	XX/XX/XXXX	* 2.29-21-02.1	XX/XX/XXXX
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* 2.28-31-02.1	XX/XX/XXXX	* 2.29-30-01.1	XX/XX/XXXX
* 2.28-31-02.2	XX/XX/XXXX	* 2.29-30-02.1	XX/XX/XXXX
* 2.28-31-03.1	XX/XX/XXXX	* 2.29-31-01.1	XX/XX/XXXX
* 2.28-31-04.1	XX/XX/XXXX	* 2.29-31-02.1	XX/XX/XXXX
* 2.28-31-04.2	XX/XX/XXXX	* 2.29-31-02.2	XX/XX/XXXX
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* 2.29-32-01.1	XX/XX/XXXX	Section 2 - ATA 31 (tab)	
* 2.29-32-01.2	XX/XX/XXXX	* 2.31.TOC.1-4	XX/XX/XXXX
* 2.29-32-01.3	XX/XX/XXXX	* 2.31-09-01.1	XX/XX/XXXX
* 2.29-32-02.1	XX/XX/XXXX	* 2.31-09-01.2	XX/XX/XXXX
* 2.29-32-02.2	XX/XX/XXXX	* 2.31-09-01.3	XX/XX/XXXX
* 2.29-33-01.1	XX/XX/XXXX	* 2.31-09-01.4	XX/XX/XXXX
* 2.29-33-01.2	XX/XX/XXXX	* 2.31-09-01.5	XX/XX/XXXX
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* 2.30-11-01.1	XX/XX/XXXX	* 2.31-09-02.3	XX/XX/XXXX
* 2.30-11-01.2	XX/XX/XXXX	* 2.31-09-02.4	XX/XX/XXXX
* 2.30-11-02.1	XX/XX/XXXX	* 2.31-31-01.1	XX/XX/XXXX
* 2.30-11-03.1	XX/XX/XXXX	* 2.31-31-01.2	XX/XX/XXXX
* 2.30-11-03.2	XX/XX/XXXX	* 2.31-31-02.1	XX/XX/XXXX
* 2.30-11-04.1	XX/XX/XXXX	* 2.31-31-02.2	XX/XX/XXXX
* 2.30-11-04.2	XX/XX/XXXX	* 2.31-31-02.3	XX/XX/XXXX
* 2.30-11-04.3	XX/XX/XXXX	* 2.31-31-03.1	XX/XX/XXXX
* 2.30-11-05.1	XX/XX/XXXX	* 2.31-31-03.2	XX/XX/XXXX
* 2.30-11-05.2	XX/XX/XXXX	* 2.31-33-01.1	XX/XX/XXXX
* 2.30-21-01.1	XX/XX/XXXX	* 2.31-51-01.1	XX/XX/XXXX
* 2.30-21-01.2	XX/XX/XXXX	* 2.31-51-02.1	XX/XX/XXXX
* 2.30-21-01.3	XX/XX/XXXX	* 2.31-51-03.1	XX/XX/XXXX
* 2.30-21-01.4	XX/XX/XXXX	* 2.31-61-01.1	XX/XX/XXXX
* 2.30-21-02.1	XX/XX/XXXX	* 2.31-61-01.2	XX/XX/XXXX
* 2.30-21-02.2	XX/XX/XXXX	* 2.31-61-01.3	XX/XX/XXXX
* 2.30-21-03.1	XX/XX/XXXX	* 2.31-61-01.4	XX/XX/XXXX
* 2.30-21-03.2	XX/XX/XXXX	* 2.31-61-01.5	XX/XX/XXXX
* 2.30-21-04.1	XX/XX/XXXX	* 2.31-61-01.6	XX/XX/XXXX
* 2.30-21-04.2	XX/XX/XXXX	* 2.31-61-01.7	XX/XX/XXXX
* 2.30-31-01.1	XX/XX/XXXX	* 2.31-61-02.1	XX/XX/XXXX
* 2.30-31-01.2	XX/XX/XXXX	* 2.31-61-02.2	XX/XX/XXXX
* 2.30-31-01.3	XX/XX/XXXX	* 2.31-61-04.1	XX/XX/XXXX
* 2.30-31-01.4	XX/XX/XXXX	* 2.31-61-04.2	XX/XX/XXXX
* 2.30-31-01.5	XX/XX/XXXX	* 2.31-61-04.3	XX/XX/XXXX
* 2.30-33-01.1	XX/XX/XXXX	* 2.31-61-04.4	XX/XX/XXXX
* 2.30-41-01.1	XX/XX/XXXX	* 2.31-61-05.1	XX/XX/XXXX
* 2.30-41-01.2	XX/XX/XXXX	* 2.31-61-05.2	XX/XX/XXXX
* 2.30-41-02.1	XX/XX/XXXX	* 2.31-61-06.1	XX/XX/XXXX
* 2.30-41-02.2	XX/XX/XXXX	* 2.31-61-06.2	XX/XX/XXXX
* 2.30-41-03.1	XX/XX/XXXX	* 2.31-61-06.3	XX/XX/XXXX
* 2.30-41-04.1	XX/XX/XXXX	* 2.31-61-06.4	XX/XX/XXXX
* 2.30-42-01.1	XX/XX/XXXX	* 2.31-61-07.1	XX/XX/XXXX
* 2.30-42-01.2	XX/XX/XXXX	* 2.31-61-07.2	XX/XX/XXXX
* 2.30-71-01.1	XX/XX/XXXX	* 2.31-61-08.1	XX/XX/XXXX
* 2.30-81-01.1	XX/XX/XXXX	* 2.31-61-09.1	XX/XX/XXXX
* 2.30-81-01.2	XX/XX/XXXX	* 2.31-61-09.2	XX/XX/XXXX

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* 2.31-61-10.2	XX/XX/XXXX	* 2.32-44-02.1	XX/XX/XXXX
* 2.31-61-11.1	XX/XX/XXXX	* 2.32-44-02.2	XX/XX/XXXX
* 2.31-61-11.2	XX/XX/XXXX	* 2.32-44-03.1	XX/XX/XXXX
* 2.31-61-13.1	XX/XX/XXXX	* 2.32-44-03.2	XX/XX/XXXX
* 2.31-61-13.2	XX/XX/XXXX	* 2.32-45-01.1	XX/XX/XXXX
* 2.31-61-14.1	XX/XX/XXXX	* 2.32-45-01.2	XX/XX/XXXX
* 2.31-61-14.2	XX/XX/XXXX	* 2.32-45-01.3	XX/XX/XXXX
* 2.31-61-14.3	XX/XX/XXXX	* 2.32-45-02.1	XX/XX/XXXX
* 2.31-61-14.4	XX/XX/XXXX	* 2.32-45-03.1	XX/XX/XXXX
* 2.31-61-15.1	XX/XX/XXXX	* 2.32-45-03.2	XX/XX/XXXX
* 2.31-61-16.1	XX/XX/XXXX	* 2.32-46-01.1	XX/XX/XXXX
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* 2.32.TOC.1-4	XX/XX/XXXX	* 2.32-51-01.1	XX/XX/XXXX
* 2.32-00-01.1	XX/XX/XXXX	* 2.32-51-01.2	XX/XX/XXXX
* 2.32-08-01.1	XX/XX/XXXX	* 2.32-53-01.1	XX/XX/XXXX
* 2.32-08-01.2	XX/XX/XXXX	* 2.32-53-01.2	XX/XX/XXXX
* 2.32-08-01.3	XX/XX/XXXX	* 2.32-61-01.1	XX/XX/XXXX
* 2.32-08-01.4	XX/XX/XXXX	* 2.32-61-01.2	XX/XX/XXXX
* 2.32-08-01.5	XX/XX/XXXX	* 2.32-61-02.1	XX/XX/XXXX
* 2.32-08-01.6	XX/XX/XXXX	* 2.32-61-03.1	XX/XX/XXXX
* 2.32-11-01.1	XX/XX/XXXX	* 2.32-61-03.2	XX/XX/XXXX
* 2.32-30-01.1	XX/XX/XXXX	* 2.32-61-03.3	XX/XX/XXXX
* 2.32-30-02.1	XX/XX/XXXX	* 2.32-71-01.1	XX/XX/XXXX
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* 2.32-35-01.2	XX/XX/XXXX	* 2.33-16-01.1	XX/XX/XXXX
* 2.32-35-01.3	XX/XX/XXXX	* 2.33-16-01.2	XX/XX/XXXX
* 2.32-35-02.1	XX/XX/XXXX	* 2.33-21-01.1	XX/XX/XXXX
* 2.32-35-02.2	XX/XX/XXXX	* 2.33-21-01.2	XX/XX/XXXX
* 2.32-41-01.1	XX/XX/XXXX	* 2.33-24-01.1	XX/XX/XXXX
* 2.32-41-02.1	XX/XX/XXXX	* 2.33-24-01.2	XX/XX/XXXX
* 2.32-41-03.1	XX/XX/XXXX	* 2.33-24-01.3	XX/XX/XXXX
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* 2.32-42-02.1	XX/XX/XXXX	* 2.33-41-01.1	XX/XX/XXXX
* 2.32-42-03.1	XX/XX/XXXX	* 2.33-42-01.1	XX/XX/XXXX
* 2.32-42-04.1	XX/XX/XXXX	* 2.33-42-01.2	XX/XX/XXXX
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* 2.33-44-01.1	XX/XX/XXXX	* 2.34-42-01.1	XX/XX/XXXX
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* 2.33-44-01.3	XX/XX/XXXX	* 2.34-42-01.3	XX/XX/XXXX
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* 2.33-51-01.3	XX/XX/XXXX	* 2.34-43-01.2	XX/XX/XXXX
* 2.33-51-02.1	XX/XX/XXXX	* 2.34-43-01.3	XX/XX/XXXX
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* 2.34-12-02.4	XX/XX/XXXX	* 2.34-58-01.3	XX/XX/XXXX
* 2.34-12-03.1	XX/XX/XXXX	* 2.34-61-01.1	XX/XX/XXXX
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* 2.34-21-01.1	XX/XX/XXXX	* 2.35-21-01.1	XX/XX/XXXX
* 2.34-21-01.2	XX/XX/XXXX	* 2.35-21-01.2	XX/XX/XXXX
* 2.34-21-01.3	XX/XX/XXXX	* 2.35-21-02.1	XX/XX/XXXX
* 2.34-23-01.1	XX/XX/XXXX	* 2.35-21-02.2	XX/XX/XXXX
* 2.34-24-01.1	XX/XX/XXXX	* 2.35-21-03.1	XX/XX/XXXX
* 2.34-24-01.2	XX/XX/XXXX	* 2.35-21-04.1	XX/XX/XXXX
* 2.34-24-01.3	XX/XX/XXXX	* 2.35-21-05.1	XX/XX/XXXX
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* 2.34-31-01.2	XX/XX/XXXX	* 2.35-31-01.1	XX/XX/XXXX
* 2.34-31-02.1	XX/XX/XXXX	* 2.35-31-01.2	XX/XX/XXXX
* 2.34-31-02.2	XX/XX/XXXX	* 2.35-31-02.1	XX/XX/XXXX
* 2.34-31-03.1	XX/XX/XXXX	* 2.35-31-02.2	XX/XX/XXXX
* 2.34-31-03.2	XX/XX/XXXX		
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* 2.36-00-01.3	XX/XX/XXXX	* 2.38-10-01.2	XX/XX/XXXX
* 2.36-00-01.4	XX/XX/XXXX	* 2.38-30-01.1	XX/XX/XXXX
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* 2.36-11-01.1	XX/XX/XXXX	* 2.38-30-01.3	XX/XX/XXXX
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* 2.36-11-02.3	XX/XX/XXXX	* 2.42-21-01.4	XX/XX/XXXX
* 2.36-11-03.1	XX/XX/XXXX	* 2.42-21-01.5	XX/XX/XXXX
* 2.36-11-03.2	XX/XX/XXXX	* 2.42-21-01.6	XX/XX/XXXX
* 2.36-11-04.1	XX/XX/XXXX	* 2.42-21-01.7	XX/XX/XXXX
* 2.36-11-04.2	XX/XX/XXXX	* 2.42-21-01.8	XX/XX/XXXX
* 2.36-11-05.1	XX/XX/XXXX	* 2.42-21-02.1	XX/XX/XXXX
* 2.36-11-05.2	XX/XX/XXXX	* 2.42-21-02.2	XX/XX/XXXX
* 2.36-12-01.1	XX/XX/XXXX	* 2.42-21-02.3	XX/XX/XXXX
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Section 0

Introduction

General

Document Purpose

This MMEL defines the standard of MMEL as approved by the Federal Aviation Administration (FAA). The Preamble and Definitions of this MMEL should be applied to any MEL generated by use of this MMEL.

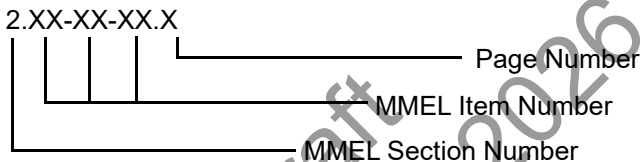
Document Content and Organization

The MMEL is divided into two sections as follows:

SECTION 0 - GENERAL

SECTION 2 - MMEL

This section contains the FAA MMEL. For ease of use, page numbering uses the MMEL item number as follows:



For example, MMEL item 21-51-01 would be found on page 2.21-51-01.1 in Section 2.

Each MMEL item is separated by a double horizontal line, with each applicable sub item separated by a single horizontal line.

The UK CAA MMEL Definitions and Preamble are printed in this section.

Airplane Configurations

This MMEL is applicable to the following Boeing 777X variants only:

- 777-9

Document Administration

FAA MMELs are available on MyBoeingFleet in Adobe Portable Document Format (PDF) digital media.

Boeing DDGs are available on MyBoeingFleet in Adobe Portable Document Format (PDF) and Adobe FrameMaker digital media.

Operators may purchase Boeing DDGs as Hyper Text Markup Language (HTML) and Extensible Markup Language (XML) digital media.

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Operators should use the Boeing Service Requests Application on MyBoeingFleet for comments or questions on these products and services.

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Section 2

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General Notes

This section contains MMEL Definitions, the MMEL Preamble, and the MMEL items. The MMEL items have a table of contents for each ATA.

MMEL Definitions

The Definitions must be inserted here in each Minimum Equipment List (MEL) from current FAA MMEL Policy Letter PL-25, MMEL and MEL Definitions, in accordance with PL-25 Appendix B.

The 14 CFR regulatory requirements applicable to specific MMEL chapters can be found in PL-25 Appendix A. Regulatory requirements must be incorporated into each specific MEL relief by the MEL user in accordance with the kinds of operations being conducted by the user.

MMEL Preamble

Introduction

The applicable Preamble must be inserted here in each Minimum Equipment List (MEL). For operations under 14 CFR parts 91 subpart K (part 91K), 121, 125, 125 LODA, 129, and 135, refer to the current FAA MMEL Policy Letter PL-34, MMEL and MEL Preamble. For operations under 14 CFR Part 91, refer to the current FAA MMEL Policy Letter PL-36, 14 CFR Part 91 MEL Approval and Preamble.

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21-73-01-01 VOC/Ozone Converters

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21-00-01 Environmental Control System Miscellaneous Cards (ECSMC)**21-00-01-01 FCAC Installed**

21-00-01-01A

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative ECSMC is deactivated,
- Remaining operative Recirculation Fans are verified before each departure,
- Both Air Conditioning Packs operate normally,
- Both ARINC signal gateway (ASG) cards in opposite cardfile operate normally,
- Both Equipment Cooling Controllers operate normally,
- Opposite Equipment Cooling Supply Fan operates normally,
- Opposite Lavatory/Galley Ventilation Fan operates normally,
- For left ECSMC inoperative, AFT CARGO TEMP selector remains OFF,
- For right ECSMC inoperative, BULK CARGO TEMP selector remains OFF, and
- Appropriate performance adjustments are applied.

[For Aft Chiller Boost Fans installed:](#)

- Associated Aft Chiller Boost Fan is considered inoperative.

21-00-01 Environmental Control System Miscellaneous Cards (ECSMC)**21-00-01-01 FCAC Installed**

21-00-01-01B

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative ECSMC is deactivated,
- Remaining operative Recirculation Fans are verified before each departure,
- Both ARINC signal gateway (ASG) cards in opposite cardfile operate normally,
- Both Equipment Cooling Controllers operate normally,

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- e. Opposite Equipment Cooling Supply Fan operates normally,
- f. Opposite Lavatory/Galley Ventilation Fan operates normally,
- g. FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing,
- h. For left ECSMC inoperative, AFT CARGO TEMP selector remains OFF,
- i. For right ECSMC inoperative, BULK CARGO TEMP selector remains OFF, and
- j. Appropriate performance adjustments are applied.

[For Aft Chiller Boost Fans installed:](#)

- k. Associated Aft Chiller Boost Fan is considered inoperative.

21-00-01 Environmental Control System Miscellaneous Cards (ECSMC)

21-00-01-02 FCAC Not Installed

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- a. Inoperative ECSMC is deactivated,
- b. Remaining operative Recirculation Fans are verified before each departure,
- c. Both ARINC signal gateway (ASG) cards in opposite cardfile operate normally,
- d. Both Equipment Cooling Controllers operate normally,
- e. Opposite Equipment Cooling supply Fan operates normally,
- f. Opposite Lavatory/Galley Ventilation Fan operates normally,
- g. For left ECSMC inoperative, AFT CARGO TEMP selector remains OFF,
- h. For right ECSMC inoperative, BULK CARGO TEMP selector remains OFF, and
- i. Appropriate performance adjustments are applied.

[For Aft Chiller Boost Fans installed:](#)

- j. Associated Aft Chiller Boost Fan is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-00-01-01.

The two identical ECS miscellaneous cards (ECSMC) are used in the control of non-critical functions of the equipment cooling and air distribution system. The ECSMCs are redundant except that the left ECSMC controls aft cargo heat and the left aft chiller fan (if installed); the right ECSMC controls bulk cargo heat and the right aft chiller fan (if installed). Backup control of critical functions (both EE cooling supply fans and both EE cooling override valve motors) is supplied by the equipment cooling controllers.

ECSMCs also perform control of non-critical functions for the IFE cooling system, and the air distribution system including forward chiller exhaust fan, galley area heat, door area heat, gasper ventilation and captain and first officer shoulder and foot heat.

Consequences of Failure

Failure of an ECSMC is indicated by the ECS CARD L or R Status message.

For left ECSMC inoperative:

Left lower and forward upper recirc fans, left aft chiller boost fans, and door 2 galley area heaters (if installed) will be inoperative. Loss of door 1 and 2 heaters. Aft Cargo heating will be inoperative. Loss of overheat protection on the following fans: EE Vent Fan, Left Lavatory/Galley Vent Fan, Left EE Supply Fan, Forward Cargo Exhaust Fan, Gasper Fan, IFE Cooling Fan, Left Aft Chiller Fan. Restrictions: Left Aft Chillers inoperative. Temperature sensitive cargo should not be carried in the aft cargo compartment.

For right ECSMC inoperative:

Right lower and aft upper recirc fans, right aft chiller boost fans, and door 3 galley area heater (if installed) will be inoperative. Loss of door 3, 4 and Service Door (if installed) heaters. Bulk Cargo heating will be inoperative. Loss of overheat protection on the following fans: Bulk Cargo Vent Fan, Right Lavatory/Galley Vent Fan, Right EE Supply Fan, Right Aft Chiller Fan. Restrictions: Right Aft Chillers are inoperative. Temperature sensitive cargo should not be carried in the bulk cargo compartment. FCAC (if installed) must remain OFF.

Remaining air distribution systems operate normally. Equipment cooling continues to operate in normal mode with one ECS card inoperative. EE Cooling Override capability is available through the remaining card.

Consequences of Next Critical Failure

Equipment cooling override condition: Equipment cooling system automatically reconfigures to override mode.

Failure of remaining ECSMC: Critical control functions remain operational through the equipment cooling controller(s). Loss of all non-essential electronic functions (EE Cooling smoke detection, In Flight Entertainment cooling [IFE loss], EE Cooling vent fan, cargo heat, door area heat, galley area heat, lav/galley ventilation and F/O foot and shoulder heaters. If installed optional equipment: gasper boost, forward chiller exhaust, left and right aft chillers.)

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Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

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21-22-01 Flight Deck Flow Regulating Valve (FRV)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Flight Deck Flow Regulating Valve is deactivated open.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-51-03 (777F).

The flight deck flow regulating valve is located downstream of the pack, in the main duct that supplies conditioned air to the flight deck. Unlike a SOV, the FRV offers a way to regulate the air flow within the duct to attempt to maintain a constant airflow to the flight deck depending on air conditioning system demands.

Consequences of Failure

The FLIGHT DECK A/C FRV Status message will be displayed when the Flight Deck flow Regulating Valve (FRV) is not in the commanded position, or the RVT for the valve has failed.

When the FRV is inoperative deactivated open, the flow to the flight deck is unregulated. This may cause an unbalanced air flow situation in the airplane.

Consequences of Next Critical Failure

None. For a smoke event, positive air flow to the flight deck is maintained.

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21-24-01 Gasper Fan

21-24-01A

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative provided:

- GASPER switch remains off, and
- Repairs are made within 1 flight.

21-24-01 Gasper Fan

21-24-01B

Interval	Installed	Required	Procedure
D	1	0	(M)

May be inoperative provided Gasper Fan is deactivated.

21-24-01 Gasper Fan

21-24-01-01 GASPER Switch ON Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-24-01.

An optional gasper system provides airflow in the passenger cabin through adjustable outlets in the overhead passenger service units. Airflow is boosted by a gasper fan above the cabin ceiling, with ducts connecting the fan to the air outlets. The system is selected on by a switch on the air conditioning panel on the flight deck.

ON Light: When the alternate action pushbutton switch is pressed to ON, the gasper fan operates.

Consequences of Failure

Passengers will be provided with reduced individual airflow through the PSU outlets.

ON Light: The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

None identified.

ON Light: None identified.

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Interval	Installed	Required	Procedure
C	4	0	(M) (O)

May be inoperative provided:

- Inoperative Recirculation Fan(s) is verified prior to each departure,
 - Inoperative Recirculation Fan(s) is deactivated,
 - Both Air Conditioning Packs operate normally, and
 - Appropriate performance adjustments are applied.
-

21-25-01 Recirculation Fans**21-25-01-01 FCAC Installed***********21-25-01-01B**

Interval	Installed	Required	Procedure
C	4	2	(M) (O)

May be inoperative provided:

- Inoperative Recirculation Fan(s) is verified prior to each departure,
 - Inoperative Recirculation Fan(s) is deactivated,
 - Both lower Recirculation Fans operate normally, and
 - Appropriate performance adjustments are applied.
-

21-25-01 Recirculation Fans**21-25-01-01 FCAC Installed***********21-25-01-01C**

Interval	Installed	Required	Procedure
C	4	0	(M) (O)

May be inoperative provided:

- Inoperative Recirculation Fan(s) is verified prior to each departure,
- Inoperative Recirculation Fan(s) is deactivated,

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- c. FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing, and
- d. Appropriate performance adjustments are applied.
-

21-25-01 Recirculation Fans**21-25-01-02 FCAC Not Installed*********

Interval	Installed	Required	Procedure
C	4	0	(M) (O)

May be inoperative provided:

- a. Inoperative Recirculation Fan(s) is verified prior to each departure,
- b. Inoperative Recirculation Fan(s) is deactivated, and
- c. Appropriate performance adjustments are applied.
-

21-25-01 Recirculation Fans**21-25-01-03 RECIRC FANS Switch ON Light**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-25-01-01.

There are two upper and two lower recirculation fans installed in the cabin air distribution system. Their function is to draw filtered air from the cabin and return it to the distribution system, supplementing conditioned air from the packs. The recirculation fans are selected on by two switches on the air conditioning overhead panel on the flight deck. Control of the fans is provided by the cabin temperature controllers (CTC's).

ON Light: When each alternate action pushbutton switch (two installed) is pressed to ON, the associated recirculation fans are controlled automatically.

Consequences of Failure

Failure of one or more cabin air recirculation fans, or electrical load control unit (ELCU), results in display of the RECIRC FAN Status message.

The CTC's command higher pack flow rate to compensate for reduced flow in the distribution system. This results in higher engine fuel flow. Ventilation and temperature control are degraded for some flight phases when multiple recirculation fans are inoperative.

ON Light: The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

Dispatch with any or all recirculation fans inoperative:

Failure of one air conditioning pack - Cabin pressurization and air conditioning is supplied by the remaining pack. Ventilation and temperature control are further degraded.

For a smoke event, both air conditioning pack must be operating to prevent smoke penetration in the cabin. If operating with a single air conditioning pack, acceptable smoke penetration characteristics may be achieved if either both lower recirculation fans operate normally, or forward cargo air conditioning (FCAC) is not be used during takeoff, climb, descent or landing.

ON Light: None.

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21-26-01 Lavatory/Galley Ventilation Fans

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative Lavatory/Galley Ventilation Fan is deactivated, and
- Opposite Environmental Control System Miscellaneous Card (ECSMC) operates normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-26-01.

The Lav/Galley fans draw air from the galleys and lavatories to exhaust air away from the galleys and lavatories. Only one fan operates, with the other as an automatic backup. There are no flight deck controls associated with these fans. They are controlled automatically by ELMS, and the ECS miscellaneous cards (ECSMC). The fans pull air through the E10, E11 and E13 equipment racks providing aft equipment cooling. Additionally, the fans pull air through flight deck, cabin and cargo temperature sensors. The equipment cooling provided by the Lav/Galley fans is non-essential. Any essential LRUs on these racks operate without cooling or have an alternate source of cooling.

Consequences of Failure

The LAV-GALLEY FAN L, R Status message will be displayed for failure of the left or right lavatory/galley ventilation fan or if the associated ELCU no longer provides overcurrent protection.

None. Loss of redundancy only. Only one fan is required for full ventilation and cooling capability.

Consequences of Next Critical Failure

Failure of the remaining fan: Loss of lavatory/galley ventilation, aft equipment cooling, and temperature sensing. Flight deck and cabin temperature control may be degraded. Also, aft and bulk cargo heat will be commanded OFF.

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21-26-02

Chiller Boost Fan - Forward

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Forward Chiller Exhaust Fan is deactivated.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-26-02.

The Forward Chiller System transports warm/hot chiller condenser exhaust air from the Door 1 and 2 centerline galleys to the lower lobe cheeks located outboard of the forward cargo compartment. The system is designed to prevent the chiller condensers from ingesting the condenser exhaust which can impact chiller performance and reliability. The chillers are located in the crown above the galley ceilings. The system consists of an exhaust fan, mufflers, ducting and the control software for the fan is in the environmental control system miscellaneous cards (ECSMC). The forward chiller exhaust fan operates only on the ground when the total air temperature (TAT) is greater than or equal to 45 degrees F. Exhaust fan will be commanded OFF for AUTO Fire Arm FWD, FWD Cargo Arm selected, FWD Cargo Smoke detected, fan overheat, or Fwd Chiller Fan Disable is True (EQUIP COOLING FAULT Advisory message is True).

Consequences of Failure

The CHILLER BOOST FAN FWD Status message will be displayed if the fan fails to go to the commanded state or an overheat condition is detected.

Inoperative fan must be deactivated. The chillers will exhaust their hot air out of exhaust spuds along the chiller exhaust ducting. The hot chiller condenser exhaust air will be exhausted into the crown through the relief spuds located on the exhaust ducts. This will raise the crown temperatures which could reduce the cabin temperature pull down performance and could impact equipment located in the crown including the chillers.

As a result of increased crown temperatures, galley chillers may have decreased cooling performance (or go into temporary shutdown) which may result in inadequate food temperatures.

Consequences of Next Critical Failure

Failure of a galley chiller: Associated galley will not have chilled air in its refrigerator carts and/or compartments.

21-26-03 Bulk Cargo Ventilation Fan**21-26-03A**

Interval	Installed	Required	Procedure
A	1	0	(M) (O)

May be inoperative provided:

- Bulk Cargo Ventilation Fan is verified OFF, and
- Repairs are made within 1 flight.

21-26-03 Bulk Cargo Ventilation Fan**21-26-03B**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Bulk Cargo Ventilation Fan is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-26-03.

The bulk cargo heat system includes a ventilation fan. The fan draws air from outside the compartment which is supplied to the bulk compartment through a ceiling mounted outlet. The fan is used when transporting animal cargo. The HIGH switch setting of Bulk Cargo Heat will enable the fan.

The bulk cargo vent fan is activated automatically when the Bulk Cargo Temp Control switch is selected HIGH. The fan is commanded off when the Bulk CARGO TEMP SELECT setting is LOW or OFF. On LOW, the system controls to 45 +/- 5 degrees F.

Consequences of Failure

Failure of the bulk cargo ventilation fan is indicated by the CARGO VENT FAN BULK Status message.

Fan verified OFF: Fan must be verified OFF for dispatch (one flight only).

Fan deactivated: Fan must be deactivated for dispatch.

Bulk cargo compartment ventilation is not available. Animal cargo should not be carried in the bulk compartment.

Consequences of Next Critical Failure

For dispatch with fan verified OFF or with fan deactivated:

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Failure of bulk cargo heating system: No effect unless temperature sensitive cargo other than animals is carried in bulk compartment (animals should not be carried due to vent fan failure).

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21-26-04 Forward Cargo Air Conditioning (FCAC) Exhaust Fan
*****21-26-04A**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided FCAC exhaust fan is deactivated.

21-26-04 Forward Cargo Air Conditioning (FCAC) Exhaust Fan
*****21-26-04B**

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- FCAC exhaust fan is deactivated; and
 - FWD CARGO A/C selector remains OFF.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-26-05.

The forward cargo air conditioning (FCAC) system, an optional system, provides conditioned air from the mix manifold to the cargo compartment. Trim air from the right trim air system is mixed with cool air from the mix manifold upstream of the FCAC flow regulating valve (FRV) to achieve the desired compartment temperature. The FCAC Exhaust Fan is installed to prevent forward cargo odors from migrating to the cabin and flight deck. The fan assists in preventing odors by drawing forward cargo air into the cargo heat ducts and toward the overboard exhaust duct. When the FCAC Exhaust Fan is not in the commanded state, the CARGO EXH FAN FWD status message is displayed.

Consequences of Failure

The CARGO EXH FAN FWD Status message will be displayed when the ECSMC detects loss of forward cargo exhaust fan or fan is not in commanded state.

FCAC operational: Forward cargo air conditioning (FCAC) is available, however forward cargo odors may migrate to the cabin and flight deck.

FCAC selected off: Temperature sensitive cargo such as perishable goods should not be carried in the lower forward cargo compartment.

Consequences of Next Critical Failure

For FCAC operational:

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Forward cargo compartment fire: The fire protection integrity of the forward cargo compartment is maintained as the FCAC flow regulating valve (FRV) is commanded closed by the cabin temperature controller (CTC) in control and the FCAC Exhaust Fan is deactivated off for dispatch.

FCAC fails to off (FRV fails closed or temp sensors fail): forward cargo heat is available in lieu of air conditioning.

For FCAC selected off:

Forward cargo compartment fire: The fire protection integrity of the forward cargo compartment is maintained as the FCAC FRV is commanded closed when the FWD CARGO A/C is selected off and the FCAC Exhaust Fan is deactivated off for dispatch.

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21-26-05

Chiller Boost Fans - Aft

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Inoperative Chiller Boost Fan(s) is deactivated, and
- Associated chiller(s) is deactivated.

SUBSTANTIATION**Background**

For 777-9, the optional aft chillers have been relocated from the lower lobe into the crown area above the galley. The crown area where the chillers are located does not have any active ventilation due to the Overhead Flight Attendant Rest (OFAR) being located forward of the galley in the crown. As the enclosed unventilated area will not support the required inlet temperatures for the chillers, ducting was added to the inlet and outlet of the chiller. The chiller inlet ducting is required to prevent the chiller from bypassing the Return Air Grille (RAG) flow.

The added chiller exhaust ducting adds too much back pressure for the chiller condenser fan to provide sufficient airflow across the condenser which will result in poor chiller performance and potential chiller shutdown. To aid the chillers, a boost fan was added to each of the two optional chillers that could be installed.

Consequences of Failure

The CHILLER BOOST FAN AFT L or CHILLER BOOST FAN AFT R Status message will be displayed if the fan fails to go to the commanded state or an overheat condition is detected.

Inoperative fan and associated chiller must be deactivated. The galley carts or chilled compartment associated with that chiller will not be cooled. Each chiller typically provides cooling for approximately 7 carts.

Consequences of Next Critical Failure

None.

21-27-01 Equipment Cooling Air Filter

Interval	Installed	Required	Procedure
C	1	0	(M)

May be operated with Equipment Cooling Air Filter removed.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-27-01.

The equipment cooling system draws ambient air from the left cheek, adjacent to the lower forward cargo compartment. A barrier filter is installed upstream of the 2 supply fans to prevent ingestion of particles.

Consequences of Failure

Equipment cooling air will be unfiltered.

Consequences of Next Critical Failure

None identified. Equipment cooling is accomplished with unfiltered air until filter is replaced (10 day repair interval specified in MMEL).

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Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Left Equipment Cooling Supply Fan is deactivated,
 - Right Equipment Cooling Supply Fan operates normally,
 - Right Environmental Control System Miscellaneous Card (ECSMC) operates normally,
 - Both Equipment Cooling Override Valve Motors operate normally,
 - Right Equipment Cooling Controller operates normally, and
 - Flight is conducted pressurized.
-

21-27-02 Equipment Cooling Supply Fans**21-27-02-02 Right Supply Fan**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Right Equipment Cooling Supply Fan is deactivated,
 - Left Equipment Cooling Supply Fan operates normally,
 - Left Environmental Control System Miscellaneous Card (ECSMC) operates normally,
 - Both Equipment Cooling Override Valve Motors operate normally,
 - Flight is conducted pressurized.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-02.

The equipment cooling system provides cooling airflow to electrical equipment in the E/E bay and the flight deck. It has 2 supply fans and one vent (exhaust) fan. The supply fans blow air through the equipment cooling ducts. Only one supply fan operates with the other as an automatic backup. The fans are controlled by the ECS miscellaneous cards and powered by ELMS. Backup control is provided by the equipment cooling controllers. The equipment cooling system operates automatically, with a flight deck switch provided to select AUTO or OVRD mode. In override mode, cabin air pressure provides reverse airflow through the equipment and exits overboard via the override valve. This does not require operation of either supply fan or the vent fan.

Consequences of Failure

Failure of the left or right electrical equipment cooling air supply fan or associated ELCU will result in the EQUIP COOLING FAN L or R Status message.

None. Loss of redundancy. Only one fan is required for full cooling capacity. Inoperative fan must be deactivated for dispatch.

Consequences of Next Critical Failure

Failure of remaining supply fan: The equipment cooling system automatically reconfigures to OVRD mode. The backup converter fan is automatically switched on by the Backup Electrical Power System for backup converter cooling. In override mode, cabin air pressure provides reverse airflow through the equipment for cooling and exits overboard via the override valve during pressurized flight.

Loss of opposite equipment cooling controller (ECC):

With Left Fan deactivated and loss of Right ECC: R Supply Fan and R Override motor become inoperative. Override mode still available with L Override Motor.

With Right Fan deactivated and loss of Left ECC: Equipment cooling system driven into override mode and L Supply Fan becomes inoperative.

Equipment cooling override mode is indicated by the EQUIP COOLING OVRD Advisory message. The EQUIP COOLING FAULT Advisory message may be displayed if operating at low altitude. Operating with the EQUIP COOLING FAULT Advisory message displayed for greater than 30 minutes may result in loss of voice communication, transponder, weather radar, VHF datalink and primary window heat. This proposal assumes that, in accordance with non-normal procedures, the flight crew will not hold at an altitude low enough that the EQUIP COOLING FAULT Advisory message will appear. Therefore S&MF ECS-1 does not apply for this item. S&MF ECS-1 is classified as 'Hazardous.'

This fan is controlled via an Electrical Load Control Unit (ELCU). Deactivation of this component includes both opening the associated ELCU control circuit breaker and disconnect / cap / stow of the electrical connector. Failure of ELCU contacts in a way that the monitored contact is open but one or two of the other phases are welded closed might lead to an uncontrolled or smoking fan. Therefore, the electrical connector for the inoperative fan must be disconnected, capped and stowed for dispatch.

21-27-03 Equipment Cooling Override Valve Motors**21-27-03-01 Left Motor**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Left Equipment Cooling Override Valve Motor is deactivated,
 - Right Equipment Cooling Override Valve Motor operates normally,
 - Both Equipment Cooling Supply Fans operate normally, and
 - Right Equipment Cooling Controller operate normally.
-

21-27-03 Equipment Cooling Override Valve Motors**21-27-03-02 Right Motor**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Right Equipment Cooling Override Valve Motor is deactivated,
 - Left Equipment Cooling Override Valve Motor operates normally, and
 - Both Equipment Cooling Supply Fans operate normally.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-03.

Dual motors provide actuation for the override valve. Only one motor is required to actuate the valve. The valve has two discs to configure the equipment cooling flow path for normal or override mode operation. One disc is in the air supply duct and the other is in a duct to an overboard vent. In normal mode, the overboard duct disc is closed and the supply duct disc is open to allow equipment cooling using the supply and vent fans. In override mode, the supply duct disc is closed and the overboard disc is open. Cabin air pressure causes reverse air flow through the equipment cooling system, vented overboard. When the system is operated in AUTO, override mode is automatically selected if any of the following conditions are detected: Both supply fans inoperative, smoke detected, low flow detected, or forward cargo fire extinguisher bottles armed.

Consequences of Failure

Failure of an equipment cooling override valve motor is indicated by the OVRD VALVE MOTOR L or OVRD VALVE MOTOR R Status message.

None. Loss of redundancy. Only one motor is required for full override valve capability.

Consequences of Next Critical Failure

Failure of remaining motor: Equipment cooling system cannot be configured for override mode.

Override condition detected: System automatically reconfigures to override mode.

Loss of opposite equipment cooling controller (ECC):

With Left Motor deactivated and loss of Right ECC: Equipment cooling system cannot be configured for override mode and R Supply Fan becomes inoperative.

With Right Motor deactivated and loss of Left ECC: Equipment cooling system driven into override mode and L Supply Fan becomes inoperative.

Equipment cooling override mode is indicated by the EQUIP COOLING OVRD Advisory message.

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21-27-04 Equipment Cooling System Low Flow Sensors**21-27-04-01 Main Equipment Center Low Flow Sensor**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Main Equipment Center Low Flow Sensor is deactivated,
 - Flight Deck Low Flow Sensor operates normally,
 - Both Equipment Cooling Controllers operate normally, and
 - All Equipment Cooling Duct Pressure Sensors operate normally.
-

21-27-04 Equipment Cooling System Low Flow Sensors**21-27-04-02 Flight Deck Low Flow Sensor**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative Flight Deck Low Flow Sensor is deactivated,
 - Main Equipment Center Low Flow Sensor operates normally, and
 - All Equipment Cooling Duct Pressure Sensors operate normally.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-04-01.

The equipment cooling system includes 2 low flow detectors. They detect conditions of low cooling airflow for the flight deck equipment racks and the main equipment racks. On ground, only one detector is required to detect low cooling airflow allowing automatic system response. In air, both detectors are required to detect low cooling airflow allowing automatic system response. For annunciation of low flow (or high airflow temperatures) on ground, one detector must sense high temps or low flow for 5 minutes. For annunciation of low flow (or high airflow temperatures) in air, both detectors must sense high temps or low flow for 8 minutes.

Note: With a sensor inoperative, system logic preserves annunciation in air utilizing the functioning sensor.

Consequences of Failure

The EQUIP FLOW DET Status message will be displayed for an main equipment center low flow detector that has failed its BITE test.

The FLT DECK FLOW DET Status message will be displayed for a flight deck low flow detector that has failed its BITE test.

The FLOW DET DISAGREE Status message is displayed when the main equipment center and flight deck low flow detector outputs do not agree.

If sensor fails "good flow" in air, there is no effect. Cooling system continues to operate in normal mode without low flow detection capability. If sensor fails "low flow" in air, there is no effect. Cooling system continues to operate in normal mode and low flow detection capability is maintained. Low flow check mode will detect flow detector disagreement upon landing.

Inoperative low flow sensor is deactivated for dispatch. The FLOW DET DISAGREE Status message will be displayed.

Consequences of Next Critical Failure

Failure of remaining low flow detector:

Cooling system continues to operate in normal mode without low flow detection capability. Auto override capability remains for smoke detected, forward cargo bottles armed, or both supply fans failed. The associated EQUIP FLOW DET or FLT DECK FLOW DET Status message will be displayed.

Blockage of cooling air supply:

Remaining low flow detector senses low flow, causing equipment cooling to automatically reconfigure to override mode. The EQUIP COOLING OVRD Status message will be displayed.

21-27-05 Equipment Cooling Vent Fan

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Equipment Cooling Vent Fan is deactivated,
- Equipment cooling supply smoke detector operates normally, and
- For ground operations with OAT 30°C (86°F) or higher, both Air Conditioning Packs are operated or airplane is supplied with conditioned air.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-05.

The equipment cooling system includes two supply fans and one vent (exhaust) fan. The supply fans blow cooling air into the equipment cooling ducts to the flight deck equipment racks and the electrical/electronics (E/E) bay racks. The vent fan draws air out of the equipment racks in the flight deck and E/E bay for venting into the forward cargo area (or overboard). For airplanes without forward cargo air conditioning (FCAC) installed, the warm exhaust air provides the only means of forward cargo heating in flight.

Consequences of Failure

The EQUIP VENT FAN Status message will be displayed if the fan has failed or the electrical load control unit (ELCU) no longer provides current protection.

The equipment cooling vent fan must be deactivated for dispatch. E/E Bay ambient temperatures will be higher. However, sufficient cooling will still be provided by the E/E Cooling Supply Fan. Forward Cargo Heat will be inoperative on airplanes without FCAC installed. Without forward cargo heat, temperature sensitive cargo should not be carried in the forward cargo compartment.

Equipment cooling supply smoke detector requires that equipment cooling vent must operate normally. Therefore, the equipment cooling supply smoke detector must operate normally.

Consequences of Next Critical Failure

Failure of one equipment cooling supply fan: Indicated by EQUIP COOLING FAN L or EQUIP COOLING FAN R Status message. Equipment cooling continues to operate in normal mode.

Smoke in the E/E Bay: E/E Bay smoke detection is unavailable without the Vent Fan (Failure to detect smoke is Major). Potential for smoke penetration into the flight deck and/or adjacent compartments. May result in FIRE CARGO FWD Warning message or EQUIP COOLING OVRD Advisory message.

21-27-06 Equipment Cooling Vent Valve

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Equipment Cooling Vent Valve is deactivated closed,
- Equipment Cooling Vent Fan is deactivated, and
- For ground operations with OAT 30°C (86°F) or higher, both Air Conditioning Packs are operated or airplane is supplied with conditioned air.

For FCAC installed:

- FCAC exhaust fan is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-06-01.

The equipment cooling vent valve provides venting of the equipment cooling exhaust air overboard instead of the forward cargo area for OAT above 55 degrees F. The vent discharge duct directs the exhaust air in the vicinity of the Cabin Pressure Control System forward outflow valve, where it is drawn outside the fuselage.

Consequences of Failure

The EQUIP VENT VALVE Status message will be displayed when the valve is not in its commanded position.

FCAC not installed:

Equipment cooling vent valve must be deactivated closed and equipment cooling vent fan must be deactivated. Valve is closed during normal flight and on ground with total air temperature (TAT) <50 degrees F so there is no effect. Forward cargo heat functions normally. On ground with TAT >55 degrees F, electrical/electronics (E/E) bay vent fan is commanded OFF. For ground operations above 30 degrees C, both packs are selected on or conditioned air is supplied to the airplane.

FCAC installed:

Equipment cooling vent valve must be deactivated closed and equipment cooling vent fan must be deactivated. FCAC exhaust fan must also be deactivated. Forward cargo compartment will have degraded temperature control which could affect temperature sensitive cargo. Odors in the forward cargo compartment may migrate to the flight deck and cabin.

Consequences of Next Critical Failure

Smoke in E/E Bay: Loss of smoke detection in the E/E Cooling vent system.
Possible smoke migration into other compartments (e.g. flight deck, fwd cargo).
Crew would perform Smoke, Fire, Fumes procedure and put the E/E Cooling system in Override to evacuate the smoke.

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21-27-07 Forward Cargo Heat Valve

21-27-07-01 FCAC Installed

21-27-07-01A

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Forward Cargo Heat Valve is deactivated closed, and
 - Equipment cooling inboard valve operates normally.
-

21-27-07 Forward Cargo Heat Valve

21-27-07-01 FCAC Installed

21-27-07-01B

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Forward Cargo Heat Valve is deactivated closed,
 - Equipment Cooling Vent Valve operates normally, and
 - Equipment Cooling Divert Valve operates normally.
-

21-27-07 Forward Cargo Heat Valve

21-27-07-02 FCAC Not Installed

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Forward Cargo Heat Valve is deactivated closed, and
 - Equipment Cooling Vent Valve operates normally.
-

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-27-07.

The forward cargo compartment is heated with warm exhaust air from the forward equipment cooling system. This air is supplied to the cargo compartment during flight, and on the ground if the outside air temperature (OAT) is less than or equal to 50°F. Otherwise, the E/E Cooling exhaust air is diverted overboard. The valve is also commanded closed if there is a forward cargo smoke detection signal, forward cargo fire suppression system arm signal (CFES), E/E Bay smoke detection signal, or selection of the Equipment Cooling System to override.

Consequences of Failure

The CARGO HEAT VALVE FWD Status message will be displayed when the valve is not in the commanded position or fails the BITE test. For erroneous valve position indication, the EQUIP VENT FAN Status message may be displayed.

The forward cargo heat valve is deactivated closed for dispatch.

For FCAC installed, inboard valve must operate normally OR vent valve and divert valve must operate normally. FCAC will operate normally.

For FCAC not installed, vent valve must operate normally, forward cargo heat will not be available in-flight and on ground with total air temperature (TAT) less than 50°F. Temperature sensitive cargo may be affected.

Consequences of Next Critical Failure

None identified.

21-27-08 Equipment Cooling Controllers

Interval	Installed	Required	Procedure
A	2	1	(M)

Right Equipment Cooling Controller may be inoperative provided:

- Inoperative Right Equipment Cooling Controller is deactivated,
- Right Equipment Cooling Supply Fan is deactivated,
- Right Equipment Cooling Override Valve Motor is deactivated,
- Left Equipment Cooling Controller operates normally,
- Left Equipment Cooling Supply Fan operates normally,
- Left Equipment Cooling Override Valve Motor operates normally,
- Both Environmental Control System Miscellaneous Cards (ECSMC) operate normally,
- Main Equipment Center Low Flow Sensor operates normally, and
- Repairs are made within 10 calendar-days.

NOTE: Dispatch is not allowed for an inoperative Left Equipment Cooling Controller.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-08.

The two identical equipment cooling controllers (ECCs) provide control for the essential equipment cooling functions (both supply fans and the smoke/override valve). The L and R controllers independently control the respective (L or R) supply fans and (L or R) override valve motors. The ECCs normally drive the Supply Fan Electrical Load Control Units (ELCUs) and Override Valve Motor relays in the Electrical Load Management System (ELMS) panels according to the environmental control system miscellaneous card (ECSMC) discrete commands. However, the ECCs will provide backup control logic should the ECSMCs fail and equipment cooling low flow is detected.

Consequences of Failure

A failure of an ECC detected by the ECSMCs will be indicated by the EQUIP COOLING CTRL L or EQUIP COOLING CTRL R Status message.

Loss of redundancy. Equipment cooling continues to operate in normal mode and the remaining controller provides backup override control if required.

Failure of the Right ECC:

Loss of redundancy. Equipment cooling continues to operate in normal mode and the remaining controller provides backup override control if required. The right equipment cooling controller and cooling override valve

motor must be deactivated for dispatch.

Failure of the Left ECC:

Equipment cooling is driven to override mode and cannot be commanded back to normal. Sufficient cooling is provided in flight. MMEL dispatch is not proposed for an inoperative left equipment cooling controller.

Consequences of Next Critical Failure

Unannounced loss of all forced air cooling to equipment located in the forward E/E Bay and Flight Deck for greater than 505 minutes:

After 505 minutes this hazard condition is considered 'Catastrophic'. This failure condition can potentially cause loss of functionality of flight critical equipment and essential equipment that supports flight critical functions. This failure condition is impacted when operating with an inoperative Right Equipment Cooling Controller. However, an acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with an inoperative Right Equipment Cooling Controller. When operating in this configuration, the resulting probability of unannounced loss of all forced air cooling to equipment located in forward E/E Bay and Flight Deck for greater than 505 minutes is extremely improbable (on the order of $3.17\text{E-}11$).

For loss of forced air cooling, the EQUIP COOLING FAULT Advisory message will be displayed. By procedure the flight crew must plan to land within 505 minutes.

After 30 minutes, the following non-flight critical functions may be lost:

All voice communications via VHF, HF, SATCOM will be inoperative. ISS functions including Transponder, Weather Radar, Windshear alerting, TCAS, Ground proximity and Altitude Callouts will be inoperative. VHF datalink will be inoperative but HF and SATCOM datalink are still available. ADF/DME will be inoperative. Window Heat will be inoperative.

Announced loss of forced air cooling to equipment located in the forward E/E Bay and Flight Deck for greater than 30 minutes and less than 505 minutes:

This failure condition can potentially cause loss of functionality of essential equipment that does not support flight critical functions.

This failure condition is considered 'Hazardous'. This failure condition can potentially cause loss functionality of equipment that supports non-flight critical functions.

This failure condition is impacted when operating with an inoperative Right Equipment Cooling Controller, however, an acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with an inoperative Right Equipment Cooling Controller. When operating in this configuration, the resulting probability of announced loss of forced air cooling to equipment located in forward E/E Bay and Flight Deck for greater than 30 minutes and less than 505 minutes is extremely remote (on the order of $1.29\text{E-}9$).

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Failure of the left supply fan or left controller:

Loss of supply fan cooling. System reconfigures automatically to override mode. The EQUIP COOLING OVRD Advisory message will be displayed. The EQUIP COOLING FAULT Advisory message may be displayed if operating at low altitude. Operating with the EQUIP COOLING FAULT Advisory message displayed for greater than 30 minutes may result in loss of voice communication, transponder, weather radar, VHF datalink and primary window heat. This proposal assumes that, in accordance with non-normal procedures, the flight crew will not hold at an altitude low enough that the EQUIP COOLING FAULT Advisory message will appear.

Failure of the left override valve motor:

Forward equipment cooling override mode is not available. Equipment cooling override condition: System reconfigures automatically to override mode using the available controller and override valve motor when low flow or smoke is detected in the E/E or Fwd Cargo Bay.

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21-27-09

In-Flight Entertainment (IFE) Cooling System Fan

Interval	Installed	Required	Procedure
D	1	0	(M)

May be inoperative provided:

- Inoperative IFE Cooling System Fan is deactivated, and
- Associated IFE equipment is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-10-01.

The In-Flight Entertainment (IFE) equipment in the entertainment equipment cabinet (and e-boxes) is ventilated by the dedicated IFE cooling system fan. The equipment will vary by customer, but most will have their head-end equipment installed on the E1-5 shelf, in the entertainment equipment cabinet.

The 777-9 IFE cooling system will draw air from the right cheek, pull it through the entertainment equipment cabinet and e-boxes, then through the fan in the left cheek, and exhaust it to the mix bay. Cooling flows will vary per customer configuration.

High-Wall Suite Configuration has e-boxes for each suite which are also ventilated by the dedicated IFE cooling system fan.

Consequences of Failure

The IFE COOLING FAN Status message is displayed when the IFE cooling fan is not in its commanded state or has overheated.

For dispatch, the IFE cooling fan and IFE system must be deactivated. All of the IFE equipment in the entertainment equipment cabinet and purser work station (PWS)/video control center (VCC) will not be available for use by passengers.

Consequences of Next Critical Failure

None.

21-27-10 In-Flight Entertainment System (IFE) Cooling System Smoke Detector

Interval	Installed	Required	Procedure
D	1	0	(M)

May be inoperative provided:

- Inoperative IFE Cooling System Smoke Detector is deactivated,
- IFE Cooling System Fan is deactivated, and
- Associated IFE equipment is deactivated.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-27-11B.

The In-Flight Entertainment (IFE) equipment in the entertainment equipment cabinet (and e-boxes) is ventilated by the dedicated IFE cooling system fan. The equipment will vary by customer, but most will have their head-end equipment installed on the E1-5 shelf, in the entertainment equipment cabinet.

The 777-9 IFE cooling system will draw air from the right cheek, pull it through the entertainment equipment cabinet (and e-boxes), then through the fan in the left cheek, and exhaust it to the mix bay. Cooling flows will vary per customer configuration.

Smoke detector ports are installed in the system exhaust duct across the IFE cooling fan to detect smoke in the IFE Cooling system. When smoke is detected, the electrical load management system (ELMS) commands the IFE cooling fan off and the IFE equipment in the entertainment equipment cabinet and the purser work station (PWS)/video control center (VCC) is shutdown.

Consequences of Failure

Failure of the IFE cooling system smoke detector is indicated by the DETECTOR IFE SMOKE Status message.

For dispatch, the IFE cooling fan, IFE smoke detector and IFE system must be deactivated. All of the IFE equipment in the entertainment equipment cabinet and PWS/VCC will not be available for use by passengers.

Consequences of Next Critical Failure

None.

21-27-11 Equipment Cooling Duct Pressure Sensors

Interval	Installed	Required	Procedure
C	4	0	(M)

May be inoperative provided:

- Inoperative duct pressure sensor(s) is deactivated,
- Main Equipment Center Low Flow Sensor operates normally, and
- Flight Deck Low Flow Sensor operates normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-12.

The equipment cooling system includes four duct pressure sensors. They detect conditions of low pressure in the ducts leading to the electronic components that require active cooling. Low pressure in a duct indicates a possible compromise of the duct's integrity, which could result in cooling air leaks and reduced cooling of the associated electronic components. On the ground when any of the sensors detects low pressure for five minutes, the EQUIP COOLING FAULT Advisory message is displayed and the ground crew warning horn is sounded.

Consequences of Failure

Any inoperative pressure sensor will have no effect on system operation. The hazard associated with any particular pressure sensor is not worse than any other pressure sensor. All pressure sensors (FD, E4, E5 & BUC) inoperative will have no effect on system operation. Hazard condition is 'Minor'.

Duct pressure sensor fails out-of-range: The DUCT PRESS SENSOR BUC, E4, E5 or F/D Status message will be displayed and this MMEL item may be used to dispatch the airplane. Equipment cooling will continue to operate normally, although the ability to detect compromised ducts is degraded in the area of the failed sensor.

Duct pressure sensor fails in-range: On the ground after five minutes, the EQUIP COOLING FAULT Advisory message is displayed and the ground call warning horn is activated. Equipment cooling will continue to operate normally provided the inoperative sensor is deactivated, the surrounding ducting is checked for obvious signs of leaks, ruptures or disconnects and EQUIP COOLING FAULT Advisory message does not reappear after 5 minutes.

Consequences of Next Critical Failure

Equipment cooling pressure sensors are included as part of the following FTA analyses:

'Loss of all E/E Supply Cooling for >505 minutes from landing with no annunciation'. The associated hazard condition for this FTA is 'Catastrophic'. Probability of this condition with all pressure sensors failed is

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extremely improbable (on the order of $8.72\text{E-}12$).

'Annunciated loss of all E/E Supply Cooling for >30 minutes <505 minutes from landing. The associated hazard condition for this FTA is 'Hazardous'. Probability of this condition with all pressure sensors failed is extremely improbable (on the order of $2.06\text{E-}10$)

Analysis of the associated FTAs with all pressure sensors (FD, E4, E5 & BUC) failed indicates no perceptible change to the top event probability.

Leak in a duct with an inoperative pressure sensor: Cooling system continues to operate in normal mode, however, electronic components cooled by air from the duct with the leak may receive less than optimum cooling. Development of a duct leak in the duct with the inoperative sensor in the dispatch period is unlikely, given that verification that a leak does not exist must be conducted prior to the first dispatch. Automatic reconfiguration to equipment cooling override mode is still provided for low cooling air flow, dual equipment cooling supply fan failure, equipment cooling smoke detected, and forward cargo fire extinguishing system armed.

777X forward EE cooling system is an essential system, and all client EE LRUs that are required for continued safe flight and landing will be qualified for extended operations (505 minutes) without cooling. Reduced airflow will therefore not likely cause imminent failure.

21-27-12

Equipment Cooling Divert Valve

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Inoperative Equipment Cooling Divert Valve is deactivated closed,
- Equipment Cooling Vent Fan is deactivated, and
- For ground operations with OAT 30 °C or higher, both Air Conditioning Packs are operated or airplane is supplied with conditioned air.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-13.

The equipment cooling divert valve is only installed on airplanes equipped with the optional forward cargo air conditioning (FCAC) system installed. It provides venting of the equipment cooling exhaust air inboard instead of overboard when FCAC is on in flight. The divert valve directs the exhaust air through the Equipment Cooling Inboard valve and out in the vicinity of the mix bay, where it is drawn into the lower recirculation fans and back into the cabin.

Consequences of Failure

When the equipment cooling divert valve is not in the commanded position, the EQUIP DIVERT VALVE Status message is displayed.

For dispatch, the equipment cooling divert valve is deactivated closed. When the divert valve is inoperative and deactivated closed, the equipment cooling vent fan must also be deactivated to ensure the fan does not dead-head and overheat when the FCAC inboard valve is closed. This could occur if FCAC is selected off or the FCAC inboard valve fails closed, and the ECSMC in control believes the E/E vent valve is open due to a limit switch fault. An equipment cooling divert valve that has failed open may allow cargo odors into the cabin or flight deck.

For the equipment cooling divert valve deactivated closed, FCAC is available. However, when FCAC is selected OFF, cargo heat is not provided to the forward cargo compartment. Deactivating the equipment cooling vent fan requires positive action to ensure adequate equipment cooling air is provided during warm conditions on- ground. This is accomplished by selecting both packs on or supplying conditioned air.

Consequences of Next Critical Failure

Smoke in EE Bay - Loss of smoke detection in the EE Cooling vent system. Possible smoke migration into other compartments (e.g. flight deck, fwd cargo). Crew would perform Smoke, Fire, Fumes procedure and put the EE Cooling system in Override to evacuate the smoke.

21-27-13

Equipment Cooling Inboard Valve

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Inoperative Equipment Cooling Inboard Valve is deactivated closed,
- Equipment Cooling Vent Fan is deactivated, and
- For ground operations with OAT 30 °C or higher, both Air Conditioning Packs are operated or airplane is supplied with conditioned air.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-27-14-01.

The equipment cooling inboard valve is only installed on airplanes equipped with the optional forward cargo air conditioning (FCAC) system installed. It provides venting of the equipment cooling exhaust air inboard instead of overboard when FCAC is on in flight. The Equipment Cooling Inboard valve allows the EE Cooling exhaust air to vent out in the vicinity of the mix bay, where it is drawn into the lower recirculation fans and back into the cabin, or prevent equipment cooling vent air from going inboard when on-ground or FCAC is selected off.

Consequences of Failure

When the equipment cooling inboard valve is not in the commanded position, the EQUIP INBOARD VALVE status message is displayed.

For dispatch, the equipment cooling inboard valve is deactivated closed. When the inboard valve is inoperative and deactivated closed, the equipment cooling vent fan must also be deactivated to ensure the fan does not dead-head and overheat. This condition could occur if a limit switch fault occurred on the inboard valve and the ECSMC card in control believed the inboard valve was open when it is deactivated closed. The ECSMC would then close the divert valve resulting in the fan dead-heading against the two closed valves. An equipment cooling inboard valve that has failed closed will result in the equipment cooling divert valve to close and may allow cargo odors into the cabin or flight deck.

Forward cargo air conditioning (FCAC) is available, however the equipment cooling vent fan must be deactivated which requires positive action on the ground to ensure adequate equipment cooling. This is accomplished by selecting both packs on or supplying conditioned air

Consequences of Next Critical Failure

Smoke in EE Bay - Loss of smoke detection in the EE Cooling vent system.
Possible smoke migration into other compartments (e.g. flight deck, fwd cargo).
Crew would perform Smoke, Fire, Fumes procedure and put the EE Cooling system in Override to evacuate the smoke.

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Federal Aviation Administration (FAA)**ATA 21****777-9 Master Minimum Equipment List****Section 2****21-27-14 EQUIP COOLING Switch Lights****21-27-14-01 OVRD Light**

Interval	Installed	Required	Procedure
C	1	0	

21-27-14 EQUIP COOLING Switch Lights**21-27-14-02 AUTO Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

When the flight deck EQUIP COOLING alternate action switch is set to AUTO, the equipment cooling system is controlled automatically. When set to Off (AUTO not visible), both equipment cooling supply fans and vent fan are not operating, the override valve is open and the forward cargo heat valve is closed.

When OVRD (override) is illuminated in the lower half of the flight deck EQUIP COOLING alternate action switch, the equipment cooling override valve is opened. The equipment cooling system re-configures to override mode when:

- Both fans are failed in the air
- Both of the low flow detectors indicate low flow in supply fan mode in the air
- Smoke is detected in the Forward Equipment Cooling System or the Forward Equipment Ventilation System
- Forward Cargo Fire Extinguishing System Arming Switch is set to "Armed"
- Forward Cargo Compartment Smoke Detection
- Auto Fire Arm FWD is enabled
- Left ECC Failed off
- EE Override is selected by the EQUIP COOLING Switch

Consequences of Failure

Internal AUTO switch legend:

If switch legend is failed not showing AUTO, there is no indication on the switch to confirm the system is in auto mode.

OVRD Light:

No indication on the switch to confirm the system is in override mode. Associated "EQUIP COOLING OVRD" EICAS Advisory message remains operative and will indicate when the system is in override mode.

Consequences of Next Critical Failure

AUTO switch legend: None.

OVRD Light: None.

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21-28-01 Forward Cargo Air Conditioning (FCAC) Flow Regulating Valve

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- FCAC Flow Regulating Valve is deactivated closed, and
- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-28-02.

The Forward Cargo Air Conditioning (FCAC) system is an optional system designed to provide conditioned air to the forward cargo compartment to maintain a constant, target temperature. It consists of an air distribution system and an exhaust system with the necessary fans and valves for managing airflow in normal and non-normal operation. The baseline forward cargo heat system will operate under normal logic control when the FCAC system is selected OFF. However, the two systems cannot operate concurrently.

The system draws air from the ECS mix manifold. A Flow Regulating Valve (FRV) controls the quantity of air supplied through the system. The main supply duct inside the cargo compartment is installed below the cargo compartment floor. Branch ducts feed discreet air outlets located in the left and right vertical sidewall liners of the compartment. The supplied air is exhausted through the compartment floor and ventilated out through the exhaust system.

Trim air is provided from the right trim system as necessary to maintain the cargo compartment target temperature. The right Cabin Temperature Controller (CTC) performs the closed loop temperature control. A temperature selector is installed on the Flight Deck P5 panel. The FCAC system is automatically shut down when forward cargo fire protection is armed, or forward cargo smoke is detected.

Consequences of Failure

When the FCAC FRV is not in the commanded position, the CARGO A/C FRV FWD Status message is displayed. In addition, the CARGO A/C FAULT FWD Advisory message will be displayed.

FCAC FRV is deactivated closed. FCAC is set to OFF. Forward cargo air conditioning is not available and temperature sensitive cargo such as perishable goods should not be carried in the compartment.

Consequences of Next Critical Failure

Forward cargo compartment fire: The fire protection integrity of the forward cargo compartment is maintained as the FCAC FRV is deactivated closed for dispatch.

21-29-01 Overhead Flightcrew/Attendant Rest Supply Shutoff Valves

21-29-01-01 Overhead Flightcrew Rest (OFCR)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative OFCR Supply Shutoff Valve is deactivated closed, and
- OFCR is considered inoperative.

21-29-01 Overhead Flightcrew/Attendant Rest Supply Shutoff Valves

21-29-01-02 Overhead Flight Attendant Rest (OFAR)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative OFAR Supply Shutoff Valve is deactivated closed, and
- OFAR is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-29-04.

Optional crew rest modules may be installed in the main cabin overhead (above the ceiling). Each module is supplied untrimmed conditioned air from the left pack through a dedicated duct to the particular crew rest. The ELMS P210 panel controls the shutoff valve (SOV). The SOV is either open or closed and is provided to shutoff air supply to the crew rest when smoke is detected, during low altitude flight (< 25,000 ft. MSL), on the ground with the left air conditioning pack on, and on the ground with both left and right air conditioning packs off.

Current installations include:

The (forward) Overhead Flight Crew Rest - This crew rest may be installed in the overhead near the door 1/2 area and provides flight crew resting accommodations. There are two bunks installed and two business class seats in the common area. All conditioned air supplied to this crew rest is sourced from the left pack through the dedicated duct and SOV. A dedicated exhaust valve is provided for smoke clearance.

The (aft) Overhead Flight Attendant Rest - This crew rest may be installed

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in the overhead near the door 3/4 area and provides cabin attendant resting accommodations. There are options for 6, 8, or 10 bunks. There are no seats in the common area. The OFAR is supplied air similarly to the OFCR. All conditioned air supplied to this crew rest is sourced from the left pack through the dedicated duct and SOV. A dedicated exhaust valve is provided for smoke clearance.

Consequences of Failure

Failure of the OFCR or OFAR supply shutoff valve such that it is not in its commanded position will result in the SOV REST UPR FWD or SOV REST UPR AFT Status message respectively.

The inoperative supply shutoff valve must be deactivated closed for dispatch and the associated crew rest must be considered inoperative.

Conditioned air will not be available to the crew rest with the shutoff valve deactivated closed. Because there is no fresh air supply, the crew rest must not be occupied.

Consequences of Next Critical Failure

None, as the crew rest is deactivated closed and will not be used.

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21-29-02 Overhead Flightcrew/Attendant Rest Exhaust Valves
*********21-29-02-01 Overhead Flightcrew Rest (OFCR)**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative OFCR Exhaust Valve is deactivated closed, and
 - OFCR is considered inoperative.
-

21-29-02 Overhead Flightcrew/Attendant Rest Exhaust Valves
*********21-29-02-02 Overhead Flight Attendant Rest (OFAR)**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative OFAR Exhaust Valve is deactivated closed, and
 - OFAR is considered inoperative.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-29-05.

Optional crew rest modules may be installed in the main cabin overhead (above the ceiling). Each module is supplied untrimmed conditioned air from the left pack through a dedicated duct to the particular crew rest. The ELMS P210 panel controls the exhaust valve, which when open vents air from the crew rest into the Lav/Galley Vent system ducting. The exhaust valve is either open or closed and is provided to vent smoke out of the airplane when smoke is detected in the crew rest, which prevents smoke from migrating to the cabin. The exhaust valve is normally closed, and is opened when smoke is detected in the crew rest. If the OFCR has the Taxi, Takeoff & Landing Installation then the OFCR exhaust valve will also open when no airflow is available from either supply source in order to provide a small amount of airflow.

777X installations include:

The (forward) Overhead Flight Crew Rest - This crew rest may be installed in the overhead near the door 1/2 area and provides flight crew resting accommodations. There are two bunks installed and two business class seats in the common area. All conditioned air supplied to this crew rest is sourced from the left pack through the dedicated duct and SOV. A

dedicated exhaust valve is provided for smoke clearance.

The (aft) Overhead Flight Attendant Rest - This crew rest may be installed in the overhead near the door 3/4 area and provides cabin attendant resting accommodations. There are options for 6, 8, or 10 bunks. There are no seats in the common area. The OFAR is supplied air similarly to the OFCR. All conditioned air supplied to this crew rest is sourced from the left pack through the dedicated duct and SOV. A dedicated exhaust valve is provided for smoke clearance.

Consequences of Failure

Failure of the OFCR or OFAR exhaust valve such that it is not in its commanded position will result in the EXH REST UPR FWD or EXH REST UPR AFT status message respectively.

The inoperative supply shutoff valve must be deactivated closed for dispatch and the associated crew rest must be considered inoperative.

With the exhaust valve deactivated in the closed position, crew rest exhaust flow during smoke event will be lost, which would result in smoke penetration to the cabin from the overhead crew rest. Therefore, the rest area must not be occupied.

Consequences of Next Critical Failure

None, as the crew rest is deactivated closed and will not be used.

21-29-03 Overhead Flightcrew Rest (OFCR) Supply Shutoff Valves (Taxi, Takeoff & Landing Installation)

21-29-03-01 Primary Supply Shutoff Valve

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative OFCR Primary Supply Shutoff Valve is deactivated closed,
- OFCR Secondary Supply Shutoff Valve operates normally, and
- Left Air Conditioning Pack operates normally.

21-29-03 Overhead Flightcrew Rest (OFCR) Supply Shutoff Valves (Taxi, Takeoff & Landing Installation)

21-29-03-02 Secondary Supply Shutoff Valve

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Inoperative OFCR Secondary Supply Shutoff Valve is deactivated closed,
- OFCR Primary Supply Shutoff Valve operates normally,
- OFCR Pressure Sensor operates normally,
- Left Air Conditioning Pack operates normally, and
- OFCR is not occupied at FL 250 or below.

21-29-03 Overhead Flightcrew Rest (OFCR) Supply Shutoff Valves (Taxi, Takeoff & Landing Installation)

21-29-03-03 Primary and Secondary Supply Shutoff Valves

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Inoperative OFCR Primary Supply Shutoff Valve is deactivated closed,
- Inoperative OFCR Secondary Supply Shutoff Valve is deactivated closed, and

c. OFCR is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-29-06.

An optional Overhead Flight Crew Rest (OFCR) module may be installed in the main cabin overhead (above the ceiling) near the door 1/2 area. The OFCR is supplied untrimmed conditioned air from the left pack through a dedicated duct and shutoff valve (SOV). The OFCR includes a customer option that allows the crew rest to be occupied during taxi, takeoff and landing (TT&L). With this design the OFCR has a secondary air supply source and SOV from the Zone F Air Distribution System ducting, which mitigates the possibility of the ducts of the primary airflow source (the left pack) becoming blocked from frozen moisture while on the ground and at low altitude flight. During this condition, as detected with a pressure sensor in the supply ducting downstream of both supply SOVs, the airflow source is switched from primary to secondary with the SOVs. The ELMS P210 panel controls the SOVs. Since the secondary supply is not prone to freezing, occupation during TT&L can still be approved for a single (primary) valve inoperative, but not for a single (secondary) valve inoperative.

In the event smoke is detected within the crew rest, the supply shutoff valves are closed to prevent smoke penetration into the main cabin and a dedicated exhaust valve is opened to enable air to be exhausted via the Lav/Galley Vent System. The exhaust valve will also open when no airflow is available from either supply source in order to provide a small amount of airflow.

Current installations include:

The (forward) Overhead Flight Crew Rest with Taxi, Takeoff & Landing - This crew rest may be installed in the overhead near the door 1/2 area and provides flight crew resting accommodations. There are two bunks installed and two business class seats in the common area. Conditioned air supplied to this crew rest is sourced from two paths. The primary path is from the left pack through a dedicated duct and primary SOV. The secondary path is from the Zone F ducting and secondary SOV. A dedicated exhaust valve is provided for smoke clearance.

Consequences of Failure

For Primary Supply Shutoff Valve inoperative:

Failure of the OFCR primary supply shutoff valve such that it is not in its commanded position will result in the SOV REST UPR FWD Status message.

For dispatch, the inoperative primary supply shutoff valve must be deactivated closed. Secondary supply shutoff valve and left pack must operate normally. Air will not be supplied to the crew rest through the primary valve but is still available through the secondary valve.

For Secondary Supply Shutoff Valve inoperative:

Failure of the OFCR secondary supply shutoff valve such that it is not in its commanded position will result in the SOV REST UPR SEC FWD Status message.

For dispatch, the inoperative secondary supply shutoff valve must be deactivated closed. Primary supply shutoff valve and left pack must operate normally. Air will not be supplied to the crew rest through the secondary valve but is still available through the primary valve. Due to the possibility of frozen moisture blocking primary airflow at low altitudes, the crew rest must not be occupied during taxi, takeoff and landing.

For both supply shutoff valves inoperative:

Both primary and secondary supply shutoff valves must be deactivated closed. No fresh air will be supplied to the crew rest. Crew rest must be considered inoperative and not occupied.

Consequences of Next Critical Failure

For Primary Supply Shutoff Valve Inoperative:

If the secondary supply SOV fails closed, loss of temperature control. Exhaust valve opens to provide small amount of air flow. Discomfort to crew rest occupants.

If the secondary supply SOV fails open, airflow management control with crew rest fire will be lost, resulting in smoke penetration from the overhead crew rest.

For Secondary Supply Shutoff Valve Inoperative:

If the primary supply SOV fails closed, loss of temperature control. Exhaust valve opens to provide small amount of air flow. Discomfort to flight crew.

If the primary supply SOV fails open, airflow management control with crew rest fire will be lost, resulting in smoke penetration from the overhead crew rest.

For Both Inoperative: None, as the crew rest is deactivated closed and will not be used.

**21-29-04 Overhead Flightcrew Rest (OFCR) Pressure Sensor
(Taxi, Takeoff & Landing Installation)**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Inoperative OFCR Primary Supply Shutoff Valve is deactivated closed,
- OFCR Secondary Supply Shutoff Valve operates normally, and
- OFCR is not occupied on ground when left Air Conditioning Pack is OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-29-07.

An optional Overhead Flight Crew Rest (OFCR) module may be installed in the main cabin overhead (above the ceiling) near the door 1/2 area. The OFCR is supplied untrimmed conditioned air from the left pack through a dedicated duct and shutoff valve (SOV). The OFCR includes a customer option that allows the crew rest to be occupied during taxi, takeoff and landing (TT&L). With this design the OFCR has a secondary air supply source and SOV from the Zone F Air Distribution System ducting, which mitigates the possibility of the ducts of the primary airflow source (the left pack) becoming blocked from frozen moisture while on the ground and at low altitude flight. During this condition, as detected with a pressure sensor in the supply ducting downstream of both supply SOVs, the airflow source is switched from primary to secondary with the SOVs. The ELMS P210 panel controls the SOVs. In the event smoke is detected within the crew rest, the supply shutoff valves are closed to prevent smoke penetration into the main cabin and a dedicated exhaust valve is opened to enable air to be exhausted via the Lav/Galley Vent System. The exhaust valve will also open when no airflow is available from either supply source, as detected with the duct pressure sensor, in order to provide a small amount of airflow.

Consequences of Failure

Failure of the OFCR duct pressure sensor will result in the PRESS SNSR REST UPR FWD Status message.

For dispatch, the inoperative primary supply shutoff valve must be deactivated closed. Secondary supply shutoff valve and left pack must operate normally. Air will not be supplied to the crew rest through the primary valve but is still available through the secondary valve.

Consequences of Next Critical Failure

If the secondary supply SOV fails closed, loss of temperature control. Exhaust valve opens to provide small amount of air flow. Discomfort to crew rest occupants.

21-31-01 Auto Cabin Pressure Controls (L and R)**21-31-01A**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Manual Cabin Pressure Outflow Valve Control is verified to operate normally on both Outflow Valves before each departure,
 - Remote Cabin Pressure Sensor operates normally, and
 - Autopilot is available for use.
-

21-31-01 Auto Cabin Pressure Controls (L and R)**21-31-01B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- One Outflow Valve is deactivated 7.4% open,
- Manual Cabin Pressure Outflow Valve Control is verified to operate normally on remaining Outflow Valve,
- Remote Cabin Pressure Sensor operates normally,
- Autopilot is available for use,
- One Air Conditioning Pack operates normally, and other Air Conditioning Pack operates normally or in Standby Cooling Mode,
- Both Cabin Temperature Controllers (CTCs) operate normally, and
- Both engine bleed systems operate normally.

[For OFCR installed:](#)

- OFCR is considered inoperative.

[For OFAR installed:](#)

- OFAR is considered inoperative.

NOTE: Single Air Conditioning Pack operation is not allowed.

21-31-01 Auto Cabin Pressure Controls (L and R)**21-31-01C**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- For extended overwater flight, Manual Cabin Pressure Outflow Valve Control is verified to operate normally on both Outflow Valves.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

For first class suites installed:

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-31-01.

The 777-9 cabin pressure control system (CPCS) maintains an overall system architecture that is similar to the 777-300ER CPCS, and consists of a modified 777-300ER CPCS that includes the following components: two outflow valves (OFV) with integral electronic controller units (ECU), two air supply and cabin pressure controller(s) (ASCPC), a remote sensor unit (RSU), flight deck control panel (FDCP) switches (outflow valve auto/manual, outflow valve manual open/closed, and manual landing altitude selector), and protective, fail-safe, elements which include two (2) positive pressure relief valves (PPRV) and four (4) negative pressure relief valves (NPRV) that are installed as part of the fuselage structure. Automatic system control for the CPCS is provided by the air supply & cabin pressure controller(s) (ASCPC).

The CPCS utilizes the Generation 3 Outflow Valve (G3OFV), which contains processors that run software (SW) and airborne electronic hardware (AEH). In addition, the CPCS shares the ASCPCs with the air supply control system (ASCS).

Relative to 777-300ER, differences in the 777-9 CPCS include the following:

Cabin Altitude:

- 7,000 foot maximum cabin altitude, with options for an 8,000 foot maximum
- 9.0 psi cabin to ambient differential with options for 8.6 and 8.5 psid

Supporting Functions:

- Architecture changes to support independent power and control for manual OFV operation
- OFV frame and gate changes required to support thrust recovery improvements.

Similar to 777-300ER, a single OFV is located below both the left forward and left aft passenger doors. The OFV's control cabin pressure by controlling the rate at which air supplied by the packs is vented from the cabin. Each G3OFV has two auto motors and a third, independent manual motor. Power for manual control is provided separately from that provided to the auto motors. New C/Bs for the manual power are located in the P11 panel. Each G3OFV receives automatic control inputs from the two air supply and cabin pressure controllers (ASCPCs), which alternate each flight. The OFV's can also be controlled manually by the two toggle switches on the flight deck. When selected to manual control, power to auto motors is disabled. Power is then provided to the independent manual motor, which is then driven by means of the toggle switches.

The 777X has a new air supply cabin pressure controller (ASCPC), including a new (upgraded) pressure sensor, installed within the ASCPC, for reading cabin ambient pressure. Cabin pressure control remains identical to the 777-300ER, though the limits differ (per optional cabin pressure schedules), and CPCS functionality is the same as 777-300ER.

Consequences of Failure

The CABIN ALT AUTO L Status message will be displayed when there loss of automatic control of the forward and aft outflow valves (OFVs) from the left ASCPC.

The CABIN ALT AUTO R Status message will be displayed when there loss of automatic control of the forward and aft outflow valves (OFVs) from the right ASCPC.

Dispatch with one (L or R) auto controller inoperative, Option A:

Loss of redundancy (Auto Control) only. The remaining controller provides continued AUTO control of both outflow valves.

Dispatch with one (L or R) auto controller inoperative, Option B:

Loss of redundancy (Auto Control) only. One Outflow Valve deactivated 7.4% open. Manual control must verified to operate normally on remaining Out flow Valve.

Dispatch with both (L and R) auto controls inoperative:

Manual control of both outflow valves is available, but flight is conducted unpressurized due to crew workload and subsequent failure considerations.

Manual control of both valves must be verified before extended overwater flight to ensure the valves can be closed in the event of a water landing.

Consequences of Next Critical Failure

Dispatch with one (L or R) auto control inoperative, Option A:

Failure of remaining auto control - Manual control of both outflow valves is available for flight crew pressurization control.

Unannounced depressurization condition is classified as Catastrophic. Depressurization without indication will compromise crew who may not react to situation, leading to hypoxic crew and passengers. Top event probability is $3.64\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with either Cabin Pressure Control Function inoperative.

Annunciated depressurization condition is classified as 'Hazardous'. Loss of pressurization results in oxygen deployment and rapid descent. Passenger oxygen deployment will occur once 13,500 feet cabin altitude is exceeded. Occupants not on oxygen may become incapacitated, or sustain physiological harm. Unplanned rapid descent. Top event probability is $8.46\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with either Cabin Pressure Control Function inoperative.

Dispatch with one (L or R) auto control inoperative, Option B:

Unannounced depressurization condition is classified as Catastrophic. Depressurization without indication will compromise crew who may not react to situation, leading to hypoxic crew and passengers. Top event probability is $3.64\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with one outflow valve deactivated.

Annunciated depressurization condition is classified as 'Hazardous'. Loss of pressurization results in oxygen deployment and rapid descent. Passenger oxygen deployment will occur once 13,500 feet cabin altitude is exceeded. Occupants not on oxygen may become incapacitated, or sustain physiological harm. Unplanned rapid descent. Top event probability is $8.46\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with one outflow valve deactivated.

Dispatch with one OFV inoperative, deactivated 7.4% open and remaining operative outflow valve becomes inoperative and cannot be controlled in manual:

This failure is very unlikely on a single flight, as the status message OUTFLOW VALVE AFT or FWD is displayed upon failure of one control channel. At this point the airplane may not be dispatched until one outflow valve is made fully operative. If complete failure does occur, descent will be required if the valve fails in an open position. If the valve fails in a closed position the flight can continue with the positive pressure relief valves preventing over-pressurization. In this case, the DDG provides procedures to depressurize the airplane for landing.

For the aft outflow valve inoperative: The inoperative switch must remain

in the MAN position. In the event of a cargo fire, CACTCS software looks at the position of the aft OUTFLOW VALVE switch. If the aft switch is MAN, CACTCS reconfigures to shutoff flow to forward cargo air conditioning (FCAC).

Smoke or Fire event with one OFV deactivated 7.4% open:

MMEL configurations for a deactivated Outflow Valve (locked 7.4% open) were evaluated in flight test to determine the worst case conditions for both smoke penetration and halon concentration. For smoke penetration, the OFV closest to the cargo compartment with the smoke event was deactivated (forward or aft). For halon concentration, the OFV farthest from the location of the 'fire' event was deactivated. From this testing, both the smoke penetration characteristics and halon concentrations were validated for the OFV MMEL items. In addition these characteristics are verified for single pack operation as well. The worst case of these test cases are used to establish the allowable halon concentration times.

Dispatch with both (L and R) auto controls inoperative:

Failure of forward or aft outflow valve manual control - No effect since flight is conducted unpressurized.

Airplane condition requiring ditching - Outflow valves can be closed using manual control.

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21-31-02 Manual Cabin Pressure Outflow Valve Controls (FWD and AFT)

21-31-02A

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Outflow Valve is deactivated 7.4% open,
- Manual Cabin Pressure Outflow Valve Control is verified to operate normally on remaining Outflow Valve,
- Both Auto Cabin Pressure Controls operate normally,
- One Air Conditioning Pack operates normally,
- Other Air Conditioning Pack either operates normally or in standby cooling mode,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- Both Engine Bleed Air Systems operate normally, and
- For FWD Outflow Valve inoperative, at least one Air Conditioning Pack must be operated or airplane supplied with conditioned air for ground operations when OAT is 0°C or higher.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

NOTE: Single Air Conditioning Pack operation is not allowed.

21-31-02 Manual Cabin Pressure Outflow Valve Controls (FWD and AFT)

21-31-02B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are deactivated full open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- Extended overwater flight is prohibited.

For OFCR installed:

e. OFCR is considered inoperative.

For OFAR installed:

f. OFAR is considered inoperative.

For first class suites installed:

g. First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-31-02.

Direct manual control of each outflow valve (OFV) is provided by the switches on the pressurization panel on the flight deck overhead panel. Manual control is selected for either OFV using the associated pushbutton switch. Valve position is controlled by the associated toggle switch which bypasses both ASCPC's to directly control an actuator motor on the OFV. Indications of valve positions (if available), cabin pressure, cabin rate, and cabin delta pressure are provided on primary EICAS for flight crew reference in manual control.

Consequences of Failure

1. Dispatch with manual control of one OFV inoperative and with one auto control operating normally: There is no operational effect since primary or backup auto control is available for pressurization at dispatch, and manual control is available for subsequent failures.
2. Dispatch with manual control of both OFV's inoperative and no auto control capability: Flight is limited to unpressurized configuration and extended overwater flight is prohibited due to subsequent failure considerations.

Consequences of Next Critical Failure

1. Dispatch with manual control of one OFV inoperative and with one auto control operating normally:
Failure of the remaining (L or R) auto control - Pressurization for the remainder of the flight must be controlled manually using the remaining manual control of one OFV.

Airplane condition requiring ditching - Remaining OFV can be closed manually.

For the aft outflow valve inoperative: The inoperative switch must remain in the MAN position. In the event of a cargo fire, CACTCS software looks at the position of the aft OUTFLOW VALVE switch. If the aft switch is MAN, CACTCS reconfigures to shutoff flow to forward cargo air conditioning (FCAC).

Smoke or Fire event with one OFV deactivated 7.4% open:

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M MEL configurations for a deactivated Outflow Valve (locked 7.4% open) were evaluated in flight test to determine the worst case conditions for both smoke penetration and halon concentration. For smoke penetration, the OFV closest to the cargo compartment with the smoke event was deactivated (forward or aft). For halon concentration, the OFV farthest from the location of the 'fire' event was deactivated. From this testing, both the smoke penetration characteristics and halon concentrations were validated for the OFV MEL items. In addition these characteristics are verified for single pack operation as well. The worst case of these test cases are used to establish the allowable halon concentration times.

2. Dispatch with manual control of both OFV's inoperative and no auto control capability:

No additional pressurization system failures are considered since flight is restricted to unpressurized configuration and overwater flight is prohibited.

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21-31-03 Outflow Valves (FWD and AFT)**21-31-03A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Outflow Valve is deactivated 7.4% open,
- Manual Cabin Pressure Outflow Valve Control is verified to operate normally on remaining Outflow Valve,
- Both Auto Cabin Pressure Controls operates normally,
- One Air Conditioning Pack operates normally, and other Air Conditioning Pack operates normally or in Standby Cooling Mode,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- Both Engine Bleed Systems operate normally, and
- For FWD Outflow Valve inoperative, at least one Air Conditioning Pack must be operated or airplane supplied with conditioned air for ground operations when OAT is 0 °C or higher.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

NOTE: Single Air Conditioning Pack operation is not allowed.

21-31-03 Outflow Valves (FWD and AFT)**21-31-03B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are deactivated full open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- Extended overwater flight is prohibited.

For OFCR installed:

- OFCR is considered inoperative.

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For OFAR installed:

f. OFAR is considered inoperative.

For first class suites installed:

g. First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

21-31-03 Outflow Valves (FWD and AFT)
21-31-03-01 OUTFLOW VALVE Switch Lights
21-31-03-01-01 MAN Lights

Interval	Installed	Required	Procedure
C	2	0	

21-31-03 Outflow Valves (FWD and AFT)
21-31-03-01 OUTFLOW VALVE Switch Lights
21-31-03-01-02 AUTO Lights

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal is based on 777 MMEL item 21-31-03.

The 777X outflow valve (OFV) has been simplified to remove functionality that is currently not used on 777-300ER and is not required for 777-9. This changed OFV for 777-9 is referred to as the Generation 3 OFV (G3OFV). These changes do not affect the interfaces, and the actuator and basic housing of the OFV remains the same. Changes include the removal of pressure sensors internal to the OFV electronic controller unit (ECU), whose protective function has been replaced by means of architectural revisions in conjunction with augmentation of the RSU usage for the given function (cabin altitude limiting). In addition, extensive service experience with the 777-300ER cabin pressure OFV (CPOV) has led to additional optimization, which includes the following items:

1. Use of existing connector interfaces to provide for a manual power source direct to the G3OFV manual motor and manual motor drive. This source provides wiring directly from the flight deck control panel (FDCP) and improves manual motor availability relative to the 777-300ER. Manual control function for loss of conditioned inflow (LOCI) remains identical to 777-300ER, and this change further helps to drive robustness into the design.
2. Elimination of the manual motor pre-wired board assembly (PBA), which provided for manual motor power switching between auto and manual sources. This eliminates a source of nuisance and other faults in addition to susceptibility to inadvertent depressurization, which was discovered during in-service operation and an improvement implemented on 777-300ER production airplanes.
3. Elimination of a bracket and wire bundle harness, which was necessary to provide backward compatibility with the original OFV provided to earlier 777 models. This bundle and associated bracket were not required as there are no plans to use the older style OFV as a spare or replacement to the G3OFV used on 777-9.

As part of airplane mission optimization, the G3OFV is also being fitted with new gates and a modified frame, which will provide improved airplane thrust recovery in addition to expected noise improvements. This change is designed specifically to maintain usage of the existing actuator motor and linkages and preserves the same structural interface and effective open area as the OFV, which was used on 777-300ER. This design also maintains electrical power characteristics equivalent to the original OFV used on 777-300ER.

These changes also necessitate revisions to the G3OFV control architecture and embedded software (SW), including revisions to the associated control laws. However, there are no changes to the components associated with G3OFV control function. Electrical power sources and wiring interfaces have also changed to accommodate manual power selection, elimination of the wiring harness, and improvements to power availability relative to 777-300ER.

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Section 2

Similar to 777-300ER, a single OFV is located below both the left forward and left aft passenger doors. The OFV's control cabin pressure by controlling the rate at which air supplied by the packs is vented from the cabin. Each G3OFV has two auto motors and a third, independent manual motor. Power for manual control is provided separately from that provided to the auto motors. The new C/Bs for the manual power are located in the P11 panel. Each G3OFV receives automatic control inputs from the two air supply and cabin pressure controllers (ASPCs), which alternate each flight. The OFV's can also be controlled manually by the two toggle switches on the flight deck. When selected to manual control, power to auto motors is disabled. Power is then provided to the independent manual motor, which is then driven by means of the toggle switches.

OUTFLOW VALVE Switch AUTO Lights: The associated outflow valve (FWD or AFT) is controlled automatically. MAN is extinguished when switch is pressed (AUTO).

OUTFLOW VALVE Switch MAN Lights: The associated outflow valve (FWD or AFT) is controlled manually via the associated (FWD or AFT) OPEN/CLOSE toggle switch. AUTO is extinguished when switch is out (MAN).

Consequences of Failure

Dispatch with one OFV inoperative, deactivated 7.4% open:

Normal cabin pressurization control will be maintained by the remaining operative OFV. For this configuration, display of the OUTFLOW VLV INOP AFT, FWD Advisory message would annunciate that one channel of the remaining operative OFV is inoperative. Therefore, verification that manual control operates normally on the remaining operative outflow valve need only be conducted once at the beginning of the dispatch period. In this instance, the manual control verification ensures the OFV switch and OFV manual switch, and wiring from these switches to the associated OFV are operative.

The aft outflow valve is used for overhead exhaust in the event of a fire. Therefore, the OFCR and OFAR, if installed, must not be occupied if the aft outflow valve is deactivated.

For forward OFV deactivated 7.4% open: For ground operations with OAT of 0 degrees C or higher, active cooling must be provided by pack or ground cart in order to prevent the EE bay from overheating. If the EE bay remains overheated, non-essential equipment may fail after 30 minutes and critical equipment may fail after 505 minutes.

With both packs operating on the ground: Opening a door may result in the door opening forcefully. When closing the passenger door(s), an uncomfortable pressure change may result. Both of these issues may be avoided by selecting the right pack OFF when either reopening a door or closing a door.

Dispatch with both OFVs inoperative:

Both OFVs must be deactivated full open and the flight conducted unpressurized. Overwater flight is prohibited with the OFVs deactivated full open.

NOTE: The provisos requiring both CTCs to operate normally are consistent with the requirement for both outflow valves to operate normally in 777X MMEL item 21-61-01 (for one CTC inoperative). These cross-referenced requirements minimize the possibility of a single subsequent failure causing a rapid depressurization.

OUTFLOW VALVE Switch AUTO Lights: The associated switch position is discernible by the switch flush with the surrounding panel.

OUTFLOW VALVE Switch MAN Lights: The associated OUTFLOW VALVE FWD or AFT Advisory message operates normally and is displayed when switch is in the out or MAN position. The message is also displayed for a fault of the valve prompting crew action to cycle the associated switch from AUTO to MAN. But if the MAN light is inop, another flight deck effect of positioning the switch to MAN is the pop-up of the outflow valve position indicators on EICAS providing another awareness the switch is in MAN. Also AUTO is extinguished when switch is out (MAN).

Consequences of Next Critical Failure

Unannunciated depressurization condition is classified as Catastrophic. Depressurization without indication will compromise crew who may not react to situation, leading to hypoxic crew and passengers. Top event probability is $3.64\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with one outflow valve deactivated.

Annunciated depressurization condition is classified as 'Hazardous'. Loss of pressurization results in oxygen deployment and rapid descent. Passenger oxygen deployment will occur once 13,500 feet cabin altitude is exceeded. Occupants not on oxygen may become incapacitated, or sustain physiological harm. Unplanned rapid descent. Top event probability is $8.46\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with one outflow valve deactivated.

Dispatch with one OFV inoperative, deactivated 7.4% open and remaining operative outflow valve becomes inoperative and cannot be controlled in manual:

This failure is very unlikely on a single flight, as the status message OUTFLOW VALVE AFT or FWD is displayed upon failure of one control channel. At this point the airplane may not be dispatched until one outflow valve is made fully operative. If complete failure does occur, descent will be required if the valve fails in an open position. If the valve fails in a closed position the flight can continue with the positive pressure relief valves preventing over-pressurization. In this case, the DDG provides procedures to depressurize the airplane for landing.

For the aft outflow valve inoperative: The inoperative switch must remain in the MAN position. In the event of a cargo fire, CACTCS software looks at the position of the aft OUTFLOW VALVE switch. If the aft switch is MAN, CACTCS reconfigures to shutoff flow to forward cargo air conditioning (FCAC).

Smoke or Fire event with one OFV deactivated 7.4% open:

MMEL configurations for a deactivated Outflow Valve (locked 7.4% open)

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were evaluated in flight test to determine the worst case conditions for both smoke penetration and halon concentration. For smoke penetration, the OFV closest to the cargo compartment with the smoke event was deactivated (forward or aft). For halon concentration, the OFV farthest from the location of the 'fire' event was deactivated. From this testing, both the smoke penetration characteristics and halon concentrations were validated for the OFV MMEL items. In addition these characteristics are verified for single pack operation as well. The worst case of these test cases are used to establish the allowable halon concentration times.

Dispatch with both OFVs inoperative using unpressurized flight:
None identified.

OUTFLOW VALVE Switch AUTO Lights: None

OUTFLOW VALVE Switch MAN Lights: None.

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Feb 26, 2026

21-31-04 Remote Cabin Pressure Sensor

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided both Auto Cabin Pressure Controls operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-31-04.

The Remote Sensor Unit (RSU) is unchanged from the 777-300ER. However, it has been augmented to contribute to the Altitude Limiting architecture that was previously provided by the CPOV internal sensors, which were removed as part of the changes to the OFV Electronic Controller Unit (ECU).

A remote cabin pressure sensor located in the main equipment center is provided as a third source of cabin pressure data. It serves as a backup to the integral pressure sensors incorporated in each ASCPC by providing an analog signal to the Common Core System, which is then converted to digital signals for display. In addition it provides an analog signal to ELMS which is converted to digital and sent to each ASCPC on the ARINC 629 data buses for system built-in-tests of sensing integrity which are used to determine if the L or R ASCPC will be in control.

Consequences of Failure

Failure of the remote cabin pressure sensor is indicated by the CPCS REMOTE SENSOR Status message.

The two ASCPC sensors remain for use by the cabin pressure controllers and flight deck indications.

Consequences of Next Critical Failure

Failure of an ASCPC controller or pressure sensor: No operational effect since one pressure sensor and auto control remain for use in cabin pressure control and flight deck indication.

Loss of an additional pressure sensor: Loss of a pressure sensor in one of ASCPCs results in loss of voted pressure and will result in loss of the Altitude Limiting function. No operational effect.

21-31-05

Cabin Rate of Climb Indication

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- For extended overwater flight, Manual Cabin Pressure Outflow Valve Control is verified to operate normally on both Outflow Valves.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

For first class suites installed:

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-31-05.

Cabin rate of climb is calculated from the change of cabin pressure provided by the ASCPCs or remote cabin pressure sensor. The rate is displayed in the ECS data block on primary EICAS in units of feet per minute at sea level. Cabin rate is one of the primary parameter used in manual pressurization control.

Consequences of Failure

Cabin rate indication is not available for use in the event that manual pressurization control is required. Dispatch with both auto controls operating is required, or flight must be conducted unpressurized. In either case, reference to cabin rate is not required.

Consequences of Next Critical Failure

- Dispatch pressurized: Failure of an auto control has no operational effect since the remaining auto control continues to control cabin pressurization.
- Dispatch unpressurized: Cabin rate is the same as airplane rate of climb.

21-31-06 Cabin Differential Pressure Indication**21-31-06A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Cabin Altitude Indication operates normally, and
- A chart is provided to convert cabin altitude to cabin differential pressure.

21-31-06 Cabin Differential Pressure Indication**21-31-06B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- For extended overwater flight, Manual Cabin Pressure Outflow Valve Control is verified to operate normally on both Outflow Valves.

[For OFCR installed:](#)

- OFAR is considered inoperative.

[For OFAR installed:](#)

- OFAR is considered inoperative.

[For first class suites installed:](#)

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION**Background**

Cabin differential pressure is calculated from cabin pressure and ambient static pressure. It is displayed as 'delta (symbol)' P on the primary EICAS display in the ECS data block. The differential pressure is in psi. Pressure is displayed in white text in the normal range, amber when above the normal range and red when excessive. The CAB DIFF PRESS HIGH Advisory message will be displayed when cabin differential pressure is above the normal range.

Consequences of Failure

Cabin differential pressure will not be displayed on EICAS. Either the cabin altitude indication must be operating normally is for dispatch, or flight must be conducted unpressurized. For pressurized flight, a chart must be used to convert cabin altitude to cabin differential pressure.

Consequences of Next Critical Failure

1. Failure of both auto controls (assuming dispatch with one auto control inop): Manual control of pressurization is accomplished by reference to cabin rate and altitude indications.
2. Failure of cabin altitude indication: No operational effect since cabin pressurization is normally controlled in AUTO without flight crew reference to cabin altitude or delta P indication.

21-31-07

Cabin Altitude Indication

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- For extended overwater flight, Manual Cabin Pressure Outflow Valve Control is verified to operate normally on both Outflow Valves.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

For first class suites installed:

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION

Background

Cabin altitude is calculated from cabin pressure. It is displayed in the ECS data block on primary EICAS in feet.

Consequences of Failure

Cabin altitude will not be displayed on EICAS. Dispatch with cabin delta P indication operating normally is required, or flight must be conducted unpressurized. For pressurized flight, a chart must be used to convert cabin delta P to cabin altitude.

Consequences of Next Critical Failure

- Failure of both auto controls (assuming dispatch with one auto control inop): Manual control of pressurization is accomplished by reference to cabin rate and delta P indications.
- Failure of cabin delta P indication: No operational effect since cabin pressurization is normally controlled in AUTO without flight crew reference to cabin delta P or altitude indication.

21-31-08 Outflow Valve Position Indications

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL 21-31-08.

Position of each OFV is sensed by dual RVDT position feedback sensors. OFV positions are displayed in the ECS data block on primary EICAS using a half-dial and needle for each OFV. The indications are for pilot awareness and are not required for crew operation.

Consequences of Failure

Indication of the associated OFV position(s) is not available. Outflow Valves can be positioned manually. (Note: EICAS messages will continue to be available for crew notification of non-normal conditions.)

Consequences of Next Critical Failure

None. Outflow Valves can be positioned manually.

21-32-01 Positive Pressure Relief Valves**21-32-01A**

Interval	Installed	Required	Procedure
C	2	1	(M)

One Positive Pressure Relief Valve may be inoperative provided it is deactivated closed.

21-32-01 Positive Pressure Relief Valves**21-32-01B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits, and
- Extended overwater flight is prohibited.

[For OFCR installed:](#)

- OFCR is considered inoperative.

[For OFAR installed:](#)

- OFAR is considered inoperative.

[For first class suites installed:](#)

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-32-01.

The 777X incorporates changes to the cabin altitude schedule to provide enhanced passenger comfort by lowering the maximum cabin altitude to 7,000 feet. This change requires revisions to the existing positive pressure relief valve (PPRV) to accommodate the higher pressure differential relative to 777-300ER. Revisions to the PPRV include a change to the primary and secondary set-points for PPRV actuation. In addition, a revision to PPRV housing ensures that an earlier PPRV configuration cannot be incorrectly installed on 777-9. This revision also ensures that a 777-9 PPRV cannot be inadvertently installed onto other 777 models.

The two positive pressure relief valves, located in the forward cargo compartment opposite the cargo door, provide pressure vessel protection by venting cabin air to ambient air if the maximum cabin differential pressure limit is exceeded. In normal AUTO cabin pressurization control, the ASCPCs provide limit protection of 9.0 psi maximum delta P. The PPRVs are designed to open if $9.35 + 0.1$ psi delta P is reached for any reason. Each PPRV also has a backup setting of $9.82 + 0.15$ psi delta P.

Consequences of Failure

Dispatch with one PPRV inoperative closed: The remaining PPRV provides delta P limit relief if required.

Dispatch with both PPRVs inoperative: If more than one valve is inoperative or an inoperative valve cannot be deactivated closed, the airplane must be operated unpressurized.

Consequences of Next Critical Failure

Dispatch with one PPRV inoperative closed:

Failure of the remaining PPRV: Overpressure protection is not available from PPRVs. Overpressure condition can only occur if both outflow valves go full closed. Positive pressure caution/warning is displayed on ECS data block.

Cabin overpressure condition: Remaining PPRV opens when maximum delta P limit is reached to relieve overpressure. Note: The CAB DIFF PRESS HIGH Advisory message will be displayed when cabin differential pressure is above the normal range.

Dispatch with one or both PPRVs inoperative: No additional failures are considered since the airplane is dispatched in unpressurized configuration.

21-32-02

Negative Pressure Relief Vents

Interval	Installed	Required	Procedure
C	4	0	(M) (O)

May be inoperative provided:

- Both Outflow Valves are open,
- Flight is conducted unpressurized,
- Extended overwater flight is prohibited,
- Both Outflow Valves are deactivated open, and
- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits.

For OFCR installed:

- OFCR is considered inoperative.

For OFAR installed:

- OFAR is considered inoperative.

For first class suits installed:

- First Class Suites are considered inoperative.

NOTE: Operator MELs must define which items are approved for inclusion in fly away kits and which materials can be used as ballast.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-32-02.

Four negative pressure relief vents (NPRVs), located in the forward cargo compartment opposite the cargo door, provide pressure vessel protection by venting ambient air to cabin air if the minimum cabin differential pressure limit is exceeded.

The negative pressure relief vents open when cabin pressure is less than ambient pressure. This prevents negative cabin pressure. Too much negative cabin pressure could damage the fuselage structure.

The negative pressure relief vent is a spring-loaded door. The door starts to open at a negative differential pressure of 0.25 psi. The NPRVs are specifically in place to prevent a negative pressure differential greater than 0.75 psid.

Consequences of Failure

Dispatch with one or more NPRVs inoperative: Airplane must be operated unpressurized.

Consequences of Next Critical Failure

Dispatch with one or more NPRVs inoperative: No additional failures are considered since the airplane is dispatched in unpressurized configuration.

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Feb 26, 2026

21-41-01 Overhead Flightcrew Rest (OFCR) Electric Heater Systems

21-41-01A

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated OFCR Electric Heater System is deactivated.

21-41-01 Overhead Flightcrew Rest (OFCR) Electric Heater Systems

21-41-01B

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Both OFCR Electric Heater Systems are deactivated, and
- OFCR is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-41-04.

An optional Overhead Flight Crew Rest (OFCR) module may be installed in the main cabin overhead (above the ceiling) near the door 1/2 area. The OFCR is supplied untrimmed conditioned air from the left pack through a dedicated duct and shutoff valve (SOV). The OFCR includes a customer option that allows the crew rest to be occupied during taxi, takeoff and landing (TT&L). With this design the OFCR has a secondary air supply source and SOV from the Zone F Air Distribution System ducting. In the event smoke is detected within the crew rest, the supply shutoff valve(s) is(are) closed to prevent smoke penetration into the main cabin and a dedicated exhaust valve is opened to enable air to be exhausted via the Lav/Galley Vent System. For the OFCR with TT&L, the exhaust valve will also open when no airflow is available from either supply source in order to provide a small amount of airflow. The ELMS P210 panel controls the SOVs.

Two 1500 Watt electric heaters installed in parallel in the OFCR supply ducting are used to provide temperature control to the crew rest. Power to the heaters is enabled whenever the OFCR supply SOV is open. With power enabled, the closed loop system employs a closed loop temperature controller (CLTC) with a temperature selection range of 13°C to 32°C (55°F to 90°F). The CLTC will provide the associated heaters with a required duty cycle based on the crew rest occupant's selected temperature and the input from the OFCR ambient and duct temperature sensors. The crew rest air duct temperature sensor is located downstream of the crew rest heaters, and the ambient temperature sensor is located in a return air sampling port within OFCR. The electric heaters are depowered when the OFCR supply SOV is commanded closed.

Consequences of Failure

For one heater inoperative: The inoperative heater must be deactivated. Temperature control may be degraded potentially resulting in a colder than desired crew rest temperature.

For both heaters inoperative: Both inoperative heaters must be deactivated. Without supplemental heating, crew rest must not be occupied.

Consequences of Next Critical Failure

For one heater inoperative:

Remaining heater fails on: Heater will operate continuously resulting in uncommanded or excessive heating. If thermal protection fails to prevent overheat, smoke may enter crew rest.

Remaining heater fails off: Temperature control will be lost potentially resulting in lower than desired crew rest temperature. Possible discomfort to occupants.

For both heaters inoperative: None. Both heaters are deactivated and crew rest will be unoccupied.

21-41-02 Overhead Flight Attendant Rest (OFAR) Electric Heater Systems

21-41-02A

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated OFAR Electric Heater System is deactivated.

21-41-02 Overhead Flight Attendant Rest (OFAR) Electric Heater Systems

21-41-02B

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Both OFAR Electric Heater Systems are deactivated, and
 - OFAR is considered inoperative.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-41-04.

An optional Overhead Flight Attendant Rest (OFAR) module may be installed in the main cabin overhead (above the ceiling) near the door 3/4 area. The OFAR is supplied untrimmed conditioned air from the left pack through a dedicated duct and shutoff valve (SOV). In the event smoke is detected within the crew rest, the supply shutoff valve is closed to prevent smoke penetration into the main cabin and a dedicated exhaust valve is opened to enable air to be exhausted via the Lav/Galley Vent System. The ELMS P210 panel controls the SOV.

Two 2250 Watt electric heaters installed in parallel in the OFAR supply ducting are used to provide temperature control to the crew rest. Power to the heaters is enabled whenever the OFAR supply SOV is open. With power enabled, the closed loop system employs a closed loop temperature controller (CLTC) with a temperature selection range of 13°C to 32°C (55°F to 90°F). The CLTC will provide the associated heaters with a required duty cycle based on the crew rest occupant's selected temperature and the input from the OFAR ambient and duct temperature sensors. The crew rest air duct temperature sensor is located downstream of the crew rest heaters, and the ambient temperature sensor is located in a return air sampling port within OFAR. The electric heaters are depowered when the OFAR supply SOV is commanded closed.

Consequences of Failure

For one heater inoperative: The inoperative heater must be deactivated. Temperature control may be degraded potentially resulting in a colder than desired crew rest temperature.

For both heaters inoperative: Both inoperative heaters must be deactivated. Without supplemental heating, crew rest must not be occupied.

Consequences of Next Critical Failure

For one heater inoperative:

Remaining heater fails on: Heater will operate continuously resulting in uncommanded or excessive heating. If thermal protection fails to prevent overheat, smoke may enter crew rest.

Remaining heater fails off: Temperature control will be lost potentially resulting in lower than desired crew rest temperature. Possible discomfort to occupants.

For both heaters inoperative: None. Both heaters are deactivated and crew rest will be unoccupied.

21-44-01 Aft Cargo Heat Valves (SOV & TCV)

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Aft Cargo Heat Shutoff Valve (SOV) is deactivated,
- Aft Cargo Heat Temperature Control Valve (TCV) is deactivated,
- At least one valve (SOV or TCV) is verified closed, and
- AFT CARGO TEMP selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-44-01.

Pneumatic system air provides a heat source for the aft cargo compartment. Air flow is controlled by a shutoff control valve (SOV) and a temperature control valve (TCV). Control of the valves is provided by the ECS Miscellaneous Cards and ELMS. The SOV is commanded open when the flight crew selects LOW or HIGH on the selector switch provided no inhibits are TRUE. The TCV maintains 40-50 degrees F in the compartment in LOW, or 65-75 degrees F in HIGH. Both valves are commanded closed if smoke is detected in the compartment. The aft cargo heating system is independent of the bulk cargo heating system.

Consequences of Failure

Failure of either the aft cargo heat shutoff valve (SOV) or temperature control valve (TCV) is indicated by the CARGO HEAT VALVE AFT Status message.

Aft cargo temperature selector must be set OFF and electrical power removed from both valves. At least one valve must be verified closed with the pneumatic system pressurized. If both valves remain open with the system pressurized, one valve must be replaced.

Aft cargo heat is not available. Temperature sensitive cargo should not be carried.

Consequences of Next Critical Failure

No additional failures are considered since the system is deactivated.

21-44-02 Aft Cargo Compartment Temperature Sensor

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided AFT CARGO TEMP SELECT switch remains OFF.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-44-02.

The lower aft cargo compartment temperature sensor provides temperature feedback used in the control of the compartment temperature control valve (TCV).

Consequences of Failure

Failure of the aft cargo temperature sensor is indicated by the CARGO TEMP SNSR AFT Status message.

Control of the lower aft cargo TCV and SOV are inoperative. System cannot be used since temperature control is inoperative. Aft cargo temperature selector must remain set to OFF.

Aft cargo heat is not available. Temperature sensitive cargo should not be carried.

Consequences of Next Critical Failure

No additional failures are considered since system is not used.

21-44-03 Bulk Cargo Heat Valves (SOV & TCV)

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Bulk Cargo Heat Shutoff Valve (SOV) is deactivated,
- Bulk Cargo Heat Temperature Control Valve (TCV) is deactivated,
- At least one valve (SOV or TCV) is verified closed, and
- BULK CARGO TEMP selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on MMEL item 21-44-03.

Pneumatic system air provides a heat source for the bulk cargo compartment. Air flow is controlled by a shutoff control valve (SOV) and a temperature control valve (TCV). Control of the valves is provided by the ECS Miscellaneous Cards and ELMS. The SOV is commanded open when the flight crew selects LOW or HIGH on the selector switch provided no inhibits are TRUE. The TCV maintains 40-50 degrees F in the compartment in LOW, or 65-75 degrees F in HIGH. Both valves are commanded closed if smoke is detected in the compartment. The bulk cargo heating system is independent of the aft cargo heating system.

Consequences of Failure

Failure of either the bulk cargo heat shutoff valve (SOV) or temperature control valve (TCV) is indicated by the CARGO HEAT VALVE BULK Status message.

Bulk cargo temperature selector must be set OFF and electrical power removed from both valves. At least one valve must be verified closed with the pneumatic system pressurized. If both valves remain open with the system pressurized, one valve must be replaced.

Aft cargo heat is not available. Temperature sensitive cargo should not be carried.

Consequences of Next Critical Failure

No additional failures are considered since system is deactivated.

21-44-04 Bulk Cargo Compartment Temperature Sensor

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided BULK CARGO TEMP SELECT switch remains OFF.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-44-04.

The bulk cargo compartment temperature sensor provides temperature feedback used in the control of the compartment temperature control valve (TCV).

Consequences of Failure

Failure of the bulk cargo temperature sensor is indicated by the CARGO TEMP SNSR BULK Status message

Control of the bulk cargo TCV and SOV are inoperative. System cannot be used since temperature control is inoperative.

Bulk cargo heat is not available. Temperature sensitive cargo should not be carried.

Consequences of Next Critical Failure

No additional failures are considered since system is not used.

21-45-01 Flight Deck Foot Heaters**21-45-01A**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Inoperative Flight Deck Foot Heater(s) is failed off, and
- Associated FOOT HEATERS selector(s) remains OFF.

21-45-01 Flight Deck Foot Heaters**21-45-01B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative Flight Deck Foot Heater(s) is deactivated,
- Associated FOOT HEATERS selector(s) remains OFF, and
- Associated Flight Deck Shoulder Heater(s) is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-45-01.

Supplemental heating is provided for additional flight crew comfort. Individual controls are provided for the shoulder and foot heaters on both sides. The shoulder heaters provide supplemental heat to the air exiting the window outlets of the flight deck air distribution system. The foot heaters provide supplemental heat in the foot rests at both flight crew stations. The supplemental heaters operate only in the air.

Consequences of Failure

Foot heater failed off:

One or more of the flight deck foot heaters is not available.

Foot heater failed on:

Associated foot and shoulder heaters are deactivated.

Consequences of Next Critical Failure

None identified.

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21-45-02 Flight Deck Shoulder Heaters

21-45-02A

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Inoperative Flight Deck Shoulder Heater(s) is failed off, and
- Associated SHOULDER HEATERS control(s) remains OFF.

21-45-02 Flight Deck Shoulder Heaters

21-45-02B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Associated Flight Deck Shoulder Heater(s) is deactivated,
- Associated SHOULDER HEATERS control(s) remains OFF, and
- Associated Flight Deck Foot Heater(s) is deactivated.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-45-02.

Supplemental heating is provided for additional flight crew comfort. Individual controls are provided for the shoulder and foot heaters on both sides. The shoulder heaters provide supplemental heat to the air exiting the window outlets of the flight deck air distribution system. The foot heaters provide supplemental heat in the foot rests at both flight crew stations. The supplemental heaters operate only in the air.

Consequences of Failure

One or more of the flight deck shoulder heaters is not available.

Consequences of Next Critical Failure

None identified.

21-51-01 Air Conditioning Packs**21-51-01-01 FCAC Installed**

21-51-01-01A

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Both lower Recirculation Fans operate normally,
- Remaining Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack inoperative, Center System Demand ADP C2 operates normally,
- Inoperative Air Conditioning Pack remains OFF,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-51-01 Air Conditioning Packs**21-51-01-01 FCAC Installed**

21-51-01-01B

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Remaining Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack inoperative, Center System Demand ADP C2 operates normally,
- Inoperative Air Conditioning Pack remains OFF,
- FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

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21-51-01 Air Conditioning Packs

21-51-01-02 FCAC Not Installed

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Remaining Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack inoperative, Center System Demand ADP C2 operates normally,
- Inoperative Air Conditioning Pack remains OFF,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-51-01 Air Conditioning Packs

21-51-01-03 PACK Switch Lights

21-51-01-03-01 OFF Lights

Interval	Installed	Required	Procedure
C	2	0	

21-51-01 Air Conditioning Packs

21-51-01-03 PACK Switch Lights

21-51-01-03-02 AUTO Lights

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL items 21-51-01-04 and 21-51-01-05.

Two air conditioning packs provide conditioned air for the passenger cabin and flight deck. Bleed air is supplied by the airplane's two main engines or from the APU. High pressure ground pneumatic air can be used to operate the air conditioning system on the ground. Air is cooled in the primary section of the dual heat exchanger, using ram air. The air is then compressed by the Air Cycle Machine (ACM) compressor and then ported to the secondary portion of the dual heat exchanger. Here, the heat of compression is removed by using ram air. The air is then routed to the condenser/reheater where it is subcooled within the condenser by using the cold exhaust air from the first stage turbine as the heat sink. This cooling process condenses water from the air to permit it to be centrifugally collected by the water collector. The collected water is routed to the spray nozzle located in the secondary ram inlet header of the dual heat exchanger. The water is sprayed on the ram-air face of the heat exchanger core to enhance heat exchanger performance through evaporative cooling. After exiting the water collector, the air flows through the reheater portion of the condenser/reheater where it is pre-heated to enhance first-stage-turbine performance. After expansion through the ACM first-stage turbine the air passes through the condenser cold-side where it serves as the heat sink for condensation. After exiting the condenser cold-side, the air enters the ACM second-stage turbine where it is expanded to provide the cold air source for cabin cooling.

An economy-cooling mode of operation also exists in which the economy-cooling valve is opened by the CTC (via ELMS). This provides a bypass around the condenser/reheater and the first-stage turbine to port flow directly from the secondary heat exchanger outlet to the second-stage-turbine inlet.

If an ACM becomes inoperative, the associated pack automatically reconfigures in standby cooling mode. In this mode of operation, the economy-cooling valve and the turbine bypass valve are opened fully by signals from the CACTCS controller to allow air to bypass the failed ACM and pass directly from the secondary heat exchanger to the pack discharge duct. Standby cannot be selected by the flight crew. When standby mode is active, the PACK IN STBY MODE L, R Advisory message is displayed, and STDBY COOLING is displayed in amber on the AIR synoptic. Pack operation in standby is limited by OAT and/or altitude. The associated pack automatically shuts down at lower altitudes and higher OAT's when ambient conditions do not permit heat exchanger-only cooling. The pack automatically restarts when altitude/OAT conditions permit heat exchanger-only standby cooling. The PACK MODE (L,R) advisory message remains displayed when it is operating during standby mode.

Consequences of Failure

Failure of a pack is indicated by the PACK L, R Status or PACK OFF L, R Advisory message.

Associated pack must be selected OFF for dispatch. The associated PACK OFF L, R Advisory message will be displayed and the pack switch will indicate OFF.

1. One pack inoperative: The remaining pack provides air conditioning and pressurization. No altitude limitation is required because airplane can maintain cabin altitude of less than 15,000 ft during emergency descent from any altitude in flight envelope, in the event of a subsequent pack failure. The remaining pack will compensate for the inoperative pack although temperature control will be degraded and all zones may not meet the selected temperatures. The crew rest areas may have warmer than selected temperatures depending on the ambient conditions.

When one pack is inoperative, the operating pack will compensate by increasing flow to make up for the inoperative pack. A lower temperature bleed may be used if the operating pack can't achieve the difference in flow. This will use more fan flow as the Fan Air Modulation Valve (FAMV) controls more open to achieve a lower bleed temperature. Performance adjustments must be made to account for the increased flow on one side and the additional fan air flow. The EEC will make a thrust adjustment based on single pack operation communicated from the CTC.

For an inoperative pack, an ADP on the the same side will be automatically turned on and run for the entire flight. Therefore, for a right pack inoperative, ADP C2 must operate normally. Since an ADP will be operating continuously, fuel temperature at takoff must be less than 45 degrees C (113 degrees F) to ensure hydraulic cooling does not raise the fuel temperature high enough to damage the fuel pumps.

2. Switch AUTO Lights: The position of the switch can be discerned by being flush with the surrounding light plate.
3. Switch OFF Lights: The PACK OFF L, R Advisory message operates normally.

Consequences of Next Critical Failure

1. Dispatch with one pack inoperative:
 - A. Failure of ACM on remaining pack: One pack pressurization remains operational in standby cooling mode. Cabin temperature may be different than selected.
 - B. Failure of remaining pack: Loss of air conditioning and pressurization. Airplane must descend to maintain cabin pressure altitude below 15,000 ft. For a subsequent event requiring the crew to discharge the fire extinguisher on the flight deck, QRH procedures will shut off the recirculation fans which reduces the ventilation to the flight deck to essentially zero. This results in a condition where the agent concentration will not decay to a safe level. For this reason, the dual pack inoperative configuration is no longer a valid dispatch configuration.

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- C. Flow Control Valve on inoperative pack: An Upper or Lower Flow Control Valve (FCV) failing open would be the worst-case Next Critical Failure. This failure would result in loss of pack temperature control and an inability to shut down the heating/cooling source. This failure condition is hazardous provided flights remain within 60 minutes of the nearest airport. Since the FCVs are closed for dispatch (valves are closed with pack inoperative), the failure mode of interest is a broken shaft assembly, which could cause a closed FCV to subsequently fail open. The combined probability of this failure happening on either FCV is $9.8\text{E-}9$ per flight hour. There are other failure modes for the FCV that result in the valve failing open, however, these failure modes are only applicable when the valve is already open during the flight.
- D. Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.
2. Switch Lights: None.

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Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Inoperative Upper FCV(s) is locked closed, and
 - Associated Lower FCV operates normally.
-

21-51-02 Pack Flow Control/Shutoff Valves (FCV)**21-51-02-02 Lower FCVs**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative Lower FCV is locked closed,
 - Associated Upper FCV operates normally,
 - Opposite Air Conditioning Pack operates normally, and
 - Associated Ozone Converter is considered inoperative.
-

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL items 21-51-02-01 and 21-51-02-02.

The flow of pneumatic system air to the packs is controlled by modulation of Flow Control Valves (FCV's) which are electrically controlled and pneumatically actuated butterfly valves. Each pack uses two FCV's installed in parallel to allow pack air flow to either pass through or bypass an ozone converter. The ozone converters are normally bypassed at altitudes below 25,000'. The Cabin Temperature Controllers (CTC's) use input from the respective pack flow sensor and input temperature sensor to calculate airflow. The CTC's send commands to the FCV actuators to position the FCV to obtain the desired air flow rate.

Consequences of Failure

The PACK FCV LWR L or R, UPR L or R Status message will be displayed when the pack flow control/shutoff valve is not in its commanded position.

The associated pack(s) continue to be supplied with air using the remaining FCV with one locked closed. If the lower FCV is locked closed, the associated ozone converter will be bypassed at all altitudes. Cabin ozone concentration may be higher than normal. If the upper FCV is locked closed, the associated ozone converter will be used at all altitudes.

Consequences of Next Critical Failure

Failure of remaining FCV (closed): Associated pack is inoperative. Remaining pack provides all conditioned air.

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21-52-01 Air Cycle Machines (ACM)

21-52-01-01 FCAC Installed

21-52-01-01A

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated second stage turbine bypass valve is locked open,
- Both lower Recirculation Fans operate normally,
- Ram Air Inlet Doors operate normally or are secured open,
- Ram Air Exhaust Doors operate normally or are secured open,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right ACM inoperative, Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

21-52-01 Air Cycle Machines (ACM)

21-52-01-01 FCAC Installed

21-52-01-01B

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated second stage turbine bypass valve is locked open,
- Ram Air Inlet Doors operate normally or are secured open,
- Ram Air Exhaust Doors operate normally or are secured open,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right ACM inoperative, Center System Demand ADP C2 operates normally,
- FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing, and
- Appropriate performance adjustments are applied.

21-52-01 Air Cycle Machines (ACM)**21-52-01-02 FCAC Not Installed**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated second stage turbine bypass valve is locked open,
- Ram Air Inlet Doors operate normally or are secured open,
- Ram Air Exhaust Doors operate normally or are secured open,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right ACM inoperative, Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-52-01.

The air cycle machine (ACM) in each pack provides additional cooling capacity in addition to the heat exchanger. After passing through the primary heat exchanger, supply air is first compressed by the ACM, then expanded by a two-stage turbine. Between the compressor and first stage turbine cycles, the supply air is routed through a secondary heat exchanger and a re-heater/condenser where water is condensed and centrifugally removed to help maintain the health of the ACM. The air is then expanded by the second stage turbine before entering the mix manifold to provide the cold air source for cabin cooling. The ACM in each pack can be partially bypassed in the economy cooling mode, or completely bypassed in the standby cooling mode (heat exchanger only cooling).

Consequences of Failure

The PACK ACM L, R Status will be displayed when the CTC detects a failure of the associated ACM.

The associated second stage turbine bypass valve must be locked open for dispatch.

The associated pack will operate in standby cooling mode, which provides heat-exchanger-only cooling. During standby cooling mode operation, the associated PACK IN STBY MODE L, R Advisory message is displayed and STBY COOLING is displayed in amber on the AIR synoptic. The pack will remain off on the ground and at low altitudes until reaching the minimum ambient conditions (altitude and OAT) where standby cooling can be sustained, somewhere around 20,000 feet. The associated pack automatically starts and the pack OFF light extinguishes when conditions exist for standby cooling mode. The associated pack remains in standby cooling mode for the remainder of climb, cruise, and descent until returning to lower altitudes and higher outside air temperatures. The associated pack automatically shuts down (if the other pack is operating normally) when ambient conditions do not permit standby cooling.

Bleed air consumption must be adequate to protect the bleed air ducts. Therefore, for pack-off conditions due to operating in standby cooling mode, an ADP on the same side will be automatically turned on and run while the pack is off.

Therefore, for a right pack ACM inoperative, ADP C2 must operate normally. Since an ADP will be operating continuously during pack-off conditions, fuel temperature at takeoff must be less than 45 degrees C (113 degrees F) to ensure hydraulic cooling does not raise the fuel temperature high enough to damage the fuel pumps.

Two factors require performance adjustments due to reduced available thrust. As mentioned above, when the ACM is inoperative, the affected pack will not operate on the ground or during takeoff and climb. This causes the operative pack to schedule high flow which draws additional bleed air from that side engine. This results in reduced thrust. Also, since a single pack has to work harder, the ASCPC may command the FAMV more open to aid in pre-cooling the bleed air. This additional diversion of air from the fan through the pre-cooler causes the EEC to reduce thrust in order to protect EGT margins. Since that affected engine has reduced thrust both EECs reset to the lower thrust to maintain symmetry.

Consequences of Next Critical Failure

1. Failure of the associated ram air system or pack: Other pack provides pressurization and cooling for cabin air supply. Flight deck and cabin temperatures may become warmer.
2. Failure of the other pack: Pressurization and cabin air supply cooling is provided by the pack operating in the standby cooling mode. The pack in standby cooling mode will continue to operate, regardless of altitude or outside air temperature, to maintain cabin pressurization. The pack operating in the standby cooling mode will maintain cabin pressurization at cruise altitudes. The pack cooling capacity will be decreased at the lower altitudes.
3. Associated flow control valve (FCV) mechanically fails open. Pack will continue to operate at reduced altitudes. Cooling capacity will be decreased. Flight deck and cabin temperatures may become warmer during approach.

-
4. Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

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21-52-02 Economy Cooling Valves (ECV)

21-52-02-01 FCAC Installed

21-52-02-01A

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- a. Opposite Air Conditioning Pack operates normally,
 - b. Both Engine Bleed Air Systems operate normally,
 - c. For right ECV inoperative, Center System Demand ADP C2 operates normally,
 - d. Both lower Recirculation Fans operate normally, and
 - e. Appropriate performance adjustments are applied.
-

21-52-02 Economy Cooling Valves (ECV)

21-52-02-01 FCAC Installed

21-52-02-01B

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- a. Opposite Air Conditioning Pack operates normally,
 - b. Both Engine Bleed Air Systems operate normally,
 - c. For right ECV inoperative, Center System Demand ADP C2 operates normally,
 - d. FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing, and
 - e. Appropriate performance adjustments are applied.
-

21-52-02 Economy Cooling Valves (ECV)**21-52-02-01 FCAC Installed**

21-52-02-01C

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided inoperative Economy Cooling Valve(s) is locked closed.

21-52-02 Economy Cooling Valves (ECV)**21-52-02-02 FCAC Not Installed**

21-52-02-02A

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right ECV inoperative, Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

21-52-02 Economy Cooling Valves (ECV)**21-52-02-02 FCAC Not Installed**

21-52-02-02B

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided inoperative Economy Cooling Valve(s) is locked closed.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-52-02.

Each pack has an economy cooling valve controlled by the associated cabin temperature controller (CTC) and ELMS. The valve is commanded closed when cabin cooling requirements are in higher demand and bleed pressure is more available. At higher altitudes, when engine bleed pressure is reduced and less cooling is required, the valve is commanded open to bypass the ACM first stage turbine, thereby reducing the pressure drop of the pack. In the event of an ACM failure, the economy cooling valve and second stage turbine bypass valve are both opened to completely bypass the ACM. The associated pack then operates in the standby cooling mode.

If the Economy Cooling Valve (ECV) is not locked closed (C/2/1 entry), standby cooling mode (PACK MODE) operation occurs on the affected pack. This pack will automatically shut off at low altitude and high OAT conditions, at which point the opposite pack switches to high flow to make up for the inoperative pack. High pack flow causes the EECs to reset thrust limits to lower levels, which requires a performance adjustment. If the ECV is locked closed (C/2/0 entry), normal pack flow occurs at all flight conditions and normal thrust is available.

Consequences of Failure

The ECON COOL VALVE L or R Status message is displayed when the CTC detects that the valve is not in the commanded position.

Economy cooling mode is not available on the associated pack.

For inoperative valve not locked closed:

This results in standby cooling mode and the other pack compensates for air conditioning and cabin pressurization. This compensation requires accompanying performance adjustments. The PACK IN STBY MODE L, R Advisory message will be displayed and STBY COOLING is displayed in amber on the AIR synoptic.

Bleed air consumption must be adequate to protect the bleed air ducts. Therefore, for pack-off conditions due to operating in standby cooling mode, an ADP on the the same side will be automatically turned on and run while the pack is off.

Therefore, for a right pack ECV inoperative, ADP C2 must operate normally.

Since an ADP will be operating continuously during pack-off conditions, fuel temperature at takeoff must be less than 45 degrees C (113 degrees F) to ensure hydraulic cooling does not raise the fuel temperature high enough to damage the fuel pumps.

For inoperative valve locked closed:

This results in maximum cooling regardless of flight condition or cabin cooling demand. This results in degraded temperature control on cold ambient conditions and degraded ventilation when bleed pressure is reduced.

Consequences of Next Critical Failure

Failure of associated ACM: If ECV is locked closed, pack cannot be operated in standby cooling mode and remaining pack provides air conditioning and pressurization. If ECV is not locked closed, pack can be operated in standby cooling mode and remaining pack compensates for air conditioning and cabin pressurization.

Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

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21-52-03 Compressor Discharge Temperature Sensors

Interval	Installed	Required	Procedure
C	6	2	(M)

May be inoperative provided one Compressor Discharge Temperature Sensor for each Air Conditioning Pack is verified to operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-52-03.

Each pack has a compressor discharge temperature sensing system consisting of three sensors and associated wiring. The temperature data is used in the compressor discharge overtemperature control logic in each CTC. Only one sensor per pack is required for the control logic. The EICAS status messages indicate failure of both sensors connected to one CTC or the sensor connected to the ASCPC. The ASCPC compressor discharge temperature sensor for the associated pack serves as a backup. This provides a backup if both CTC sensors fail or if the CTC itself fails.

Consequences of Failure

The CMPSR TEMP SENSOR L or R Status will be displayed for failure of either both Cabin Temperature Controller (CTC) compressor outlet temperature sensors (on one side) OR the single ASCPC compressor outlet temperature sensor.

The remaining compressor discharge temperature sensors provide a source of temperature data for continued pack operation with compressor discharge overtemperature protection.

Consequences of Next Critical Failure

Failure of the remaining discharge temperature sensor: Compressor discharge overheat protection is inoperative on the affected pack and a precautionary pack shut down occurs automatically. The PACK OFF L, R Advisory message will display.

21-52-04 Pack Discharge Temperature Sensors

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided associated Air Conditioning Pack is considered inoperative.

SUBSTANTIATION**Background**

Each pack has two discharge temperature sensors, with one being from the cabin temperature controller (CTC) and the second being the backup air supply and cabin pressure controller (ASCPC) pack discharge temperature sensor.

The CTC uses either temperature sensor to provide protective controls to keep the pack from overheating or shutdown the pack if it overheats. If the CTC fails, the ASCPC will control the pack and base the flow set point on the ASCPC pack discharge temperature sensor.

Consequences of Failure

The PACK OUT TEMP SNSR L or R Status message will be displayed when there is a failure of the associated ASCPC pack outlet temperature sensor.

Failure of the ASCPC pack outlet temperature sensor results loss of ASCPC backup overheat protection. Subsequent failure of the CTC increases the chance of extreme hot or cold temperature resulting in pack shutdown. Therefore, for MMEL dispatch, the airplane is dispatched with the associated pack deactivated.

Consequences of Next Critical Failure

Failure of the remaining pack, or the air cycle machine (ACM) on remaining pack. Refer to air conditioning pack item (21-51-01).

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21-52-05 Ram Air Inlet Door Systems

21-52-05-01 FCAC Installed

21-52-05-01A

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Associated Ram Air Inlet Door is secured full open,
- Associated Trim Air Control System operates normally,
- Associated Trim Air PRSOV operates normally,
- For Left Ram Air Inlet Door inoperative, Flight Deck Zone Trim Air Modulating Valve operates normally,
- Appropriate performance adjustments are applied, and
- Repairs are made within 10 flight-days.

NOTE: Airplane may not be dispatched with associated TRIM AIR switch selected OFF.

21-52-05 Ram Air Inlet Door Systems

21-52-05-01 FCAC Installed

21-52-05-01B

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Ram Air Inlet Door is verified closed,
- Both lower Recirculation Fans operate normally,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-52-05 Ram Air Inlet Door Systems**21-52-05-01 FCAC Installed**

21-52-05-01C

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Ram Air Inlet Door is verified closed,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is not used, and
- FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing.
- Flight remains within 60 minutes of landing at a suitable airport.
- Appropriate performance adjustments are applied.

21-52-05 Ram Air Inlet Door Systems**21-52-05-01 FCAC Installed**

21-52-05-01D

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Ram air inlet cover plate is installed on associated inlet,
- Both lower Recirculation Fans operate normally,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and

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- i. Appropriate performance adjustments are applied.
-

21-52-05 Ram Air Inlet Door Systems**21-52-05-01 FCAC Installed***********21-52-05-01E**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Ram air inlet cover plate is installed on associated inlet,
 - Opposite Air Conditioning Pack operates normally,
 - Both Engine Bleed Air Systems operate normally,
 - Both Outflow Valves operate normally,
 - For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
 - Associated Air Conditioning Pack is not used, and
 - FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing.
 - Flight remains within 60 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

21-52-05 Ram Air Inlet Door Systems**21-52-05-02 FCAC Not Installed***********21-52-05-02A**

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Associated Ram Air Inlet Door is secured full open,
- Associated Trim Air Control System operates normally,
- Associated Trim Air PRSOV operates normally,
- For Left Ram Air Inlet Door inoperative, Flight Deck Zone Trim Air Modulating Valve operates normally,
- Appropriate performance adjustments are applied, and
- Repairs are made within 10 flight-days.

NOTE: Airplane may not be dispatched with associated TRIM AIR switch selected OFF.

21-52-05 Ram Air Inlet Door Systems

21-52-05-02 FCAC Not Installed

21-52-05-02B

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Ram Air Inlet Door is verified closed,
 - Opposite Air Conditioning Pack operates normally,
 - Both Engine Bleed Air Systems operate normally,
 - Both Outflow Valves operate normally,
 - Associated Air Conditioning Pack is not used,
 - For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
 - Flight remains within 60 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

21-52-05 Ram Air Inlet Door Systems

21-52-05-02 FCAC Not Installed

21-52-05-02C

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Ram air inlet cover plate is installed on associated inlet,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- Associated Air Conditioning Pack is not used, and
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally.
- Flight remains within 60 minutes of landing at a suitable airport, and

h. Appropriate performance adjustments are applied.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-52-05.

The ram air systems for both packs control the amount of ram air available for the primary and secondary heat exchangers. The inlet door system for each pack consists of a door, a drive mechanism, an actuator, and a position transducer. Door position is controlled by the associated CTC.

Consequences of Failure

The RAM AIR INLET DOOR L or R Status message will be displayed when the associated air inlet door is not in commanded position or there is a loss of position feedback.

For associated pack used:

The associated door must be secured full open. There is no effect on pack operation with door secured open. Fuel burn will increase due to drag increment with inlet door full open. Heat exchanger outlet temperature may be colder than normal. The ram outlet door and pack turbine bypass will attempt to compensate. In some ambient conditions, cabin temperature may not reach selected temperature.

For operation with a Ram Air Inlet Door secured full open, the associated pack may not be capable of reaching the selected temperature. Therefore, the associated trim air control system must operate normally to prevent cold temperatures in the flight deck (left side) and cabin.

For ram air door closed or cover plate installed:

Associated pack is not used if door is inoperative in the closed position or cover plate is installed. Only one pack may be not used for dispatch. Cover plate is required if ram air inlet door or inlet duct is damaged.

Consequences of Next Critical Failure

For associated pack used:

For Ram Air Inlet/Exhaust Door secured full open:

Failure of the Trim Air System will result in cold cabin or flight deck temperature. In this condition, the pack on the affected side may be shut down by the flight crew. Excessively cold supply air to cabin or flight deck and inability to shut off the cooling source is classified as 'Catastrophic'. The probability of this hazard with a ram air inlet/exhaust door secured full open is 3.35E-08. Maximum dispatch time is 891 flight hours.

Failure of associated ram exit door: Limited pack cooling capacity that may result in reduced pack flow or pack shutdown.

For ram air door closed or cover plate installed (associated pack not used):

Failure of remaining pack: Loss of air conditioning and pressurization. Airplane must descend to maintain cabin pressure altitude below 15,000 ft.

For a subsequent event requiring the crew to discharge the fire extinguisher on the flight deck, QRH procedures will shut off the recirculation fans which reduces the ventilation to the flight deck to essentially zero. This results in a condition where the agent concentration will not decay to a safe level. For this reason, the dual pack inoperative configuration is no longer a valid dispatch configuration.

Flow Control Valve on inoperative pack: An Upper or Lower Flow Control Valve (FCV) failing open would be the worst-case Next Critical Failure. This failure would result in loss of pack temperature control and an inability to shut down the heating/cooling source. This failure condition is hazardous provided flights remain within 60 minutes of the nearest airport. Since the FCVs are closed for dispatch (valves are closed with pack inoperative), the failure mode of interest is a broken shaft assembly, which could cause a closed FCV to subsequently fail open. The combined probability of this failure happening on either FCV is $9.8\text{E-}9$ per flight hour. There are other failure modes for the FCV that result in the valve failing open, however, these failure modes are only applicable when the valve is already open during the flight.

Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

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21-52-06 Ram Air Exhaust Door Systems

21-52-06-01 FCAC Installed

21-52-06-01A

Interval	Installed	Required	Procedure
A	2	0	(M) (O)

May be inoperative provided:

- Associated Ram Air Exhaust Door is secured full open,
- Associated Trim Air Control System operates normally,
- Associated Trim Air PRSOV operates normally,
- For Left Ram Air Exhaust Door inoperative, Flight Deck Zone Trim Air Modulating Valve operates normally,
- Appropriate performance adjustments are applied, and
- Repairs are made within 10 flight-days.

NOTE: Airplane may not be dispatched with associated TRIM AIR switch selected OFF.

21-52-06 Ram Air Exhaust Door Systems

21-52-06-01 FCAC Installed

21-52-06-01B

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Both lower Recirculation Fans operate normally,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-52-06 Ram Air Exhaust Door Systems**21-52-06-01 FCAC Installed**

21-52-06-01C

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Opposite Air Conditioning Pack operates normally,
 - Both Engine Bleed Air Systems operate normally,
 - Both Outflow Valves operate normally,
 - For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
 - Associated Air Conditioning Pack is not used,
 - FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing,
 - Flight remains within 60 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

21-52-06 Ram Air Exhaust Door Systems**21-52-06-02 FCAC Not Installed**

21-52-06-02A

Interval	Installed	Required	Procedure
A	2	0	(M) (O)

May be inoperative provided:

- Associated Ram Air Exhaust Door is secured full open,
- Associated Trim Air Control System operates normally,
- Associated Trim Air PRSOV operates normally,
- For Left Ram Air Exhaust Door inoperative, Flight Deck Zone Trim Air Modulating Valve operates normally,
- Appropriate performance adjustments are applied, and
- Repairs are made within 10 flight-days.

NOTE: Airplane may not be dispatched with associated TRIM AIR switch selected OFF.

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Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- For right Air Conditioning Pack not used, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 21-52-06-01.

The ram air systems for both packs control the amount of ram air available for the primary and secondary heat exchangers. The exit door system for each pack consists of a louvered door, a drive mechanism, an actuator, and a position transducer. Door position is controlled by the associated CTC.

Consequences of Failure

The RAM AIR EXIT DOOR L or R Status message will be displayed when the associated air exit door is not in commanded position or there is a loss of position feedback.

For associated pack used:

The associated door must be secured full open. No effect on pack operation if door(s) is secured open. Performance adjustments are required to account for drag created by the open exhaust door. Heat exchanger outlet temps may be colder than normal. The ram inlet doors and pack turbine bypass will attempt to compensate. In some ambient conditions, cabin temps may not reach selected temperatures.

For operation with a Ram Air Exhaust Door secured full open, the associated pack may not be capable of reaching the selected temperature. Therefore, the associated trim air control system must operate normally to prevent cold temperatures in the flight deck (left side) and cabin.

For associated pack not used:

Associated pack is not used if door is inoperative in anything but the full open position.

Consequences of Next Critical Failure

For associated pack used:

For Ram Air Inlet/Exhaust Door secured full open:

Failure of the Trim Air System will result in cold cabin or flight deck temperature. In this condition, the pack on the affected side may be shut down by the flight crew. Excessively cold supply air to cabin or flight deck and inability to shut off the cooling source is classified as 'Catastrophic'. The probability of this hazard with a ram air inlet/exhaust door secured full open is 3.35E-08. Maximum dispatch time is 891 flight hours.

Failure of associated ram inlet door: Limited pack cooling capacity that may result in reduced pack flow or pack shutdown.

For associated pack not used:

Failure of remaining pack: Loss of air conditioning and pressurization. Airplane must descend to maintain cabin pressure altitude below 15,000 ft. For a subsequent event requiring the crew to discharge the fire extinguisher on the flight deck, QRH procedures will shut off the recirculation fans which reduces the ventilation to the flight deck to essentially zero. This results in a condition where the agent concentration will not decay to a safe level. For this reason, the dual pack inoperative configuration is no longer a valid dispatch configuration.

Flow Control Valve on inoperative pack: An Upper or Lower Flow Control Valve (FCV) failing open would be the worst-case Next Critical Failure. This failure would result in loss of pack temperature control and an inability to shut down the heating/cooling source. This failure condition is hazardous provided flights remain within 60 minutes of the nearest airport. Since the FCVs are closed for dispatch (valves are closed with pack inoperative), the failure mode of interest is a broken shaft assembly, which could cause a closed FCV to subsequently fail open. The combined probability of this failure happening on either FCV is 9.8E-9 per flight hour. There are other failure modes for the FCV that result in the valve failing open, however, these failure modes are only applicable when the valve is already open during the flight.

Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

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21-52-07 Condenser Inlet Temperature Control Systems

21-52-07-01 FCAC Installed

21-52-07-01A

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated condenser low limit valve is locked open,
- Both lower Recirculation Fans operate normally,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right Condenser Inlet Temperature Control System inoperative, Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

21-52-07 Condenser Inlet Temperature Control Systems

21-52-07-01 FCAC Installed

21-52-07-01B

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated condenser low limit valve is locked open,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right Condenser Inlet Temperature Control System inoperative, Center System Demand ADP C2 operates normally,
- FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing, and
- Appropriate performance adjustments are applied.

21-52-07 Condenser Inlet Temperature Control Systems**21-52-07-02 FCAC Not Installed**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated condenser low limit valve is locked open,
- Opposite Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- For right Condenser Inlet Temperature Control System inoperative, Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-52-07.

Each pack has a condenser inlet temperature sensing system consisting of two sensors, a low limit valve, and associated wiring. The temperature data is used in the condenser inlet temperature control logic in each CTC. The CTC controls the position of the condenser low-limit valve to maintain condenser inlet temperature at or above 34 degrees F to preclude icing in the condenser. Only one sensor per pack is required for the control logic. The EICAS status messages indicate failure of both sensors in the left or right pack.

Because of the Low Limit Valve Being Locked Open, a request of 250 Deg F manifold Temperature Control get sent to the ASCPC which in turn controls the Fan Air Modulating Valve (FAMV) Open.

Consequences of Failure

The CONDENSER TEMP CONTROL L or R Status message will be displayed when either both of the associated pack condenser inlet temperature sensors have failed and the ACM has not failed, or the low limit valve has failed.

The associated condenser low limit valve must be locked open for dispatch. Locking the condensor low limit valve open may result in the associated ECON COOL VALVE L or R Status message. No additional maintenance or operational actions are required.

Pack cooling capacity is limited due to condenser low-limit valve locked open, mixing warm reheater-outlet air with the ACM first stage turbine discharge air.

Standby Cooling Mode: The associated pack will operate in standby cooling mode, which provides heat-exchanger-only cooling. During standby cooling mode operation, the associated PACK IN STBY MODE L, R Advisory message is displayed and STBY COOLING is displayed in amber on the AIR synoptic. The pack will remain off on the ground and at low altitudes until reaching the minimum ambient conditions (altitude and OAT) where standby cooling can be sustained, somewhere around 20kft. The associated pack automatically starts and the pack OFF light extinguishes when conditions exist for standby cooling mode. The associated pack remains in standby cooling mode for the remainder of climb, cruise, and descent until returning to lower altitudes and higher outside air temperatures. The associated pack automatically shuts down (if the other pack is operating normally) when ambient conditions do not permit standby cooling.

For a pack OFF during Standby Cooling Mode: Bleed air consumption must be adequate to protect the bleed air ducts. Therefore, for pack-off conditions due to operating in standby cooling mode, an ADP on the same side will be automatically turned on and run while the pack is off. Therefore, for a right pack ACM inoperative, ADP C2 must operate normally. Since an ADP will be operating continuously during pack-off conditions, fuel temperature at takeoff must be less than 45 degrees C (113 degrees F) to ensure hydraulic cooling does not raise the fuel temperature high enough to damage the fuel pumps.

Performance penalties for Standby Cooling Mode: Two factors require performance adjustments due to reduced available thrust. In standby cooling mode, the affected pack will not operate on the ground or during takeoff and climb. This causes the operative pack to schedule high flow which draws additional bleed air from that side engine. This results in reduced thrust. Also, since a single pack has to work harder, the ASCPC may command the FAMV more open to aid in pre-cooling the bleed air. This additional diversion of air from the fan through the pre-cooler causes the EEC to reduce thrust in order to protect EGT margins. Since that affected engine has reduced thrust both EECs reset to the lower thrust to maintain symmetry.

Consequences of Next Critical Failure

Failure of the opposite pack: Air conditioning is provided by a single pack with limited cooling capability.

Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

21-61-01 Cabin Temperature Controllers (CTC)**21-61-01-01 Left Controller****21-61-01-01-01 FCAC Installed**

21-61-01-01-01A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Right CTC operates normally,
 - Right Air Conditioning Pack operates normally,
 - Both Engine Bleed Air Systems operate normally,
 - Both Outflow Valves operate normally,
 - Both lower Recirculation Fans operate normally,
 - Left Air Conditioning Pack is not used,
 - Flight remains within 60 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

21-61-01 Cabin Temperature Controllers (CTC)**21-61-01-01 Left Controller****21-61-01-01-01 FCAC Installed**

21-61-01-01-01B

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Right CTC operates normally,
 - Right Air Conditioning Pack operates normally,
 - Both Engine Bleed Air Systems operate normally,
 - Both Outflow Valves operate normally,
 - Left Air Conditioning Pack is not used,
 - FWD CARGO A/C selector remains OFF for takeoff, climb, descent, and landing,
 - Flight remains within 60 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

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21-61-01 Cabin Temperature Controllers (CTC)

21-61-01-01 Left Controller

21-61-01-01-02 FCAC Not Installed

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Right CTC operates normally,
- Right Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- Left Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-61-01 Cabin Temperature Controllers (CTC)

21-61-01-02 Right Controller

21-61-01-02-01 FCAC Installed

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Electrical power on the right AC Transfer Bus is verified before each departure,
- FCAC Flow Regulating Valve is deactivated closed,
- Left CTC operates normally,
- Left Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- Both lower Recirculation Fans operate normally,
- Center System Demand ADP C2 operates normally,
- Right Air Conditioning Pack is not used,
- FWD CARGO A/C selector remains OFF,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

21-61-01 Cabin Temperature Controllers (CTC)**21-61-01-02 Right Controller****21-61-01-02-02 FCAC Not Installed**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Electrical power on the right AC Transfer Bus is verified before each departure,
- Left CTC operates normally,
- Left Air Conditioning Pack operates normally,
- Both Engine Bleed Air Systems operate normally,
- Both Outflow Valves operate normally,
- Center System Demand ADP C2 operates normally,
- Right Air Conditioning Pack is not used,
- Flight remains within 60 minutes of landing at a suitable airport, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-61-01-04 and 21-61-01-06.

The cabin air conditioning and temperature control system (CACTCS) uses two dual channel digital electronic controllers to provide automatic control of the following four functions: fresh air flow, recirculation flow, cooling pack temperatures, and zone temperature control. The right CTC controls the right pack, trim air for 3 zones and the recirculation fans (if FCAC option is installed, right CTC also controls trim air and Flow Regulating Valve for FCAC zone). The left CTC controls the left pack, trim air for 4 zones, Flight Deck Flow Regulating Valve and provides backup recirculation fan control. Both CTCs have 2 fully redundant channels to provide primary and backup control for each function. The EICAS status messages indicate failure of both channels in the left or right CTC.

Consequences of Failure

The CABIN TEMP CTRL L or R status message will be displayed with loss of both associated CTC channels or a combination of one CTC channel and loss of backup control from the ASCPC.

The associated pack control functions are inoperative, and the pack cannot be used.

Associated pack must be selected OFF for dispatch. The associated PACK OFF L, R Advisory message will be displayed and the pack switch will indicate OFF.

For the right CTC inoperative:

Electrical power on the right AC transfer bus must be verified to ensure that the CABIN TEMP CTRL R Status message is the result of a right CTC failure and not the result of an unpowered right AC transfer bus. For FCAC installed, the FCAC flow regulating valve must be deactivated closed and FCAC must remain OFF.

The remaining pack provides air conditioning and pressurization. No altitude limitation is required because airplane can maintain cabin altitude of less than 15,000 ft during emergency descent from any altitude in flight envelope, in the event of a subsequent pack failure. The remaining pack will compensate for the inoperative pack although temperature control will be degraded and all zones may not meet the selected temperatures. The crew rest areas may have warmer than selected temperatures depending on the ambient conditions.

When one pack is inoperative, the operating pack will compensate by increasing flow to make up for the inoperative pack. A lower temperature bleed may be used if the operating pack can't achieve the difference in flow. This will use more fan flow as the Fan Air Modulation Valve (FAMV) controls more open to achieve a lower bleed temperature. Performance adjustments must be made to account for the increased flow on one side and the additional fan air flow. The EEC will make a thrust adjustment based on single pack operation communicated from the CTC.

For an inoperative pack, an ADP on the the same side will be automatically be turned on and run for the entire flight. Therefore, for a right pack inoperative, ADP C2 must operate normally. Since an ADP will be operating continuously, fuel temperature at takeoff must be less than 45 degrees C (113 degrees F) to ensure hydraulic cooling does not raise the fuel temperature high enough to damage the fuel pumps.

Consequences of Next Critical Failure

Dispatch with one pack not used:

1. Failure of ACM on remaining pack: One pack pressurization remains operational in standby cooling mode. Cabin temperature may be different than selected.
2. Failure of remaining pack: Loss of air conditioning and pressurization. Airplane must descend to maintain cabin pressure altitude below 15,000 ft. For a subsequent event requiring the crew to discharge the fire extinguisher on the flight deck, QRH procedures will shut off the recirculation fans which reduces the ventilation to the flight deck to essentially zero. This results in a condition where the agent concentration will not decay to a safe level. For this reason, the dual pack inoperative configuration is no longer a valid dispatch configuration.

3. Flow Control Valve on inoperative pack: An Upper or Lower Flow Control Valve (FCV) failing open would be the worst-case Next Critical Failure. This failure would result in loss of pack temperature control and an inability to shut down the heating/cooling source. This failure condition is hazardous provided flights remain within 60 minutes of the nearest airport. Since the FCVs are closed for dispatch (valves are closed with pack inoperative), the failure mode of interest is a broken shaft assembly, which could cause a closed FCV to subsequently fail open. The combined probability of this failure happening on either FCV is $9.8\text{E-}9$ per flight hour. There are other failure modes for the FCV that result in the valve failing open, however, these failure modes are only applicable when the valve is already open during the flight.
4. Failure of opposite CTC controller: Opposite pack would run in ASCPC backup mode. Pack would continue to operate but with degraded temperature control.
5. Smoke event: If operating with a single air conditioning pack, both lower recirculation fans must operate normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event. The configuration requirement does not apply for right CTC since FCAC is deactivated.

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21-61-02 Zone Trim Air Modulating Valve Systems

21-61-02-01 Flight Deck Zone Trim Air Modulating Valve

21-61-02-01A

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative provided:

- Left TRIM AIR switch remains off,
- For Left Ram Air Inlet Door inoperative, left Air Conditioning Pack is not used,
- For Left Ram Air Exhaust Door inoperative, left Air Conditioning Pack is not used, and
- Repairs are made within 10 flight-days.

NOTE: For Left Ram Air Inlet Door inoperative, Inlet Door must either be closed or cover plate installed.

21-61-02 Zone Trim Air Modulating Valve Systems

21-61-02-01 Flight Deck Zone Trim Air Modulating Valve

21-61-02-01B

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- Flight Deck Zone Trim Air Modulating Valve is deactivated closed,
- For left Ram Air Inlet Door inoperative, left Air Conditioning Pack is not used,
- For left Ram Air Exhaust Door inoperative, left Air Conditioning Pack is not used, and
- Repairs are made within 10 flight-days.

NOTE: For Left Ram Air Inlet Door inoperative, Inlet Door must either be closed or cover plate installed.

21-61-02 Zone Trim Air Modulating Valve Systems**21-61-02-02 Cabin Zone A, C, & E Trim Air Modulating Valves (Left Side)****21-61-02-02A**

Interval	Installed	Required	Procedure
A	3	0	(O)

May be inoperative with associated Cabin Zone Trim Air Modulating Valve in any position provided:

- Left TRIM AIR switch remains off,
- For left Ram Air Inlet Door inoperative, left Air Conditioning Pack is not used,
- For left Ram Air Exhaust Door inoperative, left Air Conditioning Pack is not used, and
- Repairs are made within 10 flight-days.

NOTE: For Left Ram Air Inlet Door inoperative, Inlet Door must either be closed or cover plate installed.

21-61-02 Zone Trim Air Modulating Valve Systems**21-61-02-02 Cabin Zone A, C, & E Trim Air Modulating Valves (Left Side)****21-61-02-02B**

Interval	Installed	Required	Procedure
C	3	0	(M)

May be inoperative provided associated Cabin Zone Trim Air Modulating Valve(s) is deactivated closed.

21-61-02 Zone Trim Air Modulating Valve Systems**21-61-02-03 Cabin Zone B, D, & F Trim Air Modulating Valves (Right Side)****21-61-02-03A**

Interval	Installed	Required	Procedure
A	3	0	(O)

May be inoperative with associated Cabin Zone Trim Air Modulating Valve in any position provided:

- Right TRIM AIR switch remains off,

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- b. For right Ram Air Inlet Door inoperative, right Air Conditioning Pack is not used,
- c. For right Ram Air Exhaust Door inoperative, right Air Conditioning Pack is not used, and
- d. Repairs are made within 10 flight-days.

For FCAC installed:

- e. For right TRIM AIR switch selected off, FWD CARGO A/C selector remains OFF.

NOTE: For Right Ram Air Inlet Door inoperative, Inlet Door must either be closed or cover plate installed.

21-61-02 Zone Trim Air Modulating Valve Systems

21-61-02-03 Cabin Zone B, D, & F Trim Air Modulating Valves (Right Side)

21-61-02-03B

Interval	Installed	Required	Procedure
C	3	0	(M)

May be inoperative provided associated Cabin Zone Trim Air Modulating Valve(s) is deactivated closed.

21-61-02 Zone Trim Air Modulating Valve Systems

21-61-02-04 FCAC Zone Trim Air Modulating Valve

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. FCAC Zone Trim Air Modulating Valve is deactivated closed,
- b. FCAC Flow Regulating Valve is deactivated closed, and
- c. FWD CARGO A/C selector remains OFF.

SUBSTANTIATION

Background

Proposal based 777 MMEL items 21-61-02-01, 21-61-03 & 21-61-07-01.

The Zone Temperature Control System controls the temperature in the Flight Deck, Cabin Zones, and Forward Cargo Compartment (For FCAC installed). The temperature in these areas is controlled by the addition of hot trim air from the pneumatic system to the conditioned air from the cooling system. The system consists of Cabin Temperature Controllers (CTC), Zone Trim Air Modulating Valves (TAMV) and Zone Air Temperature Sensors. FCAC includes FCAC compartment temperature sensors and zone duct temperature sensors.

The left and right CTCs control the zone temperature control and indication system, as well as other Environmental Control System (ECS) subsystems. The following controls on the air conditioning panel on the P5 overhead panel are used to set a target temperature for the associated areas: Flight Deck Temperature Selector, Cabin Temperature selector and Forward Cargo Temperature selector (For FCAC installed). Each zone temperature is controlled independently. The left CTC controls the flight deck and zones A, C, and E. The right CTC controls zones B, D, and F. The right CTC also controls the forward cargo compartment.

Air temperature in the different zones is controlled by mixing hot air from the Trim Air Pressure Regulating Shut Off Valve (PRSOV) with conditioned air. The flight deck gets conditioned air directly from the left Air Conditioning pack. The cabin zones get conditioned air from the mix manifold. The forward cargo compartment also gets conditioned air from the mix manifold.

The flight deck and zones A, C, and E get hot trim air from the left Trim Air PRSOV. Zones B, D, and F get hot trim air from the right Trim Air PRSOV. The forward cargo compartment also gets hot trim air from the right Trim Air PRSOV. The zone TAMVs regulate the amount of hot trim air that mixes with the conditioned air to get the correct zone temperature.

The CTCs control the Air Conditioning packs to regulate the temperature of the conditioned air and the zone TAMVs to regulate the addition of hot trim air to control the temperature in the zones.

The flight deck temperature selector on the air conditioning panel provides control input of the flight deck temperature. The flight deck temperature selector sets the flight deck zone TAMV to AUTO or MAN control. AUTO sets the flight deck target temperature between 65°F (18°C) and 85°F (29°C). In automatic mode, the left CTC automatically modulates the flight deck zone TAMV to maintain the target temperature in the flight deck. The MAN selection manually adjusts the position of the flight deck zone TAMV. Manual control allows the flight crew to manually control the amount of hot air that mixes with the flight deck air supply rather than setting a target temperature.

The cabin temperature selector on the air conditioning panel provides control input of the master cabin temperature. The master cabin temperature is the base temperature of the cabin zones, between 65°F (18°C) and 85°F (29°C). The individual zone temperatures can be adjusted using the cabin attendant panel. The individual zones can be adjusted 10°F (6°C) from the master cabin temperature, within the 65°F (18°C) and 85°F (29°C) limit. The CTCs automatically modulate the zone TAMVs independently to get the desired individual zone temperatures.

The forward cargo temperature selector on the air conditioning panel provides control input of the forward cargo compartment temperature. The forward cargo temperature selector sets the forward cargo compartment temperature between 39°F (4°C) and 81°F (27°C). The right CTC automatically modulates the forward cargo air conditioning zone TAMV to get the desired forward cargo compartment temperature.

Consequences of Failure

The TRIM MOD VLV L Status message is displayed when the L CTC detects any left zone trim modulating valve not in commanded position or loss of position feedback. Left side trim control zones are Flight Deck and Cabin Zones A, C, E.

The TRIM MOD VLV R Status message is displayed when the R CTC detects any right zone trim modulating valve not in commanded position or loss of position feedback. Right side trim control zones are Cabin Zones B, D, F and FCAC.

MMEL dispatch options allow for either the associated TRIM AIR switch to be selected OFF or the inoperative Trim Air Modulating Valve(s) deactivated closed.

For Trim Air Switch selected OFF:

Associated PRSOV will be commanded closed. No trim air will be available for all zones controlled by the associated PRSOV. Air temperature supplied to the affected zones will be controlled by the air conditioning packs without trim air available to adjust the zone temperatures.

For operation with trim air switch off, the associated zone temperatures will be controlled by the associated air conditioning pack. For an air conditioning pack to provide adequate temperature control, the associated Ram Air Inlet Door and Ram Air Exhaust Door must operate normally.

The associated Air Conditioning Pack will control the temperature to the zone requiring the lowest temperature. The flight deck temperature setting is included in the "voting" for temperature zone needing the most cooling. The cabin zone temperatures are based on the master cabin temperature setting selected in the flight deck. However, individual cabin zone temperature settings can be biased up or down by up to 10 deg F on the Cabin Attendant Panels (CAP). The pack will control the temperature to the zone requiring the most cooling.

For Inoperative TAMV deactivated closed:

No trim air will be supplied to affected zone. Air temperature supplied to affected zone will be controlled by the associated air conditioning pack without trim air available to adjust the zone temperature. Adjacent zones will provide mixing for temperature control.

For Flight Deck Zone TAMV deactivated closed, flight deck temperature control is provided directly by the left air conditioning pack. For the left air conditioning pack to provide adequate temperature control, the associated left Ram Air Inlet Door and Ram Air Exhaust Door must operate normally.

The left Air Conditioning Pack will control the flight deck temperature based on the zone requiring the lowest temperature. The flight deck temperature setting is included in the "voting" for temperature zone needing the most cooling. The cabin zone temperatures are based on the master cabin temperature setting selected in the flight deck. However, individual cabin zone temperature settings can be biased up or down by up to 10 deg F on the Cabin Attendant Panels (CAP). The pack will control the temperature to the zone requiring the most cooling.

For Cabin Zone TAMV(s) deactivated closed, cabin zone temperature control is provided by the by the air conditioning packs through the mix manifold. At least one air conditioning pack must operate normally for dispatch which will ensure adequate temperature control.

For FCAC installed:

Both the FCAC Zone TAMV Valve and FCAC Flow Regulating Valve (FRV) must be closed. If only the FCAC Zone TAMV is closed, pack air could still flow past an open FRV. If only the FRV is closed, trim air could backflow into the mix manifold past an open TAMV.

Since FCAC must be selected off for dispatch, lower forward cargo air conditioning is not available and temperature sensitive cargo such as perishable goods should not be carried in the lower forward cargo compartment. The FCAC will not control to a default temperature when selected OFF. The zone temperature will be controlled by the cargo heating system (no air conditioning is available).

Consequences of Next Critical Failure

For Trim Air Switch selected OFF & Flight Deck Zone TAMV deactivated closed:

Failure of the associated pack will result in cold cabin or flight deck temperature. Failure of the associated pack resulting in cold temperature without pack shutdown capability will result in excessively cold temperature to the cabin or flight deck. Excessively cold supply air to cabin or flight deck and inability to shut off the cooling source is classified as 'Catastrophic'. The probability of this hazard with the trim air selected OFF is 1.15E-08. Maximum dispatch time is 298 flight hours.

For failure of a pack resulting in loss of temperature control (hot or cold), the flight crew may apply QRH procedure to turn the associated pack off.

Failure of an air conditioning pack:

Remaining pack will provide adequate air for all zones. For left pack failure, flight deck air will be provided by the mix manifold.

For FCAC installed:

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

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21-61-03 Temperature Control Selectors

21-61-03-01 CABIN TEMP Control Selector

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-61-04.

The passenger cabin temperature selector allows the flight crew to select a master cabin temperature (all zones simultaneously) between 'C' (65 degrees F/18 degrees C) and 'W' (85 degrees F/29 degrees C). The selected temperature can be biased by 10 deg F, up to 85 F or down to 65 F, in each individual zone at the cabin attendant panel in the passenger cabin. The CTC computes a target zone temperature using these two inputs.

Consequences of Failure

CABIN TEMP Control Selector:

The CTC cabin temperature target cannot be changed. Default temperature used by the system is 75 F.

Consequences of Next Critical Failure

Failure of a pack or CTC: Pressurization and air conditioning is provided by the remaining pack at a default target cabin temperature.

21-61-04

FCAC Temperature Control

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- FCAC Zone Trim Air Modulation Valve is deactivated closed,
- FCAC Flow Regulating Valve is deactivated closed, and
- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-61-08-01.

The forward cargo air conditioning (FCAC) system, an optional system, provides conditioned air from the mix manifold to the cargo compartment. Trim air from the right trim air system is mixed with cool air from the mix manifold upstream of the FCAC FRV to achieve the desired compartment temperature. The FCAC Flight Deck Control provides on/off and forward cargo temperature control capability.

The FCAC Control allows the flight crew to control the forward cargo temperature from 40 degrees F to 80 degrees F.

Consequences of Failure

When the position of the FCAC control is missing or invalid, the right CTC sends a signal to the Displays and Crew Alerting (DCA) application in the Common Core System, and the CARGO A/C SELECT FWD Status message is displayed and the CARGO A/C FAULT FWD Advisory message will be displayed.

Both the forward cargo zone trim air modulation valve and FCAC flow regulating valve (FRV) are required to be either verified closed or deactivated closed. If both valves are not deactivated, the right CTC will default to on and control FCAC to 60 F and will not be able to shut off.

Because FCAC must be selected off for dispatch, lower forward cargo air conditioning is not available and temperature sensitive cargo such as perishable goods should not be carried in the lower forward cargo compartment. The FCAC will not control to a default temperature when selected OFF. The zone temperature will be controlled by the cargo heating system (no air conditioning is available).

Consequences of Next Critical Failure

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

21-61-05 FCAC Compartment Temperature Sensing System

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- FCAC Zone Trim Air Modulation Valve is deactivated closed,
- FCAC Flow Regulating Valve is deactivated closed, and
- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-61-06.

The forward cargo air conditioning (FCAC) system, an optional system, provides conditioned air from the mix manifold to the cargo compartment. Trim air from the right trim air system is mixed with cool air from the mix manifold to achieve the desired compartment temperature. Two temperature sensors are installed in the forward cargo compartment, one forward in the compartment and one aft in the compartment. These sensors provide temperature feedback to the right CTC, which compares the actual compartment temperature to the required compartment temperature to achieve the desired compartment temperature by modulating the trim modulation valve and adjusting pack temperature demand. Only one operational temperature sensor is required for the FCAC system to operate, however, temperature may vary in the compartment fore and aft depending upon which sensor is inoperative.

Consequences of Failure

When both temperature sensors are inoperative, the CARGO TEMP SNRS FWD status message and the CARGO A/C FAULT FWD Advisory message are displayed and the system must be selected off for dispatch.

Both the forward cargo zone trim air modulation valve and FCAC flow regulating valve (FRV) are required to be either verified closed or deactivated closed. If only the trim valve modulation valve is closed, pack air could still flow past an open flow regulating valve. If only the flow regulating valve is closed, trim air could back pressure into the mix manifold past an open trim modulating valve.

Because FCAC must be selected off for dispatch, lower forward cargo air conditioning is not available and temperature sensitive cargo such as perishable goods should not be carried in the lower forward cargo compartment. The FCAC will not control to a default temperature when selected OFF. The zone temperature will be controlled by the cargo heating system (no air conditioning is available).

Consequences of Next Critical Failure

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

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21-61-06 FCAC Duct Temperature Sensing System

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- FCAC Zone Trim Air Modulation Valve is deactivated closed,
- FCAC Flow Regulating Valve is deactivated closed, and
- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-61-05-01.

The forward cargo air conditioning (FCAC) system, an optional system, provides conditioned air from the mix manifold to the cargo compartment. Trim air from the right trim air system is mixed with cool air from the mix manifold to achieve the desired compartment temperature. Two temperature sensors are installed in the FCAC duct between the mix manifold and the flow regulating valve (FRV). These sensors provide temperature feedback to the right CTC, which compares the actual duct temperature to the required duct temperature to achieve the desired compartment temperature by modulating the trim modulation valve. Only one operational temperature sensor is required for the FCAC system to operate normally.

Consequences of Failure

When both temperature sensors are inoperative, the CARGO DUCT SNRS FWD status message and the CARGO A/C FAULT FWD Advisory message are set and the system must be selected off for dispatch. Both the forward cargo zone trim air modulation valve and FCAC flow regulating valve (FRV) are required to be either verified closed or deactivated closed. If only the trim valve modulation valve is closed, pack air could still flow past an open flow regulating valve. If only the flow regulating valve is closed, trim air could back pressure into the mix manifold past an open trim modulating valve.

Because FCAC must be selected off for dispatch, lower forward cargo air conditioning is not available and temperature sensitive cargo such as perishable goods should not be carried in the lower forward cargo compartment. The FCAC will not control to a default temperature when selected OFF. The zone temperature will be controlled by the cargo heating system (no air conditioning is available).

Consequences of Next Critical Failure

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

21-62-01 Trim Air Control Systems**21-62-01A**

Interval	Installed	Required	Procedure
A	2	1	(O)

One may be inoperative provided:

- Associated TRIM AIR switch remains off,
- For associated Ram Air Inlet Door inoperative, associated Air Conditioning Pack is not used,
- For associated Ram Air Exhaust Door inoperative, associated Air Conditioning Pack is not used, and
- Repairs are made within 10 flight-days.

[For FCAC installed:](#)

- For right TRIM AIR switch selected off, FWD CARGO A/C selector remains OFF.

NOTE: For Ram Air Inlet Door inoperative, associated Inlet Door must either be closed or cover plate installed.

21-62-01 Trim Air Control Systems**21-62-01B**

Interval	Installed	Required	Procedure
A	2	0	(O)

May be inoperative provided:

- Both TRIM AIR switches remain off,
- Both Air Conditioning Packs operate normally, and
- Repairs are made within 10 flight-days.

[For FCAC installed:](#)

- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-62-01-01.

The Trim Air Control System adjusts, monitors, and distributes trim air supply pressure to the Trim Air Modulating Valve (TAMV)s. The Cabin Temperature Controllers (CTC) control and monitor the operation of this part of the air conditioning system. The left and right CTCs control the respective left and right Trim Air Pressure Regulating and Shutoff Valves (PRSOV) to control the trim air supply pressure.

The trim air switches enable trim air operation when they are set to ON. The switches turn off the trim system when they are in the out position.

The left system is controlled by the left CTC and provides trim air for the Flight Deck, and Cabin Zones A, C, and E. The right system is controlled by the right CTC and provides trim air for Cabin Zones B, D, and F, and (if FCAC is installed) the forward cargo compartment.

Consequences of Failure

The TRIM AIR L Status message will be displayed when the CTC detects a loss of the left cabin temperature control system. The associated TRIM AIR FAULT L Advisory message will also be displayed.

The TRIM AIR R Status message will be displayed when the CTC detects a loss of the right cabin temperature control system. The associated TRIM AIR FAULT R Advisory message will also be displayed.

Trim air will not be available for the associated zones.

For operation with Trim Air switch selected OFF, the associated zone temperatures will be controlled by the associated air conditioning pack. For an air conditioning pack to provide adequate temperature control, the associated Ram Air Inlet Door and Ram Air Exhaust Door must operate normally. Pack output temperature control and trim control of neighboring zones (if trim is enabled for those zones) provide the only means of varying the affected cabin zone temperature(s).

For both Trim Air switches selected OFF, both packs must operate normally. Pack output temperature control provides the only means of varying the affected cabin zone temperature(s). For right trim air control inoperative, FCAC must remain off.

Consequences of Next Critical Failure

For Trim Air Switch selected OFF:

Failure of the associated pack will result in cold cabin or flight deck temperature. Failure of the associated pack resulting in cold temperature without pack shutdown capability will result in excessively cold temperature to the cabin or flight deck. Excessively cold supply air to cabin or flight deck and inability to shut off the cooling source is classified as 'Catastrophic'. The probability of this hazard with the trim air selected OFF is 1.15E-08. Maximum dispatch time is 298 flight hours.

For failure of a pack resulting in loss of temperature control (hot or cold), the flight crew may apply QRH procedure to turn the associated pack off.

Failure of an air conditioning pack:

Remaining pack will provide adequate air for all zones. For left pack failure, flight deck air will be provided by the mix manifold.

For FCAC installed:

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

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777-9 Master Minimum Equipment List

Section 2

21-62-02 Trim Air Pressure Regulating/Shutoff Valves (PRSOV)

21-62-02A

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Trim Air PRSOV is locked closed,
- Associated TRIM AIR switch remains off,
- For associated Ram Air Inlet Door inoperative, associated Air Conditioning Pack is not used,
- For associated Ram Air Exhaust Door inoperative, associated Air Conditioning Pack is not used, and
- Repairs are made within 10 flight-days.

For FCAC installed:

- For right Trim Air PRSOV locked closed, FWD CARGO A/C selector remains OFF.

NOTE: For Ram Air Inlet Door inoperative, associated Inlet Door must either be closed or cover plate installed.

21-62-02 Trim Air Pressure Regulating/Shutoff Valves (PRSOV)

21-62-02B

Interval	Installed	Required	Procedure
A	2	0	(M) (O)

May be inoperative provided:

- Both Trim Air PRSOVs are locked closed,
- Both TRIM AIR switches remain off,
- Both Air Conditioning Packs operate normally, and
- Repairs are made within 10 flight-days.

For FCAC installed:

- FWD CARGO A/C selector remains OFF.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 21-62-02-01.

The Trim Air Control System adjusts, monitors, and distributes trim air supply pressure to the Trim Air Modulating Valve (TAMV)s. The Cabin Temperature Controllers (CTC) control and monitor the operation of this part of the air conditioning system. The left and right CTCs control the respective left and right Trim Air Pressure Regulating and Shutoff Valves (PRSOV) to control the trim air supply pressure.

The trim air switches enable trim air operation when they are set to ON. The switches turn off the trim system when they are in the out position.

The left system is controlled by the left CTC and provides trim air for the Flight Deck, and Cabin Zones A, C, and E. The right system is controlled by the right CTC and provides trim air for Cabin Zones B, D, and F, and (if FCAC is installed) the forward cargo compartment.

Consequences of Failure

The TRIM AIR PRSOV L Status message will be displayed when there is a failure of the left Trim Air PRSOV. The associated TRIM AIR FAULT L Advisory message will also be displayed.

The TRIM AIR PRSOV R Status message will be displayed when there is a failure of the right Trim Air PRSOV. The associated TRIM AIR FAULT R Advisory message will also be displayed.

Trim air will not be available for the associated zones.

For operation with PRSOV locked closed, the associated zone temperatures will be controlled by the associated air conditioning pack. For an air conditioning pack to provide adequate temperature control, the associated Ram Air Inlet Door and Ram Air Exhaust Door must operate normally. Pack output temperature control and trim control of neighboring zones (if trim is enabled for those zones) provide the only means of varying the affected cabin zone temperature(s).

For both PRSOVs locked closed, both packs must operate normally. Pack output temperature control provides the only means of varying the affected cabin zone temperature(s). For dispatch, the associated trim air switch must remain off. For right trim air control inoperative, FCAC must remain off.

Consequences of Next Critical Failure

For Trim Air Switch selected OFF:

Failure of the associated pack will result in cold cabin or flight deck temperature. Failure of the associated pack resulting in cold temperature without pack shutdown capability will result in excessively cold temperature to the cabin or flight deck. Excessively cold supply air to cabin or flight deck and inability to shut off the cooling source is classified as 'Catastrophic'. The probability of this hazard with the trim air selected OFF is $1.15E-08$. Maximum dispatch time is 298 flight hours.

For failure of a pack resulting in loss of temperature control (hot or cold), the flight crew may apply QRH procedure to turn the associated pack off.

Failure of an air conditioning pack:

Remaining pack will provide adequate air for all zones. For left pack failure, flight deck air will be provided by the mix manifold.

For FCAC installed:

Lower forward cargo compartment fire: The fire protection integrity of the lower forward cargo compartment is maintained as the FCAC FRV is deactivated closed.

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21-62-03 TRIM AIR Switch Lights**21-62-03-01 FAULT Lights**

Interval	Installed	Required	Procedure
C	2	0	

21-62-03 TRIM AIR Switch Lights**21-62-03-02 ON Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 21-62-03-01.

Both trim air control switches have an ON light. ON means that the command to the associated master trim air valve is to open and its associated zone trim air valves to open are controlled automatically. When ON is not visible, the command to associated master trim air valve is to close. The light is not dependent on the valve position.

Both trim air system control switches have a FAULT light to indicate when the associated trim system PRSOV is shut off automatically, or by the flight crew. An associated TRIM AIR FAULT L, R Advisory message is displayed if trim air is shutdown automatically or manually.

Consequences of Failure

ON Light: The position of the switch can be easily discerned by being flush with the surrounding panel.

FAULT Light: Trim air fault condition will not be annunciated in the associated pushbutton switch however the associated message operates normally.

Consequences of Next Critical Failure

ON Light: None.

FAULT Light: Failure of the associated trim air system: Trim air system failure will be annunciated on EICAS and the appropriate non-normal procedure can be performed without the trim air FAULT light indication.

21-71-01 Flight Deck Humidification System

21-71-01A

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. Flight deck humidifier shutoff valve is verified closed, and
- b. HUMID switch remains off.

21-71-01 Flight Deck Humidification System

21-71-01B

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. Flight deck humidifier shutoff valve is deactivated closed, and
- b. HUMID switch remains off.

21-71-01 Flight Deck Humidification System

21-71-01-01 HUMID Switch ON Light

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 21-71-01.

An optional flight deck humidifier is available to be installed in the main flight deck supply line. The humidifier consists of a humidifier pad, a water shut-off valve, a water pulse valve, and a water level sensor and is controlled by the Humidifier Control Unit (HCU). The flight deck humidification system is a nonessential system and is not required to safely dispatch the airplane. It provides supplemental humidity to the flight deck to improve crew comfort. Water from the potable water supply is evaporated through a wetted pad into the air stream. The humidifier is automatically activated during cruise and switched off at the start of descent. In addition, the humidifier is controllable from the cockpit HUMID switch located on the optional section of the CARGO TEMP overhead panel.

Faults are annunciated by CMCF message only.

Consequences of Failure

Supplemental humidity is not available to the flight deck.

ON Light: The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

None identified. System is optional.

ON Light: None

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Section 2

21-71-02 Overhead Flightcrew Rest (OFCR) Humidification System

21-71-02A

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- OFCR humidifier shutoff valve is verified closed, and
- Cabin attendant panel HUMIDIFIER CONTROL OFCR soft key is OFF.

21-71-02 Overhead Flightcrew Rest (OFCR) Humidification System

21-71-02B

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- OFCR humidifier shutoff valve is deactivated closed, and
- Cabin attendant panel HUMIDIFIER CONTROL OFCR soft key is OFF.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 21-71-02.

An optional overhead flight crew rest humidifier is available to be installed in the main flight deck supply line. The humidifier consists of a humidifier pad, a water shut-off valve, a water pulse valve, and a water level sensor and is controlled by the Humidifier Control Unit (HCU). The overhead flight crew rest humidification systems is nonessential and optional. It is not required to safely dispatch the airplane. It provides supplemental humidity to the overhead flight crew rest compartment to improve crew comfort. Water from the potable water supply is evaporated through a wetted pad into the air stream from the flight deck distribution duct entering the crew rest.

The humidifier is automatically activated during cruise and switched off at the start of descent. In addition, the humidifier is controllable from the cockpit HUMID switch located on the optional section of the CARGO TEMP overhead panel.

The humidifier control unit (HCU) automatically controls the humidification system by regulating the water supply. The system can be controlled by the cabin attendant panel.

Faults are annunciated by CMCF message only.

Consequences of Failure

Supplemental humidity is not available to the OFCR.

Consequences of Next Critical Failure

None identified. System is optional.

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Section 2

21-71-03 Overhead Flight Attendant Rest (OFAR) Humidification System

21-71-03A

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- OFAR humidifier shutoff valve is verified closed, and
- Cabin attendant panel HUMIDIFIER CONTROL OFAR soft key is OFF.

21-71-03 Overhead Flight Attendant Rest (OFAR) Humidification System

21-71-03B

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- OFAR humidifier shutoff valve is deactivated closed, and
- Cabin attendant panel HUMIDIFIER CONTROL OFAR soft key is OFF.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 21-71-02.

An optional overhead flight attendant rest humidifier is available to be installed in the main flight deck supply line. The humidifier consists of a humidifier pad, a water shut-off valve, a water pulse valve, and a water level sensor and is controlled by the Humidifier Control Unit (HCU). The overhead flight attendant rest humidification systems is nonessential and optional. It is not required to safely dispatch the airplane. It provides supplemental humidity to the overhead flight attendant rest compartment to improve crew comfort. Water from the potable water supply is evaporated through a wetted pad into the air stream from the flight deck distribution duct entering the crew rest.

The humidifier is automatically activated during cruise and switched off at the start of descent. In addition, the humidifier is controllable from the cockpit HUMID switch located on the optional section of the CARGO TEMP overhead panel.

The humidifier control unit (HCU) automatically controls the humidification system by regulating the water supply. The system can be controlled by the cabin attendant panel.

Faults are annunciated by CMCF message only.

Consequences of Failure

Supplemental humidity is not available to the OFAR.

Consequences of Next Critical Failure

None identified. System is optional.

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Section 2

21-71-04 Passenger Cabin Premium Zone Humidification System

21-71-04-01 Zone A

21-71-04-01A

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. ZONE A humidifier shutoff valve is verified closed, and
 - b. Cabin attendant panel HUMIDIFIER CONTROL ZONE A soft key is OFF.
-

21-71-04 Passenger Cabin Premium Zone Humidification System

21-71-04-01 Zone A

21-71-04-01B

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. ZONE A humidifier shutoff valve is deactivated closed, and
 - b. Cabin attendant panel HUMIDIFIER CONTROL ZONE A soft key is OFF.
-

21-71-04 Passenger Cabin Premium Zone Humidification System

21-71-04-02 Zone B

21-71-04-02A

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- a. ZONE B humidifier shutoff valve is verified closed, and
 - b. Cabin attendant panel HUMIDIFIER CONTROL ZONE B soft key is OFF.
-

21-71-04 Passenger Cabin Premium Zone Humidification System

21-71-04-02 Zone B**21-71-04-02B**

Interval	Installed	Required	Procedure
D	1	0	(M) (O)

May be inoperative provided:

- ZONE B humidifier shutoff valve is deactivated closed, and
- Cabin attendant panel HUMIDIFIER CONTROL ZONE B soft key is OFF.

SUBSTANTIATION**Background**

New proposal for 777X.

An optional passenger cabin humidifier is available to be installed in the main flight deck supply line. The humidifier consists of a humidifier pad, a water shut-off valve, a water pulse valve, and a water level sensor and is controlled by the Humidifier Control Unit (HCU). The passenger cabin humidification systems is nonessential and optional. It is not required to safely dispatch the airplane. It provides supplemental humidity to the passenger cabin to improve passenger comfort. Water from the potable water supply is evaporated through a wetted pad into the air stream from the flight deck distribution duct entering the crew rest.

The humidifier is automatically activated during cruise and switched off at the start of descent. In addition, the humidifier is controllable from the cockpit HUMID switch located on the optional section of the CARGO TEMP overhead panel.

The humidifier control unit (HCU) automatically controls the humidification system by regulating the water supply. The system can be controlled by the cabin attendant panel.

Faults are annunciated by CMCF message only.

Consequences of Failure

Supplemental humidity is not available to the affected cabin zones.

Consequences of Next Critical Failure

None identified. System is optional.

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Section 2

21-73-01 Ozone Converters

Interval	Installed	Required	Procedure
C	2	0	

As required by 14 CFR.

21-73-01 Ozone Converters

21-73-01-01 VOC/Ozone Converters

Interval	Installed	Required	Procedure
C	2	0	

As required by 14 CFR.

SUBSTANTIATION

Background

Proposal based on 777 FAA MMEL item 21-73-01.

Both packs have an ozone converter that is used only at altitudes above 25,000 feet. Pneumatic system air is routed through the converters before it enters each pack. The converters decompose ozone that may be present in the airflow. Cabin ozone concentration must be controlled per FAR 121.578. Techniques for analyzing and controlling cabin ozone concentration are provided in FAA AC 120-38 and in Boeing document D6-49779. Since the converters are not a fault monitored system and there is no other readily discernible effect, an inoperative converter can only be determined in the following manner:

Dispatch with an inoperative lower pack lower flow control valve per MMEL item 21-51-02.

Expiration of the time change requirement for the ozone converter.

For 777X, an optional VOC/Ozone (Volatile Organic Compound) converter is offered. The VOC converter provides purification of cabin supply air to reduce the concentration of VOC that might be pulled into the cabin, e.g. fumes during engine start. The VOC converter function is controlled via the EXTERNAL AIR FILTER switch on the P5 overhead panel. The AUTO position allows for automatic operation under the same conditions that ozone conversion occurs (in air above 25000 ft). The ON position allows for the system to be manually activated in other conditions, typically during ground operations (e.g. engine start), at flight crew discretion. There is no regulatory requirement for the VOC function, and it is not a monitored system. In addition to the VOC converter function, the VOC/Ozone converter provides all the functions that the baseline ozone converter does.

Consequences of Failure

For Ozone Converter inoperative, the associated pack is incapable of removing ozone from air supplied to the cabin. Airplane may be dispatched at a lower altitude and/or a routing at a lower latitude.

A Retention factor of 0.70 should be used for the 777X.

For airplanes equipped with the combination VOC/Ozone Converter: In addition to not removing ozone, the converter will not perform VOC reductions for the associated pack.

Operators may refer to 14 CFR 121.578 for guidance when operating with a VOC/Ozone Converter inoperative.

Consequences of Next Critical Failure

None.

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22-11-01 Autoflight Interface

22-11-02 Autopilot Backdrive Actuator Systems

22-11-02A

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22-11-03 Flight Director Display Function

22-11-04 Mode Control Panel Windows

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22-11-05 Mode Control Panel Selectors

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22-11-06 Mode Control Panel Switches

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22-11-01 Autoflight Interface

Interval	Installed	Required	Procedure
C	1	0	(M)

May be dispatched with AUTOFLIGHT INTERFACE Status message displayed provided A/P DISENGAGE bar is verified to operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-01.

The autoflight function (AFF) provides the functions necessary for automatic airplane control and/or flight director guidance. The autopilot controls airplane heading, track, speed, altitude, navigation paths, and go-around. The flight director provides guidance commands for each of those functions plus guidance commands for takeoff.

The AFF consists of the autopilot and flight director functions. It operates through the following components: one mode control panel (MCP), four integrated flight control electronics (IFCE) cabinets, one column backdrive actuator, one wheel backdrive actuator, and two pedal backdrive actuators.

The AFF also includes the following flight deck controls: two wheel-mounted autopilot disconnect switches, two throttle-mounted TO/GA switches.

The three flight control modules (FCMs) within the IFCE cabinets provide the AFF computational platform for the autopilot, flight director, and backdrive functions. Flight director guidance is displayed on the PFD and HUD for directed manual control of airplane attitude and flight path. Automatic control commands generated by the autopilot function are supplied to the primary flight control function (PFCF) to control flight control surfaces. Utilizing the backdrive actuators, the backdrive function moves the column, wheel, and pedals while the autopilot is engaged, thus providing visual and tactile indications of expected airplane response to the automatic control. See proposed 777X MMEL item 27-02-02 for additional FCM system description.

Consequences of Failure

The AUTOFLIGHT INTERFACE Status message annunciates faults which affect autoflight redundancy but not function. The AUTOFLIGHT INTERFACE Status message may also be displayed for a detected failure of one or more MCP pushbuttons.

These faults include:

- Single MCP lane failure
- Single MCP disengage bar switch failure
- MCP interface degradation
- FCM Option Selection miscompare detected
- Radio altimeter test Inhibit fault (either radio altimeter not test inhibited)

NOTE: These faults affect autoflight system redundancy but do not affect autopilot operation nor autoland status.

Consequences of Next Critical Failure

Subsequent autoflight faults generally result in a NO LAND 3 condition.

Second MCP lane failure: the autopilot would issue a mode failure if the autopilot was engaged at the time, and the pilot would disengage the autopilot once it was obvious (blank windows, no response) that the MCP had failed. Once the autopilot has been disengaged, the pilot would not be able to re-engage the autopilot.

Draft
Feb 26, 2026

22-11-02 Autopilot Backdrive Actuator Systems**22-11-02A**

Interval	Installed	Required	Procedure
C	4	3	(M)

One may be inoperative provided:

- Inoperative Autopilot Backdrive Actuator is deactivated,
- Autopilot disconnect warning indications are verified to operate normally before each departure, and
- For wheel Autopilot Backdrive Actuator inoperative, Bank Angle Protection is considered inoperative.

22-11-02 Autopilot Backdrive Actuator Systems**22-11-02B**

Interval	Installed	Required	Procedure
B	4	0	(M) (O)

May be inoperative provided:

- Inoperative Autopilot Backdrive Actuator(s) is deactivated,
- Autopilot disconnect warning indications are verified to operate normally before each departure,
- For wheel Autopilot Backdrive Actuator inoperative, Bank Angle Protection is considered inoperative, and
- For both Autopilot Pedal Backdrives inoperative, approach minimums do not require their use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-02.

The backdrive function of the integrated flight control electronics (IFCE) autoflight function (AFF) provides flight deck indication of autopilot activity by producing corresponding movement of the column, wheel, and pedals during autoflight control. There is no regulatory requirement for autopilot backdrive.

There is 1 backdrive actuator for each of the pitch and roll axes and 2 backdrive actuators for the yaw axis. When the autopilot is engaged, the autopilot commands are calculated in the IFCE by the AFF partition, sent to the primary flight control function (PFCF) to calculate backdrive commands, and then output to the actuator control electronics (ACE) via point to point buses. The ACE generates analog commands to drive the servos. The backdrive commands are returned to the PFCF via the ACE for monitoring.

Consequences of Failure

An inoperative column backdrive actuator is indicated by the A/P BACKDRIVE COLUMN Status message and NO BACKDRIVE COLUMN Advisory message.

An inoperative wheel backdrive actuator is indicated by the A/P BACKDRIVE WHEEL Status message and NO BACKDRIVE WHEEL Advisory message.

An inoperative pedal backdrive actuator is indicated by the associated A/P BACKDRIVE PEDAL L, R Status message. Failure of both left and right pedal backdrive actuators will result in display of the NO BACKDRIVE PEDAL Advisory message.

For a single failure, the column or wheel is not backdriven. Pedals are backdriven unless both pedal backdrive units are inoperative. Loss of both pedal backdrive units is a NO LAND 3 condition. AFF remains fully functional. To ensure crew awareness of inadvertent autopilot override/disconnect, verification of autopilot disconnect indication is required prior to each departure. The proposed MMEL requires deactivation of the inoperative backdrive system(s) to prevent transmission of erroneous backdrive signals.

Consequences of Next Critical Failure

Failure of additional backdrive system: Affected controller axes not backdrive. AFF remains fully functional.

Inadvertent autopilot override: AUTOPILOT DISC Warning message is displayed to alert crew.

In the unlikely event that the Primary Flight Control Function (PFCF) switches to secondary mode, the Autopilot Backdrive Function will be inoperative.

22-11-03 Flight Director Display Function

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided procedures do not require their use.

NOTE: Flight Director Displays are the steering bars/indications that are displayed on the Primary Flight Display (PFD).

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-03.

The integrated flight control electronics (IFCE) autoflight function (AFF) provides the functions necessary for flight director (F/D) guidance. Information generated by the AFF function can be displayed on each pilot's primary flight display (PFD) and HUD (if installed) for manual control guidance of airplane. There are two F/D switches located on the MCP. When a F/D switch is selected on (F/D ON), the PFD of the side selected will display F/D guidance and the associated pitch and roll modes will be annunciated on both PFDs.

Loss of F/D function due to AFF or IFCE fault is highly unlikely. This item allows dispatch if F/D display(s) become inoperative due to other faults such as F/D switches (ref proposed MMEL item 22-11-06-04).

Consequences of Failure

Flight director display information is not available on one or both PFDs. MMEL precludes approaches or operations which would require F/D use.

Consequences of Next Critical Failure

None.

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22-11-04 Mode Control Panel Windows

22-11-04-01 Airspeed (IAS-MACH)

Interval	Installed	Required	Procedure
C	1	0	

22-11-04 Mode Control Panel Windows

22-11-04-02 Heading (HDG-TRK)

Interval	Installed	Required	Procedure
C	1	0	

22-11-04 Mode Control Panel Windows

22-11-04-03 Vertical Speed (V/S-FPA)

Interval	Installed	Required	Procedure
C	1	0	

22-11-04 Mode Control Panel Windows

22-11-04-04 Altitude (ALTITUDE)

Interval	Installed	Required	Procedure
C	1	0	

22-11-04 Mode Control Panel Windows

22-11-04-05 All Windows

Interval	Installed	Required	Procedure
B	1	0	

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 22-11-04.

The mode control panel (MCP) located on the glareshield is the primary interface between the pilots and the autopilot, flight director, and autothrottle. It provides the means to engage autoflight functions, select autoflight modes, and establish flight path targets and reference values. This MMEL item allows dispatch with inoperative MCP windows. There are 4 windows on the MCP to display the selected airspeed or Mach (IAS-MACH), heading or track (HDG-TRK), vertical speed or flight path angle (V/S-FPA), and altitude (ALTITUDE). Each of these selected parameters is also displayed on both primary flight displays (PFDs).

For PFCF Secondary Mode Autopilot, only the basic autopilot cruise modes of Vertical Speed/Flight Path Angle, Heading/Track Hold and Heading/Track Select are supported.

Consequences of Failure

Primary window(s) or lighting inoperative:

The selected parameter(s) is not displayed in the associated window(s). Flight crew can use the PFD indications to select or verify the associated parameter(s). If the window lighting fails, all 4 windows will be unreadable but selected parameters must be available on both PFDs. Since this may affect crew operation of the AFF more than any single window failure, a repair interval of 3 days is proposed for window lighting inoperative.

Consequences of Next Critical Failure

A subsequent failure resulting in the MCP generating erroneous target values used by AFF, Displays, TMF, FME, and Crew alerting would be undetected by the crew via the MCP displays. Crew may detect automatic control inconsistencies via airplane response or by observing PFD target changes and disengage the autopilot.

Considering the 10 day (or 3 day) repair interval required, it is unlikely that there would be a buildup of multiple dissimilar failures on the MCP that would significantly impact crew workload.

Federal Aviation Administration (FAA)**ATA 22****777-9 Master Minimum Equipment List****Section 2****22-11-05 Mode Control Panel Selectors****22-11-05-01 V/S - FPA Selector (DOWN, UP)**

Interval	Installed	Required	Procedure
C	1	0	

22-11-05 Mode Control Panel Selectors**22-11-05-02 BANK LIMIT Selector (AUTO, 10, 15, 20, 25, 30)**

Interval	Installed	Required	Procedure
C	1	0	

22-11-05 Mode Control Panel Selectors**22-11-05-03 Altitude Increment Selector (AUTO, 1000)**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided AUTO position is verified to operate normally.

22-11-05 Mode Control Panel Selectors**22-11-05-04 Selector Push Functions****22-11-05-04-01 IAS - MACH**

Interval	Installed	Required	Procedure
C	1	0	

22-11-05 Mode Control Panel Selectors**22-11-05-04 Selector Push Functions****22-11-05-04-02 HDG - TRK SEL**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided both Multifunction Keypads (MFK) operate normally.

22-11-05 Mode Control Panel Selectors**22-11-05-04 Selector Push Functions****22-11-05-04-03 ALTITUDE**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-05.

The mode control panel (MCP) located on the glareshield is the primary interface between the pilots and the autopilot, flight director, and autothrottle. It provides the means to engage autoflight functions, select autoflight modes, and establish flight path targets and reference values. This MMEL item allows dispatch with inoperative MCP selectors. There are 6 selectors on the MCP: airspeed (IAS-MACH), heading/track (HDG-TRK), bank angle limit (BANK LIMIT), vertical speed/flight path angle (V/S-FPA), altitude, and altitude increment (AUTO, 1000). Three of these selectors include a built-in push function in addition to the rotary selection function. The rotary functions of these selectors (IAS-MACH, HDG-TRK, and ALTITUDE) are not covered in the MMEL and must operate normally.

For PFCF Secondary Mode Autopilot, only the basic autopilot cruise modes of Vertical Speed/Flight Path Angle, Heading/Track Hold and Heading/Track Select are supported.

BANK LIMIT selector includes bank angle limits of 10, 15, 20, 25, 30, and AUTO. With AUTO selected, the bank angle is limited to 25 degrees and decreases to 15 degrees for high speeds. These limits apply to the Heading/Track Select, Heading/Track Hold, and Takeoff Roll Modes.

Below 75 ft AGL, there is an 8-deg bank angle limit for Takeoff, Go-Around pitch, Localizer, and Backcourse autopilot modes. Between 75 ft and 200 ft AGL this bank angle limit varies from 8 deg to 30 deg.

The Go-Around autopilot roll mode has an 8-deg bank angle limit below 75 ft AGL. From 75 ft to 200 ft AGL, this bank angle limit increases from 8 deg to 30 deg. Above 200 ft AGL, the Go-Around autopilot roll mode has a 30-deg bank angle limit.

The bank angle is limited in heading/track select to the selected bank angle limit. The AUTO setting gives a limit that is based on true airspeed. Also, regardless of BANK LIMIT selection, below 75 ft AGL an 8-deg bank angle limit is applied and from 75 ft to 200 ft AGL the bank angle limit varies from 8 deg to 30 deg. The F/D has an 8-deg bank angle limit below 200 ft AGL. The annunciation HDG SEL or TRK SEL appears in the roll active window on the PFD. In addition, bank angle is limited between 15 deg and 25 deg for speeds below $V_2 + 90$ knots following a takeoff during which an engine out is experienced before flap retraction or before air speed reaches $V_2 + 90$ knots.

The logic that controls bank angle limiting is the same regardless of whether the Flight Control Modules (FCMs) are in secondary mode or normal mode, so the same limits will apply when doing a heading/track turn in secondary mode. One caveat is that Autopilot is inhibited below 800 ft while in secondary mode so the below 200 ft gear altitude bank angle limit will not be active.

Consequences of Failure

1. V/S - FPA selector inoperative: Selected vertical speed and flight path angle cannot be changed. Autopilot operation in V/S or FPA pitch mode is limited to the displayed value or may be inoperative.
2. BANK LIMIT Selector inoperative: The bank angle limit cannot be selected or changed for autopilot Heading Select or Track Select roll mode operation. BANK LIMIT will remain in the default position that was last selected when the selector failed. If failed in AUTO position, all AUTO functions will operate normally. If failed in another BANK LIMIT position, bank angle limit will be based on that position except where overridden by automatic bank angle limits.
3. Altitude increment selector inoperative: The selected altitude cannot be changed by 1000 foot increments.
4. IAS-MACH selector push function inoperative: Airspeed intervention in VNAV is unavailable from the MCP. Selected airspeed or Mach number cannot be blanked or unblanked by pressing selector.
5. HDG-TRK selector push function inoperative: Autopilot HDG SEL and TRK SEL roll modes cannot be selected on.
MFK MMEL requires HDG-TRK SEL switch to operate normally. Therefore, both MFKs must operate normally.
6. Altitude selector push function inoperative: Altitude intervention in VNAV is unavailable from the MCP.

Consequences of Next Critical Failure

No additional MCP failures are considered since the failure consequences of each function are generally unrelated. Considering the 10 day repair interval required, it is unlikely that there would be a buildup of multiple dissimilar failures on the MCP that would significantly impact crew workload.

22-11-06 Mode Control Panel Switches**22-11-06-01 A/P Engage Switches****22-11-06-01A**

Interval	Installed	Required	Procedure
C	2	1	

22-11-06 Mode Control Panel Switches**22-11-06-01 A/P Engage Switches****22-11-06-01B**

Interval	Installed	Required	Procedure
B	2	0	

May be inoperative provided:

- Autopilot is not used,
- Approach minimums do not require use of autopilot,
- Number of flight segments and segment duration is acceptable to flightcrew, and
- Operations do not require use of autopilot.

22-11-06 Mode Control Panel Switches**22-11-06-02 Autothrottle Arm Switches (A/T ARM L, R)****22-11-06-02A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Autothrottle Servo Motor is deactivated,
- EEC Normal Mode operates normally on both EECs,
- Both thrust levers are manually set for takeoff and go-around thrust, and
- Approach minimums do not require autothrottle use.

Federal Aviation Administration (FAA)**ATA 22****777-9 Master Minimum Equipment List****Section 2****22-11-06 Mode Control Panel Switches****22-11-06-02 Autothrottle Arm Switches (A/T ARM L, R)****22-11-06-02B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Autothrottle Servo Motors are deactivated,
 - EEC Normal Mode operates normally on both EECs,
 - Approach minimums do not require autothrottle use, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

22-11-06 Mode Control Panel Switches**22-11-06-03 A/T Engage Switch****22-11-06-03A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- EEC Normal Mode operates normally on both EECs,
 - Approach minimums do not require autothrottle use, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

NOTE: Any autothrottle mode which operates normally may be used.

22-11-06 Mode Control Panel Switches**22-11-06-03 A/T Engage Switch****22-11-06-03B**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- EEC Normal Mode operates normally on both EECs,
 - Both A/T ARM switches are OFF,
 - Approach minimums do not require autothrottle use, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

22-11-06 Mode Control Panel Switches**22-11-06-04 F/D Switches**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided procedures do not require Flight Director use.

22-11-06 Mode Control Panel Switches**22-11-06-05 IAS - MACH Reference Switch**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided IAS is displayed in associated window.

22-11-06 Mode Control Panel Switches**22-11-06-06 HDG - TRK Reference Switch**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided HDG is displayed in associated window.

22-11-06 Mode Control Panel Switches**22-11-06-07 V/S - FPA Reference Switch**

Interval	Installed	Required	Procedure
C	1	0	

22-11-06 Mode Control Panel Switches**22-11-06-08 APP Switch**

Interval	Installed	Required	Procedure
C	1	0	

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May be inoperative provided approach minimums do not require use of autopilot or Flight Director.

22-11-06 Mode Control Panel Switches

22-11-06-09 CLB CON, LNAV, VNAV, FLCH, VS/FPA, Heading/Track HOLD, Altitude HOLD, and LOC/FAC Switches

Interval	Installed	Required	Procedure
C	8	0	

May be inoperative provided operations do not require their use.

22-11-06 Mode Control Panel Switches

22-11-06-10 Arm/Engage Lights

Interval	Installed	Required	Procedure
C	11	0	

May be inoperative provided the associated mode indications on both PFDs operate normally.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 22-11-06.

The mode control panel (MCP) located on the glareshield is the primary interface between the pilots and the autopilot, flight director, and autothrottle. It provides the means to engage autoflight functions, select autoflight modes, and establish flight path targets and reference values. This MMEL item allows dispatch with inoperative MCP switches and lights. There are 19 switches on the MCP (momentary action pushbutton or toggle type). The only switch not covered is the autopilot DISENGAGE bar which must operate normally. The integral lights provide on-switch display of engagement/arming of selected A/P, A/T, LNAV, VNAV, FLCHG, HOLD, V/S-FPA, LOC/FAC and APP functions. Each of these selected parameters is also displayed on both primary flight displays (PFDs).

Proposal is consistent with Appendix P to FAR 121 Amdt. 121-329, 2/15/2007.

For PFCF Secondary Mode Autopilot, only the basic autopilot cruise modes of Vertical Speed/Flight Path Angle, Heading/Track Hold and Heading/Track Select are supported.

Consequences of Failure

1. A/P engage switch(es) inoperative: The autopilot cannot be engaged using the affected switch. If both are inoperative, the autopilot cannot be engaged; planned flight segments and durations are subject to flight crew acceptability and routes where approach minimums do not require use of autopilot.
2. A/T arm switch(es) inoperative: The associated engine autothrottle cannot be armed.

NOTE: FAA Policy Letter 40 considerations: Autothrottle is required for ETOPS beyond 180 minutes.

3. A/T engage switch inoperative, autothrottle operative: Autothrottle will be engaged automatically using FLCH, VNAV and TOGA modes when airborne and will function normally including all mode changes. Other autothrottle modes cannot be manually engaged. Airplane cannot be operated on flights where approach minimums require use of autothrottle.
A/T engage switch inoperative, autothrottle inoperative: Autothrottle is deactivated by setting A/T ARM switches to OFF. Autothrottle is inoperative. Airplane cannot be operated on flights where approach minimums require use of autothrottle.

NOTE 1: For Auto-throttle inoperative: If folding wing tips are not extended while taxiing onto the departure runway, the WINGTIPS Position Indication on EICAS will not indicate 'In-Transit' or 'EXTENDED' and the Electronic Checklist (ECL) System will determine that the Before Takeoff Checklist is incomplete and will set the CHKL INCOMPLETE NORM Caution level alert. If the alert is disregarded and the takeoff is continued, selection of a TO/GA switch, per the normal takeoff checklist, will immediately result in the CONFIG WINGTIPS Warning message. However, if a TO/GA switch is not selected as a result of the inoperative Auto-Throttle, manually setting the thrust levers for takeoff will result in the CONFIG WINGTIPS Warning message. The 'REJECT, REJECT' Time Critical Warning alert will operate normally. Ref. FAA issue paper O-25.

NOTE 2: FAA Policy Letter 40 considerations: Autothrottle is required for ETOPS beyond 180 minutes.

4. F/D switch(es) inoperative: The flight director command bars cannot be manually activated on the associated (L or R) PFD or HUD (if installed). (Automatic display of the command bars may operate normally on both PFDs and HUDs (if installed) when a TO/GA switch is pushed. If TO/GA switch is inoperative, dispatch per 22-11-09 is required.)
5. Reference switch(es) inoperative: The associated window display and mode cannot be changed to the alternate display and mode.

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6. APP switch inoperative: The Approach mode (LOC, FAC or BCRS roll modes and G/S or G/P pitch modes) cannot be armed or engaged. Airplane cannot be operated on flights where approach minimums require use of A/P or F/D.
7. Other mode switch(es) inoperative: The associated autopilot and flight director mode(s) cannot be armed or engaged, as follows.
 - CLB CON - Climb/continuous thrust mode
 - LNAV - Lateral navigation roll mode
 - VNAV - Vertical navigation pitch mode
 - FLCH - Flight level Change pitch mode
 - VS/FPA - Vertical speed or flight path angle pitch mode
 - Heading/Track HOLD - Heading hold or track hold roll modes
 - Altitude HOLD - Altitude hold pitch mode
 - LOC/FAC - Localizer or final approach course roll modes
8. Arm/Engage lights inoperative: The selected mode indicator on the pushbutton does not illuminate when the mode is armed or engaged. Flight crew can use the PFD flight mode annunciations to verify engagement of the associated mode. Inoperative switch lights may affect crew operation of the autopilot or flight director.
9. IAS-MACH switch inoperative: ATC usually assigns a flight level within Minimum Navigation Performance Specification (MNPS) and adequate longitude spacing to allow the airplanes to fly the ECON Mach calculated by the FMC. When operating in VNAV in cruise, VNAV will call for the appropriate thrust (speed on throttle control) to maintain the ECON Mach. The only limitation for the crew is if they wanted to use MCP speed intervention to control to a constant selected Mach. The workaround for this (with the IAS window on the MCP stuck in IAS) would be to adjust the IAS target in the MCP speed window, until the airplane accelerated or decelerated to the desired Mach (indicated on the PFD below the speed tape). Alternatively, the pilot can set thrust manually to achieve the desired Mach on the Mach indicator. Some of the older airplanes without autothrottle still fly in the MNPS today.

Consequences of Next Critical Failure

No additional MCP failures are considered since the failure consequences of each function are generally unrelated. Considering the category C (or category B) repair interval required, it is unlikely that there would be a buildup of multiple dissimilar failures on the MCP that would significantly impact crew workload.

22-11-07 Automatic Landing System (Autoland)

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided approach minimums do not require its use.

22-11-07 Automatic Landing System (Autoland)**22-11-07-01 Triple Channel Autoland (LAND 3)**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided approach minimums do not require its use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-07.

The autoland system provides autoflight approach and landing capability. The system is composed of several components of other systems. At the heart of the system is the AFF in the three FCMs, engaged in the approach mode, and the common core system (CCS) autothrottle function controlling to the selected speed. Other components providing input include two ILS/GLS receivers with localizer antenna switching, two radio altimeters, the inertial reference system and air data reference system and other airplane sensors. Autoland status annunciations are provided by CCS on the PFDs and HUDs. Component failures resulting in loss of redundancy required for fail operative autoland and complete loss of autoland capability are annunciated on EICAS.

Proposal is consistent with Appendix P to FAR 121 Amdt. 121-329, 2/15/2007. The rule states that, for greater than 180 minute ETOPS, it is required to have "One-engine-inoperative auto-land capability, if flight planning is predicated on its use." 777X type design includes one engine inop autoland, but If autoland is inoperative, flight planning cannot be predicated on its use by definition, so the 180 min restriction appears meaningless. The standard "approach minimums" proviso is adequate to address flight planning both for destination and alternates.

Consequences of Failure

Failures which uniquely affect ability to conduct ILS, GLS or LPV (if installed) autoland are annunciated by the NO AUTOLAND ILS, NO AUTOLAND GLS or NO AUTOLAND LPV (if installed) Advisory messages, respectively.

Most component failures affecting the autoland system will result in messages associated with the component (for example, RADIO ALTIMETER L, ILS L, etc). In addition, component failures will result in a NO LAND 3 or NO AUTOLAND message. These messages indicate a degradation or loss of autoland capability. The operational effect is that approaches to lower weather minimums associated with the use of autoland cannot be performed. Compliance with the MMEL provisions (if any) for dispatch with the specific component failure(s) is also required.

Consequences of Next Critical Failure

Runway approach minimums on routes to be flown must be considered before dispatch with degraded or inoperative autoland capability. Consequences of subsequent failures are considered in the MMEL items for the individual component failures.

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Feb 26, 2026

22-11-08 Control Wheel Autopilot Disconnect Switches**22-11-08A**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- Autopilot is not used at 1,500 feet AGL or below, and
- Approach minimums do not require use of the autopilot.

22-11-08 Control Wheel Autopilot Disconnect Switches**22-11-08B**

Interval	Installed	Required	Procedure
B	2	0	

May be inoperative provided:

- Autopilot is not used,
- Approach minimums do not require use of the autopilot,
- Number of flight segments and segment duration is acceptable to flightcrew, and
- Operations do not require use of the autopilot.

22-11-08 Control Wheel Autopilot Disconnect Switches**22-11-08-01 Switch Circuits**

Interval	Installed	Required	Procedure
C	3	2	(M)

One circuit may be inoperative with NO LAND 3 Status/Advisory message displayed provided:

- Autopilot disconnect function is verified to operate normally on both captain's and first officer's autopilot switches, and
- Approach minimums do not require its use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-11-08.

Refer to Policy Letter 93.

Push-button switches are provided on both control wheels for quick autopilot disengagement. An alternate disengage capability is provided by the disengage bar located at the bottom edge of the MCP. Also, any force on the flight deck controls exceeding a specified limit will initiate an autopilot disconnect.

The wheel-mounted Autopilot-disconnect switches provide the primary means for disengaging the Autopilot in addition to the MCP Autopilot-disengage bar and the pilot override mechanisms (control wheel, control column, and rudder pedals). Each wheel-mounted switch assembly has three independently wired contacts. Pairs of contacts, with one contact in each wheel-switch assembly (Captain's and First Officer's), are wired in series to form a single input to the IFCEs. There are three such inputs. Each of the three inputs is brought into the IFCEs through a separate ACE. All FCMs will receive all three input states from the three ACE units. The three inputs are processed with 2-out-of-3 discrete majority voting (DMV) logic if none have been detected failed. If one input is detected failed, the remaining two inputs are used in 1-out-of-2 logic such that either input indicating a crew request for disconnect will result in AP disengagement.

The Autopilot Disconnect Switch, which is open/ground, has three normally ground disconnect contacts and one normally open warn reset contact. The switches are wired in series such that a particular contact in the Captain's switch is wired in series to the corresponding contact in the First Officer's switch. The three switch contacts are connected to FCM and last contact (warn reset contact) is connected to the RDC (Remote Data Concentrator). The Autoflight Function processes the comparison monitor and voter input triplex algorithm. Additionally, there is built-in monitoring that compares each of the triplex Autopilot wheel disconnect switch inputs with the voted switch position. A miscompare results in an autoland status downgrade. The NO LAND 3 fault message annunciation in EICAS during 2-out-of-3 logic and the NO AUTOLAND fault message annunciation in EICAS during 1-out-of-2 logic.

Consequences of Failure

NO LAND 3 message is annunciated for any detected wheel disconnect switch failure.

One inoperative: Pilot using associated control wheel cannot disengage A/P using push-button on wheel. Disengage can be accomplished by other available means.

Both inoperative: Autopilot not used.

Consequences of Next Critical Failure

One inoperative at dispatch, failure of remaining wheel disengage switch: Neither pilot can disengage A/P using wheel switch. Two means of disconnect remain available (disengage bar on MCP, or pilot override control input on wheel/column).

One inoperative at dispatch, authority-limited hardover, slowover, or amplitude-frequency-limited oscillatory autopilot pitch or roll command: Autopilot disconnect is accomplished by any of the following means: Remaining wheel disengage switch, disengage bar on MCP, pilot corrective action input on either control wheel/column. Altitude restriction on autopilot use ensures adequate terrain clearance in the event of an authority-limited hardover, slowover, or amplitude-frequency-limited oscillatory autopilot pitch command when the disengage switch is inoperative for pilot flying the approach.

A delay in crew detection and response during low altitude may result in excessive workload to recover airspeed and vertical flight path. The crew may opt to use pilot override (either control wheel, column, or one of pedals) to disconnect the autopilot and take over the manual flight operation during the approach and landing.

Two of three switch contacts inoperative (two of three switch contacts are detected as failure): The autopilot engagement is inhibited.

Both inoperative at dispatch: None

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22-11-09 Takeoff/Go-Around (TO/GA) Switches

22-11-09A

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided approach minimums do not require its use.

22-11-09 Takeoff/Go-Around (TO/GA) Switches

22-11-09B

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- EEC Normal Mode operates normally on both EECs,
- Both thrust levers are operated manually for takeoff and go-around,
- Autopilot and Flight Director are not used below 500 feet AGL or applicable approach minimums, whichever is higher,
- Approach minimums do not require its use, and
- Alternate procedures are established and used.

22-11-09 Takeoff/Go-Around (TO/GA) Switches

22-11-09-01 Switch Circuits

Interval	Installed	Required	Procedure
C	3	2	(M)

One circuit may be inoperative with NO LAND 3 Status/Advisory message displayed provided:

- Both TO/GA switches are verified to operate normally, and
- Approach minimums do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 22-11-09.

The TO/GA switches are located on the forward side of each thrust lever. Either TO/GA switch is pressed to select the pitch and roll autopilot modes and display flight director guidance for go-around. If both autothrottles are armed, the system will be engaged in THR REF mode for takeoff (on ground) or THR mode (in the air). A second push in the go-around situation engages the A/T in the THR REF mode to provide full rated go-around thrust.

Each TO/GA switch assembly has three contacts. Each contact in both switches is wired in series to provide three single inputs to the IFCEs. Each of the three inputs is brought into the IFCEs through a separate ACE. All FCMs will receive all three input states from the three ACE units. The three inputs are processed with 2-out-of-3 discrete majority voting (DMV) logic if none have been detected failed. If one input is detected failed, the remaining two inputs are used in 2-out-of-2 logic such that both inputs must indicate a crew request for TO/GA to cause the control laws to transition to the TO/GA mode.

The voted TO/GA mode request state is used for two distinct phases. When the airplane is on the ground, the Autoflight Function (AFF) responds to the TO/GA mode request by transitioning to takeoff mode and providing guidance on the Primary Flight Display (PFD). At the same time, the TO/GA mode state is also provided to the TMF via CDN for initiation of autothrottle setting take-off thrust. When the airplane is in the air and the flaps or slats are not fully retracted, the AFF responds to the TO/GA mode request by transitioning to the go-around mode and the TMF responds by providing go-around thrust. The AFF go-around mode provides both Flight Director (FD) guidance and Autopilot (AP) control for wind-shear survivability.

Proposal is consistent with Appendix P to FAR 121 Amdt. 121-329, 2/15/2007.

Consequences of Failure

TO/GA engagement cannot be accomplished by the affected TO/GA switch.

For both TO/GA switches are inoperative: Thrust must be set manually for takeoff and go-around. Flight director go-around/windshear guidance will not be available with both TO/GA switches inoperative. Aural windshear alerts will still operate normally.

The Electronic Checklist (ECL) System must operate normally.

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NOTE: For TO/GA switches inoperative: If the Folding Wing Tips are not extended while taxiing onto the departure runway, the WINGTIPS Position Indication on EICAS will not indicate 'In-Transit' or EXTENDED and the Electronic Checklist (ECL) System will determine that the Before Takeoff Checklist is incomplete and will set the CHKL INCOMPLETE NORM Caution level alert. If the alert is disregarded and the takeoff is continued, selection of a TO/GA switch, per the normal takeoff checklist, will immediately result in the CONFIG WINGTIPS Warning message. However, if the TO/GA switch is inoperative or not selected as a result of the inoperative Auto-Throttle, manually setting the thrust levers for takeoff will result in the CONFIG WINGTIPS Warning message. The 'REJECT, REJECT' Time Critical Warning alert will operate normally. Ref. FAA issue paper O-25.

For one switch contact inoperative: TO/GA switches will operate normally. However, the NO LAND 3 Advisory and Status messages will be displayed.

For two or more switch contacts inoperative: Both TO/GA switches will be inoperative. Thrust levers must be operated manually for takeoff and go-around. The NO AUTOLAND Advisory and Status messages will be displayed.

Consequences of Next Critical Failure

Failure of remaining TO/GA switch or dispatch with both switches inoperative: TO/GA cannot be engaged using either switch. If a go-around is required, manual procedures must be used. MMEL provisions restrict operation to airports where approach minimums do not require use of TO/GA switch to initiate go-around.

22-31-01 Autothrottle System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- EEC Normal Mode operates normally on both EECs,
- Approach minimums do not require its use,
- Appropriate performance adjustments are applied, and
- Flight remains within 180 minutes of landing at a suitable airport.

NOTE: Any autothrottle mode which operates normally may be used.

SUBSTANTIATION**Background**

Proposal based on 787 MEL item 22-31-01.

The thrust management function (TMF) provides automatic control of thrust via autothrottle (A/T) commands to acquire and maintain reference values of speed or thrust within prescribed airplane and engine operating limits. Autothrottle control law calculations are provided by the dual TMF applications within the common core system (CCS). The TMF provides autothrottle servo control, limited authority N1 trim outputs to the EECs, and data display on the PFD and EICAS. Each thrust lever is driven separately by individual servo motors, and each may be separately disconnected from the A/T system. The system operates with EECs in normal or reversion modes. A/T arming and mode selection is provided on the MCP and via the TOGA switches.

The dual TMFs operate in a master / hot spare environment where both maintain identical states through synchronization. The master TMF maintains control of thrust management. The spare TMF performs the same calculations as the master, but none of its data is used in active control. The spare takes over control if the master fails.

Consequences of Failure

An inoperative autothrottle function is annunciated by the AUTOTHROTTLE SYS Status message.

A/T control functions are inoperative, and thrust must be set by manual thrust lever control. EEC normal mode is required to ensure EEC N1 Max and TMF N1 Max is available. With autothrottle inoperative, the engine high efficiency cruise (HEC) function will be disabled in the EEC resulting in a fuel burn penalty.

The electronic checklist (ECL) system must operate normally.

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NOTE: For Autothrottle System inoperative: If the Folding Wing Tips are not extended while taxiing onto the departure runway, the WINGTIPS Position Indication on EICAS will not indicate 'In-Transit' or EXTENDED and the Electronic Checklist (ECL) System will determine that the Before Takeoff Checklist is incomplete and will set the CHKL INCOMPLETE NORM Caution level alert. If the alert is disregarded and the takeoff is continued, selection of a TO/GA switch, per the normal takeoff checklist, will immediately result in the CONFIG WINGTIPS Warning message. However, if the TO/GA switch is not selected as a result of the inoperative Auto-Throttle, manually setting the thrust levers for takeoff will result in the CONFIG WINGTIPS Warning message. The 'REJECT, REJECT' Time Critical Warning alert will operate normally. Ref. FAA issue paper O-25.

ETOPs is limited to 180 minutes per PL-40 and Appendix P to CFR Part 121.

Consequences of Next Critical Failure

None: Thrust levers are manually operated and MMEL provisions restrict operation to airports where approach minimums do not require autothrottle use.

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22-31-02 Autothrottle Servo Motors**22-31-02A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Autothrottle Servo Motor is deactivated,
- EEC Normal Mode operates normally on both EECs,
- Approach minimums do not require its use, and
- Both thrust levers are manually set for takeoff and go-around thrust.

22-31-02 Autothrottle Servo Motors**22-31-02B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Autothrottle Servo Motors are deactivated,
- EEC Normal Mode operates normally on both EECs,
- Approach minimums do not require use of the autothrottles, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 22-31-02.

Each thrust lever is driven separately by individual servo motors, and each may be separately disconnected from the A/T system.

Consequences of Failure

Failure of each autothrottle servo is annunciated by the associated AUTOTHROTTLE SERVO L or R Status message.

Associated thrust lever(s) cannot be controlled by the thrust management function (TMF). Thrust must be set by manual control of the associated thrust lever(s). For dispatch with one servo motor inoperative, both thrust levers must be set manually for takeoff and go-around to preclude potentially large, transient asymmetric thrust conditions.

The electronic checklist (ECL) system must operate normally.

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NOTE: For Autothrottle System inoperative: If the Folding Wing Tips are not extended while taxiing onto the departure runway, the WINGTIPS Position Indication on EICAS will not indicate 'In-Transit' or EXTENDED and the Electronic Checklist (ECL) System will determine that the Before Takeoff Checklist is incomplete and will set the CHKL INCOMPLETE NORM Caution level alert. If the alert is disregarded and the takeoff is continued, selection of a TO/GA switch, per the normal takeoff checklist, will immediately result in the CONFIG WINGTIPS Warning message. However, if the TO/GA switch is not selected as a result of the inoperative Auto-Throttle, manually setting the thrust levers for takeoff will result in the CONFIG WINGTIPS Warning message. The 'REJECT, REJECT' Time Critical Warning alert will operate normally. Ref. FAA issue paper O-25.

For one autothrottle servo motor inoperative, the 180 minute ETOPS restriction does not apply for FAA but does apply for EASA.

For both inoperative, ETOPS is limited to 180 minutes per PL-40 and Appendix P to CFR Part 121.

Consequences of Next Critical Failure

Dispatch with one servo motor inoperative:

Failure of remaining servo motor: Both thrust levers must be manually controlled.

Dispatch with both servo motors inoperative:

None identified (system is deactivated and thrust levers are set manually).

22-31-03 Autothrottle Disconnect Switches**22-31-03A**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both A/T ARM Switches operate normally.

22-31-03 Autothrottle Disconnect Switches**22-31-03B**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative and autothrottle used provided both A/T ARM Switches operate normally.

22-31-03 Autothrottle Disconnect Switches**22-31-03C**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Both A/T ARM switches operate normally,
 - EEC Normal Mode operates normally on both EECs,
 - Autothrottles are not armed,
 - Approach minimums do not require use of autothrottles, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 22-31-03.

The autothrottle disconnect switches are located on the outside of each throttle lever. A single push of either switch will cause the A/T system to disconnect, but remains armed.

Consequences of Failure

Dispatch with one switch inoperative: A/T disconnect cannot be initiated by the affected disconnect switch. Disconnect can be accomplished by the other switch.

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Dispatch with both switches inoperative: Dispatch options are available for autothrottle used and autothrottle not used. For autothrottle used, autothrottle disconnect is accomplished using the A/T ARM switches. For autothrottle not used, thrust levers are operated manually.

The electronic checklist (ECL) system must operate normally.

NOTE: For Autothrottle System inoperative: If the Folding Wing Tips are not extended while taxiing onto the departure runway, the WINGTIPS Position Indication on EICAS will not indicate 'In-Transit' or EXTENDED and the Electronic Checklist (ECL) System will determine that the Before Takeoff Checklist is incomplete and will set the CHKL INCOMPLETE NORM Caution level alert. If the alert is disregarded and the takeoff is continued, selection of a TO/GA switch, per the normal takeoff checklist, will immediately result in the CONFIG WINGTIPS Warning message. However, if the TO/GA switch is not selected as a result of the inoperative Auto-Throttle, manually setting the thrust levers for takeoff will result in the CONFIG WINGTIPS Warning message. The 'REJECT, REJECT' Time Critical Warning alert will operate normally. Ref. FAA issue paper O-25.

For both inoperative, ETOPs is limited to 180 minutes per PL-40 and Appendix P to CFR Part 121.

Consequences of Next Critical Failure

Dispatch with one switch inoperative: Failure of remaining disconnect switch: A/T disconnect cannot be accomplished using either throttle switch. Disconnect can be accomplished by selecting the A/T ARM switches to OFF.

Dispatch with both switches inoperative: No additional failures are considered since autothrottles are not armed.

23-11-01 High Frequency (HF) Communication Systems

23-11-01A

23-11-01B

23-11-01-01 HF Data Link

23-11-01-01A

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23-12-01 VHF Communications Systems

23-12-01-01 VHF Data Link

23-12-01-01A

23-12-01-01B

23-12-02 Tuning and Control Panels (TCP)

23-12-02-01 Left TCP Backup Navigation Function

23-12-02-02 Switch Lights, Key Lights, OFF Lights

23-12-02-03 Displays

23-15-01 Satellite Communication (SATCOM) Systems

23-15-01A

23-15-01B

23-15-01C

23-15-01-01 SATCOM Data Link

23-15-01-01A

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23-21-01 Selective Call Systems (SELCAL)

23-21-01A

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23-21-01-01 Channels

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23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

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23-24-02-01-01 Remote ELT Switch

23-24-02-02 ADT Trigger Unit (ATU)

*23-24-02-02A**23-24-02-02B**23-24-02-02C**23-24-02-02D***23-25-01 Low Frequency Underwater Locator Device (LF-ULD)***23-25-01A**23-25-01B***23-27-01 Communication Management System (Data Link)***23-27-01A**23-27-01B**23-27-01C*

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23-41-01-01 Nose Gear Jack

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23-41-01-02 Main Gear Jack

23-43-01 Ground Crew Call System

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23-51-01-02 First Observer's Audio Control Panel

23-51-01-03 Network Channels

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23-51-02 Flight Deck Hand Microphones

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23-51-03 Flight Deck Headsets/Headphones and Boom Microphones

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23-51-04 Microphone (MIC)/Interphone Switches

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23-93-01 Pilot's Overhead Panel Control/Communication Channels

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23-11-01 High Frequency (HF) Communication Systems

23-11-01A

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative.

23-11-01 High Frequency (HF) Communication Systems

23-11-01B

Interval	Installed	Required	Procedure
C	-	1	(O)

May be inoperative while conducting operations that require two LRCS provided:

- At least one aircraft SATVOICE system operates normally,
 - SATVOICE services are available as a LRCS over the intended route of flight,
 - The ICAO Flight Plan is updated (as required) to notify ATC of the communications equipment status of the aircraft, and
 - Alternate procedures are established and used.
-

23-11-01 High Frequency (HF) Communication Systems

23-11-01-01 HF Data Link**23-11-01-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

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Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION**Background**

FAA proposal based on 777 FAA MMEL item 23-11-01. Consistent with MMEL Policy Letter PL-106, Revision 5.

The High Frequency (HF) Communications System provides long range communications in the frequency range of 2 to 30 MHz to transmit and receive information. The HF communications system interfaces with aircraft power, the Air/Ground Relays resident in Electrical Load Management System (ELMS), Tuning and Control Panels via Remote Data Concentrators (RDCs), Communication Management Function (via RDCs), Audio Gateway Units and Central Maintenance Computing Function (via RDCs).

For 777X, one HF is basic with an option for two HF.

Consequences of Failure

High frequency communication is lost. Very High Frequency (VHF) radio and SATCOM capability remain.

The HF DATALINK FAIL Advisory message will display when both (or one, if in a 1 HF config) HF radio have failed. If the airplane is not configured with an high frequency data radio (HFDR) then the option selectable software (OSS) would be set as such, which would prevent the Advisory message from displaying. If the airplane is configured for single HFDR via OSS, and it is missing, then the message will display.

Consequences of Next Critical Failure

None identified. CFR's require that navigation and communication equipment must be appropriate for the route being flown. Where this equipment is excess or not required, it may be inoperative for an extended time.

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23-12-01 VHF Communications Systems

Interval	Installed	Required	Procedure
D	3	-	

Any in excess of those required by 14 CFR may be inoperative provided left VHF radio operates normally.

23-12-01 VHF Communications Systems

23-12-01-01 VHF Data Link

23-12-01-01A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

23-12-01 VHF Communications Systems

23-12-01-01 VHF Data Link

23-12-01-01B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 23-12-01.

Relief based on MMEL Policy Letter 95, Rev 2.

Three Very High Frequency (VHF) communications systems provide air-to-ground and air-to-air and/or data communications in the 118 to 136.975 MHz range with channel spacing at 8.33 KHz. Each VHF communication system consists of an independent VHF Voice/Data Radio (VDR). Each VDR is connected to a dedicated blade antenna located on the exterior of the fuselage.

The left VHF radio is powered by the Captain's Flight Instrument bus which is also powered by the battery bus. The right VHF radio is powered by the right main DC bus and the center VHF radio is powered by the left main DC bus.

Three Tuning and Control Panels (TCPs) provide an active/standby interface for tuning the VHF radios. The VHF pages on the TCPs are used by the flight crew to control the VHF radios. The crew can control the active (or tuned) and the standby (or pre-tuned) frequency for all three VHF radios. Additional VHF pages allow entry of additional pre-tuned, or stored, frequencies for all three radios. The COMM management function controls which radio can be used for data link communications.

The standby window displays DATA when selection of the frequency transfer switch "XFR" would reconfigure the selected radio to DATA mode. Only the center or right radios can be put in data mode as determined by the COMM management function. If a radio fails in flight or is inoperative for dispatch, "---x---" will be displayed where frequency is normally displayed in the line item of the failed radio.

Consequences of Failure

VHF communication is lost on one independent system. VHF communication is retained on remaining systems. HF radio and SATCOM, if available, can also be used for communication. Failure of a VHF communication system is indicated by the VHF RADIO FAIL C, L, R Advisory message.

The left VHF is powered by the captain's instrument bus which remains powered by the battery if all main and backup generators become inoperative and is considered an emergency bus. Since PL-95 states that relief should not be permitted for communications equipment that is powered by an emergency bus, the left VHF radio must operate normally.

If VHF Datalink capability is lost, the VHF DATALINK FAIL Advisory message will be displayed.

Consequences of Next Critical Failure

None identified. FAR's require that navigation and communication equipment must be appropriate for the route being flown. Where this equipment is in excess or not required, it may be inoperative for an extended time.

23-12-02 Tuning and Control Panels (TCP)

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided:

- Left Tuning and Control Panel operates normally,
 - Inoperative Tuning and Control Panel remains OFF,
 - Both Multifunction Keypads (MFK) operate normally, and
 - Alerting and Transponder Control Panel operates normally.
-

23-12-02 Tuning and Control Panels (TCP)**23-12-02-01 Left TCP Backup Navigation Function**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided right Flight Management Function operates normally.

23-12-02 Tuning and Control Panels (TCP)**23-12-02-02 Switch Lights, Key Lights, OFF Lights**

Interval	Installed	Required	Procedure
C	-	0	

23-12-02 Tuning and Control Panels (TCP)**23-12-02-03 Displays**

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided left Tuning and Control Panel operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 23-24-01.

Three identical Tuning and Control Panels (TCPs) are installed in the flight deck aisle stand to control all communication radios (three VHF radios, two HF radios if installed and one SATCOM). The TCPs (Center, Left, and Right) also provide the crew interface for the passenger address and cabin interphone systems, Ground Proximity Warning System (GPWS), weather radar, ATC transponder, and Traffic Alert and Collision Avoidance System (TCAS). The TCP also provides a backup navigation tuning function and display of present position if normal tuning commands from the FMC are lost to the left navigation radio system. The left TCP has a redundant dedicated ARINC 429 connection to the left VHF and navigation radios and is powered by the standby bus. Each of the 3 TCP is identical, so an inoperative TCP in a non-dispatchable position may be swapped with a TCP in a dispatchable position.

The left TCP has a dedicated ARINC 429 input from the left multi-mode receiver to receive GPS position information. This input supports a backup navigation feature which allows for single waypoint navigation via the left TCP in the extremely remote event of unrecoverable loss of all flight deck displays.

The flight crew can select the TRANSPONDER MODE function on the TCPs when the ALERT/XPDR backup mode is selected on any one of the TCPs. Selecting the ALERT/XPDR prompt on the TCP MENU page displays the ALERT/XPDR page. This page provides backup controls for the alerting and transponder control panel (ATP) and provides for MMEL dispatch if the ATP is inoperative.

Individual switches and key labels are illuminated by lights within the switch/key and/or backlighting.

Consequences of Failure

Failure of a TCP is indicated by the TCP C, TCP L, or TCP R Status message. The associated TCP FAIL C, TCP FAIL L, TCP FAIL R Advisory message will also be displayed. Radio tuning capability and display/control for other interfacing systems is lost on the affected TCP. The remaining TCPs are capable of controlling all the communication radios and flight crew communications functions. If there is a software mismatch detected between the 3 TCP's, the TCP S/W CONFIG Status message is displayed. If the mismatch is in either TCP C or TCP R, that TCP may be turned off and declared inoperative. The Status message will no longer be displayed in this case and the airplane may be dispatched. Invalid software in TCP L is not dispatchable since that TCP may not be declared inoperative. The TCP that does not match software will display SYSTEM NOT AVAILABLE on the screen.

MFK MMEL requires all TCPs to operate normally. Therefore, both MFKs must operate normally.

Loss of the left TCP backup navigation function is indicated by the TCP L BACKUP NAV Status message. The backup navigation function is not used in normal operation. While the TCP backup nav function is enabled, the TCP ALTN NAV ON Advisory message will be displayed.

Individual switch and key lighting inoperative. Displays respond to use of the switch or key by changing displays or by inserting a numerical or alphabetical character on the display screen. Isle stand and ambient lighting also serves to illuminate keys in the absence of backlighting. If the OFF switch OFF light is inoperative the light will not illuminate when the TCP is selected off, however the TCP will still turn off as intended which provides confirmation of the action.

Display inoperative: Working TCPs may be used, and PFD auxiliary data display area shows entered and active frequency.

Consequences of Next Critical Failure

One TCP inoperative at dispatch followed by failure of one of the two remaining TCPs: remaining TCP is capable of controlling all associated functions.

Left TCP Backup Navigation Function inoperative at dispatch, followed by failure of the left Common Computing Resource cabinet: right flight management (FM) function remains and performs all FM functions.

Left TCP Backup Navigation Function inoperative at dispatch, followed by loss of all flight deck displays: there is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed, and heading remain available. Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

For lights: None identified.

For displays: None identified.

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23-15-01 Satellite Communication (SATCOM) Systems

23-15-01A

Interval	Installed	Required	Procedure
D	2	1	

23-15-01 Satellite Communication (SATCOM) Systems

23-15-01B

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided:

- Alternate procedures are established and used, and
- Flight remains within 180 minutes of landing at a suitable airport.

23-15-01 Satellite Communication (SATCOM) Systems

23-15-01C

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require its use.

23-15-01 Satellite Communication (SATCOM) Systems

23-15-01-01 SATCOM Data Link**23-15-01-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

23-15-01 Satellite Communication (SATCOM) Systems

23-15-01-01 SATCOM Data Link**23-15-01-01B**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 23-15-01 and 23-15-01-02.

The Satellite communications systems provide crew air-to-ground and ground-to-air voice and data communication capability via INMARSAT satellite constellation (in geosynchronous orbit) and Iridium satellite constellation (in low earth orbit) to or from fixed ground stations with connections to existing voice and data networks. The system is utilized in conjunction with current methods for flight crew communications. Three Tuning and Control Panels (TCPs) enable the flight crew to control the SATCOM system using dedicated SAT pages. For each system, two SATCOM channels are available for SATCOM voice communications and one channel is devoted to data.

The two systems provide basically the same function with regards to flight deck communication, however, operation is mutually exclusive. For operations beyond 180 minutes from a suitable alternate airport, FAR 121.99 and 121.122 require SATCOM voice or, in polar regions, HF voice and HF data link.

NOTE: The ATC configuration will consist of a single INMARSAT system. The dual SATCOM configuration will be introduced post-ATC.

Consequences of Failure

For dual SATCOM installation:

The SATCOM SYS L Status message indicates a failure of the Iridium SATCOM system and the SATCOM SYS R Status message indicates a failure of the INMARSAT SATCOM system. Failure of both SATCOM systems will cause the SATCOM FAIL Advisory Message to be displayed. Failure of SATCOM data link capability by itself will cause the SAT DATALINK FAIL Advisory Message to be displayed. Temporary loss of SATCOM voice capability by itself will cause the SATVOICE LOST Advisory Message to be displayed.

Dual SATCOMs installed: One SATCOM system inoperative, or loss of voice or data link in one system:

Remaining system (INMARSAT or Iridium) remains available to provide SATCOM capability. Route must take availability of system into account.

Both SATCOM systems inoperative, or single SATCOM installed:

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Voice and data link communication capability via satellite is lost. Many routes will not require satellite communication capability and therefore it may be inoperative for an extended time. Single HF capability remains for long range voice and data link communication. VHF capability can be used when in-range.

For 777-9, one HF is basic with an option for two HF.

Consequences of Next Critical Failure

Dual SATCOMs installed: One SATCOM system inoperative, failure of remaining system:

HF capability remains for long range voice and data link communication.

Dual HF is available as an option.

VHF capability can be used when in-range.

Both SATCOM systems inoperative, or single SATCOM installed:

None.

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23-21-01 Selective Call Systems (SELCAL)**23-21-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

23-21-01 Selective Call Systems (SELCAL)**23-21-01B**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

23-21-01 Selective Call Systems (SELCAL)**23-21-01-01 Channels****23-21-01-01A**

Interval	Installed	Required	Procedure
C	5	0	(O)

May be inoperative provided alternate procedures are established and used.

23-21-01 Selective Call Systems (SELCAL)**23-21-01-01 Channels****23-21-01-01B**

Interval	Installed	Required	Procedure
D	5	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 23-21-01.

Relief based on MMEL Policy Letter 117, Rev 0.

The SELCAL (Selective Call) function serves as a ground-to-aircraft paging function or pager which alerts the flight crew to an incoming voice message designated for that specific airplane. The SELCAL function interfaces with HF and VHF communications transceivers to relieve the flight crew of continually monitoring the communications radios. Each airplane has a different SELCAL code. A ground station transmits this code on VHF or HF to contact an airplane. A SELCAL decoder on the airplane monitors for audio tones, and if the tones are the same as the code, the SELCAL decoder sends a signal to display a COMM medium EICAS message, SELCAL, as well as an aural chime to the aural warning speakers. A signal is also sent to the audio control panels to turn on the CALL light for the transceiver that received the SELCAL code.

Three Audio Gateway Units (AGUs) provide the SELCAL decoder function for each of the VHF and HF radios.

There is no dedicated hardware for the SELCAL function; it is a software function within the AGU. It may be useful to consider a channel as an input from a communication radio to the AGU used to detect SELCAL.

Each AGU has two audio inputs dedicated to SELCAL that are processed independently, but not all input capacity is used. Both aft AGUs have a VHF and HF SELCAL audio input for a total of 4. The forward left AGU has a single VHF SELCAL audio input and the forward right AGU has no SELCAL audio inputs. Therefore, the total number of SELCAL channels actually used on the 777X is 5. (The total installed capacity is 8, with 3 not used.)

Consequences of Failure

SELCAL function is lost and the crew must monitor the radios for message traffic intended for them.

Consequences of Next Critical Failure

None identified. This equipment is not required for airplane operations.

23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

23-24-01A

Interval	Installed	Required	Procedure
A	-	0	(M)

May be inoperative provided:

- System is deactivated, and
 - Repairs are made within 90 consecutive calendar-days.
-

23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

23-24-01B

Interval	Installed	Required	Procedure
A	-	0	(M)

May be missing provided:

- Placard stating "ELT not installed" is placed in view of the pilot, and
 - Repairs are made within 90 consecutive calendar-days.
-

23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

23-24-01C

Interval	Installed	Required	Procedure
D	-	-	(M)

Any in excess of those required by 14 CFR may be inoperative provided system is deactivated.

23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

23-24-01D

Interval	Installed	Required	Procedure
D	-	-	

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Any in excess of those required by 14 CFR may be missing.

23-24-01 Emergency Locator Transmitter (ELT) (Fixed)

23-24-01-01 Remote ELT Switch

Interval	Installed	Required	Procedure
D	1	0	(M)

May be inoperative provided:

- Remote ELT Switch is deactivated, and
- ELT Switch is placed in the ARMED mode.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 23-24-02.

Relief based on Policy Letter 120, Revision 3.

FAR 91.207 establishes the requirements for Emergency Locator Transmitters (ELT).

NOTE: Portable ELT's are covered in AMM Chapter 25 whereas the fixed ELT's are covered in AMM Chapter 23.

There is one fixed ELT installed on the 777-9 as standard equipment. Note that the Airplane Description and Selections document indicates that the fixed ELT is a customer-selectable option. However, it is expected that all airlines will make this selection and therefore, no *** is indicated in the MMEL/DDG for this item.

The ELT ON Advisory message will be displayed when the ELT is on.

Consequences of Failure

Operations determined by applicable FARs.

The ELT may be deactivated or missing for dispatch.

Consequences of Next Critical Failure

None identified.

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23-24-02 Aircraft Autonomous Distress Tracking (ADT) System

23-24-02-01 Emergency Locator Transmitter - Distress Tracking (ELT-DT)

23-24-02-01A

Interval	Installed	Required	Procedure
A	-	0	(M)

May be inoperative provided:

- System is deactivated, and
- Repairs are made within 90 consecutive calendar-days.

23-24-02 Aircraft Autonomous Distress Tracking (ADT) System

23-24-02-01 Emergency Locator Transmitter - Distress Tracking (ELT-DT)

23-24-02-01B

Interval	Installed	Required	Procedure
A	-	0	(M)

May be missing provided:

- Placard stating "ELT-DT not installed" is placed in view of the pilot, and
- Repairs are made within 90 consecutive calendar-days.

23-24-02 Aircraft Autonomous Distress Tracking (ADT) System

23-24-02-01 Emergency Locator Transmitter - Distress Tracking (ELT-DT)

23-24-02-01C

Interval	Installed	Required	Procedure
D	-	0	(M)

Any in excess of those required by 14 CFR may be inoperative provided system is deactivated.

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23-24-02 **Aircraft Autonomous Distress Tracking (ADT) System**

23-24-02-01 **Emergency Locator Transmitter - Distress Tracking (ELT-DT)**

23-24-02-01D

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be missing.

23-24-02 **Aircraft Autonomous Distress Tracking (ADT) System**

23-24-02-01 **Emergency Locator Transmitter - Distress Tracking (ELT-DT)**

23-24-02-01-01 Remote ELT Switch

Interval	Installed	Required	Procedure
D	1	0	(M)

May be inoperative provided:

- Remote ELT switch is deactivated, and
- ELT-DT Switch is placed in the ARMED mode.

23-24-02 **Aircraft Autonomous Distress Tracking (ADT) System**

23-24-02-02 **ADT Trigger Unit (ATU)**

23-24-02-02A

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- System is deactivated,
- ELT-DT is set to fixed ELT mode, and
- Repairs are made within 90 consecutive calendar-days.

23-24-02 Aircraft Autonomous Distress Tracking (ADT) System
*****23-24-02-02 ADT Trigger Unit (ATU)****23-24-02-02B**

Interval	Installed	Required	Procedure
A	1	0	(M)

May be missing provided:

- ELT-DT is set to fixed ELT mode,
 - Placard stating "ATU not installed" is placed in view of the pilot, and
 - Repairs are made within 90 consecutive calendar-days.
-

23-24-02 Aircraft Autonomous Distress Tracking (ADT) System
*****23-24-02-02 ADT Trigger Unit (ATU)****23-24-02-02C**

Interval	Installed	Required	Procedure
D	1	0	(M)

Any in excess of those required by 14 CFR may be inoperative provided:

- System is deactivated, and
 - ELT-DT is set to fixed ELT mode.
-

23-24-02 Aircraft Autonomous Distress Tracking (ADT) System
*****23-24-02-02 ADT Trigger Unit (ATU)****23-24-02-02D**

Interval	Installed	Required	Procedure
D	1	0	(M)

Any in excess of those required by 14 CFR may be missing provided ELT-DT is set to fixed ELT mode.

SUBSTANTIATION**Background**

Global Aeronautical Distress and Safety System (GADSS) Autonomous Distress Tracking (ADT) system is a new item for 777. The GADSS configuration with Emergency Locator Transmitter with Distress Tracking (ELT-DT) and the fixed ELT configuration are mutually exclusive configurations on the 777.

New mandates are going into effect that require aircraft to be equipped with robust and automatic means to accurately determine the location of the point of end of flight following an accident during which the airplane is severely damaged. For airplanes with a maximum certificated take-off mass over 27 000 kg (59,525 lbs), for which the individual certificate of airworthiness is first issued on or after 1 January 2023, ICAO Amendment 44 to Annex 6 Part 1 includes a standard requiring that those aircraft be equipped with a system to autonomously transmit information from which a position can be determined by the operator at least once every minute, when in distress, in accordance with ICAO Annex 6, Part 1, Appendix 9.

The European Aviation Safety Agency (EASA) via Commission Implementing Regulation (EU) 2019/1384 of 24 July 2019 mandates compliance to the ICAO standard by January 2023. The EASA mandate is also applicable to non-European Union (EU) commercial air operators, referred to as Third Country Operators (TCOs) as stated in Federal Aviation Administration (FAA) information for Operators (inFO 16018).

Boeing will certify the new Global Aeronautical Distress and Safety System (GADSS) Autonomous Distress Tracking (ADT) system with two Emergency Locator Transmitter with Distress Tracking (ELT-DT) suppliers on all production airplanes starting in late 2022 as one means of satisfying the requirements noted above.

The Boeing GADSS ADT system will consist of an ADT Trigger Unit (ATU), an Emergency Locator Transmitter with Distress Tracking (ELT-DT) Transmitter, an ELT-DT Antenna, an ELT-DT Airplane Configuration Module (ACM) and a flight deck control panel.

The ATU will monitor a number of parameters on the aircraft to determine if/when an aircraft is in a situation, if left uncorrected, is likely to result in an accident (i.e. in distress). When the ATU detects the aircraft is in a distress situation, it will send a distress trigger to the ELT-DT Transmitter.

When triggered by the ATU, the ELT-DT Transmitter will broadcast aircraft position via the ELT-DT Antenna over a 406 MHz signal to search and rescue. When detected by the satellite(s) of the international COSPAS-SARSAT program, the 406-MHz signals are transmitted to the ground, and then processed into ELT messages that are delivered to the competent Search and Rescue (SAR) center. This allows for the location of the point of end of flight soon after the distress trigger detection.

If the accident is survivable, the ELT-DT will transmit the 406-MHz signals and a 121.5-MHz homing signal after the impact to provide accurate location of the point of end of flight and to support the on-site location and rescue of potential survivors.

The ELT will also include an Aircraft Configuration Module (ACM). The ACM allows for storage of aircraft specific information and allows reprogramming of the 406 MHz message in the ETL-DT Transmitter. When installed, the ACM is attached/mounted to the ELT-DT Transmitter on a dedicated connector.

The ELT-DT Flight Deck Control Panel will allow the crew to manually trigger the ELT-DT. This panel will be unchanged from the currently certified fixed ELT flight deck control panel.

The GADSS ADT System is designed around a single status message, ELT SYS, which indicates that one or more components of the system are deactivated, inoperative, or missing. The message could be driven by either part of the GADSS ADT system, the ATU or the ELT-DT. Keeping with the current fixed ELT design philosophy, the ELT-DT is as separated from the aircraft system interfaces as possible. The ATU reports the failures for the overall system. An LED on the front panel of the ATU will indicate an ATU or ELT-DT failure.

The ELT SYS message is controlled by a discrete output signal in the ATU, which is received by RDC-18 and RDC-23. When the discrete output switch is closed (GND) it indicates a system failure, powered off, or the fixed ELT mode. The fault report labels 350 and 352 indicate to CMCF the reason for the corresponding FDE.

The GADSS ADT system includes a switch in the lower cargo area that allows the system to be placed in to a Fixed ELT mode for situations where the ATU should not automatically trigger an ELT alert to search and rescue (ex. air-show, flight test, etc.) OR when there is a system failure of the ATU where the system can continue to operate as a fixed ELT.

Consequences of Failure

None. A failure of the GADSS ADT system has no impact on crew operations or continue safe flight and landing.

ATU failure: The ELT-DT is configured to fixed ELT mode and continues to alert search and rescue in the event of a manual trigger from the flight deck or in the event of a crash triggering the internal crash sensor within the ELT-DT Transmitter.

ELT-DT: If the antenna or transmitter fails, the airplane would not have GADSS ADT or fixed ELT functionality. The ATU does not provide useful functionality without a functional ELT-DT.

Consequences of Next Critical Failure

None.

Federal Aviation Administration (FAA)**ATA 23****777-9 Master Minimum Equipment List****Section 2****23-25-01 Low Frequency Underwater Locator Device (LF-ULD)***********23-25-01A**

Interval	Installed	Required	Procedure
C	-	0	

May be inoperative or missing.

23-25-01 Low Frequency Underwater Locator Device (LF-ULD)*********23-25-01B**

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative or missing provided operations do not require its use.

SUBSTANTIATION**Background**

New item for 777X.

The Low Frequency Underwater Locating Device (ULD) is a cylindrical, ruggedized, waterproof, and weatherproof housing that can withstand extreme environmental conditions, high acceleration impact shock, and deep-sea pressure up to 20,000 feet below sea level.

The ULD is in continuous standby mode and is intended to operate only in the event of an accident over water. The ULD automatically activates upon being immersed in saltwater or freshwater and transmits a pulsed sonic signal for ninety days to aid in the location of submerged airplane wreckage.

Consequences of Failure

None identified.

Consequences of Next Critical Failure

None identified.

23-27-01 Communication Management System (Data Link)**23-27-01A**

Interval	Installed	Required	Procedure
C	2	1	

23-27-01 Communication Management System (Data Link)**23-27-01B**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Alternate procedures are established and used, and
- Flight remains within 180 minutes of landing at a suitable airport.

23-27-01 Communication Management System (Data Link)**23-27-01C**

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative provided procedures do not require its use.

23-27-01 Communication Management System (Data Link)**23-27-01-01 ACPT/CANC/RJCT Switches**

Interval	Installed	Required	Procedure
C	6	0	(O)

May be inoperative provided alternate procedures are established and used.

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23-27-01 Communication Management System (Data Link)

23-27-01-02 ACPT/CANC/RJCT Switch Lights

Interval	Installed	Required	Procedure
C	6	0	

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 23-27-01.

The data communications management system consists of dual software applications that reside on the Common Core System (CCS). A redundant application is installed on each of the left and right Common Computing Resources (CCR) cabinets. The system provides Aircraft Communications, Addressing and Reporting System (ACARS) and Aeronautical Telecommunications Network (ATN) data link functions. It also provides the COMM Multi Function Display (MFD) displays used for Company, Air Traffic Control, and Flight Information data link, as well as VHF and HF failure indications to the Tuning and Control Panels. In addition, it is required for SATCOM voice and data link operation.

Selecting COMM on one of the MFDs will display the COMM Main Menu, from which all functions are accessed. COMM is used to transmit (downlink) and receive (uplink) messages using HF, VHF or SATCOM data links.

Each pilot's glareshield panel also contains three switches for controlling data link messages. These switches are labeled ACPT, CANC and RJCT. These switches provide the same function as selecting the MFD COMM display keys ACCEPT, CANCEL, and REJECT, respectively.

One Communication Management application is designated as "master" and the other is a "standby". Synchronization is established between the master and standby applications, and switching between master and standby is based on the health status of the interfacing hardware and the physical connection between the hardware.

Consequences of Failure

With one data communication management system inoperative or with one or more ACPT, CANC or RJCT switches inoperative on one of the pilot's glareshield panels, the remaining system will continue to provide full functionality.

With both data communication management systems inoperative, the FAA requires that the airplane be operated within 180 minutes of a suitable airport to meet dual independent communication requirements for long range operations.

The DATA COMM MGMT Status message will be displayed when both software applications on the CCR General Processing Modules (GPMs) are not available or when the comm radio systems are failed, preventing data link operations. These would typically be non-dispatchable conditions (e.g. loss of multiple GPMs, or loss of multiple VHF radios or TCPs). However, it could also be indicated due to the unlikely failure of both software applications independent of other failures. The DATA COMM MGMT Status message will also be displayed when the airplane identification (ICAO address, tail number and airline ID) have not been properly entered into the Displays Maintenance page. If procedures do not require use of data link, both systems may be inoperative with no provisos.

For ACPT, CANC or RJCT switch lights inoperative, switches continue to operate normally and the MFD COMM functions continue to operate normally.

Consequences of Next Critical Failure

With one Communication Management System inoperative at dispatch or with one of the ACPT, CANC or RJCT switches inoperative at dispatch, the next critical failure would be loss of the remaining system or switch. Failure of both Communication Management systems is indicated by the DATA COMM MGMT Status message. Capability to communicate information via data link is lost. This includes ACARS via VHF, SATCOM and HF, as well as FANS and ATN applications. All data link services for Flight Management, Central Maintenance, Aircraft Condition Monitoring, Engine Monitoring Unit, Electronic Flight Bag and maintenance pages will be unavailable. SATCOM voice will be inoperative if SATCOM system is powered off and then powered up again.

With both Communication Management Systems inoperative at dispatch, there is no next critical failure identified. Either alternate procedures are established and used or procedures do not require the use of the systems.

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23-41-01 Service Interphone System

23-41-01-01 Nose Gear Jack

23-41-01-01A

Interval	Installed	Required	Procedure
C	1	0	(O)

Service interphone flight deck to ground/ground to flight deck function may be inoperative provided:

- Nose gear flight interphone jack operates normally, and
- Alternate procedures are established and used.

23-41-01 Service Interphone System

23-41-01-01 Nose Gear Jack

23-41-01-01B

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided alternate procedures are established and used.

23-41-01 Service Interphone System

23-41-01-02 Main Gear Jack

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 23-41-01.

Relief based on MMEL Policy Letter 9, Revision 12.

The Service Interphone System (SIS) provides voice communication among the ground crew members. The system can be connected to the Flight Interphone System via the Service Interphone switch on the overhead panel. A Service Interphone jack is located at the nose gear P40 service/APU shutdown panel as well as at the P56 wheel well electrical service panel.

Consequences of Failure

The ability of the ground crew to communicate from one Service Interphone station to another, or from a Service Interphone station to the flight deck is lost. The flight deck is able to communicate with personnel on the ground through the Flight Interphone system and the Flight Interphone jack located on the nose landing gear.

Consequences of Next Critical Failure

Failure of the Flight Interphone System: alternate normal or emergency procedures are established and used to communicate with the ground crew.

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23-43-01 Ground Crew Call System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 44-43-01.

The ground crew call system has these three functions: 1) It notifies flight deck personnel that there is a call from the ground, 2) it notifies ground personnel that there is a call from the flight deck, 3) it provides awareness to ground personnel that the earth reference system (ERS) is on battery power or that there is an equipment cooling failure. The ground crew call horn and the service and APU shutdown panels are in the nose wheel well area.

The ground crew call system consist of the following components: (1) Ground crew call horn, (2) Flight deck call switch (on P40 panel), (3) Horn relays in the P310 power management panel-standby, (4) Displays & Crew Alerting Small S/W Application.

The ground crew call system also interfaces with the: (1) Common core system (CCS) through a remote data concentrator (RDC), (2) Cabin services system controller (CSSC), (3) P310 power management panel-standby.

The flight crew and the ground crew use the ground crew call system to tell each other to answer a call on the service interphone system. The ground crew call system supplies aural and visual signals in the flight deck and in the nose wheel well area.

The ground crew call horn operates on the ground by 28V DC power that connects through relays in the P310 panel. CCS functions cause horn operation with normal electrical power on the airplane for these conditions:

GROUND CREW to FLIGHT DECK call: The Flight Deck Call switch on the P40 panel sends a flight deck call signal to the Cabin Services System Controller (CSSC). The CSSC sends a flight call signal to the Audio Control Panel (ACP) and a light comes on the ACP. The CSSC sends a signal to Displays & Crew Alerting (DCA) to initiate a chime in the flight deck and provide a Communication Message on the flight deck displays. The ground crew uses the flight interphone system for voice communication with the flight deck. (The 777X CSS system performs the alerting system for ground crew call such as activating the horn, flight deck chime, EICAS messages, and TCP messages & dialing functions. If the CSSC fails, these functions will not be available. Audio is still possible because it is thru the service interphone.)

FLIGHT DECK to GROUND CREW call: The flight crew uses the TCP or the Flight Deck Handset (FDH) to initiate a ground crew call. This causes the ground crew call horn to activate for 3 seconds. Voice communication is then accomplished thru the flight interphone system.

Consequences of Failure

An inoperative ground crew call horn will not annunciate loss of Forward and Aft E/E Cooling or Inertial Reference System operating on battery power.

Consequences of Next Critical Failure

Alternate procedures are required to ensure appropriate action in the event a fault during ground operation: (1) E/E Cooling (to prevent LRU overheat), or (2) Earth Reference System is not operating on Main Battery power which can result in battery drainage.

E/E Cooling failure on ground is considered an economic loss. Discharging the main battery bay powering the ERS on ground is considered an economic loss.

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Federal Aviation Administration (FAA)**ATA 23****777-9 Master Minimum Equipment List****Section 2****23-51-01 Flightcrew Audio Control Panels (ACP)****23-51-01-01 Captain's Audio Control Panel**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided First Observer's Audio Control Panel operates normally.

NOTE: Any function that operates normally may be used.

23-51-01 Flightcrew Audio Control Panels (ACP)**23-51-01-02 First Observer's Audio Control Panel**

Interval	Installed	Required	Procedure
A	1	0	

May be inoperative provided:

- Captain's Audio Control Panel operates normally, and
- Repairs are made within 2 flight-days.

NOTE: Any function that operates normally may be used.

23-51-01 Flightcrew Audio Control Panels (ACP)**23-51-01-03 Network Channels****23-51-01-03-01 Captain**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

23-51-01 Flightcrew Audio Control Panels (ACP)**23-51-01-03 Network Channels****23-51-01-03-02 First Officer**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

23-51-01 Flightcrew Audio Control Panels (ACP)
23-51-01-03 Network Channels
23-51-01-03-03 First Observer

Interval	Installed	Required	Procedure
D	2	1	

One may be inoperative.

23-51-01 Flightcrew Audio Control Panels (ACP)
23-51-01-04 MIC/CALL Lights
23-51-01-04-01 Captain and First Officer

Interval	Installed	Required	Procedure
C	-	0	

23-51-01 Flightcrew Audio Control Panels (ACP)
23-51-01-04 MIC/CALL Lights
23-51-01-04-02 First Observer

Interval	Installed	Required	Procedure
D	-	0	

23-51-01 Flightcrew Audio Control Panels (ACP)
23-51-01-05 Receiver Lights
23-51-01-05-01 Captain and First Officer

Interval	Installed	Required	Procedure
C	-	0	

May be inoperative provided procedures do not require their use.

23-51-01 Flightcrew Audio Control Panels (ACP)**23-51-01-05 Receiver Lights****23-51-01-05-02 First Observer**

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require their use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 23-51-01.

Refer to FAA policy letter 56.

Audio Control Panels (ACPs) are provided for the Captain and First Officer as well as for the first observer seat. Switches on the ACPs permit selection of the following types of audio communication: transceiver audio, navigation receiver audio, cabin interphone audio, passenger address audio, flight interphone audio, and SATCOM audio. Push-to-talk (PTT) switches are located on each ACP as well as on the Captain's and First Officer's control wheels and glare shields.

All (3) 777X ACPs are powered by the Captain's Flight Instrument bus. The F/O ACP also receives power from a second source, the F/O Flight Instrument bus. (Same power architecture as legacy 777)

The OBS AUDIO Switch, located on the aisle stand, allows either the First Officer or the Captain to use the first observer's ACP in the event that their ACP fails.

Each ACP is connected to the Common Data Network (CDN) by redundant communication channels. These channels provide the digital communication path which enables control and command signals to be received and transmitted between the ACP and the using systems.

Description of light functions:

Transmitter Select Switches: Push - The MIC light illuminates and the MIC light for any other transmitter extinguishes. Selects the respective transmitter (radio or intercommunications) for transmission from this crew station. Normally, only one switch is selected at a time for each crew station. CAB and SAT may be selected at the same time for cabin to SATCOM conferencing. Pressing the transmitter select button also selects the associated receiver audio on, if not already manually selected on. Pushing the CAB transmitter select switch twice within one second places a priority call to a selected cabin station. A second push will deselect the transmitter and deselects receiver audio. Note - Second push of the CAB select switch deselects the transmitter and receiver audio only after one second has elapsed from the first push.

MIC Lights Illuminated (green) - indicates the transmitter is selected.

CALL Lights Illuminated (white) - indicates a call on SELCAL, the flight interphone (FLT), the cabin interphone (CAB), or SATCOM (SAT). It will reset when the respective transmitter select switch is pushed or, if already pushed, by pressing a MIC/INTERPHONE switch (the SATCOM CALL light remains illuminated until the call ends). The PA does not have a CALL light.

Receiver Lights Illuminated (green) - indicates the respective receiver volume control is manually selected on. (Note: Pressing the associated transmitter select switch will automatically turn the associated receiver audio on as discussed above)

Receiver Volume Controls: Push - Turns the respective receiver audio on or off. Rotate - controls receiver volume.

Consequences of Failure

Failure of an audio control panel is indicated by the ACP FAIL C, L, R Advisory message. The left ACP is the captain's ACP. The right ACP is the first officer's ACP. The center ACP is the first observer's ACP.

Captain's or First Observer's ACP inoperative: The opposite (CAPT or FOBS) ACP must operate normally. MMEL relief is not proposed for the first officer's ACP which provides for a functioning audio control panel on a separate electrical power bus. The captain's ACP also has a hard-wired connection to the left VHF which allows communication in the event of loss of the Common Data Network (CDN). This function will be unavailable when dispatching with the captain's ACP inoperative.

Failure of one network communication channel for any ACP: The Status message ACP CHANNEL CAPT, ACP CHANNEL F/O or ADP CHANNEL FOBS is displayed. This indicates loss of redundancy in the communication path between the affected ACP and the Common Data Network (CDN). The remaining channel supports full capability for operation of the ACP.

MIC/CALL lights: Pressing the transmitter select switch is primary means for selecting the desired transmitter. Extinguishing of light for any other transmitter gives confirmation that a different transmitter has been selected. Response to transmissions provides confirmation as well.

Receiver lights: Proviso has been included stating that lights may be inoperative provided procedures do not require its use. This was to provide relief for receiver lights for audio receivers that are not required for operations such as an HF or SAT receiver.

Consequences of Next Critical Failure

1. For captain's or first observer's ACP inoperative: Failure of one of the remaining two control panels (opposite ACP or first officer's ACP) provides functionality.
2. Captain's flight instrument bus: remaining control panel (first officer's) provides functionality.
3. First Officer's flight instrument bus: remaining control panel (captain's or first observer's) and first officer's control panel remain powered by captain's flight instrument bus.

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4. Failure of the second network communication channel for one ACP: The ACP becomes inoperative. Remaining control panel(s) provide functionality.

Lights - None identified.

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23-51-02 Flight Deck Hand Microphones

23-51-02A

Interval	Installed	Required	Procedure
C	-	0	

May be inoperative or missing provided associated Headset Boom Microphone operates normally.

23-51-02 Flight Deck Hand Microphones

23-51-02B

Interval	Installed	Required	Procedure
D	-	0	

Any in excess of those required by regulation may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 23-51-02.

Refer to FAA policy letter PL-58.

Each flight crew member's station is equipped with a jack outlet for a boom microphone/headset or hand microphone and headphones. The airplane will be delivered with hand microphones installed/delivered if option is selection by operator. The hand microphones provide for easy radio and interphone transmission while the pilots have their headsets removed. Hand microphones are usually used in conjunction with the flight deck speakers.

Consequences of Failure

The MIC PTT SW CAPT HANDMIC, MIC PTT SW F/O HANDMIC or MIC PTT SW OBS HANDMIC Status is displayed for a PTT switch failed shorted. No message if PTT switch failed open. Hand microphones cannot be used for voice communication. Boom microphones provide required capability.

Consequences of Next Critical Failure

Failure of a flight crew member boom microphone: flight crew member loses voice communication capability. Communication can be performed by using the other crew member's boom microphone, or by either flight crew member using their oxygen mask microphone.

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23-51-03 Flight Deck Headsets/Headphones and Boom Microphones

23-51-03-01 Headset Boom Microphones

23-51-03-01A

Interval	Installed	Required	Procedure
A	-	0	

May be inoperative provided:

- Associated Flight Deck Hand Microphone is installed and operates normally, and
- Repairs are made within 3 flight-days.

23-51-03 Flight Deck Headsets/Headphones and Boom Microphones

23-51-03-01 Headset Boom Microphones

23-51-03-01B

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by regulation may be inoperative.

23-51-03 Flight Deck Headsets/Headphones and Boom Microphones

23-51-03-02 Headset Earphones/Headphones

23-51-03-02A

Interval	Installed	Required	Procedure
C	-	1	

May be inoperative provided associated Flight Deck Speaker operates normally.

23-51-03 Flight Deck Headsets/Headphones and Boom Microphones**23-51-03-02 Headset Earphones/Headphones****23-51-03-02B**

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by regulation may be inoperative.

23-51-03 Flight Deck Headsets/Headphones and Boom Microphones**23-51-03-02 Headset Earphones/Headphones****23-51-03-02-01 Active Noise Canceling/Reduction Function**

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided normal audio function operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 23-51-03.

Refer to MMEL Policy Letter 58.

Communication jack panels for headsets/boom microphones are provided at each flight deck crew station. Boom microphones are optional for the flight crew above 18,000 feet, but are required by FARs to provide input to the cockpit voice recorder below 18,000 feet. The 777X is delivered with provisions for hand microphones. There is an option for hand microphones to be installed. The proviso allowing dispatch with all boom microphones inoperative is provided for operators with hand microphones installed.

Consequences of Failure

Capability to communicate through the inoperative boom microphone is lost. Flight deck crew members are required to have an operative headset/boom microphone or be equipped with an operating hand microphone.

Consequences of Next Critical Failure

Failure of one of the crew member headset/boom microphones: radio voice communications can be performed using the hand held microphone (if installed) or the microphone in the oxygen mask or through the normally operating headset/boom microphone. Cabin communication can be performed using the flight deck handset. Audio can be heard over the flight deck speakers. Input to the Cockpit Voice Recorder is provided by area microphones on the flight deck.

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23-51-04 Microphone (MIC)/Interphone Switches

23-51-04-01 Control Wheel Microphone/Interphone Switches

23-51-04-01A

Interval	Installed	Required	Procedure
A	2	1	(M)

One may be inoperative provided:

- Inoperative Control Wheel Microphone/Interphone Switch is verified failed open,
- Associated Audio Control Panel MIC/INT Switch is verified to operate normally, and
- Repairs are made within 3 calendar-days.

23-51-04 Microphone (MIC)/Interphone Switches

23-51-04-01 Control Wheel Microphone/Interphone Switches

23-51-04-01B

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative Control Wheel Microphone/Interphone Switch is deactivated open, and
- Associated Audio Control Panel MIC/INT Switch is verified to operate normally.

23-51-04 Microphone (MIC)/Interphone Switches

23-51-04-02 Flightcrew Audio Control Panel MIC/INT Switches

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative Flightcrew Audio Control Panel MIC/INT Switch is verified to be failed open, and
- Associated Control Wheel Microphone/Interphone Switch is verified to operate normally.

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23-51-04 Microphone (MIC)/Interphone Switches
23-51-04-03 First Observer's Audio Control Panel MIC/INT Switch

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided MIC/INT switch is verified failed open.

23-51-04 Microphone (MIC)/Interphone Switches
23-51-04-04 Glareshield MIC Switches
23-51-04-04A

Interval	Installed	Required	Procedure
A	2	1	(M)

One may be inoperative provided:

- a. Inoperative Glareshield MIC Switch is verified failed open, and
- b. Repairs are made within 3 calendar-days.

23-51-04 Microphone (MIC)/Interphone Switches
23-51-04-04 Glareshield MIC Switches
23-51-04-04B

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- a. Associated CLOCK/MAP/MIC switch panel is deactivated,
- b. Associated CLOCK Switch is considered inoperative, and
- c. Associated Flight Compartment Illumination System (MAP light) is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 23-51-04.

Each primary crew member has access to two combination microphone (MIC)/interphone switches and one glareshield mounted MIC switch. The MIC/interphone switches are located on the associated crew member's control wheel and audio control panel (ACP). A MIC/interphone switch is also located on the first observer's ACP. The MIC/interphone switches allow transmission on the selected ACP transmitter and the flight interphone. The MIC switch installed on the left and right sides of the glareshield allows transmission on the selected ACP transmitter.

Consequences of Failure

Control wheel MIC/interphone switch:

The MIC PTT SW CAPT CTRL WHEEL or MIC PTT SW F/O CTRL WHEEL Status message will be displayed for a switch that has been keyed on (switch stuck closed) for longer than 300 seconds. Switch must be deactivated open and will not be available for use. Dispatch is allowed provided the associated ACP MIC/interphone switch is verified to operate normally. And additional option is available if the switch is inoperative open. An inoperative open switch is not required to be deactivated. As in the previous option, dispatch is allowed provided the associated ACP MIC/interphone switch is verified to operate normally.

ACP MIC/interphone switch: The MIC PTT SW CAPT ACP or MIC PTT SW F/O ACP Status message is displayed; the switch is not available for use, but the control wheel MIC/interphone switch is required to be available and has the same capability as the ACP MIC/interphone switch. Additionally, the glareshield MIC switch would be available if operative and the optional hand MIC would be available if installed and operative. The MIC PTT SW OBS ACP Status message is displayed for an inoperative switch on the first observer's ACP.

Glareshield MIC switch: The MIC PTT SW CAPT GLARE SHLD or MIC PTT SW F/O GLARE SHLD Status message is displayed; the switch is not available for use, but either the control wheel MIC/interphone switch or the ACP MIC/interphone switch is required to be available. Additionally, the optional hand MIC would be available if installed and operative.

For an inoperative microphone push-to-talk switch on the first observer's seat audio control panel or hand microphone, the following Status messages will be indicated: MIC PTT SW OBS ACP and MIC PTT SW OBS HANDMIC.

Consequences of Next Critical Failure

Control wheel MIC/interphone switch inoperative:

ACP MIC/interphone switch fails: Crew member could use the glareshield MIC switch if operative or the optional hand MIC if installed and operative. Otherwise, the flight would have to be completed with the affected crew member unable to initiate transmission on available communications devices.

ACP MIC/interphone switch inoperative and control wheel MIC/interphone switch fails:

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Crew member could use the glareshield MIC switch if operative or the optional hand MIC if installed and operative. Otherwise, the flight would have to be completed with the affected crew member unable to initiate transmission on available communications devices.

Glareshield MIC switch inoperative, and control wheel MIC/interphone switch inoperative and ACP MIC/interphone switch fails, or ACP MIC/interphone switch inoperative and control wheel MIC/interphone switch fails: affected crew member must use the optional hand mic if installed and operative, or complete the flight unable to initiate transmission on available communications devices.

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23-51-05 Flight Deck Speaker Systems

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- Associated Headset Earphones/Headphones are installed and operate normally,
- Both master WARNING lights operate normally, and
- Both master CAUTION lights operate normally.

SUBSTANTIATION**Background**

Proposal same as 787 23-51-05.

In general, warning and caution conditions are presented to the flight deck using the Master Warning/Caution Lights, an aural tone and an EICAS message. There are two comm/warning speakers located in the overhead panels in the flight deck. All aural are generated by the Displays and Crew Alerting System. In addition, the Displays and Crew Alerting System receives requests to annunciate warning and caution conditions from other systems such as Ground Proximity Warning System, Traffic Alert and Collision Avoidance System, Flight Controls, etc.

The warning speakers are common with the flight deck communication speakers, not separate units (ref 777 MMEL item 23-51-2); the proposed 777X relief is the union of 777 warning speaker function and flight deck communication speaker function relief.

Crew alerting audio is not provided through the headsets.

For certain warning and caution conditions, depressing either Master Warning / Caution light will also extinguish the aural annunciation associated with the condition. These warnings are referred to as "resettable".

The following identifies the aural tone associated with warning, as well as if the aural can be extinguished by depressing either Master Warning light (MWL):

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Warning	Effect of Depressing MWL	Tone
Autopilot Disconnect	extinguish MWL only	wailer
Cabin Altitude	extinguish MWL and aural	siren
Crew Awareness Monitor	extinguish MWL and aural	siren
Fire	extinguish MWL and aural	fire bell
GPWS/Windshear	extinguish MWL only	voice
Resettable Landing Config.	extinguish MWL and aural	siren
Non-resettable Landing Config.	extinguish MWL only	siren
Overspeed Alert	extinguish MWL only	siren
Takeoff Config.	extinguish MWL only	siren
Unschld Stab. Movement	extinguish MWL and aural	siren
Pitch Trim Limit	extinguish MWL and aural	siren
Engine Fail Alert	extinguish MWL only	voice
Caution Alert	extinguish MWL and aural	beeper

All warnings are accompanied by an EICAS message to help the crew identify the warning condition.

The Displays and Warning System prioritizes all aural requests as listed in a prioritization table for warnings and selected caution level messages (primarily those from the Integrated Surveillance System). Generally, warning level aural have the highest priority, followed by the caution aural.

The volume level of the aural generated by the Displays and Crew Alerting System are automatically adjusted to overcome the varying ambient noise level in the flight deck.

Consequences of Failure

The FLIGHT DECK SPEAKER L or R Status message is displayed, indicating failure of one of the two flight deck/aural warning speakers. The remaining speaker continues to provide aural warnings and communication audio.

Consequences of Next Critical Failure

Failure of remaining flight deck/aural warning speaker. CONFIG WARN FAULT Advisory message is displayed. Flight deck speaker function will be lost for the remainder of the flight. MMEL provisos ensure that master warning / caution lights and EICAS messages will be available to alert the crew of subsequent failure conditions. Capability of the flight crew to hear radio, navigation, or crew communication without the use of headsets or headphones is lost. MMEL provisos ensure that headsets are available for communication.

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23-51-06 Audio Gateway Units (AGU)

Interval	Installed	Required	Procedure
C	4	3	(O)

Forward right AGU may be inoperative provided:

- Forward left AGU operates normally,
- Both aft left and aft right AGUs operate normally,
- Service Interphone System-Nose Gear Jack is considered inoperative, and
- Alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 23-51-06.

The Audio Gateway Units (AGUs) serve as the interface to the Common Data Network (CDN) for the communication and navigation radios. The AGUs convert analog audio signals from the communication and navigation radios to digital format which is supported on the CDN. The AGUs also convert digital audio signals from the CDN to analog signals before routing it to the communication radios for transmission.

In addition, the AGUs provide the SELCAL decoder function. They detect the presence of the airplane's SELCAL tone sequence on analog inputs received from each of the VHF and HF radios. The AGU decodes SELCAL tones resulting in visual and aural annunciations on the flight deck.

The left AGUs (Fwd and Aft) are installed on the EE bay E1-3 shelf. The right AGUs (Fwd and Aft) are installed on the EE bay E2-2 shelf.

The forward left AGU is powered from the Captains flight instrument bus. In the event of total loss of primary power, the forward left AGU will support VHF-L communication and left Instrument Landing System audio. The aft left AGU is powered from the left main 28V DC bus. Both the forward right and the aft right AGUs are powered from the right main 28V DC bus.

Consequences of Failure

NOTE: MMEL dispatch is only allowed for the forward right AGU.

Failure of the aft left audio gateway unit (AGU) is indicated by the AUDIO GATEWAY UNIT AFT L Status message. The following Advisory messages will also be displayed: HF AUDIO FAIL L, SAT 1 AUDIO FAIL, VHF AUDIO FAIL C. Dispatch is not allowed.

Failure of the aft right audio gateway unit (AGU) is indicated by the AUDIO GATEWAY UNIT AFT R Status message. The following Advisory messages will also be displayed: HF AUDIO FAIL R, SAT 2 AUDIO FAIL, VHF AUDIO FAIL R. Dispatch is not allowed.

Failure of the forward left audio gateway unit (AGU) is indicated by the AUDIO GATEWAY UNIT FWD L Status message. The following Advisory messages will also be displayed: NAV AUDIO FAIL L, VHF AUDIO FAIL L. Dispatch is not allowed.

Failure of the forward right audio gateway unit (AGU) is indicated by the AUDIO GATEWAY UNIT FWD R Status message. The following Advisory message will also be displayed: NAV AUDIO FAIL R. Dispatch is allowed.

Only the forward right AGU may be inoperative for dispatch. The forward right AGU interfaces with the following functions: ILS/GLS audio identification and VOR audio identification from the right multi-mode receiver (MMR, DME and ADF audio identification from those respective receivers); the nose gear service interphone jack (P40 panel). With audio identification not available, the PFD and ND can be used to verify the tuned station's identifier and frequency. Audio identification is not normally used. For the nose gear service interphone inoperative, see MMEL 23-41-01.

With the forward right AGU inoperative, all communication and left navigation radio audio will operate normally, and SELCAL functionality will be available through the remaining AGUs.

The forward left AGU may not be inoperative since it supports the left VHF comm radio which is required for dispatch. The forward left AGU also supports a backup analog communication function in the event of total loss of primary power and total CDN failure. The aft left and right AGUs may not be inoperative for dispatch in order to support the requirement for two independent communication systems.

Consequences of Next Critical Failure

Loss of one of the remaining 3 AGU's, rendering the associated communication/navigation radios inoperative. The remaining 2 AGU's would provide functionality for the remaining navigation and communication radios to permit continued, safe flight.

23-51-07 Flight Deck Analog Audio Communication

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

This proposal is the same as 787 23-51-07.

The Audio Gateway Units (AGUs) serve as the interface to the Common Data Network (CDN) for the communication and navigation radios. The AGUs convert analog audio signals from the communication and navigation radios to digital format which is supported on the CDN. The AGUs also convert digital audio signals from the CDN to analog signals before routing it to the communication radios for transmission.

In the event that digital communication through the CDN is not available, an analog communication path for audio signals is available between the captain's audio control panel (ACP) and left VHF via the forward left AGU.

Consequences of Failure

Failure of the flight deck analog audio is indicated by the CDN REVERSION BYPASS Status message. This indicates that a fault is detected in the analog communication path between the captain's ACP and the forward left AGU. Normal communication systems are unaffected by this fault.

Consequences of Next Critical Failure

In the unlikely event that there is total loss of digital communication on the common data network, the flight crew would be unable to transmit or receive audio signals through the radios. Failure of the CDN is extremely improbable.

23-93-01 Pilot's Overhead Panel Control/Communication Channels

Interval	Installed	Required	Procedure
C	20	10	

One Overhead Panel Control/Communication Channel (either A or B) may be inoperative for each overhead control panel.

SUBSTANTIATION
Background

Proposal based on 787 MMEL item 23-93-01.

The Flight Deck Control Panel (FDCP) system provides digital switch position data to airplane systems and provides annunciation of airplane system status to the pilot via the Common Data Network (CDN). Each control panel in the P5 Pilots' Overhead Panel packages and transmits panel/switch data into Controller Area Network (CAN) messages onto the CDN to the FDCP hosted application resident in the Common Computing Resource (CCR). The FDCP hosted application is installed in three General Processing Modules (GPMs) of the CCR and provides the interface between the flight deck control panels and the airplane systems, including the Onboard Health Management Function. The application processes and transmits the panel/switch data to airplane systems through two Remote Data Concentrators (RDCs) per channel located in the flight deck.

The P5 Pilots' Overhead Panel is composed of 10 separate control panels. Each control panel has two independent Panel Interface Pods (PIP) to process redundant digital switch data (A and B). Each PIP has a separate Controller Area Network (CAN) bus transmitter to transmit redundant PIP panel data to the RDCs. Channel A (PIP A) data is transmitted to two RDCs and channel B (PIP B) data is transmitted to two RDCs.

Consequences of Failure

Failure is indicated by the EICAS status message P5 xxxxx CHAN A(B) where xxxxx can be the following:

AIR COND, ANTI-ICE, CARGO FIRE/ENG CHAN, ELEC, FUEL, HYD, PASS SIGNS, PFC/IRS, PRESS, or WINDOW HEAT. Failure of one of the two control panel PIP's (channel A or B) will not affect transmittal of switch data to airplane systems. The remaining PIP channel provides full functionality.

Consequences of Next Critical Failure

Failure of the remaining PIP channel (A or B) or remaining switch pole:

Loss of some essential system switch data will result. Airplane system functions are required to perform in a manner to allow continued safe flight and landing in the event of loss of or invalid P5 overhead control panel switch data. This requirement is accomplished either by using hard

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wired connections from critical switches to their associated LRU, or by the establishment of default LRU state following loss of communication.

Dispatch with a PIP channel B inoperative followed by a standby power condition:
The effects are the same as for failure of the remaining PIP channel as described above. However, normal FDCP functionality returns when electrical power is restored.

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24-00-01 Electrical Synoptic Display

24-00-02 IFE/PASS SEATS Power Switch Lights

24-00-02-01 OFF Light

24-00-02-02 ON Light

24-00-03 CABIN/UTILITY Power Switch Lights

24-00-03-01 OFF Light

24-00-03-02 ON Light

24-09-01 Electrical Load Management System (ELMS) Power Management Channels

24-09-01-01 P110 Channels

24-09-01-01A

24-09-01-01B

24-09-01-02 P210 Channels

24-09-01-02A

24-09-01-02B

24-09-01-03 P310 Channels

24-11-01 Engine Driven Generator Systems (Integrated Drive Generator, Generator Circuit Breaker)

24-11-01-01 GEN CTRL Switch Lights

24-11-01-01-01 OFF Lights

24-11-01-01-02 ON Lights

24-11-01-02 DRIVE DISC Switch DRIVE Lights

24-11-02 Integrated Drive Generator (IDG) Oil Pressure Indication Systems

24-21-01 APU Driven Generator System (APU Generator, APU Generator Control Unit, Auxiliary Power Breaker)

24-21-01-01 APU GEN Switch Lights

24-21-01-01-01 OFF Light

24-21-01-01-02 ON Light

24-22-01 Alternating Current (AC) Bus Control System

24-22-01-01 Ground Handling Bus

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24-25-01	Backup AC Electrical Power System (Backup Generators, Converter and CCBs)
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24-25-01-02	Backup Generator Input Shaft
24-25-01-02A	
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24-25-01-04	BACKUP GEN Switch Lights
24-25-01-04-01	OFF Lights
24-25-01-04-02	ON Lights
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24-31-01C	
24-31-02	Auxiliary Power Unit (APU) Battery Charger
24-31-02A	
24-31-02B	
24-31-03	BATTERY Switch Lights
24-31-03-01	OFF Light
24-31-03-02	ON Light
24-41-01	External Power Systems
24-41-01-01	AVAIL Lights (Flight Deck)
24-41-01-02	ON Lights (Flight Deck)
24-41-01-03	External Power Connected Lights (External Power Panel)
24-41-01-04	External Power Not In Use Lights (External Power Panel)
24-41-02	Bus Power Control Unit (BPCU)

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24-51-01 Electrical Load Control Units (ELCUs)

24-51-01-01 Left Utility Bus ELCU

24-51-01-02 Right Utility Bus ELCU

24-61-01 Ground Handling Transformer Rectifier Unit

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Blank

24-00-01 Electrical Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-00-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display(MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

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Interval	Installed	Required	Procedure
C	1	0	

24-00-02 IFE/PASS SEATS Power Switch Lights**24-00-02-02 ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-00-02.

The IFE/PASS SEATS switch placed in the ON position powers the IFE system and passenger seat systems (including the optional - Power PASS Window Shades), cabin power window shades, flight deck entry visual surveillance systems, passenger connectivity system, ground maneuvering camera system and non-essential DC power for galleys and area heaters. The ON light is a mechanical indication that shows the switch is in its latched-in (depressed) position.

The IFE/PASS SEATS switch placed in the OFF position disconnects power from the systems/functions listed above. The OFF Light is Illuminated (amber) – IFE/PASS SEATS power switch is off and the airplane has AC power.

Consequences of Failure

ON Light: The flight crew can determine switch position from flush state with panel.

OFF Light: Alternate action switch is visibly in the out position. Effects in the cabin are a suitable indication.

Consequences of Next Critical Failure

On Light: None

OFF Light: None

24-00-03 CABIN/UTILITY Power Switch Lights**24-00-03-01 OFF Light**

Interval	Installed	Required	Procedure
C	1	0	

24-00-03 CABIN/UTILITY Power Switch Lights**24-00-03-02 ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-00-03.

The CABIN/UTILITY power switch placed in the ON position powers the cabin and utility systems. The ON light is a mechanical indication that shows the switch is in its latched-in (depressed) position.

The CABIN/UTILITY power switch placed in the OFF position disconnects power from cabin and utility systems, while some cabin lights are still powered. The OFF Light is Illuminated (amber) – CABIN/UTILITY power switch is off and the airplane has AC power.

Consequences of Failure

ON Light: The flight crew can determine switch position from flush state with panel.

OFF Light: Alternate action switch is visibly in the out position. Effects in the cabin are a suitable indication.

Consequences of Next Critical Failure

ON Light: None

OFF Light: None

Federal Aviation Administration (FAA)**ATA 24****777-9 Master Minimum Equipment List****Section 2****24-09-01 Electrical Load Management System (ELMS) Power Management Channels****24-09-01-01 P110 Channels****24-09-01-01A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One channel may be inoperative provided:

- Remaining channel is verified to operate normally before the first flight of each day, and
 - Appropriate center-of-gravity limit adjustments are applied.
-

24-09-01 Electrical Load Management System (ELMS) Power Management Channels**24-09-01-01 P110 Channels****24-09-01-01B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One channel may be inoperative provided:

- Remaining channel is verified to operate normally before the first flight of each day,
 - Both Main Tank Jettison Pumps are deactivated, and
 - Appropriate performance adjustments are applied.
-

24-09-01 Electrical Load Management System (ELMS) Power Management Channels**24-09-01-02 P210 Channels****24-09-01-02A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One channel may be inoperative provided:

- Remaining channel is verified to operate normally before the first flight of each day, and
 - Appropriate center-of-gravity limit adjustments are applied.
-

24-09-01 Electrical Load Management System (ELMS) Power Management Channels**24-09-01-02 P210 Channels****24-09-01-02B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One channel may be inoperative provided:

- Remaining channel is verified to operate normally before the first flight of each day,
 - Both Main Tank Jettison Pumps are deactivated, and
 - Appropriate performance adjustments are applied.
-

24-09-01 Electrical Load Management System (ELMS) Power Management Channels**24-09-01-03 P310 Channels**

Interval	Installed	Required	Procedure
A	2	1	(M)

One channel may be inoperative provided:

- Remaining channel is verified to operate normally before the first flight of each day,
 - Procedures do not require use of APU, and
 - Repairs are made within 10 flight-days.
-

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-09-01.

The Electrical Load Management System (ELMS) is responsible for primary and secondary electrical power distribution.

The power management panels (P110, P210, P310) contain buses and switching elements to configure the secondary power system and to distribute loads which draw 20A or less. Various subsystems communicate with ELMS via ARINC 629 buses, to remotely switch and status essential and non-essential airplane subsystem loads. There is a dual channel configuration with each channel capable of providing full functionality.

ELMS is functionally the same as the 777-300ER in that ELMS:

1. Receives electrical power from multiple 115 Volts/400Hz AC electrical generation sources, 28 Volts DC battery sources, 115 Volts/400Hz AC conversions, and 28 Volts DC conversions
2. Distributes electrical power (both AC and DC), to individual systems
3. Monitors systems relays, circuit breaker and/or contactors
4. Communicates systems status to flight crew
5. Monitors the electrical power available to the airplane and will manage sheddable buses/loads by removing and/or restoring electrical loads as needed, to protect against overloading of an individual AC/DC power source.
6. Provides panel bus power interconnection capability, so that electrical power can be distributed based on the type and number of 115-Vac power sources or 28-Vdc conversion is available.
7. Controls the configuration of the DC and standby systems
8. Controls some but not all of the contactors in the associated power panel and controls many of the switched loads in the power management panels themselves.

All of the ELMS panels for the 777-9 have extensive changes from the 777-300ER. Some key differences in ELMS for the 777-9 include:

1. The addition of the P130 and P230 distribution panels.
2. New Power Panel Controller (PPC) and software in the P100 and P200 panels.
3. Revised Computing and Communications Unit (CCU) software.
4. Use of door mounted Printed Wiring Board Assemblies (PWBAs) for power distribution.
5. New Thermal Circuit Breaker design, plug-in style, that mates with the new door mounted PWBAs.
6. Upsized panel connectors to comply with EWIS requirements.

Consequences of Failure

The ELMS P110 CHANNEL, ELMS P210 CHANNEL or ELMS P310 CHANNEL Status message will be displayed when one, but not both channels, of the associated ELMS panel has failed.

Loss of a single channel will not adversely affect ELMS operations since the remaining channel will continue to provide full functionality with communication over at least one ARINC 629 bus.

In the P310 panel, single channel operation may prevent operation of half the refueling valves. Therefore, the time to refuel may be increased.

Consequences of Next Critical Failure

The next critical failure is the loss of communication on the remaining, operative channel. Loss of both management channels results in the associated ELMS P110 PANEL, ELMS P210 PANEL, ELMS P310 PANEL Status message. Subsequent dispatch is not allowed. Control and communication with the associated management panel will not be available or will be degraded. The following summarizes the effects of losing both channels in a particular ELMS panel:

P110 Panel:

Fuel Systems:

Left Override/Jettison Pump pressure indication and low pressure shutoff will be inoperative, however, the pump will still operate. Failure occurring before or during jettison will result in manual jettison mode. Main tank jettison delay will be inoperative resulting in simultaneous jettison from all fuel tanks, potentially leading to a forward CG excursion. Automatic Jettison shutoff will be inoperative. FUEL JETT AUTO FAIL (C) message will be displayed.

Forward CG excursion can be mitigated by ensuring CG remains within limits with center tank fuel weight added to airplane zero fuel weight (Option A).

Forward CG excursion can be mitigated by deactivating the Main Tank Jettison Pumps (Option B).

Left Scavenge system will be inoperative. The FUEL SCAVENGE FAULT, FUEL IMBALANCE and INSUFFICIENT FUEL Advisory messages may be displayed.

[Hazard condition is 'Major']

Equipment Cooling:

The Equipment Cooling Vent Valve and Forward Cargo Heat Valve will close, and will shut off the Equipment Cooling Vent Fan and Left Lavatory/Galley Ventilation Fan.

Loss of Equipment Cooling Vent Fan results in loss of Equipment Cooling Exhaust Smoke Detection. Equipment Cooling Supply Smoke Detection is still available. This also results in slightly warmer EE Bay temperature and loss of fwd cargo heat.

The left Equipment Cooling Supply Fan will remain in its last commanded state due to loss of current monitor.

Loss of EE bay smoke detection is classified as a 'Major' hazard condition. Requiring the Equipment Cooling Supply Smoke Detector to operate normally will allow for annunciation of smoke in the EE bay. Unannunciated smoke would result in the Smoke, Fire, Fumes non-normal checklist. For IFE installed: Loss of IFE Cooling and IFE smoke detection capability. Loss of IFE cooling will result in IFE equipment shutdown. No effect on safety. Loss of IFE smoke detection combined with smoke event assumes crew will accomplish Smoke, Fire, Fumes checklist. Hazard condition is

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considered not worse than 'Major'.

For FCAC installed: Loss of Fwd Cargo Exhaust fan and, consequently, loss of Fwd Cargo exhaust contributing to degraded forward cargo temperature control.

[Hazard condition is 'Minor' assuming no smoke event, 'Major' with smoke event]

Air Conditioning:

Left Economy Cooling Valve (ECV) will fail open resulting in left pack operating in standby mode. PACK IN STBY MODE L Advisory message will be displayed. Degraded ventilation and temperature control due to left recirculation fan erroneously detected as on by the CTC. Flight Deck temperature control will be degraded.

[Hazard condition is 'Minor']

Smoke Detection:

For Overhead Cabin Stowage Option (OCSO) installed: Loss of smoke detection system. Loss of ability to annunciate detection and to shut down galley power and upper recirculation fans in the event of a fire. The probability of loss of OCSO smoke detection (both P110 channels) combined with fire event is extremely improbable (less than $1.0E-09$).

[Hazard condition is 'Minor']

Hydraulics:

Loss of R ACMP. Both R EDPs remain operative.

Loss of C1 ACMP. Loss of C2 ADP Heater and C3 ADP Heater. C2 ADP will run continuously for remainder of flight. ADP 3 will be faulted. ACMP C2, C1 ADP and C2 ADP will remain to provide power for center hydraulic system.

[Hazard condition is 'Minor']

Lights:

Loss of left wing Landing Light, left NLG Landing Light, left Taxi Light and left Runway Turnoff Light.

Loss of left Position Light (red), left rear Marker Light (white) and tail Position Light (white).

Loss of left wing tip anti-collision light (white). Loss of tailcone anti-collision light (white). Loss of right wing tip anti-collision light (white).

Loss of Ground Maneuver Camera Lights.

[Hazard condition is 'Minor']

Bleed Air:

Insufficient bleed pressure to support airplane level flow schedule 2.5 flow demand. Pack flows will remain above flow schedule 4 to support cabin pressurization.

[Hazard condition is 'Minor']

Cabin:

Loss of ability to cabin attendants to control/monitor affected cabin temperature zones via Cabin Attendant Panels.

[Hazard condition is 'Minor']

NGS:

Loss of NGS Ram Fan and NGS Ram Air Door Actuator resulting in possible loss of NGS.

[Hazard condition is 'Minor']

Doors:

Loss of P110 CCU/SIU control of high side power to left PED/SED flight lock relays results in loss of left PED/SED flight lock functionality (flight locks remain disengaged when commanded to engage).

PSDCs will also lose left PED/SED flight lock relay status and failure indication reporting from ELMS.

Flight Locks are typically commanded to engage when airspeed and ground speed reach 80 knots or higher, and commanded to disengage when either airspeed or ground speed falls below 70 knots. [PSDCs use airspeed, the ELMS Panels use ground speed.]

[Hazard condition is 'Minor']

EICAS messages which may be displayed:

AIR/GROUND (Status)
 CARGO HEAT OFF AFT (Advisory)
 DOOR FLIGHT LOCK 1L (Status)
 DOOR FLIGHT LOCK 2L (Status)
 DOOR FLIGHT LOCK 3L (Status)
 DOOR FLIGHT LOCK 4L (Status)
 DOOR FLT LOCK SVC EXIT L (Status)
 ECON COOL VALVE L (Status)
 ELEC STBY SYS FAULT (Advisory/Status)(on-ground)
 ELMS P110 PANEL (Status)
 ENG REVERSER SNSR L (Status)
 FUEL JETT AUTO FAIL (Caution)(when attempting jettison)
 FUEL SCAVENGE FAULT (Advisory)
 FUEL IMBALANCE (Advisory)
 HYD DEM FAULT C3 (Advisory)
 HYD DEM FAULT R (Advisory)
 HYD PRI FAULT C1 (Advisory)
 INSUFFICIENT FUEL (Advisory)
 NITROGEN GEN PERF (Status)
 PACK IN STBY MODE L (Advisory)

P210 Panel

Fuel Systems:

Right Override/Jettison Pump pressure indication and low pressure shut-off will be inoperative, however, the pump will still operate. Failure occurring before or during jettison will result in manual jettison mode. Main tank jettison delay will be inoperative resulting in simultaneous jettison from all fuel tanks, potentially leading to a forward CG excursion. Automatic Jetti-

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son shutoff will be inoperative. FUEL JETT AUTO FAIL (C) message will be displayed.

Forward CG excursion can be mitigated by ensuring CG remains within limits with center tank fuel weight added to airplane zero fuel weight (Option A).

Forward CG excursion can be mitigated by deactivating the Main Tank Jettison Pumps (Option B).

Right Scavenge system will be inoperative. The FUEL SCAVENGE FAULT, FUEL IMBALANCE and INSUFFICIENT FUEL Advisory messages may be displayed.

[Hazard condition is 'Major']

Equipment Cooling:

Loss of P210 Computing and Communications Units (CCUs) will shut off the Right Lav/Galley Vent Fan. Loss of current monitor to Right EE Supply Fan, fan remains in last commanded state. Loss of circuit breaker status for Flight Deck flow sensor, assumes unpowered if low flow or powered if no low flow.

For FCAC installed: Inboard and Divert valves will close resulting in loss of EE Cooling Vent Fan. The consequence of loss of vent fan is loss of EE bay exhaust smoke detection, slightly warmer EE Bay and loss of fwd cargo heat. Loss of EE bay exhaust smoke detection combined with smoke event assumes Flight Crew will accomplish Smoke, Fire, Fumes checklist.

[Hazard condition is 'Minor' assuming no smoke event, 'Major' with smoke event]

Air Conditioning:

Right ECV will fail open resulting in right pack operating in standby mode. PACK IN STBY MODE R Advisory message will be displayed. Degraded ventilation and temperature control due to right recirculation fan erroneously detected as on by the CTC.

[Hazard condition is 'Minor']

Smoke Detection:

Complete loss of OFCR and OFAR smoke detection.

[Hazard condition is 'Minor']

Loss of DR 3 OCSO Smoke Detection. Loss of ability to shut down aft upper recirculation fan in the event of a fire.

The probability of loss of smoke detection (P210 channels) combined with a fire event is extremely improbable (less than 1.0E-09).

[Hazard condition is 'Minor']

Hydraulics:

Loss of L ACMP. Both L EDPs remain operative.

Loss of C2 ACMP. Loss of C1 ADP Heater. C1 ADP will be inoperative. Loss of RAT Heater. ACMP C1, C2 ADP and C3 ADP will remain to provide power for center hydraulic system.

No restriction is required for inoperative RAT Heater. Airplane can operate for up to 20 flights with an inoperative RAT Heater (Ref. RAT Heater

MMEL item).
[Hazard condition is 'Minor']

Lights:

Loss of right wing Landing Light, right NLG Landing Light, right Taxi Light and right Runway Turnoff Light.

Loss of right Position Light (green), right rear Marker Light (white).

Loss of forward upper body anti-collision light (red). Loss of aft upper body anti-collision light (red). Loss of lower body anti-collision light (red).

[Hazard condition is 'Minor']

Bleed Air:

Insufficient bleed pressure to support airplane level flow schedule 2.5 flow demand. Pack flows will remain above flow schedule 4 to support cabin pressurization.

[Hazard condition is 'Minor']

Cabin:

Loss of ability to cabin attendants to control/monitor affected cabin temperature zones via Cabin Attendant Panels.

[Hazard condition is 'Minor']

Loss of passenger address audio via IFE headsets. Cabin speakers are remain operable.

[Hazard condition is 'Minor']

Doors:

Loss of P210 CCU/SIU control of high side power to right PED/SED flight lock relays results in loss of right PED/SED flight lock functionality (flight locks remain disengaged when commanded to engage).

PSDCs will also lose right PED/SED flight lock relay status and failure indication reporting from ELMS.

Flight Locks are typically commanded to engage when airspeed and ground speed reach 80 knots or higher, and commanded to disengage when either airspeed or ground speed falls below 70 knots. PSDCs use airspeed, the ELMS Panels use ground speed].

[Hazard condition is 'Minor']

EICAS messages which may be displayed:

AIR/GROUND (Status)

CARGO HEAT OFF BULK (Advisory)

DOOR FLIGHT LOCK 1R (Status)

DOOR FLIGHT LOCK 2R (Status)

DOOR FLIGHT LOCK 3R (Status)

DOOR FLIGHT LOCK 4R (Status)

DOOR FLT LOCK SVC EXIT R (Status)

ECON COOL VALVE R (Status)

ELEC STBY SYS FAULT (Advisory/Status)(on-ground)

ELMS P210 PANEL (Status)

ENG REVERSER SNSR R (Status)

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FUEL JETT AUTO FAIL (Caution)(when attempting jettison)
FUEL SCAVENGE FAULT (Advisory)
FUEL IMBALANCE (Advisory)
HYD DEM FAULT C1 (Advisory)
HYD DEM FAULT L (Advisory)
HYD PRI FAULT C2 (Advisory)
INSUFFICIENT FUEL (Advisory)
PACK IN STBY MODE R (Advisory)

P310 Panel

Fuel Systems:

Loss of Left Fwd Boost pump pressure indication. No impact to pump operation. Loss of Aft Crossfeed valve indication. No impact to valve operation.
Loss of APU DC pump. Loss of APU auto-start capability. Loss of APU spar valve. APU will be inoperative.
Loss of Defuel valve indication. Loss of all refuel valves and refuel capability.
Dispatch is not allowed if use of APU is required.
[Hazard condition is 'Major']

Fire Protection:

Loss of the following functions for the Cargo fire suppression system: Squib test for Lower Lobe Cargo Compartment Fire Bottles and Flow valve squibs. Unable to perform Auto relay test for Auto Suppression relays and report results. Bottles 1A and 1B can still be discharged manually. Cargo fire bottle metering bottles will be inoperative. Cargo Fire Auto Suppression capability will be lost.
[Hazard condition is 'Minor'.]
The probability of loss of cargo fire functions (P310 channels) combined with a fire event is extremely improbable (on the order of 5.6E-12).
[Hazard classification for cargo fire without fire suppression is 'Catastrophic'.]

EICAS messages which may be displayed:

AIR/GROUND (Status)
ELMS P310 PANEL (Status)
MAIN BATTERY LOW (Advisory) (on ground)

24-11-01 Engine Driven Generator Systems (Integrated Drive Generator, Generator Circuit Breaker)

Interval	Installed	Required	Procedure
B	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Integrated Drive Generator (IDG) is disconnected,
- Backup AC Electrical Power System is verified to operate normally before each departure,
- Left, right, and APU generator control units (GCU) are verified to operate normally,
- APU Driven Generator System operates normally,
- APU is operated throughout the flight to supply electrical power,
- Fuel jettison is not used above FL 390,
- Appropriate performance adjustments are applied, and
- Flight remains within 180 minutes of landing at a suitable airport.

24-11-01 Engine Driven Generator Systems (Integrated Drive Generator, Generator Circuit Breaker)
24-11-01-01 GEN CTRL Switch Lights
24-11-01-01-01 OFF Lights

Interval	Installed	Required	Procedure
C	2	0	

24-11-01 Engine Driven Generator Systems (Integrated Drive Generator, Generator Circuit Breaker)
24-11-01-01 GEN CTRL Switch Lights
24-11-01-01-02 ON Lights

Interval	Installed	Required	Procedure
C	2	0	

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Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 24-11-01.

The Left IDG, Right IDG, and the Auxiliary Generator have been increased in capacity to support the increased electrical loads on the 777-9. The Generator Control Units (Quantity 3) and the Bus Power Control Unit (Quantity 1) are functionally similar to the 777. The component design is based on the 787 GCU and BPCU designs. In addition, the distribution elements have been sized up accordingly, which include feeders and distribution elements of the ELMS panels such as bus bars, wiring, Bus Tie Breakers (BTBs), Generator Control Breakers (GCBs), and the APU Power Breaker (APB).

The Main AC System is based on the 777-300ER Main AC System. It is comprised of two engine-driven IDGs, one auxiliary generator driven by the APU, and two external ground power connections. The components and connections have been sized-up to meet the higher electrical power demands on the 777-9. Each IDG provides up to 150 kVA to the main AC buses. The two engine-driven IDGs are operated independently to provide isolation. The APU-driven auxiliary generator may be used for ground operation, in lieu of external power, to supply the airplane load buses, thus making the airplane independent of ground sources. The APU may also be used in flight as a replacement to an IDG source. While the APU generator is rated for 150 kVA, it is limited to 140 kVA at flight levels greater than 39,000 feet due to limitations of the APU engine. While on the ground, the APU generator is limited to 140 kVA to maximize time between overhaul of the APU engine. Up to two external 90 kVA power sources may be used for ground operations, each supplying one main bus, or one external power source in combination with the APU generator, each supplying one main bus. Power transfers are no-break to and from all power sources while on the ground during normal operations. The system is designed for automatic operation. Manual controls are provided to over-ride the automatic control features.

Boeing intends to obtain a beyond (greater than) 180-minute ETOPS Type Design Approval for the 777-9 at entry into service for a diversion time limit that is consistent with the design capability of the airplane. The 777-9 is expected to be capable of 330 + 15 minute [345 minutes] ETOPS diversions. Loss of left and right IDGs does not affect the airplane safety as backup converter will pick up transfer buses and APU will autostart. APU generator will power main AC buses.

The generator control switch is an alternate action, mechanically latched, push-button switch; each (L and R) incorporates an amber "OFF" indicator light and a mechanical shuttered "ON" indicator. The "OFF" indicator light will illuminate whenever the associated Generator Circuit Breaker (GCB) is open: this may be from manual operation of the associated generator control switch to the out position or from automatic operation of a Generator Control Unit (GCU) protection function or if the power transfer control circuit trips the GCB. The 777X EICAS display is on Standby Power. The "ON" indication will be visible (and is backlighted) whenever the switch is depressed arming the generator breaker.

The generator drive switch is an alternate action, mechanically latched, push-button switch; each (L and R) incorporates an amber "DRIVE" indicator light. Push: Disconnects the integrated drive generator (IDG) from the engine, and requires maintenance action on the ground to reconnect the IDG. When the DRIVE light is illuminated (amber), the IDG oil pressure is low.

Consequences of Failure

The ELEC GEN SYS L or R Status message will be displayed for an IDG protective trip, bus tie breaker (BTB) protective trip, IDG GCB disagrees with command, BTB disagrees with command, IDG disconnect or an IDG control system fault.

The APU driven generator is used as a primary AC electrical power source instead of the engine-driven IDG. Two of the three primary 150 KVA AC power sources can supply all electrical power required by the airplane loads. Performance adjustments for flight planning fuel must be applied to account for the APU running and the drag created by the open APU inlet door.

Flight must remain within 180 minutes of landing at a suitable airport, consistent with conditions specified in FAA MMEL Policy Letter 40.

ON Light: The position of the switch flush with the panel can be determined and ambient light will indicate the shutter is open revealing ON.

OFF Light: The light will not be available for crew notification. The ELEC GEN OFF (L or R) advisory will remain operative.

DRIVE Light: The light will not be available for crew notification. The ELEC DRIVE FAULT L, R Advisory message will remain operative.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

Subsequent failure of either the APU, the APU generator, the engine with the operative IDG, or the remaining engine driven IDG would leave one operative 150 KVA AC power source. The Backup AC Electrical Power System would then assume the load on one AC Transfer Bus. Additionally, load shedding of non-essential loads would occur to ensure sufficient power is available for essential loads. Fuel jettison is prohibited (and unlikely to be required regardless) above FL 390 to protect the APU generator when its output is limited to 140 KVA.

ON Light: None

OFF Light: None

DRIVE Light: None

24-11-02 Integrated Drive Generator (IDG) Oil Pressure Indication Systems

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 24-11-02.

Generator Drive Lights illuminate on the Electrical Control Panel when there is low oil pressure in the IDGs. A low oil pressure condition simultaneously illuminates the Generator Drive Light and initiates an ELEC DRIVE FAULT L, R Advisory message.

Consequences of Failure

The Generator DRIVE lights will not be available. The ELEC DRIVE FAULT L, R Advisory messages are still available to notify the crew of a low oil pressure condition unless the IDG has been disconnected as a result of the Drive Disconnect switch being actuated or engine speed is below minimum idle.

Consequences of Next Critical Failure

With both the Generator Drive Light and the ELEC DRIVE FAULT L, R Advisory messages failed, a low oil pressure condition would not be annunciated. Continued operation with low oil pressure may damage the IDG, however the IDG does have a thermal disconnect feature in the event of high oil temperature. Subsequent failure of the IDG would cause the associated ELEC GEN OFF Advisory message to be displayed. The IDG may trip offline due to underfrequency protection before a thermal disconnect occurs. In this case the ELEC GEN SYS Status message will be displayed along with the ELEC GEN OFF Advisory message. Another effect of a failed IDG includes electrical load shedding.

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24-21-01 APU Driven Generator System (APU Generator, APU Generator Control Unit, Auxiliary Power Breaker)

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Both engine driven generator systems operate normally,
- Procedures do not require use of APU for electrical power,
- APU GEN switch remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

NOTE: APU may be used as a pneumatic source.

24-21-01 APU Driven Generator System (APU Generator, APU Generator Control Unit, Auxiliary Power Breaker)

24-21-01-01 APU GEN Switch Lights

24-21-01-01-01 OFF Light

Interval	Installed	Required	Procedure
C	1	0	

24-21-01 APU Driven Generator System (APU Generator, APU Generator Control Unit, Auxiliary Power Breaker)

24-21-01-01 APU GEN Switch Lights

24-21-01-01-02 ON Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 24-21-01.

The Left IDG, Right IDG, and the Auxiliary Generator have been increased in capacity to support the increased electrical loads on the 777-9. The Generator Control Units (Quantity 3) and the Bus Power Control Unit (Quantity 1) are functionally similar to the 777. The component design is based on the 787 GCU and BPCU designs. In addition, the distribution elements have been sized up accordingly, which include feeders and distribution elements of the ELMS panels such as bus bars, wiring, Bus Tie Breakers (BTBs), Generator Control Breakers (GCBs), and the APU Power Breaker (APB).

The Main AC System is based on the 777-300ER Main AC System. It is comprised of two engine-driven IDGs, one auxiliary generator driven by the APU, and two external ground power connections. The components and connections have been sized-up to meet the higher electrical power demands on the 777-9. Each IDG provides up to 150 kVA to the main AC buses. The two engine-driven IDGs are operated independently to provide isolation. The APU-driven auxiliary generator may be used for ground operation, in lieu of external power, to supply the airplane load buses, thus making the airplane independent of ground sources. The APU may also be used in flight as a replacement to an IDG source. While the APU generator is rated for 150 kVA, it is limited to 140 kVA at flight levels greater than 39,000 feet due to limitations of the APU engine. While on the ground, the APU generator is limited to 140 kVA to maximize time between overhaul of the APU engine. Up to two external 90 kVA power sources may be used for ground operations, each supplying one main bus, or one external power source in combination with the APU generator, each supplying one main bus. Power transfers are no-break to and from all power sources while on the ground during normal operations. The system is designed for automatic operation. Manual controls are provided to over-ride the automatic control features.

The auxiliary generator is an oil-cooled, synchronous type machine which operates at 24,000 RPM and includes a Permanent Magnet Generator which provides self-sustaining power for start-up, control, and protection of the auxiliary generator channel.

Boeing intends to obtain a beyond (greater than) 180-minute ETOPS Type Design Approval for the 777-9 at entry into service for a diversion time limit that is consistent with the design capability of the airplane. The 777-9 is expected to be capable of 330 + 15 minute [345 minutes] ETOPS diversions. Loss of left and right IDGs does not affect the airplane safety as backup converter (BUG) will pick up transfer buses and APU will autostart. APU generator will power main AC buses. The Backup Electrical Power System (BEPS) is rated for 50 kVA.

The APU generator control switch is an alternate action, mechanically latched, push-button switch which incorporates an amber "OFF" indicator light and a mechanical shuttered "ON" indicator. The "OFF" indicator light will illuminate whenever the Auxiliary power Breaker (APB) is open and the switch is out or when the APB and secondary External Power Contactor (EPC) are open and the APU is operating at greater than 95% speed. The "ON" indicator light will illuminate whenever the APU generator breaker is armed - switch depressed.

Consequences of Failure

The ELEC GEN SYS APU Status message will be displayed when a protective trip or failure has occurred in the APU Generator system.

For ground operations, an external AC electrical power source must be used when the engines are not running. In-flight, the primary sources of AC electrical power are the two engine-driven IDGs, and the APU is not normally operating. Flight must remain within 180 minutes of landing at a suitable airport, consistent with conditions specified in FAA MMEL Policy Letter 40 and prescribed in FAR 121 Appendix P.

ON Light: The position of the switch flush with the panel can be determined and ambient light will indicate the shutter is open revealing ON.

OFF Light: The light will not be available for crew notification. An alert level EICAS message "ELEC GEN OFF APU" will be displayed indicating the APB and secondary EPC are open with the APU running.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27E-10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

Subsequent failure of either an IDG or an engine would leave one operative 150KVA AC power source. The Backup AC Electrical Power System would then assume the load on one AC Transfer Bus. Additionally, load shedding of non-essential loads would occur to ensure sufficient power is available for essential loads.

ON Light: None.

OFF Light: None

Federal Aviation Administration (FAA)

ATA 24

777-9 Master Minimum Equipment List

Section 2

24-22-01 Alternating Current (AC) Bus Control System

24-22-01-01 Ground Handling Bus

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided equipment on the ground handling bus is deactivated before each departure.

24-22-01 Alternating Current (AC) Bus Control System

24-22-01-02 Ground Service Select Relay

Interval	Installed	Required	Procedure
C	1	0	(M)

Control of the relay may be inoperative provided the relay remains in the engine running position.

24-22-01 Alternating Current (AC) Bus Control System

24-22-01-03 Ground Service Transfer Relay

Interval	Installed	Required	Procedure
C	1	0	(M)

Control of the relay may be inoperative provided the relay remains in the engine running position.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 24-22-01.

Ground Handling Relay

Electrical loads such as cargo lighting, service outlets, and engine turning system, which are used only on the ground, are supplied from the ground handling bus. This bus is energized automatically, only on the ground, when either the auxiliary generator is energized or when a ground power source is connected to the primary external power receptacle.

Ground Service Select Relay

The Ground Service Bus provides power for electrical loads such as interior lights and battery charging during ground maintenance. The Ground Service Bus is supplied by the right AC bus, through the Ground Service Transfer and Ground Service Select Relays, whenever the AC bus is energized. The Ground Service Bus can also be supplied through the APU or from the primary external power source, through the Ground Service Select Relay, when the ground service switch is ON.

Ground Service Transfer Relay

The Ground Service Bus provides power for electrical loads such as interior lights and battery charging during ground maintenance. The Ground Service Bus is supplied by the right AC bus, through the Ground Service Transfer and Ground Service Select Relays, whenever the AC bus is energized.

Consequences of Failure

The ELEC GND HDLG BUS Status message will be displayed for an inoperative ground handling relay. The ELEC GND HDLG FAULT Advisory message will also be displayed. The ELEC GND HDLG BUS Status message will not be set for an inoperative ground service select relay or ground service transfer relay.

Ground Handling Relay - The Ground Handling Buses will not be available. (Cargo handling, Cargo compartment lighting etc.) For 777X, the Engine Turning System (ETS) will also be inoperative (see ATA 80). If the relay is stuck in the APU position, the ground handling loads may not have their power removed when the airplane is in flight.

Ground Service Select Relay - With the Ground Service Select Relay failed in the engine running position, power for the Ground Service Bus will only be available from the R. Main AC bus.

Ground Service Transfer Relay - With the Ground Service Transfer Relay failed in the engine running position, power for the Ground Service Bus will be available from the R. Main AC bus or the APU.

The following is a list of equipment that will not be powered when the Ground Handling AC bus is deactivated:

1. Forward and aft cargo handling.
2. Forward interior and exterior cargo lights.
3. Aft and bulk interior and exterior cargo lights.
4. Engine cowl drive motors.
5. Door service outlets.
6. OFAR/OFCR service outlets.
7. Engine turning system.
8. Ground handling TRU.
9. Flight Deck service outlet.

The following is a list of equipment that will not be powered when the Ground Handling DC bus is deactivated:

1. Service interphone.

Federal Aviation Administration (FAA)

ATA 24

777-9 Master Minimum Equipment List

Section 2

-
2. Cargo Handling Control
 3. Refueling control/indication
 4. Refueling valves
 5. Defueling
 6. Water system control/indication
 7. Lavatory flow control
 8. Cargo door control
 9. Engine cowl drive motor control
 10. EE Bay hatch

Consequences of Next Critical Failure

Ground Handling Relay - None.

Ground Service Select Relay - Electrical power will not be available for the equipment on the Ground Service bus, if the Ground Service Select Relay is completely failed.

Ground Service Transfer Relay - Electrical power will not be available for the equipment on the Ground Service bus, if the Ground Service Transfer Relay is completely failed.

Draft
Feb 26, 2020

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)

Interval	Installed	Required	Procedure
C	1	N/A	(M)

May be dispatched with ELEC BACKUP SYS Status message displayed provided:

- Backup generator oil system status is verified normal,
- Flight control system is verified to operate normally before each departure,
- Both Engine Driven Generator Systems operate normally,
- Both Backup Generator Input Shafts operate normally,
- APU Driven Generator System operates normally, and
- Flight remains within 180 minutes of landing at a suitable airport.

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)
24-25-01-01 Backup Generators

Interval	Installed	Required	Procedure
C	2	N/A	(M)

May be dispatched with ELEC BACKUP GEN L and/or ELEC BACKUP GEN R Status message(s) displayed provided:

- Backup generator oil system status is verified normal,
- Flight control system is verified to operate normally before each departure,
- Both Engine Driven Generator Systems operate normally,
- Both Backup Generator Input Shafts operate normally,
- APU Driven Generator System operates normally, and
- Flight remains within 180 minutes of landing at a suitable airport.

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)
24-25-01-02 Backup Generator Input Shaft
24-25-01-02A

Interval	Installed	Required	Procedure
A	2	1	(M)

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Section 2

One Backup Generator Input Shaft may be inoperative (disconnected) provided:

- Oil is drained from disconnected generator,
 - Accessory Gearbox (AGB) Backup Generator pad seal drain is capped,
 - Flight Control System is verified to operate normally before each departure,
 - Opposite Backup Generator Input Shaft operates normally,
 - Both Engine Driven Generator Systems operate normally,
 - APU Driven Generator System operates normally,
 - PFCS Interface is considered inoperative,
 - Flight remains within 180 minutes of landing at a suitable airport, and
 - Repairs are made within 3 flight-days.
-

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)

24-25-01-02 Backup Generator Input Shaft

24-25-01-02B

Interval	Installed	Required	Procedure
C	2	1	(M)

One Backup Generator Input Shaft may be inoperative (disconnected) provided:

- Associated Backup Generator is removed and an appropriate dispatch kit is installed,
 - Flight Control System is verified to operate normally before each departure,
 - Opposite Backup Generator Input Shaft operates normally,
 - Both Engine Driven Generator Systems operate normally,
 - APU Driven Generator System operates normally,
 - PFCS Interface is considered inoperative, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)

24-25-01-03 Backup Generator Disconnect Mechanism

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Associated magnetic chip collector is checked for contaminants, and
 - Associated backup generator oil system status is verified normal.
-

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)**24-25-01-04 BACKUP GEN Switch Lights****24-25-01-04-01 OFF Lights**

Interval	Installed	Required	Procedure
C	2	0	

24-25-01 Backup AC Electrical Power System (Backup Generators, Converter and CCBs)**24-25-01-04 BACKUP GEN Switch Lights****24-25-01-04-02 ON Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 24-25-01.

The Backup Electrical Power System (BEPS) is a non-time limited power source for essential airplane loads connected to the Transfer Busses in the event of loss of power to one or both Main AC Busses. The system also provides power to a single transfer bus during single Main AC power source operation and following engine starts when the system performs an automatically initiated operational test. During normal operation, when the Main Electrical Power System is providing power to the transfer busses, BEPS operates in a standby mode, ready to provide 115 VAC, 400 Hz power. When possible, BEPS performs a no-break power transfer (NBPT) to minimize power interrupts to the transfer bus loads.

BEPS consists of two variable speed generators (one per engine), a frequency converter, 18 single phase current transformers (CTs) and four power contactors. Other BEPS equipment such as the Current Transformers and contactor design requirements are covered by the Electrical Load Management System (ELMS). The system is rated for 50 kVA. A single generator sources power to the converter while the alternate generator remains in a standby mode. Communication with the airplane is via two independent ARINC 629 databuses. Backup Generator (BUG)

The generator, driven by a dedicated engine gearbox pad, converts variable speed mechanical power to variable frequency electrical power. Each generator is oil cooled and normally operates between 14,071 to 27,693 rpm. The generator is sized such that the backup converter can supply rated power given feeder and converter losses.

The generator housing contains an oil pump, filter, oil pressure sensor and oil level sensor. A sight glass is also provided to visually check the oil level. The generator housing also contains two permanent magnet generators (PMGs) dedicated to supplying three phase power to the Integrated Flight Control Electronics Cabinets and a single control PMG for providing control, protection and excitation power to the frequency converter. The Flight Controls PMGs are integrated as part of the BUG. They are electrically separate from the BUG with the exception of sharing a common input shaft from the accessory gearbox (AGB).

The following is a description of the BUG and associated PMGs that power certain parts of the flight control system:

- If any 2 of the 4 Flight Controls PMGs are inoperative, the PFCS INTER-FACE Status message will be shown (ATA 27).
- If 3 or more of the 4 Flight Controls PMGs are inoperative, the FLIGHT CONTROL SYS Status message will be shown (no dispatch). There is no dispatch relief for this message. Note that it is possible for a BUG to have a fault even though the PMG for flight control system is operative.

Based on the above, it is possible to have both BUGs inoperative and still be able to dispatch the airplane (provided BUG PMGs are functioning). However, if both BUG shafts are sheared (or dispatch kits are installed in place of both BUGS), the FLIGHT CONTROL SYS message will not allow dispatch.

Backup Generator Disconnect Functions:

The Backup Generator Input Shaft includes a shear section. When the Backup Generator Input Shaft shears, the coupling to the gearbox is severed, and therefore isolates the Backup Generator from the engine.

For 777X, for compliance with FAR 25.1163(c), in addition to a shear neck, a new Backup Generator Disconnect Mechanism is incorporated to protect the AGB from BUG failure modes that may damage the AGB. The BUG contains an electrical disconnect device that allows the generator to be mechanically disengaged from the AGB shaft via automatic means. Activating the device severs the BUG input shaft, resulting in a loss of the BUG and the associated flight control PMGs. Once the device has been activated, there is no action from the flight deck that could re-connect the input shaft. The Backup Generator Disconnect Mechanism command is generated by the integrated flight control electronics (IFCE). The command triggers a relay that releases a spring loaded cutter. Decision data comes from the Electronic Engine Control (EEC) and Electrical Management System (ELMS) via CDN, and is based on detected vibration near the BUG.

Backup Converter (BUC)

The converter receives variable frequency input power from either generator and converts it to 3-phase, 115/200 V AC, 400 Hz output. It provides excitation to the generators and provides control, protection and metering for coordinated system performance. System status, maintenance data and flight deck messages are transmitted to the flight deck through the Common Data Network via redundant ARINC 629 databuses. The converter initiates an automatic system test upon engine start to verify proper operation and uses BITE to detect system failures.

The converter is installed in the forward equipment center. The converter is normally cooled by the main equipment cooling system when supplying power to a single transfer bus. An external supplemental fan is used to provide additional cooling when the converter is supplying power to both transfer buses and during abnormal conditions. The supplemental fan is powered, controlled, and protected by the converter.

Backup Generator Control Switch

The backup generator control switch is an alternate action, mechanically latched, push-button switch which incorporates an amber "OFF" indicator light and a mechanical flag "ON" indicator. The "OFF" indicator light will illuminate whenever the associated generator control relay (GCR) is open, the backup generator switch is off, or a fault occurred, or engine is shutdown, or engine fire switch is out, and both OFF lights will be illuminated when the backup generator converter is failed. This may be from manual operation of the associated generator control switch to the out position or from an automatic protection operation. Manually setting the switch to OFF resets the fault circuit and opens the backup gen control relay. The "ON" indication will be visible (and is backlighted) whenever the switch is depressed arming the generator breaker.

Consequences of Failure

Backup Electrical Power System (Backup Generators, Converter and CCBs) inoperative:

Failure of the BEPS is indicated by the ELEC BACKUP SYS Status message. The ELEC BACKUP SYS OFF Advisory message will also be displayed. BEPS will be inoperative. AC electrical power will be provided by the Main AC Electrical Power sources (IDGs, APU).

Failure of a BEPS Generator is indicated by either the ELEC BACKUP GEN L or ELEC BACKUP GEN R Status message. The associated BEPS Generator will not be available to power the BEPS. Remaining BEPS Generator remains available. The associated ELEC BKUP GEN OFF L or ELEC BKUP GEN OFF R Advisory message will also be displayed.

The ELEC BACKUP GEN L and ELEC BACKUP GEN R Status messages are inhibited if the ELEC BACKUP SYS Status message is displayed.

Backup Generator Input Shaft Disconnect:

A Backup Generator Input Shaft Disconnect resulting from activation of Backup Generator Disconnect Mechanism is indicated by either the ELEC BACKUP GEN DRIVE L or ELEC BACKUP GEN DRIVE R Status message.

The associated Backup Generator Input Shaft will be disconnected. The

associated Backup Generator will be inoperative. Both associated Permanent Magnet Generators (PMGs) will be inoperative resulting in the PFCS INTERFACE Status message. If either of the opposite side PMGs are inoperative, the FLIGHT CONTROL SYS Status message will be displayed.

Generator Remains Installed:

The Backup Generator Disconnect Mechanism physically cuts the Backup Generator Input Shaft which generates metallic debris in the AGB/BUG cavity. Dispatch requires the oil to be drained from the disconnected generator. In addition, the Accessory Gearbox (AGB) Backup Generator pad seal drain must be capped and a idle leak test performed.

Generator Removed - Dispatch Kit Installed:

Disconnected Backup Generator is removed and dispatch kit is installed. Dispatch kit provides a seal to prevent oil leakage from the AGB.

Backup Generator Disconnect Mechanism inoperative:

Failure of the Backup Generator Disconnect Mechanism or vibration detection function is indicated by either the ELEC BACKUP DISC CTRL L or ELEC BACKUP DISC CTRL R Status message. Associated Backup Generator will not automatically disconnect when conditions are present that would activate the disconnect mechanism. Inspection of the magnetic chip collector and oil system status are required to mitigate potential conditions that could result in a disconnect.

ON Light: The position of the switch flush with the panel can be determined and ambient light will indicate the shutter is open revealing ON.

OFF Light: The light will not be available for crew notification. The ELEC BKUP GEN OFF L, R Advisory message will remain operative.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

Backup Electrical Power System (Backup Generators, Converter and CCBs) inoperative at dispatch, or, Backup Electrical Generator Disconnect and generator removed at dispatch:

Subsequent failure of either the APU or one engine driven generator system would still leave two operative main generators. Two main generators provide sufficient power to meet all aircraft loads.

Backup Electrical Generator Disconnect - Generator Installed:

Metallic debris potentially migrates to AGB pad seal resulting in seal damage. Damage to AGB seal could result in leakage of engine oil resulting in in-flight shutdown (IFSD). Part power leak check at initial dispatch and drainmast inspection before each departure ensures that leakage has not occurred.

Backup Generator Disconnect Mechanism inoperative at dispatch:

BUG will not disconnect when commanded by the IFCE due to a BUG failure that would normally result in a disconnect command. Damage may occur to the AGB. AGB failure modes can result in loss of AGB oil and may result in an in-flight shutdown (IFSD).

ON Light: None

Federal Aviation Administration (FAA)

ATA 24

777-9 Master Minimum Equipment List

Section 2

OFF Light: If the light is failed and GCR opens, the ELEC BKUP GEN OFF L, R Advisory message will be displayed. The system is designed such that if either generator is inoperative, the other generator can provide power to the transfer busses via the frequency converter.

Draft
Feb 26, 2026

24-28-01 BUS TIE Switch Lights**24-28-01-01 ISLN Lights**

Interval	Installed	Required	Procedure
C	2	0	

24-28-01 BUS TIE Switch Lights**24-28-01-02 AUTO Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-28-03.

The Bus Tie switch is an alternate action, mechanically latched, push-button switch which incorporates an amber "ISLN" light and a mechanical shuttered "AUTO" indication. The "ISLN" indicator light will illuminate (amber) whenever the Bus Tie switch is operated to the out position, or from automatic operation of a protection function where the bus tie is opened due to a fault. The "AUTO" indication is visible (and backlighted) whenever the switch is depressed which arms the bus tie breaker.

Consequences of Failure

AUTO Light: The position of the switch flush with the panel can be determined and ambient light will indicate the shutter is open revealing AUTO.

ISLN Light: The light will not be available for crew notification.

Consequences of Next Critical Failure

AUTO Light: None

ISLN Light: If the light is failed and another fault occurs which prevents normal BTB operation, the ELEC BUS ISLN L, R Advisory message will be displayed. The ELEC AC BUS OFF L, R Caution messages will also be available to alert the flight crew if the ISLN light is inoperative and an AC bus is isolated.

Federal Aviation Administration (FAA)**ATA 24****777-9 Master Minimum Equipment List****Section 2****24-31-01 Auxiliary Power Unit (APU) Battery****24-31-01A**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Battery Charger is deactivated,
 - APU is started before departure and is operated for the entire flight, and
 - Appropriate performance adjustments are applied.
-

24-31-01 Auxiliary Power Unit (APU) Battery**24-31-01B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Battery Charger is deactivated,
 - Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of the APU, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

24-31-01 Auxiliary Power Unit (APU) Battery**24-31-01C**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative removed provided:

- APU battery is removed,
 - APU Battery Charger is deactivated,
 - Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of the APU, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-31-01.

The APU is designed with an electric and an air turbine starter. The air turbine starter is the primary means of starting the APU when pneumatic power is available. If pneumatic power is not available, the APU controller uses the electric starter. The APU battery supplies electrical power for APU turbine cranking and control.

Consequences of Failure

Failure of the APU battery is indicated by the APU BATTERY Status message. An APU battery overheat condition is indicated by the APU BATTERY OVHT Status message.

For APU required:

With a failed APU battery, the APU battery charger will shut down and the APU battery will not be recharged. After the APU battery discharges, the APU will not have electric start capability. Although an air turbine starter (ATS) is part of the APU design for both the 777-300ER and 777X, some inflight failure modes which call for an APU start may render pneumatic air unavailable. For this reason, if the APU is required and APU battery is inoperative, APU must be started before departure and run the entire flight. The APU battery charger must be deactivated.

For APU not required:

APU is not used. APU battery charger is deactivated. Other procedures must not require use of APU.

Consequences of Next Critical Failure

For APU required:

Subsequent failure of APU, or IDG or engine would leave at least two 150 kVA AC power sources.

For APU not required:

Subsequent failure of either an IDG or an engine would leave at least one operative 150 kVA AC power source. If one 150 kVA AC source remains, the Backup AC Electrical Power System would then assume the load on one AC Transfer Bus. Additionally, load shedding of non-essential loads would occur to ensure sufficient power is available for essential loads.

Federal Aviation Administration (FAA)**ATA 24****777-9 Master Minimum Equipment List****Section 2****24-31-02 Auxiliary Power Unit (APU) Battery Charger****24-31-02A**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Battery Charger is deactivated,
 - APU is started before departure and is operated for the entire flight, and
 - Appropriate performance adjustments are applied.
-

24-31-02 Auxiliary Power Unit (APU) Battery Charger**24-31-02B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Battery Charger is deactivated,
 - Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of APU, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 777 24-31-02.

The APU battery charger system is used to maintain the APU battery at a fully charged state.

Consequences of Failure

Failure of the APU battery charger is indicated by the BAT CHARGER APU Status message.

For APU required:

With a failed APU battery charger the APU battery will not be recharged. After the APU battery discharges, the APU will not have electric start capability. Although an air turbine starter (ATS) is part of the APU design for both the 777-300ER and 777X, some inflight failure modes which call for an APU start may render pneumatic air unavailable. For this reason, if the APU is required and APU battery is inoperative, APU must be started before departure and run the entire flight. The APU battery charger must be deactivated.

For APU not required:

APU is not used. APU battery charger is deactivated. Other procedures must not require use of the APU.

Consequences of Next Critical Failure

For APU required:

Subsequent failure of the APU, or an IDG or engine would leave at least two 150 kVA AC power sources.

For APU not required:

Subsequent failure of either an IDG or an engine would leave at least one operative 150 kVA AC power source. If one 150 kVA AC source remains, the Backup AC Electrical Power System would then assume the load on one AC Transfer Bus. Additionally, load shedding of non-essential loads would occur to ensure sufficient power is available for essential loads.

Draft
Feb 26, 2026

Federal Aviation Administration (FAA)**ATA 24****777-9 Master Minimum Equipment List****Section 2****24-31-03 BATTERY Switch Lights****24-31-03-01 OFF Light**

Interval	Installed	Required	Procedure
C	1	0	

24-31-03 BATTERY Switch Lights**24-31-03-02 ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 777.24-31-03.

The Main Battery control switch is an alternate action, mechanically latched, push-button switch which incorporates an amber "OFF" indicator light and a mechanical shuttered "ON" indicator. The light is located on the overhead (P5) electrical panel. The "OFF" indicator light will illuminate and EICAS Advisory ELEC BATTERY OFF is displayed whenever the switch is in the OFF position. This will de-energize the "On-Ground Battery Only" mode. The main battery provides power for the following:

OFF:

- On the ground, Battery Bus 2 is not powered.
- Illuminated (amber) – the battery switch off and the airplane has AC power.

ON:

On ground and airplane does not have AC power:

- Some switch annunciator lights are illuminated
- Allows the APU to be started

On the ground after AC power is disconnected or lost:

- Standby busses and emergency lighting are powered
- The left inboard, outboard, and upper center displays, and the left CDU are powered

Consequences of Failure

OFF Light: The OFF light will not be available for crew notification. EICAS advisory message informs the flight crew of OFF state.

ON Light: None. The switch depressed in provides confirmation that the switch is in ON position.

Consequences of Next Critical Failure

OFF Light: None.

ON Light: None.

Draft
Feb 26, 2026

Federal Aviation Administration (FAA)

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777-9 Master Minimum Equipment List

Section 2

24-41-01 External Power Systems

Interval	Installed	Required	Procedure
C	2	0	

24-41-01 External Power Systems

24-41-01-01 AVAIL Lights (Flight Deck)

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

24-41-01 External Power Systems

24-41-01-02 ON Lights (Flight Deck)

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

24-41-01 External Power Systems

24-41-01-03 External Power Connected Lights (External Power Panel)

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

24-41-01 External Power Systems

24-41-01-04 External Power Not In Use Lights (External Power Panel)

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION

Background

Proposal is based on 777 MMEL item 24-41-01.

An external ground power source can be used to supply the airplane with electrical power for the electrical buses for Ground Handling, Ground Service and Main AC.

The bus power control unit (BPCU) provides external power protection and coordinates power transfers between auxiliary generator power, external power, and engine generator power. The BPCU also controls the external power contactors, the ground handling relay and the ground service relays (GSSR/GSTR).

The external power panel has two external power receptacles that have a continuous supply capacity of 90 kVA each. The panel is immediately to the right of the main equipment center access door approximately 10 ft (3 m) above the ground. The forward receptacle is for primary external power. The aft receptacle is for secondary external power. Each receptacle has four large pins for ac power and two small ones for the interlock. Above each receptacle are two indication lights; CONNECTED and NOT IN USE. Placards inside the panel access door list specific information about connecting external power. If the power quality from the ground cart is within acceptable range, the BPCU supplies power to turn on the related CONNECTED and NOT IN USE lights. Selecting primary external power or ground service power causes the primary NOT IN USE light to extinguish. Selecting secondary external power causes the secondary NOT IN USE light to extinguish.

Pressing the flight deck Primary External Power switch connects primary external power to the main AC buses. The BPCU closes the primary EPC and the GCUs close the BTBs to connect the power. Pressing the flight deck Secondary External Power switch connects secondary external power to the main AC buses. The BPCU closes the secondary EPC and the GCUs close the BTBs to connect the power. If primary external power was on the right main AC bus, the right GCU opens the right BTB first to perform a break-power transfer. Note: The secondary external power source does not supply power to the BPCU. To use secondary external power, you must connect the primary external power or push the battery switch on.

The AVAIL and ON lights are located on the overhead panel. The AVAIL light illuminates when external power is plugged in and power quality is within acceptable range. Push the battery switch on and push the primary external power switch to apply primary ground power to the airplane electrical system. Push the secondary external power switch to apply secondary ground power to the airplane electrical system. When you supply power, the AVAIL light extinguishes and the ON light illuminates.

Therefore, the alternate procedure would include a way for flight crew and ground crew to communicate each other of the external power status. For example, when the AVAIL lights are inoperative, ground crew would inform flight crew using interphone when CONNECTED and NOT IN USE lights come on (this is the same condition as when the AVAIL light comes on). When the ON lights are inoperative, ground crew would inform flight crew when NOT IN USE light comes off. The same procedure for when CONNECTED and/or NOT IN USE lights are inoperative.

Consequences of Failure

Failure of the BPCU trips the external power contactors, the ground handling relay, the ground service select relay and the ground service transfer relay. Electrical power for the Ground Handling Bus will not be available. An alternate power source, such as the APU, would be needed to supply electrical power to the Ground Service Bus.

Failure of the misc lights: Alternate procedure is required for the flight crew and ground crew to communicate with each other about the external power status.

Consequences of Next Critical Failure

Loss of the APU is considered the next critical failure. Without the APU, an engine driven generator could supply the electrical power needed for the Ground Service Bus.

Misc lights: None.

24-41-02 Bus Power Control Unit (BPCU)

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Alternating Current (AC) Bus Control System - Ground Handling Bus is considered inoperative, and
- Engine Turning System is considered inoperative.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 24-41-02.

The external power contactors are controlled by the Bus Power Control Unit (BPCU). The BPCU provides external power protection and coordinates power transfers between auxiliary generator power, external power, and engine generator power. The BPCU controls the external power contactors, the ground handling relay and the ground service relay.

Consequences of Failure

Display crew alerting system (DCAS) will display the ELEC BPCU Status message when bus communication stops. The BPCU may have failures resulting in the contactors not being driven to the correct position but the message will not be set if there is valid bus communication.

Failure of the BPCU trips the external power contactors, the ground handling relay, the ground service select relay and the ground service transfer relay. Electrical power for the Ground Handling Bus will not be available. An alternate power source, such as the APU, would be needed to supply electrical power to the Ground Service Bus. For 777X, the Engine Turning System (ETS) will also be inoperative (see ATA 80).

Consequences of Next Critical Failure

Loss of the APU is considered the next critical failure. Without the APU, an engine driven generator could supply the electrical power needed for the Ground Service Bus.

Federal Aviation Administration (FAA)

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777-9 Master Minimum Equipment List

Section 2

24-51-01 Electrical Load Control Units (ELCUs)

24-51-01-01 Left Utility Bus ELCU

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- Inoperative left ELCU is deactivated,
- Captain's Flight Deck Foot Heater is considered inoperative,
- Captain's Flight Deck Shoulder Heater is considered inoperative,
- Nitrogen Generation System (NGS) is considered inoperative, and
- Repairs are made within 10 flight-days.

For Gasper Fan installed:

- Gasper Fan is considered inoperative.

24-51-01 Electrical Load Control Units (ELCUs)

24-51-01-02 Right Utility Bus ELCU

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Inoperative right ELCU is deactivated,
- Forward Cargo Heat Valve is considered inoperative,
- First officer's Flight Deck Foot Heater is considered inoperative,
- First officer's Flight Deck Shoulder Heater is considered inoperative, and
- Logo Lights are considered inoperative.

For Aft Chiller Boost Fans installed:

- Right Aft Chiller Boost Fan is considered inoperative.

SUBSTANTIATION

Background

New proposal for 777X.

The Electrical Load Control Units (ELCU) operate as a remote controlled power contactor with current overload protection to the power feeder circuit. Current of each power phase is sensed. The current monitoring circuitry includes an overcurrent detector which monitors current according to time-current (I2T) characteristics. If the current in any phase exceeds the time-current threshold of the detector, the ELCU trips (opens the contacts). The threshold matches the overload limits for wires and cables.

Consequences of Failure

The L (or R) UTIL ELCU status message will be displayed if ELMS detects a current sensor fault.

Failure of an ELCU current sensor results in loss of the overcurrent protection function. A subsequent wiring short could potentially result in a fire hazard or loss of the primary upstream AC bus. For dispatch, the associated ELCU is deactivated. All equipment powered by the associated utility bus will be unavailable. Next critical failure is mitigated by deactivation of the associated ELCU.

Consequences of Next Critical Failure

None.

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Feb 26, 2026

24-61-01 Ground Handling Transformer Rectifier Unit

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal is based on 777 MMEL item 24-61-01.

The Ground Handling TRU converts main AC power to unregulated 28 volt DC power for the DC loads required during ground operations. The Ground Handling TRU is unpowered during flight.

Consequences of Failure

If the Ground Handling TRU is failed, electrical power will not be available to the Ground Handling DC Bus. (Cabin Interphones, Cargo Door Control, Cargo Handling Control, Engine Cowl Door Control, etc.)

Consequences of Next Critical Failure

None.

25-00-01 Non-Essential Equipment and Furnishings (NEF)

25-11-01 Flightcrew Seats

25-11-01-01 Powered Adjustment Systems

25-11-01-01-01 Powered Lumbar Adjustment

25-11-01-02 Manual Adjustment Systems

25-11-01-02-01 Recline Systems

25-11-01-02-02 Vertical Adjustments

25-11-01-02-02A

25-11-01-02-02B

25-11-01-02-03 Armrests

25-11-01-02-03A

25-11-01-02-03B

25-11-01-02-04 Lumbar/Thigh Supports

25-11-01-02-05 Headrests

25-11-01-02-06 Seat Pan Tilt

25-11-01-02-07 Armrest Extensions

25-11-01-02-08 Thigh Support Extensions

25-11-02 Observer Seat(s)

25-11-02-01 First Observer Seat (Including Associated Equipment)

25-11-02-01A

25-11-02-01B

25-11-02-01C

25-11-02-02 Second Observer Seat (Including Associated Equipment)

25-18-01 Extended Over-Water Operation Emergency Equipment

25-24-01 Partitions & Class Dividers

25-24-01-01 Viewing Window

25-25-01 Flight Attendant Seat Assembly

25-25-01-01 Required Flight Attendant Seats

25-25-01-01A

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25-25-02 Passenger Seats

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25-25-02-02 Positioning Controls for Taxi, Takeoff, and Landing (TTL) (Mechanical and/or Electrical)

25-25-02-02A

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25-25-02-04-02 Without Seat Positioning Controls for Taxi, Takeoff, and Landing (TTL) and/or Other Controls

25-25-02-05 Seat Belt/Air Bag Restraint System

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25-25-02-05B

25-25-02-06 Delethalization Pads

25-25-03 First Class Suites

25-25-03-01 Entry Door

25-25-03-01A

25-25-03-01B

25-25-04 Business Class Mini-Suites

25-25-04-01 Entry Doors

25-25-04-01A

25-25-04-01B

25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets

25-28-01A

25-28-01B

25-28-01C

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25-29-01-02	Door Lock
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25-29-01-04	Bunks
25-29-02	Overhead Flight Attendant Rest (OFAR)
25-29-02A	
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25-64-03B
25-64-03-01 Tamper Seals or Tags
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25-64-04A
25-64-04B
25-64-04-01 Tamper Seals or Tags
- 25-64-05 First Aid Kit (FAK) and/or Associated Equipment**
25-64-05A
25-64-05B
25-64-05-01 Tamper Seals or Tags

25-00-01

Non-Essential Equipment and Furnishings (NEF)

Interval	Installed	Required	Procedure
-	-	0	

May be inoperative, damaged, or missing provided that the item(s) is deferred in accordance with the operator's NEF deferral program. The NEF program, procedures, and processes must be outlined in the operator's appropriate document. (M) and (O) procedures, if required, must be available to the flightcrew and included in the operator's appropriate document.

NOTE: Exterior lavatory door ash trays are not considered NEF items.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-00-01.

Refer to Policy Letter 116.

Consequences of Failure

Items are not essential for safe flight and are not required for operation of the aircraft.

Consequences of Next Critical Failure

None.

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Section 2

25-11-01 Flightcrew Seats

25-11-01-01 Powered Adjustment Systems

Interval	Installed	Required	Procedure
D	2	0	(M)

May be inoperative provided inoperative powered adjustment system(s) is deactivated.

25-11-01 Flightcrew Seats

25-11-01-01 Powered Adjustment Systems

25-11-01-01-01 Powered Lumbar Adjustment

Interval	Installed	Required	Procedure
D	2	0	(M)

May be inoperative provided:

- Inoperative powered lumbar adjustment system(s) is deactivated, and
- Seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-01 Recline Systems

Interval	Installed	Required	Procedure
A	2	0	(M)

May be inoperative provided:

- Seat is secured in an upright position acceptable to affected crewmember, and
- Repairs are made within 2 flight-days.

25-11-01 Flightcrew Seats**25-11-01-02 Manual Adjustment Systems****25-11-01-02-02 Vertical Adjustments****25-11-01-02-02A**

Interval	Installed	Required	Procedure
A	2	0	

May be inoperative provided:

- Seat is acceptable to affected crewmember, and
- Repairs are made within 2 flight-days.

25-11-01 Flightcrew Seats**25-11-01-02 Manual Adjustment Systems****25-11-01-02-02 Vertical Adjustments****25-11-01-02-02B**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided associated vertical Powered Adjustment System operates normally.

25-11-01 Flightcrew Seats**25-11-01-02 Manual Adjustment Systems****25-11-01-02-03 Armrests****25-11-01-02-03A**

Interval	Installed	Required	Procedure
B	4	0	(M)

May be inoperative provided:

- Inoperative armrest is stowed in the retracted position, and
- Seat is acceptable to affected crewmember.

Federal Aviation Administration (FAA)

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777-9 Master Minimum Equipment List

Section 2

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-03 Armrests

25-11-01-02-03B

Interval	Installed	Required	Procedure
B	4	0	(M)

May be inoperative provided:

- Inoperative armrest is removed, and
- Seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-04 Lumbar/Thigh Supports

Interval	Installed	Required	Procedure
C	4	0	

May be inoperative provided seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-05 Headrests

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-06 Seat Pan Tilt

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Inoperative seat pan tilt is secured in the horizontal (untilted) position, and

b. Seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-07 Armrest Extensions

Interval	Installed	Required	Procedure
D	4	0	

May be inoperative provided seat is acceptable to affected crewmember.

25-11-01 Flightcrew Seats

25-11-01-02 Manual Adjustment Systems

25-11-01-02-08 Thigh Support Extensions

Interval	Installed	Required	Procedure
D	4	0	

May be inoperative provided seat is acceptable to affected crewmember.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 25-11-01.

The captain's and first officer's seats are constructed with various features to improve comfort and adjust seating position for optimum visibility. Electrical adjustments include vertical, horizontal (forward and aft direction) and lumbar adjustments. Manual adjustments include recline, vertical, horizontal, armrest/armrest extension, thigh support/thigh support extension, headrest and seat pan tilt.

Consequences of Failure

Power adjustment systems may be inoperative provided they are deactivated. Seats can be adjusted manually in the event that the electrical vertical and horizontal adjustments are inoperative. Lumbar adjustment is not manually adjustable. Power lumbar adjustment may be inoperative if acceptable to the affected crew member.

Manual adjustment systems:

Recline system: Seat is secured in upright position.

Vertical system: May be inoperative if associated power system operates normally.

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Section 2

Horizontal system: Dispatch is not allowed for inoperative horizontal manual adjustment.

Armrests/armrest extensions, thigh supports/thigh support extensions: May be inoperative removed or in stowed position provided it is acceptable to affected crew member.

Thigh supports/thigh support extensions: May be inoperative if acceptable to affected crew member.

Headrests: May be inoperative if acceptable to affected crew member.

Seat pan tilt: May be inoperative provided seat is secured in horizontal position and is acceptable to affected crew member.

Consequences of Next Critical Failure

None.

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Feb 26, 2026

Federal Aviation Administration (FAA)**Section 2****777-9 Master Minimum Equipment List****ATA 25****25-11-02 Observer Seat(s)****25-11-02-01 First Observer Seat (Including Associated Equipment)****25-11-02-01A**

Interval	Installed	Required	Procedure
A	1	0	

May be inoperative provided:

- A passenger seat in the passenger cabin is made available to an FAA inspector for the performance of official duties, and
 - Repairs are made within 2 flight-days.
-

25-11-02 Observer Seat(s)**25-11-02-01 First Observer Seat (Including Associated Equipment)****25-11-02-01B**

Interval	Installed	Required	Procedure
A	1	0	

May be inoperative provided:

- Second observer seat is available and acceptable to an FAA inspector for the performance of official duties, and
 - Repairs are made within 2 flight-days.
-

25-11-02 Observer Seat(s)**25-11-02-01 First Observer Seat (Including Associated Equipment)****25-11-02-01C**

Interval	Installed	Required	Procedure
A	1	0	

May be inoperative provided:

- Required minimum safety equipment (safety belt and oxygen) is available,
- Seat is acceptable to the FAA inspector for performance of official duties, and
- Repairs are made within 2 flight-days.

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Section 2

NOTE 1: These provisos are intended to provide for occupancy of the above seat by an FAA inspector when the minimum safety equipment (oxygen and safety belt) is functional and the inspector determines the conditions to be acceptable.

NOTE 2: The pilot-in-command will determine if the minimum safety equipment is functional for other persons authorized to occupy an observer seat(s).

25-11-02 Observer Seat(s)

25-11-02-02 Second Observer Seat (Including Associated Equipment)

Interval	Installed	Required	Procedure
D	-	0	

NOTE: The pilot in command will determine if the minimum safety equipment is functional for the other persons authorized to occupy any observer seat(s).

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 25-11-02.

Refer to MMEL Policy letter 56.

The first and second observer seats provide comfort and protection for additional flight crew.

The first observer seat includes a headrest, armrests, restraint system, and seat manual adjustment controls for recline, vertical, horizontal, armrest, headrest, and lumbar adjustment. The left armrest lifts to a vertical position for entry and exit. The right armrest contains a folding work table. The restraint system has a shoulder harness, lap belt, and crotch strap. The support base has bogies that attach the seat to the floor tracks. The floor tracks give forward/aft adjustment. There are also adjustment levers to adjust the horizontal and vertical position of the seat.

The second observer seat includes a headrest, armrests and restraint system. The restraint system has a shoulder harness, lap belt, and crotch strap. The seat structure attaches to the aft flight deck bulkhead. The bottom of the seat and the armrests fold up for stowage. Straps (not shown) hold the seat bottom in the folded position. There are no adjustments on the second observer seat.

Consequences of Failure

FAA relief is based on MMEL Policy Letter 56: For an inoperative First Observer Seat, either the Second Observer Seat or a passenger seat may be made available to an FAA inspector. For a First Observer Seat with inoperative associated equipment, the First Observer Seat may be used if it is acceptable to the FAA inspector.

EASA relief is based on CS-MMEL: The First Observer and/or Second Observer Seat may be inoperative if the associated seat is not required.

Consequences of Next Critical Failure

None.

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Feb 26, 2026

25-18-01 **Extended Over-Water Operation Emergency Equipment**

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or missing provided required distribution is maintained.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-18-01.

For FAA: 14 CFR 121.339 and 121.340 establish the requirements for emergency equipment for extended over-water operations and emergency flotation means. Required equipment includes personal flotation devices, life rafts, signaling devices, emergency locator transmitters, and survival kits. Equipment is specified in terms of the number of passengers embarked and the type of operation being conducted.

For EASA: Refer to CS-MMEL items 25-60-6 & 25-60-7.

Consequences of Failure

Only applies to equipment in excess of that required.

Consequences of Next Critical Failure

None identified.

25-24-01

Partitions & Class Dividers

25-24-01-01

Viewing Window

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative provided Viewing Window is secured open.

- - - - -

SUBSTANTIATION

Background

New proposal for 777X.

The class divider viewing window is located midway up on the panel embedded into the structure and facilitates attendant passenger observation. The window can flip down/up and secure to enhance class division when passenger viewing would otherwise be restricted from the configuration of the interior monuments.

Consequences of Failure

Failure would result in the flight attendants having to observe passengers directly and inability for the class divider to properly limit light between classes (if option was selected).

Consequences of Next Critical Failure

None Identified.

Federal Aviation Administration (FAA)**ATA 25****777-9 Master Minimum Equipment List****Section 2****25-25-01 Flight Attendant Seat Assembly****25-25-01-01 Required Flight Attendant Seats****25-25-01-01A**

Interval	Installed	Required	Procedure
B	-	-	(M) (O)

One seat position may be inoperative provided:

- Affected seat position or seat assembly is not occupied,
- Flight Attendant(s) displaced by inoperative seat(s) occupies either an adjacent flight attendant seat or the passenger seat which is most accessible to the inoperative seat(s) so as to most effectively perform assigned duties,
- Alternate procedures are established and used as published in crewmember manuals,
- Folding type seat stows automatically or is secured in the retracted position, and
- Passenger seat assigned to Flight Attendant is placarded "FOR FLIGHT ATTENDANT ONLY".

NOTE 1: An automatic folding seat that will not stow automatically is considered inoperative.

NOTE 2: A seat position with an inoperative or missing restraint system is considered inoperative.

NOTE 3: Individual operators, when operating with inoperative seats, will consider the locations and combinations of seats to ensure that proximity to exits and distribution requirements of the applicable 14 CFRs are met.

25-25-01 Flight Attendant Seat Assembly**25-25-01-01 Required Flight Attendant Seats****25-25-01-01B**

Interval	Installed	Required	Procedure
C	-	0	(M) (O)

May be inoperative provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger-carrying operations,
- Folding type seat stows automatically or is secured in the retracted position,
- Affected seat is not occupied, and

e. Alternate procedures are established and used.

NOTE 1: An automatic folding seat that will not stow automatically is considered inoperative.

NOTE 2: A seat position with an inoperative or missing restraint system is considered inoperative.

25-25-01 Flight Attendant Seat Assembly

25-25-01-02 Excess Flight Attendant Seats

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided:

- Affected seat position or seat assembly is not occupied, and
- Folding type seat stows automatically or is secured in the retracted position.

NOTE 1: An automatic folding seat that will not stow automatically is considered inoperative.

NOTE 2: A seat position with an inoperative or missing restraint system is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL 25-25-01.

Refer to MMEL Policy Letter 97 and 125.

Operators are provided with layout of each unique interior configuration that shows the attendant seats required to be occupied for takeoff and landing to meet FAA/JAA direct view of cabin requirements. Included on the layout are the acceptable alternate attendant seats for each direct view zone of the airplane. Dual seat assemblies are not installed on the 777X.

Consequences of Failure

Flight attendant duties can still be accomplished.

Consequences of Next Critical Failure

None.

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25-25-02 Passenger Seats

25-25-02-01 Passenger Seats (Includes all Configurations and Locations)

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative provided:

- Seat does not restrict access to any emergency exit, egress route, or main aisle, and
- The affected seat(s) is blocked and placarded "DO NOT OCCUPY".

NOTE 1: A seat with an inoperative seat belt or shoulder harness is considered inoperative.

NOTE 2: Affected seat(s) may include the seat(s) behind and/or adjacent outboard seats.

NOTE 3: Inoperative seats do not affect the required number of flight attendants.

25-25-02 Passenger Seats

25-25-02-02 Positioning Controls for Taxi, Takeoff, and Landing (TTL) (Mechanical and/or Electrical)

25-25-02-02A

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative and seat occupied provided seat is secured in the taxi, takeoff, and landing (TTL) position.

25-25-02 Passenger Seats

25-25-02-02 Positioning Controls for Taxi, Takeoff and Landing (TTL) (Mechanical and/or Electrical)

25-25-02-02B

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative and seat occupied provided seat is immovable in the taxi, takeoff, and landing (TTL) position.

25-25-02 Passenger Seats**25-25-02-03 Under Seat Baggage Restraining System**

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative provided:

- Baggage is not stowed under seat with inoperative restraining system,
- Associated seat is placarded "DO NOT STOW BAGGAGE UNDER THIS SEAT", and
- Procedures are established to alert Cabin Crew of inoperative restraining system.

25-25-02 Passenger Seats**25-25-02-04 Armrests****25-25-02-04-01 With Seat Positioning Controls for Taxi, Takeoff, and Landing (TTL) and/or Other Controls**

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative or missing and seat occupied provided:

- Armrest does not restrict access to any emergency exit, egress route, or main aisle, and
- If armrest with seat control is missing or removed, seat is secured in taxi, takeoff, and landing (TTL) position.

25-25-02 Passenger Seats**25-25-02-04 Armrests****25-25-02-04-02 Without Seat Positioning Controls for Taxi, Takeoff, and Landing (TTL) and/or Other Controls**

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative or missing and seat occupied provided it does not restrict access to any emergency exit, egress route, or main aisle.

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25-25-02 Passenger Seats

25-25-02-05 Seat Belt/Air Bag Restraint System

25-25-02-05A

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative provided affected seat is blocked and placarded "DO NOT OCCUPY".

25-25-02 Passenger Seats

25-25-02-05 Seat Belt/Air Bag Restraint System

25-25-02-05B

Interval	Installed	Required	Procedure
D	-	-	(M)

May be inoperative or disconnected provided:

- Seat Belt/Air Bag restraint system is disconnected, and
- Seat belt operates normally.

25-25-02 Passenger Seats

25-25-02-06 Delethalization Pads

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative or missing provided affected seat is blocked and placarded "DO NOT OCCUPY".

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 25-25-02.

Refer to MMEL Policy Letter 79.

A passenger seat secured in the upright position can be occupied, while an inoperative seat in a position other than upright shall not be occupied.

The Delethalization Pad was added to find compliance for Head Injury Criteria (HIC) FAR 25.785(d) - Front Row Head Strike Zone. Each occupant of a seat that makes more than an 18° angle with the vertical plane containing the airplane centerline must be protected from head injury by a safety belt and an energy absorbing rest that will support the arms, shoulders, head, and spine, or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object.

Added MMEL provisos and repair category for Seat Belt Air Bag Restraint Systems. These items are customer configuration dependant only installed on seats which cannot meet occupant injury criteria.

Consequences of Failure

For passenger seats that are inoperative, the affected seat must be blocked and placarded DO NOT OCCUPY.

For passenger seats with inoperative positioning controls, the must either secured or the taxi, takeoff and landing (TTL) position or inoperative in the TTL position.

An inoperative under seat baggage restraining system must be placarded DO NOT STOW BAGGAGE UNDER THIS SEAT and not used.

For an inoperative passenger seat armrest, the seat may be occupied provided egress is not restricted.

Seat belt/air bag restraint system may be inoperative provided either seat is not occupied or not required by regulation.

For an inoperative or missing delethalization pad, the affected seat is blocked and placarded DO NOT OCCUPY.

Consequences of Next Critical Failure

None identified.

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Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided:

- Affected seat is not occupied, and
 - Affected seat is considered inoperative.
-

25-25-03 First Class Suites*********25-25-03-01 Entry Door****25-25-03-01A**

Interval	Installed	Required	Procedure
D	-	0	(M)

One or more may be inoperative and seat occupied provided the affected door(s) is secured in the fully open position or removed.

25-25-03 First Class Suites*********25-25-03-01 Entry Door****25-25-03-01B**

Interval	Installed	Required	Procedure
D	-	0	

One or more may be inoperative provided:

- Affected seat is not occupied, and
 - Affected seat is considered inoperative.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 25-25-05.

The First Class High Wall Passenger Suites installation consists 6 First-Class Suites. The walls of the suites extend 67" upward from the floor. Each suite has an entry door that can be closed for privacy.

The first-class suites are equipped with dual independent sliding doors opening in opposite directions, in order to provide the occupant dual means of egress.

Each suite is for a single occupant during taxi, takeoff, and landing but there is an ottoman in each suite which may be occupied in-flight only.

The seats may also be in bed mode while in-flight only.

The center suites have the ability to switch into "tandem" mode allowing for both seats to operate at the same time. The center suites also have a privacy divider that has four configurations that may be placed in while in-flight.

The wall height of the suites is 67 inches along the aisle. The gap opens into open cabin and allows for the air from the air distribution system to circulate in and out the suites.

Consequences of Failure

The affected suites are not occupiable.

Door secured open or removed - None.

Consequences of Next Critical Failure

None identified.

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Interval	Installed	Required	Procedure
D	-	0	(M)

One or more may be inoperative and seat occupied provided the affected door(s) is secured in the fully open position or removed.

25-25-04 Business Class Mini-Suites*********25-25-04-01 Entry Doors****25-25-04-01B**

Interval	Installed	Required	Procedure
D	-	0	

One or more may be inoperative provided:

- Affected seat is not occupied, and
 - Affected seat is considered inoperative.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 25-25-06.

Each Business Class Plus mini-suite features one pocket style door per passenger. The primary means of egress out of the suite is through the opening available when the door is stowed.

Business Class Mini-Suites have added features to provide additional passenger privacy. Privacy is provided with a combination of doors and emergency passage features (EPFs). For taxi, takeoff and landing, door(s) and EPF(s) need to be stowed in the open position. Each suite is accessible from the aisle by sliding door(s). Each suite door and EPF include two latching mechanisms, primary and secondary, as well as guide rails that support the opening and closing movement. Each latching mechanism has visible indicators as to the position of the latch.

Consequences of Failure

Door secured open or removed - None.

Upon latch and/or guide rail failure, the suite door could become inoperative in a closed/ajar position, obstructing entry/exit to the suite. Suite may be used, provided that the affected door(s) and/or EPF is secured in the fully open position.

Consequences of Next Critical Failure

None identified.

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25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets**25-28-01A**

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided:

- Procedures are established to secure the affected bin, compartment, or closet in the closed position,
- Affected bin, compartment, or closet is prominently placarded "DO NOT USE",
- Any emergency equipment located in affected bin, compartment, or closet is considered inoperative, and
- Affected bin, compartment, or closet is not used for storage of any items except for those permanently affixed.

NOTE 1: For overhead bins, if no partitions are installed, the entire overhead bin is considered inoperative.

NOTE 2: Proviso is not intended to preclude crewmember inspections.

25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets**25-28-01B**

Interval	Installed	Required	Procedure
C	-	-	(M) (O)

May be inoperative provided:

- For nonretractable doors, affected door is removed,
- For retractable doors, affected door is removed or secured in the retracted (fully open) position,
- Affected bin, compartment, or closet is prominently placarded "DO NOT USE",
- Affected bin, compartment, or closet is not used for storage of any items except those permanently affixed,
- Procedures are established and used to alert crewmembers and passengers of inoperative bins, compartments, or closets, and
- Passengers are briefed that affected bin, compartment, or closet is not used.

NOTE 1: For overhead bins, if no partitions are installed, the entire overhead bin is considered inoperative.

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NOTE 2: Any emergency equipment located in the affected bin, compartment, or closet (permanently affixed) is available for use.

25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets**25-28-01C**

Interval	Installed	Required	Procedure
C	-	-	

May be inoperative in closed position provided:

- Affected bin, compartment, or closet is prominently placarded "DO NOT USE",
- Any emergency equipment located in affected bin, compartment, or closet is considered inoperative, and
- Location placarding for any emergency equipment stored in affected bin, compartment, or closet is removed or obscured.

NOTE: Use of this proviso may be dependent upon an operator's aircraft security program, as appropriate.

25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets**25-28-01-01 Multi Latch/Quarter Turn Lug Installations**

Interval	Installed	Required	Procedure
C	-	-	

One latch/lug per compartment may be inoperative provided:

- Remaining latch(es)/lug(s) on affected compartments operates normally, and
 - If affected compartment is used for a galley cart, the cart remains empty.
-

25-28-01 Storage Bins/Cabin, Galley, and Lavatory Storage Compartments/Closets**25-28-01-02 Storage Compartment Key Locks*********

Interval	Installed	Required	Procedure
D	-	0	(M)

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May be inoperative in the unlocked position provided doors can be secured by other means.

SUBSTANTIATION

Background

Proposal is based on 787 MMEL item 25-28-01.

Refer to MMEL Policy Letter 104.

Consequences of Failure

Inoperative Compartment: Storage compartment must be secured closed, or affected door removed, or closed and placarded. Affected storage compartment must not be used.

One inoperative latch/lug: Remaining lug(s)/latch(es) keep compartment closed.

Consequences of Next Critical Failure

Inoperative Compartment: None

Failure of additional latch/lug: Affected compartment will be inoperative.

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25-28-02 Overhead Cabin Stowage Option (OCSO)

Interval	Installed	Required	Procedure
D	-	0	(M)

May be inoperative provided affected OCSO is deactivated closed.

25-28-02 Overhead Cabin Stowage Option (OCSO)

25-28-02-01 Electric Extend/Retract Function

Interval	Installed	Required	Procedure
D	-	0	(M)

May be inoperative provided associated electric motor is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 25-28-02, modified for similar 777X installation.

The Overhead Cabin Stowage Option (OCSO) is a customer selectable option on the 777X airplane that provides 13.5 cubic feet of stowage in the overhead space between two main deck galleys. (The OCSO performs a similar function as the Overhead Cross Aisle Stowage (OCAS) option available on the 777-300ER.)

OCSO is an electrical-mechanical system that lowers and raises a BFE stowage unit from the overhead space into the galley workspace. The OCSO will be used for stowage of articles that are commonly stowed in galleys and closets, such as linens, coats and galley amenities. The OCSO stows completely above the galley ceiling, the bottom of the OCSO forms part of the galley ceiling. The box can carry up to 250 lbs of payload, the box itself can weigh up to 90 lbs. The OCSO unit is capable of being installed at door 2 and door 3 above a lowered ceiling. A motor provides power assist via cables that hoist the stowage box up and down. Guide rails provide support during travel. The cable system and hands-on control means the unit can't exert more downward force than an attendant applies themselves by pulling down on the unit. This avoids the possibility of causing damage to any obstructions, such as an open galley compartment door. There will be a manual backup system much like OCAS.

The safety objective of protecting the airplane from fire is met by designing the OCSO stowage box to contain a fire. The FAA has determined that for overhead stowage boxes less than 25 cubic feet such as OCSO, smoke detection is not required for compliance to FAR 25.853. Boxes 25 cu. ft. or larger have to meet the fire containment requirement and have smoke detection.

Consequences of Failure

Inoperative Compartment: Cannot use the affected storage compartment.

Inoperative electric mechanism: Use mechanical override mechanism.

Consequences of Next Critical Failure

Compartment: None

Mechanical override mechanism: Stuck-down compartment could block galley and egress path (cross-aisle). No exits are blocked.

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25-28-03 Overhead Ceiling Stowage Boxes

25-28-03A

Interval	Installed	Required	Procedure
D	-	0	(M)

May be inoperative provided affected Overhead Ceiling Stowage Box is closed.

25-28-03 Overhead Ceiling Stowage Boxes

25-28-03B

Interval	Installed	Required	Procedure
D	-	0	(M)

May be inoperative provided affected Overhead Ceiling Stowage Box is secured closed.

SUBSTANTIATION**Background**

New proposal for 777X.

Overhead Ceiling Stowage Boxes are a customer selectable option. The option is offered in four locations: the left hand and right hand lowered ceiling area at passenger entry doors 1 and 4. Overhead Ceiling Stowage Boxes offer miscellaneous or bassinet stowage. The stowage box door hinges on a station line and opens facing the main cabin. The stowage box includes a restraining net to prevent the contents of the box from falling out of the box when it is opened.

The latch system is designed with one latch housing that operates separate latch/pawl mechanisms on either side of the stowage box. The stowage box has two rate controls to slow the rate of opening and closing. The stowage box is equipped with two spring loaded actuators that assist in opening and closing. The spring actuator assists in the opening and closing of the stowage. The design also includes two dash pots (snubbers) to prevent the stowage box door from slamming closed.

Consequences of Failure

There are two proposed dispatch options:

Option A requires that all items are removed from the stowage box and that the stowage box door remains closed. Option B requires that all items are removed from the stowage box and that the stowage box door is secured closed.

Latch system:

A stowage box loaded to capacity will open unassisted if unlatched, however, an unlatched stowage box that is unloaded will remain closed under all conditions using only the actuators and rate controls.

Failure of one Spring actuator:

Remaining actuator is available will be available to assist in opening and closing the stowage box.

Failure of one Rate Control:

Remaining Rate Control will still control the rate that the door opens. The stowage box will open and close at a faster rate than normal.

Consequences of Next Critical Failure

Inoperative Latch System and Spring Actuators:

If the stowage box door is unable to latch, the door will be held closed by the actuators provided the stowage box is empty. A fully loaded door that is unlatched will open at a controlled rate. If the door is unable to latch and one actuator fails, an empty stowbox door will remain closed. If both actuators fail, the door will open. An open door will interfere, but not block, passenger and cabin crew movement (Hazard is 'Major'). If the stowbox is unloaded, the door will remain closed.

Inoperative rate dampers:

If both Rate Controls are inoperative, a fully loaded stowbox door will rapidly swing open with the potential of personal injury. These potential hazards are mitigated by unloading the stowage box.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01A

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- OFCR is deactivated closed, and
- Appropriate adjustments to flightcrew Flight Duty Period (FDP) times are applied.

NOTE: This provision is not intended to prohibit OFCR inspections by crewmembers.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01B

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided operations do not require its use.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01-01 Door

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided OFCR door is removed.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01-02 Door Lock

Interval	Installed	Required	Procedure
C	1	0	(M)

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May be inoperative provided:

- OFCR door is verified to open from the outside using the override feature, and
- OFCR door is verified to open and close normally from the inside.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01-03 Seats

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Seat position or seat assembly is not occupied, and
- Appropriate adjustments to flightcrew FDP times are applied.

NOTE: A seat position with an inoperative or missing restraint system is considered inoperative.

25-29-01 Overhead Flightcrew Rest (OFCR)

25-29-01-04 Bunks

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Associated bunk is not occupied, and
- Appropriate adjustments to flight crew flight duty period (FDP) times are applied.

NOTE: A bunk with an inoperative or missing restraint system is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-29-01.

Refer to FAA policy letter 130.

Optional crew rest modules may be installed in the main cabin floor, or in this case, the main cabin overhead (above the ceiling).

Current installations include:

The (forward) Overhead Flight Crew Rest - This crew rest may be installed in the overhead near the door 1/2 area and provides flight crew resting accommodations. There are two bunks installed and two business class seats in the common area.

The (aft) Overhead Flight Attendant Rest - This crew rest may be installed in the overhead near the door 3/4 area and provides cabin attendant resting accommodations. There are eight bunks installed.

Each flight attendant and flight crew rest area has an entrance door to close off the area.

Consequences of Failure

Crew rest area is not available, or seat is not available.

Consequences of Next Critical Failure

None identified.

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25-29-02 Overhead Flight Attendant Rest (OFAR)

25-29-02A

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided OFAR is deactivated closed.

NOTE: This provision is not intended to prohibit OFAR inspections by crewmembers.

25-29-02 Overhead Flight Attendant Rest (OFAR)

25-29-02B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided operations do not require its use.

25-29-02 Overhead Flight Attendant Rest (OFAR)

25-29-02-01 Door

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided associated OFAR door is removed.

25-29-02 Overhead Flight Attendant Rest (OFAR)

25-29-02-02 Door Lock

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- OFAR door lock is verified to open from the outside using the override feature, and

b. OFAR door is verified to open and close normally from the inside.

25-29-02 Overhead Flight Attendant Rest (OFAR)

25-29-02-03 Bunks

Interval	Installed	Required	Procedure
C	-	0	

May be inoperative provided bunk is not occupied.

NOTE: A bunk with an inoperative or missing restraint system is considered inoperative.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 25-29-02.

Optional crew rest modules may be installed in the main cabin floor, or in this case, the main cabin overhead (above the ceiling).

Current installations include:

The (forward) Overhead Flight Crew Rest - This crew rest may be installed in the overhead near the door 1/2 area and provides flight crew resting accommodations. There are two bunks installed and two business class seats in the common area.

The (aft) Overhead Flight Attendant Rest - This crew rest may be installed in the overhead near the door 3/4 area and provides cabin attendant resting accommodations. There are eight bunks installed.

Each flight attendant and flight crew rest area has an entrance door to close off the area.

Consequences of Failure

Crew rest area is not available.

Consequences of Next Critical Failure

None identified.

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25-30-01 Galley/Cabin Waste Receptacles Access Door/Covers

Interval	Installed	Required	Procedure
C	-	-	(M) (O)

May be inoperative provided:

- The container is empty and the access is secured to prevent waste introduction into the compartment, and
- Procedures are established to ensure that sufficient galley/cabin waste receptacles are available to accommodate all waste that may be generated on a flight.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-30-01.

Refer to MMEL Policy Letter 96.

14 CFR 121.215(e) states that each receptacle for used towels, papers, and wastes must be of fire-resistant material and must have a cover or other means of containing possible fires started in the receptacles. This does not include lavatory waste containers which are addressed under separate relief.

Consequences of Failure

Each receptacle with an inoperative door/cover must be empty and the door/cover secured to prevent waste introduction into the associated compartment. In addition, procedures must ensure that sufficient waste receptacles are available for use on the flight.

Consequences of Next Critical Failure

None.

25-41-01 Exterior Lavatory Ashtrays

Interval	Installed	Required	Procedure
A	-	-	

50% may be inoperative or missing provided repairs are made within 10 calendar-days.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 25-41-01.

Refer to MMEL Policy Letter 85 (archived).

Lavatories have ashtrays installed on the exterior, near the lavatory door.

Consequences of Failure

For airlines that allow smoking on flights, a passenger that is smoking may not have an immediately available place to extinguish smoking materials.

The FAA AD 74-08-09 R3 is applicable to all transport category airplanes, certificated in any category, that have one or more lavatories equipped with paper or linen waste receptacles. This is a revision to an existing AD originally prompted by fires occurring in lavatories which was caused by, among other things, smoking materials deposited by passengers or crew.

FAA MMEL Policy Letter 85, which is now archived, states that 50 percent of exterior lavatory door ashtrays may be missing or inoperative for 10 days.

Consequences of Next Critical Failure

None identified.

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25-41-02 Lavatory Waste Receptacle Flapper/Access Doors

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided:

- Associated waste receptacle is empty,
- Access is secured to prevent waste introduction into the waste receptacle,
- Associated lavatory is used only by crewmembers, and
- Associated lavatory entrance door is locked closed and placarded "INOPERATIVE - DO NOT ENTER".

NOTE: These provisions are not intended to prohibit lavatory use or inspections by crewmembers.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-41-02.

Lavatories have waste compartments. Each has a flapper door that is kept closed by a spring load. In the unlikely event of a fire in the waste compartment, the spring-closed door will contain the flame.

Consequences of Failure

An inoperative lavatory waste compartment flapper door may degrade the ability to contain a flame. The lavatory cannot be used by passengers.

Consequences of Next Critical Failure

None identified.

25-52-01 Lower Cargo Compartment Lining (Forward, Aft and Bulk)

Interval	Installed	Required	Procedure
C	-	-	(O)

May be damaged or missing provided procedures are established and used to verify the associated cargo compartment remains empty or contains only ballast, empty cargo handling equipment (ballast may be loaded in ULDs), or fly away kits.

NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 25-52-01.

Cargo compartment linings are intended to resist flame penetration, help contain smoke and help contain fire extinguishing agent in case of fire.

Consequences of Failure

MMEL restrictions must be observed.

Consequences of Next Critical Failure

None.

25-53-01 Lower Cargo-Handling Systems

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative or portions of the system may be missing.

NOTE: Any portion of the system which operates normally may be used.

SUBSTANTIATION

Background

Proposal based 777 MMEL item 25-53-01.

The cargo compartments each have a powered cargo loading system. There is a Main Control Panel (MCP) and Joystick near each cargo door and an auxiliary joystick located on the Cargo Maintenance Display Unit (CMDU) mounted inside doorway. Power Drive Units (PDUs) move containers into and out of the cargo compartments.

Consequences of Failure

Manual operation features of the cargo handling system allow loading and unloading of unit load devices (ULDs) when electrical components are inoperative.

Consequences of Next Critical Failure

None.

25-53-02 Lower Cargo Restraint Systems**25-53-02A**

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative or missing provided approved cargo-loading limits are observed. The only source documents are:

- Type Certificate (TC),
- Supplemental Type Certificate (STC),
- Airplane Flight Manual (AFM),
- Airplane Flight Manual Supplement (AFMS),
- TC/STC Weight and Balance Manual (WBM).

NOTE 1: For missing doorsill equipment, appropriate hardware is installed to maintain structural integrity.

NOTE 2: Appropriate cargo handling equipment must remain installed to stabilize cargo floor beams and frames.

25-53-02 Lower Cargo Restraint Systems**25-53-02B**

Interval	Installed	Required	Procedure
D	-	-	

May be inoperative or missing provided associated cargo compartment remains empty.

NOTE 1: For missing doorsill equipment, appropriate hardware is installed to maintain structural integrity.

NOTE 2: Appropriate cargo handling equipment must remain installed to stabilize cargo floor beams and frames.

25-53-02 Lower Cargo Restraint Systems**25-53-02C**

Interval	Installed	Required	Procedure
D	-	-	

Individual cargo zones may be inoperative provided aircraft is operated in accordance with Original Equipment Manufacturer (OEM) W&B source document.

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NOTE 1: For missing doorsill equipment, appropriate hardware is installed to maintain structural integrity.

NOTE 2: Appropriate cargo handling equipment must remain installed to stabilize cargo floor beams and frames.

SUBSTANTIATION

Background

Proposal based on 777 FAA MMEL 25-53-02.

Refer to FAA Policy Letter 100.

The cargo restraint system limits the movement of cargo during flight, and also prevents it from moving unexpectedly during loading/unloading.

Consequences of Failure

Cargo Compartment Used:

Inoperative or missing cargo restraint equipment will not be available for use. Cargo compartment may be used provided approved cargo loading limits are observed using available cargo restraint equipment. Special procedures must be followed to safely tie down cargo when any of the restraint hardware is missing or inoperative. Refer to the Weights and Balance Manual or applicable source documents for tie down methods. Appropriate cargo handling equipment must remain installed to ensure that the cargo floor beams and frames are stabilized. For any cargo handling doorsill hardware that is missing, fasteners must be installed to maintain the structural integrity between the doorsill and airplane structure.

Cargo Compartment Remains Empty:

Appropriate cargo handling equipment must remain installed to ensure that the cargo floor beams and frames are stabilized. For any cargo handling doorsill hardware that is missing, fasteners must be installed to maintain the structural integrity between the doorsill and airplane structure.

Individual Cargo Zones:

Individual cargo zones may be inoperative. Inoperative or missing cargo restraint equipment will not be available for use. Cargo zone may be used provided approved cargo loading limits are observed using available cargo restraint equipment. Special procedures must be followed to safely tie down cargo when any of the restraint hardware is missing or inoperative. Refer to the Weights and Balance Manual or applicable source documents for tie down methods.

Appropriate cargo handling equipment must remain installed to ensure that the cargo floor beams and frames are stabilized. For any cargo handling doorsill hardware that is missing, fasteners must be installed to maintain the structural integrity between the doorsill and airplane structure.

Consequences of Next Critical Failure

None. Next critical failures are mitigated by MMEL restrictions.

25-63-01**Emergency Evacuation Signal System**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are used.

NOTE: Any portion of the system which operates normally may be used.

SUBSTANTIATION**Background**

Proposal is based on 787 MMEL item 25-63-01.

An Emergency Evacuation panel is located on the aft aisle stand in the flight deck. An EVAC COMMAND switch is installed on the panel. The switch is a 3 position switch (ARM/ON/OFF). An Emergency Evacuation panel is also located at each of the flight attendant stations. Each flight attendant panel includes an EVAC COMMAND switch, an EVAC light, a horn and a horn shutoff switch.

Setting any of EVAC COMMAND switches to ON results in the EVAC COMMAND ON Warning message and unique aural tone through the flight deck speakers. In the passenger cabin the EVAC light will illuminate and a horn will sound at all stations.

Consequences of Failure

If the Emergency Evacuation Signal System is inoperative, alternate evacuation procedures must be used.

Consequences of Next Critical Failure

None.

25-63-02 “FASTEN SEAT BELT WHILE SEATED” Sign or Placard

Interval	Installed	Required	Procedure
C	-	-	

One or more signs or placards may be illegible or missing provided a legible sign or placard is visible from each occupied passenger seat.

SUBSTANTIATION

Background

Proposal based on 787 25-63-02.

Refer to MMEL Policy Letter 89.

The placard “Fasten Seat Belt While Seated” appears on the back of each passenger seat and on monument surfaces or sidewalls for the front row passengers where there is no seat back visible. Similar MMEL relief exists for other aircraft.

Consequences of Failure

None. The proviso requires that a placard be visible from each occupied passenger seat.

Consequences of Next Critical Failure

None.

25-63-03**Emergency Locator Transmitter (ELT)(Survival)**

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or missing.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 25-63-03.

Refer to MMEL Policy Letter 120 and CS-MMEL, 25-63-3.

14 CFR 91.207, 121.353 and 121.339 establish the requirements for Emergency Locator Transmitters (ELT). In general, these FARs require an ELT for extended overwater operations and operations over uninhabited areas. Note that portable ELT's are covered in AMM Chapter 25 whereas the fixed ELT's are covered in AMM Chapter 23.

For EASA, survival type ELTs are required by CAT.IDE.A.280, CAT.IDE.A.285, CAT.IDE.A.305.

There is one fixed ELT installed on the 777X as standard equipment.

Consequences of Failure

Only applies to equipment in excess of that required.

Consequences of Next Critical Failure

None identified.

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25-64-01 Megaphones

25-64-01A

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or removed provided:

- a. Inoperative megaphone remains in a certified location until removed from the aircraft at the next suitable maintenance facility,
- b. Location placarding is removed or obscured, and
- c. Required distribution is maintained.

25-64-01 Megaphones

25-64-01B

Interval	Installed	Required	Procedure
C	-	0	(O)

May be missing or inoperative provided:

- a. No passengers are carried,
- b. A maximum of 19 persons are carried as authorized by 14 CFR for non passenger carrying operations, and
- c. Alternate procedures are established and used.

25-64-01 Megaphones

25-64-01-01 Tamper Seals or Tags

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper installation and operation is verified at each preflight.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 25-64-01.

Refer to MMEL Policy Letters 125 and 132.

Requirements for megaphones are established in 14 CFR 121.309. Two megaphones are required by regulation for airplanes with seating capacity of more than 99 passengers.

For EASA, megaphones are required by CAT.IDE.A.270.

Consequences of Failure

Only applies to equipment in excess of that required unless operations are conducted without passengers.

Consequences of Next Critical Failure

None.

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Section 2

25-64-02 Portable Flashlights/Flashlight Holders

25-64-02A

Interval	Installed	Required	Procedure
C	-	-	

May be inoperative or removed provided:

- Crewmember assigned to the affected position has an equivalent operative flashlight readily available,
- Inoperative flashlight remains in a certified location or is removed from the aircraft, and
- Location placarding is removed or obscured.

25-64-02 Portable Flashlights/Flashlight Holders

25-64-02B

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or removed provided:

- Inoperative flashlight remains in a certified location until removed from the aircraft at the next suitable maintenance facility, and
- Location placarding is removed or obscured.

25-64-02 Portable Flashlights/Flashlight Holders

25-64-02C

Interval	Installed	Required	Procedure
C	-	0	(O)

May be missing or inoperative provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non passenger carrying operations, and
- Alternate procedures are established and used.

25-64-02

Portable Flashlights/Flashlight Holders

25-64-02-01

Tamper Seals or Tags

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper installation and operation is verified at each preflight.

SUBSTANTIATION

Background

Refer to FAA MMEL Policy Letter 132.
Portable flashlight requirements are provided in 14 CFR 121.310 and 121.549.

Consequences of Failure

None. A missing or inoperative flashlight is replaced with an equivalent flashlight that is readily available. Equipment in excess of those required may be inoperative or removed.

Consequences of Next Critical Failure

None.

Federal Aviation Administration (FAA)**ATA 25****777-9 Master Minimum Equipment List****Section 2****25-64-03 Automated External Defibrillator (AED) and/or Associated Equipment****25-64-03A**

Interval	Installed	Required	Procedure
A	-	0	(O)

May be incomplete, inoperative, or removed provided:

- AED is labeled or placarded in a manner that will identify it as a unit that cannot be mistaken for a fully serviceable unit,
- Location placarding is removed or obscured, and
- Repairs or replacements are made within one flight.

NOTE: Medical equipment installed in the aircraft as part of an Emergency Medical Service (EMS) operation is not considered part of the normal complement of equipment. No MMEL relief applies to that equipment and 14 CFR maintenance and inspection requirements do not apply.

25-64-03 Automated External Defibrillator (AED) and/or Associated Equipment**25-64-03B**

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be incomplete, inoperative, or removed.

25-64-03 Automated External Defibrillator (AED) and/or Associated Equipment**25-64-03-01 Tamper Seals or Tags*********

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper servicing is verified at each preflight.

SUBSTANTIATION

Background

Refer to MMEL Policy Letter 132.

First Aid kits, Emergency Medical kits and Automated External Defibrillators are required per 14 CFR 121.803.

Consequences of Failure

May be incomplete, inoperative, or removed for one flight. Reduced availability of first aid materials for emergency treatment of passengers/crew members.

Any in excess of those required by regulation may be incomplete, inoperative, or removed.

Consequences of Next Critical Failure

None

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25-64-04 Emergency Medical Kit (EMK) and/or Associated Equipment

25-64-04A

Interval	Installed	Required	Procedure
A	-	0	(O)

May be incomplete or removed provided:

- EMK is labeled or placarded in a manner that will identify it as a unit that cannot be mistaken for a fully serviceable unit,
- Location placarding is removed or obscured, and
- Repairs or replacements are made within one flight.

NOTE: Medical equipment installed in the aircraft as part of an EMS operation is not considered part of the normal complement of equipment. No MMEL relief applies to that equipment and 14 CFR maintenance and inspection requirements do not apply.

25-64-04 Emergency Medical Kit (EMK) and/or Associated Equipment

25-64-04B

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be incomplete or removed.

25-64-04 Emergency Medical Kit (EMK) and/or Associated Equipment

25-64-04-01 Tamper Seals or Tags

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper EMK servicing is verified at each preflight.

SUBSTANTIATION

Background

Refer to MMEL Policy Letter 132.

First Aid kits, Emergency Medical kits and Automated External Defibrillators are required per 14 CFR 121.803.

Consequences of Failure

May be incomplete, inoperative, or removed for one flight. Reduced availability of first aid materials for emergency treatment of passengers/crew members.

Any in excess of those required by regulation may be incomplete, inoperative, or removed.

Consequences of Next Critical Failure

None

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Federal Aviation Administration (FAA)**ATA 25****777-9 Master Minimum Equipment List****Section 2****25-64-05 First Aid Kit (FAK) and/or Associated Equipment****25-64-05A**

Interval	Installed	Required	Procedure
A	-	-	(O)

If more than one is required by 14 CFR, only one of the required FAKs may be incomplete or removed provided:

- The FAK is labeled or placarded in a manner that will identify it as a unit that cannot be mistaken for a fully serviceable unit,
- Location placarding is removed or obscured, and
- Repairs or replacements are made within one flight.

NOTE: Medical equipment installed in the aircraft as part of an EMS operation is not considered part of the normal complement of equipment. No MMEL relief applies to that equipment and 14 CFR maintenance and inspection requirements do not apply.

25-64-05 First Aid Kit (FAK) and/or Associated Equipment**25-64-05B**

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be incomplete or removed.

25-64-05 First Aid Kit (FAK) and/or Associated Equipment**25-64-05-01 Tamper Seals or Tags*********

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper FAK servicing is verified at each preflight.

SUBSTANTIATION**Background**

Refer to MMEL Policy Letter 132.

First Aid kits, Emergency Medical kits and Automated External Defibrillators are required per 14 CFR 121.803.

Consequences of Failure

May be incomplete, inoperative, or removed for one flight. Reduced availability of first aid materials for emergency treatment of passengers/crew members.

Any in excess of those required by regulation may be incomplete, inoperative, or removed.

Consequences of Next Critical Failure

None

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26-11-01 Engine Fire Detection Loops

26-11-01-01 Left Engine

26-11-01-02 Right Engine

26-11-02 Engine Overheat Detection Circuits

26-11-02-01 Left Engine

26-11-02-02 Right Engine

26-13-01 Lavatory Smoke Detection Systems

26-13-01A

26-13-01B

26-13-01-01 Lavatory Call Light Smoke Detected Function

26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

26-14-01-01 Bunk Smoke Detectors

26-14-01-02 Seat Area Smoke Detectors

26-14-01-03 Closet Smoke Detector

26-14-01-04 Stairwell Smoke Detector

26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

26-14-02-01 Bunk Smoke Detectors

26-14-02-02 Common Area Smoke Detectors

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26-14-02-03 Aisle Smoke Detectors

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26-15-01-01C

26-15-01-02A

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26-17-01 Wheel Well Fire Detection Loops

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26-11-01 Engine Fire Detection Loops**26-11-01-01 Left Engine**

Interval	Installed	Required	Procedure
B	2	1	

One may be inoperative.

26-11-01 Engine Fire Detection Loops**26-11-01-02 Right Engine**

Interval	Installed	Required	Procedure
B	2	1	

One may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-11-01.

The fire detection system for each engine consists of a series of dual loop detection elements, a fire/overheat detector card in the cardfile, and flight deck indications. The fire warning system requires a fire detection signal from both loops. If an open loop fault in a detector loop occurs after initial system power-up, the loop will continue to detect a fire condition. If a loop becomes shorted or is open during initial power-up, it is automatically deselected. If one loop is deselected, the fire warning system automatically reverts to single loop detection.

Master Warning Lights and the fire bell are inhibited for fire warning during a takeoff. If a fire condition exists when the inhibit is removed, both the Master Warning Lights and the fire bell activate.

Consequences of Failure

Failure of an engine fire detection loop is indicated by the FIRE LOOP 1 or 2 ENG L or R Status message..

The failed detection loop will no longer provide engine fire detection. The remaining detection loop will provide engine fire detection.

Consequences of Next Critical Failure

Failure of remaining loop: Fire detection will not be available on associated engine. Indicated by the DET FIRE FAIL ENG L, R Advisory message.

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False fire warning: Erroneous fire detection from remaining loop results in the FIRE ENG L or R Warning message, fire bell aural warning, master warning light, fuel cutoff switch light and fire handle light/solenoid unlock. In-flight engine shutdown.

Fire in associated engine: Fire detection and warnings provided by remaining single loop. Indicated by FIRE ENG L or R Warning message, fire bell aural warning, master warning light, fuel cutoff switch light and fire handle light/solenoid unlock.

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26-11-02 Engine Overheat Detection Circuits**26-11-02-01 Left Engine**

Interval	Installed	Required	Procedure
B	2	1	

One may be inoperative.

26-11-02 Engine Overheat Detection Circuits**26-11-02-02 Right Engine**

Interval	Installed	Required	Procedure
B	2	1	

One may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 FAA MMEL item 26-11-02.

The overheat detection system for each engine consists of dual loop fire detection elements, a fire/overheat detector card in the cardfile, and flight deck indicators. The overheat caution system requires an overheat detection signal from both loops. If an open loop fault in a detector loop occurs after initial system power-up, the loop will continue to detect an overheat condition. If a loop becomes shorted or is open during initial system power-up, it is automatically deselected. If one loop is deselected, the overheat caution system automatically reverts to single loop detection.

If the overheat detection system fails, the engine fire protection system monitors the same engine region; both systems employ the same physical fire/overheat detection elements.

Consequences of Failure

Failure of an engine overheat detection loop is indicated by the OVERHEAT CIRCUIT L1, L2, R1 or R2 Status message..

The failed detection circuit will no longer provide engine overheat detection. The remaining detection circuit will still provide engine overheat detection.

Consequences of Next Critical Failure

Failure of remaining loop: Overheat detection will not be available on associated engine. Indicated by the DET OVHT FAIL ENG L, R Advisory message. Engine fire detection continues to operate normally.

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False overheat warning: Erroneous overheat detection from remaining loop results in the OVERHEAT ENG L or R Caution message, master caution light and aural warning. In-flight engine shutdown.

Overheat in associated engine: Overheat detection and warnings provided by remaining single loop. Indicated by OVERHEAT ENG L or R Caution message, master caution light and aural warning.

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Federal Aviation Administration (FAA)**Section 2****777-9 Master Minimum Equipment List****ATA 26****26-13-01 Lavatory Smoke Detection Systems****26-13-01A**

Interval	Installed	Required	Procedure
C	-	-	(M) (O)

For each lavatory, the lavatory smoke detection system may be inoperative provided:

- Lavatory waste receptacle is empty,
- Associated lavatory door is locked closed and placarded, "INOPERATIVE - DO NOT ENTER", and
- Lavatory is used only by crewmembers.

NOTE: These provisions are not intended to prohibit lavatory use or inspections by crewmembers.

26-13-01 Lavatory Smoke Detection Systems**26-13-01B**

Interval	Installed	Required	Procedure
D	-	0	

Any in excess of that required by 14 CFR may be inoperative.

26-13-01 Lavatory Smoke Detection Systems**26-13-01-01 Lavatory Call Light Smoke Detected Function**

Interval	Installed	Required	Procedure
C	-	0	

NOTE: Attendant call and occupancy indications are considered NEF.

SUBSTANTIATION**Background**

Proposal based 777 FAA MMEL item 26-13-01.

Refer to FAA Policy Letter (PL) 24.

Individual smoke detectors are installed in each lavatory. The unit is a photoelectric type capable of sensing smoke and providing indication within 60 seconds from the time of ignition of a fire or smoke source. Each unit interfaces with the Cabin Services System (CSS) for a remote test capability and for the activation of the associated master call light and cabin chimes which are configured by the CSS database. When an actual smoke event occurs in the lavatory, the smoke detector installed in that unit will sound the internal alarm horn, the status indicator light will illuminate red and the lavatory call light/reset switch above the lavatory door will flash amber. The smoke detector will also send a signal to the CSS which will result in the master call lights flashing, a continuous chime in the cabin near the lavatory, a SMOKE DETECTED pop-up window displayed on all cabin attendant panels with the affected lavatory location listed in the window, and the SMOKE LAVATORY or SMOKE LAV/COMPT message displayed on the flight deck. All smoke indications will remain until the smoke detector no longer detects smoke.

Consequences of Failure

Loss of capability to detect and annunciate smoke in the associated lavatory.

Consequences of Next Critical Failure

Fire in associated lavatory: Fire extinguisher system automatically discharges Halon in the lavatory when the heat sensor detects temperature greater than 174 deg F.

If fire extinguisher system is inoperative, the MMEL provisions prevent use of the lavatory by passengers and crewmembers in order to effectively eliminate any source of fire ignition.

26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- OFCR Smoke Detection System is deactivated, and
- OFCR is considered inoperative.

26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

26-14-01-01 Bunk Smoke Detectors

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Associated bunk is not used and personal items are removed,
- Both Seat Area Smoke Detectors operate normally, and
- A conspicuous barrier strap or rope is placed across the associated bunk with a placard attached stating that the bunk is not to be used.

26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

26-14-01-02 Seat Area Smoke Detectors

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided:

- Both Bunk Smoke Detectors operate normally,
- For bunk curtains installed, curtains are secured open or removed, and
- Stairwell Smoke Detector operates normally.

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26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

26-14-01-03 Closet Smoke Detector

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Closet is not used and personal items are removed, and
- A conspicuous barrier strap or rope is placed across the closet door with a placard attached stating the closet is not to be used.

26-14-01 Overhead Flightcrew Rest (OFCR) Smoke Detection System

26-14-01-04 Stairwell Smoke Detector

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided both Seat Area Smoke Detectors operate normally.

SUBSTANTIATION

Background

Proposal based on 777 FAA MMEL item 26-14-04.

There are six smoke detectors throughout the Overhead Flight Crew Rest (OFCR). There are two smoke detectors in the vestibule module, two smoke detectors in the seat module, and two smoke detectors in the bunk module.

One smoke detector in the vestibule module is on the aft wall next to the seat module doorway at the top of the stairs. The other vestibule module smoke detector is inside the closet.

One smoke detector in the seat module is on the forward wall next to the seat module doorway at the top of the stairs. The other seat module smoke detector is on the ceiling between the two crew rest seats.

In the bunk module, one smoke detector is located on the ceiling above bunk 1, and the other is on the ceiling above bunk 2.

Faults are determined by performing the system operational test using the cabin management system, the system functional test using actual smoke or the smoke detector self-test. The smoke detectors are not fault monitored by EICAS.

Detection of smoke results in the air supply shutoff valve (SOV) automatically closing and the exhaust valve automatically opening to provide escape route for the smoke into the Lav/Galley vent system so that it does not enter the cabin.

The smoke detectors report to appropriate systems when smoke is detected, which results in visual and aural alerts. These alerts include the SMOKE REST UPR DR 1 Caution message, an aural alert and master caution light illuminated on the flight deck; sounding smoke detector horns and a red illuminated LED on any detector in alarm in the crew rest, and a pop-up message on the cabin attendant panel, flashing master call lights, a flashing crew rest attendant call light above its associated door, and chimes in the cabin.

Consequences of Failure

OFCR smoke detection system inoperative: The OFCR smoke detection system must be deactivated and the OFCR must be deactivated closed.

Bunk smoke detector inoperative: Associated bunk must not be used. Personal items must be removed.

Seat Area Smoke Detectors inoperative: Both bunk smoke detectors must operate normally. Bunk curtains, if installed must be secured open or removed. Smoke detection capability will be reduced, however, Bunk Smoke Detectors and Stairwell Smoke Detector will provide for adequate smoke detection capability.

Closed Smoke Detector inoperative: Closet must not be used.

Stairwell Smoke Detector inoperative: Both Seat Area Smoke Detectors must operate normally. Smoke detection capability will be reduced, however, Seat Area Smoke Detectors will provide for adequate smoke detection capability.

Consequences of Next Critical Failure

OFCR Smoke Detection System inoperative: None identified, as the OFCR smoke detection system is deactivated and the OFCR is deactivated closed.

Bunk Smoke Detector inoperative: None identified, as the associated bunk may not be used.

Seat Area Smoke Detectors inoperative: In the event of a smoke event, bunk smoke detectors and Stairwell Smoke Detector will provide smoke detection capability.

Closet Smoke Detector inoperative: None identified, as the closet may not be used. Personal items must be removed.

Stairwell Smoke Detector inoperative: In the event of smoke event, Seat Area Smoke Detectors will provide smoke detection capability.

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26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- OFAR Smoke Detection System is deactivated, and
- OFAR is considered inoperative.

26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

26-14-02-01 Bunk Smoke Detectors

Interval	Installed	Required	Procedure
C	-	0	(M)

May be inoperative provided:

- Associated bunk is not used and personal items are removed, and
- A conspicuous barrier strap or rope is placed across the associated bunk with a placard attached stating that the bunk is not to be used.

26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

26-14-02-02 Common Area Smoke Detectors

26-14-02-02A

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided adjacent Aisle Smoke Detector operates normally.

26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

26-14-02-02 Common Area Smoke Detectors**26-14-02-02B**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- No more than one Bunk Smoke Detector in adjacent bunk area(s) is inoperative, and
- For bunk curtain installed, curtain(s) for bunk(s) with operative smoke detector(s) is secured open or removed.

26-14-02 Overhead Flight Attendant Rest (OFAR) Smoke Detection System

26-14-02-03 Aisle Smoke Detectors

Interval	Installed	Required	Procedure
C	-	-	

May be inoperative provided adjacent Aisle/Common Area Smoke Detector(s) operates normally.

SUBSTANTIATION**Background**

Proposal based on 777 FAA MMEL item 26-14-04.

Optional overhead flight attendant rest (OFAR) modules may be installed in the main cabin overhead (above the ceiling). There are two smoke detectors in the OFAR common area module and three OFAR smoke detectors in each of the OFAR bunk modules. The total number of smoke detectors depends on how many bunk modules are installed.

For the common area module, one smoke detector is on the ceiling near the aft closet above the vestibule module. The other common area smoke detector is on the ceiling near the entrance to the bunk modules.

For each bunk module, one smoke detector is located is on the ceiling above the left bunk, one is located above the ceiling above the right bunk, and one is located in the ceiling above the aisle. On the end bunk module at the forward end of the OFAR, the aisle OFAR smoke detector is above the forward closet instead of on the ceiling.

Faults are determined by performing the system operational test using the cabin management system, the system functional test using actual smoke or the smoke detector self-test. The smoke detectors are not fault monitored by EICAS.

Detection of smoke also results in the air supply shutoff valve (SOV) automatically closing and the exhaust valve automatically opening to provide escape route for the smoke into the Lav/Galley vent system so that it does not enter the cabin.

The smoke detectors report to appropriate systems when smoke is detected, which results in visual and aural alerts. These alerts include the SMOKE REST UPR DR 4 Caution message, an aural alert and master caution light illuminated on the flight deck; sounding smoke detector horns and a red illuminated LED on any detector in alarm in the crew rest, and a pop-up message on the cabin attendant panel, flashing master call lights, a flashing crew rest attendant call light above its associated door, and chimes in the cabin.

Consequences of Failure

OFAR Smoke Detection System inoperative: The OFAR smoke detection system must be deactivated and the OFCR must be deactivated closed.

Bunk smoke detector inoperative: Associated bunk must not be used. Personal items must be removed.

Aisle Smoke Detectors inoperative: Adjacent aisle/common area smoke detector(s) must operate normally. Smoke detection capability will be reduced, however, remaining adjacent smoke detectors will provide for adequate detection capability.

Common Area Smoke Detector inoperative: One may be inoperative provided the adjacent aisle smoke detector operates normally, or at least one bunk smoke detector in adjacent bunk area operates normally and bunk curtain(s) is secured open or removed. Smoke detection capability will be reduced, however, remaining adjacent smoke detectors will provide for adequate detection capability.

Consequences of Next Critical Failure

OFAR Smoke Detection System inoperative: None identified, as the OFAR smoke detection system is deactivated and the OFAR is deactivated closed.

Bunk Smoke Detector inoperative: None identified, as the associated bunk is deactivated and may not be used.

Common Area Smoke Detectors inoperative: In the event of a smoke event, remaining common area smoke detectors and adjacent aisle/bunk smoke detectors will provide smoke detection capability.

Aisle Smoke Detectors inoperative: In the event of a smoke event, adjacent aisle smoke detectors and bunk smoke detectors will provide smoke detection capability.

26-15-01 APU Fire Detection System**26-15-01-01 APU Fire Detection Loops****26-15-01-01A**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-15-01 APU Fire Detection System**26-15-01-01 APU Fire Detection Loops****26-15-01-01B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of APU,
 - APU selector remains OFF, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

26-15-01 APU Fire Detection System**26-15-01-01 APU Fire Detection Loops****26-15-01-01C**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU Shutdown Panel (P40) operates normally,
- APU is used for ground operations only,
- APU is continuously monitored by ground personnel when operating,
- APU is not used during taxi, and

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g. Flight remains within 180 minutes of landing at a suitable airport.

26-15-01 APU Fire Detection System

26-15-01-02 APU Fire Detection Card

26-15-01-02A

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU selector remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

26-15-01 APU Fire Detection System

26-15-01-02 APU Fire Detection Card

26-15-01-02B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU Shutdown Panel (P40) operates normally,
- APU is used for ground operations only,
- APU is continuously monitored by ground personnel when operating,
- APU is not used during taxi, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-15-01.

The APU fire detection system includes three dual loop fire detector elements in the APU compartment, an APU fire detection card in the cardfile, and flight deck indications. The APU is shutdown automatically and the APU fire extinguisher is automatically discharged if a fire is detected. The fire warning signal normally requires a fire detection signal from both loops. If one loop is inoperative, the fire warning signal automatically reverts to single-loop detection.

Consequences of Failure

An APU fire detection card fault or failure or loss of communication with the card is indicated by the FIRE CARD APU Status message. Failure of an APU fire detection loop is indicated by the FIRE LOOP 1 APU or FIRE LOOP 2 APU Status message.

Fire card or both fire detector loops inoperative: No fire detection available on the APU, and the APU auto shutdown and fire extinguisher auto discharge features are inoperative. APU may be used for ground operations only provided it is continuously monitored by ground personnel. The APU may not be used for taxi operations.

Single inoperative fire loop: None, as the APU fire detection system reverts to single loop fire detection providing complete APU fire detection.

Consequences of Next Critical Failure

Fire card or both fire detector loops inoperative: Fire occurs in APU compartment during allowed ground operations - Monitoring ground personnel visually detect the APU fire and manually discharge APU fire extinguisher from external APU control panel.

Single inoperative fire loop:

Fire occurs in APU compartment - Remaining operative APU fire detection loop detects fire resulting in APU auto shutdown and auto discharge of APU fire extinguisher.

Remaining APU fire loop fails - None, as failure of remaining fire loop and APU fire occurring on a single flight is considered highly unlikely. The DET FIRE FAIL APU Advisory message will be displayed.

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26-15-02 APU Fire Warning Speakers

26-15-02A

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative during electrical power up provided external power is used.

26-15-02 APU Fire Warning Speakers

26-15-02B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative during electrical power up provided:

- APU is monitored by ground personnel during APU start until EICAS display is operating, and
- APU Shutdown Panel (P40) operates normally.

SUBSTANTIATION

Background

New proposal for 777X.

An analog APU fire detection function has been implemented for scenarios where airplane power-up is conducted by APU without external power. In this situation, the displays & crew alerting (DCA) function within the common core system (CCS) is not initially powered, and would not generate APU fire annunciations if a fire were to occur. Dedicated speakers are installed to generate aural warning for detected APU fire until DCA functionality is operating. This function is tested as part of the daily fire protection test.

Consequences of Failure

Electrical power up using external power: None.

Electrical power up using APU: Flight deck APU fire detection is not available during APU start until EICAS display is operating. APU must be monitored by ground personnel during this period.

Consequences of Next Critical Failure

Electrical power up using external power: None.

Electrical power up using APU: Fire occurs in APU compartment during APU start and prior to EICAS display operating - monitoring ground personnel visually detect the APU fire and manually discharge APU fire extinguisher from external APU control panel.

26-16-01 Lower Cargo Compartment Smoke Detection Systems**26-16-01-01 Forward**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Procedures are established and used to ensure the associated compartment remains empty, or is verified to contain only empty cargo handling equipment, ballast (ballast may be loaded in ULDs), and/or fly away kits.

For FCAC installed:

- FWD CARGO A/C selector remains OFF.

NOTE: Operator MELs should define which items are approved for inclusion in the fly away kits, and which materials can be used as ballast.

26-16-01 Lower Cargo Compartment Smoke Detection Systems**26-16-01-01 Forward****26-16-01-01-01 Detectors**

Interval	Installed	Required	Procedure
C	23	-	

One smoke detector in each detector zone may be inoperative provided adjacent smoke detectors operate normally.

NOTE: For a detector zone with more than one inoperative smoke detector, the associated detector zone must be considered inoperative.

26-16-01 Lower Cargo Compartment Smoke Detection Systems**26-16-01-01 Forward****26-16-01-01-02 Detector Zones**

Interval	Installed	Required	Procedure
C	3	-	(M) (O)

May be inoperative provided procedures are established and used to ensure the associated zone remains empty, or is verified to contain only empty cargo handling equipment, ballast (ballast may be loaded in ULDs), and/or fly away kits.

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NOTE: Operator MELs should define which items are approved for inclusion in the fly away kits, and which materials can be used as ballast.

26-16-01 Lower Cargo Compartment Smoke Detection Systems

26-16-01-02 Aft

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided procedures are established and used to ensure the associated zone remains empty, or is verified to contain only empty cargo handling equipment, ballast (ballast may be loaded in ULDs), and/or fly away kits.

NOTE: Operator MELs should define which items are approved for inclusion in the fly away kits, and which materials can be used as ballast.

26-16-01 Lower Cargo Compartment Smoke Detection Systems

26-16-01-02 Aft

26-16-01-02-01 Detectors

Interval	Installed	Required	Procedure
C	19	-	

One smoke detector in each detector zone may be inoperative provided adjacent smoke detectors operate normally.

NOTE: For a detector zone with more than one inoperative smoke detector, the associated detector zone must be considered inoperative.

26-16-01 Lower Cargo Compartment Smoke Detection Systems

26-16-01-02 Aft

26-16-01-02-02 Detector Zones

Interval	Installed	Required	Procedure
C	3	-	(M) (O)

May be inoperative provided procedures are established and used to ensure the associated zone remains empty, or is verified to contain only empty cargo handling equipment, ballast (ballast may be loaded in ULDs), and/or fly away kits.

NOTE: Operator MELs should define which items are approved for inclusion in the fly away kits, and which materials can be used as ballast.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-16-02.

Refer to FAA policy letters 102 and 108.

The 777X utilizes smoke detectors in each of three zones for a total of 23 detectors installed in the forward lower cargo compartment and 19 detectors installed in the aft lower cargo compartment. Each of the spot-type photoelectric smoke detectors has two independent channels for redundancy. An inoperative channel in any single detector sets an associated maintenance message as the fault by itself does not affect the operation of the detector, nor affect dispatch.

The number of detectors and their spacing was determined to provide a rapid response for smoke detection. The cargo smoke detection system (CSDS) controller's alarm logic requires an alarm signal from both channels of any two detectors in an alarm grouping be set, before a cargo fire warning is generated. In the event that a single detector is inoperative, the alarm algorithm will consider this in its evaluation for alarm. This alarm logic improves the reliability of the detection system in two ways. First, it aids in preventing nuisance alarms should contamination or a spurious signal affect a single detector. Second, it allows dispatch when a single detector is inoperative without increasing the alarm response time from the fully operational configuration. The smoke detectors include features to reduce the likelihood of nuisance fire alarms associated with non-smoke aerosols (dust, fog, etc.) and condensation. There is an integral temperature sensor within each detector that continually monitors, and broadcasts the ambient temperature in the cargo compartment to the cargo smoke detection (CSD) Controller. The detectors will output an over-temperature alarm signal if the temperature in the cargo compartment exceeds 115 degrees C for all detectors in a logical grouping. In addition, each detector incorporates a status light that is visible from the cargo compartment used to provide a visible indication of the detector's health.

During normal operation, for smoke detected, a fire warning alert is provided to the flight crew. The flight deck indications for a lower lobe cargo compartment fire warning are: 1. LWR FWD or LWR AFT Cargo Fire Switch Light (red), 2. Master Warning Lights (red), 3. EICAS Warning message: FIRE CARGO FWD or FIRE CARGO AFT, 4. Fire Bell, and 5. Automatic discharge of extinguisher bottles.

Consequences of Failure

Cargo compartment smoke detection system inoperative:

For an inoperative lower forward cargo compartment smoke detection system (all smoke detection zones in the lower forward cargo compartment are inoperative), the DET FAIL CARGO FWD Advisory message is displayed. For an inoperative lower aft cargo compartment smoke detection system (all smoke detection zones in the lower aft cargo compartment are inoperative), the DET FAIL CARGO AFT Advisory message is displayed. For this dispatch condition, cargo is restricted to non-combustible material or the associated cargo compartment must remain empty.

For a zone with one smoke detector inoperative:

For a single inoperative detector within any one of a compartment's three zones, the associated DET ZONE 1, 2 or 3 CARGO FWD or AFT Status message is displayed. There are no restrictions for dispatch provided not more than one detector is inoperative in each of the three zones. Remaining operable smoke detectors are adequate for smoke detection.

Smoke detector zone inoperative:

For two or more inoperative detectors in any single zone of a compartment, the CSD ZONE 1, 2 or 3 CARGO FWD or AFT Status message is displayed. System capability to detect smoke in the affected zone is reduced for the associated compartment. For this dispatch condition, cargo is restricted to non-combustible material or the associated cargo compartment zone must remain empty.

Consequences of Next Critical Failure

Cargo compartment smoke detection system inoperative:

Cargo compartment fire is mitigated by requiring the compartment to be empty or only contain non-combustible material.

For a zone with one smoke detector inoperative:

Remaining smoke detectors are capable of detecting smoke.

Failure of an additional smoke detector would reduce the associated zone's detection capability.

Smoke detector zone inoperative:

Cargo compartment fire is mitigated by requiring the associated compartment zone to be empty or only contain non-combustible material.

26-16-02 Cargo Smoke Detection (CSD) System Controller
26-16-02-01 CSD Controller Power Bus

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with CSD POWER BUS Status message displayed.

26-16-02 Cargo Smoke Detection (CSD) System Controller
26-16-02-02 CSD Controller Channels

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-16-02 Cargo Smoke Detection (CSD) System Controller
26-16-02-03 CSD Controller Area Network Buses
26-16-02-03-01 Forward Cargo Compartment

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-16-02 Cargo Smoke Detection (CSD) System Controller
26-16-02-03 CSD Controller Area Network Buses
26-16-02-03-02 Aft Cargo Compartment

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-16-04.

The 777X utilizes smoke detectors distributed in the forward and aft lower cargo compartments. There are three zones in each compartment with a total of 23 detectors installed in the forward compartment and 19 detectors installed in the aft compartment. Each of the spot-type photoelectric smoke detectors has two independent channels for redundancy. An inoperative channel in any single detector sets an associated maintenance message as the fault by itself does not affect the operation of the detector, nor affect dispatch.

The number of detectors and their spacing was determined to provide a rapid response for smoke detection. The cargo smoke detection system (CSDS) controller's alarm logic requires an alarm signal from both channels of any two detectors in an alarm grouping be set, before a cargo fire warning is generated. In the event that a single detector is inoperative, the alarm algorithm will consider this in its evaluation for alarm. In this scenario an alarm signal from both channels of any remaining detector in the logical alarm grouping will generate a cargo fire warning. This alarm logic improves the reliability of the detection system in two ways. First, it aids in preventing nuisance alarms should contamination or a spurious signal affect a single detector. Second, it allows dispatch when a single detector is inoperative without increasing the alarm response time from the fully operational configuration. The smoke detectors include features to reduce the likelihood of nuisance fire alarms associated with non-smoke aerosols (dust, fog, etc.) and condensation. There is an integral temperature sensor within each detector that continually monitors, and broadcasts the ambient temperature in the cargo compartment to the cargo smoke detection (CSD) Controller. The detectors will output an over-temperature alarm signal if the temperature in the cargo compartment exceeds 115 degrees C for all detectors in a logical grouping. In addition, as a visual aid for determining smoke detector health, each detector channel has a red light that illuminates when a FAULT condition is detected.

During normal operation, for smoke detected, a fire warning alert is provided to the flight crew. The flight deck indications for a lower lobe cargo compartment fire warning are: 1. LWR FWD or LWR AFT Cargo Fire Switch Light (red), 2. Master Warning Lights (red), 3. EICAS warning message: FIRE CARGO FWD or FIRE CARGO AFT, 4. Fire Bell.

The system uses a Cargo Smoke Detection (CSD) System Controller. The controller has two redundant (L & R) power busses, two redundant controller channels (A & B). The controller also has four Control Area Network (CAN) busses. Two CAN busses connect the string of detectors in the forward cargo compartment and two busses connect the string of connectors in the aft cargo compartment.

Consequences of Failure

CSD Controller Power Busses: An inoperative CSD power bus is indicated by the CSD POWER BUS Status message. The result is a loss of redundancy only. Remaining operable power bus provides full smoke detection functionality.

CSD Controller Channels: Failure of a single CSD controller channel is indicated by either the CSD CONTROLLER CH A or CSD CONTROLLER CH B Status message. The result is loss of redundancy only. Remaining channel is provides full smoke detection functionality.

CSD Controller Area Network (CAN) Busses: A failure of one bus in either or both cargo compartments is indicated by the CSD CAN BUS Status message. The result is loss of redundancy only. One remaining operable CAN bus for each string of detectors provides full smoke detection capability.

Consequences of Next Critical Failure

CSD Controller Power Busses: Loss of the remaining CSD power bus is indicated by the DET FAIL CARGO FWD and DET FAIL CARGO AFT Advisory messages. The result is loss of all smoke detection in both the forward and aft cargo compartments.

CSD Controller Channels: For loss of the remaining CSD controller channel, both the DET FAIL CARGO FWD and DET FAIL CARGO AFT Advisory messages will be displayed. The result is loss of all smoke detection in both the forward and aft cargo compartments.

CSD Controller Area Network (CAN) Busses: Loss of a remaining CSD CAN bus is indicated by the associated DET FAIL CARGO FWD or DET FAIL CARGO AFT Advisory message. The result is loss of all smoke detection in the associated cargo compartment.

For the DET FAIL CARGO FWD or DET FAIL CARGO AFT Advisory messages displayed, subsequent dispatch is allowed provided the associated cargo compartment remains empty (or only contains allowable items). There is no hazard to the airplane provided a smoke or fire event does not occur.

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26-17-01 Wheel Well Fire Detection Loops

26-17-01A

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both wheel well fire detection loops are deactivated,
- Brake temperature monitoring system (BTMS) operates normally, and
- BRAKE TEMP HIGH message is not displayed prior to retracting landing gear.

NOTE: BTMS provides real time brake temperature information.

26-17-01 Wheel Well Fire Detection Loops

26-17-01B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both wheel well fire detection loops are deactivated,
- After takeoff, landing gear remains down for ten minutes, and
- Appropriate performance adjustments are applied.

NOTE: In the event of engine failure after V1, retract landing gear until obstacles are cleared.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-17-01.

The Wheel Well Fire Detection System (WWFDS) consists of two parallel detection loops. Each of the two parallel loops consists of two overheat detection sensors in series. One sensor from each loop is located in the left wheel well and one sensor from each loop is located in the right wheel well (separated by the keel beam). Each overheat detection loop is connected to a separate Duct Leak Overheat Detection System (DLODS) card. The architecture allows one control card or one loop to fail without causing the loss of any subsystem function.

The primary purpose of the WWFDS is to protect the airplane from a fire ignited by overheated brakes, wheels or tires. The wheel wells are a unique flammable fluid or vapor leakage zone. Hot brakes, wheels or tires retracted into the wheel wells are capable of igniting flammable fluids or vapors.

The fire detection system is continuously monitored by BITE. In addition, a test is performed once daily from the flight deck by pressing the FIRE/OVHT TEST button on the overhead panel.

The Wheel Well Fire Detection System indicates a fire by detecting an overheat condition in the wheel well resulting in display of the EICAS Warning message FIRE WHEEL WELL along with the Master Warning light and aural alarm.

The overheat detect set point temperature threshold has been selected so that normal braking will not result in a fire warning. A fire warning will only occur when the temperature which is not normally present except in the presence of a fire. The temperature threshold for the warning takes into account the composite structure above the wheels and brake protective features of that structure.

Flight crew response to the message is to lower the landing gear and plan to land at the nearest suitable airport. When the FIRE WHEEL WELL message blanks, the flight crew is to wait for 20 minutes to allow the fire to fully extinguish. After the 20 minutes time period the flight crew can retract the landing gear and continue to the nearest suitable airport.

Consequences of Failure

Failure of either Wheel Well Fire Detection Loop is indicated by the following Status messages:

DET FIRE WHEEL WELL LOOP 1

DET FIRE WHEEL WELL LOOP 2

There is no additional message to indicate that both detection loops are inoperative.

The EICAS Advisory message DET FAIL WHEEL WELL will be displayed if the system fails the once daily fire system test initiated by pressing the FIRE/OVHT TEST button.

Dispatch is not allowed with only one detection loop operating normally. If only one operative detection loop were allowed at dispatch and that loop were to fail resulting in erroneous fire indication during a subsequent flight, the Non-Normal procedure would require the flight crew to lower extend the landing gear.

However, lowering the landing gear will not result in extinguishing the erroneous fire indication. This could result in landing gear remaining extended which can lead to fuel starvation before reaching a suitable airport to land. For this reason, when dispatching with an inoperative wheel well fire detection loop, both detection loops must be deactivated.

There are two dispatch options:

Brake Temperature Monitoring System (BTMS) Operates Normally (Option A):

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For this dispatch option, both wheel well fire detection loops are deactivated and the BTMS function is used to substitute for the inoperative Wheel Well Fire Detection System function. The BRAKE TEMP HIGH message will be display if the brake/wheel/tire temperature exceeds what would be allowed by the WWFDS. The BTMS can also be monitored using the Landing Gear Synoptic Display. Brake temperatures are indicated on a scale of 0.0 to 9.9. For brake temperatures 5.0 and higher, the BRAKE TEMP HIGH Caution message will be displayed and the temperature indication on the synoptic display will be shown in amber.

Engineering analysis has shown that a BTMS value of 5.0 will result in wheel well temperatures that are less than the WWFDS temperature trip point. Therefore, using the BTMS high temperature threshold of 5.0 is a reasonable substitute for an inoperative WWFDS.

BTMS Inoperative (Option B):

For this dispatch option, both wheel well fire detection loops are deactivated. There will be no available equipment to detect overheated brakes, wheels or tires. In this configuration, a potential fire threat is mitigated by requiring the landing gear to remain extended for 10 minutes after takeoff. Leaving the gear extended will allow potentially overheated brakes, wheels and tires to cool before they are retracted into the wheel well. Appropriate performance adjustments must be applied to account for the additional drag due to the extended landing gear while it remains extended.

Consequences of Next Critical Failure

BTMS Operates Normally (Option A):

Overheated brakes, wheels or tires: BTMS will detect the overheat condition. Flight crew will either leave gear extended or extend gear to cool prior to retraction into the wheel well.

If BTMS was not available, the item can be substantiated based numerical probability. The probability of a threatening wheel well fire event is 1.5E-08/FH.

The probability of failure resulting is loss of one wheel well fire detection loop (DET FIRE WHEEL LOOP 1 or 2) resulting in MMEL application is 8.86E-05. The maximum dispatch time for this scenario (no BTMS to mitigate hazard) would be 752 hours.

BTMS Inoperative (Option B):

The potential for wheel well fire is mitigated by allowing the brakes, wheels and tires to cool prior to retracting the landing gear.

26-18-01 Wing Duct Leak Detection Loops**26-18-01-01 Left Wing**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-18-01 Wing Duct Leak Detection Loops**26-18-01-02 Right Wing**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-18-01.

(SUBSTANTIATION is same as item 26-18-02).

Dual element detectors are routed near the high pressure metal ducting system in the wing inboard fixed leading edge and around each air conditioning pack in the pack bay.

For the 777-9, the duct leak and overheat detection system (DLODS) wing and pack bay subsystems have now been separated (at side of body) and have their own independent subsystem and associated Status messages. The EICAS Caution messages remain unchanged and indicate the same whether there is a duct leak/burst in the wing or the pack bay. Additional/new detectors have also been added to the pack bay to help protect the composite floor structure above the packs.

(The new pack bay detector loops are incorporated on 777X to protect composite floor structure above each pack.) The loop detection devices will detect bleed air leakage and duct bursts which may present hazards to critical structure and/or potential for fuel ignition. Under normal operation, both loops are required to signal an overheat condition. 'AND' logic is performed by the redundant detectors connected to separate control cards. Each card can independently detect its respective loop failures. Detectors incorporate fail-safe logic so that if a single card or loop failure is detected, the system automatically ignores inputs and outputs from the failed card or loop.

Consequences of Failure

Failure of a wing duct leak detection loop or associated control card is indicated by the BLEED LOOP 1 or 2 WING L or R Status message.

The failed loop no longer provides the normal redundant overheat protection. The remaining loop still provides full functionality for overheat protection.

Consequences of Next Critical Failure

Duct leak or burst duct: There would be no consequence as the remaining functioning DLODS loop would detect the overheat and react as per design, also providing indication of the correlated BLEED LEAK L or R Advisory message.

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26-18-02 Pack Bay Duct Leak Detection Loops**26-18-02-01 Left Pack**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-18-02 Pack Bay Duct Leak Detection Loops**26-18-02-02 Right Pack**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-18-01.

(SUBSTANTIATION is same as item 26-18-01).

Dual element detectors are routed near the high pressure metal ducting system in the wing inboard fixed leading edge and around each air conditioning pack in the pack bay.

For the 777-9, the duct leak and overheat detection system (DLODS) wing and pack bay subsystems have now been separated (at side of body) and have their own independent subsystem and associated Status messages. The EICAS Caution messages remain unchanged and indicate the same whether there is a duct leak/burst in the wing or the pack bay. Additional/new detectors have also been added to the pack bay to help protect the composite floor structure above the packs.

(The new pack bay detector loops are incorporated on 777X to protect composite floor structure above each pack.) The loop detection devices will detect bleed air leakage and duct bursts which may present hazards to critical structure and/or potential for fuel ignition. Under normal operation, both loops are required to signal an overheat condition. 'AND' logic is performed by the redundant detectors connected to separate control cards. Each card can independently detect its respective loop failures. Detectors incorporate fail-safe logic so that if a single card or loop failure is detected, the system automatically ignores inputs and outputs from the failed card or loop.

Consequences of Failure

Failure of a wing duct leak detection loop or associated control card is indicated by the BLEED LOOP 1 or 2 PACK L or R Status message.

The failed loop no longer provides the normal redundant overheat protection. The remaining loop still provides full functionality for overheat protection.

Consequences of Next Critical Failure

Duct leak or burst duct: There would be no consequence as the remaining functioning DLODS loop would detect the overheat and react as per design, also providing indication of the correlated BLEED LEAK L or R Advisory message.

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26-18-03 Body Duct Leak Detection Loops**26-18-03-01 Loop 1**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Body Duct Leak Detection Loop 2 operates normally, and
- Both Right System Cardfile ASG Cards operate normally.

26-18-03 Body Duct Leak Detection Loops**26-18-03-02 Loop 2**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Body Duct Leak Detection Loop 1 operates normally, and
- Both Left System Cardfile ASG Cards operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-18-02.

The Auxiliary Power Unit/Air Driven Pump (APU/ADP) Duct Leak Detector Loops are dual redundant loops routed through the body near the high pressure metal ducting running to the APU and to the ADP. The loop detection devices will detect bleed air leakage and duct bursts which may present hazards to critical structure and/or potential for fuel ignition. Under normal operation, both loops are required to signal an overheat condition. 'AND' logic is performed by the redundant detectors connected to separate control cards. One control card or one detector loop may fail without causing the loss of any system functionality.

Consequences of Failure

Failure of a body duct leak detection loop or associated control card is indicated by the BLEED LOOP 1 BODY or BLEED LOOP 2 BODY Status message.

The failed loop no longer provides the normal redundant overheat protection. The remaining loop still provides full functionality for overheat protection.

Consequences of Next Critical Failure

A duct leak or burst duct: There would be no consequence as the remaining functioning DLODS loop would detect the overheat and react as per design providing indication of the associated BLEED LEAK BODY Advisory message.

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Section 2

26-18-04 Engine Strut Overheat Detection Loops

26-18-04-01 Left Strut

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

26-18-04 Engine Strut Overheat Detection Loops

26-18-04-02 Right Strut

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-18-03.

The engine strut overheat detector system uses dual loop elements to detect bleed air leakage and duct bursts which may present hazards to critical structure and/or potential for fuel ignition.

The duct leak and overheat detection system (DLODS) strut subsystem consists of three redundant detectors installed in series. This includes one dual-element compact sensor that resides within the Strut Box volume, and two dual-element linear sensors mounted parallel to the High Pressure Ducting (HPD) within the strut to fixed leading edge cavity.

The redundant detectors are connected to separate control cards that reside within the cardfiles. Under normal operation, both loops are required to signal an overheat condition. 'AND' logic is employed by the redundant detectors. One control card or one detector loop may fail without causing the loss of any system functionality.

Consequences of Failure

Failure of a strut overheat detection loop or associated control card is indicated by the BLEED LOOP 1 or 2 STRUT L or R Status message.

The failed loop no longer provides the normal redundant overheat protection. The remaining loop still provides full functionality for overheat protection.

Consequences of Next Critical Failure

A duct leak or burst duct: There would be no consequence as the remaining functioning DLODS loop would detect the overheat and react as per design providing indication of the associated BLEED LEAK STRUT L or R Advisory message.

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Section 2

26-18-05 Engine Fan Case Overheat Detection Loops

26-18-05-01 Left Engine

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

NOTE: Dispatch is not allowed with the associated inoperative engine anti-ice valve locked in the mid-position.

26-18-05 Engine Fan Case Overheat Detection Loops

26-18-05-02 Right Engine

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

NOTE: Dispatch is not allowed with the associated inoperative engine anti-ice valve locked in the mid-position.

26-18-05 Engine Fan Case Overheat Detection Loops

26-18-05-03 Both Overheat Detection Loops On One Engine

Interval	Installed	Required	Procedure
B	4	1	(O)

Both Detection Loops on one engine may be inoperative provided:

- At least one Fan Case Overheat Detection Loop on opposite engine operates normally,
- Associated Engine Anti-Ice selector remains OFF,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

NOTE: Dispatch is not allowed with an inoperative Fan Case Overheat Detection Loop if the associated Engine Anti-Ice Valve is locked in the mid-position.

SUBSTANTIATION

Background

Proposal based on 777 FAA MMEL item 26-18-04-01.

Refer to FAA MMEL policy letter 40 (PL-40).

The purpose of DLODS fan case subsystem is to detect bleed air leakage and/or duct bursts which could possibly lead to EEC overheating and causing engine shutdown, and/or fan cowl/fan case structural failure.

The engine fan case overheat detection system consists of one compact dual loop detector per engine. The detectors are dual loop for redundancy and are bolted directly to the engine fan case. Under normal operation, both loops are required to signal an overheat condition. 'AND' logic is performed by the redundant detectors connected to separate control cards. Each card can independently detect loop failures. The Duct Leak and Overheat Detection System (DLODS) detectors incorporate fail-safe logic so that if a single card or loop failure is detected, the system automatically ignores inputs and outputs from the failed card or loop. There is no loss of any subsystem function.

The fan case overheat detectors are located between the engine anti-ice ducting and the electronic engine controller (EEC) to detect duct leaks.

If DLODS detects an overheat condition, the associated EAI LEAK L or EAI LEAK R Caution message will be displayed and the flight crew will accomplish the associated Non-Normal Checklist.

Consequences of Failure

Failure of a single detection loop or DLODS card results in display of any one of the following Status messages:

EAI LOOP 1 FANCASE L
EAI LOOP 1 FANCASE R
EAI LOOP 2 FANCASE L
EAI LOOP 2 FANCASE R

Failure of one detection loop:

Loss of redundancy only. The remaining detection loop will provide the overheat detection function.

Failure of both detection loops on one side (one engine):

Loss of ability to detect an engine anti-ice (EAI) duct leak on the associated engine. For dispatch, the associated EAI must selected OFF. The airplane must not be operated into known or forecast icing conditions. A least one detection loop must operate normally on the opposite engine.

PL-40 Considerations:

For ETOPS beyond 120 minutes, no MMEL relief is allowed for items that have a proviso restricting the airplane from operating into known or forecast icing.

For EASA, no ETOPS is allowed for inoperative EAI when operating into known or forecast icing conditions.

Engine Anti-Ice (EAI) Valves - Valve Locked in Mid Position MMEL item requires associated engine fan case overheat detection system to operate normally.

Therefore, an inoperative EAI valve associated with one or both fan case overheat detection loops must not be locked in the mid position.

Consequences of Next Critical Failure

For a single loop inoperative:

A duct leak or burst duct would be detected by the remaining functioning DLODS loop. The associated EAI LEAK L, R Caution message would be displayed and the flight crew would accomplish the appropriate Non-Normal Checklist which will mitigate consequences due to an overheat condition.

For both loops inoperative on one side:

There is no next critical failure as compliance with the proviso eliminates the possibility of both an engine anti-ice duct leak or burst and also the possible icing accumulation which could lead to engine vibration and possible damage, followed by engine shutdown.

ETOPS beyond 120 minutes is not allowed when airplane is restricted from operation into known or forecast icing (FAA).

ETOPS beyond 60 minutes (no ETOPS) is not allowed when airplane is restricted from operation into known or forecast icing (EASA).

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26-19-01 Equipment Cooling Smoke Detectors**26-19-01-01 Supply Smoke Detector**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Equipment Cooling Vent Fan operates normally, and
 - Equipment Cooling Exhaust Smoke Detector operates normally.
-

26-19-01 Equipment Cooling Smoke Detectors**26-19-01-02 Exhaust Smoke Detector**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Equipment Cooling Vent Fan is deactivated,
 - Equipment Cooling Supply Smoke Detector operates normally, and
 - For ground operations with OAT 30°C or higher, both Air Conditioning Packs are operated or airplane is supplied with conditioned air.
-

SUBSTANTIATION**Background**

The equipment cooling system includes 2 smoke detectors. One detector is installed in the electrical/electronic (E/E) cooling vent system and detects smoke in the E/E bay, flight deck, from equipment and from the vent fan. The other detector is installed in the E/E Cooling supply system and will detect smoke from the supply fans and the forward left cheek.

Consequences of Failure

The DET SMOKE E/E SUPPLY Status message is displayed when both channels fail on the Supply Smoke Detector. The Supply Smoke Detector will not be available to detect a smoke event from the supply fans and forward cheek. For dispatch, the Exhaust Smoke Detector must operate normally and is used to provide smoke detection. The Equipment Cooling Vent Fan must operate normally to ensure Equipment Center vent air is exhausted to the Exhaust Smoke Detector.

The DET SMOKE E/E EXH Status message is displayed when both channels a fail on the Exhaust Smoke Detector. The Exhaust Smoke Detector will not be available to detect a smoke event in the E/E Bays and Flight Deck instruments via the Vent Fan. For dispatch, the Supply Smoke Detector must operate normally and is used to provide smoke detection. The Vent (exhaust) Fan is deactivated in the event the vent fan does not properly shut down upon detection. This ensures the exhaust system will not act as a smoke conduit which could cause E/E Bay smoke to migrate to other compartments.

For ground operations, deactivation of the Vent Fan will result in degraded equipment cooling capability. For hot temperatures on-ground, either both packs must be operated or conditioned air must be supplied.

Note that a requirement for an associated Supply Fan to operate normally is not included in the dispatch relief for an inoperative exhaust detector because one of the two supply fans must always be operative.

Consequences of Next Critical Failure

Supply detector deactivated:

Smoke event upstream of the supply smoke detector: Smoke will be detected by the exhaust detector once it travels through the system. Crew may see some smoke in the flight deck due to this delayed detection. Results in SMOKE EQUIP COOLING Caution message and EQUIP COOLING OVRD Advisory message. Hazard classification for this event is 'Major'.

Exhaust detector deactivated:

Smoke event in EE Bay or downstream of the supply smoke detector will not be detected. Possible smoke penetration to the flight deck and cabin. QRH Smoke, Fire Fumes checklist will put system in Override which will aid in smoke evacuation. In addition, the vent (exhaust) fan is deactivated to prevent smoke penetration via the exhaust system ducting. Results in EQUIP COOLING OVRD Advisory message. Hazard classification for this event is 'Major'.

Failure of remaining smoke detector combined with a smoke or fire event:

Without smoke detection, smoke would enter the cabin/Flight Deck and/or adjacent compartments. If this occurs, the flight crew will accomplish the Smoke, Fire, Fumes and/or SMOKE EQUIP COOLING Non-Normal checklist to mitigate this condition and possible diversion. If this event result in the FIRE CARGO FWD message, fire suppressent would be discharged and diversion would be required. Hazard classification for this event is 'Major'.

26-21-01 Fire BTL DISCH Lights (Engine, APU, Cargo)

Interval	Installed	Required	Procedure
C	6	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-21-01.

Lights on the aft aisle stand in the flight deck are illuminated when pressure drops below a specified level in the engine or APU fire bottles (ENG BTL 1 or 2 DISCH - each engine, APU DISCH). The DISCH light on the CARGO FIRE DISCH switch on the overhead panel is illuminated when pressure caused by extinguishant flow rises in the fire bottle discharge lines for the cargo fire extinguishing system

The BOTTLE ENG (L1, L2, R1, R2), the BOTTLE APU, and the BOTTLE (1A, 1B, 2A, 2B, 2C, 2D, 2E, 2F, 2G) CARGO Status messages indicate either a failure of the discharge squib or low pressure in the engine, APU, or cargo fire bottles, respectively. In addition to the previously listed messages, the cargo fire suppression bottles will display the BOTTLE DISCH CARGO Advisory message when both cargo fire high rate discharge bottles (1A and 1B) have low bottle pressure. The BOTTLE DISCH ENG (L1, L2, R1, R2) Advisory message alerts the crew when the engine bottles have discharged.

Consequences of Failure

Flight deck indication from the discharge light is not available to confirm fire bottle discharge. The associated Advisory and Status messages will indicate if the bottle(s) has been discharged or is in a low pressure condition.

Consequences of Next Critical Failure

Failure that results in loss of BOTTLE DISCH (APU, CARGO, ENG _) Advisory messages or BOTTLE (APU, _ CARGO, ENG _) Status messages: The flight crew will be unaware of the fire bottle condition. If bottle(s) has been discharged or is in a low pressure condition, fire extinguishing capability is unavailable.

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Section 2

26-21-02 Fire Extinguishing Squib Test System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided squib electrical continuity is verified before each departure.

26-21-02 Fire Extinguishing Squib Test System

26-21-02-01 Cargo Squib Test System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- May be inoperative provided procedures are established and used to verify lower cargo compartments remain empty or contain only ballast, empty cargo handling equipment (ballast may be loaded in ULDs), or fly away kits.

NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 26-21-02.

Fire bottle squib electrical continuity checks are automatically performed when ELMS receives power during airplane power-up and following engine shutdown. This typically results in a check twice per flight cycle. Exceptions to this would occur if ELMS is not depowered and/or engines are not shut down between flights. The test can also be performed from the maintenance access terminal.

Consequences of Failure

The ENG/APU SQUIB TEST or the CARGO SQUIB TEST Status message will be displayed when the squib test is ran by ELMS and the relay monitor does not sense voltage downstream of the of squib test relay indicating that a fault is detected in the Engine/APU fire extinguishing squib test system or in the cargo fire extinguishing squib test system, respectively. If both messages are annunciated, the fault may be located in the squib test circuit relay.

The associated BOTTLE (2A, 2B, 2C, 2D, 2E, 2F or 2G) CARGO, BOTTLE APU or BOTTLE ENG (L1, L2, R1 or R2) Status message will also be displayed.

The maintenance procedure changes the relay in the squib test circuit with another relay from the ELMS cabinet. The test may then be rerun. If the test is completed successfully, the fire extinguishing squibs are functional. If the failure is downstream of the Squib Test Control Relay, then individual status messages may be displayed. Dispatch is not allowed for a failed Engine/APU Squib Test System unless the electrical squib test is conducted with the use of a substitute relay before each departure.

Dispatch is allowed for the Cargo Squib Test System provided the compartments remain empty or only non-combustibles are carried.

Consequences of Next Critical Failure

Squib Test Control Relay: APU/engine and/or cargo fire: APU/engine fire detection or cargo detection and fire extinguishing system detects and extinguishes fire. Squib continuity is verified before each departure and failure of a fire bottle squib during the subsequent flight is unlikely.

Cargo Squib Test System: none, as the compartments must remain empty or only non-combustibles are carried.

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Feb 26, 2026

26-22-01 APU Fire Extinguisher System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Backup AC Electrical Power System is verified to operate normally before each departure,
- b. Other procedures do not require use of APU,
- c. APU selector switch remains OFF, and
- d. Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION

Background

Proposal similar to 777 MMEL item 26-22-01.

The APU fire extinguishing system is a single shot, high rate discharge system. The fire extinguisher bottle is located on the forward side of the APU firewall and discharges directly into the APU compartment. The fire bottle can be discharged using either the APU fire handle located on the pilots overhead panel or the ground control panel located on the nose gear.

Consequences of Failure

The BOTTLE APU Status message will be displayed for APU fire bottle low pressure or failure of the automated squib continuity check.

Ability to discharge extinguishant into the APU compartment is lost.

Consequences of Next Critical Failure

None identified. Not operating the APU effectively eliminates the possibility of APU compartment fire.

26-22-02

APU Auto Discharge Function

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided APU is monitored during APU ground operations for fire warning.

SUBSTANTIATION**Background**

Proposal same as 777 MMEL item 26-22-02.

Unattended Fire Alarm: The APU fire detection card cardfile can automatically operate the APU fire extinguishing system when the airplane is in unattended mode. The airplane is in unattended mode when it is on the ground and neither engine is running. The APU fire detection card operates the system through the unattended fire alarm. During an unattended fire alarm when the APU fire switch on the overhead P5 panel is not out, the APU remote warning relay closes. The unattended fire alarm from the APU fire detection card energizes the APU fire bottle auto discharge relay after a 10-second delay. When the APU remote warning relay and APU fire bottle auto discharge relay are both energized, power from the hot battery bus goes to the APU fire extinguishing bottle squib which fires and releases the Halon from the bottle into the APU compartment.

The BTL DISCH APU Advisory message and the discrete panel light indicate when the APU fire bottle is discharged or when the fire bottle pressure is low.

Service and APU Shutdown Panel: The APU FIRE SHUTDOWN and APU BOTTLE DISCHARGE switches on the P40 service and APU shutdown panel are used to operate the APU fire extinguishing system. When the APU FIRE SHUTDOWN switch is pushed, the APU external shutdown relay energizes, the BOTTLE ARMED light comes on and power is available at the APU BOTTLE DISCHARGE switch. When the APU BOTTLE DISCHARGE switch is pushed, power goes to the APU fire extinguishing bottle squib which fires and releases the Halon from the bottle into the APU compartment.

APU Fire Switch: The APU fire switch on the overhead P5 panel can be used to operate the APU fire extinguishing system in both attended and unattended modes, as well as when the airplane is in the air. When the APU fire switch is in the left or right discharge position, power goes through the APU fire switch contacts to the APU fire extinguishing bottle squib which fires and releases the Halon from the bottle into the APU compartment.

Consequences of Failure

APU automatic fire extinguishing system will not function when the APU is operated in unattended mode. Ground crew must monitor the APU and, in the event of an APU fire, activate the fire extinguishing system using the P40 service and APU shutdown panel. An APU fire can also be extinguished using the APU fire switch on the overhead P5 panel.

Consequences of Next Critical Failure

APU fire: fire is extinguished by manually operating the APU extinguishing system.

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26-23-01 Lower Cargo Compartment Fire Extinguisher Bottles

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits.

NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

26-23-01 Lower Cargo Compartment Fire Extinguisher Bottles**26-23-01-01 Metered Bottles**

Interval	Installed	Required	Procedure
C	-	1	(M) (O)

May be inoperative provided:

- Fire Extinguisher (dump) Bottles 1A and 1B operate normally,
- Fire Extinguisher (metered) Bottle 2A operates normally,
- Associated bottle is deactivated,
- Airplane is operated pressurized, and
- Appropriate flight planning adjustments are applied to account for remaining fire suppression capability.

26-23-01 Lower Cargo Compartment Fire Extinguisher Bottles**26-23-01-02 Bottle Pressure Switches**

Interval	Installed	Required	Procedure
C	-	0	(M)

May be inoperative provided:

- Associated bottle is verified full, and
- Associated bottle squib firing circuit is verified operating normally before each departure.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 26-23-01.

The cargo fire suppression system (CFSS) supplies Halon to either the forward or the aft lower cargo compartment, as selected. Six bottles are used to contain the suppressant. Upon activation, two bottles (1A and 1B) are rapidly discharged into the selected cargo compartment. Metered bottles are used to maintain an inert environment in the selected cargo compartment after the initial rapid discharge. The contents of these bottles are metered into the selected cargo compartment at a controlled rate to replace extinguishing agent lost to leakage. Metered discharge from all these bottles (2A, 2B, 2C, 2D, 2E, 2F, 2G, depending on configuration) begins 5 minutes after the rapid discharge has occurred in flight. If the airplane is on the ground when the cargo fire extinguishing system is activated, bottle 2A discharges 5 minutes following system activation. If the airplane is airborne and the cargo fire extinguisher system is activated and then lands prior to 5 minutes elapsing, bottle 2A is discharged when the airplane lands. The basic CFSS provides a total of 195 minutes of fire suppression in the selected compartment. Metered bottle 2A is required to provide 60 minutes (TBV) of cargo compartment fire protection otherwise cargo remains empty because, as mentioned above, it's the only bottle that will operate during ground operations. Each single operable metered bottle adds about 60 minutes operating time (TBV).

Bottle Pressure Switches: Each lower cargo compartment fire extinguishing bottle has a pressure switch to indicate when the bottle pressure is low. This signal is or'd with the squib status signal, so that when the switch is closed (pressure low) or the associated bottle squib has failed a squib test, the associated bottle status message is displayed (BOTTLE XX CARGO). If the switch fails closed the associated fire bottle status message will be displayed (BOTTLE XX CARGO), yet the bottle pressure would be normal and the bottle would function normally in the event of a cargo compartment fire provided the associated squib operated normally. If the failure occurs, weighing the bottle verifies that the bottle is full of fire extinguishing agent and verifying the squib operates normally before each departure will ensure the squib will fire in the event a cargo fire occurs. The bottle installation procedure requires a bottle squib test. A squib test is also automatically initiated after each landing after at least one engine is shutdown. A squib test is also automatically initiated upon airplane power-up.

Consequences of Failure

The BOTTLE n CARGO Status message (n=1A, 1B, 2A, 2B, 2C, 2D, 2E, 2F or 2G) when the associated cargo compartment fire extinguishant bottle pressure is low from a leak or because bottle has been discharged, OR failure of discharge squib associated with bottle. The BOTTLE FAULT CARGO Advisory message will also be displayed.

For rapid discharge bottles inoperative (1A, 1B or 2A):

Cargo compartments must remain empty.

For metered bottle(s) inoperative:

Metered extinguishing agent from the associated bottle is not available. Flight planning adjustments must be applied to ensure the total time of fire suppression is reduced proportional to the number of bottles that are failed.

Bottle Pressure Switches:

None. Associated bottle must be verified full and squib firing circuit must be verified to operate normally prior to each departure.

Consequences of Next Critical Failure**Cargo compartment fire:****For rapid discharge bottles inoperative:**

No combustable cargo is carried in the cargo compartments.

For metered bottle(s) inoperative:

Fire extinguishing system functions normally with reduced fire suppression agent, the distance to an airport is commensurate with the available fire protection provided by the reduced fire suppression agent.

Another fire bottle fails: available fire suppression time is further reduced, however failure of an additional bottle and a cargo fire occurring on one flight is highly unlikely.

Bottle Pressure Switch:

Cargo compartment fire: fire bottle will operate normally in the event of a cargo compartment fire as the bottle was weighed at the start of the dispatch period to verify that it is full and the squib was verified to operate normally before the flight.

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Section 2

26-23-02 Lower Cargo Compartment Fire Extinguisher Flow Valves (Forward or Aft)

26-23-02A

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated flow valve is capped,
- Associated flow valve squib electrical connectors are capped and stowed, and
- Procedures are established and used to verify the associated cargo compartment remains empty or contains only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits.

NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

26-23-02 Lower Cargo Compartment Fire Extinguisher Flow Valves (Forward or Aft)

26-23-02B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Procedures are established and used to verify cargo compartments remain empty or contain only ballast, empty cargo-handling equipment (ballast may be loaded in ULDs), or fly away kits.

NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

SUBSTANTIATION

Background

Proposal is similar to 777 MMEL item 26-23-02.

Two flow valves are used in the lower cargo fire extinguishing system, one for the forward compartment and one for the aft. Both valves are closed to flow in their normal state. The flow of extinguishant is directed to the selected compartment by opening the respective flow valve. The flow valve is opened by the flow valve cartridge (squib) actuation in a manner similar to the way the fire bottles are discharged. A single squib is used in each flow valve. The squib is actuated to open the valve for flow in a discharge event.

Consequences of Failure

Failure of a lower cargo compartment fire extinguisher flow valve is indicated by the FLOW VALVE CARGO AFT or FWD Status message.

The associated fire extinguishing system can not supply extinguishing agent to the associated cargo compartment.

For one valve inoperative:

Associated valve must be capped and squib electrical connectors must be disconnected, capped and stowed. Associated cargo compartment must remain empty.

For both valves inoperative:

Cargo compartments must remain empty.

Consequences of Next Critical Failure

Cargo compartment fire: There is no combustible cargo carried in the affected cargo compartment.

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Federal Aviation Administration (FAA)**ATA 26****777-9 Master Minimum Equipment List****Section 2****26-24-01 Lavatory Fire Extinguisher Systems****26-24-01A**

Interval	Installed	Required	Procedure
C	-	0	

For each lavatory, the Lavatory Fire Extinguisher System may be inoperative provided the associated Lavatory Smoke Detection System operates normally.

26-24-01 Lavatory Fire Extinguisher Systems**26-24-01B**

Interval	Installed	Required	Procedure
C	-	0	(M) (O)

For each lavatory, the Lavatory Fire Extinguisher System may be inoperative provided:

- Lavatory waste receptacle is empty.
- Associated lavatory door is locked closed and placarded, "INOPERATIVE - DO NOT ENTER", and
- Lavatory is used only by crewmembers.

NOTE: These provisions are not intended to prohibit lavatory use or inspections by crewmembers.

26-24-01 Lavatory Fire Extinguisher Systems**26-24-01C**

Interval	Installed	Required	Procedure
D	-	0	

Any in excess of that required by 14 CFR may be inoperative.

SUBSTANTIATION**Background**

Proposal same as 777 MMEL items 26-24-01-01A, B and C.

Refer to FAA policy letter 24.

The lavatory fire extinguishing system consists of a fire extinguishing bottle that discharges when a heat sensor detects temperatures above 174 degrees F. The extinguishing agent flows through two nozzles into the waste compartment.

Consequences of Failure

Fire extinguishing agent would not automatically discharge in the event of a fire in the lavatory.

Consequences of Next Critical Failure

None identified. Compliance with provisos effectively eliminates possibility of an undetected fire in the associated lavatory.

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Section 2

26-26-01 Portable Fire Extinguishers

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or removed provided:

- Inoperative fire extinguisher remains in a certified location until removed from the aircraft at the next suitable maintenance facility,
- Location placarding is removed or obscured, and
- Required distribution is maintained.

NOTE: Inoperative fire extinguishers, removed from a certified location or removed from the aircraft, are subject to 49 CFR dangerous goods regulations.

26-26-01 Portable Fire Extinguishers

26-26-01-01 Tamper Seals or Tags

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged or missing provided proper installation and servicing is verified at each preflight.

SUBSTANTIATION

Background

Proposal based on 777 FAA MMEL item 26-26-01.

Refer to FAA policy letter 132.

A portable, Halotron BrX (2-Bromotrifluoropropene or 2-BTP) filled fire extinguisher is installed in the flight compartment. Portable fire extinguishers are installed in the passenger compartment per CFR 14 25.851. Fire extinguishers must be of a type and quantity appropriate to the passenger configuration and the kinds of fires likely to occur where used. May be water filled or Halotron BrX (2-Bromotrifluoropropene or 2-BTP) filled.

Consequences of Failure

The associated extinguisher is inoperative. Compliance with the proviso insures that the remaining extinguishers provide the required capability.

Consequences of Next Critical Failure

Fire in the flight deck or cabin: portable extinguishers are used to extinguish the fire.

- 27-00-01 Flight Controls Synoptic Display**
- 27-02-01 Bank Angle Protection**
- 27-02-02 Flight Control Modules (FCMs)**
 - 27-02-02-01 Primary Flight Computers DISC Light
- 27-02-03 PFCS Interface**
- 27-02-04 Actuator Delta Pressure Function**
- 27-02-05 Actuator Monitor Sensor Function**
- 27-02-06 Flight Control Hydraulic Shutoff Valves**
- 27-02-07 Flight Controls Dedicated Inertial Sensors**
- 27-02-08 Modal Suppression Accelerometers (MSA)**
- 27-11-01 Alternate Control Wheel Position Transducers**
- 27-11-02 Aileron Actuator Remote Electronics Unit (REU) Channels**
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27-00-01

Flight Controls Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 27-00-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

27-02-01 Bank Angle Protection

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-02-01.

The primary flight control function (PFCF) includes a bank angle protection (BAP) function to provide enhanced situational awareness of excessive bank angle to the pilot via tactile cues. The function becomes active at bank angles greater than 35 degrees or at bank angles as low as 20 degrees in overspeed conditions. BAP has two modes, depending upon whether or not pilot hands are detected on the wheel. If pilot hands are detected on the wheel, then the PFCF generates a wheel backdrive command to provide corrective tactile force cue while the bank angle exceeds 30 degrees. If pilot hands are not detected on the wheel, then the PFCF generates a wheel backdrive command to maintain 30 degrees bank angle. Pilots can manually override this function by applying control wheel force.

BAP is inoperative for any of the following conditions:

- The autopilot wheel backdrive is inoperative
- Both the captain's and f/o's control wheel force transducer is inoperative
- Flight controls not in normal mode (non-dispatchable)
- R integrated flight control electronics (IFCE) is inoperative (non-dispatchable)

Consequences of Failure

Failure of the BAP function is annunciated by the BANK ANGLE PROTECT Status message or the A/P BACKDRIVE WHEEL Status message.

Constant wheel force is not required to maintain bank angles in excess of 35 degrees and no tactile cue would be given to the pilot when the bank angle exceeds 35 degrees.

Consequences of Next Critical Failure

Bank angle excursion beyond the bank angle protection boundary: Return to normal flight attitude is accomplished by the pilot using normal control wheel inputs. Flight characteristics are similar to other Boeing models which do not have the BAP function (e.g., 737, 747, 757, 767).

27-02-02 Flight Control Modules (FCMs)

Interval	Installed	Required	Procedure
B	3	2	(M)

One may be inoperative provided associated FCM is deactivated.

27-02-02 Flight Control Modules (FCMs)**27-02-02-01 Primary Flight Computers DISC Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal for 27-02-02 based on to 787 MMEL items 27-02-02-01, -02, -03.

Proposal for 27-02-02-01 based on 787 MMEL item 27-02-02-04.

The 777-9 Integrated Flight Control Electronics (IFCE) is designed with several levels of dissimilarity and redundancy for high integrity and reliability.

There are four IFCE cabinets, which are made up of the Power Control Module (PCM) and Actuation Control Electronics (ACE) housed in a dedicated electrical cabinet. There are three Flight Control Modules (FCM), co-located next to three of the IFCE cabinets in stand-alone trays. The FCMs perform most of the complex computations and functions, including computing high integrity trusted sensor values and control surface position commands. The FCM typically interfaces with sensors and actuation equipment via the ACEs. The FCMs provide direct interface to other airplane systems and the Common Computing System (CCS) via their ARINC 664 Common Data Network (CDN) interface. The FCMs interface with other IFCS components through the ACEs. The FCMs and ACEs communicate via point-to-point Inter Module Busses (IMB).

The IFCE suite is redundant by design in order to provide IFCS integrity and availability. The redundancy of FCMs, ACEs, and PCMs support IFCS availability through the systems' ability to operate with many combinations of these components failed. IFCS integrity is facilitated through multiple voting schemes between the FCMs and ACEs. The FCMs are all connected to each other via IMBs, enabling each FCM to independently calculate input and output signals, as well as compare its calculations to each of the other FCMS before transmitting to the ACEs. Additionally, each FCM interfaces with each ACE, via IMB, facilitating the ACEs' voting of FCMs' transmissions. This redundancy allows dispatch relief with a single FCM inoperative.

The 777X FCM design incorporates lessons learned from known 787 FCM reset and channel mistrack issues.

Consequences of Failure

For FCM:

Failure of any single FCM is annunciated by the FCM CHANNEL C, L, R Status message. The PFCS INTERFACE Status message will also be displayed due to loss of communication between the failed FCM and the CDN; see further discussion under proposed MMEL item 27-02-03.

Loss of redundancy. Upon failure of a single FCM, the two remaining FCMs are fully capable of providing the primary flight controls function (PFCF), high lift function (HLF), autoflight function (AFF), and air data reference function (ADRF) without degradation of operating mode or safety monitoring.

For DISC Light:

None. FCTL IN DIRECT MODE Caution message (accompanied by Beeper) is the primary means of notifying flight crew that the primary flight control (PFC) system is operating in direct mode regardless of whether this is due to manual selection via the PFC switch or from a failure. EICAS message directs to a QRH procedure which requires toggling of the PRIMARY FLIGHT COMPUTERS switch (when direct mode is not intentional), but does not require operation of DISC light.

Consequences of Next Critical Failure

For FCM: Failure of a separate IFCE cabinet (ACE and PCM failure as well as an additional FCM) results in failure effects similar to single hydraulic system failure, with individual flight control actuators unpowered depending on specific failed IFCE. Flight deck effects include:

- SPOILER PAIRS FAULT Advisory
- NO LAND 3 Advisory
- STABILIZER FAULT C or R Advisory (for IFCE C or R)
- AUTO SPDBRAKE FAULT Advisory (for IFCE L1, C or R)
- NO BACKDRIVE COLUMN Advisory (for IFCE L1)
- NO BACKDRIVE WHEEL Advisory (for IFCE R)
- ISFD blank (for IFCE L2)

IFCE failure (except for L2) combined with the inoperative FCM leaves a single remaining FCM which supports PFCF, HLF, AFF, and ADRF without degradation of operating mode or safety monitoring. Additional flight deck effects associated with the single FCM configuration include:

- F/D SINGLE SOURCE Advisory
- ENG EEC IN ALTN L, R Advisory
- ENG EEC MODE L, R Status

For DISC Light:

None.

27-02-03 PFCS Interface

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be dispatched with PFCS INTERFACE Status message displayed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-02-03.

The primary flight control function (PFCF) relies on information from other systems in order to perform its function. The primary systems and interfaces that support PFCF operation are; earth reference system (ERS), air data sensors, angle of attack sensors, common core system (CCS), CCS hosted applications, propulsion system, fuel system, proximity sensing system, hydraulic system, thrust control system, and electrical power system.

The PFCF monitors the availability of necessary input signals. Some reduction in the availability of redundant signals can be tolerated without any loss of PFCF functionality. The PFCS INTERFACE Status message is designed to be displayed when interface redundancy is reduced but remains acceptable for continued normal operation. (Note: the acronym "PFCS" is used for consistency with the same status message on 777.)

Consequences of Failure

The PFCS INTERFACE Status message is set if the common core system (CCS) detects a failure of any common data network (CDN) link to or from the flight control modules (FCMs).

PFCS INTERFACE Status message is also displayed when redundancy is reduced due to faults detected in one or more of the following systems:

Stall warning: Loss of any 2 of 4 separate Stall Warning data sources from DCA hosted function.

Permanent magnet generators (PMG): Loss of two flight control PMGs with the associated engine(s) running.

Throttle position: Either throttle position coincidence monitor has tripped.

Slow On Ground signal miscompare: The Strut Compressed miscompare fault is latched.

Engine status validity monitor trip: One of the EEC signals used for actuator reconfiguration is invalid (related to managing hydraulic power to specific actuators in certain engine failure scenarios).

IRU/AHRU/PFCS interface: Exactly one inertial reference unit (IRU) or attitude/heading reference unit (AHRU) is inoperative.

ACE to CCS interface: Any actuator control electronics (ACE) to remote data concentrator (RDC) wiring fault.

Fuel quantity indication system: Any fuel quantity comparison monitor has

tripped.

Fuel temperature indication system: Either fuel temperature comparison monitor has tripped.

Consequences of Next Critical Failure

Failure of an additional (like) interface signal may degrade PFCF functionality.

PMG: Opposite engine failure will result in loss of 2 additional PMGs. All IFCEs remain powered.

Throttle position: If the throttle position switch has failed open, the next failure may result in loss of RTO auto speedbrakes. Depending on the next failure, there may be an AUTO SPDBRAKE FAULT Advisory message.

Databus or transmitter/receiver faults between IFCE cabinets and CDN switches: subsequent CCS ARINC 664 remote network switch failure may result in data from only one FCM not being available to other airplane systems. Flight control functionality will be retained.

Slow on ground signal: Failure of radio altimeter will result in the FLIGHT CONTROL SYS Status message.

Engine status validity monitor trip: Actuators are commanded to fail-safe condition, which precludes inadvertent command to bypass mode.

ACE Status Analog Discretes: In the extremely unlikely event of a transition to PFCF Direct Mode, flight deck annunciation may not occur (i.e., FCTL IN DIRECT MODE Caution message may not be displayed).

IRU/AHRU/PFCS Interface: A second IRU or AHRU wire failure of PFCS internal failure of an IRU/AHRU signal or actual IRU/AHRU failure will result in a FLIGHT CONTROL SYS Status message.

27-02-04

Actuator Delta Pressure Function

Interval	Installed	Required	Procedure
A	N/A	N/A	

May be dispatched with ACTUATOR DELTA PRESS Status message displayed provided repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-02-04.

Elevator, rudder, aileron, and flaperon surfaces are positioned by hydraulic actuators. Actuator control is provided by the actuator control electronics (ACEs) within the integrated flight control electronics (IFCEs). A force fight equalization feature is incorporated in the control of each surface with more than one actuator. Force fight equalization relies on the pressure sensors used to measure the differential pressure across each actuator piston. The IFCEs monitor these pressures and adjusts the position command to the lagging actuator to equalize the force between the redundant actuators on the same surface.

Consequences of Failure

The ACTUATOR DELTA PRESS Status message is set if the difference in pressure exceeds specified limits on any or all of the multi-actuator surfaces. Affected surface behaves normally. Airplane handling qualities and control are not affected. Operation is limited to three days to minimize the exposure to greater force fight on the affected control surface.

Consequences of Next Critical Failure

If the force fight becomes unacceptable such that the fatigue monitor in the IFCEs determine that approximately 10% of the fatigue life will be consumed during the flight, the monitor will disable the suspect actuator(s) on the surface provided sufficient control remains available for continued safe flight and landing. The appropriate "SURFACE" SYS Status message will be set to prevent dispatch (where "SURFACE" is AILERON, ELEVATOR, FLAPERON, or RUDDER).

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777-9 Master Minimum Equipment List

Section 2

27-02-05

Actuator Monitor Sensor Function

Interval	Installed	Required	Procedure
A	N/A	N/A	

May be dispatched with ACTUATOR MONITOR SENSOR Status message displayed provided repairs are made within 3 flight-days.

SUBSTANTIATION

Background

New proposal for 777X. Ref. 787 27-02-04.

The actuator monitor sensor function is used detect faults that result in erroneous actuator motion that may result in exceeding local and global structural requirements due to repeated occurrences. The monitor sets the ACTUATOR MONITOR SENSOR Status message when an intermittent fault is detected in any of the following actuation sensor in-line monitors: The primary surface Main Ram LVDT Common Mode Monitor (MRCMM), the primary surface electrohydraulic servo valve (EHSV) Current Monitor (IMON), primary surface SOV Coincidence Monitor (SCM), or the Spoiler Resolver Inline Monitor (RSILM)

Consequences of Failure

The ACTUATOR MONITOR SENSOR Status message is displayed to indicate intermittent actuation sensor failures that cause low rates of fatigue accumulation. Affected surface behaves normally. Airplane handling qualities and control are not affected. Operation is limited to three days to minimize the exposure to additional fatigue on the affected control surface.

Consequences of Next Critical Failure

For the aileron, elevator, flap/aileron and rudder actuators: If the local and structural limits are exceeded by a predetermined limit; a fault is latched, the associated actuator will be disabled, and the associated "SURFACE" Status message will be displayed (AILERON SURFACE, ELEVATOR SURFACE, FLAPERON SURFACE or RUDDER SURFACE). The associated surface will continue to be controlled by the remaining operative actuator(s). Subsequent dispatch is not allowed.

For a spoiler actuator, the associated spoiler will be inoperative. For the spoilers, if the spoiler flap contact induced by the wire failure becomes unacceptable such that the contact monitor in the integrated flight control electronics (IFCE) determines that approximately 10 full stall contacts have occurred, the monitor will disable the suspected spoiler provided sufficient control remains available for continued safe flight and landing. The SPOILERS FAULT Advisory message will be displayed.

27-02-06

Flight Control Hydraulic Shutoff Valves

Interval	Installed	Required	Procedure
C	6	3	(M)

May be inoperative provided the associated valve is deactivated open.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 27-02-06 and 747-8 MMEL item 27-23-02.

The flight control hydraulic power shutoff valves are provided for maintenance use. Guarded switches are provided on the overhead maintenance panel for L, C, R wing flight control hydraulics and L, C, R tail flight control hydraulics. Each guarded switch has an associated amber light to indicate when the valve is closed.

Consequences of Failure

The FLT CONTROL VALVE Advisory message will be displayed if one or more valves is failed or commanded closed.

Inoperative valve is deactivated open and lockwired. The associated electrical connector may be disconnected, capped and stowed.

Indication of valve position on the overhead maintenance panel is inoperative. Valve(s) and light(s) are not used by the flight crew for any normal or non-normal procedures.

Maintenance activities that require a SOV closed may not be able to be performed. If required, the lockwire may be temporarily removed and SOV temporarily closed.

Consequences of Next Critical Failure

No additional failures are considered since the associated valve is deactivated in the open position.

27-02-07

Flight Controls Dedicated Inertial Sensors

Interval	Installed	Required	Procedure
A	4	3	

May be dispatched with FLT CTRL INERTIAL SENSOR Status message displayed provided repairs are made within 10 flight-days.

SUBSTANTIATION**Background**

New proposal for 777X. Ref 787 27-02-06.

The FCDIS provide angular rates and normal and lateral accelerations to the Actuator Control Electronics (ACE) to support flight control normal mode functionality. In flight control secondary and direct mode, the sensors provide the default source of inertial data to support augmentation in the pitch, roll and yaw axes.

The 777X Flight Controls Dedicated Inertial Sensors (FCDIS) provide similar functionality to the Direct Mode rate Sensors (DMRS) of the 787.

Consequences of Failure

Failure of any 1 of 4 FCDIS results in display of the FLT CTRL INERTIAL SNSR Status message. Loss of redundancy only. No system effect.

Consequences of Next Critical Failure

Failure of an additional FCDIS (loss of 2 FCDIS):

No effect. The flight control system will remain in normal mode. The FLIGHT CONTROL SYS Status message will be displayed and subsequent dispatch is not allowed.

Loss of two additional FCDIS (loss of 3 FCDIS):

Flight control system will drop to secondary mode and will use the earth reference system as a source of inertial data for augmentation. FCTL IN SEC MODE message will be displayed. If flight control system enters direct mode due selection by flight crew during accomplishment of non-normal checklist, the ACE connected to the inoperative FCDIS may be commanded to fail-safe or lose augmentation commands. Surface will be controlled by the remaining actuators

Oscillatory failure of a FCDIS:

No additional effects because the voting logic will not include sensor with the oscillatory failure in the voted output.

For one FCDIS failed plus one FCDIS with oscillatory failure: no additional effects because:

If the oscillatory failure is above the signal selection and fault detection (SSFD) threshold, the failed FCDIS is voted out and the system will retain normal mode.

If the oscillatory failure is below SSFD threshold (and in the range that affects global structure) there is no effect because the voting scheme keeps the erroneous sensor out of the output.

Potential catastrophic hazard:

Dispatch with an inoperative FCDIS leaves the airplane two failures away from a catastrophic hazard. The two additional failures involve oscillatory failures of two additional FCDIS in a specific range of frequency and amplitude. One of these oscillatory failures can be considered latent. A quantitative assessment indicates that the probability of this catastrophic hazard is acceptable.

Quantitative assessment:

The probability of oscillatory failure of two additional FCDIS is 4.54E-08 per flight hour [current estimate].

The probability of a failure resulting in an inoperative FCDIS (probability of dispatch condition) 1.20E-05 per flight hour [current estimate].

Based on the probabilities list above, the maximum allowable dispatch time is 1,836 hours.

Draft
Feb 26, 2026

27-02-08 Modal Suppression Accelerometers (MSA)

Interval	Installed	Required	Procedure
C	3	2	

May be dispatched with MODAL ACCELEROMETER Status message displayed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item for 27-02-07.

The Lateral Modal Suppression Function (LMS) improves ride quality by reducing aft body lateral accelerations resulting from the excitation of airplane structural modes.

Three identical twin-axis Modal Suppression Accelerometers (MSA) are installed in the aft section of the airplane just forward of the rear pressure bulkhead. Only the lateral acceleration measurements from the MSAs are used by the IFCE for the Lateral Modal Suppression function.

Lateral Modal Suppression is accomplished with rudder control in response to signals from the MSAs.

Consequences of Failure

The MODAL ACCELEROMETER Status message is displayed when one modal accelerometer has failed. The modal suppression function will continue to operate normally with the remaining two MSAs.

Consequences of Next Critical Failure

Failure of an additional Modal Suppression Accelerometer will result in loss of the Lateral Modal Suppression Function. The FLIGHT CONTROL SYS Status message will be displayed.

Results in degraded passenger ride quality with potential physical discomfort in the presence of turbulence

The resulting airplane level hazard condition is no worse than 'Major'.

27-11-01 Alternate Control Wheel Position Transducers

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-11-02.

The 777X includes dedicated control wheel position sensors (LVDTs) to command spoilers 6 and 13 for the alternate roll control function following loss of all fly-by-wire electronics signaling resulting in loss of flight control functionality provided by PFCF Normal, Secondary and Direct modes. If loss of ACE C occurs, the alternate control wheel will retain the ability to command spoilers 6 and 13. This alternate spoiler functionality is similar to the 777 cable-commanded spoiler pair. These alternate control wheel transducers are not used to compute spoiler commands in IFCE Normal, Secondary and Direct modes; they are, however, compared to the normal control wheel transducers for monitoring purposes.

The alternate control wheel transducer is a redundant design feature that is not required for type certification. Loss of PFCF Normal, Secondary and Direct modes is extremely improbable.

Consequences of Failure

Failure of one or both transducers is annunciated by the ALTN CONTROL WHEEL XDCR Status message.

No effect; the alternate control wheel transducer is not used in normal operation. Alternate mode is not available for the spoiler with the failed sensor.

Consequences of Next Critical Failure

For loss of PFCF Normal, Secondary and Direct modes, spoiler control for the associated spoiler(s) 6 and/or 13 will not be available. Although the alternate roll control function is designed to provide roll axis control if there is a loss of PFCF Normal, Secondary and Direct modes, the probability of this occurring during the MMEL dispatch interval on a given airplane is extremely unlikely.

27-11-02 Aileron Actuator Remote Electronics Unit (REU) Channels

Interval	Installed	Required	Procedure
C	12	11	

One may be inoperative provided REU channels for at least three of the following remaining actuator types operate normally:

- Flaperon
- Rudder
- Elevator
- Spoiler

SUBSTANTIATION

Background

New item for 777X.

Each aileron surface has two actuators, and each actuator is controlled by a single REU. Within each REU are three command paths (referred to as channels) for redundancy and integrity. For a given surface, each REU is controlled by a different IFCE cabinet for maximum availability. The actuators provide redundant actuation and operate in an active/active load sharing fashion. The actuators prevent surface flutter by means of redundant surface stiffness and damping. None of the surfaces are mass balanced. The flutter prevention requirements are met for all appropriate failure combinations.

Consequences of Failure

Failure of one of the twelve aileron REU channels will result in the AILERON REU CHANNEL status message.

Loss of redundancy only. MMEL proviso excluding REU channel fault on more than one additional actuator type is included to limit the combinations of REUs with a failed channel to ensure sufficient monitor coverage and fault detection response in the event of additional failures.

Consequences of Next Critical Failure

Failure of two or more aileron REU channels in different REUs will result in the AILERON REU SYS status message. Failure of two or more channels in a single REU will result in the AILERON SYS status message. MMEL dispatch is not allowed with these messages displayed.

Failure of a second channel in the same REU results in loss of the REU and associated actuator. The remaining actuator controls the surface.

27-11-03 Flaperon Actuator Remote Electronics Unit (REU) Channels

Interval	Installed	Required	Procedure
C	12	11	

One may be inoperative provided REU channels for at least three of the following remaining actuator types operate normally:

- Aileron
- Rudder
- Elevator
- Spoiler

SUBSTANTIATION**Background**

New item for 777X.

Each flaperon surface has two actuators, and each actuator is controlled by a single REU. Within each REU are three command paths (referred to as channels) for redundancy and integrity. For a given surface, each REU is controlled by a different IFCE cabinet for maximum availability. The actuators provide redundant actuation and operate in an active/active load sharing fashion. Note that the flaperons are not flutter critical, so flutter prevention requirements do not apply to these surfaces.

Consequences of Failure

Failure of one of the twelve flaperon REU channels will result in the FLAPERON REU CHANNEL status message.

Loss of redundancy only. MMEL proviso excluding REU channel fault on more than one additional actuator type is included to limit the combinations of REUs with a failed channel to ensure sufficient monitor coverage and fault detection response in the event of additional failures.

Consequences of Next Critical Failure

Failure of two or more flaperon REU channels in different REUs will result in the FLAPERON REU SYS status message. Failure of two or more channels in a single REU will result in the FLAPERON SYS status message. MMEL dispatch is not allowed with these messages displayed.

Failure of a second channel in the same REU results in loss of the REU and associated actuator. The remaining actuator controls the surface.

27-21-01 Rudder Trim Switch High Rate Function

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-21-01.

Rudder trim is selected by the flight crew with a rotary control on the aisle stand. Rotation of the control in the direction of desired trim sends a trim signal to the IFCEs through the ACEs, which command motion of the rudder trim actuator. The trim actuator moves the rudder pedals, resulting in rudder trim through the rudder control system. (For the 777X, in normal mode, "rudder trim" is actually a bias in the sideslip command to the p-Beta control law.) Trim rate is set at low rate (1/2 unit per second) or high rate (1 unit per second) according to displacement of the rotary control. This item provides for dispatch with the high rate trim feature inoperative.

The low speed trim rate must be operational in order for the high speed trim rate to operate normally. Therefore only the high speed trim rate may be inoperative.

NOTE: The 777 rudder trim MANUAL TRIM CANCEL switch, located next to the rudder trim switch on the aisle stand, is not installed on the 777X because the p-Beta control law makes it unnecessary. 777X p-Beta control law provides automatic lateral / directional trim and requires less pilot manual rudder trim than previous models, including 777.

Consequences of Failure

High trim rate feature is not available for rudder trim. Manual trim is accomplished at the low rate.

Consequences of Next Critical Failure

Failure of remaining trim capability: Manual rudder trim is not available. Detected failures are automatically zeroed in normal and secondary modes. Any non-detected failures will be automatically zeroed at landing touchdown while in normal mode. In secondary mode, these non-detected failures would not be zeroed at landing and require the pilot to use pedals to compensate.

27-21-02 Rudder Actuator Remote Electronics Unit (REU) Channels

Interval	Installed	Required	Procedure
C	9	8	

One may be inoperative provided REU channels for at least three of the following remaining actuator types operate normally:

- Aileron
- Flaperon
- Elevator
- Spoiler

SUBSTANTIATION

Background

New item for 777X.

The rudder surface has three PCUs, each controlled by a single REU. Within each REU there are three command paths (referred to as channels) for redundancy and integrity. Each REU is controlled by a different IFCE cabinet for maximum availability. The PCUs provide redundant actuation control and operate in an active/active/active load sharing fashion. The rudder is a flutter critical surface and any one PCU in active mode is sufficient to provide adequate flutter stiffness and damping. The rudder surface is partially mass-balanced (horn balance).

Consequences of Failure

Failure of one of the nine rudder REU channels will result in the RUDDER REU CHANNEL Status message.

Loss of redundancy only. MMEL proviso excluding REU channel fault on more than one additional actuator type is included to limit the combinations of REUs with a failed channel to ensure sufficient monitor coverage and fault detection response in the event of additional failures.

Consequences of Next Critical Failure

Failure of two or more rudder REU channels in different REUs will result in the RUDDER REU SYS status message. Failure of two or more channels in a single REU will result in the RUDDER SYS status message. MMEL dispatch is not allowed with these messages displayed.

Failure of a second channel in the same REU results in loss of the REU and associated actuator. The remaining two rudder actuators control the surface.

27-31-01 Elevator Actuator Remote Electronics Unit (REU) Channels

Interval	Installed	Required	Procedure
C	18	17	

One may be inoperative provided REU channels for at least three of the following remaining actuator types operate normally:

- Aileron
- Flaperon
- Rudder
- Spoiler

SUBSTANTIATION**Background**

New item for 777X.

The elevators have three PCUs controlled by three independent REUs on each surface. Within each REU are three command path channels for redundancy. For a given surface, each REU is controlled by a different IFCE cabinet for maximum availability. The PCUs provide redundant actuation control and operate in an active/active/active load sharing fashion. The elevators are flutter critical surfaces and any one PCU in active mode is sufficient to provide adequate flutter stiffness and damping. The surfaces are not mass-balanced.

Consequences of Failure

Failure of one of the eighteen elevator REU channels will result in the ELEVATOR REU CHANNEL Status message.

Loss of redundancy only. MMEL proviso excluding REU channel fault on more than one additional actuator type is included to limit the combinations of REUs with a failed channel to ensure sufficient monitor coverage and fault detection response in the event of additional failures.

Consequences of Next Critical Failure

Failure of two or more elevator REU channels in different REUs will result in the ELEVATOR REU SYS status message. Failure of two or more channels in a single REU will result in the ELEVATOR SYS status message. MMEL dispatch is not allowed with these messages displayed.

Second command path channel failure within the REU(s) on MMEL results in failure of the REU and associated actuator. The remaining two elevator actuators control the surface.

27-32-01

Stick Shaker Systems

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 27-32-01.

Tactile annunciation of a stall warning condition is provided by activation of stick shaker motors attached to the control columns. The stall warning function resides in the common core system (CCS) which provides signal processing in each of four crew alerting partitions. Both stick shaker motors are activated when the complementary filtered angle of attack exceeds the calculated stick shaker trip point.

In addition to performing the stick shaker activation logic, the stall warning function also computes and transmits the following stall or speed limit related data, both while the airplane is on ground and in air:

- Autoslat enable requests
- Vmin, Vmax, Vssng, Vloc
- Pitch limit for display on the PFDs
- Alpha stick shaker trip for stall protection
- Predictive ice protection (PIDS)
- Annunciation of overspeed (flaps up and flaps down)
- Enhanced stall protection

NOTE: An inoperative stall warning function in the left and/or right common computing resource (CCR) cabinet is annunciated by the associated status message STALL WARNING SYS. This condition is non-dispatchable.

Consequences of Failure

An inoperative stick shaker is annunciated by the associated status message STICK SHAKER L, R.

One stick shaker is inoperative. Both pilots receive adequate stall warning with either stick shaker deactivated. General processing modules (GPMs) and remote data concentrators are required to operate normally to ensure that activation pathways on remaining stick shaker system operate normally.

Consequences of Next Critical Failure

Failure of the remaining stick shaker renders stall warning inoperative. The other stall warning functions (PFD pitch limit indications (PLI), Vmin) are not affected.

27-41-01 Control Wheel Pitch Trim Switches

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided Alternate Pitch Trim Switch operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-41-01.

Dual thumbswitches on each control wheel provide nose up or nose down pitch trim control. The switches are located on the outboard horns of both control wheels. They provide separate arm and control discretes, both of which are required to provide trim commands. The switches send pitch trim signals to the ACEs and IFCEs, which process trim commands.

On Ground, or in PFCF Secondary Mode and Direct Mode in air, the Captain or the First Officer can command the stabilizer directly from the Control Wheel Pitch Trim Switches. In the PFCF Normal Mode, stabilizer trim command from the Control Wheel Pitch Trim Switches only changes the trim reference speed and does not directly result in stabilizer motion. The change in trim reference speed leads to a change in the elevator position; then, as part of the pitch control law, the average elevator position is automatically off-loaded to the stabilizer. In steady state flight, as in cruise or a steady climb or descent, the average elevator command approaches zero as the stabilizer is adjusted.

Consequences of Failure

Loss of pitch trim control (PFCF Normal Mode in-air) or direct stabilizer control (PFCF Normal Mode on-ground or Secondary and Direct Mode) from the affected control wheel pitch trim switch. Trim is accomplished by the other pilot, or by use of the alternate pitch trim switches located on the aisle stand. Autoflight is not affected.

Consequences of Next Critical Failure

Failure of remaining control wheel pitch trim switch: Manual pitch trim cannot be accomplished with control wheel trim switches by either pilot. Trim is accomplished with the alternate pitch trim switches located on the aisle stand. Automatic elevator off-load and autoflight are not affected.

27-41-02 Alternate Pitch Trim Switch

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided both Control Wheel Pitch Trim Switches operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-41-02.

The alternate pitch trim dual thumbswitches provide a redundant means of adjusting pitch trim through discrete inputs to the ACEs and horizontal stabilizer trim actuator (HSTA) remote electronic units (REUs). In normal mode in-air, these switches command an adjustment to the trim reference speed only. In normal mode on-ground, or in secondary or direct Mode, or if the HSTA REUs have lost digital communication with the integrated flight control electronics (IFCE) cabinets, use of the alternate pitch trim switches will command stabilizer directly at high rate.

The change in trim reference speed leads to a change in the elevator position; then, as part of the pitch control law, the average elevator position is automatically off-loaded to the stabilizer. In steady state flight, as in cruise or a steady climb or descent, the average elevator command approaches zero as the stabilizer is adjusted.

Consequences of Failure

Failure of the alternate pitch trim switch is indicated by either the ALTN PITCH TRIM SWITCH Status message or when pitch trim will not respond to alternate trim commands.

Alternate pitch trim is not available. Trim is accomplished by either of the control wheel pitch trim switches

Consequences of Next Critical Failure

Failure of either the captain's or first officer's control wheel pitch trim switch would require trim to be maintained from the one remaining control wheel trim switch. Autoflight is not affected.

27-41-03 Stabilizer Trim Control Modules (STCM)
27-41-03-01 Rate Control Solenoid Valves

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with STAB VALVE Status message displayed.

27-41-03 Stabilizer Trim Control Modules (STCM)
27-41-03-02 Directional Control Valve LVDTs

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with STAB VALVE Status message displayed.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 27-41-03.

Stabilizer Trim Rate Solenoid Valves:

A solenoid valve in each of the two Stabilizer Trim Control Modules (STCM) is used to control the trim rate valve in each trim channel. The trim rate solenoid valve operates the trim rate valve by sending high pressure hydraulic fluid to shift the spool to the low rate position when "low rate" is commanded and venting the spool to return pressure when high rate is commanded or power is removed from the solenoid valve. The trim rate solenoid valve is closed when unpowered to provide the associated trim motor with a high fluid flow rate via the trim rate valve. Energizing the solenoid opens the trim rate solenoid valve and provides a lower fluid flow rate to the trim motor via the trim rate valve. Energizing and de-energizing of each trim rate solenoid valve is controlled by the interfacing HSTA REU. In Normal Mode, each HSTA REU receives a high or low trim rate command from the PFCF. In Secondary Mode, Direct Mode or during total loss of communication with the ACEs, the rate defaults to high trim rate. Each STCM drives a hydraulic motor, which in turn drives a mechanical ballscrew actuator to position the stabilizer. The stabilizer is trimmed on demand including use of both STCMs if needed. The shaft speeds from the two hydraulic motors are mechanically summed by a differential gearbox which allows either motor or both motors to control the stabilizer position. The maximum rate is obtained with both motors operating at high rate. The minimum rate is obtained with a single motor operating at low rate. Intermediate rates are obtained with combinations of single or dual motors operating at high and/or low rate.

Stabilizer Direction Control Valve Linear Variable Differential Transducer (LVDT):

A linear variable differential transducer (LVDT) is used to measure the directional control valve spool position in each of the two stabilizer trim control modules (STCM) and provide position feedback and status of the LVDT to the interfacing HSTA REU. Each interfacing REU in turn sends the data to the interfacing IFCE for use in the directional control valve spool position monitor and other IFCE monitors.

With a detected fault of the LVDT, a directional control valve LVDT in-line fault specific to the stabilizer channel will be set by the IFCE. When the fault is detected on one directional control valve LVDT, the status message STAB VALVE will show on the EICAS display. When the fault is detected on both directional control valve LVDTs, the status message STABILIZER SYS will show on the EICAS display.

Consequences of Failure

Failure of a Rate Control Solenoid Valve in one STCM will result loss of low rate operation for the associated STCM. Associated STCM will only operate at high rate. The other STCM continues to provide high or low rate trim when commanded. The STAB VALVE Status message will be displayed. Hazard condition is 'Minor'.

Failure of a Directional Control Valve LVDT in one STCM will result in loss of the control valve spool position monitoring function in the associated STCM. Stabilizer control function is unaffected. The STAB VALVE Status message will be displayed. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

For inoperative Rate Control Solenoid Valve:

Failure of Rate Control Solenoid Valve in other STCM. Rate Control Solenoid Valves will be inoperative in both STCMs. Stabilizer trim function will operate at high rate in both STCMs. STABILIZER SYS Status message will be displayed. STAB VALVE Status message will be inhibited. Hazard condition is 'Minor'.

For inoperative Directional Control Valve LVDT:

Failure of Directional Control Valve in other STCM. Direction Control Valve LVDT will be inoperative in both STCMs. Stabilizer control function is unaffected. Both control channels will be available. STABILIZER SYS Status message will be displayed. STAB VALVE Status message will be inhibited. Hazard condition is 'Minor'.

27-48-01 Stabilizer Position Transducers

Interval	Installed	Required	Procedure
C	3	2	

May be dispatched with STAB POSITION XDCR Status message displayed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-48-01 with simplification.

Stabilizer position is sensed by three independent transducers. The three sensors are resolver devices and are identified as Stabilizer Position Sensor (SPS) 1, 2 and 3. All three sensors are mounted to the gearbox assembly and are mechanically linked to the ballscrew shaft by independent gear trains. IFCE L2 cabinet directly interfaces with SPS 1 and performs demodulation and excitation of SPS 1. HSTA REU C directly interfaces with SPS 2, performs demodulation and excitation of SPS 2 and sends data to IFCE C cabinet via the Actuation Data Bus. HSTA REU R directly interfaces with SPS 3, performs demodulation and excitation of SPS 3 and sends data to IFCE R cabinet via the Actuation Data Bus. All four IFCEs share stabilizer position information via the inter-module data buses. The IFCEs use stabilizer position in processing the following stabilizer trim commands and functions: elevator offload function, stabilizer uncommanded motion monitor, stabilizer creep monitor, stabilizer inoperative (dead trim) monitoring, stabilizer command limiting, stabilizer rate snubbing, stabilizer position indication, and stabilizer takeoff configuration warning.

Consequences of Failure

Loss of one stabilizer position transducer results in loss of redundancy only. No effect on system operation. The STAB POSITION XDCR Status message will be displayed. Hazard condition is 'Minor'.

Erroneous input from one position transducer will be detected and the transducer will be shut down. No effect on system operation. The STAB POSITION XDCR Status message will be displayed. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

Loss of an additional stabilizer position transducer:

Results in loss of redundancy only. One transducer will remain. No effect on system operation. The STABILIZER SYS Status messages will be displayed. Hazard condition is 'Minor'.

Miscompare between the remaining two transducers:

Results in invalid stabilizer position data. IFCE will automatically shutdown both stabilizer channels. The result is loss stabilizer control and annunciation to the flight crew. Pitch trim control is still provided by the elevators. The STABILIZER FAIL Warning message will be displayed. Hazard condition is 'Major'.

Loss of the remaining two position transducers: Results in loss of all position data resulting in invalid data. IFCE will automatically shutdown both stabilizer channels. The result is loss of stabilizer control and annunciation to the flight crew. Pitch trim control is still provided by the elevators. The STABILIZER FAIL Warning message will be displayed. Hazard condition is 'Major'.

Loss of one remaining position transducer and erroneous position transducer input from the last remaining position transducer:

May result in temporary elevator or stabilizer movement that will be detected by the uncommanded motion monitoring function. The result is that both stabilizer channels will be automatically shutdown and annunciated to the flight crew. The STABILIZER FAIL Warning message will be displayed. Hazard condition is 'Major'.

The probability of two position transducers failing or erroneous data from both transducers is extremely improbable.

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27-51-01 Flap Lever Position Transducers

Interval	Installed	Required	Procedure
C	4	2	(M)

May be inoperative provided:

- Flaps alternate mode is verified to operate normally before each departure, and
 - Slats alternate mode is verified to operate normally before each departure.
-

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-51-01.

The high lift function (HLF) is used to increase the wing camber and enhance aerodynamic properties for takeoffs, landings and to improve stall characteristics. The wing camber is increased by extending the leading edge (slats) and/or the trailing edge (flaps). The aerodynamic properties of the wing are enhanced through the drooping of the spoilers. This drooping decreases the effective gap between flap and the fixed trailing edge, thus decreasing associated drag forces. The ailerons and flaperons are symmetrically drooped in unison with the flaps as a function of the flap position to improve low speed performance.

The leading edge consists of one slat inboard of the engine, six slats outboard of the engine, and one inboard seal Krueger flap per wing. The inboard and outboard slats are three-position slats and the seal Krueger slat is a two position surface. There are three trailing edge flaps per wing: one single slotted outboard flap, a single slotted mid-span flap, and one single slotted inboard flap.

The flaps and slats are driven by an array of torque tubes that are powered by hydraulic or electric motors (depending on HLF Mode). These motors are part of the flap and slat power drive units (PDUs). In primary mode, the PDUs are controlled by the primary control valves (PCVs) and interfaced with integrated flight control electronics (IFCE) cabinets. In secondary mode, the HLF surfaces are powered by hydraulic and electric motors. In alternate mode, the HLF surfaces are powered by electric motors.

The HLF has three modes of operation: primary, secondary, and alternate. Primary mode provides full-rate high lift operations; it is powered by the center hydraulic system. Secondary mode provides reduced-rate high lift operation via hydraulic and electric motors. In both HLF primary and secondary modes, control is closed-loop with command input through the flap lever. In HLF alternate mode, the control path is independent of the flap lever with command input through the alternate flap arm and control switches. Alternate retract is controlled via the IFCE cabinets. Alternate extend is independent of microprocessor computing. HLF secondary mode is automatically engaged when HLF primary mode fails to drive or drives too slowly and/or when an engine fails combined with a low quantity indication signal from the center hydraulic system. The control modes for the flaps and slats are independent of each other except when in HLF alternate mode.

The HLF also contains automatic (pilot-independent) functions that help improve the performance of the airplane. The autoslat function is enabled when the leading edge slats are in their middle (takeoff) position if the plane is headed toward a stall; this function extends the slats to increase the airplane maximum lift and improve stall handling characteristics.

The trailing edge variable camber function has two modes; one is used during cruise to improve the aerodynamics of the airplane to reduce drag and subsequently reduce fuel burn, the other is used to alleviate wing box load at high gross weights. Trailing edge variable camber is accomplished by independently positioning the inboard and outboard flaps. The cruise inhibit function prevents the flaps and slats from being extended in primary and secondary modes due to inadvertent flap lever command at cruise speeds, thereby preventing possible damage to the surfaces. The load relief function prevents excess loads from being placed on the flap and slat surfaces, by retracting the surfaces if the airspeed exceeds the flap placard speed. The TE load relief function operates in HL primary mode, and the LE load relief function operates in HL secondary mode.

Sensors throughout the HLF drive system provide absolute and relative drive system position information for control and monitoring. Actuator no-back brakes are used to prevent air loads from back driving the drive systems. The electric motors contain their own power-off brakes. All LE and TE actuators, with the exception of the seal Krueger actuators, have no-back brakes.

HLF data are provided by the IFCE cabinets, in all modes of operation, for the EICAS display and other systems via the common data network (CDN). The HLF data received by the IFCE cabinets come from flight deck sensors and switches, the inertial reference units (IRUs), attitude heading reference units (AHRUs), slat and flap skew sensors, slat position sensors, and flap position sensors.

There are 12 (dual channel) flap skew sensors (2 per flap), 4 (dual channel) flap position sensors, 8 slat skew sensors (4 inboard, 2 outboard, and at slat 6/9), and 2 (dual channel) slat position sensors.

These sensors detect position, skew/loss, asymmetry, and uncommanded motion (UCM). Most of the skew and position sensors provide an analog signal to spoiler remote electronics units (REUs) and leading edge REUs for conversion to a digital signal for transmission to the IFCE cabinets. The IFCE cabinets also receive data from other systems for use by the HLF via the common data network (CDN).

The flap lever drives one inboard gear and one outboard gear. Each gear drives two position sensors for redundancy. One valid sensor from either gear is required for transmitting valid pilot commands to the IFCEs for primary and secondary mode operation.

Consequences of Failure

Failure of a single flap lever position transducer or one transducer on each side of the lever is annunciated by the FLAP LEVER XDCR Status message .

Loss of redundancy only. The flap lever position remains valid when there is at least one valid sensor on each side of the flap lever. Flaps and slats alternate mode must be verified prior to each departure.

Consequences of Next Critical Failure

Loss of the second sensor on the same gear:

None. This will result in the PILOT CONTROL SYS Status message. Flap lever input remains valid, however subsequent dispatch not allowed.

Failure of all sensors, or detection of a broken shaft of one gear:

This results in an invalid flap lever position indicated by the FLAP LEVER INOP Caution message in addition to the PILOT CONTROL SYS Status message. Alternate mode may be used.

27-51-04 Flap/Slat Bypass Valves

Interval	Installed	Required	Procedure
C	3	0	

NOTE: An inoperative Flap/Slat Bypass Valve is indicated by the FLAP/SLAT BYPASS VALVE Status message.

SUBSTANTIATION**Background**

New proposal for 777X.

(For full high lift function description, see proposal for item 27-51-01.) A bypass valve is used as a means to remove hydraulic power to each of the slat and flap drive systems in Primary mode operation.

When detecting a primary mode uncommanded motion, the high lift function shuts down the affected actuation system with the shutoff valve. If the shutoff valve is failed, the bypass valve ensures that hydraulic power is rerouted away from the PCV, disabling Primary mode.

Primary Control Valves (PCV) (Flap)

The Integrated Flight Control Electronics (IFCE) electrically control the solenoids in the leading edge slat and trailing edge flap Primary Control Valve (PCV)s. The solenoids and valves in the leading edge slat PCV control the flow of pressurized hydraulic fluid to the leading edge slat Power Drive Unit (PDU) hydraulic motor, which controls the operation of the leading edge slat drive system. The solenoids and valves in the trailing edge flap PCVs control the flow of pressurized hydraulic fluid to the trailing edge flap Power Drive Unit (PDU) hydraulic motors, which controls the operation of the trailing edge flap drive system. All the solenoids have dual coils.

For all solenoids in the slat PCV, except the bypass solenoid, one coil is controlled by IFCE L1 and the other by IFCE L2. All the solenoids are normally de-energized.

For all solenoids in the flap PCVs, except the bypass solenoid, one coil is controlled by the IFCE R and the other by IFCE C. All the solenoids are normally de-energized.

Bypass Valve and Bypass Solenoid: The bypass valve isolates the trailing edge flap PDU hydraulic motor from hydraulic system pressure. The bypass valve also prevents a hydraulic lock and allows backdrive of the trailing edge flap or slat PDU hydraulic motor. A dual-coil bypass solenoid valve controls pilot pressure to the bypass valve. One coil is controlled by IFCE C during primary mode. The other coil is controlled through Electrical Load Management System (ELMS) relays during secondary or alternate mode. When the bypass solenoid is energized, it removes pilot pressure from the open side of the bypass valve. This closes the bypass valve, which connects the hydraulic lines to both sides of the trailing edge flap PDU hydraulic motor. The bypass valve is spring-loaded and hydraulically controlled to the closed position. The open side of the valve has a larger surface area for the pilot pressure than the close side of the valve. When the center hydraulic system pressure is low, springs automatically force the bypass valve to close. When the center hydraulic system pressure is high, the bypass valve opens.

The PCV bypass valves are automatically checked by a periodic post-flight test designed to detect bypass valve being failed. The test runs after landing. When each drive system (flap or slat) is waiting, the directional control valve is commanded to retract, the shutoff valve is commanded open and the bypass valve is commanded to bypass. Therefore, the only device preventing motion is the bypass valve. If no motion is detected, the bypass valve is considered functional. If motion is detected during this time, the valve is considered faulty and the FLAP/SLAT BYPASS VALVE status message shows on EICAS.

Leading Edge and Trailing Edge is checked once every 100 flights after landing.

Consequences of Failure

The FLAP/SLAT BYPASS VALVE Status message will be displayed when any one (slat, inboard flap, outboard flap) bypass valve fails an automated test.

The bypass valve failure condition results in loss of redundancy only. The bypass valve is only one of multiple means for arresting a system failure in the affected slat, inboard flap, or outboard flap system. Other means of arresting a system failure are: Directional control (selector) valve, shutoff valve and electric motor clutch. For the inboard and outboard flaps, removal of power from the PCV will also arrest the system.

Consequences of Next Critical Failure

A condition causing surface asymmetry, skew, or uncommanded motion will result in the affected slat or flap drive system being arrested by the directional control (selector) valve, shutoff valve. The electric motor clutch, and removal of power (flaps) can also arrest the system.

The associated SLATS IN SEC MODE, FLAPS IN SEC MODE, SLATS INOP or FLAPS INBOARD INOP/FLAPS OUTBOARD INOP Caution message will be displayed, respectively. Non-normal landing is required with the remaining flap or slat drive systems.

The resulting probability of uncommanded motion without shutdown capability is extremely improbable.

Leading edge uncommanded motion during takeoff and landing is classified as 'Catastrophic'. The resulting top event probability of this condition with an inoperative slat bypass valve is extremely improbable (on the order of $9.28\text{E-}10$).

Leading edge uncommanded motion during cruise is classified as 'Catastrophic'. An inoperative slat bypass valve will not impact the top event probability of the fault tree analysis.

Trailing edge uncommanded motion without Shutdown is classified as 'Catastrophic'. The resulting top event probability with inoperative inboard and outboard flap bypass valves is extremely improbable (on the order of $4.48\text{E-}10$).

Trailing edge uncommanded motion from flaps up beyond shutdown limits is classified as 'Catastrophic'. Inoperative inboard and outboard flap bypass valves will not impact the top event probability of the fault tree analysis.

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777-9 Master Minimum Equipment List

Section 2

27-51-05 Flap/Slat Primary Control Valve (PCV) Channels

Interval	Installed	Required	Procedure
C	6	3	(M)

One channel on each (Slat, Inboard Flap, Outboard Flap) PCV may be inoperative provided slat secondary mode is verified to operate normally once each flight day.

SUBSTANTIATION

Background

Proposal similar to 787 MMEL item 27-51-05.

(For full high lift function description, see proposal for item 27-51-01.)

The flaps and slats are driven by an array of torque tubes that are powered by hydraulic motors which are part of the flap and slat power drive units (PDUs). In primary mode, the PDUs are controlled by the primary control valves (PCVs) and interfaced with integrated flight control electronics (IFCE) cabinets. Each PCV is capable of being controlled by two different IFCE Cabinets for primary mode operation, via dual coil solenoids.

There are 3 PCVs (Inboard Flap, Outboard Flap and Slats). Each PCV includes 5 solenoid valves (Shutoff, Low-Speed, Extend, Retract, Bypass) that control the associated valve functions (shutoff valve, low-speed piston, directional control (selector) valve, bypass valve). There are 2 coils for each solenoid, one for each command channel. Each channel of the inboard and outboard flap PCVs is driven by separate IFCE cabinets (R & C). Each channel of the slat PCV is driven by separate IFCE Cabinets (L1 & L2). Automated tests are provided to detect failures of the PCVs.

Consequences of Failure

Failure of one coil on one or more solenoid valves will result in display of the FLAP/SLAT CHANNEL Status message. Failure is detected when either IFCE channel fails to drive the slats or flaps but the other IFCE channel successfully drives the slats and/or flaps.

The result is loss of redundancy only. PCV will operate normally using the remaining control channel. This message is inhibited in the IFCE by the FLAP LEVER INOP message.

Consequences of Next Critical Failure

In general, failure of the second coil (to open state) on the same solenoid will result in loss of primary mode operation of the affected system and display of the FLAPS IN SEC MODE or SLATS IN SEC MODE Caution message. An exception to this is the Slat Low Speed Solenoid, where failure of both coils results in the non-dispatchable FLAP/SLAT FLOW LIMITER Status message, but does not result in loss of primary mode operation of the slats. Availability of secondary mode is ensured by MMEL provisos requiring verification of slat secondary mode. Flap secondary mode is exercised automatically several times each flight by the variable camber (cruise flaps) function, and associated faults are annunciated by status message. Therefore, verification that flap secondary normal operation is not required.

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Section 2

27-51-06 Alternate Flap/Slat Control Function

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be dispatched with FLAP ALTERNATE SWITCH Status message displayed provided:

- At least two surface (slat, inboard flap, or outboard flap) alternate control systems are verified to operate normally once each flight day, and
- Flap Lever Position Transducers operate normally.

27-51-06 Alternate Flap/Slat Control Function

27-51-06-01 ALTN FLAPS ARM Switch ALTN Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 27-51-08.

(For full high lift function description, see proposal for item 27-51-01.)

The HLF has three modes of operation: primary, secondary, and alternate. Primary mode provides full-rate high lift operations; it is powered by the center hydraulic system. Secondary mode provides reduced-rate high lift operation via hydraulic or electric motors. In both HLF primary and secondary modes, control is closed-loop with command input through the flap lever.

HLF Alternate Mode provides a means to extend slats and flaps in the event of loss of all FCMs or failure of the flap lever. HLF Alternate Mode is enabled with the alternate flap arm switch and controlled with the control selector switch. The alternate flap arm and control switches supply signals to the IFCE and also directly to the electric motor control relays, independently of the IFCE. Flap and slat retraction automatically shuts off at the up position. Flap and slat extension automatically shuts off at the 20 and Middle positions. Because HLF Alternate Mode extend operates independently of the IFCE, alternate extend remains operational even when all IFCE functionality is lost. Alternate retract requires at least one FCM, plus ACE L1 and ACE R. When HLF Alternate Mode is selected, the Caution level message FLAP LEVER INOP and the HLF Alternate Mode position display show on EICAS.

ARM switch ALTN light:

When the ARM switch is pressed the ALTN light will illuminate. Also, the alternate flap control mode and alternate flaps selector are enabled. Primary and secondary flap/slat modes are disabled. If not already present, the FLAP LEVER INOP Caution message is displayed and beeper sounds.

Consequences of Failure

A single switch pole failure of either alternate flap arm (ARM) or control (EXT/RET) switch is indicated by the FLAP ALTERNATE SWITCH Status message.

Either slat, inboard flap, or outboard flap alternate control (one of three systems) may be inoperative. Primary and secondary modes are not affected.

ALTN light:

Light will not illuminate. If not already present, the FLAP LEVER INOP Caution message will be displayed and beeper will sound. The alternate flaps selector will still operate. The EICAS flap position indicator displays also change when in alternate mode. Each wing is shown and flap/slat positions are shown independently. Magenta and green line indications are removed when transitioning from secondary mode to alternate mode.

Consequences of Next Critical Failure

Failure of the flap handle module:

FLAP LEVER INOP Caution message is displayed and alternate mode operation is required. One of the three alternate mode systems may be inoperative. DDG Operations (O) guidance is provided to select appropriate speed for approach based on high lift configuration. Verification of slat or flap alternate mode each flight day ensures at least two systems remain operative. (O) procedure provides appropriate approach configuration and speed information to the flight crew.

Failure of a second alternate flap arm or control switch pole may result in loss of flap and slat alternate Mode. Flaps primary and secondary mode are not affected. Daily (M) procedure check will fail and dispatch will not be allowed.

27-51-07 Flap Support Sensors

Interval	Installed	Required	Procedure
C	16	8	(M)

One sensor per sensor pair may be inoperative with FLAP SUPPORT SENSOR ___ Status message(s) displayed provided associated sensor(s) is verified to operate normally.

SUBSTANTIATION**Background**

New proposal for 777X.

(For full high lift function (HLF) description, see proposal for item 27-51-01.)

Sensors are installed in conjunction with fuse pins in each midspan and outboard trailing edge flap segment to annunciate a structural failure condition of the flap support. There are a total of 8 flap support fuse pins, and each fuse pin has an associated set of sensor pairs.

Consequences of Failure

A failure of a single flap support sensor of any dual channel pair is indicated by the FLAP SUPPORT SENSOR n (n=1-4, 9-12) Status message. The result is a loss of redundancy. For dispatch, the remaining sensor of any affected pair must be verified to operate normally. The remaining sensor will provide full capability to indicate of structural failure of the flap support.

Consequences of Next Critical Failure

Failure of the remaining flap support sensor would result in both sensors of the sensor pair being inoperative. The sensor pair would lose capability to indicate failure of the flap support. The FLAPS INSPECTION n (n=1-4, 9-12) Status message would be displayed. Subsequent dispatch is not allowed. The FLAPS INSPECTION n Status message will also be displayed for failure of the associated Spoiler REU or ACE.

The flap support sensors are part of the "LE abd TE Fail to Drive without Crew Awareness" FTA. The top event probability of this FTA with failed flap support sensors is extremely improbable (on the order of 1.0E-15).

Hazard classification is 'Minor'.

27-51-08

Flap/Slat ELMS Interface Function

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be dispatched with FLAP/SLAT ELMS INTERFACE Status message displayed.

SUBSTANTIATION**Background**

Flap and Slat ELMS relay data is used to drive the High Lift Alternate mode EICAS display & the upper barberpole following loss of all three FCMs.

Consequences of Failure

The FLAP/SLAT ELMS INTERFACE Status message will be displayed if the Flap or slat electric motor relay on/off status provided by ELMS is erroneous. No effect.

Consequences of Next Critical Failure

Failure of all three FCMs. The hazard classification of loss of all three FCMs is 'Hazardous'. The probability of loss of all three FCMs is 1.58E-12.

27-58-01 Flap Position/Skew Sensors

Interval	Installed	Required	Procedure
C	32	16	

One sensor per sensor pair may be inoperative with FLAP POSN/SKEW SENSORS Status message displayed provided:

- All Slat Position/Skew Sensors operate normally, and
- All Spoiler Actuators operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-58-01.

(For full high lift function (HLF) description, see proposal for item 27-51-01.) Sensors throughout the HLF drive system provide absolute and relative drive system position information for control and monitoring.

The trailing edge flap system consists of 4 (dual channel) position sensors and 12 (dual channel) skew sensors. The position sensors are used for the following functions: TE flap position control, asymmetry protection, uncommanded motion protection, and for communication of TE flap position information to other airplane systems via common data network (CDN). The flap skew sensors are used to detect misalignment (skew) of the flap surface.

Skew and position sensors provide an analog signal to spoiler remote electronics units (REUs) for conversion to a digital signal for transmission to the integrated flight control electronics (IFCE) cabinets.

The high lift function (HLF) annunciates and shuts down the flap drive when a flap asymmetry or misalignment (skew) is detected. Annunciation is provided by the FLAPS INBOARD INOP or FLAPS OUTBOARD INOP Caution message. The position and skew sensors used for the asymmetry and skew protection functions are all dual-channel; protection is retained when a single transducer of each pair is inoperative.

Consequences of Failure

Failure of a single flap position or skew sensor in any or all sensor pairs is annunciated by the status message FLAP POSN/SKEW SENSORS.

Loss of sensor redundancy only. Flap position and skew sensing remains fully functional with remaining sensors. MMEL provisos requiring slat position sensors and spoiler systems operate normally preclude combinations of faults which are one subsequent failure away from loss of both flaps and slats drives.

Consequences of Next Critical Failure

Failure of a redundant sensor of a sensor pair or the redundant sensor's interfacing spoiler REU or ACE:

The drive system will be shut down and the FLAPS INBOARD INOP or

FLAPS OUTBOARD INOP Caution message will be displayed. Non-normal split flap landing is required with the slats drive system and remaining inboard or outboard flap system.

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Feb 26, 2026

27-61-01 Speedbrake Lever Position Transducers

Interval	Installed	Required	Procedure
B	4	3	(O)

One may be inoperative provided:

- Automatic Speedbrake Function operates normally, and
- Speedbrakes are verified to operate normally before each landing.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-61-01.

The speedbrake lever has 4 identical position transducers. Each transducer provides input to the actuator control electronics (ACEs) which convert the analog position signals to digital form. The 4 individual digital position signals are transmitted on the flight controls inter-cabinet data buses to the three FCMs. The IFCEs process the redundant lever position inputs along with airplane sensor data to obtain spoiler actuation commands.

Consequences of Failure

Failure of a single speedbrake lever position transducer is annunciated by the SPEEDBRAKE LEVER XDCC Status message.

Redundancy management within each IFCE provides continued speedbrake command processing with the remaining 3 lever position inputs. The PFCF remains fully functional in normal or secondary mode with one lever position transducer inoperative.

Consequences of Next Critical Failure

No single additional PFCF failure will cause flight control system degradation from normal to either secondary or direct mode.

- Detected failure of another transducer on speedbrake lever: PILOT CONTROL SYS Status message is displayed with a second failure - redundancy management within each IFCE provides continued speedbrake command processing with the remaining 2 lever position inputs.

-
2. Erroneous output of adjacent transducer, or mechanical disconnect of opposite pair of transducers: RVDT input signal processing results in output command of zero - speedbrakes are not available except during a rejected takeoff when speedbrake panels will deploy regardless of RVDT command. (O) procedure established to verify speedbrakes operate normally prior to each landing, with non-normal performance adjustments applied in the event speedbrakes do not function. (Note: this (O) procedure makes use of S/B ARMED detent annunciation, which rules out this item in combination with autospeedbrake function (MMEL item 27-61-03.))
 3. Selection of PFCF direct mode: One or two spoiler pairs may not operate as speedbrakes in direct mode.

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27-61-02 Spoiler Actuators

27-61-02-01 Spoilers 1, 2, 3, 4, 5, 14, 15, 16, 17, 18

Interval	Installed	Required	Procedure
C	10	9	(M) (O)

One may be inoperative provided:

- Inoperative Spoiler Actuator is deactivated,
- Spoiler Actuators 6, 7, 8, 9, 10, 11, 12 & 13 operate normally,
- Position of deactivated spoiler is verified before each departure,
- Flap Position/Skew Sensors operate normally,
- Slat Position/Skew Sensors operate normally,
- For Spoiler Actuator 17 inoperative, fuel temperature is greater than -20°F (-29°C) prior to takeoff,
- Appropriate weight and center-of-gravity limits are observed, and
- Appropriate performance adjustments are applied.

27-61-02 Spoiler Actuators

27-61-02-02 Spoilers 6, 7, 8, 9, 10, 11, 12, 13

Interval	Installed	Required	Procedure
C	8	7	(M) (O)

One may be inoperative provided:

- Inoperative Spoiler Actuator is deactivated,
- Spoiler Actuators 1, 2, 3, 4, 5, 14, 15, 16, 17 & 18 operate normally,
- Position of deactivated spoiler is verified before each departure,
- Flap Position/Skew Sensors operate normally,
- Slat Position/Skew Sensors operate normally, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 27-61-02.

777X fly by wire flight control system adopts the 787 control laws for the roll and yaw axes. The "p-Beta" control law generates surface commands for ailerons, flaperons, spoilers, and rudder based on roll rate and sideslip commands generated by the pilot's wheel and pedals. The system also performs active maneuver load alleviation as a means to reduce airplane structural weight. Spoilers are also used for speedbrake control in response to manual or automatic speedbrake lever input.

The high lift function incorporates a spoiler droop function to provide for improved flaps-down performance. Spoiler trailing edge is commanded down as flaps are extended to tailor the camber of the wing at flaps down conditions.

Consequences of Failure

Failure of a single spoiler actuator or associated remote electronics unit (REU) is annunciated on the ground by the SPOILERS FAULT Advisory message. After the Maintenance (M) procedure is accomplished, the SPOILER ACTUATOR Status message will be displayed. Flap retraction is inhibited on the ground to prevent spoiler/flap contact, annunciated by the FLAPS GROUND INHIBIT Status message; inhibit is removed by the (M) procedure.

No effect on normal mode handling qualities because control laws compensate for the inoperative spoiler in both roll and pitch (speedbrake). There is a slight reduction in flight descent and deceleration capability with an inoperative spoiler. Effect of inoperative spoiler on stopping performance is accounted for by applying a takeoff and landing performance penalty. Effect on maneuver load alleviation is accounted for by applying a takeoff gross weight/CG restriction and maximum zero fuel weight/CG restriction. Loss of droop function for affected spoiler accounted for by performance penalty and possible approach speed additive. If inoperative spoiler is caused by associated REU fault, some redundant high lift sensors may be inoperative; MMEL provisos requiring flap position/skew sensors and slat position sensors operate normally preclude combinations of faults which are one subsequent failure away from loss of both flaps and slats drives.

Spoiler 17 plays an important role in the "cold hydraulic function", which warms hydraulic fluid under cold ambient conditions (fuel temperature below -20 deg F/-28.9 deg C). Spoiler 17 is the furthest outboard right wing spoiler on the left hydraulic system, which provides the most benefit of any spoilers to the right outboard aileron actuator, which experiences the coldest hydraulic fluid temperatures. When the cold hydraulic function is engaged, the maintenance bypass function of spoiler 17 is essential for warming the right outboard aileron actuator prior to approach and landing. For this reason, a fuel temperature limitation is imposed on this specific spoiler.

Consequences of Next Critical Failure

Failure of hydraulic system not associated with inoperative spoiler: several additional spoilers will become inoperative, as well as aileron actuator(s) and flaperon actuator(s). Airplane continues to meet all requirements for continued safe flight and landing. Subsequent dispatch not allowed.

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Selection of direct flight control mode: inoperative spoiler will cause asymmetric roll response to wheel input. Deployment of speedbrake will generate rolling moment which will require pilot compensation. Some roll surfaces may not follow the proper droop schedule when flaps are extended; roll asymmetry may result which will require pilot compensation.

Failure of a redundant sensor of a slat position sensor pair associated with the inoperative spoiler REU: the slats drive system will be shut down and the SLATS INOP Caution message will be displayed. Non-normal landing is required.

Failure of a redundant sensor of a flap position or skew sensor pair associated with the inoperative spoiler REU: the flap inboard or outboard drive system will be shut down and the FLAPS INBOARD INOP or FLAPS OUTBOARD INOP Caution message will be displayed. Non-normal landing is required.

Alternate roll control from spoilers 6 & 13: For spoiler 6 or 13 inoperative, alternate roll control capability will be reduced in the event of loss of all Fly-by-Wire electronics. However, the probability of loss of all Fly-by-Wire electronics is less than 1.0E-09. Alternate roll control from spoilers 6 & 13 is not required for type certification.

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27-61-03 Automatic Speedbrake Function

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Speedbrake Lever Position Transducers operate normally,
- ARMED detent is not used, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-61-03.

The speedbrake lever on the control stand is used for manual and automatic deployment of the spoilers as speedbrakes. The speedbrake lever has two detents: DOWN and ARMED. The ARMED detent is used for automatic deployment of the spoilers upon landing. When the airplane lands with the lever armed, the primary flight control function (PFCF) commands the auto speedbrake actuator to drive the lever up, causing the spoilers to fully deploy. If the lever is in the DOWN position at landing, auto speedbrake deployment is commanded if reverse thrust is selected.

In the event of an RTO on ground above 85 knots, the speedbrakes are deployed when the thrust levers are brought to idle. In this situation, the speedbrakes are deployed even if the motor cannot move the speedbrake handle. Pilot control of the speedbrakes is restored when the handle is again matched to the speedbrake position.

Below 85 knots the speedbrakes are deployed when reverse thrust is used or the speedbrake lever is placed in the ARM position.

777X incorporates the 787 aural warning for landing and RTO auto speedbrakes. If the speedbrake lever does not move as commanded, a "SPEEDBRAKES SPEEDBRAKES" aural will alert the pilot to deploy manual speedbrakes.

The 777X incorporates an autostow feature that will automatically retract the speedbrake lever in air or on ground when either thrust lever is moved to a high thrust position.

Consequences of Failure

Failure of the auto speedbrake function is annunciated by the AUTO SPEEDBRAKE Status message. The annunciation indicates the auto speedbrakes may be delayed or inoperative. If inoperative, electrical power is automatically removed from the auto speedbrake actuator and associated circuit card. To conservatively preclude unlikely failures where power might be reapplied to the actuator, the ARMED detent is not to be used (there is no practical way to deactivate the actuator by (M) procedure).

With the AUTO SPDBRAKE FAULT Advisory message displayed, the flight crew should assume that automatic speedbrake deployment is not available, and speedbrakes must be manually deployed and manually stowed.

Consequences of Next Critical Failure

AFM takeoff and landing performance includes a weight decrement to account for auto speedbrake inoperative.

Loss of the manual speedbrakes:

NOTE: These failure modes have the same airplane level effect with or without the automatic speedbrake function inoperative. The following is included for information only.

The loss of manual speedbrakes, resulting from a jam of the lever or another failure, would prevent manual deployment of the speedbrake lever and result in SPEEDBRAKE time critical warning during landing. Loss of manual speedbrakes would prevent deployment of speedbrakes during landing, however other means are available to decelerate the airplane. Manual speedbrake loss would not prevent deployment of speedbrakes during a rejected takeoff as spoilers will deploy automatically. Speedbrake lever jam would prevent speedbrakes from being manually stowed during a Go Around after touchdown. Failure to retract speedbrakes during a Go Around is a Catastrophic failure. The probability of failure to retract speedbrakes during a Go Around is 1.93E-10 per flight hour.

27-61-04 Spoiler Actuator Remote Electronics Unit (REU) Channels

Interval	Installed	Required	Procedure
C	54	53	

One may be inoperative provided REU channels for at least three of the remaining actuator types operate normally:

- Aileron
- Flaperon
- Rudder
- Elevator

SUBSTANTIATION

Background

New item for 777X.

Each spoiler has one actuator, and each actuator is controlled by a single REU. Within each REU are three command paths (referred to as channels) for redundancy and integrity.

Consequences of Failure

Failure of one of the fifty four REU channels will result in the SPOILER REU CHANNEL status message.

Loss of redundancy only. MMEL proviso excluding REU channel fault on more than one additional actuator type is included to limit the combinations of REUs with a failed channel to ensure sufficient monitor coverage and fault detection response in the event of additional failures.

Consequences of Next Critical Failure

Failure of an additional spoiler REU channel(s) in a different REU(s) will result in the SPOILER REU SYS Status message. Subsequent MMEL dispatch is not allowed.

Failure of an additional spoiler REU channel(s) in a single REU will result in loss of the associated REU and spoiler actuator. The SPOILERS FAULT Advisory message and SPOILER ACTUATOR Status message will be displayed. Subsequent MMEL dispatch requires deactivation of the affected spoiler actuator (which will suppress the SPOILERS FAULT Advisory message).

27-81-01 Slat Secondary Mode

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided Flap/Slat Primary Control Valve (PCV) channels operate normally.

NOTE: Dispatch is not allowed with inoperative Inboard nor Outboard Flap Secondary Mode.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-81-01A.

(For full high lift function description, see proposal for item 27-51-01.)

The HLF has three modes of operation: primary, secondary, and alternate. Primary mode provides full-rate high lift operation; it is powered by the center hydraulic system. Secondary mode provides reduced-rate high lift operation via hydraulic or electric motors. In both HLF primary and secondary modes, closed-loop control is provided by the FCMs with command input through the flap lever. In HLF alternate mode, the extend control path is independent of the FCMs and flap lever with command input through the alternate flap arm and control switches. Alternate retract is controlled via the IFCE cabinets.

HLF secondary mode is automatically engaged when HLF primary mode fails to drive or drives too slowly and/or when an engine fails combined with a low quantity indication signal from the center hydraulic system. The control modes for the flaps and slats are independent of each other except when in HLF alternate mode. In the case of a loss of all FCMs, alternate control is with command input through the alternate flap arm and control switches.

Consequences of Failure

Failure of slats secondary mode is annunciated by the SLATS SECONDARY FAIL Status message.

Slat operation is not available in secondary mode. There is no effect on slat normal operation since primary mode is normally used. Slat alternate mode is also inoperative but flaps alternate mode is not affected.

Flap/slat primary control valve (PCV) channels MMEL item requires slat secondary mode to operate normally (verified once per day), therefore flap/slat primary valve (PCV) control channels must operate normally.

Consequences of Next Critical Failure

Failure of slat primary mode: SLATS INOP Caution message will be displayed. Non-normal landing is required with the flaps drive system.

Flap secondary mode is exercised automatically several times each flight by the variable camber (cruise flaps) function, and associated faults are annunciated by status message. Non-normal landing has a high probability of at least one flap drive system operating.

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27-81-02

Slat Remote Electronics Units (REU)

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative slat REU is deactivated, and
- Slats secondary mode is verified to operate normally once each flight day.

SUBSTANTIATION

Background

New proposal for 777X.

Two Slat REUs provide an interface between IFCEs L1/L2 and the Slat Primary Control Valve and Slat Skew Sensors. IFCE L1 and IFCE L2 interface with Slat REU 1 and Slat REU 2 respectively. Slat REUs 1 and 2 provide for redundant command inputs to the Slat Primary Control Valve and Autoslat Priority Valve. Each Slat REU (1 and 2) provides feedback to one of the IFCEs from one channel of each Slat Skew Sensor (sensors 1, 6, 7, 8, 9 & 14). Each Slat REU also provides feedback to the IFCEs from each Kruger Flap Position Sensor.

Slat position feedback is not provided to the IFCEs via the Slat REUs. Left Slat Position Sensor input is routed through Spoiler REU 2 (sensor A) and Spoiler REU 6 (sensor B). Right Slat Position Sensor input is routed through Spoiler REU 16 (sensor A) and Spoiler REU 18 (sensor B).

Consequences of Failure

Failure of a slat REU is indicated by the SLAT REU1 or SLAT REU 2 Status message.

Failure of one slat REU results in loss of redundancy in slat primary mode control and slat skew sensor feedback. The inoperative REU must be deactivated and slat secondary mode must be verified once each flight day.

Consequences of Next Critical Failure

Loss of the remaining LE REU will result in loss of slat primary mode, annunciated by the SLATS IN SEC MODE Caution message and SLAT REU SYS Status message. Slats will continue to operate in secondary mode. Availability of slat secondary mode is ensured by proviso.

Loss of a skew sensor on the remaining LE REU will result in loss of both slat primary and slat secondary control, annunciated by the SLATS INOP Caution message. Alternate mode is still available, however, the SLATS INOP non-normal checklist does not allow alternate mode operation because asymmetry and uncommanded motion protection is not available in alternate mode.

27-81-03

Main Gear (Autoslat) Priority Valve Control Channels

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative.

SUBSTANTIATION**Background**

New proposal for 777X.

The autoslat extension function improves the wing stall performance if the airplane gets near a stall condition. This function also makes sure that the leading edge slats get enough hydraulic power when the autoslat function is active.

The autoslat function operates only in the primary mode and when the leading edge slats are in the MIDDLE position. The Display Crew Alerting System (DCAS) sends an autoslat request to the Integrated Flight Control Electronics (IFCE)s if the airplane angle of attack gets near a trip point. If the trailing edge flap control lever module is between detent position 1 and detent position 20, the IFCEs command the leading edge slats to extend to the EXTENDED position. At the same time, the IFCEs energize the solenoid in the Main Gear (Autoslat) Priority Valve. This reduces the hydraulic flow to the Main Landing Gear (MLG) systems allowing more hydraulic power to go to the leading edge slat system.

The DCAS removes the autoslat request when the Angle of Attack (AOA) decreases below the trip point. After the autoslat request is removed, the IFCEs command the Leading Edge (LE) slats back to their commanded position and de-energize the solenoid in the Main Gear (Autoslat) Priority Valve.

The Main Gear (Autoslat) priority valve is a pressure-sensitive flow limiter with a solenoid override feature. The Main Gear (Autoslat) priority valve includes a single coil solenoid valve and a control valve. The control valve receives pilot pressure from the solenoid valve and from the center hydraulic system. When the solenoid valve is de-energized, the control valve allows full hydraulic flow to the MLG system.

There are two control channels that control the single coil solenoid valve. One from IFCE L1 through Slat (LE) REU 1, and one from IFCE L2 through Slat (LE) REU 2.

During autoslat operation, the solenoid valve energizes. This moves the control valve to the reduced flow position, decreasing hydraulic flow to the MLG system and giving priority to the slats.

If the center hydraulic system pressure is less than approximately 2,550 psi, springs force the control valve to the reduced flow position. This decreases hydraulic flow to the MLG system and gives priority of the hydraulic power to the flaps and slats.

Consequences of Failure

The MAIN GEAR PRIORITY VLV 1 Status message will be indicated when Slat (LE) REU 1 has failed to energize the priority valve solenoid.

The MAIN GEAR PRIORITY VLV 2 status message will be indicated when Slat (LE) REU 2 has failed to energize the priority valve solenoid.

Failure of one command channel to energize the solenoid results in a loss of redundancy only. Main Gear (Autoslat) Priority Valve continues to operate normally.

Consequences of Next Critical Failure

Failure of the remaining control channel results in failure to energize the solenoid. This results in loss of autoslat function during gear retraction.

Loss of autoslat function during gear retraction may result in the SLATS IN SEC MODE FAIL Caution message. The MAIN GEAR PRIORITY VLV SYS Status message will be displayed for failure of both control channels.

The MAIN GEAR PRIORITY VLV SYS Status message will also be displayed in the unlikely failure of an erroneously energized solenoid. An erroneously energized solenoid will result in slow gear retraction. For slow gear retraction, the GEAR DISAGREE Caution message or GEAR DOOR NOT CLOSED Caution message may be displayed.

The airplane level hazard of loss of autoslat during gear retraction, or slow main landing gear retraction is 'Major'.

27-88-01 Slat Position/Skew Sensors

Interval	Installed	Required	Procedure
C	24	12	

One sensor per sensor pair may be inoperative provided:

- All Flap Position/Skew Sensors operate normally, and
- All Spoiler Actuators operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 27-58-01 adapted to slats.

(For full high lift function (HLF) description, see proposal for item 27-51-01.)

Sensors throughout the HLF drive system provide absolute and relative drive system position information for control and monitoring. The leading edge slat system consists of 2 (dual channel) position sensors, 2 (dual channel) Krueger position sensors, and 8 (dual channel) skew sensors. The position sensors are used for the following functions: LE slat position control, asymmetry protection, uncommanded motion protection, and for communication of LE slat position information to other airplane systems via common data network (CDN). For the 8 (dual channel) skew sensors, 4 are on slats 7/8, 2 are on slats 6/9, and the remaining 2 cover slats 1-5/10-14.

The slat skew sensors are used to detect misalignment (skew) of the slat surface. Skew and position sensors provide an analog signal to leading edge and spoiler remote electronics units (REUs) for conversion to a digital signal for transmission to the integrated flight control electronics (IFCE) cabinets.

The high lift function (HLF) annunciates and shuts down the slat drive when a slat asymmetry or misalignment (skew) is detected. Annunciation is provided by the SLATS INOP Caution message. The position and skew sensors used for the asymmetry and skew protection functions are all dual-channel; protection is retained when a single transducer of each pair is inoperative.

Consequences of Failure

Failure of a single slat position or skew sensor in any or all sensor pairs is annunciated by the status message SLAT POSN/SKEW SENSORS.

Loss of sensor redundancy only. Slat position and skew sensing remains fully functional with remaining sensors. MMEL provisos requiring flap position/skew sensors and spoiler systems operate normally preclude combinations of faults which are one subsequent failure away from loss of both flaps and slats drives.

Consequences of Next Critical Failure

Failure of a redundant sensor of a sensor pair or the redundant sensor's interfacing REU or ACE: the drive system will be shut down and SLATS INOP Caution message will be displayed. Non-normal landing is required with the flaps drive system.

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Intentionally
Blank

28-11-01 Sump Drain Valves**28-11-01-01 Surge Tanks**

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided there is no evidence of leakage.

28-11-01 Sump Drain Valves**28-11-01-02 Main and Center Tanks**

Interval	Installed	Required	Procedure
C	4	3	(M)

One may be inoperative provided:

- There is no evidence of leakage, and
 - Alternate procedures are used to prevent water accumulation in associated tank.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-11-01.

Similar to the 777-300ER, the 777-9 has water scavenge systems in both main tanks. The scavenge systems transfer water from low points in the tank near each pump inlet so that water is mixed into the fuel feed system and consumed by the engine. The fuel scavenge pumps in the center tank will also ensure water in the center tank below the pump inlets is removed similar to the 777-300ER architecture without dedicated water scavenge pumps in the center tank.

The fuel tanks have fuel sump drain valves strategically located at low points in the tanks. There are six sump valves installed on the 777X. There is one in each surge tank, one in each main tank and two in the center tank. They are used for draining accumulated moisture and fuel trapped in the sumps when the tanks are defueled. The sumps are not used during or immediately following refueling since water will be suspended in the fuel. Maintenance will normally drain fuel tank sumps for water removal on a daily basis. Water may be present in fuel in three forms which are dissolved, entrained or free water. Dissolved and entrained water will be present in colloidal suspension and do not settle out of the fuel. Free water may be present as a fuel contaminant when delivered into the airplane tank system or condense on tank walls or the surface of cold fuel from high humidity air that enters the tank during descent. Free water, if left undisturbed will settle out of the fuel and can be drained from the tanks using the sump valves. A water scavenge system is installed in each fuel tank to eliminate the accumulation of water. The water scavenge jet pumps discharge in the vicinity of the engine feed pump inlet sending water out of the tank in a dilute form.

NOTE: The Nitrogen Generation System minimizes high humidity air content in the tank which could result in condensation on tank walls or the surface of cold fuel.

Consequences of Failure

The sump drain valve can not be opened. Water can not be removed using the sump valve from the associated fuel tank. The scavenge system will eliminate any accumulation of water.

A sump drain valve that has failed allowing fuel leakage. Dispatch with this failure condition is not allowed per proviso.

Consequences of Next Critical Failure

Failure of water scavenge system leading to fuel contamination due to excessive water build up. Fuel loaded with excessive water would be detected by requirement to inspect refueling equipment.

28-21-01 Pressure Fueling System**28-21-01-01 Refuel Valves****28-21-01-01A**

Interval	Installed	Required	Procedure
C	6	3	

One refuel valve in each fuel tank may be inoperative provided associated refuel valve is closed.

28-21-01 Pressure Fueling System**28-21-01-01 Refuel Valves****28-21-01-01B**

Interval	Installed	Required	Procedure
C	6	0	(M) (O)

Both refuel valves for any fuel tank may be inoperative provided:

- One refuel valve in associated tank(s) is locked closed,
- Remaining refuel valve in associated tank(s) is closed, and
- Alternate procedures are established and used for refueling.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-01 Fuel Quantity Indicators**

Interval	Installed	Required	Procedure
C	4	0	(M)

May be inoperative provided alternate procedures are used for refueling.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-02 Load Select System**

Interval	Installed	Required	Procedure
C	1	0	(M)

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May be inoperative provided:

- Refuel Valve Switches operate normally, and
- Alternate procedures are used for refueling.

NOTE: Any function which operates normally may be used.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-03 Refuel Valve Lights**

Interval	Installed	Required	Procedure
C	6	0	(M)

May be inoperative provided:

- Overfill function operates normally, and
- Associated refuel valve is verified closed after each refueling.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-04 Overfill Function (Normal/Reset Switch, Light, and Test)**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Refuel Valve Switches operate normally,
- Refuel valve lights operate normally, and
- Refuel valves are verified to close when appropriate during refueling.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-05 Defuel Valve Function (Switch and Open Light)**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided Defuel Valve is considered inoperative.

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-06 Power Switch - BATT Position**

Interval	Installed	Required	Procedure
C	1	0	

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-07 Test Functions (Indication and System)**

Interval	Installed	Required	Procedure
C	2	0	

28-21-01 Pressure Fueling System**28-21-01-02 Refuel Control and Indication Panel (RCIP)****28-21-01-02-08 Refuel Valve Switches**

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided:

- Load select system operates normally, and
- Overfill function operates normally.

SUBSTANTIATION**Background**

Proposal is similar to 777 MMEL item 28-21-01.

The refuel/defuel system architecture is similar to the 777-300ER with the exception that the 777X does not have the individual tank load select. As with the current 777-300ER, the 777-9 has a refuel station on both wings each having two refuel adapters (four total) to the baseline configuration. The 777-9 has only 1 refuel control and indication panel (RCIP) on the left wing. Each tank has two dedicated refuel shutoff valves with the center having additional refuel bypass valves, one on each side, downstream of the refuel shutoff valves.

The added bypass valves are used to prevent over pressurization in a refuel overflow condition, by limiting the flow rate into the center tank. They also allow a higher flow rate for the bulk of fueling to minimize refuel time.

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The primary refuel shutoff valves and defuel valve have been changed from the 777-300ER configuration to the ball valve design used on the 787.

One change from the 777-300ER architecture is how the refuel overfill detection works. The fuel quantity indication system (FQIS) uses tank volume and high level sense to detect Overfill. When Overfill is detected, FQIS will command refuel valves closed and then set the ground to the overfill relay. A similar architecture was used on the 787 and replaces the float switches previously found in the surge tanks on the 777-300ER.

The refueling system provides the means to fill the airplane fuel tanks. During refueling, the FQIS measures fuel volume and prevents fuel quantity from exceeding the maximum quantity approved for the tank. Also, if a tank exceeds overfill volume, overfill detection by the FQPU will shut off all fueling valves and actuate an indication light on the refueling panel indicating that an overfill condition exists.

The center tank refuel valves have two power supplies to power them closed if the system commands them closed. In the event of loss of power to either power supply during refueling, the valves will be powered closed by the SOV battery. The center tank refuel valves will not be available if the hot battery bus or SOV battery are low on power.

Single channel operation of ELMS P310 panel (MMEL Item 24-09-01) will result in half (three) of the refuel valves inoperative.

Fuel is loaded into the main tanks to the desired fuel quantity or until full after which fuel is loaded into the center tank. Up to 22,000 pounds of fuel may be loaded into the center tank with less than full main tanks provided the center fuel weight plus the actual zero fuel weight does not exceed the maximum zero fuel weight.

Refuel Valves: There are six refuel valves; two in each tank. The valve bodies are inside the tanks. The valve actuators are on the rear spar, outside the tanks. The refuel valve in the left side of the center tank is aft of the second fuel tank access door. The refuel valve in the right side of the center tank is in a similar position. The inboard refuel valve in the left main tank is aft of the fourth fuel tank access door. The outboard refuel valve in the main tank is aft of the eighteenth fuel tank access door. The refuel valves in the right main tank are in similar positions.

RCIP Fuel QTY Indicators: There are four fuel quantity indicators: Total/backup, Right main, Center and Left main. The total fuel quantity indicator can show indications for one of the other tanks if its indicator fails.

Load Select System: There is a LOAD SELECT SET switch, below the TOTAL/BACKUP display, used to select total fuel load for the aircraft. The display tank select switch permits the operator to use the total fuel quantity indicator as a backup for the left, right, or center tank indicator. Each time the switch is pressed, a different tank quantity and identifier is displayed on the total/backup display. The following is the sequence of the identifiers: TF - total fuel quantity, RM - right main tank quantity, CT - center tank quantity and LM - left main tank quantity. The total load select quantity selector permits the operator to select total fuel load quantity. The total load selector is a momentary contact switch. Toggling this switch up will increase the total load fuel quantity.

Refuel Valve Switches: Refuel valve switches send command signals to the fuel quantity processor unit (FQPU) to control the refuel valves. Dispatch relief for the RCIP refuel valve switches, which was previously included with the refuel valves, has been added to sub item -02-08.

Refuel Valve Lights: Each refuel valve open light is a blue light that indicates the position of the related refuel valve. The light illuminates when the valve opens.

Overfill Function (Normal/Reset Switch, Light and Test): The overfill reset switch disables the overfill protection. It has two positions: NORMAL and RESET. The NORMAL position arms the overfill protection. The RESET position turns off the overfill protection. The overfill test switch starts the overfill test. This causes the overfill protection to immediately close all the refuel valves. The operator can conduct the overfill test prior to or during refueling. The overfill indication light is a red light that illuminates when FQIS has detected that the fuel is at the overflow level, or when the overfill test is conducted. It remains on until the fuel is below the detection level.

Defuel Valve Function Open: The defuel valve switch opens and closes the defuel valve. The defuel valve open light is a blue light that indicates the position of the defuel valve. It illuminates when the defuel valve opens.

Power Switch: The power switch permits the operator to refuel the airplane when the ground handling bus does not have power. When the power switch is moved to the battery (BATT) position, it causes the hot battery bus to send power to the refuel system.

Using only battery power, pressure refueling is only intended to run for up to 15 minutes. Only the left main tank can be refueled during this time. After fifteen minutes, there will be enough fuel to run the APU to power the airplane and continue fueling operations.

Test Functions (Indication and System): The indicator test switch does a test of the following indications: Fuel quantity indicators, Refuel valve position indication lights, Defuel valve position indication light and OVERFILL light. During the test, a test pattern is displayed in the fuel quantity indicators, and the valve position indication lights illuminate. For the system test, the system test switch is pressed during refueling to do a test of the refuel system. During the test all the refuel valves close in sequence and the refuel valve position indication lights extinguish. Then, the valves automatically open and the lights illuminate again.

Consequences of Failure

Refuel valve failure is indicated by the following Status messages:

REFUEL VALVE CENTER L
REFUEL VALVE CENTER R
REFUEL VALVE L INBOARD
REFUEL VALVE R INBOARD
REFUEL VALVE L OUTBOARD
REFUEL VALVE R OUTBOARD

For refuel valve failed closed:

If one refuel valve is failed closed, normal fueling procedures can be used but it may take additional time to fuel the associated fuel tank. If two valves on any associated tank are failed closed, the valves can be manually opened, however, overfill protection will not be operative and fueling must be stopped when the associated tank reaches the desired quantity.

Fuel quantity indicators:

Alternate fueling procedure required.

For refuel valve switch inoperative:

Airplane refueling may be done with Load Select system using the All VALVES switch.

Consequences of Next Critical Failure

None. The airplane refueling is done prior to dispatch.

28-21-02 Refuel Adapters

Interval	Installed	Required	Procedure
C	4	2	(M)

One at each fuel station may be inoperative provided there are no fuel leaks.

SUBSTANTIATION**Background**

The refuel adapters connect the fueling nozzles to the refuel system to refuel or defuel the airplane. There are two adapters at each refuel station. On the left wing there is a refuel station aft of leading edge slat 5. On the right wing there is a refuel station aft of leading edge slat 10. The adapters attach to the front spar of the wing.

The left refuel station contains a Refuel Indication and Control Panel (RCIP) used to control refuel and defuel operations. The right refuel station does not contain an RCIP. The RCIP on the left refuel station is used when refueling at either refuel station.

The refuel adapter is an assembly that includes an inlet adapter, a break-away flange, a check valve, a poppet valve, and a refuel/defuel handle. Caps are not required on the refuel adapters. The refuel adapter also grounds the fueling nozzles to the airplane during refueling or defueling.

The inlet adapter attaches to the refuel adapter and lets the fueling nozzle attach to the refuel adapter. The inlet adapter has a break-away flange attached. This lets the inlet adapter disconnect from the refuel adapter when there is an incorrect load applied.

The two-position check valve prevents fuel in the refuel/jettison manifold from flowing back through the refuel adapter.

The poppet valve opens when the fueling nozzle is connected, and closes when the fueling nozzle is disconnected to prevent fuel leaks.

The external refuel/defuel handle operates the check valve. During refueling, the handle is placed in the refuel position. When the fueling nozzle is connected, the poppet valve opens. The forward flow of fuel opens the check valve. Reverse flow of fuel during refueling causes the check valve to move to the closed position. During defueling, the handle is placed in the defuel position. This opens the check valve to allow fuel to go out through the refuel adapter. In the defuel position, the handle prevents the door panel from being closed.

Consequences of Failure

The refuel adapter may not be functional for refueling or defueling. Any operative refuel adapter may be used if refueling or defueling is required. A leak check ensures the integral poppet and check valves are closed.

Consequences of Next Critical Failure

None.

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28-22-01 Main Tank Fuel Pumps**28-22-01A**

Interval	Installed	Required	Procedure
A	4	3	(M) (O)

One may be inoperative provided:

- Inoperative pump pressure is verified low,
- Both Engine Main Fuel Pumps (MFP) operate normally,
- Both Main Tank Fuel Quantity Indication Systems operate normally,
- Associated FUEL PUMP switch remains off,
- Flight remains within 120 minutes of landing at a suitable airport, and
- Repairs are made within one flight.

28-22-01 Main Tank Fuel Pumps**28-22-01B**

Interval	Installed	Required	Procedure
C	4	3	(M) (O)

One may be inoperative provided:

- Inoperative Main Tank Fuel Pump is deactivated,
- Both Engine Main Fuel Pumps (MFP) operate normally,
- Both Main Tank Quantity Indication Systems operate normally, and
- Flight remains within 120 minutes of landing at a suitable airport.

28-22-01 Main Tank Fuel Pumps**28-22-01-01 Switch PRESS Lights**

Interval	Installed	Required	Procedure
C	4	0	

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28-22-01 Main Tank Fuel Pumps

28-22-01-02 Switch ON Lights

Interval	Installed	Required	Procedure
C	4	0	

SUBSTANTIATION

Background

Proposal for 28-22-01 is based on 777 MMEL item 28-22-01.

Proposals for 28-22-01-01 and -02 are based on 787 MMEL items 28-22-01-01 and -02.

Refer to PL-40.

The 777X engine fuel feed system architecture is the same as the 777-300ER. It provides the capability to feed engines from the main and center tank at the required flow and pressures for all flight conditions. The engine fuel feed system consists of new pumps, valves, and transport elements that deliver fuel from the fuel tanks to the engines. When the center tank is loaded with fuel, the engines are fed from the center tank Override/Jettison (O/J) pumps that override the main tank boost pumps. The main tank boost pumps (two per tank) are always on and will begin feeding their respective engines after the center fuel tank O/J pumps are turned off. Should pressurized feed be lost, the fuel feed system is equipped with a suction feed inlet in each main tank to maintain engine access to fuel. Suction feed capability will be shown as part of certification and will be tested at regular intervals as dictated by Certification Maintenance Requirements (CMR).

The 777X main tank boost pumps have added dry run protection on the ground. Each main tank boost pump has the capacity to provide adequate fuel to one engine and the APU for all thrust conditions. The main tank boost pump and suction feed inlets are located such that all but approximately 670 lb of main tank fuel can be used. The 120 min ETOPS restriction directed by PL-40 is not proposed based on certification of suction feed capability for extended periods of time and periodic maintenance checks of the fuel manifold to ensure that suction feed will operate if the remaining pump fails inflight.

NOTE: Suction feed capability is planned to be demonstrated for 60 minutes at climb power and 600 minutes at cruise power.

PRESS Lights: Illuminated (amber) means associated fuel pump output pressure is low with the pump commanded on.

A low pressure sensor for each pump is located on the electric motor side of the pump located outside of the fuel tank on the rear spar. Output pressure is sensed at this location to provide feedback for the PRESS indication. If low pump output pressure is detected, a specific advisory alert for each pump is provided to the flight crew. Low pressure detection also illuminates the amber PRESS light on each respective switch. On the main tank pump switches, these lights are active whether a switch is ON or OFF. If both boost pumps in a main tank are inoperative, the associated engine will operate on suction feed. If both main tank pump pressures are low, the associated FUEL PUMPS LOW L, R Caution message will be displayed. This message is inhibited by the FUEL PRESS LOW ENG L, R Caution message, to indicate that suction feed is occurring to that engine. On the center tank, the FUEL LOW CENTER Advisory message will be displayed when at the wet shutoff point and the flight crew is instructed to switch the center tank pumps OFF.

ON Lights: The fuel pump is commanded on.

Consequences of Failure

The associated FUEL PUMP L, R AFT or FUEL PUMP L, R FWD Status message will be displayed for a command/pressure disagreement or pump relay fault.

The associated FUEL PUMP LOW L AFT, FUEL PUMP LOW L FWD, FUEL PUMP LOW R AFT, FUEL PUMP LOW R FWD Advisory message will also be displayed.

Pump Inoperative: Associated pump is deactivated. The remaining boost pump will continue to provide pressurized fuel flow to the engine until the pump inlet is uncovered. Relief is proposed for one flight provided pump switch remains off and pump pressure is verified to be low (same functional state as deactivated.).

PRESS Lights: Associated fuel pump state must be determined using FUEL PUMP ____ advisory message. Message remains operative.

ON Lights: The ON indication is visible in ambient light with the shutter open and the switch is flush with the surrounding panel.

Consequences of Next Critical Failure

Failure of the boost pump in the same tank would result in the associated engine operating on suction feed.

Note: similar to 777-300ER and 787, suction feed capability at high altitude (above FL 380) is limited. The FUEL PRESS LOW ENG L, R Caution message and associated non-normal checklist will instruct the crew to temporarily open the crossfeed valve and descend to an altitude where suction feed capability is sufficient for the remainder of the flight. After operating on suction feed for at least 30 minutes, the associated ENG FUEL PUMP L, R Status message will be displayed.

PRESS Lights: None.

ON Lights: None.

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28-22-02 Center Tank Fuel Override/Jettison Pumps**28-22-02A**

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Associated FUEL CENTER PUMPS switch remains off,
- Associated Center Tank Fuel Override/Jettison Pump pressure is verified low,
- Both Fuel Crossfeed Valves operate normally,
- Both Engine Main Fuel Pumps (MFP) operate normally,
- Center Tank Fuel Quantity Indication System operates normally,
- With center tank fueled, fuel quantity remaining in main tanks is adequate to reach a suitable airport if remaining center pump fails at any time,
- Appropriate zero fuel weight and center-of gravity adjustments are applied,
- Appropriate performance adjustments are applied, and
- Repairs are made within one flight.

28-22-02 Center Tank Fuel Override/Jettison Pumps**28-22-02B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Center Tank Fuel Override/Jettison Pump is deactivated,
- Both Fuel Crossfeed Valves operate normally,
- Both Engine Main Fuel Pumps (MFP) operate normally,
- Center Tank Fuel Quantity Indication System operates normally,
- With center tank fueled, fuel quantity remaining in main tanks is adequate to reach a suitable airport if remaining center pump fails at any time,
- Appropriate zero fuel weight and center-of gravity adjustments are applied, and
- Appropriate performance adjustments are applied.

28-22-02 Center Tank Fuel Override/Jettison Pumps**28-22-02C**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Center Tank Fuel Override/Jettison Pumps are deactivated,
- Center Tank Fuel Quantity Indication System operates normally,
- Center tank fuel is considered unusable, and
- Appropriate zero fuel weight and center-of gravity adjustments are applied.

NOTE: AFM fuel loading and usage limitations apply.

28-22-02 Center Tank Fuel Override/Jettison Pumps**28-22-02-01 Switch PRESS Lights**

Interval	Installed	Required	Procedure
C	2	0	

28-22-02 Center Tank Fuel Override/Jettison Pumps**28-22-02-02 Switch ON Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-22-02.

The 777X engine fuel feed system architecture is the same as the 777-300ER. It provides the capability to feed engines from the main and center tank at the required flow and pressures for all flight conditions. The engine fuel feed system consists of new pumps, valves, and transport elements that deliver fuel from the fuel tanks to the engines.

The center tank contains two AC motor driven pumps with a higher output pressure than the main tank boost pumps. With all pumps available and ON, each center tank pump output pressure overrides the associated main tank pumps, thereby depleting the center tank fuel first.

When the center tank is loaded with fuel, the engines are fed from the center tank Override/Jettison (O/J) pumps that override the main tank boost pumps. The main tank boost pumps (two per tank) are always on and will begin feeding their respective engines after the center fuel tank O/J pumps are turned off.

777X Center pump protection to prevent dry running is the same as the 777-300ER with a wet-shutoff fuel level and an auto-shutoff feature that will shut down the pumps after 15 seconds of dry running or if there are ten low pressure transitions within a sixty second period. The center pump inlets have been staggered to help mitigate any undetected water or other gross contamination will only submerge one pump inlet during takeoff and flight. This helps to ensure that only one engine could be exposed to water contamination if it occurs.

PRESS Lights: Illuminated (amber) means associated fuel pump output pressure is low with the pump commanded on (illumination is inhibited when the center tank fuel pump switch is off).

A low pressure sensor for each pump is located on the electric motor side of the pump located outside of the fuel tank on the rear spar. If low pump output pressure is detected, the associated Advisory message will be displayed:

FUEL PUMP LOW CTR L
FUEL PUMP LOW CTR R
FUEL PUMP LOW L AFT
FUEL PUMP LOW L FWD
FUEL PUMP LOW R AFT
FUEL PUMP LOW R FWD

Low pressure detection also illuminates the amber PRESS light on each respective switch. On the main tank pump switches, these lights are active whether a switch is ON or OFF. If both boost pumps in a main tank are inoperative, the associated engine will operate on suction feed. If both main tank pump pressures are low, the FUEL PUMPS LOW L, R Caution message may be displayed. This message is inhibited by the FUEL PRESS LOW ENG L, R Caution message, to indicate that suction feed is occurring to that engine. On the center tank, the FUEL LOW CENTER Advisory message will be displayed when at the wet shutoff point and the flight crew is instructed to switch the center tank pumps OFF.

ON Lights: The fuel pump is commanded on.

Consequences of Failure

The FUEL PUMP CENTER L, R Status message will be displayed for a command/pressure disagreement or pump relay fault.

One Pump Inoperative: Associated pump is verified off (option 'A') or deactivated (option 'B'). The remaining O/J pump will continue to provide pressurized fuel flow to the engines.

Operation with one O/J pump deactivated (or off) may result in fuel imbalance between the main tanks. Override performance during maximum rate climb will be partially lost on the left side and lost on the right side for the entire climb profile. However, the total amount of fuel consumed from the main tanks will be small (50 gallons from the left tank and 190 gallons from the right tank). The difference in fuel consumed is predicted to remain significantly below the lateral balance limits.

Opening both crossfeed valves when the operative O/J pump is on mitigates the fuel imbalance. Relief is proposed for one flight provided pump switch remains off and pump pressure is verified to be low (same functional state as deactivated).

Two pumps inoperative - none. The center tank fuel is unusable and is considered "payload", not usable fuel. The payload limits are met by reducing the maximum zero fuel weight limit by the amount of center tank fuel and adjusting the zero fuel weight center of gravity forward limit based on the amount of center tank fuel. FUEL UNUSABLE CTR Caution and/or FUEL SCAVENGE FAULT Advisory message may be displayed.

PRESS Lights: Associated fuel pump state must be determined using FUEL PUMP ____ advisory message. Message remains operative.

ON Lights: The ON indication is visible in ambient light with the shutter open and the switch is flush with the surrounding panel.

Consequences of Next Critical Failure

For dispatch with one pump inoperative:

If fuel jettison is required from the center tank, the rate of jettison will be approximately half the normal jettison rate from the center tank.

Failure of the remaining O/J pump:

Failure of the remaining override/jettison pump will result in all of the remaining center tank fuel being trapped and unusable. The FUEL UNUSABLE CTR Caution and FUEL SCAVENGE FAULT Advisory messages will be displayed. Main tanks fuel quantity must be adequate to reach suitable airport (either destination or diversion).

In this scenario, all center tank fuel must be considered payload because normal fuel management and the certified structural wing bending analysis assume that all center tank fuel will be used before using any wing tank fuel. By considering the center tank fuel as payload and observing the MZFW limit, the assumptions of the certified wing bending structural analysis are still met. The center tank fuel must also be considered payload to ensure that CG limits will not be exceeded if center tank fuel is trapped.

Jettison of the center tank fuel will not be possible and may lead to a diversion and overweight landing. Center tank fuel considered as payload ensures that CG limits will not be exceeded in the event that fuel is jettisoned from the main fuel tanks.

In order to ensure that return-to-land performance, takeoff weight must be limited to the maximum climb limited landing weight at departure airport, plus the amount of fuel that would be burned during a return-to-land procedure.

For dispatch with both pumps inoperative:

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The requirement for center tank indication will alert crew to a check valve failure and the resultant unavailability of fuel in the center tank. If Jettison is attempted with an aircraft loaded near the forward CG limit, jettison may be inhibited and display the FUEL JETT SYS FAIL Caution message.

PRESS Lights: None.

ON Lights: None.

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28-22-03 Fuel Crossfeed Valves

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative Fuel Crossfeed Valve is deactivated closed, and
- Remaining Fuel Crossfeed Valve is verified to operate normally before each departure.

28-22-03 Fuel Crossfeed Valves**28-22-03-01 CROSSFEED Switch VALVE Lights**

Interval	Installed	Required	Procedure
C	2	0	

28-22-03 Fuel Crossfeed Valves**28-22-03-02 CROSSFEED Switch Bar (On) Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal for 28-22-03 based on 777 MMEL item 28-22-03.

Proposals for 28-22-03-01 and -02 are based on 787 MMEL items 28-22-03-01 and -02.

The crossfeed functionality remains unchanged relative to the 777-300ER, except for the relocation and design of the crossfeed valves themselves. The valves are relocated from the rear spar of the left wing to the rear spar of the center box in the wheel well similar to the 787 installation. The engine flow rate demand to the new 777-9 is lower relative to the 777-300 due to better engine fuel efficiency, but new pump designs will be used due to increase flow demands from the fuel scavenge system.

Valve: The engine tank fuel manifolds are connected together to allow any fuel tank pump to supply fuel to either or both engines. Dual crossfeed valves, each with its own switch, isolate the left fuel manifold from the right, and provide redundant capability. These valves are normally closed, thus isolating the left and right tank-to-engine fuel feed. Either valve may be independently controlled whenever it is necessary to feed an engine from the opposite main or center tank.

VALVE Lights: Illuminated (amber) means the crossfeed valve is not in the commanded position. (On (bar visible) means the crossfeed valve is commanded open.)

Dual crossfeed valves, each with its own switch, isolate the left fuel manifold from the right, and provide redundant capability. When a crossfeed valve switch is depressed (switched on) the valve is commanded open. When a crossfeed valve switch is switched off the valve is commanded closed. If valves are not in the commanded position the associated VALVE light illuminates. The EICAS display is the primary means of informing the flight crew that the valve is not in the commanded position (FUEL XFD FAULT AFT, FWD Advisory messages).

Consequences of Failure

Valve: A fuel crossfeed valve that is not in the commanded position will be indicated by the FUEL CROSSFEED AFT, FWD Status message and FUEL XFD FAULT AFT, FWD Advisory message. Fuel may be balanced or supplied to both engines by using the remaining crossfeed valve. Inoperative valve must be deactivated closed and operative valve must be verified to operate normally prior to each departure.

NOTE: AD 2019-19-10 requires an operational check of the fuel crossfeed valve prior to each extended operations (ETOPS) flight if one fuel crossfeed valve is inoperative. The FAA is issuing this AD to prevent an airplane from being dispatched on an ETOPS flight with a single fuel crossfeed valve due to MEL dispatch of a dual crossfeed valve equipped airplane with one crossfeed valve inoperative that cannot be opened or a fuel balancing system that cannot properly operate when activated. This condition could cause the fuel in the main tank associated with a failed engine to be unavailable to the remaining operative engine, potentially resulting in a forced off-airport landing due to exhaustion of the remaining usable fuel and consequent loss of all engine thrust.

VALVE Lights: None

Consequences of Next Critical Failure

Valve: If remaining valve fails closed the fuel balancing may not be accomplished. No consequence if remaining valve fails open. Operational test of remaining crossfeed valve prior to each departure ensures valve is operating normally.

VALVE Lights: A crossfeed valve not in the commanded position would be indicated to the crew by the FUEL XFD FAULT AFT, FWD Advisory message.

28-22-04 Fuel Scavenge Systems**28-22-04-01 Scavenge Pumps**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Center Tank Fuel Quantity Indication System operates normally,
- Appropriate amount of center tank fuel is considered unusable, and
- Appropriate zero fuel weight and center-of gravity adjustments are applied.

NOTE: AFM fuel loading and usage limitations apply.

28-22-04 Fuel Scavenge Systems**28-22-04-02 Scavenge Valves**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative Fuel Scavenge Valve(s) is deactivated closed,
- Center Tank Fuel Quantity Indication System operates normally,
- Appropriate amount of center tank fuel is considered unusable, and
- Appropriate zero fuel weight and center-of gravity adjustments are applied.

NOTE: AFM fuel loading and usage limitations apply.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 28-22-04.

The fuel scavenge system in the center tank on the 777-9 has been re-designed relative to the 777-300ER, and has similar architecture to the 787. Line sizing and pressures in the fuel scavenge system have been updated to minimize the effects of icing.

Two fuel scavenge ejector-jet pumps receive motive flow from the engine fuel feed manifold. Control of the scavenge system is by dedicated scavenge isolation valves. These motor operated ball valves have no direct control input from the pilot, but instead are controlled by ELMS software when the override/jettison (O/J) pumps are both off, the main fuel quantity is low enough, defuel valve is closed, jettison system is off, and at least one boost pump operating at pressure on the associated side. In addition to the isolation valves, the fuel scavenge jet pumps are each equipped with check valves on the motive and induce sides to prevent air ingestion during suction feed. The discharge check valve and the induce check valve prevent main tank fuel transfer into the center tank.

The center wing tank scavenge system automatically removes fuel remaining in the center wing tank that cannot be pumped out by the override/jettison pumps as well as any water/contamination that accumulates in the tank. Each pump transfers center tank fuel into the associated main tank. There are no flight deck indications for the scavenge pump operation and manual deactivation of pump is not possible without turning off both boost pumps on the same side.

Left or right center tank fuel pump switches ON and center tank fuel quantity less than 6,700 lbs in air, or less than 17,000 lbs on ground with the engine not running.

The FUEL LOW CENTER Advisory message will be displayed when either override/jettison fuel pump switches are ON and center tank fuel quantity is less than 6,700 lbs while in air. When this message is displayed in air, the flight crew procedurally shuts off the center tank override/jettison pumps, and the fuel scavenge pumps transfer the remainder of the center tank fuel to the main tanks once sufficient volume is available in the main tanks. The FUEL LOW CENTER Advisory message will also be displayed when the center tank fuel quantity is less than 17,000 lbs on ground with the engines not running. When this message is displayed on ground, the flight crew will turn off the override/jettison pumps. Once the airplane is in cruise, the FUEL IN CENTER Advisory message will be displayed if there is more than 8,200 lbs of fuel in the center tank. When this occurs, the flight crew will turn on the override/jettison pumps.

Consequences of Failure

Failure of a fuel scavenge isolation valve is indicated by the FUEL SCAVENGE VALVE L or R Status message. The FUEL SCAVENGE FAULT Advisory message will be displayed if both both isolation valves remain closed when ELMS has commanded them to open. The consequence of a failed scavenge pump is the same as the consequence for a failed scavenge valve.

Single scavenge system inoperative and center tank fuel used: Scavenge performance is degraded with only a single pump operating. Fuel transfer time will be increased. Fuel imbalance may occur.

For both scavenge system inoperative and center tank fuel used: Remaining center tank fuel will not transfer once both center tank override/jettison pumps are off. The FUEL SCAVENGE FAULT Advisory message may be displayed.

Center tank fuel quantity indication must operate normally. An appropriate amount of center tank fuel must be considered unusable. Potentially unusable center tank fuel must be accounted for in the airplane weight and balance

For both scavenge pumps inoperative and center tank empty, usable fuel is reduced by a negligible amount (400 lb or less).

Consequences of Next Critical Failure

None.

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28-22-05 Fuel Main Tank Overfill

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be dispatched with FUEL MAIN TANK OVERFILL Status message displayed provided center fuel tank remains empty.

SUBSTANTIATION**Background**

New proposal for 777X.

The 777X engine fuel feed system architecture is the same as the 777-300ER. The engine fuel feed system consists of pumps, valves, and transport elements that provide the capability to feed fuel the engines from the main tanks and center tank at the required flow and pressures for all flight conditions.

When the center tank is loaded with fuel, the engines are fed from the center tank Override/Jettison (O/J) pumps that override the main tank boost pumps. The main tank boost pumps (two per tank) are always on and will begin feeding their respective engines after the center fuel tank O/J pumps are turned off.

Failure of fuel system elements that provide isolation between the center and main tanks could result in uncommanded fuel transfer from the center tank to one or both main tanks. Overfill of either main tank could potentially result in a fuel spill overboard. If failures occur resulting in uncommanded fuel transfer, the fuel system may inhibit fuel pumps while on ground.

If uncommanded fuel transfer is detected in the air, the pumps will not be inhibited.

Due to the higher performance of the O/J pumps, uncommanded fuel transfer from the center tank will result in the center O/J pumps being inhibited after an overfill condition is detected for 2 minutes.

Uncommanded fuel transfer from the center tank will result in the main tank boost pumps being inhibited after an overfill condition is detected for 30 minutes when the same side engine is shutdown.

Consequences of Failure

When any pump is inhibited due to detection of an uncommanded fuel transfer, the FUEL MAIN OVERFILL Advisory and FUEL MAIN TANK OVERFILL Status messages are displayed. Additionally, the associated pump Status and Caution messages will be displayed.

If uncommanded fuel transfer is detected in the air, the pumps will not be inhibited but FUEL MAIN OVERFILL Advisory message will be displayed and the flight crew will accomplish the Non-Normal Checklist.

Consequences of Next Critical Failure

For on-ground operation, if fuel were to remain in the center tank, an additional failure of the pump inhibit function could result in overfill of one or both main fuel tanks resulting in a fuel spill. A fuel spill on-ground is classified as 'Hazardous'.

For in-air operation, if fuel were to remain in the center tank, fuel could spill overboard resulting in potential significant fuel loss and possible diversion ('Major').

For dispatch, the airplane is required to operate with the center fuel tank empty. Operating with the center tank empty will mitigate potential next critical failures.

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28-25-01 APU DC Fuel Pump

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided APU DC fuel pump is deactivated.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 28-25-01.

A DC motor driven fuel pump, located within the center tank space but with a pump inlet in the left main tank, draws fuel from the left main tank for the APU. The APU fuel pump has no dedicated controls or displays for the flight crew. After selecting the airplane battery ON and selecting the APU to START the APU fuel valve opens and pressurized fuel is supplied to the APU from the APU DC fuel pump. This pump will continue to operate until AC power is available and one of the AC pumps is providing pressurized fuel feed to the APU, or the APU is shutdown. The DC pump will also run anytime the APU is running and the left main tank boost pumps and left override/jettison pump are either off or inoperative (assuming crossfeed valves are closed). When AC power is available, the left main tank forward boost pump operates automatically and supplies pressurized fuel to the APU.

Consequences of Failure

The FUEL PUMP APU Status message will be displayed when the fuel pump pressure is low when commanded on, fuel pump pressure is high when commanded off, or the relays controlling the pump indicate a fault.

APU DC fuel pump is not available. Fuel can be provided to the APU with AC Power. APU can also be started on suction feed.

Consequences of Next Critical Failure

None.

28-25-02 APU Fuel Shutoff Valve

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU fuel shutoff valve is deactivated closed,
- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU selector remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-25-02.

The APU fuel feed functionality is similar to the 777-300ER, in that the APU fuel feed system consists of portions of the engine feed manifold connected to a dedicated APU fuel feed manifold. On the 777-9, the APU isolation valves will be removed due to elimination of wide cut fuels such as JP-4. The APU pump, isolation check valve, and shutoff valve are new parts to the 777-9.

The APU selector switch, on the P5 overhead panel, sends a signal to ELMS to command the APU fuel shutoff valve (FSOV) to open. The APU fire switch, on the P5 panel, must be down to allow the power to go to the APU FSOV. The APU fire switch also has a direct circuit to the FSOV. This closes the valve when the fire switch is pulled. The APU fire shutdown switch, on the P40 panel on the Nose Landing Gear (NLG) strut, sends a signal to close the FSOV. The hot battery bus (ELMS) or the FSOV battery supply power to open or close the APU FSOV.

The APU FSOV is mounted on the forward face of the rear spar of the left center tank above and inboard of the DC pump. The valve actuator is mounted on the aft face of the rear spar, in the left MLG bay.

The APU Fuel Shutoff Valve (FSOV) opens to allow fuel to flow to the APU. Fuel comes from the left engine feed manifold, or from the DC pump. The APU FSOV is a motor operated valve (MOV) actuated by a 28V DC motor actuator.

The Electrical Load Management System (ELMS) uses inputs from the Auxiliary Power Unit Controller (APUC) and the APU selector to automatically control the APU FSOV.

The ELMS sends a valve open command when the APU is running or the APU selector is in the ON or START position.

The ELMS sends a valve close command when the APU is not running, the APU fire switch closes, the APU fire shutdown switch closes, or for an APU fire. The APU running signal comes from the APUC.

Consequences of Failure

The FUEL VALVE APU Status message and FUEL APU VLV FAULT Advisory message will be indicated when the APU fuel shutoff valve is not in the commanded position. The APU shutoff valve must be deactivated closed and the APU must be considered inoperative.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

None.

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Defuel Valve

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided defuel valve is secured closed.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 28-26-01.

The Refuel/Defuel system architecture remains unchanged relative to the 777-300ER. As with the current 777-300ER, the 777-9 has a refuel station on both wings each having two refuel adapters (four total) to the baseline configuration. The primary refuel shutoff valves and defuel valve have been changed from the 777-300ER configuration to the ball valve design used on the 787. The defuel operation works the same as it does on the 777-300ER.

The defuel system moves fuel from the airplane tanks to the refuel station. It also moves fuel from one airplane tank into another (tank-to-tank transfer). Defueling can be done either using the airplane fuel pumps (pressure-defuel) or ground pumps (suction-defuel).

To move fuel to the refuel station, the defuel valve must be opened. To remove fuel from the left main tank, one or both of the crossfeed valves must be opened in the engine feed manifold, which will let fuel flow to the defuel valve. The defuel valve provides a connection between the engine feed manifold and the refuel/jettison manifold, so that fuel can be removed from the fuel tanks.

The defuel valve and refuel valves are operated by the switches on the Refuel Control and Indication Panel (RCIP). The Electrical Load Management System (ELMS) supplies the power to open and close the valves. The defuel valve switch sends a signal to the ELMS to open and close the defuel valve. The refuel valve switches send valve position signals to the Fuel Quantity Processor Unit (FQPU). The FQPU commands the ELMS to open and close the refuel valves. The refuel and defuel valve position lights on the RCIP are on when the valves are open. The FQPU supplies fuel quantity data to the RCIP displays. It also supplies fuel quantity data to the flight deck displays, through the Common Core System (CCS). The fuel pumps and the crossfeed valves are operated by switches on the P5 panel on the flight deck.

The defuel valve is a remote Motor Operated Valve (MOV). The defuel valve is in the right side of the center tank on the inboard side of rib 6. Access to the defuel valve is through the third fuel tank access door in the lower surface of the right wing. The defuel valve actuator is on the rear spar in the right Main Landing Gear (MLG) wheel well.

Consequences of Failure

The DEFUEL ISOLATION VALVE Status message will be indicated when the defuel valve is not in the commanded position. For dispatch, the defuel valve must be deactivated closed.

Consequences of Next Critical Failure

None.

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28-31-01 Fuel Jettison System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both Center Tank Jettison Isolation Valves are deactivated closed,
- Both Main Tank Jettison Pumps are deactivated,
- Both Fuel Jettison Nozzle Valves are locked closed, and
- Appropriate performance adjustments are applied.

28-31-01 Fuel Jettison System

28-31-01-01 ARM Switch FAULT Light

Interval	Installed	Required	Procedure
C	1	0	

28-31-01 Fuel Jettison System

28-31-01-02 ARM Switch ARMED Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal for 28-31-01 is based on 777 MMEL item 28-31-01-01.

Proposals for 28-31-01-01 and -02 are based on 787 MMEL items 28-31-01-01 and -02.

The fuel jettison system moves fuel overboard to decrease airplane Gross Weight to prevent an overweight landing. The fuel jettison system is operated from the fuel panel on the P5 overhead panel. The Electrical Load Management System (ELMS) controls the fuel jettison system.

The jettison system uses the center override/jettison (OJ) pumps that are connected to the refuel manifold through two jettison isolation valves and two dedicated main tank jettison pumps that are connected directly to the refuel manifold. Fuel is jettisoned overboard through two jettison nozzles, one located on the trailing edge of each wing. The nozzles are isolated from the refuel manifold by the jettison nozzle valves.

Fuel can be jettisoned from the center tank or the main tanks, or from all tanks at the same time. The sequencing of the three jettison configurations is based on fuel loading and system state and is controlled automatically through the Electrical Load Management System (ELMS).

The jettison system is operated with the airplane in the air by pushing the arm switch on the P5 fuel panel. The arm switch sends a signal to the ELMS. The jettison system has two operating modes: Maximum Landing Weight (MLW) mode and MANUAL mode.

When the Fuel To Remain (FTR) rotary selector is pushed in, and the jettison system is armed, it is in the MLW mode. The CCS sends the FTR value to the ELMS. The Fuel Quantity Processor Unit (FQPU) sends the actual fuel quantity to the ELMS. The ELMS uses the FTR value and the actual fuel quantity to calculate the Time Until Jettison Complete (TUJC). The quantity of FTR in the airplane shows on the EICAS display.

When the FTR rotary selector is pulled out, and the jettison system is armed, it is in the MANUAL mode. Turning the FTR selector to the left decreases the FTR quantity. Turning the FTR selector to the right increases the FTR quantity. If the FTR rotary selector is pushed back in, it will reset the FTR to the MLW. In the air, operation of the jettison nozzle valve switches signals the ELMS to command the nozzle valves to open. Each switch also signals the ELMS to command the isolation valves to open and the fuel jettison pumps to start. The center tank pump switches command the OJ pumps to start.

Fuel jettison can cause the airplane Center of Gravity (CG) to be forward of the CG limit. If the ELMS calculates that this will happen, it stops the main tank jettison pumps until the CG will remain within limits. On the ground, the arm switch causes the ELMS to open the two jettison isolation valves and start the fuel jettison pumps.

To ensure the minimum amount of fuel required to safely operate remains on the airplane in all jettison modes, the dedicated main tank jettison pump inlets are physically located such that jettison will automatically stop before reaching that minimum amount of fuel.

ARMED Light: Indicates the fuel jettison system is armed, and the fuel-to-remain is set to the maximum landing weight (MLW) quantity.

FAULT Light: Illuminated (amber) means a fuel jettison system fault has occurred and the fuel jettison system is inoperative.

The fuel jettison system functionality remains unchanged relative to the 777-300ER. The system is comprised of new jettison pumps and isolation valves. Jettison nozzle valves are the same as those used on 787.

Consequences of Failure

Failure of the fuel jettison system is indicated by the FUEL JETTISON SYS Status message.

Fuel jettison system: For dispatch, fuel jettison system must be deactivated. Takeoff weight must be limited to maximum climb limited weight plus return to land weight.

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ARMED Light: The switch depressed in provides confirmation that switch is in the armed position. Also, when jettison is armed the fuel TO REMAIN MLW or MANUAL replaces the FUEL TEMP on the EICAS display.

FAULT Light: The FUEL JETT SYS FAIL Caution message remains operative and provides the primary indication for jettison system faults.

Consequences of Next Critical Failure

None. Limiting the maximum takeoff weight to the maximum landing climb limit weight plus 15 minutes of fuel burn will ensure that 14 CFR 25.1001 requirements are met.

ARMED Light: None.

FAULT Light: None.

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28-31-02 Center Tank Jettison Isolation Valves**28-31-02A**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative Center Tank Jettison Isolation Valve(s) is locked closed,
 - Both Center Tank Jettison Isolation Valves are deactivated,
 - Both Main Tank Jettison Pumps are deactivated,
 - Both Fuel Jettison Nozzle Valves are secured closed, and
 - Appropriate performance adjustments are applied.
-

28-31-02 Center Tank Jettison Isolation Valves**28-31-02B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative center tank jettison isolation valve(s) is locked closed, and
 - Appropriate gross weight and center-of-gravity adjustments are applied.
-

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 28-31-02-02.

The fuel jettison system moves fuel overboard to decrease airplane Gross Weight to prevent an overweight landing. The fuel jettison system is operated from the fuel panel on the P5 overhead panel. The Electrical Load Management System (ELMS) controls the fuel jettison system.

The jettison system uses the center override/jettison (OJ) pumps that are connected to the refuel manifold through two jettison isolation valves and two dedicated main tank jettison pumps that are connected directly to the refuel manifold. Fuel is jettisoned overboard through two jettison nozzles, one located on the trailing edge of each wing. The nozzles are isolated from the refuel manifold by the jettison nozzle valves.

There is one fuel jettison isolation valve in each side of the center tank. The valves are remote Motor Operated Valve (MOV)s. The valve actuators are on the rear spar just outboard from the fuselage.

The fuel jettison isolation valves open during fuel jettison from the center tank. Fuel passes from the Override/Jettison (OJ) pumps, through the jettison isolation valves, to the refuel/jettison manifold.

The fuel jettison system functionality remains unchanged relative to the 777-300ER. The system is comprised of new jettison pumps and isolation valves. Jettison nozzle valves are the same as those used on 787.

Consequences of Failure

Failure of a center tank jettison isolation valve is indicated by the JETT ISLN VALVE L or R Status message.

Single isolation valve inoperative: Degraded performance of the center tank jettison system resulting in a slower fuel offload rate.

Both isolation valves inoperative: center tank must remain empty, or the jettison system must be deactivated, or weight and balance must account for the center tank jettison inoperative and subsequent main tank jettison.

Consequences of Next Critical Failure

Jettison is required:

Center tank empty: None

Jettison system deactivated: None. Limiting the maximum takeoff weight to the maximum landing climb limit weight plus 15 minutes of fuel burn will ensure that 14 CFR 25.1001 requirements are met.

Single isolation valve inoperative: Center tank jettison will occur, but will require longer time.

Both isolation valves inoperative, fuel in center tank, and jettison system operative: weight and balance has accounted for the inoperative center tank jettison system and a subsequent main tank jettison.

28-31-03**Main Tank Jettison Pumps**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both main tank jettison pumps are deactivated, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-31-03-01.

The fuel jettison system moves fuel overboard to decrease airplane Gross Weight to prevent an overweight landing. The fuel jettison system is operated from the fuel panel on the P5 overhead panel. The Electrical Load Management System (ELMS) controls the fuel jettison system.

The jettison system uses the center override/jettison (OJ) pumps that are connected to the refuel manifold through two jettison isolation valves and two dedicated main tank jettison pumps that are connected directly to the refuel manifold. Fuel is jettisoned overboard through two jettison nozzles, one located on the trailing edge of each wing. The nozzles are isolated from the refuel manifold by the jettison nozzle valves.

There is one main tank fuel jettison pump in each main tank. They are on the rear spar, forward of the flaperons. The jettison pumps are centrifugal pumps driven by an induction motor. The pumps supply fuel from the main tanks to the refuel/jettison manifold during fuel jettison.

The fuel jettison system functionality remains unchanged relative to the 777-300ER. The system is comprised of new jettison pumps and isolation valves. Jettison nozzle valves are the same as those used on 787.

Consequences of Failure

Failure of a main tank jettison pump is indicated by the FUEL JETT PUMP L or R Status message.

Main tank fuel cannot be jettisoned. If jettison is attempted during flight, the FUEL JETT MAIN FAIL Advisory message will be displayed. Weight and balance has accounted for the inoperative main tank jettison.

For dispatch, both main tank jettison pump must be deactivated. Takeoff weight must be limited to maximum climb limited weight plus center tank fuel weight plus return-to-land fuel weight. Center tank fuel is assumed to be jettisoned during return-to-land procedure.

Consequences of Next Critical Failure

None.

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28-31-04 Fuel Jettison Nozzle Valves**28-31-04A**

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Fuel Jettison Nozzle Valve is verified closed,
 - Associated FUEL JETTISON NOZZLE switch remains off, and
 - Repairs are made within one flight.
-

28-31-04 Fuel Jettison Nozzle Valves**28-31-04B**

Interval	Installed	Required	Procedure
C	2	1	(M)

One Fuel Jettison Nozzle Valve may be inoperative provided it is locked closed.

28-31-04 Fuel Jettison Nozzle Valves**28-31-04C**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Both Center Tank Jettison Isolation Valves are deactivated closed,
 - Both Main Tank Jettison Pumps are deactivated,
 - Both Fuel Jettison Nozzle Valves are locked closed, and
 - Appropriate performance adjustments are applied.
-

28-31-04 Fuel Jettison Nozzle Valves**28-31-04-01 NOZZLE Switch VALVE Lights**

Interval	Installed	Required	Procedure
C	2	0	

28-31-04 Fuel Jettison Nozzle Valves**28-31-04-02 NOZZLE Switch ON Lights**

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal for 28-31-04 based on 777 MMEL item 28-31-04-01.

The fuel jettison system moves fuel overboard to decrease airplane Gross Weight to prevent an overweight landing. The fuel jettison system is operated from the fuel panel on the P5 overhead panel. The Electrical Load Management System (ELMS) controls the fuel jettison system.

The jettison system uses the center override/jettison (OJ) pumps that are connected to the refuel manifold through two jettison isolation valves and two dedicated main tank jettison pumps that are connected directly to the refuel manifold. Fuel is jettisoned overboard through two jettison nozzles, one located on the trailing edge of each wing. The nozzles are isolated from the refuel manifold by the jettison nozzle valves.

In the air, the nozzle valves let fuel in the refuel/jettison manifold go overboard. Operation of the jettison nozzle valve switches signals the ELMS to command the nozzle valves to open. Each switch also signals the ELMS to command the isolation valves to open and the fuel jettison pumps to start. The center tank pump switches command the OJ pumps to start.

There is one jettison nozzle valve near each end of the refuel/jettison manifold, near the trailing edge of each wing just before the jettison nozzles. The fuel jettison nozzle valves are Motor Operated Valve (MOV)s.

The fuel jettison system functionality remains unchanged relative to the 777-300ER. The system is comprised of new jettison pumps and isolation valves. Jettison nozzle valves are the same as those used on 787.

VALVE Lights: Illuminated (amber) means the jettison nozzle valve is not in the commanded position.

ON Lights: ON in flight, with the FUEL JETTISON ARM switch in ARMED, and the total fuel quantity is greater than the fuel-to-remain, the center tank fuel jettison isolation valves, the main tank jettison pumps, and the fuel jettison nozzle valves are commanded by the fuel jettison system to jettison fuel. When both CENTER PUMPS switches are off, fuel will not be jettisoned from the center tank.

Consequences of Failure

A fuel jettison nozzle valve that is not in the commanded position is indicated by the FUEL JETT NOZZLE L or FUEL JETT NOZZLE R Status messages and JETT NOZZLE FAULT L or JETT NOZZLE FAULT R Advisory messages.

One nozzle valve inoperative: Inoperative nozzle valve verified closed. Valve remains commanded closed (switch remains off). Main tank refuel valves must not be inoperative open (this dispatch option has been deleted). Fuel can be jettisoned from the operative nozzle. Jettison performance will be degraded and fuel imbalance may occur resulting in the FUEL IMBALANCE Advisory message.

One nozzle valve inoperative: There is no consequence for normal operations. Inoperative nozzle valve is secured closed. Fuel can be jettisoned from the operative nozzle.

Both nozzle valves inoperative: Both nozzle valves are deactivated and secured closed. The fuel jettison system is deactivated. Jettison system is inoperative and fuel cannot be jettisoned. Takeoff weight is limited to climb limited landing weight plus fuel burned during return-to-land procedure.

VALVE Lights: The JETT NOZZLE FAULT L, R Advisory remains operative.

ON Lights: The ON indication will be visible with ambient light and the switches shutter open and switch will be flush with surrounding panel.

Consequences of Next Critical Failure

For dispatch with one valve closed:

In the event that fuel jettison is required, fuel jettison performance will be degraded and fuel imbalance may occur resulting in the FUEL IMBALANCE Advisory message. Insufficient jettison performance by itself results in a slight reduction in safety margin. In combinations with failures of other systems could result in inability to make single engine go-around climb gradient, wet runway stopping distance, or landing speed limit. Insufficient jettison performance is considered a 'Minor' hazard.

Failure of a center tank override/jettison pump or center tank jettison isolation valve will also result in degraded jettison performance.

Failure of the remaining jettison nozzle valve results in loss of the jettison system. The FUEL JETT SYS FAIL Caution message will be displayed.

The loss of jettison capability represents a hazard only when the airplane is required to jettison fuel. Though the jettison system is the primary means to mitigate an overweight landing, the airplane is designed with multiple features to allow for landing above max landing weight, primarily through alternate flight control surface settings. Failure of the jettison system does not result in a hazardous condition for a return-to-land scenario considering normal and non-normal airplane configurations. Therefore, an inability to jettison represents a slight reduction in safety margins and is considered a 'Minor' hazard.

For dispatch with both valves closed:

There is no consequence. Limiting the maximum takeoff weight to the maximum landing climb limit weight plus 15 minutes of fuel burn will ensure that 14 CFR 25.1001 requirements are met.

VALVE Lights: None.

ON Lights: None.

28-40-01 Fuel Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided individual fuel quantity indications required for dispatch operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-40-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays, for example individual fuel quantities are available on the Fuel Quantity Maintenance Display pages. Individual fuel quantities are also available on the EICAS expanded fuel indications display, such as when a fuel imbalance occurs or when fuel quantity is low.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

Federal Aviation Administration (FAA)**ATA 28****777-9 Master Minimum Equipment List****Section 2****28-41-01 Fuel Quantity Indication Systems****28-41-01-01 Center Tank****28-41-01-01A**

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Fuel quantity in center tank is verified by an alternate procedure,
 - Both main tank fuel quantity indication systems operate normally,
 - Both center tank fuel override/jettison pumps operate normally,
 - Both fuel flow indications operate normally,
 - Both fuel scavenge systems operate normally,
 - FMC FUEL is initialized with the known total fuel quantity before each departure, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

28-41-01 Fuel Quantity Indication Systems**28-41-01-01 Center Tank****28-41-01-01B**

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Both main tank fuel quantity indication systems operate normally,
 - Both fuel flow indications operate normally,
 - Center fuel tank remains empty, and
 - FMC FUEL is initialized with the known total fuel quantity before each departure.
-

28-41-01 Fuel Quantity Indication Systems**28-41-01-02 Main Tanks**

Interval	Installed	Required	Procedure
B	2	1	(M) (O)

One may be inoperative provided:

- Fuel quantity in associated tank is verified by an alternate procedure,

- b. Both fuel pumps for the associated main tank operate normally,
- c. Center tank fuel quantity indication operates normally,
- d. Both fuel flow indications operate normally,
- e. FMC FUEL is initialized with the known total fuel quantity before each departure, and
- f. Flight remains within 180 minutes of landing at a suitable airport.

NOTE: AFM fuel loading and usage limitations apply.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 28-41-01.

A new fuel quantity indicating system (FQIS) architecture and technology will be used on the 777X. New optical based sensors will be used in-tank and connected to optical fuel quantity data concentrators (FQDC) for each tank. A new fuel quantity processor unit (FQPU) similar to the 777-300ER will continue to be the interface with the airplane and remains in control of refueling, but will have added logic for refuel overfill shutoff protection, secondary gauging to replace the mechanical measuring sticks, and additional nitrogen enriched air distribution system (NEADS) logic to prevent tank overpressure.

The fuel quantity indicating system (FQIS) measures individual tank and total fuel mass for display in the flight deck and refuel control and indication panel (RCIP). The FQIS architecture and functionality is much different than the 777-300ER. Fuel volume remains determined from capacitance based fuel height sensors, but the 777-9 will incorporate new fiber optic wiring technology in the tank for powering and communicating data from the sensors. FQIS will also provide the following functionality:

- Fuel temperature monitoring for each tank
- Automatic refuel control (Total Fuel Load Select)
- Manual refuel/defuel capability similar to the 777-300ER
- Fuel quantity uplift similar to the 777-300ER
- Fuel high level shutoff (Overfill protection) similar to the 787
- Secondary gauging while on the ground similar to the 787
- FQIS health monitoring
- Tank overpressure protection for the flammability reduction system (FRS)

The system will have sensors for the determination of fuel height, density, dielectric, and temperature. The arrangement of optical capacitance probes (OCP) provides the measurement data necessary for the primary gauging function to meet accuracy requirements with no system failures and meet degraded accuracy requirements with any single OCP failed. The FQIS also has a secondary gauging function while on the ground which calculates a secondary fuel quantity independent of the primary gauging function. The primary tank fuel quantities and total fuel quantities will be displayed on the flight deck and RCIP. Secondary tank fuel quantities are used during ground operations when there is a discrepancy between the primary fuel gauge and the fuel truck. If either of the two independent fuel quantities is not available for a tank, the available fuel quantity will be used to generate total fuel quantity. Similar to prior FQIS systems, if there are multiple failures resulting in unknown accuracy for a tank, the fuel quantity information for that tank and total fuel will be blanked (unavailable in the flight deck or RCIP).

There will be one FQDC per tank (left main tank, center tank, and right main tank). The center tank FQDC will have fuel quantity gauging sensors in both airplane sections 11 and 12 to account for the cheek area of the center tank. Each FQDC will be dual channel, fault tolerant, and will provide the interface between in-tank sensors and the FQPU. There is no single failure mode in which the FQDC will lose the sensor data for an entire channel.

The FQPU will be located in the E5-3 equipment rack, aft of the forward cargo door, and will communicate with the left and right ARINC 629 systems buses. The FQPU will transmit individual and total fuel weights to the EICAS system through these busses. It will also interface with each of the FQDCs and the RCIP via dual redundant CAN bus.

The FQPU uses a fuel height sensor's capacitance reading along with the dielectric of the fuel to determine the fuel height at each sensor. Stored lookup tables are used to convert a fuel height to a fuel volume. These lookup tables account for the attitude of the airplane, the wing deflection, and the tank geometry. The FQPU can calculate fuel volume using a minimum of one sensor. When multiple sensors are active (not dry or fully covered), the average calculated volume from each sensor's fuel height will be used to determine the volume. In the air all sensors will be used for primary gauging, and on the ground at least one sensor will be used for primary gauging and at least one sensor will be used for secondary gauging. Since there can be fuel un-leveling across baffle ribs in the fuel tanks, the tanks have been divided into cells so that a separate volume can be calculated for each side of a baffle rib. The volume of each cell is summed to obtain the tank fuel volume. The tank volumes are used with the determined tank density to calculate each tank's fuel mass and the total fuel mass.

Each fuel tank has an associated quantity indication. The summation of the three fuel tanks is displayed on EICAS full time, and the same signal is shown on flight management computer (FMC) PROGRESS page. The individual fuel tank quantities are displayed on EICAS for any of the following conditions: crossfeed valve open; one or more fuel tank quantity indications inoperative; the FUEL IN CENTER alert message displayed (center tank quantity is amber); the FUEL QTY LOW alert message is displayed (low main tank quantity is amber); the FUEL LOW CENTER Advisory message is displayed (low center tank quantity is amber); the FUEL IMBALANCE Advisory message is displayed; the FUEL SCAVENGE FAULT Advisory message is displayed; the FUEL UNUSABLE CTR Caution message is displayed; the INSUFFICIENT FUEL Advisory message is displayed; the FUEL FLOW HI ENG L or FUEL FLOW HI ENG R Advisory message is displayed; the airplane is on the ground and both engines off.

Consequences of Failure

Associated fuel tank indication, total fuel indication (on EICAS and FMC PROGRESS page) are inoperative. This condition is indicated by the FUEL QTY INDICATION Status message.

For dispatch, the flight crew must manually enter the total fuel quantity on the FMC PERF INIT page. The inoperative fuel tank quantity must be determined by the fuel used (FMC calculated fuel) and the other fuel tank quantity indications.

Center tank FQIS inoperative: For dispatch, the following must operate normally; main tank fuel quantity indication systems, both center tank override/jettison pumps, both fuel flow indications, and fuel scavenge system. The FUEL QTY DISAGREE Advisory, FUEL LOW CENTER Advisory and FUEL IN CENTER Advisory messages will be inoperative.

Center tank FQIS inoperative, center tank empty: For dispatch, the following must operate normally; main tank fuel quantity indication systems and both fuel flow indications. The FUEL QTY DISAGREE Advisory, FUEL LOW CENTER Advisory and FUEL IN CENTER Advisory messages will be inoperative.

Main tank FQIS inoperative: For dispatch, the following must operate normally; center tank fuel quantity indication system, both associated main tank fuel pumps, and both fuel flow indications. The MMEL dispatch condition without FQIS indication from a main fuel tank will result in the integrated flight control electronics using a default value in the roll control laws (due to the roll inertia, I_{xx} , estimator function declaring itself invalid shortly after takeoff). This configuration results in modest changes to roll axis handling characteristics that will be shown by analysis to be acceptable. The FUEL QTY DISAGREE and FUEL IMBALANCE Advisory messages will be inoperative. The FUEL QTY LOW Caution message for the associated tank will be inoperative.

For main tank FQIS inoperative, the Fuel Main Tank Overfill protection function will be degraded.

Degraded or Loss of NEA flow to fuel tanks, increased fuel tank flammability exposure: When fuel qty indication is lost for the center tank, the left and right NEADS valves will be commanded closed and the OPP protection will limit NEA flow to super low flow mode, resulting in no inerting to the main tanks and degraded inerting performance in the center tank. When the fuel quantity indication is lost for either of the main tanks, the NGS will be commanded into an unlatched shutdown, resulting in no inerting of any fuel tanks. There are no additional status messages set in these scenarios (NITROGEN GEN SYS and NITROGEN GEN PERF will NOT be annunciated), however all FRS fault monitoring and NGS override shutdown functionality will remain, and any additional failures of the FRS (i.e. NGS or NEADS) will be annunciated with the appropriate status message. It is not required for the NGS system to be considered inoperative.

Consequences of Next Critical Failure

Fuel imbalance must be determined and corrected by using the fuel used (FMC calculated fuel) and the other two fuel tank quantity indications. Crossfeed valves are available to correct a fuel imbalance.

Fuel leak resulting is a very large fuel imbalance.

Loss of or erroneous FMC calculated fuel due to an erroneous flowmeter or corrupted FMC display, which would cause inability to determine total fuel qty. Loss of a fuel qty indication for a second tank, which could prevent determination of fuel imbalance even with the alternate procedure described.

Additional failures may result in loss of the Fuel Main Tank Overfill protective function.

28-41-02

Fuel Quantity Processor Unit (FQPU) Channels

Interval	Installed	Required	Procedure
B	2	1	

May be dispatched with FUEL QTY FQPU CHANNEL Status message displayed provided:

- Center Tank Fuel Quantity Indication System operates normally,
- Both Main Tank Fuel Quantity Indication Systems operate normally,
- Center Tank Fuel Temperature Indicating System operates normally,
- Both Main Tank Fuel Temperature Indicating Systems operate normally,
- Both Fuel Flow Indications operate normally, and
- Nitrogen Generation System (NGS) is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 28-41-02.

The Fuel Quantity Processor Unit (FQPU) is a fuel control unit that calculates the fuel quantity contained in the fuel tanks. The FQPU gets in-tank sensor data from the Optical Fuel Quantity Data Concentrator (OFQDC)s, calculates fuel quantities, and sends signals to the flight deck through via ARINC 629.

The FQPU is connected to two isolated 28 V DC power sources simultaneously and will operate when one or both of the power sources provides electrical power. The FQPU is responsible for most Fuel Indicating System (FIS) functions. The FQPU collects tank data from the OFQDCs and processes this data through two identical channels. Both channels calculate and transmit identical sets of data to the airplane, with the exception of refuel valve data, which is divided between the FQPU channels. This data contains the characteristics and quantities of the fuel for each tank and for the airplane. The FQPU also sends data to provide controls and information for these systems:

- Automatic refuel control (fuel load select)
- Calculates the fuel weight for each tank
- Calculates the total fuel weight
- Fuel high level shutoff (overfill protection)
- Fuel Quantity Indicating System (FQIS) health monitoring
- Fuel quantity uplift
- Fuel temperature monitoring for each tank
- Manual refuel/defuel capability
- Monitors the FQIS for faults
- Shows the weights on the Integrated Refuel Panel (IRP) indicators.

Consequences of Failure

The FUEL QTY FQPU CHANNEL Status message will be displayed when an FQPU channel failure has been detected.

For FQPU Channel B inoperative, loss of redundancy for gauging purposes; nitrogen generation system will be shut down, however, the NITROGEN GEN SYS or NITROGEN GEN PERF Status message will not be displayed.

For FQPU channel A inoperative, loss of redundancy for gauging purposes; nitrogen generation system will shut down and set the NITROGEN GEN PERF Status message. Indication of additional FRS failures will be inoperative.

For dispatch, the Nitrogen Generation System (NGS) is considered inoperative. Application of the NGS MMEL will lock the NGS shutoff valve (SOV) closed. All flight deck fuel quantity and fuel temperature indications must operate normally.

Consequences of Next Critical Failure

If remaining channel fails, all fuel quantity indications, fuel temperature indication, and other fuel quantity functions will be lost. FMC would continue to provide calculated fuel for the flight.

The Fuel Main Tank Overfill protective function will be inoperative. The FUEL SCAVENGE FAULT Advisory message will be displayed when the left and right main tank quantity indication is lost. The FUEL TEMP HIGH Caution message will be inoperative. The FUEL TEMP LOW Advisory message will be displayed based on Total Air Temperature (TAT) and will trigger at -37°C or the programmed fuel freeze point, whichever is warmer.

Loss of fuel tank inerting is classified as 'Minor'. The 777-9 is designed to be compliant to the Flammability Reduction System reliability requirements of Appendix M25.1(a)(2), as well as 25.981(a) and 25.954. The existence of non-lightning related ignition sources in the fuel tank is extremely improbable, and the probability of catastrophic fuel vapor ignition due to lightning is also extremely improbable, taking into account flammability, critical lightning strikes, and failures within the fuel system.

28-41-03 Fuel Quantity Data Concentrator (FQDC) Channels
28-41-03-01 Center Tank

Interval	Installed	Required	Procedure
C	2	1	

One channel may be inoperative.

28-41-03 Fuel Quantity Data Concentrator (FQDC) Channels
28-41-03-02 Left Main Tank

Interval	Installed	Required	Procedure
C	2	1	

One channel may be inoperative.

28-41-03 Fuel Quantity Data Concentrator (FQDC) Channels
28-41-03-03 Right Main Tank

Interval	Installed	Required	Procedure
C	2	1	

One channel may be inoperative.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 28-41-02.

There is one Optical Fuel Quantity Data Concentrator (OFQDC) in each fuel tank (left main tank, center tank, and right main tank). Each OFQDC provides the interface between in-tank sensors and the Fuel Quantity Processor Unit (FQPU). The center OFQDC is connected to the fuel quantity gauging sensors in the left and right wing main fuel tanks.

Each OFQDC has dual-channel functionality and fault-tolerant capability. Each OFQDC is also the interface between the in-tank fuel sensors and the FQPU. The data collected from each individual fuel sensor is transmitted along both OFQDC channels to the FQPU.

Consequences of Failure

An inoperative OFQDC channel is indicated by any of the following Status messages:

FUEL QTY FQDC CHANNEL C

FUEL QTY FQDC CHANNEL L
FUEL QTY FQDC CHANNEL R

The result is a loss of redundancy only. The remaining channel can provide all the required in-tank data to one FQPU channel, and the FQPU channel provides the in tank data to the other FQPU channel for operation within design limits.

Consequences of Next Critical Failure

Loss of remaining channel:

For left and right main tank: NGS Overpressure Protection is lost and, as a result, NGS is turned off. The loss of left or right main tank will result in the FUEL IMBALANCE Advisory message being inoperative.

If center tank channel is lost, NGS goes to a safe state.

Loss of total fuel quantity and fuel quantity for associated tank. FMC would continue to provide calculated fuel for the flight. This fault is indicated by the FUEL QTY INDICATION Status message.

Temperature monitoring for the associated tank is also lost. The associated FUEL TEMP INDICATION (C, L, R) Status message will be displayed.

On ground, the FUEL TEMP FAULT Advisory message will be displayed.

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28-41-04 Fuel Quantity Sensor Systems**28-41-04-01 Sensors**

Interval	Installed	Required	Procedure
C	43	42	

One may be inoperative with FUEL QTY SENSOR Status message displayed.

28-41-04 Fuel Quantity Sensor Systems**28-41-04-02 Center Tank**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be dispatched with degraded quantity accuracy in the center fuel tank provided:

- Appropriate performance adjustments are applied, and
 - Appropriate zero fuel weight and center-of-gravity adjustments are applied.
-

28-41-04 Fuel Quantity Sensor Systems**28-41-04-03 Main Tanks**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be dispatched with degraded quantity accuracy in one or both main fuel tanks provided:

- Appropriate performance adjustments are applied, and
 - Appropriate zero fuel weight and center-of-gravity adjustments are applied.
-

SUBSTANTIATION**Background**

See background of item 28-41-01, Fuel Quantity Indicating System.

Analysis from the Aero Performance group has shown that fuel indication inaccuracies driven from FQIS failures can adversely impact airplane performance when in combination with additional airplane failures occurring during flight.

Consequences of Failure

The FUEL QTY SENSOR Status message will be set when any one of the 43 in-tank fuel sensors is inoperative. Acceptable fuel quantity accuracy is maintained with one sensor failed.

The FUEL QTY IND DEGRADED C, L, R Status message will be displayed when the associated in-tank sensor is inoperative and the primary FQIS does not have active sensor data for the current fuel volume. The accuracy of the indicated fuel will be degraded. Additional fuel must be loaded to the affected tank to ensure sufficient fuel is available to complete the mission under certain other airplane level failure conditions. This additional fuel accounts for accuracy errors driven into the system with sensor failures. Degraded accuracy is driven from loss of a tank unit's input to the gauging algorithm.

Consequences of Next Critical Failure

Loss of an additional tank sensor in the same cell of the same tank will result in blanking of the affected tank resulting in the FUEL QUANTITY INDICATION Status message.

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28-41-05 Fuel Quantity Indication Fault Functions**28-41-05A**

Interval	Installed	Required	Procedure
C	3	0	(M)

May be dispatched with one or more of the following Status messages displayed provided associated primary fuel quantity indication is verified to be within acceptable limits before each departure.

- FUEL QTY IND FAULT C
- FUEL QTY IND FAULT L
- FUEL QTY IND FAULT R

28-41-05 Fuel Quantity Indication Fault Functions**28-41-05B**

Interval	Installed	Required	Procedure
B	3	2	

May be dispatched with one of the following Status messages displayed provided associated Fuel Quantity Indication System is considered inoperative.

- FUEL QTY IND FAULT C
- FUEL QTY IND FAULT L
- FUEL QTY IND FAULT R

NOTE: Dispatch is not allowed with more than one Fuel Quantity Indication System inoperative.

28-41-05 Fuel Quantity Indication Fault Functions**28-41-05-01 Crosscheck Function****28-41-05-01A**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be dispatched with FUEL QTY CROSSCHK UNAVAIL Status message displayed provided primary fuel quantity indication is verified within acceptable limits before each departure.

28-41-05 Fuel Quantity Indication Fault Functions**28-41-05-01 Crosscheck Function****28-41-05-01B**

Interval	Installed	Required	Procedure
B	1	0	

May be dispatched with FUEL QTY CROSSCHK UNAVAIL Status message displayed provided associated Fuel Quantity Indication System is considered inoperative.

NOTE: Dispatch is not allowed with more than one Fuel Quantity Indication System inoperative.

SUBSTANTIATION**Background**

New item for 777X.

To ensure the FMC Calculated Fuel Remaining is initialized with the correct total fuel quantity value from FQIS (Totalizer), the FQIS performs a crosscheck between the primary fuel quantity calculation and the secondary fuel quantity calculation between every refuel and flight to ensure the difference is within specified limits.

The Secondary quantity is only designed to be accurate during static conditions. Secondary quantity is not accurate during refueling and after refueling due to fuel settling. Secondary quantity is also not accurate during taxi and flight and is not used during these phases. Once the fuel is settled after refueling, a crosscheck is performed between the Primary and Secondary for each tank on opposite channels.

Consequences of Failure

The associated FUEL QTY IND FAULT C, L, R Status message will be displayed when the post-refuel crosscheck determines that the difference between the primary fuel quantity and secondary fuel quantity for the associated tank exceeds the allowable limit.

The FUEL QTY CROSSCHK UNAVAIL Status message will be displayed when failures within the FQIS prevents the crosscheck from occurring.

Dispatch is allowed provided primary fuel quantity indications are verified to be acceptable within a given tolerance prior to each departure. If primary fuel quantity indications are not within the acceptable tolerance limits, the airplane may be dispatched with the associated FQIS considered inoperative.

Consequences of Next Critical Failure

Additional failures will result in blanking of fuel quantity and setting of the FUEL QTY INDICATION Status message.

28-43-01 Fuel Temperature Indicating Systems**28-43-01-01 Center Tank**

Interval	Installed	Required	Procedure
C	1	0	

28-43-01 Fuel Temperature Indicating Systems**28-43-01-02 Main Tanks**

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 28-43-01.

The temperature of the fuel in each of the three tanks is sensed by sensors located in each fuel tank and transmitted by the fuel quantity processor unit (FQPU) to the common core system by the left and right ARINC 629 system bus and RDCs. The fuel temperature for the lowest fuel tank temperature is displayed in white on EICAS if all three tank temperatures are below 20 deg C. If a tank temperature reaches above 25 deg C, the highest valid fuel tank temperature will be displayed. The fuel temperature will be displayed in amber and accompanied by the FUEL TEMP LOW Advisory message when the fuel temperature in any tank is less than the FMC fuel freeze threshold (fuel freeze temperature plus 3C). During preflight, the flight crew can enter a fuel freeze temperature or use the default fuel freeze temperature (-37C). The FUEL TEMP LOW Advisory message is used to indicate when hydraulic fluid temperature is cold enough to effect flight control performance.

In the event of high fuel temperature, the FUEL TEMP HIGH Caution message will be displayed and the maximum temperature of the three tanks will be displayed.

Consequences of Failure

Fuel temperature for the affected tank will not be available. This condition is indicated by FUEL TEMP INDICATION C, L or R Status messages. The remaining fuel tank temperature is used to alert the crew of low or high fuel temperatures.

Consequences of Next Critical Failure

Remaining fuel tank temperature indication fails after dispatch:

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Loss of the FUEL TEMP HIGH Caution message. Complete loss of fuel temperature indication on the ground will prevent dispatch. Loss of the FUEL TEMP HIGH message results in a slight reduction in safety margin. Hazard classification is 'Major'.

Loss of the primary means to set the FUEL TEMP LOW Advisory message. Message will instead be set if TAT is at or below 3°C above the fuel freezing temperature. This may result in a diversion or change in flight envelope to prevent fuel from freezing. The result is an increase in flight crew workload. Hazard classification is 'Major'.

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29-11-01 Engine Driven Pumps (EDP, Depressurization Function)**29-11-01-01 Left Engine**

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative EDP is removed and dispatch kit is installed,
- Both Right Engine EDPs operate normally,
- Pump Pressure Indication System operates normally for remaining EDP,
- Pump Temperature Indication System operates normally for remaining EDP,
- Pump Pressure Indication System operates normally for Left Alternating Current Motor Pump (ACMP),
- Pump Temperature Indication System operates normally for Left Alternating Current Motor Pump (ACMP),
- Fuel temperature is greater than -17°C (1°F) prior to takeoff,
- Appropriate performance adjustments are applied, and
- Repairs are made within 3 flight-days.

29-11-01 Engine Driven Pumps (EDP, Depressurization Function)**29-11-01-02 Right Engine**

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative EDP is removed and dispatch kit is installed,
- Both Left Engine EDPs operate normally,
- Pump Pressure Indication System operates normally for remaining EDP,
- Pump Temperature Indication System operates normally for remaining EDP,
- Pump Pressure Indication System operates normally for Right Alternating Current Motor Pump (ACMP),
- Pump Temperature Indication System operates normally for Right Alternating Current Motor Pump (ACMP),
- Fuel temperature is greater than -17°C (1°F) prior to takeoff,
- Appropriate performance adjustments are applied, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal for 29-11-01 new for 777X.

Power for each 777X left and right hydraulic systems is provided by two primary engine driven pumps (EDPs) and one demand alternating current motor pump (ACMP). The EDPs are driven by the respective engines, and the ACMPs are electric motor-driven. During normal operations, both EDPs are selected to ON and the ACMP is selected to AUTO. During periods of high system demand the ACMP is automatically turned on. The EDP nominal output is 48 gpm and the ACMP nominal output is 7 gpm.

Relative to 777-300ER, the 777X incorporates an additional EDP per engine. The additional EDP is required to supply increased system demands. Two EDPs per engine are required for normal operation.

The Engine Driven Pumps (EDP) are mechanically coupled through a gearbox to the airplane engine core and converts mechanical input shaft power direct from the engine into hydraulic power. In the OFF mode, the EDP is depressurized. Case drain flow is maintained to preserve EDP cooling and lubrication (except when the fire switch is actuated). The OFF mode allows the pump to rotate and be lubricated, but with its output blocked, it draws only a fraction of the shaft power it would otherwise require. The EDP is depressurized by energizing the 28V DC solenoid operated blocking valve. The solenoid is energized by placing the pump switch to OFF, actuating the engine fire switch on the control stand, detection of hydraulic overheat, overpressure indication on L1/R1 EDPs, and during hot day taxi. When the fire switch is actuated, all hydraulic flow supplied to the EDP is shut off by the EDP supply shutoff valve. Due to the lack of cooling and lubrication, this eventually results in pump failure.

The EDPs are normally ON (pressurized) for most phases of ground and flight operations. One of the two EDPs associated with each engine is commanded to depressurize when the airplane is in low hydraulic demand cruise conditions. This cruise auto-depressurization function reduces engine load and provides a small fuel burn savings. The two EDPs alternate flights in which they are commanded into the cruise auto-depressurized state. Depressurization function is commanded automatically during a windmilling engine restart. The depressurization function is automatically commanded for a pump overheat condition. The depressurization function is manually commanded by placing the pump switch to OFF, or pulling the engine fire switch out (it does not have to be rotated) on the control stand. When the fire switch is actuated, all hydraulic flow supplied to the EDP is shut off by the EDP hydraulic supply shutoff valve.

The cruise-auto depress function includes an override feature to ensure that hydraulic system performance is maintained. This is done by repressurizing the pump to prevent the hydraulic system from getting too cold. This function is also used to re-pressurize the EDP that has been turned off in cruise in the event the operating EDP fails to produce pressure.

Consequences of Failure

Engine Driven Pump:

Failure of an EDP is indicated by the HYD PUMP PRI L1, L2, R1 or R2 status message. The pump must be removed and replaced with a dispatch kit (similar to 747-400/747-8). Flow capability is reduced on the associated system for landing and during a RTO. There will be a slight reduction in flight control and/or thrust reverser performance due to reduced flow capacity from the ACMP and remaining EDP.

Depressurization Function:

Failure of the depressurization function is indicated by the HYD PUMP DEPRESS PRI L1, L2, R1 or R2 status messages.

The associated pump must be removed and dispatch kit installed (same as for an inoperative EDP).

Consequences of Next Critical Failure

Engine Driven Pump:

Opposite engine failure at V1: Both left and right hydraulic systems are operating at reduced capability. One EDP and one ACMP run on one system, and one ACMP runs on the other system. Braking for RTO or landing is supported by the center hydraulic system. The resulting hazard is considered 'Hazardous.'

Depressurization function inoperative.

Same as for EDP.

Quantitative assessment: With one side (L or R) hydraulic system degraded, failure of the opposite engine is considered 'Hazardous.' Quantitative assessment indicates that the maximum dispatch time should be 167 flight hours.

29-11-02 Center System Primary Alternating Current Motor Pumps (ACMP)

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative center ACMP is deactivated,
- Fuel temperature is greater than -23°C (-9.4°F) and less than or equal to 38°C (100°F) prior to takeoff,
- Appropriate performance adjustments are applied, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-11-02.

Primary power for the center hydraulic system is provided by two alternating current motor pumps (ACMP) and three air driven pumps (ADP). The center system ACMP's are powered by the left and right main AC buses. The ADP's are driven by pneumatic bleed air from any one or combination of the two engines and APU. During normal operations, both ACMP's are positioned ON and all three ADP's are positioned to AUTO. During periods of high system demand one or two ADP's are automatically turned on; two ADP's will be on for takeoff roll, landing gear retraction, and high lift devices extension and retraction in flight; one ADP is on for high lift devices extension and retraction on ground, landing gear extension, and folding wing tip operation. In cruise both center ACMPs are running and all the ADPs will remain off.

The ADP nominal output is 53 gpm and the ACMP nominal output is 7 gpm.

Consequences of Failure

Failure of a center system ACMP is indicated by the HYD PUMP PRI C1, C2 Status messages and HYD PRI FAULT C1, C2 Advisory messages.

One ADP will run continuously to provide adequate system performance. Operating ACMP will automatically turn off in cruise but run in addition to the ADP for takeoff and landing.

Consequences of Next Critical Failure

Tire burst or dual thrown tread event that effects the center and right hydraulic systems. May result in failure to maintain directional control below rudder effectiveness speeds (catastrophic). The probability of a tire burst or dual thrown tread event is 6.69E-9/FH.

Body duct burst leading to erroneous wheel well fire indication: Flight crew will extend landing gear as part of non-normal checklist and deploy the ram air turbine (RAT). With an inoperative ACMP, the landing gear cannot be retracted resulting in increased fuel usage and potential fuel exhaustion (catastrophic). The probability of a duct burst resulting in wheel well fire indication and gear extension is $6.46\text{E-}8$. The maximum allowable dispatch time is 207 flight hours.

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Interval	Installed	Required	Procedure
A	3	2	(M) (O)

One may be inoperative provided:

- Inoperative ADP is verified not running when selected OFF,
 - ADP Heater Function operates normally on both remaining ADPs,
 - For ADP C2 inoperative, Left and Right Bleed Isolation Valves operate normally,
 - Associated AIR DEMAND selector remains OFF, and
 - Repairs are made within 1 flight-day.
-

29-11-03 Center System Demand Air Driven Pumps (ADP)**29-11-03B**

Interval	Installed	Required	Procedure
D	3	2	(M) (O)

One may be inoperative provided:

- Inoperative ADP is deactivated,
 - ADP Heater Function operates normally on both remaining ADPs,
 - For ADP C2 inoperative, Left and Right Bleed Isolation Valves operate normally, and
 - Associated AIR DEMAND selector remains OFF.
-

29-11-03 Center System Demand Air Driven Pumps (ADP)**29-11-03C**

Interval	Installed	Required	Procedure
A	3	2	(M) (O)

One may be inoperative provided:

- Inoperative ADP is verified not running when selected OFF,
- ADP Heater Function operates normally on one remaining ADP,
- For ADP C2 inoperative, Left and Right Bleed Isolation Valves operate normally,
- Associated AIR DEMAND selector remains OFF,
- Appropriate performance adjustments are applied, and

f. Repairs are made within 1 flight-day.

29-11-03 Center System Demand Air Driven Pumps (ADP)

29-11-03D

Interval	Installed	Required	Procedure
C	3	2	(M) (O)

One may be inoperative provided:

- Inoperative ADP is deactivated,
 - ADP Heater Function operates normally on one remaining ADP,
 - For ADP C2 inoperative, Left and Right Bleed Isolation Valves operate normally,
 - Associated AIR DEMAND selector remains OFF, and
 - Appropriate performance adjustments are applied.
-

29-11-03 Center System Demand Air Driven Pumps (ADP)

29-11-03-01 ADP Heater Function

29-11-03-01A

Interval	Installed	Required	Procedure
D	3	2	(O)

One may be inoperative provided:

- Associated AIR DEMAND selector remains OFF, and
 - For ADP C2 Heater Function inoperative, Left and Right Bleed Isolation Valves operate normally.
-

29-11-03 Center System Demand Air Driven Pumps (ADP)

29-11-03-01 ADP Heater Function

29-11-03-01B

Interval	Installed	Required	Procedure
C	3	2	(O)

ADP C2 Heater Function may be inoperative provided:

- C2 AIR DEMAND selector remains AUTO,
- One remaining AIR DEMAND selector (C1 or C3) remains OFF, and

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c. Appropriate performance adjustments are applied.

29-11-03 Center System Demand Air Driven Pumps (ADP)

29-11-03-01 ADP Heater Function

29-11-03-01C

Interval	Installed	Required	Procedure
C	3	1	(O)

May be be inoperative provided:

- One associated AIR DEMAND selector remains OFF,
- Remaining associated AIR DEMAND selector remains AUTO,
- For C2 AIR DEMAND selector OFF, Left and Right Bleed Isolation Valves operate normally, and
- Appropriate performance penalties are applied.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 29-11-03.

There are 3 air driven pumps (ADPs) installed in the center system. Only two ADPs are required at any given time to meet all user demands. The 777X center hydraulic system utilizes two alternating current motor pumps (ACMPs) and three ADPs to supply hydraulic power. The center system ACMPs are powered by the left and right AC buses. The ADPs are driven by pneumatic bleed air from any one or combination of the two engines and APU. During normal operations, both ACMPs are positioned ON and all three ADPs are positioned to AUTO. During periods of high system demand one or two of the ADPs are automatically turned on; two ADPs will be on for takeoff roll, landing gear retraction, high lift extension and retraction (in air), and autoslat operation. One ADP is on for speed brakes, folding wing tip (FWT), center system driven stabilizer movement, high lift extension and retraction (on ground) and landing gear extension.

The ADPs can also provide bleed over pressure protection for the environmental control system (ECS). One or both ADPs can run for ECS failure conditions or for alternate takeoff methods such as packs off takeoff or APU-to-Pack takeoff.

Each ADP is assigned a role: primary, alternate and standby. The C1 and C3 ADPs alternate between primary and standby depending on calendar day. Whichever ADP is not primary will assume the standby role and will not run in normal operation. The C2 ADP is normally alternate, meaning that it only runs for dual ADP demands in parallel with the primary pump. The C2 ADP is assigned as the primary pump twice a month for latency purposes.

Consequences of Failure

A failure of a center hydraulic system air driven demand pump is indicated by the HYD PUMP DEM C1, C2 or C3 Status message.

The HYD DEM FAULT C1, C2 or C3 Advisory message is displayed when a pump is inoperative or has been selected off.

The HYD HEATER DEM C1, C2 or C3 Status message is displayed for an inoperative center hydraulic system ADP heater.

One Inoperative ADP - Both remaining ADP heaters operates normally:

Loss of redundancy only. Only 2 ADPs are used at any time, including high hydraulic demand periods such as takeoff and flap operation. The two remaining ADPs provide full ADP functionality.

One Inoperative ADP - One Inoperative ADP Heater on remaining ADPs:

Loss of redundancy only. The two remaining ADPs provide full ADP functionality. The ADP with the inoperative heater will run continuously to prevent freezing. An ADP running continuously will result in a fuel burn penalty.

ADP Heater Function - One ADP Heater inoperative:

Loss of redundancy only. HYDIM will treat the associated pump as inoperative. The two remaining ADPs provide full ADP functionality.

ADP Heater function - Two ADP Heaters inoperative:

Loss of redundancy only. HYDIM will treat one associated pump as inoperative. Alternatively, the pump that will be inoperative can be selected by placing the associated selector switch in the OFF position. The two remaining ADPs provide full ADP functionality. The other ADP with the inoperative heater will run continuously to prevent freezing. An ADP running continuously will result in a fuel burn penalty.

For C2 ADP inoperative:

Left and right isolation valves must operate normally to ensure center hydraulic system power is available in the event of subsequent loss of the left bleed system.

For C2 ADP Heater inoperative:

HYDIM will treat C2 ADP as inoperative, however, C2 ADP may be used by selecting either C1 ADP or C3 ADP to OFF and selecting C2 ADP to AUTO. C2 ADP will run continuously resulting in a fuel burn penalty. This option may be used if either the left or right isolation valve is inoperative.

For APU to pack takeoff:

In this configuration, the right engine bleed air system is on, the right pack is off and the center isolation valve is closed. ADP C2 must be operative. Otherwise, there will be no right bleed air system consumer to maintain bleed pressure within normal limits.

For packs off takeoff:

In this configuration, both packs will be off and center isolation valve is closed. ADP C2 must be is operative. Otherwise, there will be no right bleed air system consumer to maintain bleed pressure within normal lim-

its.

Consequences of Next Critical Failure

ADP C1, C2 or C3 inoperative:

Failure of an additional ADP results loss of autoslat capability. Increased airplane drag due to pregapped slats and slower landing gear retraction (Major).

ADP C2 inoperative:

For failure of the left bleed system, the right bleed isolation valve will re-open to right engine bleed air to supply the C1 & C3 ADPs.

While performing packs off takeoff or APU to pack takeoff and the right high pressure shutoff valve (HPSOV) fails open it will result in bleed over pressure in the right bleed system leading to duct burst. For this reason the DDG prohibits packs off takeoff and APU to pack takeoff with ADP C2 inoperative.

Loss of Captain's Instrument buss results in loss of all ADPs. High lift will be slow to move and unable to retract the landing gear. (Major)

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29-11-04 Demand Pump Selectors**29-11-04-01 Center System**

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided associated Center System Demand Air Driven Pump (ADP) is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-11-04.

Legacy sub-items for specific selector positions AUTO, ON, OFF not proposed; selector tends to fail entirely and relief for specific positions not considered meaningful.

The hydraulic system demand pump selectors have three positions; ON, AUTO and OFF. The demand pumps are only needed during periods of high system demand, which are the takeoff and landing phases of flight. The demand pump selectors are normally positioned to AUTO, which allows the HYDIM cards to signal the pumps on when they are required.

Consequences of Failure

Affected ADP must be considered inoperative, with associated ADP deactivated.

Consequences of Next Critical Failure

Refer to item 29-11-03 for next critical failure.

29-11-05 Hydraulic Interface Module (HYDIM) Cards

Interval	Installed	Required	Procedure
C	4	3	(M)

HYDIM Card HCR may be inoperative provided:

- HYDIM Card HCL operates normally,
- HYDIM Card HL operates normally,
- HYDIM Card HR operates normally,
- All Center System ADP Pressure Indication Systems operate normally,
- Both Center System ACMP Pressure Indication Systems operate normally, and
- Left, Center and Right Hydraulic Reservoir Temperature Indication Systems are considered inoperative.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 29-11-05.

Annunciation and control of the hydraulic systems are controlled by four hydraulic interface module (HYDIM) cards, two HYDIM cards for the center and one card each for the left and right systems. All of the HYDIM cards contain the same information and are made application specific for the particular hydraulic system (center, left or right) by a program pin in the card file. This allows interchangeability of the HYDIM cards between systems. The card file design is such that the center right card (HCR) position can be inoperative for dispatch. This allows the center right card to be an onboard "hot" spare that can be swapped with any other HYDIM card.

HYDIM center right (HCR) provides center system pressure indication, temperature indication for all 3 system's reservoirs, and backup control for ADP 2 when the left side electrical panels are lost.

Consequences of Failure

An inoperative hydraulic interface module (HYDIM) card is indicated by the HYDIM CARD HCL, HCR, HL or HR Status messages.

Dispatch is only allowed with the inoperative HYDIM in the center right (CR) position. The HYD SYS PRESS SNSR C Status message may be displayed. The HYD TEMP IND RSVR L, C, or R Status message may be displayed. HYDIM HCR must be depowered to ensure that interacting systems recognize the HCR data as invalid.

Loss of redundancy only.

Consequences of Next Critical Failure

Loss of L/C/R system temperature transducer:

Results in loss of reservoir indication for servicing. Sight glasses may be used for dispatch.

Loss of physical separation:

Dispatch with HYDIM HCR inoperative results in loss physical separation required by 14 CFR 25.795(c)(2), Security Considerations, Survivability of Systems. An event that this regulation is intended to address could result in loss of the left side electrical panels which could result in loss of capability of continued safe flight and landing.

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29-11-06

Reserve Brakes and Steering Isolation System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Reserve Brakes and Steering Isolation Valve is deactivated open.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 29-11-04.

The purpose of the reserve brakes and steering isolation system is to preserve hydraulic power for braking and nose wheel steering in the event of a hydraulic leak in the main portion of the hydraulic circuit. This system is required to maintain braking and directional control of the airplane on the ground below rudder effectiveness speeds in the event of a particular tire burst or thrown tread event which impacts the center hydraulic system and most of the brake lines feeding the main landing gear. The nose gear steering system is protected from a center system hydraulic fluid leak in the main landing gear portion of the circuit by the reserve steering isolation valve. The valve is a two-port motor-operated ball valve that is actuated by the HCL HYDIM card.

Reserve steering isolation is triggered when low fluid level is detected in the center system reservoir. The quantity trigger point is above the standpipe to ensure that sufficient fluid is remaining after isolation to supply fluid to nose gear steering.

With the valve closed, the center system C1 ACMP is then isolated to only supply fluid for nose wheel steering. With the valve closed, no center system fluid is supplied from pumps other than the C1 ACMP for nose landing gear extension, retraction or steering.

Consequences of Failure

The HYD VLV ISLN RSV BRK/STRG Status message is displayed when the reserve brakes and steering isolation valve position disagrees with the commanded position for more than 5 seconds.

For dispatch, the reserve brakes and steering isolation valve is deactivated in the open position. The center hydraulic system operates normally when the reserve steering isolation valve is inoperative open.

Consequences of Next Critical Failure

For tire burst or dual thrown tread event that effects the center hydraulic system and brake lines feeding the main landing gear:

The reserve brakes and steering isolation valve cannot be closed resulting in loss of the center hydraulic system.

Additional loss of up to three brakes on the truck associated with the tire event. Potential runway excursion due to loss of nose wheel steering combined with degraded braking capability. The resulting airplane level hazard is catastrophic. The probability of a tire threat event is 6.69E-09 per flight hour.

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Nose Gear Isolation System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Nose Gear Isolation Valve is deactivated open.

SUBSTANTIATION

Background

Proposal similar to 787 MMEL item 29-11-05.

The center hydraulic system is protected from an engine burst that severs the tubing to/from the nose gear by the nose gear isolation valve. When the valve is closed, the center system is isolated to prevent flow from any center system pump to any center system hydraulic tubing forward of the rear spar leading to the nose landing gear. The valve is a two-port motor-operated ball valve that is actuated by the HCL HYDIM card.

The nose gear isolation valve is normally open during the entire flight cycle. Isolation is triggered when low fluid level is detected in the center system reservoir and speed exceeds 60 knots and either an engine is failed or the nose landing gear is not up. The quantity trigger point is above the standpipe to ensure that sufficient fluid is remaining after isolation to supply fluid to primary flight controls and main landing gear for continued safe flight and landing. The nose gear isolation valve avoids sending fluid to the nose gear during the remainder of a flight when the line may be severed, then enables nose gear steering (if the line is intact) for directional control below rudder effectiveness speeds.

Consequences of Failure

The HYD VLV ISLN NOSE GEAR Status message is displayed when the nose gear isolation valve position disagrees with the commanded position.

For dispatch, the nose gear isolation valve is deactivated in the open position. The center hydraulic system operates normally when the nose gear isolation valve is inoperative open.

Consequences of Next Critical Failure

For an uncontained engine failure that results in damage to nose gear or slat actuation tubing:

The nose gear isolation valve cannot be closed to isolate the center hydraulic system. The result is loss of the center hydraulic system function. For takeoff/go-around, there will be loss of landing gear retraction capability resulting in insufficient climb gradient capability and potential inability to clear ground obstacles (catastrophic). All flight phases are considered catastrophic.

The probability of an uncontained engine failure is 6.69E-09 per flight hour.

29-11-08

Heat Exchanger Bypass Valves

Interval	Installed	Required	Procedure
C	3	0	(O)

May be inoperative provided fuel temperature is greater than -10°F (-23°C) prior to engine start.

SUBSTANTIATION**Background**

New proposal for 777X.

Each hydraulic system includes a heat exchanger that is located in the airplane fuel tanks. The left system heat exchanger is in the left wing tank. The center and right system heat exchangers are in the right wing tank.

Each heat exchanger cools the case drain hydraulic fluid from the associated hydraulic pumps before the fluid goes back to the reservoir. The heat exchangers extend the service life of the fluid and the hydraulic pumps due to cooler operating temperatures.

The 777-9 incorporates a heat exchanger fluid bypass for each hydraulic system controlled by a bypass valve. The valve provides a passive thermostatic-type means to control the temperature of the hydraulic fluid in the hydraulic system. The valve is temperature operated with no electrical control or connections. When the hydraulic fluid temperature is warm, the valve will block the bypass port and allow hydraulic fluid to pass through the heat exchanger thus cooling down the fluid. When the hydraulic fluid is cold, the heat exchanger port is blocked thus warming up the fluid by bypassing the heat exchanger.

Consequences of Failure

NOTE: Failure of a heat exchange bypass valve will only be detected during the hydraulic system cold weather operations procedure. This procedure involves running the ACMPs with the flight control shutoff valves closed.

The HYD VLV HT EXCHR BYPASS C, L or R Status message will be displayed when the associated reservoir temperature has not adequately increased after performing the hydraulic system cold weather operations procedure.

There is no effect for normal operation. For cold day operation, there may be a slight degradation in flight control and maneuver load alleviation (MLA) performance. The fuel temperature limitation for dispatch ensures that hydraulic fluid will be warm enough and all performance requirements will be met.

Consequences of Next Critical Failure

None.

29-18-01 Reservoir Quantity Gauge (Remote)

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 29-18-01.

Each hydraulic fluid reservoir has a quantity transmitter mounted at its bottom. There is one reservoir quantity gauge that can be electrically connected to each reservoir as determined by the position of the reservoir quantity selector valve handle. The reservoir fluid quantities are also displayed in the flight deck on the EICAS status page. The reservoir quantity gauge allows maintenance to fill the reservoirs without having to monitor the flight deck indications. Each fluid reservoir has two sight glasses that can be used to verify that the reservoir is properly serviced.

Consequences of Failure

None. Reservoir quantity indications on the flight deck can be used for filling the reservoirs.

Consequences of Next Critical Failure

None. Reservoir quantity gauge is only for maintenance purposes.

29-18-02 Hydraulic Reservoir Temperature Indication Systems

29-18-02A

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided associated Hydraulic System Temperature Transducer operates normally.

29-18-02 Hydraulic Reservoir Temperature Indication Systems

29-18-02B

Interval	Installed	Required	Procedure
C	3	0	(M)

May be inoperative provided associated hydraulic reservoir quantity is verified normal.

SUBSTANTIATION

Background

Proposal same as 787 MMEL item 29-18-04.

Each of the three hydraulic fluid reservoirs has a temperature sensor located within the reservoir. The Hydraulic Interface Module (HYDIM) receives data from the reservoir temperature sensors and displays temperature data on the hydraulic system Maintenance page. The reservoir temperature is used internally in HYDIM for thermal compensation of reservoir quantity.

Consequences of Failure

Associated system temperature transducer operates normally:

The HYD TEMP IND RSVR C, L or R Status message is indicated when the reservoir temperature from a sensor is not within range or is otherwise determined to be invalid, indicating a failed sensor. Thermal compensation of reservoir quantity is less accurate but still available. Unable to detect in-range temperature sensor faults for pump or system temperature transducers.

Associated system temperature transducer inoperative:

For associated system temperature also inoperative, loss of thermal compensation and loss of all quantity indication for the associated hydraulic system. Maintenance is required to verify hydraulic reservoir quantity using sight glass prior to dispatch. The effect of a system leak is not changed due to loss of reservoir and system temperature transducers. HYD QTY LOW Advisory message will still work properly since quantity sensor still works.

Consequences of Next Critical Failure

Failure of pump temperature indication:

None.

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29-21-01 Ram Air Turbine (RAT) Heater System

Interval	Installed	Required	Procedure
A	1	0	

May be inoperative provided repairs are made within 20 flights.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-21-01-01.

The ram air turbine (RAT) has a heater system installed to prevent moisture from accumulating and freezing in the RAT generator, which would prevent the RAT from operating if it were deployed. The RAT heater system is controlled by the HYDIM via the ELMS. Each heater is mechanically mounted to the inner structure of the generator. Each heater contains two heating elements. Only one element on each heater is required for normal operation. In the event that a heater fails, the other heater can be selected with a switch located in the E6 bay. The switch has two positions: HEATER 1 and HEATER 2. The entire RAT turbine/generator assembly must be removed to repair a heater. A failure of the generator heating system will be indicated by the status message RAT GEN HEAT.

Consequences of Failure

Failure of the RAT heater is indicated by the RAT GEN HEAT Status message.

Results in loss of RAT heating. RAT will continue to operate normally. Limiting dispatch to 20 flights will not allow enough moisture to accumulate to result in the RAT generator freezing.

Consequences of Next Critical Failure

None.

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29-21-02 Ram Air Turbine (RAT) Position Indication System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- RAT is verified to deploy normally, and
- RAT is verified to be stowed before each departure.

29-21-02 Ram Air Turbine (RAT) Position Indication System

29-21-02-01 Switch UNLKD Light

Interval	Installed	Required	Procedure
C	1	0	

29-21-02 Ram Air Turbine (RAT) Position Indication System

29-21-02-02 Switch PRESS Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 29-21-02.

When the RAT has been unlocked, either manually with the associated switch, or automatically by ELMS or HYDIM, the Ram Air Turbine UNLKD light is illuminated. The condition which results in illumination of this light also results in an EICAS alerting message. The RAT will normally be in the stowed position unless it is manually deployed using the switch on the P5 panel, or is automatically deployed due to loss of hydraulic pressure, loss of electrical power, or loss of both engines.

UNLKD Light: Illuminated (amber) means the RAT is not in the stowed position.

PRESS Light: Illuminated (green) means the RAT is deployed and the center system primary flight control hydraulic pressure is greater than 1500 psi.

Consequences of Failure

When the RAT position indication system (including the position indication switch) is inoperative, the RAM AIR TURBINE switch UNLKD amber light on the P5 Hydraulic panel and the RAT UNLOCKED Advisory message will be indicated. The RAT itself will operate normally. Dispatching with the RAT position indication system inoperative requires verification that the RAT is stowed prior to each flight and that the RAT deploys normally (verified once at the beginning of the dispatch period).

UNLKD Light: If the RAT is unlocked, the Ram Air Turbine UNLKD light will not illuminate. This effect will have no significant impact because there is a RAT UNLOCKED advisory message which remains operative and will be displayed to indicate that the RAT is unlocked to the pilots. Also, the RAT PRESS light will illuminate indicating the RAT is deployed and providing pressurized flow.

PRESS Light: The RAT PRESS light will not illuminate indicating the RAT is deployed and providing pressurized flow. But the flight control feedback will assure the flight crew that the system is powered.

Consequences of Next Critical Failure

A failure which results in deployment of the RAT: If RAT is deployed (either manually by the flight crew or automatically by HYDIM), and the RAT position indication system is inoperative, the UNLKD light and the RAT UNLOCKED advisory message cannot be used to verify that the RAT is extended. The RAM AIR TURBINE PRESS indication on the P5 panel can be used to independently verify that the RAT has deployed and is providing hydraulic pressure.

If only the RAT UNLKD light is inoperative and will not illuminate, the RAT UNLOCKED Advisory message will already be displayed to indicate that the RAT is unlocked. The RAM AIR TURBINE PRESS indication will illuminate indicating the RAT is deployed and providing hydraulic pressure.

Federal Aviation Administration (FAA)**ATA 29****777-9 Master Minimum Equipment List****Section 2****29-30-01 Hydraulic Pump Switch Lights****29-30-01-01 FAULT Lights**

Interval	Installed	Required	Procedure
C	11	0	

29-30-01 Hydraulic Pump Switch Lights**29-30-01-02 ON Lights**

Interval	Installed	Required	Procedure
C	6	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-30-01.

FAULT Lights: Each hydraulic pump has a FAULT light on the overhead hydraulic system control panel. The FAULT light will illuminate (amber) when the pump is commanded on and the output pressure is low, when the pump case drain line or discharge temperature is excessive, or when the pump is selected off. The primary means of informing the flight crew of these pump conditions are the HYD PRI FAULT C1, C2, L1, L2, R1 & R2 Advisory messages and HYD DEM FAULT C1, C2, C3, L & R Advisory messages. The FAULT light provides additional identification to the flight crew which pump switch needs to be positioned OFF.

ON Lights: There are six ON lights. One for each EDP (4) and one for each center system ACMP (2). When ON, the associated switch is in the ON position.

Consequences of Failure

FAULT Lights: A hydraulic pump low pressure or over temperature condition would require the flight crew to identify the associated pump switch by the HYD PRI FAULT C1, C2, L1, L2, R1, R2 or HYD DEM FAULT C1, C2, C3, L, R Advisory messages which remain operative.

ON Lights: The open shutter allows the ON indication to be illuminated by ambient lighting and the switch is flush with the light plate.

Consequences of Next Critical Failure

FAULT Lights: None.

ON Lights: None.

29-30-02 Hydraulic Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-30-02.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

29-31-01 Hydraulic System Pressure Transducers

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided Pump Pressure Indication Systems in associated hydraulic system operate normally for all operative pumps.

NOTE: Pump Pressure Indication System may be inoperative if associated pump is inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 29-31-01.

The hydraulic systems have a pressure transducer on the outlet of each hydraulic pump and one transducer in the common tubing of each hydraulic system. These transducers are used to provide individual hydraulic pump and system pressure and alerting indications. The system pressure on the status and hydraulic synoptic pages is provided by the system pressure or individual pump pressure transducer, whichever one indicates the highest pressure. If a system pressure transducer is inoperative, the system pressure will be based on the Demand or Primary pump operating at the highest indicated pressure.

Consequences of Failure

Failure of a hydraulic system pressure transducer is indicated by the HYD SYS PRESS SNSR C, L or R Status message.

Loss of redundancy. The system pressure and system alert indications are provided by the individual pump pressure transducers.

Consequences of Next Critical Failure

For center system sensor:

Loss of HYDIM Center Left results in loss of center system pressure indication to flight controls and loss of ADP 1 and Center ACMPs. Minor effects only.

For left system sensor:

Loss of HYDIM Left results in loss of left system pressure indication to flight controls and loss of ADP 2 and Left ACMP. Minor effects only.

For right system sensor:

Loss of HYDIM Right results in loss of right system pressure indication to flight controls and loss of ADP 3 and Right ACMP. Minor effects only.

29-31-02 Pump Pressure Indication Systems**29-31-02-01 Left System Engine Driven Pumps (EDP)****29-31-02-01A**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Associated pump pressure indication transducer is deactivated,
- Associated pump operation is verified normal before each departure,
- Left ACMP Pump Pressure Indication System operates normally,
- Left Hydraulic System Pressure Transducer operates normally, and
- Left Hydraulic System Temperature Transducer operates normally.

29-31-02 Pump Pressure Indication Systems**29-31-02-01 Left System Engine Driven Pumps (EDP)****29-31-02-01B**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- Associated EDP is inoperative, and
- Left ACMP Pump Pressure Indication System operates normally.

29-31-02 Pump Pressure Indication Systems**29-31-02-02 Left System Alternating Current Motor Pump (ACMP)**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Associated pump pressure indication transducer is deactivated,
- Associated pump operation is verified normal before each departure,
- Both Left EDP Pump Pressure Indication Systems operates normally,
- Left Hydraulic System Pressure Transducer operates normally, and
- Left Hydraulic System Temperature Transducer operates normally.

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29-31-02 Pump Pressure Indication Systems

29-31-02-03 Right System Engine Driven Pumps (EDP)

29-31-02-03A

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Associated pump pressure indication transducer is deactivated,
- Associated pump operation is verified normal before each departure,
- Right ACMP Pump Pressure Indication System operates normally,
- Right Hydraulic System Pressure Transducer operates normally, and
- Right Hydraulic System Temperature Transducer operates normally.

29-31-02 Pump Pressure Indication Systems

29-31-02-03 Right System Engine Driven Pumps (EDP)

29-31-02-03B

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- Associated EDP is inoperative, and
- Right ACMP Pump Pressure Indication System operates normally.

29-31-02 Pump Pressure Indication Systems

29-31-02-04 Right System Alternating Current Motor Pump (ACMP)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Associated pump pressure indication transducer is deactivated,
- Associated pump operation is verified normal before each departure,
- Both Right EDP Pump Pressure Indication Systems operates normally,
- Right Hydraulic System Pressure Transducer operates normally, and
- Right Hydraulic System Temperature Transducer operates normally.

29-31-02 Pump Pressure Indication Systems**29-31-02-05 Center System Air Driven Pumps (ADP)****29-31-02-05A**

Interval	Installed	Required	Procedure
C	3	2	(M)

One may be inoperative provided:

- Associated pressure indication transducer is deactivated,
- Associated pump is verified to operate normally before each departure,
- Both Center System ACMP Pump Pressure Indication Systems operate normally,
- Center Hydraulic System Pressure Transducer operates normally,
- Center Hydraulic System Temperature Transducer operates normally, and
- HYDIM card HCR operates normally.

29-31-02 Pump Pressure Indication Systems**29-31-02-05 Center System Air Driven Pumps (ADP)****29-31-02-05B**

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided:

- Associated pump is inoperative, and
- Both Center System ACMP Pump Pressure Indication Systems operate normally.

29-31-02 Pump Pressure Indication Systems**29-31-02-06 Center System Alternating Current Motor Pumps (ACMP)****29-31-02-06A**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Associated pressure indication transducer is deactivated,
- Associated pump is verified to operate normally before each departure,

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- c. All (3) Center System ADP Pump Pressure Indication Systems operate normally,
 - d. Center Hydraulic System Pressure Transducer operates normally,
 - e. Center Hydraulic System Temperature Transducer operates normally, and
 - f. HYDIM card HCR operates normally.
-

29-31-02 Pump Pressure Indication Systems

29-31-02-06 Center System Alternating Current Motor Pumps (ACMP)

29-31-02-06B

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- a. Associated pump is inoperative, and
 - b. All (3) Center System ADP Pump Pressure Indication Systems operate normally.
-

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 29-31-02.

Each hydraulic pump has a pressure transducer at its outlet. Pump low pressure indication is used to alert the flight crew of pump failure and is indicated by the HYD DEM FAULT __ or HYD PRI FAULT __ Advisory messages and associated overhead panel FAULT light illuminations.

Consequences of Failure

Failure of a pump pressure indication transducer will result in display of the associated HYD PRESS IND __ Status message. Pump low pressure indication is inoperative.

For dispatch, the associated pump is verified to operate normally, the associated system pressure transducer must operate normally, and the associated pressure transducer is deactivated by disconnecting the electrical connector.

The electrical connector is disconnected to preclude potentially erroneous, misleading, or intermittent flight deck indications associated with the affected pump. The flight deck effects associated with the disconnected connector are described in the DDG for flight crew awareness.

The associated pump EICAS alerting and Status messages will continue to be displayed, the pump pressure readout on the EICAS hydraulic maintenance page will be blank and the pump pressure indications Status message will be displayed. Also the hydraulic synoptic flow bars may not indicate correctly.

HYDIM cards MMEL item require all center system pump pressure indication systems to operate normally, therefore, for center system pump pressure indication systems, HYDIM cards (all) must operate normally.

Consequences of Next Critical Failure

Failure of associated pump would not be indicated to the flight crew. Continued operation of pump could result in system contamination or pump damage.

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Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided:

- Associated Left System EDP operates normally,
- Associated Pump Pressure Indication System operates normally, and
- Left Hydraulic System Temperature Transducer operates normally.

NOTE: Dispatch is not allowed with an inoperative Left System ACMP.

29-32-01 Pump Temperature Indication Systems**29-32-01-01 Left System Engine Driven Pumps (EDP) and Alternating Motor Pump (ACMP)****29-32-01-01B**

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided associated EDP is inoperative.

NOTE: Dispatch is not allowed with an inoperative Left System ACMP.

29-32-01 Pump Temperature Indication Systems**29-32-01-02 Right System Engine Driven Pumps (EDP) and Alternating Motor Pump (ACMP)****29-32-01-02A**

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided:

- Associated Right System EDP operates normally,
- Associated Pump Pressure Indication System operates normally, and
- Right Hydraulic System Temperature Transducer operates normally.

29-32-01-02B

Interval	Installed	Required	Procedure
C	3	2	

One may be inoperative provided associated pump is inoperative.

NOTE: Dispatch is not allowed with an inoperative Right System ACMP.

29-32-01 Pump Temperature Indication Systems

29-32-01-03 Center System Air Driven Pumps (ADP) and Alternating Current Motor Pumps (ACMP)

29-32-01-03A

Interval	Installed	Required	Procedure
C	5	4	

One may be inoperative provided:

- Associated Center System ADP/ACMP operates normally,
- Associated Pump Pressure Indication System operates normally, and
- Center Hydraulic System Temperature Transducer operates normally.

29-32-01 Pump Temperature Indication Systems
29-32-01-03 Center System Air Driven Pumps (ADP) and Alternating Current Motor Pumps (ACMP)

29-32-01-03B

Interval	Installed	Required	Procedure
C	5	3	

May be inoperative provided associated pump is inoperative.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 29-32-01.

The pump temperature indication is used to alert the flight crew when a pump is overheating. A pump case drain line excessive temperature will result in a HYD DEM FAULT ___ or HYD PRI FAULT ___ Advisory message and an overhead panel FAULT light illumination.

Consequences of Failure

Failure of a pump temperature indication sensor will result in display of the HYD TEMP IND ___ Status message. Associated pump temperature indication is inoperative.

For dispatch, the associated pump pressure transducer and the associated system temperature transducer must operate normally.

Consequences of Next Critical Failure

For left, right, and center system with pump operative:

Subsequent overheat of a pump whose temperature sensor is inoperative leads to the system temperature sensor experiencing overheat. That results in shutdown of all pumps on the associated system, thus a system loss. EDPs and ADPs have automatic overheat shutdown while overheated ACMPs lead to Advisory messages and flight crew action to shut them down.

Subsequent EDP or ADP overheat alert to flight crew will be based on the system temperature sensor, which results in automatically shutting down all EDPs or ADPs on associated system. Failure or overheat of associated pump will set the associated HYD PRI FAULT L1 & L2, HYD PRI FAULT R1 & R2, or HYD DEM FAULT C1, C2 & C3 Advisory messages for all EDPs or ADPs on the system resulting in commanding the pumps off.

Subsequent ACMP overheat alert to flight crew will be based on the ACMP motor integral temperature switch. Failure or overheat of associated pump will set the associated HYD DEM FAULT L or HYD DEM FAULT R or HYD PRI FAULT C1 & C2 Advisory messages resulting in commanding the pump off.

29-32-02

Hydraulic System Temperature Transducers

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided:

- Pump Pressure Indication Systems for all operative pumps in associated hydraulic system operate normally, and
- Pump Temperature Indications for all operative pumps in associated hydraulic system operate normally.

NOTE 1: Pump Pressure Indication System may be inoperative if the associated pump is inoperative.

NOTE 2: Pump Temperature Indication may be inoperative if the associated pump is inoperative.

SUBSTANTIATION

Background

Proposal new for 777X.

Due to the carbon fiber reinforced plastic structure used on the 777X, an additional layer of protection from overheat has been added relative to the legacy 777. Each of the three hydraulic systems includes a temperature transducer, which is used as part of overheat alerting to the flight crew. For 777X, pump failure and overheat are combined into Advisory level messages to consolidate Non-Normal Checklists (HYD DEM FAULT C1, C2, C3, L & R and HYD PRI FAULT C1, C2, L1, L2, R1 & R2). If an invalid temperature is sensed, the HYD TEMP IND SYS C, L or R Status message is displayed. The system temperature transducer is also used for thermal compensation of reservoir quantity.

Consequences of Failure

Failure of a hydraulic system temperature sensor is indicated by the HYD TEMP IND SYS C, L or R Status message.

None. Pump pressure indications and pump temperature indications must operate normally to ensure subsequent overheat is detected and alerted.

Hydraulic reservoir temperature transducer MMEL item requires associated hydraulic system temperature transducer to operate normally. Therefore, the hydraulic reservoir temperature transducer must operate normally.

Consequences of Next Critical Failure

Subsequent pump overheat alert to flight crew will be based on the pump temp sensor. Failure or overheat of associated pump will set the associated HYD DEM FAULT __ or HYD PRI FAULT __ Advisory message.

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Failure of the reservoir temperature transducer results in loss of thermal compensation and loss of all quantity indication for the associated hydraulic system. Requires maintenance to verify reservoir quantity using the sight glass prior to dispatch.

The effects of a system leak are not changed due to loss of reservoir and system temperature transducers. HYD QTY LOW Advisory message will still work properly since quantity sensor still works.

Failure of pump temperature transducer has no effect.

Pump overheat will be detected by the pump temperature sensor except for a blocked case drain line. Blocked case drain failure will not exceed 400 degrees F in the fuel tank or overheat structure.

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29-33-01 Hydraulic Fluid Quantity Indications (Flight Deck)**29-33-01-01 Left & Right Hydraulic Systems**

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Associated reservoir level is verified normal before each departure, and
- At least one Hydraulic Fluid Quantity Indication (C, L or R) operates normally.

29-33-01 Hydraulic Fluid Quantity Indications (Flight Deck)**29-33-01-02 Center Hydraulic System**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Center reservoir level is verified normal before each departure,
- At least one Hydraulic Fluid Quantity Indication (C, L or R) operates normally,
- Reserve Brakes and Steering Isolation System is considered inoperative, and
- Nose Gear Isolation System is considered inoperative.

SUBSTANTIATION**Background**

Proposal similar to 777 MMEL item 29-33-01.

Each hydraulic fluid reservoir has a quantity transmitter. There is one reservoir quantity gauge that can be electrically connected to each reservoir as determined by the position of the reservoir quantity selector valve handle. The reservoir fluid quantities are displayed in the flight deck on the EICAS status, hydraulic synoptic and hydraulic maintenance pages. Each reservoir has two sight glasses that can be used prior to dispatch to verify that the reservoir is full. There is a remote quantity indicator that can be used by maintenance located near the fill station to ensure the reservoir is being serviced to the correct level.

Consequences of Failure

Failure of a hydraulic fluid quantity indication is indicated by the HYD QTY IND C, L or R Status message.

Low quantity alert is inoperative. Hydraulic quantity indication on the Status, Synoptic, and Hydraulic Maintenance pages will be blank.

For center system quantity indication is inoperative, the reserve brakes and steering isolation system and nose gear isolation systems are inoperative.

Consequences of Next Critical Failure

Hydraulic system fluid leak:

Will be indicated by system low pressure alerts.

For center system quantity indication inoperative:

Uncontained engine failure resulting in center hydraulic system leak results in loss of capability of continuous safe flight and landing. Resulting hazard is catastrophic. (Refer to Nose Isolation System)

The probability of an uncontained engine failure is 6.69E-09 per flight hour.

Tire burst or dual thrown tread resulting in center hydraulic leak results in loss of capability of continuous safe flight and landing. Resulting hazard is catastrophic. (Refer to Reserve Brakes and Steering Isolation System)

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Wing Anti-Ice (WAI) Valves

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative WAI Valve is locked closed,
- WING ANTI-ICE selector remains OFF,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-11-01.

Proposal is consistent with FAA Policy Letter 40 (PL-40).

The 777-9 is powered by the General Electric GE9X engine type.

The EAI system and the WAI system are controlled by the Airfoil and Cowl Ice Protection System (ACIPS) control cards.

The wing thermal anti-ice system is part of the ACIPS, which consists of the WAI system, the left and right EAI systems and three ACIPS control cards in the Electrical/Electronic Equipment (E/E) Bay which receive inputs from the Primary Ice Detection System (PIDS) and provide for control and indication of left EAI, WAI and right EAI systems. The WAI system provides precooled engine bleed air to the wing leading edge, based on the bleed system using a mixture of 4th and 11th stage bleed ports. The protected portion of each wing has increased from that of the 777-300ER. The protected portion of each wing includes four leading edge slats outboard of the engine (slats 3, 4, 5, and a portion of slat 6 on the left wing; and slats 9, 10, 11, and a portion of slat 12 on the right wing) and half of the inboard slats (slat 7 on the left wing and slat 8 on the right wing). The WAI valve is controlled by a torque controller which is mounted on the valve housing.

Regulation of the valve is based on a flow schedule to provide the required heat for each phase of flight, e.g., climb, hold, descent, etc. Control feedback for the WAI valve is provided by control pressure sensors installed in the WAI ducting downstream of the WAI valve via the ACIPS control cards in the E/E Bay. The WAI system has new software located in the new center ACIPS card, which provides for activation and regulation of the WAI valve based on ice detection input from the PIDS. If inadequate heat flux is provided to either wing then the WAI PRESS FAULT Caution message will be displayed. No flight crew action is required for this message. The WAI system valves and pressure sensors are new parts designed for the 777-9.

A wing leading edge Slat Overheat Protection System (SOPS) has been added to detect a WAI valve failed open or leaking while on the ground to prevent overheat of the wing leading edge slats. Displays and Crew Alerting (DCA) independently monitors for slat overheat conditions while on-ground and indicates to the air supply control system (ASCS) if a respective wing anti-ice valve is deemed failed open.

Consequences of Failure

Failure of a WAI valve is indicated by the WAI VALVE L or R Status message.

The WAI VALVE CLOSED Caution message will be displayed if the WAI valve has failed in the closed position.

The WAI VALVE OPEN L, R Caution message will be displayed if the associated WAI valve has failed in the open position when the airplane is on-ground.

This failure condition results in loss of the ability to control the associated WAI valve.

For dispatch, maintenance action is required to lock the inoperative WAI valve(s) in the closed position. The WAI selector switch must remain in the OFF position.

Wing anti-ice is not available. Airplane must not be operated into known or forecast icing conditions.

NOTE 1: For the legacy 777: The flight test program demonstrated that a diversion from icing conditions is not required with an inoperative WAI system. Therefore, the 120 minutes ETOPS limit was not applied. The restriction not to operate into known or forecast icing was included as a conservative measure.

NOTE 2: For the 777-9 with an inoperative WAI system: The flight test program will demonstrate that ice accumulation will not have a significant negative effect on safety. Non-Normal procedures will direct the flight crew to avoid icing condition. Dispatch with inoperative WAI is not allowed into known or forecast icing conditions.

Consequences of Next Critical Failure

None.

30-11-02 Wing Anti-Ice (WAI) Control (Card and Switch)

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both WAI Valves are locked closed,
- WING ANTI-ICE selector remains OFF,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-11-02.

Proposal is consistent with FAA Policy Letter 40 (PL-40).

The ice protection function of the WAI system is controlled by a single control card in the R cardfile located in the electronic equipment bay. The card activates the system when the WAI control switch is selected ON, or when a signal is received from the primary ice detection system (PIDS) with the WAI switch selected to AUTO. Signals to the cardfile from the WAI control switch and PIDS are transmitted on 2 ARINC 629 systems buses from the remote data concentrator (RDC). The WAI Control Switch is located on the overhead panel. The three-position switch can be selected OFF, AUTO, or ON. The system is designed to be operated automatically in conjunction with the Primary Ice Detection System (PIDS). If PIDS is inoperative, manual control is available using the ON and OFF positions on the switch.

Consequences of Failure

Failure of the WAI card is indicated by the WAI CARD Status message.

The WAI VALVE CLOSED Caution message will also be displayed when the WAI card is inoperative.

This failure condition results in the loss of ability to control the WAI system.

For dispatch, maintenance action is required to lock both WAI valves in the closed position. The WAI selector switch must remain in the OFF position.

Wing anti-ice is not available. Airplane must not be operated into known or forecast icing conditions.

NOTE: See item 30-11-01 for comparison of legacy 777 and 777-9 WAI.

Consequences of Next Critical Failure

None.

30-11-03 Wing Anti-Ice (WAI) Control Pressure Sensors

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- a. Associated WAI Valve is locked closed,
- b. WING ANTI-ICE selector remains OFF,
- c. Airplane is not operated into known or forecast icing conditions, and
- d. Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 30-11-01.

Each wing has three WAI pressure sensors. Each pressure sensor is the same part number. All three measure the pressure in the WAI duct downstream of the WAI valve. One pressure sensor per wing is used for control, whereas the other two pressure sensors per wing are used for indication. Both "control" pressure sensors (one for left wing; one for right wing) are connected directly to the center airfoil and cowl ice protection systems (ACIPS) control card. The other two WAI "indication" pressure sensors for a given wing are connected to Remote Data Concentrators (RDC) and used solely by Displays and Crew Alerting (DCA) for monitoring WAI system failures for that wing.

As part of the on-ground Slat Overheat Protection system, which is also part of the WAI system, each wing has one temperature sensor with two independent sensing elements per sensor installed downstream of the respective WAI valve in addition to two indication pressure sensors. Both sensing elements measure the bleed air temperature being supplied to the respective wing. This temperature reading is used by DCA to determine if any other wing overheat conditions exist that require DCA to annunciated such conditions to the Air Supply Controller so that these overheat conditions can be isolated.

(Background is the same for both control and indication pressure sensors.)

Consequences of Failure

Failure of a WAI control pressure sensor is indicated by the WAI CONTROL PRESS SNSR L1 or R1 Status message.

Failure of a WAI control pressure sensor results in loss of control pressure feedback from the failed sensor(s) to the WAI control card.

For dispatch, maintenance action is required to lock the associated WAI valve(s) in the closed position. The WAI selector switch must remain in the OFF position.

Wing anti-ice is not available. Airplane must not be operated into known or forecast icing conditions.

NOTE: See item 30-11-01 for comparison of legacy 777 and 777-9 WAI.

Consequences of Next Critical Failure

None.

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30-11-04 Wing Anti-Ice (WAI) Indication Pressure Sensors

30-11-04-01 Left Sensors

30-11-04-01A

Interval	Installed	Required	Procedure
C	2	1	

One left WAI Indication Pressure Sensor (L2 or L3) may be inoperative.

30-11-04 Wing Anti-Ice (WAI) Indication Pressure Sensors

30-11-04-01 Left Sensors

30-11-04-01B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

Both left WAI Indication Pressure Sensors (L2 and L3) may be inoperative provided:

- Associated WAI Valve is locked closed,
- WING ANTI-ICE selector remains OFF,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

30-11-04 Wing Anti-Ice (WAI) Indication Pressure Sensors

30-11-04-02 Right Sensors

30-11-04-02A

Interval	Installed	Required	Procedure
C	2	1	

One right WAI Indication Pressure Sensor (R2 or R3) may be inoperative.

30-11-04 Wing Anti-Ice (WAI) Indication Pressure Sensors**30-11-04-02 Right Sensors****30-11-04-02B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

Both right WAI Indication Pressure Sensors (R2 and R3) may be inoperative provided:

- Associated WAI Valve is locked closed,
- WING ANTI-ICE selector remains OFF,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-11-03.

Each wing has three WAI pressure sensors. Each pressure sensor is the same part number. All three measure the pressure in the WAI duct downstream of the WAI valve. One pressure sensor per wing is used for control, whereas the other two pressure sensors per wing are used for indication. Both "control" pressure sensors (one for left wing; one for right wing) are connected directly to the center airfoil and cowl ice protection systems (ACIPS) control card. The other two WAI "indication" pressure sensors for a given wing are connected to Remote Data Concentrators (RDC) and used solely by Displays and Crew Alerting (DCA) for monitoring WAI system failures for that wing.

As part of the on-ground Slat Overheat Protection system, which is also part of the WAI system, each wing has one temperature sensor with two independent sensing elements per sensor installed downstream of the respective WAI valve in addition to two indication pressure sensors. Both sensing elements measure the bleed air temperature being supplied to the respective wing. This temperature reading is used by DCA to determine if any other wing overheat conditions exist that require DCA to annunciated such conditions to the Air Supply Controller so that these overheat conditions can be isolated.

(Background is the same for both control and indication pressure sensors.)

Consequences of Failure

Failure of a WAI indication pressure sensor is indicated by the WAI IND PRESS SENSOR L2, L3, R2 or R3 status messages.

Failure of one indication pressure sensor on one or both sides: Results in a loss of redundancy only. The WAI system will continue to operate normally.

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Failure of both indication pressure sensors on one or both sides: Results in loss of monitoring capability of WAI to displays and crew alerting (DCA) for the associated side.

For dispatch, maintenance action is required to lock the associated WAI valve(s) in the closed position. The WAI selector switch must remain in the OFF position.

Wing anti-ice is not available. Airplane must not be operated into known or forecast icing conditions.

NOTE: See item 30-11-01 for comparison of legacy 777 and 777-9 WAI.

Consequences of Next Critical Failure

None.

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30-11-05 Wing Anti-Ice (WAI) Temperature Sensors**30-11-05-01 Left Sensor Channels**

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with WAI TEMP SENSOR CHAN L Status message displayed.

30-11-05 Wing Anti-Ice (WAI) Temperature Sensors**30-11-05-02 Right Sensor Channels**

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with WAI TEMP SENSOR CHAN R Status message displayed.

30-11-05 Wing Anti-Ice (WAI) Temperature Sensors**30-11-05-03 Temperature Sensors**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Associated WAI Valve is locked closed,
 - WING ANTI-ICE selector remains OFF,
 - Airplane is not operated into known or forecast icing conditions, and
 - Flight remains within 120 minutes of landing at a suitable airport.
-

SUBSTANTIATION**Background**

New proposal for 777X.

As part of the on-ground Slat Overheat Protection system, which is also part of the WAI system, each wing has one temperature sensor with two independent sensing elements per sensor installed downstream of the respective WAI valve in addition to two indication pressure sensors. Both sensing elements measure the bleed air temperature being supplied to the respective wing. This temperature reading is used by DCA to determine if any other wing overheat conditions exist that require DCA to annunciated such conditions to the Air Supply Controller so that these overheat conditions can be isolated.

Consequences of Failure

Failure of a single channel of a wing anti-ice temperature sensor is indicated by the WAI TEMP SENSOR CHAN L or R status message.

Results in loss of redundancy only. The WAI system will continue to operate normally with the remaining temperature sensor channel.

Loss of both channels of a WAI temperature sensor is indicated by the WAI TEMP SENSOR L or R status message.

Results in loss of WAI temperature sensor function on the associated side.

For dispatch, maintenance action is required to lock the associated WAI valve(s) in the closed position. The WAI selector switch must remain in the OFF position.

Wing anti-ice is not available. Airplane must not be operated into known or forecast icing conditions.

NOTE: See item 30-11-01 for comparison of legacy 777 and 777-9 WAI.

Consequences of Next Critical Failure

None.

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30-21-01 Engine Anti-Ice (EAI) Valves**30-21-01A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative EAI Valve is locked closed,
 - Opposite EAI Card operates normally,
 - At least one opposite EAI Control Pressure Sensor operates normally,
 - At least one opposite EAI Indication Pressure Sensor operates normally,
 - Associated Ignition System operates normally,
 - Associated EAI selector remains OFF,
 - Airplane is not operated into known or forecast icing conditions, and
 - Flight remains within 120 minutes of landing at a suitable airport.
-

30-21-01 Engine Anti-Ice (EAI) Valves**30-21-01B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative EAI Valve is deactivated in mid-position,
 - Opposite EAI Card operates normally,
 - At least one opposite EAI Control Pressure Sensor operates normally,
 - At least one opposite EAI Indication Pressure Sensor operates normally,
 - Both associated Engine Fan Case Overheat Detection Loops operate normally,
 - Associated High Pressure Turbine Active Clearance Control (HPTACC) Valve operates normally,
 - Associated Low Pressure Turbine Active Clearance Control (LPTACC) Valve operates normally,
 - EEC Normal Mode operates normally,
 - Associated High Pressure Shutoff Valve (HPSOV) is considered inoperative,
 - Associated EAI selector remains ON, and
 - Appropriate performance adjustments are applied.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-21-01.

The 777-9 is powered by the General Electric GE9X engine type.

The Engine Anti-Ice (EAI) Systems prevent ice buildup on the leading edge of the engine cowls. There are two engine thermal anti-ice systems on each airplane: one on the left engine and one on the right engine. The EAI system is part of the airfoil and cowl ice protection systems (ACIPS), which consists of the WAI system, the left and right EAI systems and three ACIPS control cards in the electrical and electronics (E/E) bay which receive inputs from the primary ice detection system (PIDS) over two ARINC 629 buses from remote data concentrators (RDCs) and provide for control and indication of left EAI, WAI and right EAI systems. The left and right EAI systems for General Electric GE9X series engines provide engine bleed air to the engine inlet leading edge, based on the bleed system using a mixture of 4th and 11th stage bleed ports. (Note: the 777-300ER EAI system was supplied by a dedicated high-pressure engine bleed port with a flow regulating/shutoff valve and controller.)

The protected portions of the left and right engine inlets are similar to that of the 777-300ER. The EAI valve is controlled by a valve controller which is mounted on the valve housing. Regulation of the valve is based on a flow schedule to provide the required heat for each phase of flight, e.g., climb, hold, descent, etc. Control feedback for the EAI valve is provided by dual, redundant pressure sensors installed in the EAI ducting downstream of the EAI valve via the ACIPS control cards in the E/E Bay. The EAI system has new software located in the new left and right ACIPS cards, which provides for activation and regulation of each EAI valve based on ice detection input from the PIDS. The EAI system valves and pressure sensors are new parts designed for the 777-9.

The EAI selectors in the flight deck let the flight crew set automatic or manual control for each engine. With AUTO selected, the EAI system comes on when the ice detection system finds ice. The OFF and ON positions are for manual control.

One EAI Relay is installed per EAI system to provide engine inlet overheat protection, where each EAI Relay is controlled by DCA via redundant RDCs that provide a ground to the respective EAI Relay in the event that DCA determines potential inlet overheat conditions exist via high pressure and temperature (via the EAI Indication Pressure Sensors and the Intermediate Temperature Sensor) or in the event of loss of EAI control and indication. The associated EAI valve will close as a result of the activation of the EAI Relay to protect the engine inlet from an overheat condition.

The thrust management control function (TMCF) resets the target N1 based on switch position for takeoff and go-around when outside air temperature (OAT) is less than 10 degrees C. For all other conditions the actual position of the EAI valve is used. The Thrust Limit computed in both those configurations will be correct - if EAI is sensed on, (switch in the on state, and the valve fixed open) then the thrust rating will be decremented by a small amount to account for the small loss of thrust due to the air being diverted for the EAI function. If EAI is sensed off, (switch in the off position, valve locked closed) whether based on the switch for takeoff/go-around, or via the valve configuration reported for other flight phases, then that small decrement to the rating is not applied. The system operation varies depending on which EAI system component is failed. That operation is as follows when one valve is deactivated open due to an inoperative component:

EAI Valve – If the EAI valve is deactivated closed, the EAI system is inoperative and set to OFF and icing conditions must be avoided. For dispatch into icing, the GE-9X installation on 777X requires that the EAI valve be deactivated in a mid position. The valve is sensed open by the associated EAI Card using pressure reported by the EAI Pressure sensors (only one of the two sensors must be operating). The EAI Card reports the sensed position (open) to the Common Core System via the ARINC 629 system busses. The TMCF (residing in each Common Computing Resource cabinet) resets the target thrust when required. The high pressure shutoff valve (HPSOV) must be deactivated closed to preclude overpressure or overtemperature conditions, so a thrust increase is required in icing conditions to ensure adequate heat flux from the 4th stage bleed is provided. The EAI selector is positioned to AUTO for consistency with normal procedures; EAI PRESS FAULT L, R Caution message is displayed if degraded performance occurs. No flight crew action is required in response to this message.

Consequences of Failure

Failure of an engine anti-ice (EAI) valve is indicated by the EAI VALVE L or R Status message.

1. Dispatch with EAI valve locked closed: Ice protection for the associated engine cowl is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Associated engine anti-ice protection cannot be selected off. Appropriate performance adjustments must be applied. The HPSOV must be locked closed to protect downstream duct pressures with the EAI valve inoperative;

(Note: Legacy 777 imposed an ambient temperature limit of 100 degrees F to ensure that the reliability of the engine components located in the core compartment are not adversely affected by excessive heat buildup when the EAI valve is deactivated open. A similar restriction is not required for 777X with EAI valve locked in the mid position.)

Consequences of Next Critical Failure

1. Dispatch with EAI valve locked closed: Failure of remaining EAI system: Ice protection for both engines is not available. MMEL restrictions preclude operation in icing conditions.

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2. Dispatch with EAI valve deactivated in mid position: Failure of EAI duct:
The EAI duct leak/overheat detection system cannot shut off the associated system when a duct leak is detected. The EAI LEAK L, R Caution message will be displayed for flight crew action to reduce thrust on the associated engine.

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30-21-02 Engine Anti-Ice (EAI) Cards**30-21-02A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated EAI Valve is locked closed,
 - Opposite EAI Valve operates normally,
 - At least one opposite EAI Control Pressure Sensor operates normally,
 - At least one opposite EAI Indication Pressure Sensor operates normally,
 - Associated Ignition System operates normally,
 - Associated EAI selector remains OFF,
 - Airplane is not operated into known or forecast icing conditions, and
 - Flight remains within 120 minutes of landing at a suitable airport.
-

30-21-02 Engine Anti-Ice (EAI) Cards**30-21-02B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated EAI Valve is deactivated in mid-position,
 - Opposite EAI Valve operates normally,
 - At least one opposite EAI Control Pressure Sensor operates normally,
 - At least one opposite EAI Indication Pressure Sensor operates normally,
 - Both associated Engine Fan Case Overheat Detection Loops operate normally,
 - Associated High Pressure Turbine Active Clearance Control (HPTACC) Valve operates normally,
 - Associated Low Pressure Turbine Active Clearance Control (LPTACC) Valve operates normally,
 - EEC Normal Mode operates normally,
 - Associated High Pressure Shutoff Valve (HPSOV) is considered inoperative,
 - Associated EAI selector remains ON, and
 - Appropriate performance adjustments are applied.
-

SUBSTANTIATION**Background**

New MMEL item for 777X.

See item 30-21-01 for description of engine anti-ice (EAI) system.

Consequences of Failure

Failure of an engine anti-ice (EAI) control card results in the display of the EAI CARD L or R Status message.

The associated engine anti-ice valve must be considered inoperative.

1. Dispatch with EAI valve locked closed: Ice protection for the associated engine cowl is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Associated engine anti-ice protection cannot be selected off. Appropriate performance adjustments must be applied. The high pressure shutoff valve (HPSOV) must be locked closed to protect downstream duct pressures with the EAI valve inoperative;

Consequences of Next Critical Failure

1. Dispatch with EAI valve locked closed: Failure of remaining EAI system: Ice protection for both engines is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Failure of EAI duct: The EAI duct leak/overheat detection system cannot shut off the associated system when a duct leak is detected. The EAI LEAK L, R Caution message will be displayed for flight crew action to reduce thrust on the associated engine.

30-21-03 Engine Anti-Ice (EAI) Control Pressure Sensors**30-21-03-01 Left Engine****30-21-03-01A**

Interval	Installed	Required	Procedure
C	2	1	

One left EAI Control Pressure Sensor (L1 or L2) may be inoperative.

30-21-03 Engine Anti-Ice (EAI) Control Pressure Sensors**30-21-03-01 Left Engine****30-21-03-01B**

Interval	Installed	Required	Procedure
C	2	0	

Both left EAI Control Pressure Sensors (L1 and L2) may be inoperative provided:

- Both right EAI Control Pressure Sensors operate normally, and
 - Left EAI Valve is considered inoperative.
-

30-21-03 Engine Anti-Ice (EAI) Control Pressure Sensors**30-21-03-02 Right Engine****30-21-03-02A**

Interval	Installed	Required	Procedure
C	2	1	

One right EAI Control Pressure Sensor (R1 or R2) may be inoperative.

30-21-03 Engine Anti-Ice (EAI) Control Pressure Sensors**30-21-03-02 Right Engine****30-21-03-02B**

Interval	Installed	Required	Procedure
C	2	0	

Both right EAI Control Pressure Sensors (R1 and R2) may be inoperative provided:

- Both left EAI Control Pressure Sensors operate normally, and

- b. Right EAI Valve is considered inoperative.
-

SUBSTANTIATION

Background

New MMEL item for 777X.

Each engine has four EAI pressure sensors. Each sensor is the same part number. All four measure the pressure in the EAI duct downstream of the EAI valve. The left and right airfoil and ice protection systems (ACIPS) control cards use the information from two of the four pressure sensors for EAI control, whereas the other two pressure sensors are used for EICAS, and overheat protection. Each sensor pair is redundant. Only one sensor is required for each function.

Consequences of Failure

Loss of an EAI control pressure sensor is indicated by the EAI CONTROL PRESS SNSR L1, L2, R1 or R2 Status message.

Loss of one control pressure sensor:

Loss of redundancy only.

Loss of both control pressure sensors on one side:

With failure of both control pressure sensors on one side, the associated EAI card will not be able to calculate the anti-ice valve position.

The associated engine anti-ice valve must be considered inoperative.

1. Dispatch with EAI valve locked closed: Ice protection for the associated engine cowl is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Associated engine anti-ice protection cannot be selected off. MMEL requires performance adjustments. A takeoff, landing and enroute weight penalties are required. A fuel burn penalty is required since one valve is open throughout the flight. The high pressure shutoff valve (HPSOV) must be locked closed to protect downstream duct pressures with the EAI valve inoperative.

Consequences of Next Critical Failure

1. Dispatch with EAI valve locked closed: Failure of remaining EAI system: Ice protection for both engines is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Failure of EAI duct: The EAI duct leak/overheat detection system cannot shut off the associated system when a duct leak is detected. The EAI LEAK L, R Caution message will be displayed for flight crew action to reduce thrust on the associated engine.

30-21-04 Engine Anti-Ice (EAI) Indication Pressure Sensors**30-21-04-01 Left Engine****30-21-04-01A**

Interval	Installed	Required	Procedure
C	2	1	

One left EAI Indication Pressure Sensor (L3 or L4) may be inoperative.

30-21-04 Engine Anti-Ice (EAI) Indication Pressure Sensors**30-21-04-01 Left Engine****30-21-04-01B**

Interval	Installed	Required	Procedure
C	2	0	

Both left EAI Indication Pressure Sensors (L3 and L4) may be inoperative provided left EAI Valve is considered inoperative.

30-21-04 Engine Anti-Ice (EAI) Indication Pressure Sensors**30-21-04-02 Right Engine****30-21-04-02A**

Interval	Installed	Required	Procedure
C	2	1	

One right EAI Indication Pressure Sensor (R3 or R4) may be inoperative.

30-21-04 Engine Anti-Ice (EAI) Indication Pressure Sensors**30-21-04-02 Right Engine****30-21-04-02B**

Interval	Installed	Required	Procedure
C	2	0	

Both right EAI Indication Pressure Sensors (R3 and R4) may be inoperative provided right EAI Valve is considered inoperative.

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SUBSTANTIATION

Background

New MMEL item for 777X.

Each engine has four EAI pressure sensors. Each sensor is the same part number. All four measure the pressure in the EAI duct downstream of the EAI valve. The left and right airfoil and cowl ice protection systems (ACIPS) control cards use the information from two of the four pressure sensors for EAI control whereas the other two pressure sensors are used for EICAS and overheat protection. Each sensor pair is redundant. Only one sensor is required for each function.

Consequences of Failure

Loss of an EAI indication pressure sensor is indicated by the EAI IND PRESS SENSOR L3, L4, R3 or R4 Status message.

Loss of one indication pressure sensor:

Loss of redundancy only.

Loss of both indication pressure sensors on one side (L3 & L4 or R3 & R4):

The green EAI indications on EICAS will not be displayed when EAI is commanded on. EAI indications on the AIR synoptic page may also be inoperative. The associated engine anti-ice valve must be considered inoperative.

1. Dispatch with EAI valve locked closed: Ice protection for the associated engine cowl is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Associated engine anti-ice protection cannot be selected off. MMEL requires performance adjustments. A takeoff, landing and enroute weight penalties are required. A fuel burn penalty is required since one valve is open throughout the flight. The high pressure shutoff valve (HPSOV) must be locked closed to protect downstream duct pressures with the EAI valve inoperative.

Consequences of Next Critical Failure

1. Dispatch with EAI valve locked closed: Failure of remaining EAI system: Ice protection for both engines is not available. MMEL restrictions preclude operation in icing conditions.
2. Dispatch with EAI valve deactivated in mid position: Failure of EAI duct: The EAI duct leak/overheat detection system cannot shut off the associated system when a duct leak is detected. The EAI LEAK L, R Caution message will be displayed for flight crew action to reduce thrust on the associated engine.

30-31-01 Pitot Probe Heater Systems**30-31-01-01 Right Pitot Heater**

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Left and Center Pitot Probes are inspected before each departure,
- Left and Center Pitot ADMs operate normally,
- Left and Center Pitot Probe Heater Systems operate normally,
- Left, Center and Right Static ADMs operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally, and
- Approach minimums do not require its use.

30-31-01 Pitot Probe Heater Systems**30-31-01-02 Left Pitot Heater**

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Right and Center Pitot Probes are inspected before each departure,
- Right and Center Pitot ADMs operate normally,
- Right and Center Pitot Probe Heater Systems operate normally,
- Left, Center and Right Static ADMs operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally, and
- Approach minimums do not require its use.

30-31-01 Pitot Probe Heater Systems**30-31-01-03 Center Pitot Heater**

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Left and Right Pitot Probes are inspected before each departure,
- Left and Right Pitot ADMs operate normally,
- Left and Right Pitot Probe Heater Systems operate normally,

- d. Left, Center and Right Static ADMs operate normally,
 - e. Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally,
 - f. Approach minimums do not require its use,
 - g. Airplane is not operated in visible moisture,
 - h. Airplane is not operated into known or forecast icing conditions, and
 - i. Flight remains within 120 minutes of landing at a suitable airport.
-

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 30-31-01.

The air data sensor heat system provides for electrical anti-icing of air data reference system (ADRS) sensors, including Pitot probes, angle of attack (AOA) sensors (vane and case), and total air temperature (TAT) probe, located on the left and right forward lower fuselage. The ADRS architecture and components are new to the 777-9 but similar to 777-300ER and 787 ADRS. The pitot probes are similar to the 777-300ER pitot probes. The AOA sensors are similar to the 787 and 777-300ER AOA Sensors. The TAT Probe is the same as the 787 TAT Probe. All of these probes and sensors use the same anti-ice heating circuitry as their predecessor aircraft.

Flush-mounted static ports are not heated. Air data sensors are automatically heated by electrical resistance heater elements in the respective sensor assemblies. Heat control to all air data sensors is provided by the air data reference functions (ADRFs) via the common data network (CDN).

Two pitot probes are installed on the right side of the forward lower lobe and one pitot probe is installed on the left side. System software is hosted by, and controlled through, the Integrated Flight Control Electronics (IFCE). Similar to 787 design, there are no active flight deck control interfaces, i.e. switches, for the air data sensor heat system.

Airplane condition monitoring function (ACMF) ground test AIR DATA HEATER tests the pitot probe heater function: The left heater test exercises the left pitot probe heater and left AOA sensor heater. The center heater test exercises the center pitot probe heater and TAT probe heater. The right heater test exercises the right pitot probe heater and right AOA sensor heater.

Each Air Data Reference Function (ADRF) receives static pressure data, pitot pressure data, TAT data (from the airframe probe and engine probes), probes and sensor heater status, and data parameters related to static source error correction (SSEC) (AOA, pitch angle, roll angle, lateral linear acceleration, normal linear acceleration, vertical speed, speedbrake handle position, stabilizer position, air/ground, gear position, and flap position) through the Common Data Network (CDN). Corrections are made to the static pressure and pitot pressure input data and then processed for air data computations. Each ADRF calculates a single set of air data parameters. The primary set of air data parameters is calculated from all three air pressure sensor pairs (left, right, and center) using a redundancy management algorithm developed and certified on the Boeing 777/787 airplanes, and from all three temperature element pairs (left engine, airframe, right engine) using a redundancy management algorithm developed for the Boeing 787 airplane. Similar to 787, when voted air data are detected as invalid or when the AIR DATA/ATT instrument source switch is placed in the ALT position, a synthetic airspeed based on angle of attack (AOA SPD) and GPS altitude are displayed on one or both PFDs. The center air data modules (ADMs) (pitot and static) are also hard-wired to the integrated standby flight display (ISFD).

The 777X incorporates the capability to power the C pitot heater via the ram air turbine (RAT). This feature enables Normal flight control mode to be regained after about a 1 minute reversion to secondary mode. This time allows the RAT to deploy and provide sufficient power to the C pitot heater. AOA SPD will be displayed automatically during this time if the AIR DATA/ATT switch remains in the AUTO position. This capability is similar to 787, and an enhancement relative to legacy 777. An electrical load management system (ELMS) P230 relay is added, along with supporting wiring and logic changes, to implement this capability.

Consequences of Failure

Failure of a pitot probe heater is indicated by the HEAT PITOT C, L or R Status message.

1. Left or right pitot probe heat: Voted airspeed will be available and will be based on the remaining two operating pitot ADMs whose respective pitot probes are heated. The associated probe will not be heated and the HEAT PITOT FAULT L, R Caution message will be displayed.
2. Center pitot probe heat: Voted airspeed will be available and will be based on the remaining two operative pitot ADMs whose respective pitot probes are heated. The associated probe will not be heated and the HEAT PITOT FAULT C Caution level message will be displayed. Pressure data from the center pitot ADM will not be used in the voted airspeed determination because the pitot heat is inoperative. Operation must be restricted to non-icing conditions because the Center Pitot ADM will continue to be used by the Standby Airspeed Display regardless of Center Pitot Probe heater status.

Consequences of Next Critical Failure

Failure of an additional pitot ADM or pitot heater:

The voted air data will continue to be valid and will be based on the remaining operating pitot ADM whose pitot probe is heated.

Degradation of autoland status and display of the NO AUTOLAND Advisory message. NO AUTOLAND Caution will display if failure occurs during approach.

Loss of voted airspeed:

A plugged or disconnected pitot ADM will result in a loss of voted airspeed. When no voted airspeed is available, synthetic airspeed will be displayed on the PFDs and HUDs. This condition is annunciated by the AIRSPEED DATA FAULT Caution message, with PFD and HUD annunciations AOA SPD.

Flight controls cannot operate in normal mode without valid voted airspeed. With loss of voted airspeed, flight controls will revert to secondary mode and the FCTL IN SEC MODE Caution message and NO AUTO-LAND Advisory messages will be displayed.

There are rare failures that can cause multiple ADMs to output identical values that are erroneous. This situation could occur due to maintenance errors such as pneumatic tubes being disconnected from multiple static ADMs, or when multiple pitot tubes are equally blocked due to a common mode event such as overwhelming icing, mud daubers or volcanic ash. The voting algorithms cannot determine that the resulting airspeed values are wrong so the erroneous information is displayed. The Flight Control Modules (FCMs) have a Common Mode Monitor (CMM) that compares the voted airspeed data with voted AOA and voted inertial data. When the difference between these values becomes excessive, the EICAS Warning message AIRSPEED UNRELIABLE is displayed. Because the CMM could be triggered by a common mode error in the voted airspeed or a common mode error in the voted AOA, the FCMs will continue to output the voted airspeed as valid. If the redundancy management algorithm subsequently detects a single Pt or Ps miscompare, Status message PITOT ADM L/R/C or STATIC ADM L/R/C is displayed. If the redundancy management algorithm cannot determine Pt or Ps from the available sources, the voted airspeed (if Pt or Ps) and voted altitude (if Ps) and/or voted airspeed (if Pt or Ps) is declared invalid. The AIRSPEED DATA FAULT Caution message (for Pt) or AIR DATA SYS FAULT Caution message (for Ps) and synthetic airspeed (AOA SPD) is displayed on PFDs and HUDs. GPS altitude will display on PFDs and HUDs if voted altitude is set invalid. In this condition, primary flight controls will revert to secondary mode which may cause the loss of the autopilot and flight directors.

Loss of all flight deck displays: there is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed*, and heading remain available. *(ISFD airspeed is inoperative (flagged) if C pitot heater or ADM is inoperative.) Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

Draft
Feb 26, 2026

30-33-01 Total Air Temperature (TAT) Probe Heater System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- TAT probe is inspected before each departure,
- T12 TAT sensors A and B are verified to operate normally for both engines,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

The TAT probe installation is a single probe on the left forward fuselage. The probe is automatically heated by an electrical heater element, controlled by the electrical load management system (ELMS). There are no flight deck controls for the probe heat system. The probe is unheated on the ground and heated in air. On ground, the probe is commanded on when speed is greater than 50 kts and is commanded on in air. The TAT probe is a dual element aspirated probe with two analog outputs. The output signal from each element is transmitted directly to the aircraft common data network (CDN) through separate remote data concentrators (RDCs). Each air data reference function (ADRF) converts the signals to temperature and applies redundancy management algorithms to available TAT sources to produce the voted TAT value.

Consequences of Failure

Failure of the TAT probe heater is indicated by the HEAT TAT Status message.

The associated probe will not be heated, resulting in unreliable TAT signals from both sensors in the probe when icing conditions are encountered. MMEL restricts flight to remain clear of known or forecast icing conditions when dispatching with TAT probe heat inoperative.

Consequences of Next Critical Failure

Icing conditions encountered: Flight deck indication of TAT, SAT, and TAS may be erroneous due to probe icing contamination. The engine EECs automatically revert to individual T12 for temperature-dependent engine control functions.

Colder airframe TAT probe temperature will bias ADRS voted TAT which will affect the autothrottle computed thrust setting. This will result in temporary degradation of autothrottle performance resulting in lower thrust.

30-41-01

Flight Deck Forward Window Primary Heater Systems

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Both Flight Deck Side (No. 2) Window Heater Systems operate normally.
- Associated FWD WINDOW HEAT switch remains off,
- Airplane is not operated into known or forecast icing conditions, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 30-41-01.

The 777-9 flight deck window heat system and its installation features are similar to the 777-300ER.

The window heat system prevents ice and fog on the forward (No. 1) flight deck windows and prevents fogging on the side (No. 2) and aft (No. 3) flight deck windows. The windows are heated by an electrically resistive material laminated in each window. Window heat is thermostatically controlled by two Window Heat Control Units (WHCU) located in the electrical equipment bay. The left WHCU controls heat for the left forward window and the right side and aft windows. The right WHCU controls heat for the right forward window and the left side and aft windows. Flight deck switches on the overhead panel allow the flight crew to select window heat ON or off. With the WINDOW HEAT switches selected ON, window heat operates as soon as electrical power is available. A backup heating circuit provides for anti-fog capability on the forward windows only. BACKUP WINDOW HEAT switches on the P61 overhead panel allow the flight crew control of backup window heating.

Consequences of Failure

Failure of a forward window primary heater is indicated by the WINDOW HEAT L, R FWD Status messages, and WINDOW HEAT INOP LF, RF Advisory messages, resulting in the loss of anti-ice protection for the associated window. The backup system continues to provide anti-fog protection. The other forward window is fully protected. Both flight deck side (No. 2) window heater systems are required to operate normally for dispatch.

Consequences of Next Critical Failure

The MMEL restriction requiring flight to remain clear of known or forecast icing conditions precludes loss of visibility due to icing on both forward windows in the event of a subsequent window heat failure.

1. Failure of the backup heating system on associated window: Both anti-ice and anti-fog protection are lost on the associated window. The other forward window is fully protected. This condition is annunciated by the status message WINDOW HEAT SYS L, R, which precludes subsequent dispatch.
2. Failure of primary heater on the other forward window: Both front windows do not have anti-ice protection, but retain anti-fog by the backup system.
3. Failure of WHCU on opposite side: Both front windows do not have anti-ice protection, but anti-fog is retained by the backup system on one side. Anti-fog protection is lost on the No. 2 and No. 3 windows on one side (same side as original No. 1 primary heater failure).

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30-41-02 Flight Deck Side (No. 2) Window Heater Systems

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Both Flight Deck Forward Window Primary Heater Systems operate normally, and
- Associated SIDE WINDOW HEAT switch remains off.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-41-02.

The 777-9 flight deck window heat system and its installation features are similar to the 777-300ER.

The window heat system prevents ice and fog on the forward (No. 1) flight deck windows and prevents fogging on the side (No. 2) and aft (No. 3) flight deck windows. The windows are heated by an electrically resistive material laminated in each window. Window heat is thermostatically controlled by two Window Heat Control Units (WHCU) located in the electrical equipment bay. The left WHCU controls heat for the left forward window and the right side and aft windows. The right WHCU controls heat for the right forward window and the left side and aft windows. Flight deck switches on the overhead panel allow the flight crew to select window heat ON or off. With the WINDOW HEAT switches selected ON, window heat operates as soon as electrical power is available. A backup heating circuit provides for anti-fog capability on the forward windows only. BACKUP WINDOW HEAT switches on the P61 overhead panel allow the flight crew control of backup window heating.

Consequences of Failure

Failure of a flight deck side (No. 2) window heater is indicated by the WINDOW HEAT L, R SIDE Status message and WINDOW HEAT INOP LS, RS Advisory message.

Failure of a side No. 2 window heater results in the loss of anti-fog protection for the associated window.

Consequences of Next Critical Failure

- Failure of WHCU on same side: The adjacent No. 3 window anti-fog operates normally; the adjacent No. 1 window loses anti-ice protection; the opposite No. 1 window heat operates normally; and the opposite No. 2 and No. 3 windows lose anti-fog protection.

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2. Failure of WHCU on opposite side: The adjacent No. 3 window loses anti-fog protection; the adjacent No. 1 window heat operates normally; the opposite No. 1 window loses anti-ice protection; and the opposite No. 2 and No. 3 window anti-fog operates normally.

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30-41-03 Flight Deck Aft (No. 3) Window Heater Systems

Interval	Installed	Required	Procedure
D	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-41-03.

The 777-9 flight deck window heat system and its installation features are similar to the 777-300ER.

The window heat system prevents ice and fog on the forward (No. 1) flight deck windows and prevents fogging on the side (No. 2) and aft (No. 3) flight deck windows. The windows are heated by an electrically resistive material laminated in each window. Window heat is thermostatically controlled by two Window Heat Control Units (WHCU) located in the electrical equipment bay. The left WHCU controls heat for the left forward window and the right side and aft windows. The right WHCU controls heat for the right forward window and the left side and aft windows. Flight deck switches on the overhead panel allow the flight crew to select window heat ON or off. With the WINDOW HEAT switches selected ON, window heat operates as soon as electrical power is available. A backup heating circuit provides for anti-fog capability on the forward windows only. BACKUP WINDOW HEAT switches on the P61 overhead panel allow the flight crew control of backup window heating.

Consequences of Failure

Failure of one or both No. 3 window heaters results in the loss of anti-fog protection for the associated window(s).

Consequences of Next Critical Failure

1. Failure of WHCU on the same side: The adjacent No. 2 window anti-fog operates normally; the adjacent No. 1 window loses anti-ice protection; the opposite No. 1 window heat operates normally; and the opposite No. 2 and No. 3 windows lose anti-fog protection.
2. Failure of WHCU on opposite side: The adjacent No. 2 window loses anti-fog protection; the adjacent No. 1 window heat operates normally; the opposite No. 1 window loses anti-ice protection; and the opposite No. 2 and No. 3 window anti-fog operates normally.

Federal Aviation Administration (FAA)**ATA 30****777-9 Master Minimum Equipment List****Section 2****30-41-04 WINDOW HEAT Switch Lights****30-41-04-01 INOP Lights**

Interval	Installed	Required	Procedure
C	4	0	

30-41-04 WINDOW HEAT Switch Lights**30-41-04-02 ON Lights**

Interval	Installed	Required	Procedure
C	4	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-41-04.

The 777-9 flight deck window heat system and its installation features are similar to the 777-300ER.

The WINDOW HEAT switches are located on the flight deck overhead panel. There are four switches, one for each forward (No. 1) window and one for each pair of side/aft windows (No. 2 & No. 3). The INOP lights are incorporated in the push-button type switches. Inoperative window heat is annunciated on EICAS with individual advisory and status messages for L and R forward windows and L and R side windows (WINDOW HEAT L or R, FWD or SIDE).

Consequences of Failure

INOP Lights: In the event of window heat failure, the associated INOP light will not illuminate.

ON Lights: The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

INOP Lights: Failure of a window heater or window heat control unit (WHCU): Failure of a WHCU affects one forward window and the two side windows on the opposite side. Advisory messages are provided to alert the flight crew to a failure of window heat on the forward (No. 1) or side (No. 2 only) windows. Backup window heat is available to provide anti-fog on the forward windows. There is no backup for side window heat.

ON Light: None.

30-42-01 Windshield Wipers

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Airplane is not operated in precipitation within 5 statute miles of the airport of departure or intended landing, and
 - Approach minimums do not require its use.
-

30-42-01 Windshield Wipers**30-42-01-01 Low Speed Function**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided associated High-Speed Function operate normally.

30-42-01 Windshield Wipers**30-42-01-02 High-Speed Function****30-42-01-02A**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided associated Low-Speed Function operates normally.

30-42-01 Windshield Wipers**30-42-01-02 High Speed Function****30-42-01-02B**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Both Low-Speed functions operate normally, and

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- b. Airplane is not operated into known or forecast precipitation of moderate or greater intensity within 5 statute miles of the airport of departure or intended landing.

30-42-01 Windshield Wipers

30-42-01-03 Intermittent Function

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 30-42-01.

The windshield rain removal system for the #1 forward windshields consists of windshield wipers, which are sufficient to meet all visibility requirements of 14 CFR 25.773(b) for rain removal. The windshield rain removal system and its installation interfaces are identical to the 777-300ER. No certification credit is taken for the hydrophobic coating on #1 windshields. There are no changes to the system interfaces, performance or functionality, including the windshield wiper motor assembly.

Both forward flight deck windows have a three-speed electrically powered wiper, activated by separate switches on the overhead panel. The wipers are independent to allow continued operation of one wiper in the event of a single failure.

Consequences of Failure

1. Failure of one or both wipers: Visibility through associated window is reduced in precipitation. MMEL restricts operation to remain clear of precipitation in terminal areas.
2. Failure of high or low wiper speed on one or both sides: Remaining wiper speed function on each side provides adequate wiper control on the associated window.

Consequences of Next Critical Failure

1. Dispatch with one or both wipers inoperative:
No additional critical failures are identified. The MMEL restricts operation to remain clear of precipitation in terminal areas.
2. Dispatch with high or low wiper speed inoperative on one or both sides:
Failure of an additional wiper speed function results in loss of continuous wiper operation on the affected side (intermittent may be used if available).
At least one wiper speed remains available on the other windshield.

30-71-01**Drain Mast Heaters**

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Associated galley chiller is deactivated,
- Associated galley service and lavatory sinks are not used, and
- Associated galley and lavatory sink water supply shutoff valves are closed.

[For Humidification System\(s\) installed:](#)

- Associated Humidification System(s) is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-71-01.

Gray waste water from the lavatory wash basins and galley sinks is carried by drain lines to two heated drain masts where it is discharged overboard. The forward drain mast discharges waste water from lavatory and galley drains forward of and including the door 2 service area. The aft drain mast discharges waste water from drains located aft of and including the door 3 service area. The drain masts are electrically heated (28 VAC on ground and 115 VAC inflight) whenever airplane power is available.

Consequences of Failure

Waste water discharged from the associated drain mast would freeze at cruise altitudes, creating an ice blockage that would prevent further drainage. Affected drains would become unusable.

Consequences of Next Critical Failure

None identified, since the MMEL provisions prevent water supply to the affected drainage system(s).

30-81-01 Ice Detectors

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 30-81-01.

A Primary Ice Detection System (PIDS) consists of ice detectors, circuitry, integral microprocessors and the associated software. The 777 legacy ice detectors are connected to the airfoil and ice protection system (ACIPS) cards via analog paths while the 777X ice detectors are connected to the RDCs via analog wire and then to the ACIPS cards via A664/A629/A429 paths. The ice detectors are similar to the 777-300ER ice detectors but have modified circuitry to meet new hardware qualification requirements. Integral microprocessors in the left and right ice detectors provide independent discrete signals to the left and right ACIPS control cards at the onset of icing and at the end of icing. An icing signal from either ice detector can activate the WAI and both left and right EAI systems automatically. The PIDS will incorporate new software logic in the ice detectors and in the ACIPS cards to activate the WAI and EAI systems at the same time, which is different from the timing logic of the 777-300ER. The PIDS will also incorporate new software, and it will use temperature data from the air data reference system (ADRS) to eliminate Zone of Non-Detection (ZND) effects. A ZND may occur when the airplane is operating in the temperature band just below freezing, where ice accretion may occur on the wing but not be detected by the ice detectors due to local negative pressure gradients on the wing.

Ice detectors incorporate fail-safe logic, allowing a failed detector to disable itself while the remaining detector continues to provide automatic operation of the ice protection systems. The ice detectors are inhibited on the ground but are automatically activated at takeoff and throughout all flight phases. Flight deck control interfaces, i.e. switches (providing an AUTO function for PIDS activation) for the WAI and EAI system are similar to 777-300ER.

Consequences of Failure

Ice detector failures are annunciated by the ICE DETECTOR L or R Status message or ICE DETECTORS Caution message.

One or both detectors inoperative: Automatic ice detection and anti-ice actuation is inoperative. Flight crew operates EAI and WAI manually in accordance with the ICE DETECTORS non-normal checklist.

Consequences of Next Critical Failure

Both detectors inoperative: Failure of either EAI or WAI. System failure of EAI or WAI are annunciated by WAI VALVE CLOSED or EAI VALVE CLOSED L, R Caution message, and flight crew follows associated non-normal checklists.

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31-09-01 Systems Cardfile ARINC Signal Gateway (ASG) Cards

31-09-01-01 Left System Cardfile ASG Cards

31-09-01-02 Right System Cardfile ASG Cards

31-09-02 Systems Cardfile Power Supply

31-09-02-01 Left Systems Cardfile (LSCF) Power Supply
Pre-Regulators

31-09-02-02 Right Systems Cardfile (RSCF) Power Supply
Pre-Regulators

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31-09-01 Systems Cardfile ARINC Signal Gateway (ASG) Cards**31-09-01-01 Left System Cardfile ASG Cards**

Interval	Installed	Required	Procedure
C	2	1	

One Left System Cardfile ASG Card may be inoperative provided:

- Both Right System Cardfile ASG cards operate normally,
 - Right ECSMC operates normally, and
 - Body Duct Leak Detection Loop 2 operates normally.
-

31-09-01 Systems Cardfile ARINC Signal Gateway (ASG) Cards**31-09-01-02 Right System Cardfile ASG Cards**

Interval	Installed	Required	Procedure
C	2	1	

One Right System Cardfile ASG Card may be inoperative provided:

- Both Left System Cardfile ASG Cards operate normally,
 - Left ECSMC operates normally, and
 - Body Duct Leak Detection Loop 1 operates normally.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 31-09-01.

The Signal Gateway Cards or ARINC Signal Gateway (ASG) for the System Cardfiles serve as the communications gateways between the ARINC 429 and ARINC 629 buses. Each of the left and right cardfiles contain left and right ASG cards. Each ASG card connects to either the left or right ARINC 629 system busses.

Consequences of Failure

Failure of a systems cardfile ARINC signal gateway (ASG) card is indicated by any one of the following Status messages:

L SYS CARD FILE ASG L
 L SYS CARD FILE ASG R
 R SYS CARD FILE ASG L
 R SYS CARD FILE ASG R

System redundancy will be decreased with the loss of one ASG card.

Communication through the gateway associated with the EICAS message will be lost. For example, with the EICAS status message "R SYS CARD FILE ASG L" displayed, the gateway between the right ARINC 629 Systems bus and the left System Cardfile will be lost. All ARINC 629/429 data transfer on the right systems bus for the left cardfile will stop. Communication with the left System Cardfile will continue to be available via the left Systems bus.

NOTE: Provisos for left ECSMC and Body Duct Leak Detection Loop 1 were added to reflect the requirements for those items for the opposite side ASG cards to operate normally.

Consequences of Next Critical Failure

UNDETECTED CORRUPTED DATA (UCD) ON REMAINING CARDFILE ASG CARD:

The hazard classification for an inoperative ASG card in combination with UCD on the remaining ASG card in that cardfile has not been assessed. However, the probability of undetected corrupted data (UCD) on the remaining cardfile ASG card is extremely improbable (on the order of $1.0E-16$).

BOTH LEFT SYSTEM CARDFILE ASG CARDS INOPERATIVE (Ref. S&M ELEC-10):

Results in loss of left cardfile including ASG and power supply. The following Status messages will be displayed (Hazard classification is 'Major'):

L SYS CARD FILE ASG L
L SYS CARD FILE ASG R
L SYS CARD FILE POWER 1
L SYS CARD FILE POWER 2

Loss of Left main engine fire detection function. Fire Card will not activate flight deck fire indications (fire handle, fuel control switch light and master warning light), will not unlock the Eng 1 fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 1, 3 and 5 when a fire occurs in main engine 1. Hazard classification is 'Minor'.

Loss of APU fire detection function, loss of the fire shutdown command from the APU fire card to the APU controller when an APU fire or overheat condition occurs, and the loss of the automatic discharge command of the APU fire bottle when the aircraft is in unattended (aircraft on ground and main engines are not running) mode and an APU fire occurs. The APU fire card also will not unlock the APU fire handle, will not illuminate the APU fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 1 and 3 when a fire occurs in the APU compartment. Hazard classification is 'Minor'.

Loss of ability to determine 'Fast on Ground' (i.e. both trucks untilted after touchdown). The AUTO SPDBRAKE FAULT advisory will annunciate on EICAS, but the speedbrakes will still deploy automatically via MLG strut compression if the lever is armed. Some control laws will transition to on-ground at 5ft gear altitude. All other effects are limited to loss of redundancy or will only impact maintenance functionality. Hazard classification is 'Minor'.

Increased potential to set FUEL TEMP HIGH (C) after descent to planned destination airport and if in a hold or subsequent diversion due to hot fuel in left main tank as a result of fuel depletion to reserve quantities. Hazard classification is 'Minor'.

Loss of all digital data from HYDIM HCL and HYDIM HL. Loss of Center System Demand Pump (ADP 1) and Loss of Left System Demand Pump (ACMP) and associated indications. ADP C2 will operate continuously without Pressure or Temperature indication. HYD DEM FAULT C1 Advisory message is displayed. HYD DEM FAULT L Advisory message is inoperative. Loss reserve brakes and steering isolation functions. The majority of left and center hydraulic system indication is lost. Hazard classification is 'Minor'.

Left EAI valve defaults to full-open due to loss of power to the valve. At the same time – complete loss of Left ACIPS Control Card due to complete loss of power to Left Cardfile. If this scenario occurs when the Left EAI valve is full-open at high bleed temperature (i.e. a HOLD) this will lead to the Left EAI Indication Pressure Sensors and Left Intermediate Temperature Sensor indicating potential inlet overheat conditions and then DCA inlet overheat protection logic commanding the Left EAI Backup Relay to power the Left EAI valve closed to prevent an overheat of the left engine inlet. This leads to annunciated loss of the Left EAI system. Hazard classification is 'Minor'.

If GPWS RUNWAY OVRD is selected prior to selection of RWY EXIT, then Autobrake RWY EXIT is inoperative and not selectable. If RWY EXIT is armed, BTE will disengage (OFF) and will be inhibited when GPWS RUNWAY OVRD is selected. The Autobrake Indicator will reflect autobrake is OFF. AUTOBRAKE EXIT OFF (A) will be displayed. If GPWS RUNWAY OVRD is not selected, then RWY EXIT remains operational, but desired speed may not be achieved for the selected runway, autobrakes continue to apply brakes until airplane stops or manual brakes are applied. Hazard classification is 'Minor'.

Loss of NGS. NITROGEN GEN SYS Status message will be displayed. Hazard classification is 'Minor'.

BOTH RIGHT SYSTEM CARDFILE ASG CARDS INOPERATIVE (Ref. S&M ELEC-11):

Results in loss of right cardfile including ASG and power supply. The following Status messages will be displayed (Hazard classification is 'Major'):

R SYS CARD FILE ASG L
R SYS CARD FILE ASG R
R SYS CARD FILE POWER 1

R SYS CARD FILE POWER 2

Loss of Right main engine fire detection function. Fire Card will not activate flight deck fire indications (fire handle, fuel control switch light and master warning light), will not unlock the Eng 2 fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 2, 4 and 6 when a fire occurs in main engine 2. Hazard classification is 'Minor'.

The failure results in loss of the Right and Center DLODS Cards power and functionality (no detection/annunciation). The Right and Center DLODS Card's associated loops EICAS Status messages will be set by DCA after 60 seconds (due to the loss of communication). The left DLODS Card will reconfigure to OR logic and function as a single loop sub-system for the FWD Body, AFT Body, Right Wheel Well(Center Body), Left Fancase, Left Strut, Left Wing, and Left Pack Bay detection/annunciation. The failure will result in complete loss of detection/annunciation for Right Fancase, Right Strut, Right Wing, and Right Pack Bay sub-systems. Hazard classification is 'Minor'.

Loss of ability to determine 'Fast on Ground' (i.e. both trucks untilted after touchdown). The AUTO SPDBRAKE FAULT advisory will annunciate on EICAS, but the speedbrakes will still deploy automatically via MLG strut compression if the lever is armed. Some control laws will transition to on-ground at 5ft gear altitude. All other effects are limited to loss of redundancy or will only impact maintenance functionality. Hazard classification is 'Minor'.

Increased potential to set FUEL TEMP HIGH (C) after descent to planned destination airport and if in a hold or subsequent diversion due to hot fuel in left main tank as a result of fuel depletion to reserve quantities. Hazard classification is 'Minor'.

Loss of all digital data from HYDIM HR and HYDIM HCR. Loss of Center System Demand Pump (ADP 3) and Loss of Right System Demand Pump (ACMP) and associated indications. HYD DEM FAULT C3 Advisory message is displayed. HYD DEM FAULT R Advisory message is inoperative. Significant loss of indication associated with the right hydraulic system. Hazard classification is 'Minor'.

Annunciated loss of WAI due to loss of power to Center ACIPS Control Card. Both Left and Right WAI Valves will default closed due to loss of power. Right EAI valve defaults to full-open due to loss of power to the valve. At the same time – complete loss of Right ACIPS Control Card due to complete loss of power to Right Cardfile. If this scenario occurs when the Right EAI valve is full-open at high bleed temperature (i.e. a HOLD) this will lead to the Right EAI Indication Pressure Sensors and Right Intermediate Temperature Sensor indicating potential inlet overheat conditions and then DCA inlet overheat protection logic commanding the Right EAI Backup Relay to power the Right EAI valve closed to prevent an overheat of the right engine inlet. This leads to annunciated loss of the Right EAI system. Hazard classification is 'Minor'.

If GPWS RUNWAY OVRD is selected prior to selection of RWY EXIT, then Autobrake RWY EXIT is inoperative and not selectable. If RWY EXIT is armed, BTE will disengage (OFF) and will be inhibited when GPWS RUNWAY OVRD is selected. The Autobrake Indicator will reflect autobrake is OFF. AUTOBRAKE EXIT OFF (A) will be displayed. If GPWS RUNWAY OVRD is not selected, then RWY EXIT remains operational, but desired speed may not be achieved for the selected runway, autobrakes continue to apply brakes until airplane stops or manual brakes are applied. Hazard classification is 'Minor'.

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31-09-02 Systems Cardfile Power Supply

31-09-02-01 Left Systems Cardfile (LSCF) Power Supply Pre-Regulators

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated power supply pre-regulator is deactivated, and
- Alternate procedures are established and used.

31-09-02 Systems Cardfile Power Supply

31-09-02-02 Right Systems Cardfile (RSCF) Power Supply Pre-Regulators

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated power supply pre-regulator is deactivated.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 31-09-02, simplified for 31-09-02-02 (no dependency on air/ground system for 777X).

Each cardfile has two power supplies which are powered from the 28 VDC and Hot Battery buses.

Consequences of Failure

Failure of a left systems cardfile power supply is indicated by the L SYS CARD FILE POWER 1 or 2 Status message.

Failure of a right systems cardfile power supply is indicated by the R SYS CARD FILE POWER 1 or 2 Status message.

System redundancy will be decreased. Failure of one power supply pre-regulator card in each cardfile will leave one available for cardfile operation.

Consequences of Next Critical Failure

The next critical failure is the loss of the remaining operable power supply pre-regulator card in associated cabinet. Failure of both power supplies, will cause complete loss of functionality of the cardfile. All member system cards would become inoperative.

FOR BOTH POWER SUPPLIES FAILED IN THE LEFT SYSTEMS CARDFILE (Ref. S&MF ELEC-10): The following functions will be affected and messages will be displayed:

Results in loss of left cardfile including ASG and power supply. The following Status messages will be displayed (Hazard classification is 'Major'):

- L SYS CARD FILE ASG L
- L SYS CARD FILE ASG R
- L SYS CARD FILE POWER 1
- L SYS CARD FILE POWER 2

Loss of Left main engine fire detection function. Fire Card will not activate flight deck fire indications (fire handle, fuel control switch light and master warning light), will not unlock the Eng 1 fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 1, 3 and 5 when a fire occurs in main engine 1. Hazard classification is 'Minor'.

Loss of APU fire detection function, loss of the fire shutdown command from the APU fire card to the APU controller when an APU fire or overheat condition occurs, and the loss of the automatic discharge command of the APU fire bottle when the aircraft is in unattended (aircraft on ground and main engines are not running) mode and an APU fire occurs. The APU fire card also will not unlock the APU fire handle, will not illuminate the APU fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 1 and 3 when a fire occurs in the APU compartment. Hazard classification is 'Minor'.

Loss of ability to determine 'Fast on Ground' (i.e. both trucks untilted after touchdown). The AUTO SPDBRAKE FAULT advisory will annunciate on EICAS, but the speedbrakes will still deploy automatically via MLG strut compression if the lever is armed. Some control laws will transition to on-ground at 5ft gear altitude. All other effects are limited to loss of redundancy or will only impact maintenance functionality. Hazard classification is 'Minor'.

Increased potential to set FUEL TEMP HIGH (C) after descent to planned destination airport and if in a hold or subsequent diversion due to hot fuel in left main tank as a result of fuel depletion to reserve quantities. Hazard classification is 'Minor'.

Loss of all digital data from HYDIM HCL and HYDIM HL. Loss of Center System Demand Pump (ADP 1) and Loss of Left System Demand Pump (ACMP) and associated indications. ADP C2 will operate continuously without Pressure or Temperature indication. HYD DEM FAULT C1 Advisory message is displayed. HYD DEM FAULT L Advisory message is inoperative. Loss reserve brakes and steering isolation functions. The majority of left and center hydraulic system indication is lost. Hazard classification is 'Minor'.

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Left EAI valve defaults to full-open due to loss of power to the valve. At the same time – complete loss of Left ACIPS Control Card due to complete loss of power to Left Cardfile. If this scenario occurs when the Left EAI valve is full-open at high bleed temperature (i.e. a HOLD) this will lead to the Left EAI Indication Pressure Sensors and Left Intermediate Temperature Sensor indicating potential inlet overheat conditions and then DCA inlet overheat protection logic commanding the Left EAI Backup Relay to power the Left EAI valve closed to prevent an overheat of the left engine inlet. This leads to annunciated loss of the Left EAI system. Hazard classification is 'Minor'.

If GPWS RUNWAY OVRD is selected prior to selection of RWY EXIT, then Autobrake RWY EXIT is inoperative and not selectable. If RWY EXIT is armed, BTE will disengage (OFF) and will be inhibited when GPWS RUNWAY OVRD is selected. The Autobrake Indicator will reflect autobrake is OFF. AUTOBRAKE EXIT OFF (A) will be displayed. If GPWS RUNWAY OVRD is not selected, then RWY EXIT remains operational, but desired speed may not be achieved for the selected runway, autobrakes continue to apply brakes until airplane stops or manual brakes are applied. Hazard classification is 'Minor'.

Loss of NGS. NITROGEN GEN SYS Status message will be displayed. Hazard classification is 'Minor'.

FOR BOTH POWER SUPPLIES FAILED IN THE RIGHT SYSTEMS CARDFILE (Ref. S&MF ELEC-11): The following functions will be affected and messages will be displayed:

Results in loss of right cardfile including ASG and power supply. The following Status messages will be displayed (Hazard classification is 'Major'):

R SYS CARD FILE ASG L
R SYS CARD FILE ASG R
R SYS CARD FILE POWER 1
R SYS CARD FILE POWER 2

Loss of Right main engine fire detection function. Fire Card will not activate flight deck fire indications (fire handle, fuel control switch light and master warning light), will not unlock the Eng 2 fire handle, will not transmit a fire condition on the ARINC bus and it will not provide a discrete signal to RDCs 2, 4 and 6 when a fire occurs in main engine 2. Hazard classification is 'Minor'.

The failure results in loss of the Right and Center DLODS Cards power and functionality (no detection/annunciation). The Right and Center DLODS Card's associated loops EICAS Status messages will be set by DCA after 60 seconds (due to the loss of communication). The left DLODS Card will reconfigure to OR logic and function as a single loop sub-system for the FWD Body, AFT Body, Right Wheel Well(Center Body), Left Fancase, Left Strut, Left Wing, and Left Pack Bay detection/annunciation. The failure will result in complete loss of detection/annunciation for Right Fancase, Right Strut, Right Wing, and Right Pack Bay sub-systems. Hazard classification is 'Minor'.

Loss of ability to determine 'Fast on Ground' (i.e. both trucks untilted after touchdown). The AUTO SPDBRAKE FAULT advisory will annunciate on EICAS, but the speedbrakes will still deploy automatically via MLG strut compression if the lever is armed. Some control laws will transition to on-ground at 5ft gear altitude. All other effects are limited to loss of redundancy or will only impact maintenance functionality. Hazard classification is 'Minor'.

Increased potential to set FUEL TEMP HIGH (C) after descent to planned destination airport and if in a hold or subsequent diversion due to hot fuel in left main tank as a result of fuel depletion to reserve quantities. Hazard classification is 'Minor'.

Loss of all digital data from HYDIM HR and HYDIM HCR. Loss of Center System Demand Pump (ADP 3) and Loss of Right System Demand Pump (ACMP) and associated indications. HYD DEM FAULT C3 Advisory message is displayed. HYD DEM FAULT R Advisory message is inoperative. Significant loss of indication associated with the right hydraulic system. Hazard classification is 'Minor'.

Annunciated loss of WAI due to loss of power to Center ACIPS Control Card. Both Left and Right WAI Valves will default closed due to loss of power. Right EAI valve defaults to full-open due to loss of power to the valve. At the same time – complete loss of Right ACIPS Control Card due to complete loss of power to Right Cardfile. If this scenario occurs when the Right EAI valve is full-open at high bleed temperature (i.e. a HOLD) this will lead to the Right EAI Indication Pressure Sensors and Right Intermediate Temperature Sensor indicating potential inlet overheat conditions and then DCA inlet overheat protection logic commanding the Right EAI Backup Relay to power the Right EAI valve closed to prevent an overheat of the right engine inlet. This leads to annunciated loss of the Right EAI system. Hazard classification is 'Minor'.

If GPWS RUNWAY OVRD is selected prior to selection of RWY EXIT, then Autobrake RWY EXIT is inoperative and not selectable. If RWY EXIT is armed, BTE will disengage (OFF) and will be inhibited when GPWS RUNWAY OVRD is selected. The Autobrake Indicator will reflect autobrake is OFF. AUTOBRAKE EXIT OFF (A) will be displayed. If GPWS RUNWAY OVRD is not selected, then RWY EXIT remains operational, but desired speed may not be achieved for the selected runway, autobrakes continue to apply brakes until airplane stops or manual brakes are applied. Hazard classification is 'Minor'.

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-31-01 Cockpit Voice Recorder (CVR) Functions****31-31-01A**

Interval	Installed	Required	Procedure
C	2	1	

31-31-01 Cockpit Voice Recorder (CVR) Functions**31-31-01B**

Interval	Installed	Required	Procedure
A	2	0	

May be inoperative provided:

- At least one Flight Data Recorder (FDR) Function operates normally, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-31-01.

Refer to FAA Policy Letter 29.

Similar to the 787, the 777X combines CVR, FDR, and new datalink recorder (DLR) functions into a single ATA 31 LRU, Enhanced Airborne Flight Recorder (EAFR), with a dual installation on the airplane. The recording system is hosted by the common core system (CCS), and the three recording functions (voice, flight data, and datalink) record their respective data in physically separated partitions in crash protected memory (CPM).

The 777-9 recording system consists of two combi recorders, each of which encompasses a cockpit voice recorder, flight data recorder, and datalink recording function. An underwater locator beacon is also provided for each recorder. The system also includes a backup power source (forward EAFR only) and an area microphone with preamplifier. The purpose of the backup power source is to provide 10 minutes of backup power when normal aircraft power ceases. It uses the aircraft main battery as the power source.

Cockpit voice recorder (CVR) function: The voice recording function for each recorder records three audio channels from the flight crew audio control panels (ACPs) plus one analog channel from the cockpit area microphone. A minimum of the last 2 hours of all four audio channels is retained in CPM (will be revised to 25 hours in 1/1/2021 per PRR 64161). An inoperative cockpit area mic renders CVR analog function inoperative for both EAFRs. The ACP voice data will still record with an inoperative cockpit area mic.

Flight data recorder (FDR) function: Each EAFR FDR function records flight data for the most recent 25 hours of operation in a fire and crash resistant LRU.

Datalink Recorder (DLR) function: Each EAFR DLR function records Communication Navigation Surveillance/Air Traffic Management (CNS/ATM) messages similar to the 787.

The forward EAFR incorporates a backup power source which provides 10 minutes of backup power. NPRM APA 08-05, requiring this function, was adopted in Amendment 124.

Consequences of Failure

Failure of a CVR function is indicated by the VOICE RECORDER SYS AFT or VOICE RECORDER SYS FWD Status message.

One CVR inoperative: remaining CVR is available to record voice communication.

Both CVRs inoperative: CVR information will not be available. MMEL requires that at least one FDR function operates normally.

EASA repair interval for both inoperative is category A, 72 hours or eight flights.

FAA repair interval is category A, three flight days.

Consequences of Next Critical Failure

CVR

One CVR inoperative at dispatch, remaining CVR function fails: CVR information will not be available for the remainder of the flight. Subsequent flight will require at least one FDR function available to record flight parameters.

Both CVRs inoperative at dispatch: Failure of both FDRs would leave no recording capability. Upon landing, one of the recording systems (CVR or FDR) must be repaired before further flight.

Mishap occurs: MMEL provisions ensure at least one CVR or one FDR is available.

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-31-02 Flight Data Recorder (FDR) Functions****31-31-02A**

Interval	Installed	Required	Procedure
C	2	1	

31-31-02 Flight Data Recorder (FDR) Functions**31-31-02B**

Interval	Installed	Required	Procedure
A	2	0	

May be inoperative provided:

- At least one Cockpit Voice Recorder (CVR) function operates normally,
- Airplane is not dispatched from a designated airport as listed in the operator's MEL unless:
 - The FDR failure occurs after pushback but prior to takeoff, or
 - The FDR repair was attempted but was not successful.
- In those cases where repair is attempted but not successful, the airplane may be dispatched on a flight or a series of flights until the next designated airport where repair must be accomplished prior to dispatch, and
- Repairs are made within three 3 flight-days.

31-31-02 Flight Data Recorder (FDR) Functions**31-31-02-01 FDR Recording Parameters Required by 14 CFR**

Interval	Installed	Required	Procedure
A	-	-	

Up to three (3) recording parameters may be inoperative provided:

- At least one Cockpit Voice Recorder (CVR) function operates normally, and
- Repairs are made within 20 calendar-days.

31-31-02 Flight Data Recorder (FDR) Functions**31-31-02-02 FDR Recording Parameters Not Required by 14 CFR**

Interval	Installed	Required	Procedure
A	-	-	

May be inoperative provided repairs are made prior to the completion of the next heavy maintenance visit.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-31-01.

Refer to FAA Policy Letter 87.

Similar to the 787, the 777X combines CVR, FDR, and new datalink recorder (DLR) functions into a single ATA 31 LRU, Enhanced Airborne Flight Recorder (EAFR), with a dual installation on the airplane. The recording system is hosted by the common core system (CCS), and the three recording functions (voice, flight data, and datalink) record their respective data in physically separated partitions in crash protected memory (CPM).

The 777-9 recording system consists of two combi recorders, each of which encompasses a cockpit voice recorder, flight data recorder, and datalink recording function. An underwater locator beacon is also provided for each recorder. The system also includes a backup power source (forward EAFR only) and an area microphone with preamplifier. The purpose of the backup power source is to provide 10 minutes of backup power when normal aircraft power ceases. It uses the aircraft main battery as the power source.

Cockpit voice recorder (CVR) function: The voice recording function for each recorder records three audio channels from the flight crew audio control panels (ACPs) plus one analog channel from the cockpit area microphone. A minimum of the last 2 hours of all four audio channels is retained in CPM (will be revised to 25 hours in 1/1/2021 per PRR 64161). An inoperative cockpit area mic renders CVR analog function inoperative for both EAFRs. The ACP voice data will still record with an inoperative cockpit area mic.

Flight data recorder (FDR) function: Each EAFR FDR function records flight data for the most recent 25 hours of operation in a fire and crash resistant LRU.

Datalink Recorder (DLR) function: Each EAFR DLR function records Communication Navigation Surveillance/Air Traffic Management (CNS/ATM) messages similar to the 787.

The forward EAFR incorporates a backup power source which provides 10 minutes of backup power. NPRM APA 08-05, requiring this function, was adopted in Amendment 124.

Consequences of Failure

Failure of a FDR function is indicated by the FLIGHT RECORDER SYS AFT or FLIGHT RECORDER SYS FWD Status message.

One FDR inoperative: remaining FDR retains full data recording capability.

Both FDRs inoperative: FDR information will not be available. MMEL requires that at least one CVR function operates normally.

Consequences of Next Critical Failure

One FDR inoperative at dispatch, remaining FDR function fails: FDR information will not be available for the remainder of the flight. Subsequent flight will require at least one CVR function available to record voice data.

Both FDRs inoperative at dispatch: Failure of both CVRs would leave no recording capability. Upon landing, one of the recording systems (CVR or FDR) must be repaired before further flight.

Mishap occurs: MMEL provisos ensure at least one CVR or one FDR is available.

Draft
Feb 26, 2026

31-31-03 Data Link Recorder (DLR) Functions**31-31-03A**

Interval	Installed	Required	Procedure
C	2	1	

31-31-03 Data Link Recorder (DLR) Functions**31-31-03B**

Interval	Installed	Required	Procedure
A	2	0	

May be inoperative provided:

- At least one Flight Data Recorder (FDR) Function operates normally, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 31-31-01.

Similar to the 787, the 777X combines CVR, FDR, and new datalink recorder (DLR) functions into a single ATA 31 LRU, Enhanced Airborne Flight Recorder (EAFR), with a dual installation on the airplane. The recording system is hosted by the common core system (CCS), and the three recording functions (voice, flight data, and datalink) record their respective data in physically separated partitions in crash protected memory (CPM).

The 777-9 recording system consists of two combi recorders, each of which encompasses a cockpit voice recorder, flight data recorder, and datalink recording function. An underwater locator beacon is also provided for each recorder. The system also includes a backup power source (forward EAFR only) and an area microphone with preamplifier. The purpose of the backup power source is to provide 10 minutes of backup power when normal aircraft power ceases. It uses the aircraft main battery as the power source.

Cockpit voice recorder (CVR) function: The voice recording function for each recorder records three audio channels from the flight crew audio control panels (ACPs) plus one analog channel from the cockpit area microphone. A minimum of the last 2 hours of all four audio channels is retained in CPM (will be revised to 25 hours in 1/1/2021 per PRR 64161). An inoperative cockpit area mic renders CVR analog function inoperative for both EAFRs. The ACP voice data will still record with an inoperative cockpit area mic.

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Flight data recorder (FDR) function: Each EAFR FDR function records flight data for the most recent 25 hours of operation in a fire and crash resistant LRU.

Datalink Recorder (DLR) function: Each EAFR DLR function records Communication Navigation Surveillance/Air Traffic Management (CNS/ATM) messages similar to the 787.

The forward EAFR incorporates a backup power source which provides 10 minutes of backup power. NPRM APA 08-05, requiring this function, was adopted in Amendment 124.

Consequences of Failure

DLR

Failure of a DLR function is annunciated by the associated DATALINK RECORDER SYS AFT and/or DATALINK RECORDER SYS FWD Status message.

One DLR inoperative: remaining DLR retains full data recording capability.

Both DLRs inoperative: recording of datalink communications is not available.

Consequences of Next Critical Failure

DLR

One DLR inoperative at dispatch, remaining DLR fails: DLR information will not be available for the remainder of the flight.

Both DLRs inoperative at dispatch: Failure of both FDRs would leave no recording capability.

Mishap occurs: MMEL provisions ensure at least one CVR or one FDR is available.

31-33-01 Flight Deck Printer**31-33-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

31-33-01 Flight Deck Printer**31-33-01B**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

31-33-01 Flight Deck Printer**31-33-01-01 Miscellaneous Features**

Interval	Installed	Required	Procedure
D	-	-	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-33-01.

Flight management, onboard maintenance, communication management, aircraft condition monitoring, and electronic flight bag data can be sent to the printer via the onboard network system.

Consequences of Failure

Print capability in the flight deck is lost.

Consequences of Next Critical Failure

None.

31-51-01 Master WARNING Lights

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both Flight Deck Speaker Systems operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-51-01.

A warning condition is annunciated on the flight deck by the two master warning lights, an aural warning from the two overhead flight deck comm/warning speakers, and a warning message on either the EICAS or PFD.

Consequences of Failure

Failure of a master warning light or failure of its interface with the crew alerting system is indicated by the MASTER WARNING IND L or R Status message. However, the lights are exercised regularly by the AUTOPILOT DISC warning and are likely to be quickly squawked by flight crews.

Failure of one of the two master warning lights still leaves one MWL, the two overhead speakers and a warning message on EICAS or the PFD to annunciate warning conditions.

NOTE: This scenario assumes the more likely case of MWL failure to illuminate. Multiple failures are required for a MWL to be erroneously illuminated.

Consequences of Next Critical Failure

Failure of the remaining master warning light: two overhead speakers and either a Warning message on EICAS or the PFD will annunciate warning conditions. With both MWLs failed, the CONFIG WARN FAULT Advisory message is displayed.

31-51-02 Master CAUTION Lights

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both Flight Deck Speaker Systems operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-51-02.

A caution alert condition is presented to the flight deck using the master caution lights, a unique aural tone and EICAS messages. Two master caution lights are installed on the glareshield.

Consequences of Failure

Failure of a master caution light or failure of its interface with the crew alerting system is indicated by the MASTER CAUTION IND L or R Status message.

Failure of one of the two master caution lights will still leave one operative light. The aural tone and EICAS messages will also be available to alert the crew.

NOTE: This scenario assumes the more likely case of MCL failure to illuminate. Multiple failures are required for a MCL to be erroneously illuminated.

Consequences of Next Critical Failure

Failure of the remaining master caution light: two overhead speakers and an EICAS caution message will annunciate caution conditions.

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31-51-03 Autopilot Disconnect Warning Function

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Both Auto Cabin Pressure Controls operate normally,
- Autopilot is not used,
- Approach minimums do not require use of the autopilot,
- Number of flight segments and segment duration is acceptable to flightcrew, and
- Enroute operations do not require use of the autopilot.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 31-51-03.

An autopilot disconnect warning is annunciated by illumination of the master warning lights, activation of an aural indication and display of the warning message AUTOPILOT DISC. Discrete signals are sent from the autoflight function (AFF) in each of the three flight control modules (FCMs) to the Display and Crew Alerting (DCA) system to detect that an engaged autopilot has been disconnected.

Proposal is consistent with Appendix P to FAR 121 Amdt. 121-329, 2/15/2007.

Consequences of Failure

The DCA monitors for autopilot disconnect digital output from the AFF. If all AFF inputs are invalid, the A/P DISC WARN SYS Status message will be displayed.

Autopilot disconnect warning function is inoperative.

Consequences of Next Critical Failure

None - autopilot is not used.

31-61-01 Display Units (DU)**31-61-01-01 Lower DU Display Function**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Both EFIS/DSP Panels operate normally,
- Both Multifunction Keypads (MFKs) operate normally,
- Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- Display Function operates normally on remaining Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-01 Display Units (DU)**31-61-01-02 Left Inboard DU Display Function**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Left PFD/MFD selector NORM and OUTBD positions are verified to operate normally,
- Right PFD/MFD selector is verified to operate normally,
- ISFD operates normally,
- Both EFIS/DSP Panels operate normally,
- Both Multifunction Keypads (MFKs) operate normally,
- Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- Display Function operates normally on remaining Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-01 Display Units (DU)**31-61-01-03 Left Outboard DU Display Function**

Interval	Installed	Required	Procedure
C	1	0	(M)

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May be inoperative provided:

- Right PFD/MFD selector is verified to operate normally,
- ISFD operates normally,
- Both EFIS/DSP Panels operate normally,
- Both Multifunction Keypads (MFKs) operate normally,
- Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- Display Function operates normally on remaining Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-01 Display Units (DU)**31-61-01-04 Right Inboard DU Display Function**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Right PFD/MFD selector NORM and OUTBD positions are verified to operate normally,
- Left PFD/MFD selector is verified to operate normally,
- ISFD operates normally,
- Both EFIS/DSP Panels operate normally,
- Both Multifunction Keypads (MFKs) operate normally,
- Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- Display Function operates normally on remaining Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-01 Display Units (DU)**31-61-01-05 Right Outboard DU Display Function**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Left PFD/MFD selector is verified to operate normally,
- ISFD operates normally,
- Both EFIS/DSP panels operate normally,
- Both multifunction keypads (MFKs) operate normally,

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- e. Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- f. Display Function operates normally on remaining Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-01 Display Units (DU)

31-61-01-06 Display Degraded Function

Interval	Installed	Required	Procedure
C	5	4	

May be dispatched with one DISPLAY DEGRADED __ Status message displayed.

31-61-01 Display Units (DU)

31-61-01-07 Touch Screen Function

Interval	Installed	Required	Procedure
C	5	1	

May be inoperative provided:

- a. Touch Screen Function operates normally on at least one of the following Display Units:
 - Lower DU
 - Left Inboard DU
 - Right Inboard DU
- b. Both EFIS/DSP panels operate normally,
- c. Both multifunction keypads (MFKs) operate normally, and
- d. Both MFK Rotary CURSOR CONTROL Selectors operate normally.

31-61-01 Display Units (DU)

31-61-01-08 Display Unit Brightness/Contrast Controls

Interval	Installed	Required	Procedure
C	5	0	

May be inoperative provided Master Brightness Control System operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL Item 31-61-01. Items 31-61-01-04 and 31-61-01-05 based on 787 MMEL items 31-61-01-02 and 31-61-01-03. New proposal for 31-61-01-07. (Display unit relief evaluated and accepted relative to PL-30 on functionally equivalent 787 displays.)

The Displays and Crew Alerting (DCA) system provides the primary indication and control of the 777-9 avionics suite to the flight crew, including visual, auditory and tactile interaction. Four touch screen Multifunction Display Units are arranged across the main front panel with a space in the center for the integrated standby instrument and landing gear handle. The fifth touch screen Multifunction Display (MFD) is in the aisle-stand between the main panel and the throttle quadrant. The EFIS/DSP panels are located in the Glareshield outboard of the Mode Control Panel. The Multifunction Keypads (MFKs) along with the five Display Units effectively provide the functionality that the MCDUs provided on the 777. The MFKs are located outboard of the lower Display Unit on each side of the aisle stand. The two Remote Light Sensors are located at the forward side, on top of Glareshield, on both sides symmetrical to the centerline of the airplane. The RLS outputs ambient brightness data to the Display Units for use in automatic brightness control.

The optional HUD system is a wide field of view airplane display system that mounts to the aircraft structure above the pilots head and projects flight information (symbology) in the pilots' forward field of view. The HUD system uses lenses to collimate the image so that the pilots' eyes are focused at optical infinity when viewing the symbology (same as the outside world) and a special semi-reflective, transparent combiner to direct the symbology to the pilots' eyes without significantly obscuring the outside world view. The HUD system is a customer option that includes two LRU types for the 777-9, the HUD Projection Unit (HPU) and the HUD Combiner Unit (HCU) which is installed in a dual configuration. The 777-9 HPU and HCU are a modification of the 787 Model AMLCD HPU and HCU with form and fit modifications necessary for installation in the 777-9.

The Head Down Display Operational Features are adapted from the 777/787 Displays System to match the new flight deck layout and equipment, including:

- Individual display formats based on 777/787
- Reversion operations similar to 777/787
- Interactive display control using a tabber knob on the 787 MFKs and the resistive multi-touch capability on the new Adaptive Flight Display (AFD)s
- Control Panels utilizing buttons and knobs using 787 panels

In addition to these 777-compatible operations, the 777-9 DCA system supports the 787 enhanced capabilities, including an emulated CDU format, an enlarged Navigation Display format, and alternate menu selection capability. By moving to five large-format Head Down Displays, formats that currently reside on 777 independent display units must share display surfaces in the following dedicated windows:

- Primary Flight Display (PFD)
- Engine Indication and Crew Alerting (EICAS)
- Multifunction Display (MFD)
- Auxiliary Outboard (AOB)
- Mini-Map

The Multifunction Display application supports format selection/access by the pilot from the following:

- System Synoptics (SYS) and Maintenance
- Navigation Display (ND)
- Checklist (CHKL)
- Communications (COMM)
- Emulated Control Display Unit (CDU)
- INFO applications (INFO)

Two MFD windows on the same display unit can be combined into a single large ND window by selecting the ND setting on both controls for the same display. The INFO selection provides access to additional formats including Ground Camera page, Video Surveillance page, Traffic Tools, Airport Map Database page, and Operationally Approved Information format selection.

Unlike other airplane models, 777-9 will not have dual cursor controls located on the aisle-stand to the left and right of the throttle quadrant but instead will have touch screen MFDs that provide the same or better display format interaction and graphical feedback as using a CCD. Touchscreen inputs from the display are mapped into CCD equivalent inputs. Extensive menus, checklists, and graphical controls are used for non-time-critical or infrequently used system controls. The rotary cursor knob is retained as an alternative to using the touch interface.

Consequences of Failure

(Note: "C" interval proposed for each display unit based on demonstrated capabilities and reliability in 787 service.)

Lower DU inoperative: Considerable flexibility is provided in selecting display formats on remaining displays. The MFD formats can be shown on three available windows on the inboard DUs. Since one display is already inoperative, the DISPLAY DEGRADED ___ Status is not allowed on any remaining DU.

Left inboard or right inboard DU inoperative: The affected pilot has a normal PFD display on the outboard DU, which includes a mini-map. This display may be converted to a PFD/MFD format by pilot selection of the OUTBD position on the associated PFD/MFD selector. Considerable flexibility is provided in selecting display formats on remaining displays. The MFD formats can be shown on three available windows on the opposite inboard DU and the lower DU. A fourth location is potentially available if the failed inboard side is set to OUTBD, a PFD and MFD will be displayed on that outboard DU. Display system will configure such that EICAS is displayed on remaining inboard DU to ensure indications remain in both pilots' normal field of vision. Since one display is already inoperative, the DISPLAY DEGRADED ___ Status is not allowed on any remaining DU.

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NOTE: This configuration was evaluated by FAA-AEG and considered acceptable relative to PL-30 in the 787 engineering simulator in January 2010.)

Left outboard or right outboard DU inoperative: The affected pilot has a PFD/MFD display on the inboard DU, which includes a mini-map. Considerable flexibility is provided in selecting display formats on remaining displays. The MFD formats can be shown on three available windows on the opposite inboard DU and the lower DU. (Note: affected pilot's view of the inboard display is slightly off-axis, but this configuration was evaluated by FAA-AEG and considered acceptable relative to PL-30 in the 787 engineering simulator in January 2010.)

Manual display brightness/contrast control inoperative: The automatic control will adjust display brightness appropriately for the ambient light conditions, or can be adjusted manually by the master brightness control. For contrast control inoperative, the affected display unit will have no way to control the WXR/TERR/Video contrast setting. Control control stuck in high or low setting can be mitigated by selecting a different DU with functioning contrast. Since one display is already inoperative, the DISPLAY DEGRADED __ Status is not allowed on any remaining DU.

Touch Screen function inoperative: A touch interface fault will be indicated by the following Status and Advisory messages:

DISPLAY TOUCH LEFT INBD (Status)
DISPLAY TOUCH LEFT OUTB (Status)
DISPLAY TOUCH LOWER CTR (Status)
DISPLAY TOUCH RIGHT INBD (Status)
DISPLAY TOUCH RIGHT OUTB (Status)
TOUCH FAIL CENTER (Advisory)
TOUCH FAIL L INBD (Advisory)
TOUCH FAIL R INBD (Advisory)

Rotary cursor control (tabber) must be used for selections on affected DU, or format displayed and selections made on another DU.

Degraded display Status messages:

The associated DISPLAY DEGRADED __ (L INBD, L OUTBD, LOWER CTR, R INBD, R OUTBD) Status message will be displayed when there is an illumination fault in the DU. The DU has a fault but will continue to operate normally. Dispatch is allowed for one DU with display degraded fault.

Consequences of Next Critical Failure

Lower DU inoperative at dispatch, failure of another DU: three operative display units remain. The crew will continue to have considerable flexibility in assigning which formats they want to have displayed on the operative display units.

Left inboard or right inboard DU inoperative at dispatch, failure of another DU: three operative display units remain. The crew will continue to have considerable flexibility in assigning which formats they want to have displayed on the remaining display units. Most critical scenarios:

- If associated outboard DU fails, ISFD is available to provide second

source of primary flight data. Offside pilot retains normal display formats, including EICAS. Head-Up Display (optional) may be used by affected pilot if desired to obtain a PFD type display.

- If opposite inboard DU fails, EICAS will not be displayed and the pilots would be required to use the PFD/MFD selector to enable display of EICAS.

Left or right, inboard or outboard DU inoperative at dispatch, failure of offside instrument bus (Capt or First Officer's). In this remote scenario, one inboard DU and lower DU remain, as well as ISFD. Inboard DU will show a PFD/EICAS format, and the lower DU will continue as an MFD. (Note: for 777X, the lower DU is powered by the L main 28V DC bus and is not affected by Capt or F/O instrument bus failures.)

Left inboard, left outboard, right inboard or outboard DU inoperative at dispatch, followed by failure of a single CCR cabinet: Lower center DU will be inoperative. Both HUDs will be inoperative. Multiple failures are required subsequent to a CCR cabinet failure to have less than three operative DUs. Each failure has a probability of approximately $1\text{E-}5$ and the CCR cabinet failure has probability of approximately $1\text{E-}7$.

Manual display brightness/contrast control inoperative at dispatch: None. Multiple failures are required to lose the master brightness control system and automatic system. Failure of the automatic system alone requires at least a dual failure: BLS for the affected display(s) and RLS.

Touch screen function inoperative at dispatch. MMEL provisos ensure display selection capability remains following loss of additional DU.

Degraded display Status messages.

Additional failure(s) will result in loss of the display function on the associated DU.

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-61-02 Graphics Generator Systems****31-61-02-01 Graphics Generator Modules (GGMs)**

Interval	Installed	Required	Procedure
C	4	3	

One may be inoperative provided all Common Core System (CCS) equipment operates normally.

31-61-02 Graphics Generator Systems**31-61-02-02 Display Unit Interface Function**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be dispatched with DISPLAY UNIT INTERFACE Status message displayed provided:

- Both PFD/MFD selector switches are verified to operate normally,
- All Graphics Generator Modules operate normally, and
- Display Function operates normally on all Display Units.

NOTE: The DISPLAY DEGRADED Status message may be displayed for one DU.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-02.

There are four primary display graphics generator modules (GGMs) installed, with two GGMs installed in each common computing resource (CCR) cabinet. A GGM is capable of driving any two of the five primary displays, or one of the HUDs (if installed) and any one of the primary displays. Redundant fiber optic buses connect the GGMs to the displays and HUDs (if installed); these buses carry all graphics data to be displayed.

Consequences of Failure

Failure of a single GGM is annunciated by the CCR GRAPHICS GENERATOR Status message. Fiber optic or ARINC 429 bus faults are annunciated by the DISPLAY UNIT INTERFACE Status message.

For optional head-up displays (HUDs) installed: Single GGM inoperative, only one of the two optional head-up displays (HUDs) will function, annunciated by the HUD SINGLE AVAIL Advisory message. The captain's HUD has priority, however, when the captain's HUD is stowed, the first officer's HUD is available. (MMEL coverage for hard HUD failures is under item 31-61-14.) All of the five primary displays operate normally.

INFO video functions (GMCS, CIG, CEN) are limited to one display per GGM. If all displays and HUDs are operational, failure of GGM L1 or L2 will limit the display of INFO page video to either LIB or LWR but not both simultaneously. In case of dispatching with 1 failed display and/or 1 or 2 failed HUD(s) combined with a failed GGM, this limitation may occur with the failure of the R1 or R2 GGMs as well. INFO video functions will be limited to only one display of any two displays driven by the same GGM. A text message will be displayed instead of the other video to inform the pilots about the limitation. Pilots will still be able to have two video instances by moving one of the videos to another display.

Display unit interface faults: loss of redundancy to drive displays from alternate GGMs.

Consequences of Next Critical Failure

Single GGM inoperative at dispatch, followed by failure of an additional GGM: The DISPLAY SYS LIMITED Advisory message will be displayed. The displays will automatically reconfigure into a two GGM arrangement. The lower display will blank and both HUDs (if installed) HUD will be inoperative. The four remaining displays support all flight crew functions for the remainder of the flight. The DISPLAY RESOURCES Status message will be displayed and subsequent dispatch is not allowed.

Single GGM inoperative at dispatch, followed by other Common Core System component failures: None. MMEL provisos preclude dual CCS failures which would significantly degrade displays functionality.

Single GGM inoperative at dispatch, followed by failure of opposite CCR cabinet: 1 GGM remains, which will drive the two inboard display units. Each display unit has 2 windows; 1 will have a PFD and EICAS, and the other will have a PFD and MFD. (Note: Similar to 787, 777X PFD format contains a full-time mini-map.)

Single GGM configuration retains independent sources of captain's and first officer's displayed data, so autoland is still supported.

Display unit interface faults at dispatch, followed by failure of opposite CCR cabinet: multiple interface failures during the 10 day MMEL period, each with a probability of approximately 1E-5, are required for less than 3 operating displays to remain following a CCR cabinet failure (itself a 1E-7 event).

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31-61-04 Multifunction Keypads (MFKs)

Interval	Installed	Required	Procedure
A	2	1	(O)

One may be inoperative provided:

- Display Function operates normally on all Display Units (DU),
- Touch Screen Function operates normally on at least two of the following Display Units:
 - Lower DU
 - Right Inboard DU
 - Left Inboard DU
- Both EFIS/DSP Panels operate normally,
- HDG-TRK SEL Reference Switch operates normally,
- All Tuning and Control Panels (TCPs) operate normally,
- Opposite MFK operates normally,
- Opposite MFK Rotary CURSOR CONTROL Selector operates normally, and
- Repairs are made within 2 flight-days.

NOTE: The DISPLAY DEGRADED Status message may be displayed for one DU.

31-61-04 Multifunction Keypads (MFKs)

31-61-04-01 SYS, CDU, INFO, CHKL, COMM, ND Switches

Interval	Installed	Required	Procedure
C	12	6	

May be inoperative provided:

- Opposite MFK operates normally,
- Opposite MFK Rotary CURSOR CONTROL Selector operates normally,
- Both EFIS/DSP Panels operate normally, and
- Touch Screen Function operates normally on Lower DU.

31-61-04 Multifunction Keypads (MFKs)

31-61-04-02 PREV PAGE, NEXT PAGE, EXEC Switches

Interval	Installed	Required	Procedure
C	6	3	

May be inoperative provided:

- Opposite MFK operates normally,
- Opposite MFK Rotary CURSOR CONTROL Selector operates normally, and
- Touch Screen Function operates normally on Lower DU.

31-61-04 Multifunction Keypads (MFKs)

31-61-04-03 Rotary CURSOR CONTROL Selectors (Rotary Cursor Control Device/Cursor Control Select Switch)

Interval	Installed	Required	Procedure
B	2	1	(O)

One may be inoperative provided:

- Opposite MFK operates normally,
- Opposite MFK Rotary CURSOR CONTROL Selector operates normally,
- Display Function operates normally on all Display Units,
- Touch Screen Function operates normally on at least two of the following Display Units:
 - Lower DU
 - Left Inboard DU
 - Right Inboard DU
- Alternate procedures are established and used.

NOTE: The DISPLAY DEGRADED Status message may be displayed for one DU.

31-61-04 Multifunction Keypads (MFKs)

31-61-04-04 Switch Lights, Key Lights, EXEC Lights

Interval	Installed	Required	Procedure
C	-	0	

NOTE: Any function that operates normally may be used.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 31-61-04.

The multifunction keypads (MFKs) are the primary means of entering alphanumeric data for the flight management function (FMF) and for manipulating the lower center display unit.

Individual switches and key labels are illuminated by lights within the switch/key.

Once an MFD format has been selected, the rotary cursor control (tabber) knob functions as a source of cursor control for moving within menus on the format. The tabber allows the flight crew to quickly select from menus without using the touch screen capability. There are four tabbers, one on each EFIS/DSP, and one on each MFK. The tabber on the EFIS/DSP will affect only the ND selected for that DCP. The tabber on the MFK will affect the format where the cursor is located. Once the tabber highlight is on the correct menu entry, pushing the tabber selects the entry.

Consequences of Failure

Failure of a MFK is indicated by the associated DISPLAY KEYPAD L, R Status message. The associated KEYPAD FAIL MFK L, R Advisory message will also be displayed.

MFK completely inoperative: pilot with operative MFK must make all alphanumeric entries (e.g., preflight data, changes to LNAV/VNAV flight plan, company and ATC datalink requests, etc.).

Pilot with inoperative MFK must use backup TOUCH/EFIS/DSP feature to select lower center display unit formats.

Touch screen function will provide redundancy with the tabber functionality, but not any of the display format selection functionality.

Sub-item relief is also proposed for the following specific MFK switches:

LOWER MFD display select switches (SYS, CDU, INFO, CHKL, COMM, ND): affected switches are not available to select display formats for the on-side window of the lower center display unit. All formats are selectable on either inboard MFD, or on the lower MFD via the TOUCH/EFIS/DSP backup feature.

PREV PAGE, NEXT PAGE, EXEC switches: ability to use these switches for FMF page selection is inoperative. FM pages and execute function are accessible via display-based soft keys via display unit touch screens. Rotary CURSOR CONTROL selector: ability to use this switch for display selections is inoperative. Display unit touch screens may be used to perform all display control functions. Proposed relief is category B due to tabber being backup to touch screen and the CCDs being removed.

Individual switch and key lighting inoperative: Displays continue to respond appropriately to use of the switch.

Partial control stand panel lighting may be failed due to the MFK serving as power source (Left MFK inoperative: parking brake / altn pitch trim, speedbrake / stab cutout, thrust control module. Right MFK inoperative; flap lever module, altn flap module). Overhead lighting provides acceptable panel lighting.

Consequences of Next Critical Failure

MFK completely inoperative at dispatch, failure of remaining MFK: ability to manually change LNAV/VNAV flight plan with alphanumeric input is lost. (Note: there is no EFB interface for making these alphanumeric inputs.) LNAV/VNAV flight plan may be altered if necessary by the pick waypoint function, or by route uplink if available. If necessary, revised routing via radar vectors may be flown using other autopilot modes. Both pilots must use backup TOUCH/EFIS/DSP feature to select lower center display unit formats. MMEL restrictions ensure baroalt capability remains, and that maximum display system redundancy and control capability is preserved. This item was extensively evaluated on 787; 787 MFK reliability has been excellent but initial 777X repair interval proposed as same (Category A/2 flight days) based on new touch screen functionality and incorporation of brightness control.)

Switch(es) inoperative at dispatch:

- Failure of display unit: at least 2 multi-function display units remain available to perform necessary tasks, with considerable flexibility in format selection.
- Failure of opposite MFK: pilot with remaining MFK functionality will be required to make all alphanumeric inputs via the displays.

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-61-05 EFIS/DSP Panels**

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Both Multifunction Keypads (MFKs) operate normally,
- Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- Display Function operates normally on all Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may be displayed for one DU.

31-61-05 EFIS/DSP Panels**31-61-05-01 Display Lights**

Interval	Installed	Required	Procedure
C	4	0	

31-61-05 EFIS/DSP Panels**31-61-05-02 Switch Lights**

Interval	Installed	Required	Procedure
C	24	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-05.

DISPLAY SELECT PANEL - The display select panel provides control of function selection for the associated (on-side) inboard display. This panel includes display select switches which are used to select the active display window for the MFD format, function switches which are used to select the information to be displayed on the currently active display, the EICAS transfer switch, the ENG display switch, and a cancel/recall switch. Lower center display unit DSP functions are controlled from switches on the multifunction keypads (MFKs).

EFIS CONTROL PANEL - The electronic flight instrument system control panels are used to control the information displayed on the primary flight and navigation displays. The left EFIS control panel controls the captain's displays. The right EFIS control panel controls the first officer's displays.

Display lights on the display select panel illuminate to indicate the selected MFD window. Switch lights illuminate the switch label on the display select panel and on the EFIS control panel.

Consequences of Failure

Failure of an EFIS/DSP panel is indicated by the EFIS/DSP PANEL L or R Status message.

The associated EFIS/DSP PNL FAIL L, R Advisory message will be displayed.

The inoperative EFIS/DSP panel cannot be used to control the associated (on-side) displays. All EFIS/DSP functions can be accessed and controlled using the TOUCH/EFIS/DSP backup feature on the other multi-function displays.

Failed display light or switch light: desired display configuration is obtained by alternately selecting the display or switch until the desired display is achieved.

Consequences of Next Critical Failure

Failure of a display unit will leave 1 multi-function display for backup EFIS/DSP control and at least two MFDs for other purposes.

Failure of the second EFIS/DSP control panel requires that both the capt and first officer's display selections are input via the TOUCH/EFIS/DSP backup feature.

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Feb 26, 2020

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-61-06 PFD/MFD Selector Switches****31-61-06-01 OUTBD Position**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Opposite PFD/MFD Selector Switch is verified to operate normally,
- Associated PFD/MFD Selector Switch remains in NORM, and
- Display Function operates normally on all Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may be displayed for one DU.

31-61-06 PFD/MFD Selector Switches**31-61-06-02 INBD Position**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Opposite PFD/MFD Selector Switch is verified to operate normally,
- Associated PFD/MFD Selector Switch remains in NORM, and
- Display Function operates normally on all Display Units.

NOTE: The DISPLAY DEGRADED __ Status message may be displayed for one DU.

31-61-06 PFD/MFD Selector Switches**31-61-06-03 Left NORM Position****31-61-06-03A**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Left PFD/MFD Selector Switch is set INBD,
- Right PFD/MFD Selector Switch is verified to operate normally,
- ISFD operates normally,
- Both EFIS/DSP Panels operate normally,
- Both Multifunction Keypads (MFKs) operate normally,

- f. Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- g. Display Function operates normally on all remaining Display Units.

NOTE 1: Left Outboard Display Unit will blank.

NOTE 2: DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-06 PFD/MFD Selector Switches

31-61-06-03 Left NORM Position

31-61-06-03B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Left PFD/MFD Selector Switch is set OUTBD,
- b. Right PFD/MFD Selector Switch is verified to operate normally,
- c. ISFD operates normally,
- d. Both EFIS/DSP Panels operate normally,
- e. Both Multifunction Keypads (MFKs) operate normally,
- f. Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- g. Display Function operates normally on all remaining Display Units.

NOTE 1: Left Inboard Display Unit will blank.

NOTE 2: DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-06 PFD/MFD Selector Switches

31-61-06-04 Right NORM Position

31-61-06-04A

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Right PFD/MFD Selector Switch is set INBD,
- b. Left PFD/MFD Selector Switch is verified to operate normally,
- c. ISFD operates normally,
- d. Both EFIS/DSP Panels operate normally,
- e. Both Multifunction Keypads (MFKs) operate normally,

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- f. Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- g. Display Function operates normally on all remaining Display Units.

NOTE 1: Right Outboard Display Unit will blank.

NOTE 2: DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

31-61-06 PFD/MFD Selector Switches

31-61-06-04 Right NORM Position

31-61-06-04B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Right PFD/MFD Selector Switch is set OUTBD,
- b. Left PFD/MFD Selector Switch is verified to operate normally,
- c. ISFD operates normally,
- d. Both EFIS/DSP Panels operate normally,
- e. Both Multifunction Keypads (MFKs) operate normally,
- f. Both MFK Rotary CURSOR CONTROL Selectors operate normally, and
- g. Display Function operates normally on all remaining Display Units.

NOTE 1: Right Inboard Display Unit will blank.

NOTE 2: DISPLAY DEGRADED __ Status message may not be displayed for any remaining DU.

SUBSTANTIATION

Background

Proposal 31-61-06-01, -02, -03 based on 787 MMEL item 31-61-06-01, -02, -03.

Proposal 31-61-06-04 is new for the 777X.

Proposal similar to 777 MMEL item 31-61-6.

The display system automatically generates a compact PFD/MFD format on the inboard display when an outboard display unit failure is detected. There are two primary flight display (PFD) / multi-function display (MFD) selectors mounted on the forward panels, which provide the flight crew capability to hard-select the compact PFD/MFD format on the associated display units should the automatic display function fail to recognize a display failure or fail to select the proper format.

The PFD/MFD selector position functions are as follows:

NORM - normal display management, with PFD outboard and MFD inboard.

INBD - displays a compact PFD/MFD format on the associated inboard display unit, and blanks the same-side outboard display. EFIS/DSP format selections will operate normally. (NOTE: If EICAS was previously shown on the inboard display, the inboard display will be a compact PFD/EICAS format. If EICAS is transferred to the off-side inboard display, then the display will reconfigure to a compact PFD/MFD format and EFIS/DSP format selections will operate normally.)

OUTBD - displays a compact PFD/MFD format on the associated outboard display unit, and blanks the same-side inboard display. EFIS/DSP format selections will operate normally. (NOTE: If EICAS was previously shown on the inboard display, the outboard display will be a compact PFD/EICAS format. If EICAS is transferred to the off-side inboard display, then the display will reconfigure to a compact PFD/MFD format and EFIS/DSP format selections will operate normally.)

Consequences of Failure

OUTBD or INBD positions inoperative: None during normal operation. These switches are not used in published procedures. Normal automatic display selection (NORM position) is not affected. Loss of ability to manually reconfigure for an undetected display failure.

NORM position inoperative: Equivalent to inboard or outboard DU inoperative depending on selected switch position (see MMEL item 31-61-01-02, -03, -04 and -05).

Consequences of Next Critical Failure

OUTBD position inoperative at dispatch, subsequent failure of outboard display: Automatic display management will place the compact PFD/MFD format on the inboard display.

OUTBD position inoperative at dispatch, subsequent undetected failure of the associated inboard display: Loss of MFD and EICAS format on one side.

INBD inoperative at dispatch, subsequent failure of inboard display: Automatic display management will retain the normal PFD format on the outboard display.

INBD position inoperative at dispatch, subsequent undetected failure of the associated outboard display: Loss of PFD format on one side. The offside PFD format and ISFD provide sufficient redundancy of flight information for this condition. Head-Up Display (if installed) may be used by affected pilot for primary flight information.

NORM position inoperative at dispatch, subsequent DU failure: Equivalent to inboard or outboard DU inoperative dispatch (see proposed MMEL item 31-61-01-02, -03, -04 and -05).

31-61-07 Instrument Source (AIR DATA/ATT) Selector Switches**31-61-07-01 ALTN Position**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Opposite Instrument Source (AIR DATA/ATT) Selector Switch is verified to operate normally, and
- Associated selector switch remains in AUTO.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-07-01.

The AIR DATA/ATT selectors provide the crew the ability to manually select the source of air and attitude data to be displayed on the PFDs and NDs. Under normal conditions, with the selector in AUTO, the air data reference function (ADRF) and earth reference system (ERS) will provide voted air and attitude data, respectively. When the left AIR DATA/ATT selector is in the alternate (ALTN) position, synthetic airspeed (derived from angle of attack), geometric (GPS) altitude, and ISFD attitude data are provided to the left displays. When the right AIR DATA/ATT selector is in the alternate position, synthetic airspeed (derived from angle of attack), geometric (GPS) altitude, and ISFD attitude data are provided to the right displays. ISFD SPD and ISFD ALT can also show as a backup to AOA SPD and GPS ALT. In addition, with the selector in AUTO, in the event of a failure of voted airspeed or voted air data, synthetic airspeed (derived from angle of attack), and possibly geometric (GPS) altitude are automatically provided to the respective display.

The following alternate data sources are accompanied by the following flight deck effects:

Synthetic Airspeed: AOA SPD flag on PFD. AOA SPD is displayed automatically when the AIRSPEED DATA FAULT Caution message or AIR DATA SYS FAULT Caution message is displayed. AOA SPD may be manually selected with the AIR DATA/ATT selector by procedure when the AIRSPEED UNRELIABLE Warning message is displayed (depending on the scenario).

Geometric Altitude: GPS ALT flag on PFD. GPS ALT is displayed automatically when the AIR DATA SYS FAULT Caution message displays. GPS ALT may be manually selected with the AIR DATA/ATT selector by procedure when the AIRSPEED UNRELIABLE warning message displays (depending on the scenario).

ISFD Attitude: ALTN ATTITUDE CAPT or ALTN ATTITUDE F/O Advisory

message for respective AIR DATA/ATT selector in ALTN position. ATT SINGLE SOURCE Advisory message if both pilots' AIR DATA/ATT selectors are selected to ALTN. ISFD Attitude may be manually selected with the AIR DATA/ATT selector by procedure when the AIRSPEED UNRELIABLE Warning message displays (depending on the scenario).

Consequences of Failure

None unless an UNRELIABLE AIRSPEED warning message occurs. Both switches are in the normal (AUTO) position. The AIRSPEED UNRELIABLE procedure is the only procedure that directs the use of the AIR DATA/ATT selectors.

Consequences of Next Critical Failure

Normal ADRF and ERS redundancy management ensures that high integrity air and inertial data are displayed. The remaining AIR DATA/ATT selector is available for use in the rare scenario that can result in erroneous data continuing to be displayed. In some of these cases the AIRSPEED UNRELIABLE Warning message will be displayed:

There are conditions that can cause multiple air data modules (ADMs) or the AOA vanes to output identical values that are erroneous. This situation could occur due to maintenance errors such as pneumatic tubes being disconnected from multiple static ADMs, or when multiple pitot probes or static ports are equally blocked due to a common mode error such as mud daubers, icing, or volcanic ash. The voting algorithms cannot determine that the resulting airspeed values are wrong so the erroneous information is displayed. The flight control modules (FCMs) have a common mode monitor (CMM) that compares the voted airspeed data with voted AOA and voted inertial data. When the difference between these values becomes excessive, the EICAS message AIRSPEED UNRELIABLE is displayed.

Federal Aviation Administration (FAA)**ATA 31****777-9 Master Minimum Equipment List****Section 2****31-61-08 Clock****31-61-08-01 CLOCK Switches**

Interval	Installed	Required	Procedure
C	2	1	

31-61-08 Clock**31-61-08-02 Clock Displays (UTC TIME, DATE, ELAPSED TIME, Chronograph)**

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL 31-61-08.

Clocks are display functions, shown on the auxiliary area outboard of the primary flight displays. The clocks show digital UTC, date, and elapsed time at all times. Chronometer display and start/stop function is controlled via the clock switch on the outboard portion of the glareshield. There is no dispatchable failure mode which would cause loss of the clock displays themselves.

The elapsed time function is different from the UTC and chronometer in that the elapsed time is not an input to the display from an external source, it is calculated within the display system, and as such failure of the elapsed time display does not affect any other system.

Consequences of Failure

Failure of a clock switch will make the affected clock chronometer function unavailable.

Failure of one side's display functions means only one side will be available for flight crew use.

Consequences of Next Critical Failure

Failure of clock switch on remaining clock will leave chronometer functions unavailable on both clocks.

Loss of the remaining clock's display functions. The flight crew will have to rely on an alternate means to obtain UTC time, date or elapsed time.

31-61-09 Heading Reference (HEADING REF) Switch**31-61-09-01 TRUE Function**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided enroute procedures do not require its use.

31-61-09 Heading Reference (HEADING REF) Switch**31-61-09-02 NORM Light**

Interval	Installed	Required	Procedure
C	1	0	

31-61-09 Heading Reference (HEADING REF) Switch**31-61-09-03 TRUE Light**

Interval	Installed	Required	Procedure
C	1	0	

Background

Proposal based on 787 MMEL item 31-61-09.

The HEADING REF switch located on the overhead panel alternately selects NORM and TRUE for the PFDs, NDs, FMF and AFF. The NORM position allows the user systems to reference magnetic north. In this position, the user systems will automatically switch to TRUE reference when in the vicinity of the magnetic poles. The AFF roll modes, except for LNAV, will not have a north reference near the poles. The TRUE position allows the user systems to reference true north regardless of latitude. In TRUE, the AFF roll mode HDG SEL will switch to HDG HOLD whenever the switch is pressed from one mode to the other, and the AFF roll mode TRK SEL will switch to TRK HOLD whenever the switch is pressed from one mode to the other.

HEADING REF switch will default to NORM when there is a data miscompare between two data source flight data control panel (FDCP) or data from FDCP are invalid. In event of loss of CDN data from DCA and FMF, HRS will default to TRUE. AFF freezes heading reference switch input when approach or localizer is armed.

Consequences of Failure

TRUE function

NORM function is still available. The ability to manually set TRUE heading is not available. Automatic switching to TRUE remains functional. Operation is not allowed on routes where true north referencing is required. Manual setting to TRUE is required for Loss of All Displays NNC.

NORM and TRUE lights

The selection is displayed on the navigation display.

Consequences of Next Critical Failure

Loss of NORM function for switch

Systems continue to use the default condition of magnetic north as the reference.

Loss of all flight deck displays

There is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed, and magnetic and true (if operative) heading remain available. Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

NORM and TRUE lights

No next critical failure is identified.

In the case of the total loss of all switch position data from both FDCP during cruise, the AFF will default to TRUE. If the pilot is flying magnetic heading when the total loss of data occurs, and the plane is in LNAV mode, which uses the Leg Sequencing Guidance, the plane will turn to the new heading but the pilot will be alerted of the change in course via the annunciation on the heading readout on the ND map and mini-map compass rose. The AP/FD will not be able to track a magnetic heading.

If the plane is in HDG SEL mode and this fault occurs, the plane will not turn to the new heading but it will stay the course and change the mode to HDG HOLD, but the pilot will be alerted of the change in course via the annunciation on the heading readout on the ND map and mini-map compass rose. The AP/FD will not be able to track a magnetic heading.

There are no effects during autoland because the HRS selection is latched when Approach or Localizer is armed or active.

There are no effects during Low-Visibility Takeoff (LVTO) because the HRS selection is latched when LVTO is engaged.

31-61-10 Remote Light Sensor (RLS) System

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-10.

The brightness of the four forward large displays, the lower center display, the radio tuning control panels (TCP) on 777X flight deck are automatically adjusted based on ambient light as measured by bezel light sensors (BLSs) and remote light sensors (RLSs). The BLS sensors are responsible for the majority of display brightness adjustment. In addition, each of the five display units and the TCP incorporates a manual brightness control to allow the flight crew to further adjust display. Manual control serves to fine-tune the display brightness within a range around the automatic adjustment of the light sensors. Manual control cannot drive display brightness higher than the maximum value allowed by the light sensor command. The light sensor command is based on the sum of BLS and RLS inputs and manual brightness adjustment. Additionally, the RLS controls that brightness of the discretes, non-graphical, illuminated annunciators when the Master Dim and Test indicator light switch is set to AUTO.

Consequences of Failure

If the RLS system is failed (dual RLS sensor failure), maximum total brightness of all displays will be reduced. Display brightness is still adjusted automatically via the BLS sensors, but the range of automatic adjustment is diminished. Manual brightness adjustment may be necessary to help achieve desired display brightness, by using master brightness control or individual display brightness controls. In situations where RLS has significant impact (i.e., very bright outside and relatively dark inside), upward manual brightness adjustment may not be sufficient to completely reach the desired brightness level. This may result in increased adaptation time to read the displays after looking outside at a relatively bright scene, and would occur mainly in transitory ambient conditions.

The annunciator master dim & test system will go to a default BRIGHT setting when the IND LTS selector is in the AUTO position. A crew member loses automatic control of the annunciator brightness and will not be able to drive annunciation to the dim level used in nighttime operations.

Unlike 787, dual RLS sensor failure is not annunciated by status message. Dual RLS failure has been shown to be very remote in service history and will now be shown on the maintenance computer. These messages appropriately indicate a problem with the photodiode components by monitoring their voltage output and reporting values that are outside the normal operational range.

Consequences of Next Critical Failure

None. BLS failure would require the failure of five light sensors to render the system inoperative. Display brightness can be adjusted manually.

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31-61-11 Electronic Checklist (ECL) System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- WINGTIPS EICAS display indicating EXTENDED is verified prior to each departure,
- Electronic Checklist is deactivated,
- Both Wing Tips are deactivated in extended position,
- Established suitable checklist procedures are used,
- Airport operations do not require use of Folding Wing Tips.

31-61-11 Electronic Checklist (ECL) System**31-61-11-01 ECL Closed Loop Switch Indications**

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided:

- Wingtips EXTENDED closed loop indication operates normally, and
- ECL line item override procedures are used when required to complete checklists.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-11.

The electronic checklist (ECL) is designed to provide the primary means of accomplishing the required checklist procedures the flight crew must perform. It is intended to promote rapid and accurate execution of normal and non-normal checklists while reducing or eliminating crew errors associated with paper checklists.

Consequences of Failure

If ECL is not available due to system failure, corrupted database, mismatched databases, or no databases, the status message CHECKLIST SYS will be displayed.

ECL Inoperative:

Electronic Checklist function will not be available. Flight crew must use established suitable checklists such as paper versions or other suitable versions.

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The CHKL INCOMPLETE NORM Caution message will not be available to indicate that the Folding Wing Tips have not been extended. Therefore, the Folding Wing Tips must be deactivated in the extended position to ensure that the Folding Wing Tips are extended before takeoff power is applied.

Closed loop switch indications:

Associated closed loop switch indications will not appear on the ECL when expected. Therefore, the flight crew must use the line item override function to complete the associated checklist.

Consequences of Next Critical Failure

None.

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31-61-13 Airport Map Function

31-61-13A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Alternate procedures are established and used.

[For Brake to Exit Function Installed:](#)

- Brake to Exit Function is considered inoperative.

[For ADS-B In Installed:](#)

- ADS-B In is considered inoperative.

31-61-13 Airport Map Function

31-61-13B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided:

- Procedures do not require its use.

[For Brake to Exit Function Installed:](#)

- Brake to exit function is considered inoperative.

[For ADS-B In Installed:](#)

- ADS-B In is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-13.

The airport map is integrated with the navigation display (ND) as an underlay and is intended to provide the pilot with a high resolution map of the airport surface together with the airplane's position and heading. The airport surface consists of runways, taxiways, aprons and buildings with the appropriate labels. Position of the airplane is provided by the flight management function (FMF). The intended function of the airport map is to provide supplementary position awareness during taxi and is not intended to change current taxi procedures.

The airport map can be displayed in either a heading/track-up mode (MAP mode) or north-up mode (plan mode). As with the ND, when displayed in MAP mode, the airplane position is shown relative to the flight route against a moving map background. In the plan mode, the airplane position is shown relative to true north. In the plan mode, it is possible to view the origin and destination airport image without the ownship symbol depending on the location of the airplane relative to the airport at any particular point in time. If the lateral Actual Navigation Precision (ANP) exceeds an uncertainty limit, airport map is inhibited in MAP mode, but still available in PLAN mode (with airplane symbol removed), and an ARPT POS indication is displayed.

The airport map may be displayed at 4 different ranges: 5NM, 2NM, 1NM and 0.5NM. Pilots select the range on the EFIS control panel. The airport map is not directly selectable by the pilot - it is automatically displayed as long as system accuracy is met and the following conditions are present:

- (a) The airport is either the ORIGIN or DESTINATION airport as specified in the active flight plan
- (b) The airport is in the airport map database
- (c) The ND range is 5NM or less

Two cycles of the airport map database are available for pilot selection. The two cycles and their effective dates are shown on the INFO page. Under normal operating conditions, the effective (based on current date) cycle is automatically selected and no pilot action is required. Pilots can manually override the automatic selection unless one of the cycles is corrupted and no other choice is available for selection.

Consequences of Failure

Airport map database inoperative: The airport map will not be displayed when any of the following conditions occur: there is a fault in the application, the selected airport map database, or the database file for the airport to display, is corrupted, incompatible, or missing. The "ARPT MAP" flag is shown on the ND when airport map is not displayed. The message "Airport Map Not Available" will be displayed on the INFO AIRPORT MAP DB page. Brake to Exit function (if installed) will be inoperative. If enabled, the ADS-B In SURF functionality will be inoperative, and a "SURF" fail flag will be displayed on the ND.

If both airport map database cycles are expired or out-of-range (i.e., cycles are effective in the future), the most recent cycle is automatically selected and the indication <ICAO> DATE appears on the ND. Pilots will see this annunciation before engine start as part of their pre-flight procedure. Engine start inhibits the annunciation. Additionally, a help window will be displayed on the CDU when the airplane is on the ground, at flight completion, or completion of a CDU cold start. The help window will be removed from the CDU on engine start or selection of CLR Message. Airport map may still be used but, as in normal operation, it is considered supplementary information and may not be used as a primary means of taxi navigation.

Consequences of Next Critical Failure

No specific next critical failure identified.

31-61-14 Head-Up Display (HUD) Systems

31-61-14A

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Any mode which operates normally may be used.

31-61-14 Head-Up Display (HUD) Systems

31-61-14B

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative provided procedures do not require its use.

31-61-14 Head-Up Display (HUD) Systems**31-61-14-01 Low Visibility Takeoff Function**

31-61-14-01A

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided takeoff minima do not require its use.

31-61-14 Head-Up Display (HUD) Systems**31-61-14-01 Low Visibility Takeoff Function**

31-61-14-01B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

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31-61-14 Head-Up Display (HUD) Systems

31-61-14-02 Symbology Control Switches

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided procedures do not require its use.

31-61-14 Head-Up Display (HUD) Systems

31-61-14-03 Brightness (BRT) Controls

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative and associated HUD used if acceptable to affected crewmember.

31-61-14 Head-Up Display (HUD) Systems

31-61-14-04 Perspective Runway

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 31-61-14.

Dual HUD is optional for 777X, and if installed, operates similarly to the 787 system. The HUDs display air and attitude data similar to that shown on the primary flight displays (PFDs), as well as flight director and flight path vector guidance. The HUDs enhance pilot situational awareness but are not required. Individual operators may establish procedures requiring use of one or both HUDs. The HUD system includes two LRU types for the 777-9, the HUD Projection Unit (HPU) and the HUD Combiner Unit (HCU) which is installed in a dual configuration. The 777-9 HPU and HCU are a modification of the 787 Model AMLCD HPU and HCU with form and fit modifications necessary for installation in the 777-9.

The HUD system incorporates a low visibility takeoff guidance feature. This feature uses a ground roll reference (similar to flight path vector symbology) to provide pilots with guidance to track the runway centerline in low visibility conditions.

The HUD symbology control switches are used to control the amount of information displayed. A short press and release of the switch displays speed tape, altitude tape, and heading arc on the associated (on-side) HUD or replaces these items with digital readouts next to the flight path vector. A press and hold of the switch can be used to toggle perspective runway on and off.

Each HUD uses bezel light sensors on the combiners to automatically adjust HUD brightness. An associated brightness control on the forward overhead panel allows for manual adjustment of HUD brightness.

Perspective Runway (PRW) is a new display feature that will be available on the 777X Head-Up Display. It adds symbology to create a virtual VFR environment that improves situational awareness for terminal flight operations. The intent is to supplement situational awareness in conjunction with existing guidance.

Consequences of Failure

Failure of a HUD system is annunciated by the associated HUD SYS CAPT, HUD SYS F/O Status messages and HUD FAULT L, HUD FAULT R Advisory messages. Failure of the low visibility takeoff guidance function is annunciated by the HUD TAKEOFF UNAVAIL Caution message.

HUD inoperative (GGM, combiner, or projector fault):

For 1 inoperative, no impact unless procedures require its use. Opposite pilot may use operative HUD if procedures require its use.

For 2 inoperative, no impact unless procedures require their use.

Low visibility takeoff feature inoperative

Reduced visibility operations requiring this feature cannot be conducted.

Symbology control switch(es) inoperative

None. Either full- or de-cluttered-symbology mode is allowed in all phases of flight except during low visibility takeoff and go-around operations. During these operations, a change in roll mode to TO/GA or HUD TO/GA or in pitch mode to TO/GA will automatically trigger a HUD symbology transition to the full-symbology mode without interaction with the symbology control switch(es). In addition, the pilots have the ability to reset a de-cluttered symbology mode to full-symbology mode simply by stowing and re-deploying the HUD combiner. The perspective runway switch is inhibited during climb, go around, TCAS RA, windshear warning, and HUD unusual attitude. The automatic logic will turn on and turn off the perspective runway.

Brightness controls

HUD brightness may be full bright or full dim. Continued use of affected HUD is at discretion of affected crewmember.

Perspective Runway

PRW symbology is removed from HUDs. PRWY is shown with a solid hor-

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horizontal line through the middle of the PRWY indication to indicate software logic failure that is preventing the symbol from being displayed.

Consequences of Next Critical Failure

None.

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31-61-15 Display Panel Interface

Interval	Installed	Required	Procedure
C	1	0	

May be dispatched with DISPLAY PANEL INTERFACE Status message displayed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 31-61-15.

Data from each of the flight deck multifunction keypads, and EFIS/DSP panels is transmitted to the displays and crew alerting system via dual ARINC 429 buses.

Consequences of Failure

Loss of data from one (not both) of the redundant ARINC 429 buses from any of the multifunction keypads, or EFIS/DSP panels is annunciated by the DISPLAY PANEL INTERFACE Status message. (These faults were originally maintenance level, but were elevated to status level to preclude indefinite exposure to latent failures.)

Loss of redundancy only.

Consequences of Next Critical Failure

Total loss of ARINC 429 data from any single multifunction keypad, or EFIS/DSP panel results in failure of the affected panel. (Each panel has associated status message and proposed dispatch relief under items 31-61 -04, -05.)

31-61-16 Displays Airplane Sequence Number Monitor

Interval	Installed	Required	Procedure
C	1	0	

May be dispatched with DISPLAYS AP SEQ DISAGREE Status message displayed.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 31-61-16.

Data input panel (DIP) switch data from multiple general processing modules (GPM) are used by the displays and crew alerting (DCA) function to calculate the airplane sequence number (ASN). Other airplane systems use the DCA calculated ASN value at power-on initialization.

Consequences of Failure

Loss of data from one (not both) of the redundant panels is annunciated by the DISPLAYS AP SEQ DISAGREE Status message. DCA will use the value stored locally in each general processing module (GPM) to vote against the remaining DIP switch panel and calculate the ASN.

Consequences of Next Critical Failure

Effects are limited to on-ground airplane power-up only. A failure in the remaining DIP switch or erasure of the non-volatile memory in specific GPMs will prohibit DCA from calculating the ASN. The flight controls system will not be able to validate the rigging settings and will display the FLIGHT CONTROL SYS Status message.

- 32-00-01 Landing Gear Synoptic Display**
- 32-08-01 Proximity Sensor Data Concentrators (PSDC)**
 - 32-08-01-01 PSDC 3
 - 32-08-01-01-01 PSDC 3 FAULT
 - 32-08-01-02 PSDC 4
 - 32-08-01-02-01 PSDC 4 FAULT
 - 32-08-01-03 PSDC 7
 - 32-08-01-03-01 PSDC 7 FAULT
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 - 32-08-01-05 PSDC Power Faults
 - 32-08-01-06 PSDC Databus Faults
- 32-11-01 Nose Landing Gear Strut Upper Air Chamber Pressure Indicator**
- 32-30-01 Landing Gear Actuation System**
- 32-30-02 Semi-Lever Gear (SLG) System**
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32-53-01-02 With PRR 62606 or Production Equivalent Incorporated

32-61-01 Landing Gear Position Indication Systems

32-61-01-01 Nose Gear Not-Compressed Sensors

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32-71-01 Tail Strike Detector Channels

32-71-01A

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32-00-01

Landing Gear Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal same as 777 MMEL item 32-00-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

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32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-01 PSDC 3

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- PSDC 4 operates normally,
- Passenger entry door 2L and 3L indication systems are considered inoperative,
- Forward large cargo door indication system is considered inoperative, and
- Main equipment center access door indication system is considered inoperative.

32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-01 PSDC 3

32-08-01-01-01 PSDC 3 FAULT

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- PSDC 3 is deactivated, and
- PSDC 3 is considered inoperative.

32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-02 PSDC 4

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- PSDC 3 operates normally,
- Passenger entry door 2R and 3R indication systems are considered inoperative,
- Forward cargo door hook/latch system (electric mode) is considered inoperative, and
- Forward cargo door lift system (electric mode) is considered inoperative.

32-08-01 Proximity Sensor Data Concentrators (PSDC)**32-08-01-02 PSDC 4****32-08-01-02-01 PSDC 4 FAULT**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- PSDC 4 is deactivated, and
 - PSDC 4 is considered inoperative.
-

32-08-01 Proximity Sensor Data Concentrators (PSDC)**32-08-01-03 PSDC 7**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- PSDC 8 operates normally,
- Passenger entry door 4L indication system is considered inoperative,
- Aft large cargo door indication system is considered inoperative, and
- Tail Strike Detector Channel 1 is considered inoperative.

For service exit doors (SED) installed:

- Left service exit door indication system is considered inoperative.
-

32-08-01 Proximity Sensor Data Concentrators (PSDC)**32-08-01-03 PSDC 7****32-08-01-03-01 PSDC 7 FAULT**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- PSDC 7 is deactivated, and
 - PSDC 7 is considered inoperative.
-

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32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-04 PSDC 8

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- PSDC 7 operates normally,
- Passenger entry door 4R indication system is considered inoperative,
- Aft large cargo door indication system is considered inoperative,
- Aft large cargo door hook/latch system (electric mode) is considered inoperative,
- Aft large cargo door lift system (electric mode) is considered inoperative, and
- Tail Strike Detector Channel 2 is considered inoperative.

[For service exit doors \(SED\) installed:](#)

- Right service exit door indication system is considered inoperative.

32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-04 PSDC 8

32-08-01-04-01 PSDC 8 FAULT

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- PSDC 8 is deactivated, and
- PSDC 8 is considered inoperative.

32-08-01 Proximity Sensor Data Concentrators (PSDC)

32-08-01-05 PSDC Power Faults

Interval	Installed	Required	Procedure
C	6	0	

May be dispatched with PSDC 1, 2, 3, 5, 6 and/or 7 POWER message(s) displayed.

32-08-01 Proximity Sensor Data Concentrators (PSDC)**32-08-01-06 PSDC Databus Faults**

Interval	Installed	Required	Procedure
C	8	0	

May be dispatched with PSDC 1, 2, 3, 4, 5, 6, 7 and/or 8 DATABUS message(s) displayed.

SUBSTANTIATION**Background**

Proposal is based on 787 MMEL item 32-08-01.

The Proximity Sensing System consists of the Proximity Sensor Data Concentrator (PSDC) and proximity sensors.

The basic Proximity sensors will remain identical to the existing 777. For this certification there will be added proximity sensors to support Air/Gnd indication, door "secured" indication and engine cowl indication. Proximity sensor targets will be the same standardized targets used in the existing 777. The Tail Strike assembly sensor will be same as the existing 777.

There are eight (8) PSDCs located throughout the aircraft near groups of proximity sensors. Each PSDC provides for excitation and signal conditioning for up to 16 proximity sensor channels. Each PSDC contains a single Digital Signal Processor (DSP) core. The PSDCs are designed to be software loadable on the aircraft.

The electrical interface to a PSDC consists of the following:

- Sensor interface
- Dual 28Vdc power sources
- Dual ARINC 664 (A664) data busses
- Eight (8) discrete inputs
- Twelve (12) discrete outputs
- Current return
- Chassis ground

The 777-9 PSDC is based on the 787 PSDC with the following upgrades/differences:

- Dual controller area network (CAN) interfaces replaced with dual A664.
- Additional circuitry to support discrete inputs and outputs.
- One additional connector to support added signals.
- Capability to perform local processing.

Consequences of Failure

The PSDC 1, 2, 3, 4, 5, 6, 7 or 8 Status message is displayed when loss of activity is detected on both databuses of a PSDC. The PSDC 1, 2, 3, 4, 5, 6, 7 or 8 FAULT Status message is displayed when the PSDC detects an internal fault indicating loss of redundancy. The PSDC may still transmit and receive data.

NOTE:

Dispatch is not allowed for failure of PSDCs 1, 2, 5, or 6 or detection of internal faults is not dispatchable due to loss of redundancy related to landing gear and air/ground systems. PSDCs 4 and 8 only have a single power source during flight, when secondary power input (GH Bus) is unpowered. Power failure is annunciated as PSDC failure.

PSDC 3 and PSDC 4:

For PSDC 3 inoperative, the door indication systems for passenger entry doors 2L and 3L, forward large cargo door and main equipment access door must be considered inoperative. PSDC 4 must operate normally.

For PSDC 4 inoperative, the door indication systems for passenger entry doors 2R and 3R must be considered inoperative. Forward cargo door hook/latch system (electric mode) and lift system (electric mode) must be considered inoperative. PSDC 3 must operate normally.

PSDC 7 and PSDC 8:

For PSDC 7 inoperative, the door indication systems for passenger entry door 4L, aft large cargo door and left service exit door (if installed) must be considered inoperative. The TAIL STRIKE CHAN 1 Status message will be displayed. PSDC 8 must operate normally.

For PSDC 8 inoperative, the door indication systems for passenger entry door 4R, aft large cargo door and right service exit door (if installed) must be considered inoperative. Aft large cargo door hook/latch system (electric mode) and lift system (electric mode) must be considered inoperative. The TAIL STRIKE CHAN 2 Status message will be displayed. PSDC 7 must operate normally.

PSDC _ FAULT:

For a PSDC fault, the associated PSDC must be deactivated. The associated PSDC _ Status message will be displayed when deactivated.

PSDC power source:

Loss of redundancy only for affected PSDC(s): 1, 2, 3, 5, 6, 7. The status message PSDC _ POWER is displayed.

PSDC ARINC 664 databus:

Loss of redundancy only for affected PSDC(s). Status message PSDC _ DATABUS will be displayed.

Consequences of Next Critical Failure**PSDC 3 inoperative:**

None identified, since the affected door is verified to be closed, latched, and if applicable locked prior to each departure.

PSDC 4 inoperative:

None identified, since the affected door is verified to be closed, latched, and if applicable locked prior to each departure.

PSDC 7 inoperative:

For failure of PSDC 8, tail strike detection is lost. The TAIL STRIKE Caution message will be inoperative.

PSDC 8 inoperative:

For failure of PSDC 7, tail strike detection is lost. The TAIL STRIKE Caution message will be inoperative.

PSDC power source inoperative:

Failure of remaining power source for affected PSDC will result in loss of PSDC function.

PSDC ARINC 664 databus inoperative:

Failure of remaining databus for affected PSDC will result in loss of PSDC function.

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32-11-01 Nose Landing Gear Strut Upper Air Chamber Pressure Indicator

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION

Background

Proposal same as 777 MMEL item 32-11-01.

The 777X incorporates a nose landing gear strut pressure indicator. It is located on the NLG strut near the NLG strut's nameplate placard. The pressure indicator incorporates a green arc indication for quick visual confirmation by the ground crew that the NLG pressure is in an acceptable range.

A NLG gauge reading outside of the correct range indicates, at a minimum, that the NLG is not properly serviced - and in some cases, potentially that an internal seal failure has occurred. Since the gauge has a very wide range of acceptable pressures (to allow for various acceptable temperature and configuration related effects) finding the reading to be out of green band potentially indicates a gross out-of-servicing condition. Proper servicing is recommended as necessary to ensure the gear (including the loads it experiences and passes to the airframe) operates as intended.

If the gauge is broken or otherwise inoperative, the maintenance crew uses alternate means.

For 777-9, the nose landing gear pressure indicator is inspected every 100 days on a normal maintenance schedule.

Consequences of Failure

None. Maintenance crew verifies the NLG strut pressure periodically per airplane maintenance practices. Gauge is provided as a convenient way to check strut pressure. When gauge is inoperative, maintenance crew does this by alternate means.

Consequences of Next Critical Failure

None.

32-30-01 Landing Gear Actuation System

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Landing gear is secured in the down position, and
- Airplane is dispatched in accordance with the AFM Landing Gear Extended Appendix.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-30-01.

For normal actuation the Landing Gear Control Lever electrically controls the landing gear selector valves which command the hydraulic operation of the landing gear. The landing gear retracts and extends using hydraulic actuators, mechanically operated sequence valves and structural mechanisms.

The gear down placard speed of 270KIAS/0.82M applies to all flight with the gear partially or fully extended.

The more restrictive gear down dispatch speed of 270KIAS/0.73M, found in the AFM Landing Gear Extended Appendix, must be observed if an airplane is dispatched with the landing gear cavity exposed to the external airstream. The gear down dispatch speed provides a margin from the gear down structural design speed in the event of an inflight upset.

Consequences of Failure

The GEAR DISAGREE Caution message will be present if one or more landing gear fail to retract or extend. The GEAR DOOR NOT CLOSED Caution message will be present if one or more landing gear doors is not closed.

One or more of the Landing Gear will not retract or extend when the normal actuation system is used. If the gear does not extend, the alternate extend system must be used. For dispatch, the landing gear must be secured in the down position and in accordance with the AFM Landing Gear Extended Appendix. The VMO GEAR DOWN Memo message will be displayed. If VMO of 270 knots is exceeded, the OVERSPEED Warning message will be displayed.

Consequences of Next Critical Failure

None.

32-30-02 Semi-Lever Gear (SLG) System

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Semi-Lever Gear (SLG) System is deactivated, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-30-02.

The main landing gear utilizes a semi-lever gear (SLG) mechanism that forcibly tilts the main landing gear trucks to a toe up position when the airplane rotates during takeoff. This moves the axis of airplane rotation slightly aft and raises the airplane body slightly higher during rotation, allowing for an increase in takeoff angle of attack. This increase in takeoff body angle of approximately 1 degree equates to a reduction in required takeoff runway length of about 1000 ft for the 777X as compared to a takeoff without this function. The increase in airplane body height during rotation and increased rotation capability also provides tail strike clearance during takeoff. Therefore, when this system is inoperative there is an associated takeoff performance decrement that must be accommodated.

In addition to aiding in takeoff performance, the SLG system also positions the main landing gear trucks to be stowed in the wheel well during gear retraction, as well as to transition the trucks back to the toe up position during landing during gear extension.

Consequences of Failure

The SEMI LEVER GEAR Status message will be displayed if proximity sensor data concentrator (PSDC) 5 (L SLG) or PSDC 6 (R SLG) detects a SLG fail to lock, fail to hold, relay failed deenergized, engaged sensor channel fault or lock command discrete output channel fault. May reduce tail strike clearance during takeoff as well as increase the required takeoff field length.

The SEMI LEVER GEAR LOCK status message will be displayed if PSDC 5 (L SLG) or PSDC 6 (R SLG) detects a SLG locked when uncommanded or SLG relay failed energized. Results in loss of damping on touchdown (increased landing loads).

The SEMI LEVER GEAR SYS status message will be displayed if PSDC 5 (L SLG) or PSDC 6 (R SLG) detects a SLG lock command from flight control module (FCM) is invalid or electrical load management system (ELMS) reports a SLG circuit breaker fault.

The semi lever gear (SLG) system must be deactivated for dispatch. The airplane must be dispatched with the appropriate takeoff performance penalties applied.

Consequences of Next Critical Failure

Loss of an engine during takeoff results in reduced tail strike clearance during rotation.

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32-31-01 Landing Gear Lever Lock Solenoid

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Solenoid is in the locked position, and
- Alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-31-01.

The landing gear control lever is a two position lever, "up" and "down". A lever lock mechanism prevents inadvertently commanding gear retraction when the aircraft is on the ground. The lever lock mechanism is released by a solenoid which is energized when the aircraft is airborne. In the event the solenoid or its control circuit fails to release the lever lock a mechanical override can be used to permit moving the lever to "up".

Consequences of Failure

If the lever lock solenoid is inoperative, the lock will remain in the locked position. The flightcrew must use the LOCK QVRD switch to raise the landing gear lever. This is a similar procedure as the Gear Lever Lock Down Non-Normal Checklist in the QRH.

Consequences of Next Critical Failure

If the lever lock override button fails to release the lock mechanism the landing gear would remain in the extended position.

32-31-02 Landing Gear Selector Valve Electrical Control Circuits

Interval	Installed	Required	Procedure
C	2	1	(M)

One UP/DOWN Electrical Control Circuit may be inoperative provided the remaining UP/DOWN circuit is verified to operate normally each flight-day.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-31-02.

The Landing Gear Selector Valves control retract and extend hydraulic pressure to the NLG and MLG actuators and sequence valves. The Landing Gear Selector Valve is controlled by dual coil solenoids which are powered by either the Left DC BUS or the F/O FLT INST BUS. This redundant control path prevents a single electrical failure from preventing gear actuation.

Consequences of Failure

Loss of redundancy. The GEAR CONTROL Status message will appear if one or more of the gear control circuits fail. However failure of one UP and one DOWN electrical control circuit will not affect normal gear actuation.

Consequences of Next Critical Failure

Failure of the remaining UP electrical control circuit will result in the gear remaining in the extended position. Failure of the remaining DOWN electrical control circuit will prevent normal extension of the gear. The GEAR DOOR NOT CLOSED Caution and GEAR DISAGREE Caution messages will appear. The Alternate Extend system will be required for gear extension.

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Interval	Installed	Required	Procedure
B	4	2	(M) (O)

One spring on each Main Gear Door Uplock Mechanism may be missing and gear retraction allowed provided 270 KIAS/.82 Mach is not exceeded during flight.

32-32-01 Main Gear Door Uplock Spring Assemblies**32-32-01-01 Spring Retention Cords*********

Interval	Installed	Required	Procedure
C	4	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-32-01.

The main gear door is secured closed by a structure mounted uplock hook which engages a door mounted roller. The door uplock mechanism is held in the over-center locked position by two redundant springs and does not depend on hydraulic pressure to remain locked. Each spring has a spring retention cord to prevent a broken spring from departing the airplane.

Consequences of Failure

Uplock Spring Assemblies: None. There are two springs per uplock mechanism. The remaining operative spring on each door will be sufficient to securely hold the uplock mechanism.

Spring Retention Cords: None. Failure of a spring retention cord will not affect the door uplock function.

Consequences of Next Critical Failure

Uplock Spring Assemblies: Failure of remaining spring: An over-center bias will hold the uplock mechanism if the remaining operative spring fails, however, turbulence could shake the lock loose. The door may partially open until UP hydraulics are automatically re-applied to hold the door closed. Dispatch is allowed provided landing gear extend placard speeds are observed during all phases of flight.

Spring Retention Cords: None.

32-32-02

Main Gear Uplock Springs

Interval	Installed	Required	Procedure
B	4	3	(M) (O)

One spring on one Main Gear Door Uplock Mechanism may be missing and gear retraction allowed provided 270 KIAS/.82 Mach is not exceeded during flight.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-32-02.

Each main landing gear is held in the uplocked position by a structure mounted uplock hook which engages a strut mounted roller. The uplock mechanism is held in the overcenter locked position by two springs and does not depend on hydraulic pressure to remain locked.

Consequences of Failure

None. There are two springs per uplock mechanism. The remaining operative spring will be sufficient to securely hold the uplock mechanism.

Consequences of Next Critical Failure

If the other spring fails an over-center bias will hold the uplock mechanism, however, turbulence could shake the lock loose. If the gear shakes loose, UP hydraulics will be automatically applied, the door will be sequenced to hydraulically open, the gear will uplock and the door will close. GEAR DISAGREE Caution message and GEAR DOOR NOT CLOSED Caution message may be announced during above sequence. The uplock actuator will remain pressurized to lock for the remainder of the flight i.e. until gear down is selected. To mitigate any damage that could be caused, landing gear extend placard speeds are observed during all phases of flight.

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32-35-01 Landing Gear Alternate Extend System

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Landing gear are secured in the down position,
- Alternate Extend System is deactivated, and
- Airplane is dispatched in accordance with the AFM Landing Gear Extended Appendix.

32-35-01 Landing Gear Alternate Extend System

32-35-01-01 Alternate Extend Hydraulic Pressure Switch

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Inoperative Hydraulic Pressure Switch is open,
- Landing gear doors are verified to open using the Landing Gear Alternate Extend System, and
- Landing gear doors are verified to close using the Ground Door Release Control System.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 32-35-01.

Alternate Extend System: Alternate gear extension is initiated by pressing a guarded switch located on the Landing Gear Control Panel. The alternate extend switch electrically commands the alternate extend power pack, which pressurizes the gear door uplocks and separate alternate release actuators on the gear uplocks. The gear doors are unlocked and the gear free-fall to downlock by gravity and air loads. The 777-9 incorporates additional MLG Door Alternate Extend components to enable main landing gear deployment for all flight phases/configurations. The pressure differential across the 777-9 MLG door is increased relative to the 777-300ER. Under some flight conditions, during an alternate extend operation, the MLG doors may not deploy because of reduced wheelwell pressure. Alternate Extend Door Actuators, and the associated components, are used to push open the MLG doors. This system operates in conjunction with the Landing Gear Alternate Extend System.

Alternate Extend System Hydraulic Pressure Switch: The alternate extend hydraulic pressure switch controls power to the latching circuits for the alternate extend system control relays and to the ground door control switches. The alternate extend control relays provide power to the alternate extend system power pack 28V DC motor which drives the power pack hydraulic pump. The hydraulic switch is normally closed and opens when the alternate extend system reaches pressure. As a result, electric power is removed from the alternate extend system control relays and thus removes power from the power pack motor. The pressure switch failing Open allows dispatch per MMEL 32-35-01-01, however dispatch is not allowed with the hydraulic pressure switch failed closed because the system will not shut off after alternate extend is commanded causing damage to the alternate extend power pack.

Consequences of Failure

Alternate Extend System:

The ALT GEAR EXTEND Status message will display when one or more Alt extend control relays have been energized for more than 60 seconds. The ALTN GEAR SYS FAULT Advisory messages will be displayed.

The alternate extend system must be deactivated and airplane dispatched with the landing gear locked in the down position.

If the alternate extend system control relay(s) is failed energized, the alternate extend control system is inoperative. If gear is extended, retract will not be possible. The alternate extend system must be deactivated prior to dispatch with the landing gear locked in the down position. Deactivation of the alternate extend system results in loss of secondary means of gear extension and requires dispatch in accordance with AFM Landing Gear Extended Appendix.

When dispatching in accordance with the AFM Landing Gear Extended Appendix, VMO GEAR DOWN Memo message will be displayed for the entire flight as a result of setting the Overspeed Warning to GEAR DOWN on the MISC SYSTEM CTRLS (MSC) maintenance page.

The OVERSPEED Warning will be annunciated when the aircraft exceeds VMO/MMO regardless of flaps/gear configuration. OVERSPEED will extinguish once airspeed decreases back below the trip threshold.

Alternate Extend System Hydraulic Pressure Switch:

If the switch fails to the open position, the ground door control system and the alternate extend system latching circuits are inoperative. No effect for normal flight operations. For maintenance ground operations, the landing gear doors must be opened by placing the ALTN GEAR switch DOWN and holding (45 seconds maximum) until all gear doors are open.

Consequences of Next Critical Failure

Alternate Extend System:

None, as the airplane must be dispatched in accordance with AFM Landing Gear Extended Appendix.

Alternate Extend System Hydraulic Pressure Switch:

Failure of the normal landing gear extension system that requires use of

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alternate extension. The alternate extend latching circuit is inoperative, the alternate gear switch must be held in the DOWN position until all gear indicate in-transit when performing non-normal procedures which require gear alternate extension (no modification to non-normal checklist is required).

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32-35-02 Ground Door Release Control System

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Both door open control switches are verified to be open,
- Landing gear doors are verified to open using the alternate extend system, and
- Landing gear doors are closed before each departure.

32-35-02 Ground Door Release Control System**32-35-02-01 Door Open Control Switches**

Interval	Installed	Required	Procedure
B	2	0	(M) (O)

May be inoperative closed provided:

- Inoperative control switch(es) is closed,
- Landing gear are secured in the down position,
- Landing Gear Alternate Extend System is deactivated, and
- Airplane is dispatched in accordance with the AFM Landing Gear Extended Appendix.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-35-02.

Ground Door Release Control System:

The ground door release system provides a method for opening and closing of the gear wheel well doors for ground maintenance operations. Door open control switches, located on the main wheel well electrical service panel (P56), activate the alternate extend system which unlocks all landing gear doors and allows them to free fall to the open position under their own weight. Door close switches for the NLG and MLG doors are located on the APU control panel (P40) and electrical service panel (P56), respectively. When commanded, with Center hydraulic system available, the associated NLG and MLG gear doors will close. Failure of the ground door release system may indicate a failure of the alternate extend system.

Door Open Control Switches:

The door open control switches consist of the Arm Doors switch and the All Doors Open/MLG Doors Close switch. Simultaneously moving the

Arm Doors switch to the ARM position and the All Doors Open/MLG Doors Close switch to the ALL DOORS OPEN position applies power to the alternate extend system, which unlocks the doors so that they can free fall to the open position.

Consequences of Failure

Ground Door Release Control System:

If the Ground door control system fails to open the gear doors (i.e either door open switch fails Open), ground operation for door opening is possible using the ALTN GEAR switch located in the flight deck (P2-2 panel). Airplane dispatch is permitted provided both door open control switches are verified to be open, the alternate extend system is functioning and the gear doors close prior to dispatch. If the failure is common to the Alternate Extend System, i.e., the gear doors will not open with the Alternate Extend System, then the airplane must be dispatched gear down per MMEL item 32-35-01.

Door Open Control Switches:

If either the Arm Doors switch or the "All Doors Open" switch are failed closed there is no effect on the system. However, the alternate extend system must be deactivated and the airplane dispatched in accordance with AFM Landing Gear Extended Appendix due to concerns of the next critical failure (remaining switch fails closed). In the event of the next critical failure, an uncommanded gear extension may occur or if the gear is already extended, retraction will not be possible. If both switches are failed closed, the alternate extend system will operate until the hydraulic pressure reaches approximately 2100 psi and then shutdown. It will commence operation again once the pressure drops below approximately 1700 psi.

When dispatching in accordance with the AFM Landing Gear Extended Appendix, VMO GEAR DOWN Memo message will be displayed for the entire flight as a result of setting the Overspeed Warning to GEAR DOWN on the MISC SYSTEM CTRLS (MSC) maintenance page.

The more restrictive gear down dispatch speed of 270KIAS/0.73M, found in the AFM Landing Gear Extended Appendix, must be observed if an airplane is dispatched with the landing gear cavity exposed to the external airstream. The gear down dispatch speed provides a margin from the gear down structural design speed in the event of an inflight upset.

The OVERSPEED Warning will be annunciated when the aircraft exceeds VMO/MMO regardless of flaps/gear configuration. OVERSPEED will extinguish once airspeed decreases back below the trip threshold.

Consequences of Next Critical Failure

Ground Door Release Control System: None, as both door open control switches are verified to be open and the alternate extend system is verified to operate normally.

Door Open Control Switches: None, as the airplane must be dispatched in accordance with the AFM Landing Gear Extended Appendix.

32-41-01

Brake Accumulator Pressure Indicator (Wheel Well)

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided Brake Accumulator Pressure indicator (Flight Deck) operates normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-41-01.

A direct-reading accumulator pressure gauge is installed near the accumulator in the wheel well for maintenance use. The brake accumulator is a gas charged accumulator with a floating piston that separates the gas and the oil sides. It has a precharge of 1000 psi. A pressure transducer is also installed on the gas side of the brake accumulator for flight deck indication.

Consequences of Failure

Brake accumulator pressure cannot be monitored in the wheel well during maintenance. Brake accumulator pressure will still be available by the flight deck indicator.

Consequences of Next Critical Failure

Failure of the flight deck brake accumulator pressure indicator results in loss of ability to check brake accumulator pressure.

32-41-02 Brake Accumulator Pressure Indicator (Flight Deck)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided brake accumulator charge is verified normal once each flight-day.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-41-02.

The brake accumulator is a gas charged accumulator with a floating piston that separates the gas and the oil sides. It has a precharge of 1000 psi. A pressure transducer is installed on the gas side of the brake accumulator for flight deck indication. A direct-reading gauge is also installed near the accumulator in the wheel well for maintenance use.

Consequences of Failure

Gas precharge pressure cannot be monitored in the flight deck. Verification of brake accumulator pressure will still be available from the wheel well indicator.

Consequences of Next Critical Failure

Failure of the wheel well brake accumulator pressure indicator results in loss of ability to check brake accumulator precharge.

Failure of normal and alternate brake systems would annunciate the BRAKE ACCUM ONLY Advisory message and illuminate the BRAKE SOURCE light above the Brake Accumulator Pressure Indicator. This would leave the flight crew unable to assess residual braking capability from the Brake Accumulator. Flight crew procedures per the non-normal checklist remains unchanged with or without Brake Accumulator pressure indication.

32-41-03 Brake Low Pressure Indication System

Interval	Installed	Required	Procedure
A	1	0	(M) (O)

May be inoperative provided:

- Brake Accumulator Pressure Indicator (Flight Deck) operates normally,
 - Normal and alternate brake systems are verified to operate normally,
 - Brake accumulator isolation valve is verified to operate normally,
 - Alternate procedures are established and used, and
 - Repairs are made within 3 flight-days.
-

32-41-03 Brake Low Pressure Indication System**32-41-03-01 BRAKE SOURCE Light**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided Brake Low Pressure Indication System operates normally.

SUBSTANTIATION**Background**

Proposal based 777 MMEL item 32-41-03.

The brake low pressure indication system alerts the flight crew when normal and alternate source brake hydraulic system pressures are low. When the normal and alternate source brake hydraulic system pressures are low, the EICAS Advisory message BRAKE ACCUM ONLY is displayed and the BRAKE SOURCE light on the center forward panel is illuminated. When this situation occurs, the brake accumulator is the only remaining source of brake hydraulic pressure. The brake low pressure indication system consists of two pressure switches. One switch is in the right hydraulic system. The other switch is in the center hydraulic system downstream of the alternate brake source selector valve. There is a time delay module (3 seconds) in series with the switches, the BRAKE SOURCE light, the BRAKE ACCUM ONLY Advisory message, and associated wiring. The two pressure switches are wired in series and when both switches are closed (pressure low in right hydraulic system and alternate braking system powered by the center hydraulic system) a ground is provided after a three second delay to the BRAKE SOURCE light which causes the light to illuminate. This ground also provides an analog discrete to Common Core System which then displays the BRAKE ACCUM ONLY Advisory message. Relevant failures, other than a wiring problem, are either of the two switches, the time delay module, and the BRAKE SOURCE light module. Failure of either switch or the time delay module will render both the light and EICAS message inoperative, requiring relief for the system. The BRAKE SOURCE light could fail discretely, so separate relief for the light is provided in the sub-item.

The flight deck brake accumulator (BRAKE ACCUM) pressure indicator on the left forward panel, although not part of the brake low pressure indication system, provides the flight crew an indication of brake accumulator pressure. A pressure significantly less than 2,800 psi for longer than 3 seconds would indicate a loss of normal and alternate brake source hydraulic pressure.

Consequences of Failure

Brake low pressure indication system: None for normal flight operations without subsequent failure. Personnel conducting towing operations should be advised they must closely monitor the brake accumulator pressure on the flight deck gauge.

BRAKE SOURCE Light: None for normal operations without subsequent failure. Personnel conducting towing operations should be advised they must monitor EICAS for alerting of low normal and alternate source brake hydraulic pressure. For towing operations without AC power applied to the airplane, the brake low pressure indication system must be considered inoperative and the brake accumulator pressure gauge on the flight deck must be closely monitored.

Consequences of Next Critical Failure

Brake low pressure indication system:

Low normal and alternate source brake hydraulic pressure: The flight crew will have no alert indication of this condition, but they will have an indication of brake accumulator pressure on the flight deck gauge. Since the normal and alternate brake systems, and the brake accumulator isolation valve were operationally tested before departure and the departure

period is limited to three (3) flight days, multiple brake system failures or failure of the right and center hydraulic system would be required to result in low normal and alternate source brake hydraulic pressure. The non-normal procedure for low right and center hydraulic pressure (HYD PRESS LOW R+C) notes that normal and alternate brakes are inoperative. Additionally, the item (O) procedure requires that flight crews be informed that they will not be alerted to low normal and alternate source brake hydraulic pressures. The brake accumulator pressure gauge (BRAKE ACCUM) on the left forward panel may be used as an indication of when to perform the BRAKE ACCUM ONLY non-normal procedure.

BRAKE SOURCE Light:

Low normal and alternate source brake hydraulic pressure: None, as the EICAS Advisory message BRAKE ACCUM ONLY will provide an alert of this failure.

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32-42-01 Normal Antiskid Valves

32-42-01A

Interval	Installed	Required	Procedure
C	12	10	(M) (O)

One valve per each six-wheel truck may be inoperative provided:

- Associated brake is deactivated using the deactivation assembly, and
- AFM performance decrements for brake(s) deactivated are applied.

32-42-01 Normal Antiskid Valves

32-42-01B

Interval	Installed	Required	Procedure
C	12	10	(M) (O)

One valve per each six-wheel truck may be inoperative provided:

- Associated brake is deactivated by capping the brake line,
- After takeoff, landing gear remains down for two minutes before retraction,
- Appropriate performance adjustments are applied, and
- AFM performance decrements for brake(s) deactivated are applied.

NOTE: In the event of engine failure after V1, retract landing gear after takeoff.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 32-42-01, with 2 minute gear down requirement addressed similar to 787 MMEL item 32-45-01 and 777 MMEL item 32-45-04.

Antiskid protection is provided for individual wheels in the normal brake hydraulic system. Two identical normal antiskid valve modules are used, one for each main landing gear and each containing six antiskid valves.

Consequences of Failure

An antiskid normal valve fault is indicated by the ANTISKID NORM VLV L or R Status message. One antiskid valve on one wheel on one or both trucks may be inoperative.

Deactivation Tool Used:

The associated brake is deactivated using the deactivation tool. Braking performance will be degraded. Antiskid protection will be available on the other wheels. Appropriate performance penalties must be applied. Retract braking operates normally for deactivation tool used.

Brake Line Capped:

The brake line is capped on the associated brake. Braking performance will be degraded. Antiskid protection will be available on the other wheels. Appropriate performance penalties must be applied. Retract braking will be inoperative for the associated wheel(s). Landing gear must remain down for two minutes to allow spin-down.

Brake Load Alleviation function will operate normally using the remaining operative brakes.

Consequences of Next Critical Failure

The loss of an additional normal antiskid valve or wheelspeed transducer will continue to degrade brake performance. Antiskid protection will be available on the other wheels. The ANTISKID FAULT Caution message will be displayed following the next failure and autobrake operation will be inhibited.

For wheels with the brake line capped:

A subsequent failure of an engine after V1 would require that the landing gear be retracted until takeoff obstacles are cleared. The associated wheels on the main landing gear will continue to spin as they are retracted into the wheel wells.

In the improbable event of a burst tire or flailing tire tread, the spinning wheel/tire could potentially cause damage to equipment located in the wheel well. To mitigate this potential hazard, the landing gear remains down for two minutes after takeoff before they are retracted in order to allow the wheels to stop spinning.

Flight planning fuel will need to be increased due to the additional drag for the period of time after takeoff that the landing gear remains extended. In the event of engine failure after V1, the landing gear should be retracted allowing for gear retracted takeoff performance. Takeoff performance is better for both engines operating and landing gear extended than it is with one engine inoperative and landing gear retracted. Therefore, it is not necessary to apply landing gear extended takeoff performance.

The failure combination of a burst tire or flailing tire and a failed engine is extremely improbable ($<1.0E-09$).

Federal Aviation Administration (FAA)**ATA 32****777-9 Master Minimum Equipment List****Section 2****32-42-02 Antiskid Wheelspeed Transducers****32-42-02-01 Left Main Gear Truck**

Interval	Installed	Required	Procedure
C	6	5	(O)

One may be inoperative provided:

- AFM performance decrements for brake(s) deactivated are applied, and
 - No other brakes are deactivated on that truck.
-

32-42-02 Antiskid Wheelspeed Transducers**32-42-02-02 Right Main Gear Truck**

Interval	Installed	Required	Procedure
C	6	5	(O)

One may be inoperative provided:

- AFM performance decrements for brake(s) deactivated are applied, and
 - No other brakes are deactivated on that truck.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-42-02.

Each main gear wheel has one wheel speed transducer. The brake system control unit (BSCU) uses wheel speed data to detect skids and commands the antiskid valve for that wheel to reduce brake pressure until skidding ceases.

Consequences of Failure

An antiskid wheelspeed transducer fault is indicated by the ANTISKID XDCR L or R Status message. The loss of one wheelspeed transducer will appear as zero wheel speed for that wheel. The BSCU will fully release that brake for all speeds above 25 knots. Braking performance will be reduced. The associated brake does not have to be physically deactivated. Gear retract braking is not affected. Performance penalties for deactivated brake(s) must be applied. Antiskid protection will be available on the other wheels.

Consequences of Next Critical Failure

The loss of an additional transducer or antiskid valve will continue to degrade braking performance. Antiskid protection will be available on the other wheels. The ANTISKID FAULT Caution message will be displayed and autobrake operation will be inhibited.

32-42-03

Alternate Antiskid Valves

Interval	Installed	Required	Procedure
C	8	0	(M)

May be inoperative provided manual braking capability on the alternate brake system is verified to operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-42-03.

Antiskid protection is provided for individual wheels in the normal (right) brake hydraulic system. On the alternate (center/reserve) brake hydraulic system, antiskid protection is provided individually for each aft brake and for fore-mid tandem pairs.

Consequences of Failure

Failure of one or more alternate antiskid valves is indicated by the ANTISKID ALTN VALVE Status message.

None. Antiskid protection will be available through the normal brake hydraulic system. Gear retract braking is not affected.

Consequences of Next Critical Failure

Subsequent loss of the normal (right) brake hydraulic system may cause tires to skid during heavy braking or on slippery runways.

32-42-04 Autobrake System (Including Autobrake Solenoid Valve)

32-42-04A

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Autobrake solenoid valve is verified closed, and
- b. AUTOBRAKE selector remains OFF.

For Brake to Exit Function installed:

- c. Brake to Exit Function is considered inoperative.
-

32-42-04 Autobrake System (Including Autobrake Solenoid Valve)

32-42-04B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- a. Autobrake valve module is deactivated, and
- b. AUTOBRAKE selector remains OFF.

For Brake to Exit Function installed:

- c. Brake to Exit Function is considered inoperative.
-

SUBSTANTIATION

Background

Proposal based 777 MMEL item 32-42-04.

The autobrake system permits automatic braking at a pre-selected deceleration level during landing rollout or by applying full brake pressure during a rejected takeoff. The system operates only when the normal (right) hydraulic brake system is functional. Antiskid protection is provided during autobrake operation.

Consequences of Failure

Failure of the autobrake system is indicated by the AUTOBRAKE Status message.

The AUTOBRAKE SOL VALVE Status message will be displayed when the autobrake solenoid pressure indicates high when not commanded on.

Autobrake function must remain off for dispatch. Autobrake valve module must be deactivated if AUTOBRAKE SOL VALVE Status message is displayed.

Autobrake function will not be available. Pedal brakes can be used to slow and stop the airplane. Brake to exit function, if installed, will not be available.

Consequences of Next Critical Failure

None.

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32-42-05

Brake to Exit (BTE) Function

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION**Background**

New proposal for 777X.

The Brake to Exit function is a customer selectable option, controlled by the option selection software (OSS) bit that allows the flight crew to select an autobrake mode that slows the airplane to achieve runway exit speed by a selected runway exit. The runway will be selected using the Flight Management Approach Reference page or a portable Electronic Flight Bag (EFB) and uplinked to the Airplane similar to the Vspeed uplinks. Displays will validate the selected runway exit using the ARINC 816 Airport Map database loaded into Displays. After validating the selected runway-exit Displays will pass the exit distance and runway length to the Brake System Controller Unit.

Included in the Brake to Exit function is a new Brake to Exit position on the Autobrake selector displayed on EICAS. This position will be time-shared with the Rejected Take Off (RTO) position and enabled for selection after the pilot has made or confirmed a selection through FM and Displays has validated the exit.

If the selected Airport is not contained in the ARINC 816 Airport Map database loaded into Displays or the selected exit does not match the Airport Map DB the BTE selection on the Autobrake switch will not be enabled.

Once the Brake System Control Unit (BSCU) is in the BTE Autobrake Mode an "AUTOBRAKE RWY EXIT" memo message will be displayed on the EICAS page similar to the other Autobrake mode memo messages.

The Brake to Exit function is disabled and the GPWS RUNWAY OVRD Advisory message will be displayed if the crew selects the RUNWAY OVRD on the TCP.

Consequences of Failure

BTE function not available. Flight crew selects Autobrake level or manual braking as appropriate.

BTE inoperative does not change either RTO autobrake or landing autobrake functionality, performance, or methods for disabling autobrakes.

Consequences of Next Critical Failure

Failure of autobrake system: Pedal brakes can be used to slow and stop the airplane.

32-42-06

Brake Load Alleviation Function

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided appropriate gross weight and center-of-gravity adjustments are applied.

SUBSTANTIATION**Background**

New proposal for 777X.

Brake load alleviation function limits brake application rate for braking at slow speeds. The function acts to reduce forward fuselage loads generated by abrupt braking during taxi conditions. If the brake load alleviation function is inoperative, there is a potential for airplane structural damage if abrupt braking were to occur with heavy weight and forward CG.

Consequences of Failure

A failure of the brake load alleviation function is indicated by the BRAKE LOAD PROTECTION Status message which indicates failure of both normal brake metered pressure transducers or failure of the autobrake/BITE card within the brake system control unit (BSCU). When brake load alleviation is inoperative the airplane gross weight and CG must be restricted so that forward fuselage loads are not exceeded if abrupt braking were to occur. For a CG of 31.0% MAC or forward, maximum takeoff weight is limited 663,000 lb.

The BRAKE LOAD PROT INOP Caution message will be displayed when the BRAKE LOAD PROTECTION Status message is present, gross weight exceeds 663,000 lb and CG is at or forward of 31% MAC. Structural damage can only occur with abrupt braking at heavier takeoff weight and forward CG combinations. Dispatch is acceptable if weight and CG limitations are applied.

Consequences of Next Critical Failure

Potential damage due to abrupt braking loads will be mitigated provided the appropriate gross weight and center-of gravity adjustments are applied.

If the airplane weight is greater than 663,000 lb and the CG is forward of 31% MAC, the BRAKE LOAD INSPECTION Status message will be displayed if abrupt braking resulting in body longitudinal acceleration less than -0.4G is detected. Subsequent dispatch is not allowed.

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32-44-01 Brake Status Lights (On Nose Gear)**32-44-01A**

Interval	Installed	Required	Procedure
C	3	0	(O)

May be inoperative provided alternate procedures are established and used.

32-44-01 Brake Status Lights (On Nose Gear)**32-44-01B**

Interval	Installed	Required	Procedure
D	3	0	

May be inoperative provided procedures do not require their use.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-44-01.

The Brake Status Lights on the nose gear are used to inform the ground crew of the current brake status. These lights indicate: Brake On, Brake Off and Parking Brake Set.

Consequences of Failure

None. Brake status indication is still available in the flight deck. When the parking brakes are set an EICAS memo message "PARKING BRAKE SET" is displayed. If the parking brake is set and either engine is selected to takeoff thrust, the takeoff configuration aural alert is sounded and an EICAS warning message "CONFIG PARKING BRAKE" is displayed.

Consequences of Next Critical Failure

There are no further consequences of an additional failure.

32-44-02 Gear Retraction Braking System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- After takeoff, landing gear remains down for two minutes before retraction, and
- Appropriate performance adjustments are applied.

NOTE: In the event of engine failure after V1, retract landing gear after takeoff.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-44-02, with 2 minute gear down requirement addressed similar to 787 MMEL item 32-45-01 and 777 MMEL item 32-45-04.

Gear Retract braking is accomplished with the alternate brake hydraulic system. During gear retraction the gear retract braking actuators meter sufficient brake pressure to stop the wheels prior to entering the wheel well.

Consequences of Failure

The BRAKE GEAR RETRACT TRUCK status message is displayed when retract brake hydraulic pressure is not detected after the landing gear is commanded to retract.

The BRAKE GEAR RETRACT WHEEL status message is displayed when any main gear wheel speed is detected high 12.5 seconds after commanding the landing gear to retract.

Dispatch with an inoperative gear retract braking function is allowed provided the gear remains extended for two minutes after takeoff to allow the wheels to spin down. Climb limited takeoff weight is based on landing gear extended. Gear extended obstacle limits do not apply because the gear may be retracted in the event of an engine out. Flight planning fuel is increased due to added drag while the gear remains down for 2 minutes.

Consequences of Next Critical Failure

A subsequent failure of an engine after V1 would require that the landing gear be retracted until takeoff obstacles are cleared. The associated wheels on the main landing gear will continue to spin as they are retracted into the wheel wells.

In the improbable event of a burst tire or failing tire tread, the spinning wheel/tire could potentially cause damage to equipment located in the wheel well. To mitigate this potential hazard, the landing gear remains down for two minutes after takeoff before they are retracted in order to allow the wheels to stop spinning.

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Flight planning fuel will need to be increased due to the additional drag for the period of time after takeoff that the landing gear remains extended. In the event of engine failure after V1, the landing gear should be retracted allowing for gear retracted takeoff performance. Takeoff performance is better for both engines operating and landing gear extended than it is with one engine inoperative and landing gear retracted. Therefore, it is not necessary to apply landing gear extended takeoff performance.

The failure combination of a burst tire or flailing tire and a failed engine is extremely improbable ($<1.0E-09$).

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32-44-03 Parking Brake Set Indication System (Flight Deck)

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Alternate procedures are established and used,
- Parking brake valve is verified to operate normally once each flight-day,
- Parking brake and brake antiskid interface indication is verified to operate normally once each flight-day, and
- Parking brake takeoff configuration warning system is verified to operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-44-03.

The flight deck parking brake set indication system consists of the PARKING BRAKE SET EICAS Memo message and the components necessary to result in display of the message. The parking brake set status light on the nose landing gear uses many of the same components to illuminate the light, however this light is covered by MMEL item 32-44-01. The system consists of electrical power from the parking brake valve 28V DC circuit breaker which drives the parking brake valve close relay. Power is applied to the relay when a switch contact is closed when the parking brake lever is set and the valve fully closed contact on the parking brake valve switch is closed.

When the parking brake valve close relay is energized it closes a set of contacts in the relay providing an analog ground to Displays and Crew Alerting, which indicates the parking brake lever is set. Displays and Crew Alerting then displays the PARKING BRAKE SET Memo message.

Another set of contacts in the parking brake close relay also provides a ground to the parking brake set light on the nose gear. Failure of the outboard parking brake lever switch to the released position, the parking brake valve fully closed switch contacts, or the parking brake valve close relay will result in the PARKING BRAKE SET memo EICAS message not being displayed and the parking brake set light on the nose gear not illuminating when the parking brake is set.

Since the source of both the flight deck indication (PARKING BRAKE SET Memo message) and the status light on the nose gear originate from the same relay, it is possible that both indications ("indication system") will be inoperative simultaneously. In order to avoid the possibility of the ground crew initiating towing/pushback based on an extinguished (inop) PB Set status light, Boeing encourages the flight crew to communicate the parking brake status to the ground crew.

Consequences of Failure

The only positive indication of the parking brake status is the position of the parking brake lever. Daily verification of the operation of the parking brake valve will substantially reduce the possibility that the parking brake valve could be failed open when the parking brake lever is set, or failed closed when the parking brake lever is released. Establishment and use of an operations procedure will ensure flight crew and ground crew communication on the status of the parking brake. Verification of the parking brake takeoff configuration warning operation will ensure the crew will be warned should they attempt takeoff with the parking brake set.

Consequences of Next Critical Failure

Parking brake valve fails open with the parking brake lever set: flight crew must rely on visual and tactile cues regarding airplane movement. Without active right or center hydraulic power, hydraulic pressure from the accumulator will decay.

Parking brake valve fails closed with the parking brake released: CONFIG PARKING BRAKE Warning message will be active if takeoff is attempted.

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32-45-01 Wheel Brakes**32-45-01A**

Interval	Installed	Required	Procedure
C	12	10	(M) (O)

One per each six wheel truck may be inoperative provided:

- Associated brake is deactivated with a deactivation assembly, and
- AFM performance decrements for brakes deactivated are applied.

32-45-01 Wheel Brakes**32-45-01B**

Interval	Installed	Required	Procedure
C	12	10	(M) (O)

One per each six wheel truck may be inoperative provided:

- Associated brake is deactivated by capping the brake line,
- After takeoff, landing gear remains down for two minutes before retraction,
- Appropriate performance adjustments are applied, and
- AFM performance decrements for brakes deactivated are applied.

NOTE: In the event of engine failure after V1, retract landing gear after takeoff.

32-45-01 Wheel Brakes**32-45-01C**

Interval	Installed	Required	Procedure
C	12	10	(M) (O)

One per each six wheel truck may be removed from the center axle provided:

- Associated brake line is capped,
- After takeoff, landing gear remains down for two minutes before retraction,
- Appropriate performance adjustments are applied,
- AFM performance decrements for brakes deactivated are applied, and
- Brake temperature monitoring system is considered inoperative.

NOTE: In the event of engine failure after V1, retract landing gear after takeoff.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-45-01, with 2 minute gear down requirement addressed similar to 787 MMEL item 32-45-01 and 777 MMEL item 32-45-04.

The main gear wheels are fitted with multiple-disc carbon brake. The nose gear wheels are not braked.

It is acceptable to use the deactivation tool for dispatch with a brake hydraulic leak. A small quantity of hydraulic fluid will be lost, but not enough to cause loss of a hydraulic system. Three MMEL procedures are provided for brake deactivation to provide the operators with maximum flexibility. Deactivation of the brake with a tool, capping the brake line to inop the brake, and removing the brake then capping the line.

The primary advantage of brake deactivation using the deactivation tool is that gear retract braking continues to function; there is no requirement for gear remaining down for 2 minutes after takeoff. Small amounts of hydraulic leakage will occur in the case of a brake hydraulic leak.

The primary advantage of hydraulic line capping is that the brake is never pressurized and therefore the leakage of hydraulic fluid is minimized. Gear must remain down for 2 minutes after takeoff.

The primary advantage of removing the brake is to eliminate the possibility of hydraulic fluid leakage on carbon components within the brake assembly. Gear must remain down for 2 minutes after takeoff.

The second and third entries of 777 MMEL/DDG item 32-45-01 require that the gear remain extended for two minutes after takeoff to allow for wheel spindown prior to retraction. This requirement precludes potential adverse effects of a spinning tire within the wheel well, and is not related to potential inability to retract the gear. In the event of engine failure after V1, gear retraction is accomplished, which allows avoidance of very large gear down takeoff performance penalties.

Consequences of Failure

Failure of one brake per six wheel truck would result in increased stopping distance. Appropriate performance penalties are required to be applied.

Retract braking operates normally for deactivation tool used.

Brake line capped or brake removed: Retract braking will be inoperative for the associated wheel. Landing gear is required to remain down for two minutes to allow spin-down.

For center axle brake removed, disconnecting the associated brake temperature sensor will result in display of the BRAKE TEMP SYS Status message. Brake temperature monitoring system MMEL item must also be applied.

Brake Load Alleviation function will not be impacted.

Consequences of Next Critical Failure

Subsequent loss of another brake would result in further increased stopping distance.

For wheels with brake lines capped or brakes removed:

A subsequent failure of an engine after V1 would require that the landing gear be retracted until takeoff obstacles are cleared. The associated wheels on the main landing gear will continue to spin as they are retracted into the wheel wells.

In the improbable event of a burst tire or flailing tire tread, the spinning wheel/tire could potentially cause damage to equipment located in the wheel well. To mitigate this potential hazard, the landing gear remains down for two minutes after takeoff before they are retracted in order to allow the wheels to stop spinning.

Flight planning fuel will need to be increased due to the additional drag for the period of time after takeoff that the landing gear remains extended. In the event of engine failure after V1, the landing gear should be retracted allowing for gear retracted takeoff performance. Takeoff performance is better for both engines operating and landing gear extended than it is with one engine inoperative and landing gear retracted. Therefore, it is not necessary to apply landing gear extended takeoff performance.

The failure combination of a burst tire or flailing tire and a failed engine is extremely improbable ($<1.0E-09$).

32-45-02 Wheel Tie Bolts

Interval	Installed	Required	Procedure
A	-	-	(M)

One per wheel may be broken or missing provided:

- Affected wheel is removed, checked for broken parts or damage, and replaced if broken parts or damage is found,
 - Associated brake is checked for broken parts or damage, and is replaced or deactivated if broken parts or damage is found,
 - After each landing, wheel is inspected for additional broken or missing tie bolts, and
 - Repairs are made within 5 flight-cycles.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-45-02.

The wheels are of a conventional forged design consisting of inboard and outboard wheel halves that bolt together with tie bolts. Each main gear wheel has at least 18 tie bolts. Each nose gear wheel has at least 14 tie bolts.

Consequences of Failure

None. The remaining tie bolts provide sufficient strength to hold the wheel halves together. The minimum predicted roll life with one tie bolt missing is 5000 miles.

Consequences of Next Critical Failure

None. The remaining tie bolts provide sufficient strength to hold the wheel halves together.

32-45-03**Nose Gear Spin Brake**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative or missing provided:

- After takeoff, landing gear remains down for two minutes before retraction, and
- Appropriate performance adjustments are applied.

NOTE: In the event of engine failure after V1, retract landing gear after takeoff.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-45-04.

The nose gear tires rub against friction pads during retraction to stop wheel spin as they enter the nose wheel well.

The MMEL dispatch relief is based on the premise that the spin brake cleats may become worn and not perform their function at 100% effectiveness. If the spin brake cleats are worn and not 100% effective, they must be assumed to be inoperative. If they are discovered inoperative or missing, the landing gear must remain down for two minutes after takeoff to ensure the nose wheels spin down.

Consequences of Failure

Associated nose landing gear wheel rotation will not be stopped upon gear retraction. Nose gear is required to remain down for two-minutes to allow spin-down. Flight planning fuel is increased to account for leaving the gear down for two minutes.

Consequences of Next Critical Failure

A subsequent failure of an engine after V1 would require that the landing gear be retracted until takeoff obstacles are cleared. The associated wheels on the main landing gear will continue to spin as they are retracted into the wheel wells.

In the improbable event of a burst tire or failing tire tread, the spinning wheel/tire could potentially cause damage to equipment located in the wheel well. To mitigate this potential hazard, the landing gear remains down for two minutes after takeoff before they are retracted in order to allow the wheels to stop spinning.

Flight planning fuel will need to be increased due to the additional drag for the period of time after takeoff that the landing gear remains extended. In the event of engine failure after V1, the landing gear should be retracted allowing for gear retracted takeoff performance. Takeoff performance is better for both engines operating and landing gear extended than it is with one engine inoperative and landing gear retracted. Therefore, it is not necessary to apply landing gear extended takeoff performance.

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The failure combination of a burst tire or flailing tire and a failed engine is extremely improbable ($<1.0E-09$).

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32-46-01 Brake Temperature Monitoring System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided AFM Maximum Quick Turnaround Weight limitations are observed.

NOTE: Any portion of the system that operates normally may be used.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-46-01.

The tire and brake monitoring system (TBMS) monitors the brake heatsink temperature using a thermocouple installed in each main gear brake. The thermocouple measures the brake temperature and sends signals to the tire and brake monitoring unit (TBMU). The TBMU processes the signals and shows the temperature for each individual brake on the EICAS synoptic and maintenance pages.

The BRAKE TEMP HIGH Caution message is displayed when an overheat condition is detected.

Consequences of Failure

Failure of the TBMS is indicated by the BRAKE TEMP SYS Status message. Brake temperature information will not be available to the crew. Observe AFM Maximum Quick Turnaround Weight chart limitations.

Consequences of Next Critical Failure

None.

32-49-01 Tire Pressure Indication System

32-49-01A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Any portion of the system that operates normally may be used.

32-49-01 Tire Pressure Indication System

32-49-01B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 32-49-01.

The Tire Pressure Indication System (TPIS) measures the pressure in each tire. A tire pressure sensor measures the tire pressure and sends signals to the Tire and Brake Monitoring Unit (TBMU) which processes the signal for display on the EICAS synoptic and maintenance pages.

Consequences of Failure

The tire pressure for the affected tire(s) will not be indicated on the GEAR synoptic page. Periodic maintenance checks of tire pressure can be performed by alternate means.

Consequences of Next Critical Failure

There are no further consequences of an additional failure.

32-51-01

Nose Wheel Steering Pressure Sensor

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided Nose Wheel Steering Pressure Sensor is deactivated.

SUBSTANTIATION**Background**

New proposal for 777X.

The nose landing gear steering (NGS) rate jam detection and isolation system provides protection from a lateral runway excursion due to a runaway nose landing gear (rate jam) during takeoff or landing. The NGS rate jam detection and isolation system disables the NGS if a rate jam is detected by comparing the rudder pedal commanded steering position to the lower cable loop position. When a command error is detected, the rate jam isolation valve (RJIV) is powered closed to remove hydraulic pressure from the steering metering valve module. This allows the nose gear to caster. The nose gear steering rate jam detection and isolation system is hosted by integrated flight control electronics (IFCE).

The nose wheel steering pressure sensor is installed downstream of the RJIV. The function of the nose wheel steering pressure sensor is to verify that hydraulic pressure goes low indicating the RJIV has closed. The IFCE closes the RJIV once per flight during approach to limit the exposure time of a failed valve.

Output from the nose wheel steering pressure sensor is also used to:

- Display NOSE STEERING INOP Caution message when pressure is low indicating loss of nose wheel steering to the Flight Crew.

- Display nose wheel steering pressure on the Landing Gear Brakes and Steering Maintenance page.

Consequences of Failure

Failure of the sensor is indicated by the NOSE WHEEL STRG PRESS SNSR status message. For dispatch the sensor must be deactivated.

With the nose wheel steering pressure sensor deactivated, IFCE will not run the once per flight functional check of the rate jam isolation valve. The nose wheel steering system will continue to operate normally.

The NOSE STEERING INOP Caution message will not display due to low pressure at the sensor. Pressure will not display on the Landing Gear Brakes and Steering maintenance page.

Hazard classification is 'Minor'.

Consequences of Next Critical Failure

Failure of the rate jam isolation valve to close:

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Failure of the Rate Jam Isolation Valve to Isolate is part of the 'Aircraft Excursion Off Side of Runway (>30 Knots) Fault Tree'. The hazard classification of this event is 'Catastrophic'. The probability of this event is calculated to be extremely improbable (on the order of $3.8E-11$). Normally the rate jam isolation valve is monitored once every flight. However, for the purpose of the FTA calculation, it is conservatively assumed that the failure of rate jam isolation valve to close is latent for the life of the airplane (98,100 hours).

For application of this MMEL, it may be assumed that failure of the rate isolation valve to close will only be latent for the duration of the MMEL deferral.

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32-53-01 Main Gear Steering System**32-53-01-01 Without PRR 62606 or Production Equivalent Incorporated**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Main gear steering actuators are verified locked in the center position, and
 - Main gear steering system is deactivated.
-

32-53-01 Main Gear Steering System**32-53-01-02 With PRR 62606 or Production Equivalent Incorporated**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Main gear steering actuators are verified hydraulically locked in the center position, and
 - Main gear steering system is deactivated.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-53-01.

The Main Gear Steering System (MGSS) proportionally steers the main gear aft axles up to ± 6.5 degrees to assist nose gear steering. This capability reduces tire scuffing during shorter radius turns.

The flight crew has no direct control of MGSS hardware and does not require MGSS displayed information to operate the airplane.

The MGSS per PRR 62606 actuator design does not use a mechanical locking feature.

Consequences of Failure

Failure/Deactivation of the MGSS is indicated by the MAIN GEAR STEERING Status message, which will remain while on the MMEL. The main gear steering system must be locked in the centered position and deactivated.

With PRR 62606 or production equivalent incorporated, the main gear steering actuators are hydraulically locked in the centered position. Without PRR 62606 incorporated, the main gear steering actuators are mechanically locked in the centered position.

Minimum radius turns will result in increased tire scuffing, increased thrust required for the turn, and a somewhat rougher cabin ride, particularly in the area above the main gear.

The Landing Gear Brakes and Steering maintenance page aft axle information and tiller angle will be blank.

Loss of MGSS has no impact on airplane safety as MGSS is not required for Continued Safe Flight and Landing.

Consequences of Next Critical Failure

There are no further consequences of an additional failure.

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32-61-01 Landing Gear Position Indication Systems

Interval	Installed	Required	Procedure
B	2	0	(M) (O)

May be inoperative provided:

- Landing gear are secured in the down position, and
- Airplane is dispatched in accordance with the AFM Landing Gear Extended Appendix.

32-61-01 Landing Gear Position Indication Systems**32-61-01-01 Nose Gear Not-Compressed Sensors**

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with NOSE GEAR COMP SYS Status message displayed.

32-61-01 Landing Gear Position Indication Systems**32-61-01-02 Truck Tilt Sensors**

Interval	Installed	Required	Procedure
C	4	2	

One on each main landing gear may be inoperative provided automatic speedbrake function is considered inoperative.

SUBSTANTIATION**Background**

The Landing Gear Position Indication System, Nose Landing Gear Not Compressed System and Main Landing Gear Truck Tilt System consists of Proximity Sensor Data Concentrators 1, 2, 5, 6 and various proximity sensors. The sensors monitor landing gear, landing gear door position status, nose landing gear compression status and main landing gear truck tilt status. Each PSDC monitors a proximity sensor at each location to determine gear and door status.

Consequences of Failure

The GEAR INDICATION SYS Status message will be displayed with a fault in the landing gear position indication system. With an inoperative Landing Gear Position Indication System the airplane must be dispatched in accordance with the appropriate AFM Landing Gear Extended Appendix.

Nose Gear Not Compressed sensors:

The NOSE GEAR COMP SYS Status message will be displayed when one nose landing gear not compressed sensor or discrete output has failed. Loss of redundancy only.

Truck Tilt Sensors:

The TRUCK TILT SENSOR Status message will be displayed when there is a failure of either of the two left sensors and/or either of the two right sensors. Dispatch is allowed for one sensor failed on each main landing gear. An inoperative truck tilt sensor(s) will cause auto speedbrake deployment to become inoperative. The AUTO SPEEDBRAKE FAULT Advisory and AUTO SPEEDBRAKE Status messages will be displayed. Speedbrakes can be deployed manually. In addition, the autobrake selector will not automatically move from the RTO position to OFF following takeoff.

Consequences of Next Critical Failure**Gear Down:**

There are no further consequences of an additional failure.

Nose Gear Not Compressed sensors:

Loss of both nose gear not compressed sensors will result in the AIR/GROUND Status message. With both sensors inoperative equipment cooling will not have discrete signals to indicate air/ground status. With both sensors failed open (indicating GROUND), the Equipment Cooling Controller (ECC) backup mode will be inoperative in air. With both sensors failed closed (indicating AIR), the Equipment Cooling Controller (ECC) backup mode will not reset upon landing if this mode became active during flight. In this case, maintenance action will be required prior to the next flight.

Loss of equipment airflow (due to a separate fault) in addition to one nose gear not compressed sensor inoperative results in the ECCs going into takeover mode (ECCs takeover control from ECSMCs). Loss of redundancy only.

Truck Tilt Sensors:

For failure of both left sensors or both right sensors, or for disagreement for more than ten seconds between the left and right left and right main landing gear, the FLIGHT CONTROLS SYS Status message will be displayed. Subsequent dispatch is not allowed.

32-61-02 Landing Gear Door Closed Sensors**32-61-02A**

Interval	Installed	Required	Procedure
C	6	3	(M)

One per gear (nose, left main, right main) may be inoperative provided associated sensor is verified to indicate door not-closed.

32-61-02 Landing Gear Door Closed Sensors**32-61-02B**

Interval	Installed	Required	Procedure
C	6	3	(M)

One per gear (nose, left main, right main) may be inoperative provided associated sensor is deactivated.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-61-02.

The Landing Gear Position Indication System consists of two Proximity Sensor Data Concentrators and various proximity sensors. The sensors monitor landing gear and landing gear door position status. Each PSDC monitors a proximity sensor at each location to determine gear and door status. There are two door closed sensors for each landing gear.

Consequences of Failure

Appropriate status message(s) will be displayed. Gear door position indication redundancy is lost, but otherwise there is no effect.

The sensor is not allowed to be failed in the closed position because failure of the sensor in the closed position will prevent door sequencing logic to determine gear up and locked, and provide improper door position indication. Indication logic will sense the associated door as always closed.

Consequences of Next Critical Failure

Upon the failure of the redundant door sensor on the associated gear, annunciation of a GEAR DOOR NOT CLOSED Caution message will occur. The landing gear can be confirmed to be in the retracted or extended position. There will be a loss of the ability to determine gear door position. Flight crew will observe the landing gear extended placard speed limitation.

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32-61-03 Landing Gear Up Proximity Sensors

32-61-03-01 Main Landing Gear Uplock Sensors

32-61-03-01A

Interval	Installed	Required	Procedure
C	4	2	(M)

One Main Landing Gear Uplock Proximity Sensor on each gear may be inoperative provided:

- Inoperative sensor(s) is verified FAR or blank, and
- Both associated Landing Gear Door Closed Proximity Sensors operate normally.

32-61-03 Landing Gear Up Proximity Sensors

32-61-03-01 Main Landing Gear Uplock Sensors

32-61-03-01B

Interval	Installed	Required	Procedure
C	4	2	(M)

One Main Landing Gear Uplock Proximity Sensor on each gear may be inoperative provided:

- Inoperative sensor(s) is deactivated, and
- Both associated Landing Gear Door Closed Proximity Sensors operate normally.

32-61-03 Landing Gear Up Proximity Sensors

32-61-03-02 Nose Landing Gear Up Sensors

32-61-03-02A

Interval	Installed	Required	Procedure
C	2	1	(M)

One Nose Landing Gear Up Proximity Sensor may be inoperative provided:

- Inoperative sensor is verified FAR or blank, and
- Both Nose Landing Gear Door Closed Proximity Sensors operate normally.

32-61-03 Landing Gear Up Proximity Sensors**32-61-03-02 Nose Landing Gear Up Sensors****32-61-03-02B**

Interval	Installed	Required	Procedure
C	2	1	(M)

One Nose Landing Gear Up Proximity Sensor may be inoperative provided:

- Inoperative sensor is deactivated, and
- Both Nose Landing Gear Door Closed Position Sensors operate normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-61-03.

There is a main landing gear (MLG) uplock for each MLG. When the MLG is retracted, each MLG is held in the retracted position by the uplock. The uplock includes a structure mounted uplock hook which engages a roller mounted to the gear strut. There are two redundant sensors installed on the uplock. When the MLG is retracted and held by the hook of the uplock the sensors indicate NEAR. When the MLG uplock releases the main landing gear the sensors indicate FAR.

The nose landing gear (NLG) position indication system includes sensors to indicate NLG up and NLG down. There are two redundant sensors. The left and right lugs of the NLG upper drag strut assembly have brackets installed, each with two targets used to indicate either NLG up or down.

Gear door sequence monitoring and down sensor signals are used in addition to the uplock sensors to determine up and locked status for the gear.

Consequences of Failure

The L or R GEAR UPLOCK SENSOR Status message will be displayed when there is a main landing gear up & locked sensor channel fault or there is a disagreement between redundant sensors.

The NOSE GEAR UP SENSOR Status message will be displayed when there is a nose landing gear up sensor channel fault or there is a disagreement between redundant sensors.

Landing gear can still be determined to be up and locked by using the redundant sensor and/or the door sequencing and gear down signals.

The sensor is not allowed to be failed in the locked position because failure of the sensor in the locked position will provide improper gear up and locked indication. Indication logic will sense the associated gear as always up and locked.

Consequences of Next Critical Failure

Upon failure of the redundant up sensor on the associated gear, landing gear position in the retracted and extended position can still be confirmed, as determined by the door sequencing and gear down signals. The GEAR INDICATION SYS Status message will be displayed.

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32-71-01 Tail Strike Detector Channels**32-71-01A**

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with one TAIL STRIKE CHAN 1 or TAIL STRIKE CHAN 2 Status message displayed.

32-71-01 Tail Strike Detector Channels**32-71-01B**

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Tail section is visually inspected for damage before each departure,
- Alternate tail strike detection procedures are established and used, and
- TAIL STRIKE Caution message is disabled.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 32-71-01.

The Tail Strike Sensor (TSS, aka Tail Strike Protection System, TSPS) is a safety and economic enhancement installed on the 757-300, 777 series, and 787 series aircraft to aid pilots in detecting tail strikes. Tail strikes occur infrequently and pilots often have little or no experience to make a determination if a strike happened, resulting in unnecessary turnbacks. The TSS was added to give pilots positive confirmation of a strike, as well as alert pilots to an undetected strike. The TSS is not a required system for certification on any Boeing airplane.

The Tail Strike Protection System detects a tail strike on the lower aft fuselage and provides an indication to the crew. The system is internally redundant with two channels providing functionality. If either loop goes outside an acceptable voltage range, the associated TAIL STRIKE CHAN 1, 2 Status message will annunciate. If both channels fall outside this range, the TAIL STRIKE caution message will annunciate. If a strike occurs, both channels will short to ground and trigger.

The tail strike module is the only component of the Tail Strike Protection System. It is in the shape of a blade and is located on the bottom of the aft fuselage. The tail strike module has 2 internal wires near the bottom edge, which connect to PSDC 7 located on the left side of the aft cargo bay and PSDC 8 located on the right side of the aft cargo bay.

Consequences of Failure

One channel inoperative:

The TAIL STRIKE CHAN 1, 2 Status message will be displayed when PSDC 7 (channel 1), PSDC 8 (channel 2) indicate that the tail strike indication to Displays and Crew Alerting (DCA) is invalid. These messages will also be displayed when a tail strike has occurred.

Loss of one channel results in loss of redundancy only.

Both channels inoperative:

The TAIL STRIKE Caution message will be displayed when both channels detect a tail strike (both channels have an open circuit), or one channel is invalid and the other channel has an open circuit (or is open due to a tail strike). The TAIL STRIKE Caution will not be displayed if both channels are invalid. Dispatch is allowed with the TAIL STRIKE Caution message that is not the result of a tail strike.

The TSS is not available for tail strike detection. Alternate procedures are required. Visual inspection is done to make sure no strike occurred on previous flight(s).

Consequences of Next Critical Failure

One channel inoperative:

Remaining channel fails or a tail strike event. EICAS Caution message TAIL STRIKE is displayed. For channel failure, pilots determine if message is nuisance and continue, or divert. For tail strike on takeoff/rotation, the TAIL STRIKE non-normal checklist is accomplished.

Both channels inoperative:

Tail strike event occurs. Pilots (and cabin crew) must rely on audible cues and changes in aircraft behavior to detect strike. For tail strike on takeoff/rotation, the TAIL STRIKE non-normal checklist is accomplished.

33-11-01 Flight Compartment Illumination System

33-11-01-01 STORM Switch ON Light

33-13-01 Master Brightness Control System

33-16-01 Master Indicator Lights (IND LTS) Switch

33-16-01-01 AUTO Function

33-21-01 Passenger Compartment Illumination System

33-21-01-01 Airplanes without Photoluminescent Escape Path
Lighting

33-21-01-02 Airplanes with Photoluminescent Escape Path Lighting

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33-24-01-01 Flight Deck Automatic Function

33-24-01-02 Overhead Flightcrew Rest (OFCR)

33-24-01-03 Overhead Flight Attendant Rest (OFAR)

33-24-01-04 Aural Tone Function

33-31-01 Main Wheel Well and Nose Wheel Well Service Area Lights

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33-31-02 Exterior Cargo Loading Area Lights

33-37-01 Cargo Compartment Lights

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33-41-01-01 WING Switch ON Light

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33-51-03-04

Photoluminescent Escape Path Marking System

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33-11-01 Flight Compartment Illumination System

Interval	Installed	Required	Procedure
C	-	-	

Individual lights may be inoperative provided:

- Remaining lighting system lights are sufficient to clearly illuminate all required instruments, controls and other devices for which they are provided,
- Remaining lighting system lights are positioned so that direct rays are shielded from the eyes of the flightcrew,
- Lighting configuration and intensity is acceptable to the flightcrew, and
- Captain's emergency dome light operates normally.

NOTE: Individual button/switch lights and/or annunciations/indications are excluded from this relief.

33-11-01 Flight Compartment Illumination System**33-11-01-01 STORM Switch ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-11-01.

Adjustable intensity lights located in the overhead provide general flight deck area illumination. Floor lighting can be activated to help locate dropped objects and to assist entry and exit from seats. At least one map light illuminating the control column is available for use by each pilot. Each pilot and observer working surface is illuminated. Each observer position includes one reading light and one shared light. Additional area lighting is used to illuminate the aisle stand, glareshield, and forward instrument panels. The lighting architecture includes solid state LED (light emitting diode) light sources and digital network brightness control except for some area lights. A storm lighting function for driving lighting to appropriate levels is also included.

The captain's dome light has LEDs that also provide light using emergency lighting battery power.

A lighted STORM switch is installed on the overhead seat belt signs and lighting panel to control all illuminated indicator lights, glareshield flood lights, instrument panel flood lights, aisle stand flood light and dome lights. When the switch is selected ON, all of the normal controls are overridden and the previously listed lights illuminate.

Consequences of Failure

There is no status message to indicate this failure. Illumination is lost for the associated light. Other sources of lighting may be adjusted to accommodate the illumination loss.

If the function of the storm override switch is lost. Light intensity can be increased on the associated lights as needed by adjusting their individual controllers.

For STORM switch inoperative, the state of the switch is indicated by the state of the lights and the position of the switch. May result in possible nuisance to pilot's night vision only.

Consequences of Next Critical Failure

Loss of another individual light or control: Results in the inability to control the intensity or operation of the light being used. Other sources of lighting may be adjusted to accommodate the illumination loss.

Emergency lights powered by individual battery packs provide lighting for egress from the flight deck in the event of loss of all power.

33-13-01 Master Brightness Control System

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- MASTER BRIGHT switch remains off, and
- FWD PANEL BRIGHTNESS, LOWER - DSPL/CONTRAST/brightness controls operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-11-01.

The master brightness control system provides simultaneous manual brightness adjustment for all panel lighting and displays with one knob. Each instrument panel and display retain individual manual brightness control with a limited range when the master is engaged and full range control when the master is disengaged. The master brightness control knob is located on the overhead instrument panel. The head-up display (HUD) combiner (if installed), area lighting, and annunciators are not tied to the master brightness control system.

Consequences of Failure

Failure of the master brightness control system results in loss of capability to adjust the flight deck lighting and displays with a single control. Lighting and displays may be adjusted through the full range of intensity by their individual controls. Ambient light sensors and remote light sensors will automatically adjust display brightness. There is no Status message to indicate this failure.

Consequences of Next Critical Failure

Failure of a single individual adjustment control: lighting intensity for that display or panel is not adjustable.

33-16-01 Master Indicator Lights (IND LTS) Switch**33-16-01-01 AUTO Function**

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- TEST and BRT functions operate normally, and
- Light intensity and configuration is acceptable to the flightcrew.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-16-01.

The annunciators, indicators brightness control, called the Master Dim and Test (MD&T) system, controls the two-step and constant brightness for discrete annunciators and provides a test for checking that the annunciators and seven-segment LCD (liquid crystal display) work.

The intensity of indicator lights is either DIM or BRIGHT, and is controlled by the indicator lights (IND LTS) switch on the overhead panel. Master dim and test commands apply to all annunciators/indicators on the flight deck, regardless of the zone where they are located.

When the flight deck master dim and test switch is held in the TEST position, the panel lighting will illuminate to full brightness for the first 10 second followed by dimming for the following 20 seconds.

If the switch is held in the TEST position for longer than 30 seconds, the panel lighting control system will return to full brightness. Releasing the switch from test mode after this time has elapsed and then selecting test again will start the lighting test over again. This provides protection against situations where the MD&T switch is held for too long or breaks in the TEST position. It also removes the need for special inhibits as the system should not be able to fail in TEST mode. It also does not interfere with TEST mode operation in flight, which is seen as desirable by pilots.

The MD&T TEST mode can be exited at any time by returning the switch to either the bright (BRT) or AUTO mode.

Selecting TEST mode with the MD&T switch overrides the storm light switch setting if it is on.

The 777X indicator lighting systems provide an automatic feature to the MD&T system for annunciator brightness when the indicator lights switch is set to the AUTO position. In AUTO mode, annunciators will automatically go to bright if the high ambient lighting cutoff is reached on light sensors and will return to DIM mode when reset is reached. If the indicator lights switch is set to the BRT position, annunciators will remain bright regardless of Autobright input. The Storm switch "ON" disengages Autobright operation. Automatic brightness control ensures visibility of the Master Caution and Warning annunciators in all expected lighting ambient environments.

The MD&T function works whenever the pilots selects it, on ground or in flight.

The MD&T function is functional on standby electrical power.

Consequences of Failure

Capability to automatically control annunciator light illumination or a portion of the annunciator lights is not available. Affected annunciator lights will operate only in bright. Daylight operation should not be affected. Night operation may be affected depending on which lights are failed to bright and the judgment of the flight crew.

Consequences of Next Critical Failure

None identified.

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33-21-01 Passenger Compartment Illumination System 33-21-01-01 Airplanes without Photoluminescent Escape Path Lighting

Interval	Installed	Required	Procedure
C	-	-	

Individual lights may be inoperative provided sufficient lighting remains for crewmembers to perform their duties.

33-21-01 Passenger Compartment Illumination System 33-21-01-02 Airplanes with Photoluminescent Escape Path Lighting

Interval	Installed	Required	Procedure
C	-	-	

Individual lights may be inoperative provided:

- No more than two ceiling light assemblies are inoperative in a cabin zone aisle,
- Inoperative ceiling light assemblies are not adjacent,
- No more than two sidewall light assemblies are inoperative on one side of the cabin zone,
- Inoperative sidewall light assemblies are not adjacent,
- Sufficient lighting remains for crewmembers to perform their duties, and
- Light assemblies in flat lowered ceilings in cabin zone main aisles operate normally.

NOTE 1: Ceiling lights include both ceiling wash lights and cross cabin lights.

NOTE 2: A cabin zone is the passenger cabin area between two sets of Passenger Entry Door pairs or Service Exit Doors.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 33-21-01.

Passenger cabin lighting is provided by LED lights. General cabin illumination is accomplished with ceiling and sidewall lights. They are supplemented by reading, closet, galley, lavatory, threshold and attendant work lights. Lights are distributed over forward, mid and aft zones with controls located at the appropriate flight attendant panel. Door area direct lights will be controlled either from the attendant control panel and/or discrete switches.

Photoluminescent escape path lights are non-electric. They utilize a material based on strontium aluminate, which is able to absorb energy from visible and ultraviolet light sources. Light energy from natural and artificial light sources - e.g. ambient light of the aircraft cabin lighting - is stored in the photoluminescent material. As the ambient light decreases, stored energy from the photoluminescent material is re-emitted in the visible spectrum highlighting the escape path.

Photoluminescent lights are placed on both sides of each main cabin aisle on the carpet. They are typically installed on the floor adjacent to seat armrests. The system may include joggles as necessary to represent changes in path direction or width. The segments are positioned to create a continuous "light" strip except for breaks at joggles, galley matted area, or carpet thresholds. The continuous photoluminescent lights terminate at each exit prior to the inboard/outboard monuments.

Consequences of Failure

There is no status message to indicate this failure.

Failure of individual light(s) or individual LED modules: illumination is provided by remaining lights. The level of illumination may be adjusted with scene defined intensity levels. Lighting intensity is variable from zone to zone within the cabin, by individual lights, or by individual LED modules.

For airplanes with photoluminescent lighting, a minimum amount of light from the cabin interior lighting system is required to maintain the charge in the photoluminescent strip. MMEL provisions ensure that the minimum lighting is maintained.

Consequences of Next Critical Failure

None identified.

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33-24-01 Passenger Lighted Information Signs

33-24-01A

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided:

- Associated passenger seat or lavatory is not occupied from which a passenger lighted information sign is not readily legible, and
- Associated seat or lavatory is blocked and placarded - "DO NOT OCCUPY".

NOTE: These conditions are not intended to prohibit lavatory use or inspections by crewmembers.

33-24-01 Passenger Lighted Information Signs

33-24-01B

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative and associated passenger seat or lavatory may be occupied provided:

- Passenger Address System operates normally, and
- Passenger Address System is used to notify passengers and cabin crew when associated sign(s) are placed on or off.

33-24-01 Passenger Lighted Information Signs

33-24-01C

Interval	Installed	Required	Procedure
C	-	0	(O)

May be missing or inoperative provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger-carrying operations, and
- Alternate procedures are established and used.

33-24-01 Passenger Lighted Information Signs**33-24-01-01 Flight Deck Automatic Function**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Manual control function operates normally, and
- Alternate procedures are established and used.

33-24-01 Passenger Lighted Information Signs**33-24-01-02 Overhead Flightcrew Rest (OFCR)**

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided alternate procedures are established and used.

33-24-01 Passenger Lighted Information Signs**33-24-01-03 Overhead Flight Attendant Rest (OFAR)**

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided alternate procedures are established and used.

33-24-01 Passenger Lighted Information Signs**33-24-01-04 Aural Tone Function**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on FAA 777 MMEL item 33-24-01.

Refer to FAA MMEL Policy Letter 123.

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Symbolic “No Smoking” and “Fasten Seat Belt” signs are installed in the right, left and center Passenger Service Unit (PSU) runs approximately over every other seat row. These are located so that all passengers will have an unobstructed view when seated. Where this is not possible, as at the front of each zone, an additional sign is mounted on galley, lavatory, or closet walls, as required for passenger seats. Signs are installed in the overdoor panels, on galley and lavatory walls, as required, for the attendant seats. In the automatic mode, lighted signs are illuminated as a function of airplane configuration (flap and gear position, airplane altitude, cabin pressure altitude, or deployment of passenger oxygen.)

Consequences of Failure

Signs are not automatically illuminated, and/or are not visible to some or all of the passengers. Announcements are made over the passenger address system or those seats from which the No Smoking/Fasten Seat Belt signs are not visible are blocked and kept unoccupied.

Consequences of Next Critical Failure

None identified.

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33-31-01 Main Wheel Well and Nose Wheel Well Service Area Lights**33-31-01A**

Interval	Installed	Required	Procedure
C	6	0	

33-31-01 Main Wheel Well and Nose Wheel Well Service Area Lights**33-31-01B**

Interval	Installed	Required	Procedure
D	6	0	

Individual lights may be inoperative provided procedures do not require use of service lights.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-31-01.

Service compartment lights illuminate the various service compartment and wheel well areas located throughout the airplane for use by maintenance crews. The same single part number LED light assembly is utilized in 33 places across the airplane to accomplish this function. Service compartment light operation on the 777-9 is the same as the legacy aircraft using toggle switches located to power logical groups of lights (e.g. wheel wells) and are powered by 28V AC. Service lights are provided in the following areas which are the same as the 777-300ER baseline aircraft:

- Wheel wells (nose and main landing gear)
- ECS compartment (RH & LH)
- EE bays
- APU and Tail Cone compartments

The 777-9 service compartment lights perform the same function as on the 777-300ER, except will have an LED light source rather than incandescent lamp.

NOTE: Aligning with 777-300ER, relief for the Air Conditioning Compartment, APU Compartment, Stabilizer Compartment and Electrical Equipment Center Service Area Lights is included under MMEL item 25-20-01, Non-Essential Furnishings.

Consequences of Failure

Illumination from the associated light is lost.

Consequences of Next Critical Failure

None identified. Service area lights have no effect on operational safety.

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33-31-02 Exterior Cargo Loading Area Lights

Interval	Installed	Required	Procedure
D	4	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 33-31-02.

Exterior cargo loading lights are provided to illuminate the cargo handling area immediately outside the cargo compartment doors. There is a flush mounted cargo light assembly installed in the fuselage adjacent to each cargo door. Each light incorporates a LED module with its own dedicated power supply located within the light assembly.

- 1 light assembly adjacent to the forward main cargo door.
- 1 light assembly adjacent to the aft main cargo door.
- 2 light assemblies adjacent to the bulk cargo door.

The 777-9 body mounted cargo loading lights perform the same function as on the 777-300ER, except will have an LED light source rather than incandescent lamp.

Consequences of Failure

Illumination of the affected area is lost.

Consequences of Next Critical Failure

None identified. There is no effect on operational safety caused by loss of cargo loading area lights.

33-37-01 Cargo Compartment Lights

Interval	Installed	Required	Procedure
C	-	-	

Individual lights may be inoperative provided:

- Sufficient lighting remains for ground personnel to perform their duties, and
- For damaged or missing LED light assemblies, associated cargo compartment lining is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 33-37-01.

The cargo loading lighting provides general area illumination in the lower lobe cargo compartment areas for loading and unloading of cargo containers, pallets, or baggage. They also provide light for routine maintenance and inspection purposes. The lights will be located to ensure control panels, placards, and restraint and guidance system operational features are adequately illuminated. Cargo loading areas consist of three outer mold-line (OML) doors (FWD, AFT and Bulk) and the corresponding internal cargo areas.

This cargo compartment lighting system consists of 54 ceiling mounted lights plus lights installed on the interior side of each containerized compartment cargo door to illuminate the doorsill and ground loading equipment bridge. A single light will be installed on the sidewall at the bulk cargo door opening to illuminate its doorsill. These lights are all operational on the ground only. The lighting is controlled from toggle switches near the three doors and from the P43/44 OML panels.

The 777-9 cargo lights perform the same function as on the 777-300ER, except will have an LED light source rather than incandescent lamp.

Consequences of Failure

Illumination from the associated light is lost. Illumination is provided by remaining lights or portable lights.

For damaged or missing LED light assemblies, the cargo compartment will not meet requirements for containment of smoke or fire. The associated cargo compartment must be treated as if the cargo compartment lining is inoperative. Therefore the associated cargo compartment must remain empty.

Consequences of Next Critical Failure

None identified. Cargo compartment lighting has no effect on operational safety.

For damaged or missing LED light assemblies, the next critical failure would be a smoke or fire event that is not adequately contained by the damaged or missing LED light assemblies. This condition is mitigated by requiring the associated cargo compartment to remain empty.

33-41-01 Wing Icing Detection Lights

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided ground deicing procedures do not require their use.

33-41-01 Wing Icing Detection Lights**33-41-01-01 WING Switch ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-41-01.

Refer to FAA policy letter 72.

The fuselage flushed mounted wing illumination light assemblies are installed on the forward fuselage. They provide illumination of the wing leading edges and engine nacelles to facilitate ice inspection, if desired, while the airplane is on the ground and during the course of flight. Each light has a LED light module with its own dedicated power supply located within the light assembly.

The wing illumination lights are controlled by the "WING" ON/OFF push-button switch installed on the P5 Pilots Overhead panel.

The light assemblies are identical to the current assemblies on 777-300ER, except will have an LED light source rather than incandescent lamp.

Consequences of Failure

Illumination of the wing leading edge and the nacelles is lost.

Anti-ice system and ice detection system are unaffected.

Consequences of Next Critical Failure

None identified.

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33-42-01 Taxi Lights

33-42-01-01 Wing Taxi Lights (LED Arrays)

Interval	Installed	Required	Procedure
C	2	0	

NOTE: There are LED arrays inside the strakelet on each wing. These same lights are also used for Landing Lights. Landing Lights may also be affected (see MMEL item 33-42-02-01).

33-42-01 Taxi Lights

33-42-01-02 Nose Gear Taxi Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 33-42-01.

The nose gear lighting system consists of two separate light assemblies, one mounted on each side of the nose landing gear (NLG) strut. Each light has an LED module with its own dedicated power supply located within the light assembly. The landing light is primarily to provide reference information during final approach, touchdown, ground roll or take off, and illuminate any obstruction in the airplane approach glide path or the runway at night. It may also be used for signaling purposes in flight, during reduced visibility, haze, or dust. The taxi light is primarily to be used to maneuver the aircraft on the ground at night. Taxi mode is intended to provide sufficient illumination on the ground to aid the pilot to see the taxiway surface. The 777-300ER used two incandescent nose gear landing lights and two taxi lights while the 777-9 design uses only one LED nose gear landing light and one taxi light.

Each light installation is controlled by its own designated ON/OFF control toggle switch located on the flight deck P5 lighting control panel. On the left side of the P5 panel, the LANDING - NOSE switch is to control the landing light. On the right side of the P5 panel, the TAXI switch is to control the taxi lights.

The landing/taxi/runway/turnoff lights (LTRTL) system consists of a runway turnoff assembly, two LED array panels for landing and taxi modes and a power supply. The landing light mode is primarily to provide reference information during final approach, touchdown, ground roll or take off and illuminate any obstruction in the airplane approach glide path or the runway at night. It may also be used for signaling purposes in flight, during reduced visibility, haze, or dust. The taxi light mode is primarily to be used to maneuver the aircraft on the ground at night. The runway turn off mode is used to illuminate the runway turnoff locations and obstructions which might contact any parts of the aircraft. All LTRTL light functions are controlled by the P5 panel in the flight deck.

The switch that controls the LTRTL taxi function also controls the NLG taxi light. The LEFT and RIGHT switches under LANDING on the P5 panel in the flight deck turn the LTRTL LED arrays on bright for landing mode. The TAXI light switch turns on the LTRTL LED arrays in a taxi mode intensity which is less bright than the landing mode. When the TAXI light switch is in the ON position, the nose landing gear taxi and the LTRTL taxi modes both illuminate. If the LEFT or RIGHT landing light switches are in the ON position and the TAXI light switch is in the ON position, the LTRTL will remain in landing light mode.

The LTRTL system will replace the incandescent based landing and runway turnoff (RTO) lights in the wing root on the leading edge of the wing behind the strakelets of both wings in the same location as the 777-300ER wing landing and RTO lights. Each wing location houses a power supply, the LED taxi runway turnoff assembly, two interlocking LED array panels and the electrical cables between the power supply and the LED assemblies. The LED arrays are used for landing and taxi mode. In taxi mode the current is lowered. The power supply is provided 115V AC from the electrical load management system (ELMS). There are two circuit breakers, one for the left and one for the right system. The power supply receives ground discrete signals to select the operating mode, which is selected from the P5 panel in the flight deck. These components are new to the 777-9 but are identical to the LTRTL system on late model 737NG and 737-8 Max aircraft.

Consequences of Failure

Illumination from the affected light is lost. Remaining light functions will provide illumination.

Consequences of Next Critical Failure

None identified.

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33-42-02 Landing Lights
33-42-02-01 Wing Landing Lights (LED Arrays)
33-42-02-01A

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided Nose Gear Landing Light operates normally.

NOTE: There are LED arrays inside the strakelet on each wing. These same lights are also used for Taxi Lights. Taxi Lights may also be affected (see MMEL item 33-42-01).

33-42-02 Landing Lights
33-42-02-01 Wing Landing Lights (LED Arrays)
33-42-02-01B

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided operations are not conducted at night.

NOTE: There are LED arrays inside the strakelet on each wing. These same lights are also used for Taxi Lights. Taxi Lights may also be affected (see MMEL item 33-42-01).

33-42-02 Landing Lights
33-42-02-02 Nose Gear Landing Light
33-42-02-02A

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided both Wing Landing Lights operate normally.

33-42-02 Landing Lights**33-42-02-02 Nose Gear Landing Light****33-42-02-02B**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided operations are not conducted at night.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 33-42-02.

The nose gear lighting system consists of two separate light assemblies, one mounted on each side of the nose landing gear (NLG) strut. Each light has an LED module with its own dedicated power supply located within the light assembly. The landing light is primarily to provide reference information during final approach, touchdown, ground roll or take off, and illuminate any obstruction in the airplane approach glide path or the runway at night. It may also be used for signaling purposes in flight, during reduced visibility, haze, or dust. The taxi light is primarily to be used to maneuver the aircraft on the ground at night. Taxi mode is intended to provide sufficient illumination on the ground to aid the pilot to see the taxiway surface. The 777-300ER used two incandescent nose gear landing lights and two taxi lights while the 777-9 design uses only one LED nose gear landing light and one taxi light.

Each light installation is controlled by its own designated ON/OFF control toggle switch located on the flight deck P5 lighting control panel. On the left side of the P5 panel, the LANDING - NOSE switch is to control the landing light. On the right side of the P5 panel, the TAXI switch is to control the taxi lights.

The landing/taxi/runway/turnoff lights (LTRTL) system consists of a runway turnoff assembly, two LED array panels for landing and taxi modes and a power supply. The landing light mode is primarily to provide reference information during final approach, touchdown, ground roll or take off and illuminate any obstruction in the airplane approach glide path or the runway at night. It may also be used for signaling purposes in flight, during reduced visibility, haze, or dust. The taxi light mode is primarily to be used to maneuver the aircraft on the ground at night. The runway turn off mode is used to illuminate the runway turnoff locations and obstructions which might contact any parts of the aircraft. All LTRTL light functions are controlled by the P5 panel in the flight deck.

The switch that controls the LTRTL taxi function also controls the NLG taxi light. The LEFT and RIGHT switches under LANDING on the P5 panel in the flight deck turn the LTRTL LED arrays on bright for landing mode. The TAXI light switch turns on the LTRTL LED arrays in a taxi mode intensity which is less bright than the landing mode. When the TAXI light switch is in the ON position, the nose landing gear taxi and the LTRTL taxi modes both illuminate. If the LEFT or RIGHT landing light switches are in the ON position and the TAXI light switch is in the ON position, the LTRTL will remain in landing light mode.

The LTRTL system will replace the incandescent based landing and runway turnoff (RTO) lights in the wing root on the leading edge of the wing behind the strakelets of both wings in the same location as the 777-300ER wing landing and RTO lights. Each wing location houses a power supply, the LED taxi runway turnoff assembly, two interlocking LED array panels and the electrical cables between the power supply and the LED assemblies. The LED arrays are used for landing and taxi mode. In taxi mode the current is lowered. The power supply is provided 115V AC from the electrical load management system (ELMS). There are two circuit breakers, one for the left and one for the right system. The power supply receives ground discrete signals to select the operating mode, which is selected from the P5 panel in the flight deck. These components are new to the 777-9 but are identical to the LTRTL system on late model 737NG and 737-8 Max aircraft.

Consequences of Failure

Illumination from the affected light is lost.

For night operations, one landing light may be inoperative. The two remaining landing lights will provide adequate illumination.

For daylight operations, all landing lights may be inoperative.

Consequences of Next Critical Failure

For night operations, loss of one additional landing light: The remaining landing light will provide illumination.

Loss of additional runway lighting. Airplane taxi lights and turnoff lights as well as runway and taxiway lights provide illumination.

33-42-03 Runway Turnoff Lights

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 33-42-03.

The landing/taxi/runway/turnoff lights (LTRTL) system consists of a runway turnoff assembly, two LED array panels for landing and taxi modes and a power supply. The runway turn off mode is used to illuminate the runway turnoff locations and obstructions which might contact any parts of the aircraft. All LTRTL light functions are controlled by the P5 panel in the flight deck.

The LTRTL system will replace the incandescent based landing and runway turnoff (RTO) lights in the wing root on the leading edge of the wing behind the strakelets of both wings in the same location as the 777-300ER wing landing and RTO lights. Each wing location houses a power supply, the LED taxi runway turnoff assembly, two interlocking LED array panels and the electrical cables between the power supply and the LED assemblies. The LED arrays are used for landing and taxi mode. The power supply is provided 115V AC from the electrical load management system (ELMS). There are two circuit breakers, one for the left and one for the right system. The power supply receives ground discrete signals to select the operating mode, which is selected from the P5 panel in the flight deck. These components are new to the 777-9 but are identical to the LTRTL system on late model 737NG and 737-8 Max aircraft.

Consequences of Failure

Illumination provided by the runway turnoff light is lost. Taxi lights and runway and taxiway lights provide illumination.

Consequences of Next Critical Failure

Loss of taxi light. Remaining taxi light, landing light and taxiway lighting provide illumination.

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33-43-01 Position Lights

33-43-01A

Interval	Installed	Required	Procedure
C	6	3	

May be inoperative provided:

- One stationary red wing tip LED module operates normally,
- One stationary green wing tip LED module operates normally, and
- One stationary white tail LED module operates normally.

33-43-01 Position Lights

33-43-01B

Interval	Installed	Required	Procedure
C	6	0	

May be inoperative for operations between sunrise and sunset.

33-43-01 Position Lights

33-43-01-01 NAV Switch ON Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 33-43-01.

The wing position and anti-collision lights (ACL) are a combined unit, located inside the wing fold. The position lights provide a color-coded visual reference of airplane position, direction, and attitude using a red light on the left forward inner wing tip, a green light on the right forward inner wing tip, and white lights mounted on the tail cone for the aft position of the aircraft.

The power supply for the wing position, tail position, and ACL systems provides power for the new lights in both the wing and tail cone locations. The power supply is internally divided into two sections for control of the position or ACL lights separately, with circuitry electrically isolated.

The 777-9 position lights are changing from incandescent to LED lights. Each position light installation is a dual LED array.

ON Light: When the alternate action pushbutton switch is pressed to ON, the red, green, and white navigation position lights are illuminated.

Consequences of Failure

Illumination from the failed light array is lost. The remaining array provides the required illumination from the affected location.

ON Light: The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

Loss of remaining light array. Illumination from remaining position lights and anti-collision lights provide illumination.

ON Light: None identified.

Draft
Feb 26, 2026

33-43-02 Wing Tip Marker Lights

Interval	Installed	Required	Procedure
D	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 33-43-02.

The marker lights are located just inboard of the folding wing tips, facing aft. They are used to mark or draw attention to the wing tips of the aircraft. The marker light produces a uniform cone of white light which will not overlap into the red or green position light patterns. The aft facing marker lights are identical in electrical and mechanical interface to the tail cone position light with dual LED arrays.

The 777-9 wing tip marker lights appear similar to the 777-300ER aft facing position lights. They are located inside the wing fold, in order to allow the marker lights to distinguish the outermost part of the wing once the wing tips have folded after landing. The 777-9 marker lights are not required by FAR.

Consequences of Failure

None. The 777-9 marker lights are not required by FAR.

Consequences of Next Critical Failure

None identified.

33-44-01 Anti-Collision Lights**33-44-01-01 Red Upper and Lower Fuselage Beacon Light Systems****33-44-01-01A**

Interval	Installed	Required	Procedure
C	3	1	

May be inoperative provided White Tail Cone and Wing Tip Strobe Lights operate normally.

33-44-01 Anti-Collision Lights**33-44-01-01 Red Upper and Lower Fuselage Beacon Light Systems****33-44-01-01B**

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided:

- At least one White Tail Cone or Wing Tip Strobe Light operates normally, and
 - Operations are not conducted at night.
-

33-44-01 Anti-Collision Lights**33-44-01-02 White Tail and Wing Tip Strobe Light Systems****33-44-01-02A**

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided Red Upper and Lower Fuselage Beacon Lights operate normally.

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33-44-01 Anti-Collision Lights

33-44-01-02 White Tail Cone and Wing Tip Strobe Light Systems

33-44-01-02B

Interval	Installed	Required	Procedure
C	3	0	

May be inoperative provided:

- At least one Red Fuselage Beacon Light operates normally, and
- Operations are not conducted at night.

33-44-01 Anti-Collision Lights

33-44-01-03 BEACON Switch ON Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposals -01A and -01B based on 777 MMEL item 33-44-01A and -01B.

Fuselage anti-collision lights (FACL) consist of three red beacon (rotating) light assemblies: two mounted on the upper fuselage centerline and one mounted on the lower fuselage centerline. All three FACLs are controlled by the "BEACON" push button switch on the flight deck P5 lighting control panel. The 777-9 FACL perform the same function as the 777-300ER except will be LED based lights. The 777-300ER had a single upper and a single lower FACL and the 777-9 has two upper FACLs and one lower FACL. The two upper FACLs are required for compliance to FAR 25.1401 due to the new 777-9 inclusion of folding wing tips.

The 777-9 wing position and anti-collision lights (ACL) are a combined unit, located inside the wing fold. These lights are changing from incandescent to LED light modules. The power supply for the wing position, tail position, and ACL systems provides power for the new lights in both the wing and tail cone locations. The power supply is internally divided into two sections for control of the position or ACL lights separately, with circuitry electrically isolated. The wing ACL provides high intensity flashing white strobe lighting for aircraft recognition and collision avoidance. The white wing ACL lights consist of two inner wing tip mounted light assemblies.

The tail white anti-collision light provides high intensity white strobe lighting for aircraft recognition and collision avoidance. The white tail ACL light system consists of a single tail cone mounted LED light assembly, located on the tail cone section of the empennage.

The red and white anti-collision lights are redundant systems and either one is certified separately as an anti-collision light system.

ON Light: The red anticollision beacon lights are illuminated on the top and bottom of the fuselage.

Consequences of Failure

For Operations at Night:

Illumination from the affected light(s) is lost. Redundant lights provide required illumination. Two of the three red beacons may be inoperative provided all three white strobes operate normally. All three white strobes may be inoperative provided all three red beacons operate normally.

Day Operations:

All three red beacons may be inoperative provided at least one white strobe operates normally. All three white strobes may be inoperative provided at least one red beacon operates normally.

ON Light: The ON indication is visible in ambient light with the shutter open and the switch is flush with the panel.

Consequences of Next Critical Failure

Loss of remaining light(s) (red beacons or white strobes). Remaining anti-collision light(s) and position lights provide illumination. Loss of all anti-collision light(s) for day operations if dispatching with only one light operating.

ON Light: None.

Federal Aviation Administration (FAA)**ATA 33****777-9 Master Minimum Equipment List****Section 2****33-45-01 Logo Lights**

Interval	Installed	Required	Procedure
D	2	0	

33-45-01 Logo Lights**33-45-01-01 LOGO Switch ON Light**

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION**Background**

Proposal for 33-45-01 based on 777 MMEL item 33-45-01.

Proposal for 33-45-01-01 based on 787 MMEL item 33-45-01-01 and 777 MMEL item 33-45-01-01.

The logo lights consist of single assemblies, one mounted on each horizontal stabilizer illuminating the vertical stabilizer uniformly. Power to the logo lights is controlled by the "LOGO" ON/OFF push-button switch installed on the P5 Pilots Overhead panel. Each light assembly consists of a housing, power supply, replaceable LED module, and lens assembly. Each light has its own dedicated power supply. The logo lights have the purpose of illuminating the vertical stabilizer, primarily where the customer logo is located.

The 777-9 logo lights system will utilize LED light source and two lighting assemblies compared to the 777-300ER with incandescent lamps and four lighting assemblies

Consequences of Failure

Illumination from the affected light(s) is lost. Logo lights are not required by FAR.

ON light: For an inoperative LOGO switch ON light, the state of the switch is indicated by the flush position of the switch and the ON can be visible from ambient light when the shutter is open.

Consequences of Next Critical Failure

None identified.

ON Light: None.

33-51-01 Interior Emergency Lighting System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger carrying operations, and
- Alternate procedures are established and used.

33-51-01 Interior Emergency Lighting System**33-51-01-01 Main-Aisle Overhead Emergency Lights**

Interval	Installed	Required	Procedure
C	-	-	(M)

A random 25% may be inoperative provided:

- Inoperative lights are verified once each flight day,
- Inoperative lights are not adjacent,
- Door cross-aisle overhead emergency lights operate normally,
- The forward and aft main-aisle overhead emergency lights closest to each door cross-aisle operate normally, and
- Flight deck emergency dome light operates normally.

NOTE: Overhead emergency lights integrated into exit marking signs must operate normally.

33-51-01 Interior Emergency Lighting System**33-51-01-02 Exit Locator Signs**

Interval	Installed	Required	Procedure
C	-	-	(M)

One may be inoperative provided:

- Inoperative signs are verified once each flight day, and
- Associated exit marking sign operates normally.

NOTE: Lights associated with an inoperative Passenger Entry Door may be inoperative.

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33-51-01 Interior Emergency Lighting System 33-51-01-03 OFCR/OFAR Overhead Emergency Lights 33-51-01-03A

Interval	Installed	Required	Procedure
C	-	-	

A random 50% may be inoperative provided inoperative lights are verified once each flight day.

33-51-01 Interior Emergency Lighting System 33-51-01-03 OFCR/OFAR Overhead Emergency Lights 33-51-01-03B

Interval	Installed	Required	Procedure
C	-	-	

May be inoperative provided associated rest area(s) is considered inoperative.

33-51-01 Interior Emergency Lighting System 33-51-01-04 OFCR Overhead Emergency Lights (Taxi, Takeoff & Landing Installation)

Interval	Installed	Required	Procedure
C	-	-	(O)

A random 50% may be inoperative provided:

- Inoperative lights are verified once each flight day, and
- Rest area is not occupied during taxi, takeoff & landing.

SUBSTANTIATION

Background

The emergency lighting system consists of interior emergency lighting and exterior lighting that provides illumination in the absence of airplane power to assist passengers and crew members during emergency evacuation.

The 777X interior emergency lighting includes overhead emergency lighting and floor proximity lighting for the main deck and flight crew/flight attendant rest(s) (if installed).

The interior overhead emergency lighting provides illumination of the escape path leading to the exits. Aisle lights installed on the ceiling panels throughout the cabin to provide general illumination during an emergency evacuation. Emergency exit locator signs are installed overhead in the aisle adjacent to all exit doors to locate and direct passengers to each exit. The emergency exit marking signs are installed above each of the exit doors to mark each exit. Overhead lights integrated into the exit marking signs provide the required illumination of the door handle and threshold.

The emergency lighting system has 3 modes of control for the flight crew: "ON", "OFF" and "ARMED". "ON" is a manual activation while "OFF" is provided so that the system does not come on and discharge the batteries whenever electrical power is intentionally removed from the aircraft. "ARMED" is the mode normally to be used during revenue service of the aircraft. In the "ARMED" mode, the logic within each emergency power supply will monitor the charging power and turn the lights on if that power is lost.

Control of the system from the passenger cabin consists of a "NORMAL" and an "ON" mode. "NORMAL" leaves the system in the condition commanded by the flight crew while "ON" overrides the flight deck command and turns the system on. Each power supply contains rechargeable nickel-cadmium batteries that provide nominal 6 volts DC power to the connected interior and exterior emergency lighting loads.

Consequences of Failure

Main-Aisle Overhead Emergency Lights: There is no status message to indicate this failure. Illumination from the inoperative lights is lost. A maximum of 25% of the main-aisle overhead emergency lights may be inoperative. Door cross-aisle overhead emergency lights must operate normally. The main-aisle overhead emergency light adjacent to the door cross-aisle must also operate normally. With 50% of overhead lights inoperative, there remains adequate illumination to comply with the certification requirements. This item does not provide relief for the flight deck emergency dome light nor the overhead emergency lights integrated into exit marking signs.

System is checked as part of planned maintenance by turning system on using flight deck switch, cabin emergency light switch and emergency light test switch.

Exit Locator Sign: Remaining exit marking sign and exit locator sign are adequate to identify exit.

OFCR/OFAR Overhead Emergency Lights/Exit Signs: Associated rest area must be considered inoperative.

Interior Emergency Lighting System: No passengers may be carried.

Consequences of Next Critical Failure

Main-Aisle Overhead Emergency Lights: Loss of one additional light. Remaining lights provide sufficient illumination until there are two adjacent failed lights.

Exit Locator Sign: Loss of additional exit locator sign: Remaining signs will identify exit.

33-51-02 Exterior Emergency Lighting

33-51-02A

Interval	Installed	Required	Procedure
C	-	0	

May be inoperative provided operations are not conducted at night.

33-51-02 Exterior Emergency Lighting

33-51-02B

Interval	Installed	Required	Procedure
C	-	0	(O)

May be missing or inoperative provided:

- a. No passengers are carried,
- b. A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger-carrying operations, and
- c. Alternate procedures are established and used.

33-51-02 Exterior Emergency Lighting

33-51-02-01 Passenger Entry Door Escape Slide Lights

Interval	Installed	Required	Procedure
A	8	7	

One may be inoperative provided:

- a. Associated Passenger Entry Door is considered inoperative, and
- b. Repairs are made within 1 flight-day.

For Service Exit Doors installed:

- c. Service Exit Doors Escape Slide Lights operate normally.

NOTE: A light with one of two LEDs failed is considered inoperative.

33-51-02 Exterior Emergency Lighting**33-51-02-02 Service Exit Doors Escape Slide Lights**

Interval	Installed	Required	Procedure
A	2	1	

Lights associated with one Service Exit Door may be inoperative provided:

- Associated Service Exit Door is considered inoperative,
- Passenger Entry Door Escape Slide Lights operate normally, and
- Repairs are made within 1 flight-day.

NOTE: A light with one of two LEDs failed is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 33-51-02.

The exterior emergency lighting consists of fuselage mounted lights installed aft of each door to illuminate the slide and ground contact area. In addition, lights integral to the escape slide are installed at the ground end of the slide to augment the fuselage mounted light. This provides illumination levels at the ground end of the slide in all attitudes of the airplane corresponding to collapsed gear configurations.

Fuselage mounted escape slide lights are operated using the same power supplies and controls as the interior emergency lighting components. See 33-51-01 for more details on the system operation. Slide mounted lights are powered by non-rechargeable batteries and operated automatically upon slide deployment.

Consequences of Failure

Illumination from the affected light is lost. No effect on day operations. Otherwise, the associated door must be considered inoperative. See MMEL item 52-11-01 for consequences of inoperative door. See 52-21-01 for consequences of inoperative service exit door.

Consequences of Next Critical Failure

Emergency evacuation: None, as associated door must be considered inoperative and cannot be used for any purpose. Seats adjacent to the door must not be used and are required to be roped off, the door must be placarded inoperative, and the door emergency exit signs must be obscured.

33-51-03 Floor Proximity Lighting Systems

Interval	Installed	Required	Procedure
C	-	0	(O)

May be missing or inoperative provided:

- a. No passengers are carried,
- b. A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger carrying operations, and
- c. Alternate procedures are established and used.

33-51-03 Floor Proximity Lighting Systems

33-51-03-01 Powered Escape Path Lighting System

Interval	Installed	Required	Procedure
C	-	-	(M)

A random 25% of floor proximity lights may be inoperative provided:

- a. Inoperative lights are verified once each flight day, and
- b. Inoperative lights are not adjacent to each other.

NOTE: Floor proximity lights associated with an inoperative Passenger Entry Door are not required.

33-51-03 Floor Proximity Lighting Systems

33-51-03-02 Passenger Entry Door Exit Identifier Floor Lights

Interval	Installed	Required	Procedure
C	16	8	

One exit identifier floor light per Passenger Entry Door may be inoperative provided associated exit identifier backlight operates normally.

NOTE: Lights associated with an inoperative Passenger Entry Door are not required.

33-51-03 Floor Proximity Lighting Systems**33-51-03-03 Service Exit Door Exit Identifiers**

Interval	Installed	Required	Procedure
C	4	2	

One exit identifier floor light per Service Exit Door may be inoperative provided associated exit identifier backlight operates normally.

NOTE: Lights associated with an inoperative Service Exit Door are not required.

33-51-03 Floor Proximity Lighting Systems**33-51-03-04 Photoluminescent Escape Path Marking System**

Interval	Installed	Required	Procedure
C	-	-	

Segments of photoluminescent strip may be inoperative provided:

- No more than four 10-inch segments are inoperative in each cabin zone aisle,
- A minimum of 72 inches of photoluminescent strip must operate normally between inoperative segments, and
- Inoperative segments must not be laterally adjacent in an aisle.

NOTE 1: Photoluminescent strips associated with an inoperative door slide/raft are not required.

NOTE 2: A cabin zone is the passenger cabin area between two sets of door pairs (passenger entry or service exit).

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 33-51-02.

The floor proximity lights mounted on the aisle side of the center seat groups approximately 15 inches from the floor to provide a means to assist occupants in locating the exit under conditions of dense smoke. Lights are also installed in the main aisle on monuments approximately 3 to 15 inches from the floor. In addition to the main aisle, lights are also installed on monuments and/or seats in the cross aisle as required.

The exit identifiers include illuminated symbolic or literal artwork to specifically identify a door post and the flood light to illuminate vicinity of a door. One exit identifier is installed approximately at 30 inches from the floor on each side of every passenger and service (if present) entry door. The floor proximity light and exit identifiers are part of the interior emergency lighting system.

See 33-51-01 for system operation description.

Photoluminescent escape path lights are non-electric. They utilize a material based on strontium aluminate, which is able to absorb energy from visible and ultraviolet light sources. Light energy from natural and artificial light sources - e.g. ambient light of the aircraft cabin lighting - is stored in the photoluminescent material. As the ambient light decreases, stored energy from the photoluminescent material is re-emitted in the visible spectrum highlighting the escape path.

Photoluminescent lights are placed on both sides of each main cabin aisle on the carpet. They are typically installed on the floor adjacent to seat armrests. The system may include joggles as necessary to represent changes in path direction or width. The segments are positioned to create a continuous "light" strip except for breaks at joggles, galley matted area, or carpet thresholds. The continuous photoluminescent lights terminate at each exit prior to the inboard/outboard monuments.

Consequences of Failure

There is no status message to indicate this failure. Affected component is inoperative. Remarks or exceptions for MMEL will be validated by certification ground test of the system.

System is periodically checked as part of planned maintenance by turning system on using flight deck switch.

Consequences of Next Critical Failure

Failure of one of the remaining lights.

34-12-01 Pitot Air Data Modules (ADM)

- 34-12-01-01 Right Pitot ADM
- 34-12-01-02 Left Pitot ADM
- 34-12-01-03 Center Pitot ADM

34-12-02 Static Air Data Modules (ADM)

- 34-12-02-01 Right Static ADM
- 34-12-02-02 Left Static ADM

34-12-03 Angle of Attack (AOA) Vanes

- 34-12-03-01 AOA Vane Resolvers
 - 34-12-03-01A
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34-12-04 Total Air Temperature (TAT) Probe Elements

34-16-01 Altitude Alerting System

34-21-01 Earth Reference System (ERS)

- 34-21-01-01 Inertial Reference Units (IRUs)
 - 34-21-01-01-01 ON BAT Light
- 34-21-01-02 Attitude/Heading Reference Units (AHRUs)

34-23-01 Non-Stabilized Magnetic (Standby) Compass

34-24-01 Integrated Standby Flight Display (ISFD)

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Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Left and center pitot probes are inspected before each departure,
- Left and Center Pitot ADMs operate normally,
- Left and Center Pitot Probe Heater Systems operate normally,
- Left, Right and Center Static ADMs operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally, and
- Approach minimums do not require its use.

34-12-01 Pitot Air Data Modules (ADM)**34-12-01-02 Left Pitot ADM**

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Right and center pitot probes are inspected before each departure,
- Right and Center Pitot ADMs operate normally,
- Right and Center Pitot Probe Heater Systems operate normally,
- Left, Right and Center Static ADMs operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally, and
- Approach minimums do not require its use.

34-12-01 Pitot Air Data Modules (ADM)**34-12-01-03 Center Pitot ADM**

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Left and right pitot probes are inspected before each departure,
- Left and Right Pitot ADMs operate normally,
- Left and Right Pitot Probe Heater Systems operate normally,

- d. Left, Right and Center Static ADMs operate normally,
 - e. Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally, and
 - f. Approach minimums do not require its use.
-

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 34-12-01.

The Air Data Reference System (ADRS) consists of six Air Data Modules (ADM), two dual-resolver Angle of Attack (AOA) vanes, one dual-element Total Air Temperature (TAT) probe, three pairs of cross-coupled static ports, three pitot probes, and three ADRF software applications resident in Flight Control Modules (FCMs) in the Integrated Flight Control Electronics (IFCE) cabinets.

Three ADMs are used for the static ports and three ADMs are used for the pitot probes. Each static ADM is connected through a short length of hose to one center-tap on the cross-manifold tubing for a static port pair. Each pitot ADM is connected to the adjacent on-side pitot probe through a short length of hose.

The ADMs provide converted pressure data in ARINC 429 format to the Actuator Control Electronics (ACEs) of the IFCE cabinets. The ACEs then transmit the digital pressure data to the Flight Control Modules (FCMs) and forward it to the ADRFs for redundancy management and conversion to air data parameters. The converted air data parameters will then be sent back through the Common Data Network (CDN), and forwarded to the appropriate functions on the airplane.

The center pitot ADM and the center static ADM provide converted pressure data in ARINC 429 format directly to the integrated standby flight display (ISFD) to support the display of standby air data.

Consequences of Failure

Failure of a pitot ADM is indicated by the PITOT ADM C, L, or R Status message.

The ADRF is capable of isolating a single pitot pressure fault. Once isolated, this faulted pressure value is not used in the voted air data solution. The voted air data solution will still be available from the ADRF and will be based on the two remaining operative pitot ADMs whose associated pitot probes are heated.

For center pitot ADM inoperative, Integrated Standby Flight Display (ISFD) airspeed will also be inoperative.

NOTE: For center static ADM inoperative, both ISFD airspeed and altitude will be inoperative. Since there is no precedent for standby altitude relief in other model MMELs, relief for the center static ADM is not proposed.

A loss of any one pitot ADM will result display the NO LAND 3 Advisory message. The NO LAND 3 Caution level message will display if the failure occurs after LAND 3 has been annunciated.

Consequences of Next Critical Failure

Failure of an additional pitot ADM or pitot probe heater:

Voted airspeed will continue to be valid and will be based on the remaining operative pitot ADM whose respective pitot probe is heated. If C pitot ADM fails, ISFD airspeed will be inoperative. (If C pitot heater fails, C pitot ADM output is excluded from the ADRF voted airspeed solution, but is still used by the ISFD and may be erroneous in icing conditions.)

The NO AUTOLAND Advisory message will be displayed. The NO AUTO-LAND Caution level message will be displayed if the failure occurs during approach.

ADM failures that cause erroneous data transmitted as valid have a probability of $4E-9$ per flight hour. The ADRS FTA assumes an average flight length of 9 hours which result in a probability of $3.6E-8$ per flight.

Loss of voted airspeed:

ADM failure can occur by 2 primary means, sensed pressure disagreement with other ADMs or an internal fault that causes the ADM to output invalid or no data. The ADRF will respond differently to each failure mode. Sensed Pressure Disagreement: If the ADRF detects a pressure disagreement, the disagreeing ADM will be removed from the voting algorithm. Voted total or static pressure will continue to be calculated by the remaining total or static pressure ADMs. If dispatching under ADM dispatch relief and one of the remaining available ADMs experience this failure mode, voted total or static pressure will be set invalid since the remaining available ADM pressures disagree.

Internal Fault/Invalid or no data: An ADM that suffers an internal fault causing invalid or no data will automatically be removed from the voting algorithm. If dispatching under ADM dispatch relief and one of the remaining available ADMs experience this failure mode, the remaining single ADM will drive voted total or static pressure but have no fault tolerance available.

Misleading airspeed is categorized as a catastrophic hazard. When dispatching with a single ADM inoperative, the probability of additional failure resulting in misleading airspeed is $8.94E-9$ per flight hour.

PCF Secondary Mode:

The Primary Flight Control Function will automatically switch to secondary mode if the required inertial or air data signals are invalid ((Inertial data from ERS, Air data from ADRF, Voted Angle of Attack computed by IFCE, Flap/Slat data from HLF, Inertial data from FCDIS). Secondary mode also result with loss of minimum acceptable pitch control.

Secondary mode will result in loss of envelope protection and auto speed-brakes. Pitch stability augmentation is modified to use the pitch rate from FCDIS, or ERS if FCDISs are not available. Stabilizer control is direct and rudder trim is manually controlled.

Secondary mode autopilot (SMAP):

Only basic autopilot cruise modes of Vertical Speed/Flight path Angle, Heading/Track Hold and Heading/Track Select are supported. Other

modes may be selected but will be mode-failed. This includes altitude capture and hold mode which will engage and then fail when the MCP altitude vicinity is encountered. Crew can re-engage vertical speed or manually adjust the vertical speed target on the MCP to capture the altitude or disconnect and manually capture altitude. Altitude hold can be achieved through the setting of a vertical speed target of zero.

Autopilot backdrive is not supported. Secondary autopilot mode is only available above 800 AGL. Control wheel pitch trim switches will not move stabilizer. Alternate pitch trim switch will move the stabilizer but will disconnect the autopilot. Autopilot may be re-engaged after trimming.

Loss of Voted Air Data:

When no voted airspeed is available, synthetic airspeed will be displayed on the PFDs and HUDs. This condition is annunciated by the AIRSPEED DATA FAULT Caution message, with PFD and HUD annunciating AOA SPD.

There are rare failures that can cause multiple ADMs to output identical values that are erroneous. This situation could occur due to maintenance errors such as pneumatic tubes being disconnected from multiple static ADMs, or when multiple pitot tubes are equally blocked due to a common mode error such as mud daubers or volcanic ash. The voting algorithms cannot determine that the resulting airspeed values are wrong so the erroneous information is displayed. The Flight Control Modules (FCMs) have a Common Mode Monitor (CMM) that compares the voted airspeed data with synthetic airspeed derived from voted AOA and voted inertial data. When the difference between these values becomes excessive, the EICAS message AIRSPEED UNRELIABLE is displayed. Because the CMM could be triggered by a common mode error in the voted airspeed or a common mode error in the voted AOA, the FCMs will continue to output the voted airspeed as valid. If the voting algorithm subsequently detects a Pt or Ps miscompare, the voted airspeed is declared invalid and AOA SPD is displayed. The impact of the CMM tripping is the same as the loss of voted airspeed except that the voted (possibly erroneous) airspeed is still displayed on the PFD and HUD. In this condition, primary flight controls will revert to secondary mode. Basic autopilot cruise modes may be available when primary flight controls are in secondary mode.

Loss of all flight deck displays:

There is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed*, and heading remain available. *(ISFD airspeed is inoperative (flagged) if either center pitot ADM or center static ADM is inoperative.) Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

34-12-02 Static Air Data Modules (ADM)**34-12-02-01 Right Static ADM**

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- Left Static ADM operates normally,
- Left, Right and Center Pitot ADMs operate normally,
- Left, Right and Center Pitot Probe Heater Systems operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally,
- At least one GPS operates normally, and
- Approach minimums do not require its use.

NOTE: MMEL relief is not allowed with an inoperative Center Static ADM.

34-12-02 Static Air Data Modules (ADM)**34-12-02-02 Left Static ADM**

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- Right Static ADM operates normally,
- Left, Right and Center Pitot ADMs operate normally,
- Left, Right and Center Pitot Probe Heater Systems operate normally,
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally,
- At least one GPS operates normally, and
- Approach minimums do not require its use.

NOTE: MMEL relief is not allowed with an inoperative Center Static ADM.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-12-02.

The Air Data Reference System (ADRS) consists of six Air Data Modules (ADMs), two dual-resolver Angle of Attack (AOA) sensors, one dual-element Total Air Temperature (TAT) probe, three pairs of cross-coupled static ports, three pitot probes, and three ADRF software applications resident in Flight Control Modules (FCMs) in the Integrated Flight Control Electronics (IFCE) cabinets.

Three ADMs are used for the static ports and three ADMs are used for the pitot probes. Each static ADM is connected through a short length of hose to one center-tap on the cross-manifold tubing for a static port pair. Each pitot ADM is connected to the adjacent on-side pitot probe through a short length of hose.

The ADMs provide converted pressure data in ARINC 429 format to the Actuator Control Electronics (ACEs) of the IFCE cabinets. The ACEs then transmit the digital pressure data to the Flight Control Modules (FCMs) and forward it to the ADRFs for redundancy management and conversion to air data parameters. The converted air data parameters will then be sent back through the Common Data Network (CDN), and forwarded to the appropriate functions on the airplane.

The center pitot ADM and the center static ADM provide converted pressure data in ARINC 429 format directly to the ISFD to support the display of standby air data.

Consequences of Failure

Failure of a static ADM is indicated by the STATIC ADM C, L, or R Status message.

The ADRF is capable of isolating a single static pressure fault. Once isolated, this faulted pressure value is not used in the voted air data solution. Voted air data will still be available from the ADRF, and will be based on the two remaining operative static ADMs.

For center static ADM inoperative, ISFD airspeed and altitude would also be inoperative. Since there is no precedent for standby altitude relief in other model MMELs, relief for the center static ADM is not proposed.

NOTE: For center pitot ADM inoperative, only ISFD airspeed will also be inoperative. MMEL relief is provided for ISFD airspeed per PL-111.

A loss of any one static ADM will result display the NO LAND 3 Advisory message. The NO LAND 3 Caution level message will display if the failure occurs after LAND 3 has been annunciated.

Consequences of Next Critical Failure

Failure of an additional static ADM:

The voted air data will continue to be valid and will be based on the remaining valid static ADM. If C static ADM fails, ISFD airspeed and altitude will be inoperative.

The NO AUTOLAND Advisory message will be displayed. The NO AUTOLAND Caution level message will be displayed if the failure occurs during approach.

ADM failures that cause erroneous data transmitted as valid have a probability of 4E-9 per flight hour. The ADRS FTA assumes an average flight

length of 9 hours which result in a probability of $3.6\text{E-}8$ per flight.

Loss of voted airspeed:

ADM failure can occur by 2 primary means, sensed pressure disagreement with other ADMs or an internal fault that causes the ADM to output invalid or no data. The ADRF will respond differently to each failure mode. Sensed Pressure Disagreement: If the ADRF detects a pressure disagreement, the disagreeing ADM will be removed from the voting algorithm. Voted total or static pressure will continue to be calculated by the remaining total or static pressure ADMs. If dispatching under ADM dispatch relief and one of the remaining available ADMs experience this failure mode, voted total or static pressure will be set invalid since the remaining available ADM pressures disagree.

Internal Fault/Invalid or no data: An ADM that suffers an internal fault causing invalid or no data will automatically be removed from the voting algorithm. If dispatching under ADM dispatch relief and one of the remaining available ADMs experience this failure mode, the remaining single ADM will drive voted total or static pressure but have no fault tolerance available.

Misleading airspeed is categorized as a catastrophic hazard. When dispatching with a single ADM inoperative, the probability of additional failure resulting in misleading airspeed is $8.94\text{E-}9$ per flight hour.

PFCF Secondary Mode:

The Primary Flight Control Function will automatically switch to secondary mode if the required inertial or air data signals are invalid ((Inertial data from ERS, Air data from ADRF, Voted Angle of Attack computed by IFCE, Flap/Slat data from HLF, Inertial data from FCDIS). Secondary mode also result with loss of minimum acceptable pitch control.

Secondary mode will result in loss of envelope protection and auto speedbrakes. Pitch stability augmentation is modified to use the pitch rate from FCDIS, or ERS if FCDISs are not available. Stabilizer control is direct and rudder trim is manually controlled.

Secondary mode autopilot (SMAP):

Only basic autopilot cruise modes of Vertical Speed/Flight path Angle, Heading/Track Hold and Heading/Track Select are supported. Other modes may be selected but will be mode-failed. This includes altitude capture and hold mode which will engage and then fail when the MCP altitude vicinity is encountered. Crew can re-engage vertical speed or manually adjust the vertical speed target on the MCP to capture the altitude or disconnect and manually capture altitude. Altitude hold can be achieved through the setting of a vertical speed target of zero.

Autopilot backdrive is not supported. Secondary autopilot mode is only available above 800 AGL. Control wheel pitch trim switches will not move stabilizer. Alternate pitch trim switch will move the stabilizer but will disconnect the autopilot. Autopilot may be re-engaged after trimming.

Loss of Voted Air Data:

When no voted airspeed is available, synthetic airspeed will be displayed

on the PFDs and HUDs. This condition is annunciated by the AIRSPEED DATA FAULT Caution message, with PFD and HUD annunciating AOA SPD.

There are rare failures that can cause multiple ADMs to output identical values that are erroneous. This situation could occur due to maintenance errors such as pneumatic tubes being disconnected from multiple static ADMs, or when multiple pitot tubes are equally blocked due to a common mode error such as mud daubers or volcanic ash. The voting algorithms cannot determine that the resulting airspeed values are wrong so the erroneous information is displayed. The Flight Control Modules (FCMs) have a Common Mode Monitor (CMM) that compares the voted airspeed data with synthetic airspeed derived from voted AOA and voted inertial data. When the difference between these values becomes excessive, the EICAS message AIRSPEED UNRELIABLE is displayed. Because the CMM could be triggered by a common mode error in the voted airspeed or a common mode error in the voted AOA, the FCMs will continue to output the voted airspeed as valid. If the voting algorithm subsequently detects a Pt or Ps miscompare, the voted airspeed is declared invalid and AOA SPD is displayed. The impact of the CMM tripping is the same as the loss of voted airspeed except that the voted (possibly erroneous) airspeed is still displayed on the PFD and HUD. In this condition, primary flight controls will revert to secondary mode. Basic autopilot cruise modes may be available when primary flight controls are in secondary mode.

Loss of all flight deck displays:

There is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed*, and heading remain available. *(ISFD airspeed is inoperative (flagged) if either center pitot ADM or center static ADM is inoperative.) Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

34-12-03 Angle of Attack (AOA) Vanes**34-12-03-01 AOA Vane Resolvers****34-12-03-01A**

Interval	Installed	Required	Procedure
C	4	3	(M)

One may be inoperative provided both left and right AOA heaters are verified to operate normally.

34-12-03 Angle of Attack (AOA) Vanes**34-12-03-01 AOA Vane Resolvers****34-12-03-01B**

Interval	Installed	Required	Procedure
B	4	2	(M)

May be inoperative provided:

- Both left and right AOA heaters are verified to operate normally,
- One Left AOA Vane Resolver operates normally, and
- One Right AOA Vane Resolver operates normally.

SUBSTANTIATION**Background**

New proposal for 777X, derived from 787 MMEL item 34-12-03.

Angle of attack (AOA) is derived from two vanes located on each side of the forward fuselage. Each AOA vane deflection is measured by 2 resolvers. In addition to signals from these two vanes, a synthetic AOA is computed from the flight control signal processing.

AOA data is used for flight deck displays (speed tape, PLI), stick shakers, and flight controls basic and enhanced stall protection (ESP) functions. The ESP function limits maximum angle of attack at certain flight conditions and requires at least 2 (any 2) of the 4 AOA resolvers to operate normally. If more than 2 resolvers are failed, flight controls reverts to basic stall protection.

AOA data is also used to compute a synthetic airspeed as a backup for Air Data Reference Function (ADRF) voted airspeed derived by the ADRF from the pitot and static air data modules (ADMs).

AOA synthetic airspeed is displayed as AOA SPD on PFDs and HUDs and can be manually selected in-flight by placing the AIR DATA/ATT source select switch in the ALTN position. AOA SPD will replace voted primary airspeed if voted primary airspeed is set invalid by ADRF. On the ground, AOA SPD is not valid. Placing the AIR DATA/ATT switch in the ALTN position will put ISFD SPD on the PFDs.

For 777X, the right AOA heater and center pitot heater include provisions for electrical power from the ram air turbine (RAT). In remote scenarios such as dual engine flameout, the center pitot heater loses power temporarily while the RAT deploys, spools up, and its generator comes online. During this temporary loss, power to the right AOA heater is provided from the main battery. For loss of the center pitot function, the right AOA would provide a synthetic airspeed, indicated as AOA SPD until voted air data, based on heated center pitot, is restored. These capabilities are enhancements relative to 777-300ER.

Consequences of Failure

One resolver failed or one resolver failed in each AOA vane: Any single resolver failed results in appropriate AOA RESOLVER status message. Remaining resolvers provide required information to airplane systems. Both AOA heaters must be verified to operate normally. AOA heater faults are not annunciated until in-air.

Consequences of Next Critical Failure

NOTE: For AOA heater failed, the data from the associated vane (both resolvers) is declared invalid. Both resolvers are considered failed.

One Resolver Inoperative:

Remaining resolver fails on associated side: Two failed resolvers on one vane will result in the NO LAND 3 Advisory message. When LAND 3 is annunciated on the PFDs (and HUDs, if installed), the NO LAND 3 Caution message will be displayed.

One Resolver Inoperative in each AOA vane:

Remaining resolver fails on one side (three resolvers inoperative):

Flight control signal processing algorithms revert to using the remaining operative resolver, monitoring it with the synthetic AOA signal. The ESP function is disabled for the remainder of the flight. Basic stall protection, flight deck display indications, and stick shakers all continue to operate normally up to normal stick shaker angle of attack.

Remaining resolver fails on one side, and opposite vane loses heat:

Flight control signal processing uses synthetic AOA signal to support user systems. The ESP function will be disabled for as long as the heat function is disabled on the operable vane. Basic stall protection, flight deck display indications, and stick shakers all continue to operate normally up to normal stick shaker angle of attack.

Remaining right AOA resolver fails followed by dual engine flameout or other remote scenario leading to RAT power only:

Voted air data is declared invalid after approximately 8 seconds. Synthetic AOA SPD is not available, so displayed airspeed is based on (unheated) center pitot-static data and indicated as ISFD SPD. Approximately 70 seconds after primary power loss, voted air data based on heated C pitot probe is restored and any icing-induced error in ISFD airspeed will disappear. Thirty seconds after restarting one or both engines, heat will be restored to L and R pitot probes which then become redundant total pressure sources.

Remaining resolver fails, and miscompare between remaining resolvers and synthetic AOA:

Flight controls reverts to Secondary Mode. A voted AOA based on remaining resolvers is still provided to support flight deck display indications and stick shakers.

The resulting hazard classification of reversion to secondary mode is 'Major' for most flight phases. Reversion to secondary mode at Takeoff Rotation or during Go-Around Landing is classified as 'Hazardous'.

Failure of the remaining resolver combined with failures resulting in miscompare between remaining resolvers and synthetic AOA is extremely improbable.

PFCF Secondary Mode:

The Primary Flight Control Function will automatically switch to secondary mode if the required inertial or air data signals are invalid ((Inertial data from ERS, Air data from ADRF, Voted Angle of Attack computed by IFCE, Flap/Slat data from HLF, Inertial data from FCDIS). Secondary mode also result with loss of minimum acceptable pitch control.

Secondary mode will result in loss of envelope protection and auto speed-brakes. Pitch stability augmentation is modified to use the pitch rate from FCDIS, or ERS if FCDISs are not available. Stabilizer control is direct and rudder trim is manually controlled.

Secondary mode autopilot (SMAP):

Only basic autopilot cruise modes of Vertical Speed/Flight path Angle, Heading/Track Hold and Heading/Track Select are supported. Other modes may be selected but will be mode-failed. This includes altitude capture and hold mode which will engage and then fail when the MCP altitude vicinity is encountered. Crew can re-engage vertical speed or manually adjust the vertical speed target on the MCP to capture the altitude or disconnect and manually capture altitude. Altitude hold can be achieved through the setting of a vertical speed target of zero.

Autopilot backdrive is not supported. Secondary autopilot mode is only available above 800 AGL. Control wheel pitch trim switches will not move stabilizer. Alternate pitch trim switch will move the stabilizer but will disconnect the autopilot. Autopilot may be re-engaged after trimming.

34-12-04 Total Air Temperature (TAT) Probe Elements

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION**Background**

New proposal for 777X.

The Air Data Reference System includes a single TAT probe. The probe has 2 sensor elements. Each element sends analog temperature data to a Remote Data Concentrator (RDC). The TAT probe has a single 115 VAC heating element for ice protection.

Each ADRF employs a redundancy management algorithm for detection of TAT failures and for computation of a trusted, voted TAT value. For the airframe TAT, the resistance values received from the RDCs are monitored for failure and when both are valid, contribute to the voted TAT value along with the engine TAT sources provided by each EEC. Under failure conditions, only the valid elements are used. In addition, the airframe TAT values are monitored for agreement between all TAT sources; a TAT probe element that does not align with the voted TAT is set invalid. Voted TAT value is used to compute static air temperature (SAT) and true airspeed in the air data algorithms.

The ADRF's TAT function uses TAT data from three sources, the airframe TAT Probe and a TAT Sensor in each engine. Each TAT source consists of two redundant sensor elements. Under a normal dispatch, voted TAT will be a function of the airframe TAT Probe elements until $N1 > 60\%$ during takeoff. At that time, the four engine TAT Sensor elements are added to the voted TAT solution. During flight, subsequent TAT source failures will result in degraded TAT integrity. Note that each source has 2 elements. For a source to be unavailable, both elements of that source must be unavailable. When all sources are available, the ADRF will compute voted TAT with a weighted average. When only two sources are available, voted TAT is a simple average of the available sources. When only one source is available, voted TAT is the value that source provides.

The airframe TAT Probe is aspirated by engine bleed air on the ground to counter the effects of solar heating of the probe's sensing elements. In flight, the TAT Probe is naturally aspirated.

Consequences of Failure

Single airframe TAT probe element failure is annunciated by the TAT ELEMENT 1 or TAT ELEMENT 2 Status message. Airframe TAT is provided by the remaining TAT probe element. Voted TAT is based on remaining airframe TAT element and TAT sources provided by the left and right EECs from the engine T12 probes.

Consequences of Next Critical Failure

Failure of remaining airframe TAT probe element:

Airframe TAT sources will not be available for voted TAT calculation. Voted TAT will be based on the 4 TAT sources provided by the left and right EECs from the engine T12 probes. Subsequent dispatch with both airframe TAT probe elements failed is not allowed.

TAT Probe heater failure does not invalidate TAT Probe elements. See 777X DDG 30-33-01.

Draft
Feb 26, 2026

34-16-01 Altitude Alerting System

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative provided:

- Autopilot with altitude hold, and altitude capture operates normally,
- VS/FPA Switch and Selector operates normally,
- Enroute operations, i.e., RVSM, do not require its use,
- Airplane does not depart from a designated airport (as listed in the operator's MEL) where repair or replacement can be made, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-16-01.

FAA Proposal based on PL-39 rev 5.

The altitude alert function has two modes of operations, an acquisition mode and a deviation mode. The acquisition mode consists of increasing the brightness of the box surrounding the numeric altitude on the PFD. The deviation mode consist of illumination of the master caution lights, an aural indication and display of the caution level EICAS message ALTITUDE ALERT when the selected altitude differs from the actual airplane altitude by a preset amount (200-300 feet).

Consequences of Failure

Failure of the altitude alerting function is indicated by the ALTITUDE ALERT SYS Status message.

The referenced policy letter allows dispatch relief for an inoperative altitude alerting system provided the air carrier develops operational procedures and the autopilot has an operative altitude hold capability.

Policy Letter 39 considerations:

For MMEL dispatch with an inoperative altitude alerting system, PL-39 requires that, "Autopilot with altitude hold, and altitude capture operates normally,". Altitude hold and capture functions are provided by the following functions on the MCP: Altitude Window, Altitude Selector and Altitude HOLD switch. The Altitude Window may be inoperative for dispatch, however, PFD indications can be used to select or verify altitude. For the Altitude Selector, only the 1000 position may be inoperative (AUTO position must operate normally). In addition to the Altitude HOLD switch, the following pitch modes will also provide acceptable altitude hold capability: Vertical Speed (VS) or Flight Path Angle (FPA) with 000 selected, or Vertical Navigation (VNAV) with FMC flight plan, or VNAV with FMC flight plan combined with altitude intervention. Therefore, as long as the auto-

pilot system is available for use, altitude hold and altitude capture will operate normally provided Altitude HOLD, VNAV, VS or FPA modes are available.

Consequences of Next Critical Failure

For failure of the autopilot altitude hold capability, the flight crew must be aware of the airplane altitude. Failure of the autopilot altitude hold capability will result in a no dispatch condition. Loss of altitude hold capability will require exiting RVSM airspace.

Draft
Feb 26, 2026

Federal Aviation Administration (FAA)**ATA 34****777-9 Master Minimum Equipment List****Section 2****34-21-01 Earth Reference System (ERS)****34-21-01-01 Inertial Reference Units (IRUs)**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative IRU is deactivated,
 - Both Altitude/Heading Reference Units (AHRUs) operate normally, and
 - At least one GPS operates normally.
-

34-21-01 Earth Reference System (ERS)**34-21-01-01 Inertial Reference Units (IRUs)****34-21-01-01-01 ON BAT Light**

Interval	Installed	Required	Procedure
C	1	0	

34-21-01 Earth Reference System (ERS)**34-21-01-02 Attitude/Heading Reference Units (AHRUs)**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative AHRU is deactivated, and
 - Both Inertial Reference Units (IRUs) operate normally.
-

SUBSTANTIATION**Background**

Proposal based on 787 34-21-01.

The 777X earth reference system (ERS) is a hybrid GPS/inertial navigation system introduced on the 787, consisting of four primary inertial units augmented by GPS receivers. Two of the four inertial units are "Inertial Reference Units" (IRUs) with conventional stand-alone inertial navigation performance. The other two are "Attitude Heading Reference Units" (AHRUs) and are nearly identical to the IRUs. They are mechanically identical and use the same software load. However, there are two significant differences:

INERTIAL REFERENCE UNITS (IRUs)

The IRUs are self contained navigation sensors that utilize ring laser gyroscopes and quartz accelerometers to provide independent position, velocity, attitude and heading outputs. The IRUs on the 777-9 are referred to by the vendor as micro IRUs due to their small size. Each IRU receives inputs from the GPS and outputs hybrid GPS-Inertial 3D position and velocity data by combining raw GPS Satellite measurement data with Inertial data.

Because the IRUs have continual access to the GPS position, there is no requirement to enter the airplane present position during the alignment process. The CDU POS INIT page includes dashes to allow the option of manually entering present position. If no GPS position is available during the alignment process the dashes are replaced with boxes and present position must be entered to complete the alignment.

ATTITUDE HEADING REFERENCE UNITS (AHRUs)

The AHRUs are the same size and shape as the IRUs but they use lower accuracy gyros and therefore do not provide an independent inertial position solution. They do provide a very stable source of attitude and heading. The AHRUs on the 777-9 are referred to by the vendor as Super AHRS due to their ability to self determine magnetic and true heading without use of a magnetic flux gate sensor. The AHRUs require the same alignment time as the IRUs and they also use the GPS position for alignment if it is available. If present position is entered on the CDU POS INIT page, it is used by the IRUs and AHRUs.

Although the AHRUs do not have the ability to provide an independent inertial position, they do provide hybrid GPS-Inertial 3D position and velocity data by combining raw GPS Satellite measurement data with Inertial data identical to the IRUs.

The ERS provides eight possible sources (lanes) of hybrid GPS/inertial data (two IRUs and two AHRUs that can each be updated by either of two GPS receivers).

IRU Power

Initial power-up requires only main DC power or battery bus power and the IRS switches to be ON. Both main DC power and battery bus power must be available to dispatch. If the IRSs are switched off, they must complete a full realignment cycle before the airplane can be moved. If electrical power is subsequently removed from the airplane and the Battery switch is switched OFF, the hot battery bus continues to supply electrical power to the IRS. If an IRS switch is left ON in this condition, the ON BAT light illuminates, and the Ground Crew Call Horn in the landing gear wheel well sounds to alert maintenance personnel that the ERS (IRU/AHRU) is draining battery power.

Consequences of Failure

Failure of an IRU is indicated by the IRU L, R Status message. Failure of an AHRU is indicated by the AHRU L, R Status message.

Loss of Navigation mode of an IRU or AHRU (i.e. loss of alignment in-flight due to inadvertent shut down or power interrupt, or ground alignment not completed before takeoff) is annunciated by the associated IRU IN ATT MODE L, R or AHRU IN ATT MODE L, R Advisory messages. The affected unit will operate in the Reversionary Attitude mode by providing basic pitch, roll, heading, body rate and acceleration data but no navigation data. If at least one GPS receiver is operating normally, the affected IRU/AHRU will enter the Align-In-Motion mode, indicated by the simultaneous annunciation of the associated IRU ALIGN MODE L, R or AHRU ALIGN MODE L, R Memo message and after approximately 15 to 20 minutes will reenter the Navigation Mode and resume normal operation and clear the annunciations.

IRU inoperative:

No consequence, loss of redundancy only.

To preclude intermittent faults or potentially erroneous data, the affected IRU is deactivated.

Both AHRUs are required to operate normally

At least one GPS must operate normally

AHRU inoperative:

No consequence, loss of redundancy only.

To preclude intermittent faults or potentially erroneous data, the affected AHRU is deactivated.

ON BAT Light inoperative: Light will not illuminate when an IRU or AHRU is being powered by the battery only, however, the Ground Crew Call Horn will still sound in the wheel well to alert ground crew that one or more IRUs or AHRUs are draining battery power. Crew will be aware that the light is not working as it will be placarded INOP. The light is in place for ground operations, and is only illuminated when primary power is not available.

Consequences of Next Critical Failure

IRU inoperative: failure of another IRU leaves 2 AHRUs to provide attitude and heading data and hybrid GPS-AHRU navigation capability. This condition is indicated by the IRU FAIL L+R Advisory message. Autoland status will become NO AUTOLAND. No effect on RNP capability.

AHRU inoperative: failure of another AHRU or IRU leaves 2 earth reference sensors to provide attitude and heading data, pure inertial navigation capability, and GPS-IRU capability. Autoland status will become NO LAND 3. No effect on RNP capability.

ON BAT Light: None identified.

34-23-01 Non-Stabilized Magnetic (Standby) Compass

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided ISFD Heading Display operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-23-01.

Refer to FAA policy letter 10 (archived).

A standby magnetic compass is provided on the center post above the glareshield.

Consequences of Failure

None. Primary heading indications are available on the PFDs and NDs via the Earth Reference System (ERS). Dispatch restrictions for IRUs and AHRUs ensure that at least three sources of heading are available at dispatch, consistent with MMEL Policy letter #10.

Deleted

Consequences of Next Critical Failure

Failure of any single IRU or AHRU still leaves at least two sources of heading data.

Loss of all flight deck displays: there is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, ISFD attitude, altitude, airspeed, and heading remain available. Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

Federal Aviation Administration (FAA)

ATA 34

777-9 Master Minimum Equipment List

Section 2

34-24-01 Integrated Standby Flight Display (ISFD)

34-24-01-01 Attitude Indication

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- Operations are conducted in day VMC only, and
- Operations are not conducted into known or forecast over-the-top conditions.

34-24-01 Integrated Standby Flight Display (ISFD)

34-24-01-02 Airspeed Indication

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- Left and right pitot Pitot Air Data Modules (ADM) operate normally,
- Left and right Pitot Probe Heater Systems operate normally,
- Left, Right and Center Static Air Data Modules (ADM) operate normally, and
- Both Instrument Source (AIR DATA/ATT) Selector Switches operate normally.

34-24-01 Integrated Standby Flight Display (ISFD)

34-24-01-03 Approach Mode

Interval	Installed	Required	Procedure
C	1	0	

34-24-01 Integrated Standby Flight Display (ISFD)

34-24-01-04 Heading Display

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided Non-Stabilized Magnetic (Standby) Compass operates normally.

34-24-01 Integrated Standby Flight Display (ISFD)**34-24-01-05 Switch Lights**

Interval	Installed	Required	Procedure
C	5	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-24-01.

Proposal based on PL-111.

The integrated standby flight display (ISFD) displays standby airplane attitude, altitude, airspeed, heading and approach ILS/GLS information (LPV if applicable). The standby altitude display source is the center static air data module (ADM). The standby airspeed display source is both the center pitot ADM and the center static ADM. The power source for each ADM is provided independently and not by the standby instrument(s).

The ISFD contains an inertial measurement unit (IMU) that uses solid-state accelerometers and rate sensors to provide data from which attitude information is computed. To ensure accurate attitude computation, the ISFD performs an alignment phase following power up.

Airplane magnetic heading information from the L2 Integrated Flight Control Electronics and ILS or back course data are also shown on the ISFD. Individual switches on the ISFD allow the selection of the approach mode (APP), barometric setting units (HP/IN), display brightness adjustment (+ or -), and attitude reset (RST). The ISFD receives DC power from the L2 Integrated Flight Control Electronics.

The ISFD uses amber messages and failure flags to annunciate operational status. Actual ISFD failure conditions show on the display as failure flags. The appropriate failure flag replaces the displayed information. The following flags are displayed for inoperative functions in the corresponding display fields of the ISFD: Loss of attitude is ATT, loss of altitude is ALT, loss of airspeed is SPD, loss of heading is HDG, loss of glideslope is G/S and loss of localizer is LOC. Instrument system failure is indicated by OUT OF ORDER. The following amber messages indicate display status: ATT:RST - attitude must be reset. ATT 10s - attitude realignment in progress. WAIT ATT - temporary loss of attitude. INIT 90s - countdown of 90 second initialization.

Consequences of Failure

Loss of ISFD attitude: Only primary attitude is available. Per FAA Policy Letter 111 (PL-111), standby attitude indicator inoperative requires operations to be Day VMC only and must not be operated into known or forecast over-the-top conditions.

Loss of ISFD airspeed: Only primary airspeed is available. Left and right pitot air data modules, left and right pitot probe heaters, left and right static air data modules, AIR DATA/ATT source switches must operate normally.

Loss of ISFD approach mode (APP) results in loss of approach functionality on standby display. Loss of ability to select approach or backcourse modes.

Loss of ISFD heading: Heading is available on the primary display or magnetic compass.

Loss of ISFD pushbutton backlighting: Results in poor visibility in low-light conditions. APP and HP/IN indications status is shown on the ISFD. Airplane symbol will align with horizon when ATT RST switch is depressed for 2 seconds giving indication of successful reset. Display brightness will respond to brightness switches.

Consequences of Next Critical Failure

Loss of pitot or static ADM: None. Voted air data continues to be available.

Loss of voted air data: Multiple failures are required to reach a condition where a voted air data solution is lost. When no voted air data is available, synthetic airspeed (based on AOA, airplane gross weight, and CL tables) and geometric altitude (from GPS) is provided to the primary displays. This condition is annunciated by the AIR DATA SYS FAULT Caution message.

Loss of all flight deck displays: there is no identified single failure after dispatch that results in loss of all flight deck displays. This scenario is thus beyond the scope of normal MMEL acceptance criteria, but the effects are included for information purposes. In this unlikely scenario, altitude, airspeed remains available. If ISFD attitude inoperative at dispatch, day VMC is required. If ISFD heading inoperative at dispatch, magnetic compass is available. Autopilot remains available. A flight crew non-normal checklist is available to reset Common Core Resource (CCR) cabinets, and is considered likely to restore some or all flight deck displays.

For switch lights: None identified.

34-31-01 Instrument Landing Systems (ILS)

Interval	Installed	Required	Procedure
C	2	-	

Any in excess of those required by 14 CFR may be inoperative provided approach minimums do not require their use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL items 34-31-01, and FAR 121 appendix P.

Dual multi-mode receiver (MMR) units include ILS/GPS/GLS/LPV/MB/VOR receivers. Failure of each of these functions is separately annunciated.

The instrument landing system supplies guidance information to the pilots and autoflight system during approach and landing. The ILS receivers are tuned automatically by the flight management function (FMF), upon selection of a localizer (LOC) or ILS approach from the FMF ARRIVALS page, or may be tuned manually on the NAV RADIO page of the (emulated) CDU. FMF autotuning of the ILS receivers requires that an ILS or LOC approach is part of the active route. The ILS receivers can be manually tuned by entering the frequency and front course, or front course with frequency already entered. The tuned ILS frequency is displayed on the PFD.

The MMRs have two antenna inputs for the ILS; one for the localizer (azimuth) signal antenna, and the other for the glide slope (elevation) signal antenna. A single antenna with dual connectors feeds the left and right MMR.

The glideslope antenna is installed on the nose bulkhead of the airplane inside the radome. No antenna switching from the bulkhead mounted capture antenna to a track antenna on the nose landing gear door is required. The distance between the flight path of the antenna and that of the main landing gear during final approach is within limits to allow for proper wheels-over-threshold distance on the landing using the bulkhead mounted antenna.

The localizer antenna is installed on the nose bulkhead of the airplane inside the radome. A nose/tail transfer switch is utilized to allow the use of the tail cap mounted VOR/LOC antenna during the intercept phase of the flight. Automatic nose/tail antenna switching for the ILS localizer input is done internal to the MMR. During cruise and localizer-intercept flight phases, the antenna is switched to the tail VOR/LOC antenna. When the ILS frequency is selected by the FMF, and the integrated flight control electronics (IFCE) are placed in the 'approach mode', the antenna input is automatically switched to the nose localizer antenna for landing. The antenna switching is provided by the IFCE via a digital discrete on the ARINC 429 bus. The switching discrete is still provided by IFCE.

Consequences of Failure

The status message ILS L,R annunciates failure of the associated MMR ILS receiver, glideslope antenna input to the MMRs, or the localizer antenna input/switching.

ILS failures:

Single ILS receiver inoperative: data from the remaining ILS is displayed on both the captain's and first officer's displays and the APP SINGLE SOURCE Caution message is displayed. ILS autoland capability will not be available.

Both ILS receivers inoperative: No ILS approach available.

Glideslope failures:

Loss of glideslope antenna input to one MMR: ILS autoland capability will not be available.

Loss of glideslope antenna input to both MMRs: No ILS approach available.

Localizer failures:

Loss of localizer antenna input/switching to one MMR: ILS autoland capability will not be available.

Loss of localizer antenna input/switching to both MMRs: No ILS approach available.

MMR failures:

MMR unit inoperative: associated ILS, GPS, GLS, MB, VOR receivers inoperative. Each of these functions has independent MMEL coverage. Flight planning must take nav and approach capabilities into account.

Both MMR units inoperative: Flight planning must take nav and approach capabilities into account.

Consequences of Next Critical Failure

Failure of ILS function on opposite MMR unit. ILS approach not available, annunciated by the ILS FAIL Advisory message. GLS remains available, as well as MB/VOR functions. Navigation based on remaining capabilities which may include (depending on dispatch condition): single GPS, VOR/DME, DME/DME, ADF (if installed), inertial coasting, radar vectors, etc.

34-31-02 GPS Landing Systems (GLS)

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided approach minimums do not require their use.

SUBSTANTIATION**Background**

Proposal based on 787 item 34-31-02 and based on FAR 121 appendix P.

Dual multi-mode receiver (MMR) units include ILS/GPS/GLS/LPV/MB/VOR receivers. Failure of each of these functions is separately annunciated.

The GPS landing system (GLS) provides horizontal and vertical deviations to the autoflight and displays systems. The deviation scales, and autoflight pitch and roll modes are identical to an ILS approach.

The GLS uses GPS position data with correction signals and data from a ground based augmentation system (GBAS). The system is automatically tuned by the flight management function (FMF) when a GLS approach is part of the active route, or it can be tuned manually on the NAV RADIO page of the CDU by entering the 5 digit channel identifier for the desired approach. The GLS channel is entered and displayed on the same line of the NAV RADIO page as ILS frequency and front course, therefore precluding simultaneous use of ILS and GLS.

The GLS receives correction signals and specific approach geometry information from a VHF datalink signal transmitted from the GBAS station. The system uses the VOR antenna and associated VHF receiver in the MMR to receive the GLS datalink signal.

Consequences of Failure

GLS failures are annunciated by the associated status message GLS L, R.

GLS failures:

Single GLS receiver inoperative: data from the remaining GLS is displayed on both the captain's and first officer's displays and the APP SINGLE SOURCE Caution message is displayed. GLS autoland capability will not be available.

Both GLS receivers inoperative: No GLS approach available.

MMR failures:

MMR unit inoperative: associated ILS, GPS, GLS, MB, VOR receivers inoperative. Each of these functions has independent MMEL coverage. Flight planning must take nav and approach capabilities into account.

Both MMR units inoperative: Flight planning must take nav and approach capabilities into account.

Consequences of Next Critical Failure

Failure of GLS function on opposite MMR unit. GLS approach not available, annunciated by the GLS FAIL Advisory message. ILS remains available, as well as MB/VOR functions. Navigation based on remaining capabilities which may include (depending on dispatch condition): single GPS, VOR/DME, DME/DME, ADF (if installed), inertial coasting, radar vectors, etc.

Draft
Feb 26, 2026

34-31-03

Localizer Performance with Vertical Guidance (LPV)

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided approach minimums do not require their use.

SUBSTANTIATION**Background**

New proposal for 777X.

Dual multi-mode receiver (MMR) units include ILS/GPS/GLS/LPV/MB/VOR receivers. Failure of each of these functions is separately annunciated.

The LPV landing system provides horizontal and vertical deviations to the autoflight and displays systems. The deviation scales, and autoflight pitch and roll modes are identical to an ILS approach.

The LPV uses GPS position data with correction signals and data from a space-based augmentation system (SBAS). The system is automatically tuned by the flight management function (FMF) when a RNAV GPS approach is part of the active route, or it can be tuned manually on the NAV RADIO page of the CDU by entering the 5 digit channel identifier for the desired approach. The LPV channel is entered and displayed on the same line of the NAV RADIO page as ILS frequency and front course, therefore precluding simultaneous use of ILS, GLS and LPV.

The LPV receives correction signals from SBAS satellites and specific approach geometry information from an internal database.

Consequences of Failure

The LPV L, R Status message is displayed when the associated MMR (L or R) detects LPV failed.

LPV failures:

Single LPV receiver inoperative:

Data from the remaining LPV is displayed on both the captain's and first officer's displays and the APP SINGLE SOURCE Caution message is displayed. LPV autoland capability will not be available.

Both LPV receivers inoperative:

No LPV approach available.

MMR failures:

MMR unit (with LPV function) inoperative:

Associated ILS, GPS, GLS, VOR, MB receivers inoperative. Each of these functions has independent MMEL coverage. Flight planning must take Nav and approach capabilities into account.

Both MMR units inoperative: Flight planning must take Nav and approach capabilities into account.

Consequences of Next Critical Failure

Failure of LPV function on opposite MMR unit. LPV approach not available, annunciated by the LPV FAIL Advisory message. ILS and/or GLS autoland or approach may be available, depending on dispatch condition. Navigation based on remaining capabilities which may include (depending on dispatch condition): single GPS, VOR/DME, DME/DME, ADF (if installed), inertial coasting, radar vectors, etc.

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Feb 26, 2026

34-32-01 Marker Beacon System

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided approach minimums do not require its use.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-31-03.

The marker beacon system gives displays and aural tones in the flight deck when the airplane passes over a particular geographical location. The marker beacon system provides reference points along the glidepath and during landing approaches. The marker beacon function operates within the left multi-mode receiver (MMR) unit. The marker beacon antenna is located on the bottom of the fuselage.

Consequences of Failure

Marker beacon indications will not be available on the PFDS. Navigation equipment must be appropriate for the route being flown.

MMR failures:

Left MMR unit inoperative: associated ILS, GPS, GLS, VOR, MB receivers inoperative. Each of these functions has independent MMEL coverage. Flight planning must take nav and approach capabilities into account.

Both MMR units inoperative: Flight planning must take nav and approach capabilities into account.

Consequences of Next Critical Failure

None specifically for marker beacon inoperative at dispatch.

34-33-01 Radio Altimeter Systems

Interval	Installed	Required	Procedure
B	2	1	(O)

One may be inoperative provided:

- Speedbrakes are manually extended after landing,
- Automatic landing system (Autoland) is considered inoperative,
- Approach minimums do not require its use,
- Operating procedures do not require its use, and
- Touch-and-Go operations are not conducted.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-33-01.

The radio altimeter system supplies the pilots and airplane systems with height above terrain information. The 777X system has two transceiver units, and operates between 0 and 2500 feet. Radio altitude is displayed on the PFDs. Each pilot can select a decision height index using the EFIS control panel. When the radio height is equal to or less than the selected decision height, the display changes color and size and momentarily flashes "RADIO".

The radio altimeter system supplies radio altitude to the flight control electronics (IFCE) cabinets, GPWS, and TCAS.

Proposal is consistent with FAR 121 Appendix P.

Consequences of Failure

Failure of a radio altimeter is indicated by the RADIO ALTIMETER L or R Status message.

Failure of one radio altimeter will result in a NO AUTOLAND condition. The RADIO ALT SINGLE Advisory message will be displayed. Autothrottle flare retard is disabled for manual flight (autopilot not engaged).

The NO AUTOLAND Advisory message will be displayed.

Consequences of Next Critical Failure

Failure of the remaining radio altimeter is annunciated by the RADIO ALT FAULT L+R Advisory message. GPWS, TCAS, and auto speedbrakes will be lost, annunciated by associated EICAS messages. PFD radio altitude display will blank. Autopilot / flight director approach and landing modes are not available if failure occurs above 1500 feet AGL (APPROACH MODE FAIL Caution and mode fail indications). Autopilot will disconnect if engaged in approach mode below 1500 feet AGL (AUTOPILOT DISC warning). Primary flight control system will transition from air to ground mode when both fast (truck tilt) and slow (weight-on-wheels) air/ground signals indicate on-ground.

Erroneous data from remaining radio altimeter (reading high):

Autopilot is subject to degraded localizer and glideslope tracking during approach (due to offset of control law gain scheduling caused by erroneous height above ground); flight crew intervention may be required. Automatic stabilizer offload will not be inhibited and may move the stabilizer prior to and during the landing flare. At touchdown, automatic stabilizer offload and maneuver load alleviation functions will be inhibited when either fast (truck tilt) or slow (weight-on-wheels) air/ground signals indicate on-ground. Airplane handling during ground rollout considered acceptable in piloted 787 simulation evaluation using similar control laws; will be reassessed for 777-9.

A "wheelbarrow" landing will cause the stabilizer to be mistrimmed in the nose down direction resulting in limited pitch up authority (A "wheelbarrow" landing is where the nose gear is constrained by the ground, but the main landing gear are unloaded, causing the airplane to remain in the in-air mode). To mitigate this condition, speedbrakes must be manually extended after landing. Touch-and-Go landing operations must not be conducted

Erroneous data from remaining radio altimeter (reading low):

Autopilot will disconnect if single operating radio altimeter indicates less than 80 feet (AUTOPILOT DISC warning). When autopilot is not engaged, autothrottle flare retard is disabled if one radio altimeter is inoperative. Primary flight control system will transition from air to ground mode when both fast (truck tilt) and slow (weight-on-wheels) air/ground signals indicate on-ground.

34-38-01 Ground Maneuver Camera System

34-38-01A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

34-38-01 Ground Maneuver Camera System

34-38-01B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 31-61-10.

The ground maneuver camera system (GMCS) allows the flight crew to see both of the main landing gears and the nose landing gear, including the ground path in front of them. The views help the flight crew during ground maneuvering of the airplane. The 777X integrates a new, advanced ARINC 818 color HD capable GMCS that transmits landing gear proximity Field of View (FOV) video to flight deck and passenger In-Flight Entertainment (IFE) displays. GMCS video is primarily used to display video in the Camera Format/Video Window on the Display and Crew Alerting (DCA) Multi-Function Display (MFD) when GROUND CAMERA is selected on the MFD INFO Page menu. Based on the selected camera number option, the MFD presents configuration specific views for three and four camera configuration installations.

The GMCS LRUs include the following:

- Video Management Unit (VMU)
- Nose Landing Gear Taxi Camera
- Left Main Landing Gear Taxi Camera
- Right Main Landing Gear Taxi Camera
- Top Wing View Taxi Camera (optional)

The LRUs installed are based on selection of one of two camera configuration options. The standard three camera configuration will include one nose gear camera and two main gear cameras installed in the leading edge of the left and right sides of the horizontal stabilizer. The optional four camera configuration is the same as the baseline three camera configuration with the addition of a camera in the upper leading edge of the vertical stabilizer. The cameras will display these views:

- Nose gear area
- Wing tip to aft cargo door areas (symmetrical view on both left and right sides)
- Main gear areas (this image will be a magnified view of the wing tip to aft cargo area view cropped to show the main gear area)
- The optional fourth camera will provide a wing tip to wing tip top view.

The GMCS lights illuminate the nose, main landing gear and surrounding pavement areas to enable usage of the GMCS under dark or inclement weather conditions. The NLG Light is installed above the P40 Panel on the aft side of the NLG Strut. The Main Landing Gear (MLG) lights are installed on the underside of each wing, in the flap support fairing number 5, aimed downward. The 777-9 GMCS lights are changing from incandescent to LED lights. Another difference from the 777-300ER configuration is the MLG GMCS lights have been moved further inboard to Flap Support Fairing 5. The new MLG lights will attach to a doubler on the fairing and all electronic maintenance of the light will be performed through the lens assembly opening on the exterior of the aircraft.

The VMU will also receive optical ARINC 818 video from the external video sources (ONS & CEN). The VMU will provide A818 video switching capability between any of the VMU's A818 inputs (GMCS/ONS/CEN) to be outputted independently to any single, combination or all of the four (4) outputs based on the A429 commands from the Displays System via the RDC.

The GMCS is not required by 14 CFR.

Consequences of Failure

The flight crew must maneuver the airplane on the ground without the aid of visual displays of the main and nose landing gears and associated ground paths. The airplane is completely safe to maneuver without the GMCS, however it may provide some assistance to the pilots when maneuvering in areas with little clearance between pavement edge and landing gear track. If the VMU fails, flight crew will also lose ONS & CEN videos to the forward displays.

Consequences of Next Critical Failure

None identified.

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34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)

34-42-01A

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided prior to flight, authorization is obtained from ATC facilities having jurisdiction over the planned route of flight using an approved authorization process.

NOTE: Any ADS-B function that operates normally may be used.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)

34-42-01B

Interval	Installed	Required	Procedure
C	2	1	(O)

May be inoperative provided operative transponder is selected.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)

34-42-01C

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative provided:

- Enroute operations do not require its use, and
- It is not required by 14 CFR.

NOTE: Any ADS-B function that operates normally may be used.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)**34-42-01-01 ADS-B Out Extended Squitter****34-42-01-01A**

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided prior to flight, authorization is obtained from ATC facilities having jurisdiction over the planned route of flight using an approved authorization process.

NOTE: Any ADS-B function that operates normally may be used.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)**34-42-01-01 ADS-B Out Extended Squitter****34-42-01-01B**

Interval	Installed	Required	Procedure
C	2	1	(O)

May be inoperative provided operative transponder is selected.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)**34-42-01-01 ADS-B Out Extended Squitter Transmissions****34-42-01-01C**

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative provided:

- Enroute operations do not require its use, and
- It is not required by 14 CFR.

NOTE: Any ADS-B function that operates normally may be used.

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Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Any ADS-B In function that operates normally may be used.

34-42-01 Automatic Dependent Surveillance-Broadcast (ADS-B) System (In and Out)**34-42-01-02 ADS-B In***********34-42-01-02B**

Interval	Installed	Required	Procedure
D	2	0	

May be inoperative provided operations do not require its use.

NOTE: Any ADS-B In function that operates normally may be used.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-42-06.

Refer to MMEL Policy Letter PL 105.

Mode S responds to interrogations from other aircraft and ground stations. This gives the necessary data for collision avoidance coordination.

(ADS (Automatic Dependent Surveillance)-B) is a function of Mode S. It calculates the position, altitude, and velocity of other aircraft. It also controls the transmission and reception of Mode S signals.

ADS-B uses two signals to process the data exchanged between other aircraft and ground stations:

ADS-B Out - is a transmitted signal that uses the airplane GPS (Global Positioning System) position, altitude, and velocity data from the CDN (Common Data Network). Also the assigned 24-bit identification code to transmit interrogations at a rate of once per second. This is extended squitter operation. The ground station and other aircraft use this signal to identify and calculate the current track of the airplane.

ADS-B In - is the received signal to identify and calculate the position, altitude, and velocity of other aircraft. In data is calculated and sent to the navigation display function for crew situational awareness.

Consequences of Failure

ADS-B Out failure is annunciated by the ADS-B OUT DATA L or R Status message. The ISS automatically switches to the operative system for a single failure.

Dual ADS-B Out failure will result in display of the ADS-B OUT FAIL Advisory message.

The transponder equipment must be appropriate for the route being flown. Where this equipment is excess or not required, it may be inoperative for an extended time.

ADS-B In failure is annunciated with an amber ADS-B IN on the navigation display and mini-map in the lower left corner, but dual ADS-B In failure would prevent display of ADS-B traffic and functionality.

Consequences of Next Critical Failure

With one ADS-B Out system inoperative at dispatch the next critical failure is loss of the remaining ADS-B Out system or loss of second GPS. If the ADS-B OUT FAIL Advisory message displays or if ATC notifies the flight crew via voice channel that the airplane is no longer qualified to operate in an ADS-B flow of traffic and must be moved to a route commensurate with procedural separation.

With both ADS-B Out systems inoperative at dispatch, there is no next critical failure identified. Either alternate procedures are identified and used or procedures do not require the use of the systems.

Federal Aviation Administration (FAA)**ATA 34****777-9 Master Minimum Equipment List****Section 2****34-42-02 Alerting and Transponder Control Panel**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided tuning and control panels (TCPs) operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 item 34-42-04.

The 777X alerting and transponder panel includes transponder controls (STBY, ALT RPTG OFF, XPDR, TA ONLY, TA/RA, IDENT), the G/S INHIBIT switch, and the AURAL CANCEL switch. The G/S INHIBIT switch inhibits the GLIDESLOPE alert when pushed below 1,000 feet radio altitude. The AURAL CANCEL switch provides the flight crew with a method to cancel a false or nuisance aural alert or callout that could possibly distract the flight crew.

Consequences of Failure

Failure of the transponder panel is indicated by the TRANSPONDER PANEL Status message. Manual selection of TCP backup transponder panel functions results in display of the XPDR PANEL INOP Advisory message.

All panel functions except IDENT can be controlled through the tuning & control panel (TCP) backup ATP (ALERT/XPDR) menu. IDENT can be controlled through the TCP XPDR menu. When TCP backup ATP functions are selected, the ATP is completely disabled. All TCPs proposed to operate normally to minimize flight crew workload impact (e.g., allow for center TCP to be configured for ATP menu when required).

Consequences of Next Critical Failure

Failure of TCP: none. At least two TCPs remain available.

34-43-01 Weather Radar System**34-43-01A**

Interval	Installed	Required	Procedure
D	2	1	

34-43-01 Weather Radar System**34-43-01B**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Weather radar is not required by 14 CFR,
- Windshear Alert Mode (Reactive)(Mode 7) operates normally, and
- Alternate procedures are established and used.

34-43-01 Weather Radar System**34-43-01C**

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided:

- Weather radar is not required by 14 CFR, and
- Alternate procedures are established and used.

NOTE: Operator's alternate procedures should include reviewing windshear avoidance and windshear recovery procedures.

34-43-01 Weather Radar System**34-43-01-01 Predictive Windshear Alert Mode****34-43-01-01A**

Interval	Installed	Required	Procedure
D	2	1	

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34-43-01 Weather Radar System

34-43-01-01 Predictive Windshear Alert Mode

34-43-01-01B

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Windshear Alert Mode (Reactive) (Mode mode 7) operates normally, and
- Alternate procedures are established and used.

34-43-01 Weather Radar System

34-43-01-01 Predictive Windshear Alert Mode

34-43-01-01C

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Operator's alternate procedures should include reviewing windshear avoidance and windshear recovery procedures.

34-43-01 Weather Radar System

34-43-01-01 Predictive Windshear Alert Mode

34-43-01-01D

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate procedures are established and used.

34-43-01 Weather Radar System

34-43-01-02 Automatic Antenna Tilt Function

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-42-01.

Proposal based on PL-67.

The weather radar (WXR) system depicts weather conditions along the flight path. This allows the crew to change the flight path to fly around severe weather conditions. The weather radar receiver-transmitter provides weather data for display on the NDs. The predictive windshear system (PWS) makes use of doppler shift data in the WXR returns to detect windshear conditions ahead of the airplane flight path.

Dual integrated surveillance systems (ISS) include GPWS, TAWS, PWS, WXR, ATC, TCAS functions. Failure of each function is separately annunciated. Left ISS is the primary source for these functions, and switching between L and R ISS is automatic for each function. Each function source can also be manually selected by the flight crew via the tuning and control panel (TCP).

MultiScan weather radar is basic on the 777X. The AUTO function of the weather radar (as selected from the TCP) optimizes radar tilt angle automatically based in surrounding terrain features.

The automatic tilt angle minimizes ground clutter on the radar on the radar display while providing optimum weather detection capability and reducing pilot workload. Autotilt affects only the weather scans of the radar and does not affect PWS or EGPWS functions.

Consequences of Failure

Failure of WXR units is annunciated by the associated status message WEATHER RADAR SYS L, R.

Failure of the predictive windshear function is annunciated by the associated status message WINDSHEAR PREDICTIVE L, R. For <FAA> items, restrictions for dispatch are consistent with FAA Policy Letter 67. For <EASA> items, restrictions for dispatch are consistent with CS-MMEL item 34-41-01-01A.

Where weather radar equipment is excess or not required, it may be inoperative for an extended time.

If all predictive windshear capability is inoperative, windshear alerting would still be provided by the GPWS reactive windshear alerting mode. However, MMEL item 34-42-05 requires that if the GPWS reactive windshear alert mode is inoperative, alternate procedures must be established and used.

For an inop auto-tilt function, an AUTOTILT message is displayed on the ND when WXR is selected for display and in the AUTO mode as selected on TCP. The associated WEATHER RADAR SYS L, R status message may be displayed. The flight crew can manually adjust weather radar tilt angle for optimizing weather display.

Consequences of Next Critical Failure

None.

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34-45-01 Traffic Collision and Avoidance System (TCAS II)

34-45-01A

Interval	Installed	Required	Procedure
C	2	1	

34-45-01 Traffic Collision and Avoidance System (TCAS II)

34-45-01B

Interval	Installed	Required	Procedure
B	2	0	

May be inoperative provided enroute or approach procedures do not require its use.

34-45-01 Traffic Collision and Avoidance System (TCAS II)

34-45-01C

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided:

- TCAS is not required by 14 CFR, and
- Enroute or approach procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 34-42-02.

FAA proposal based on PL-32.

TCAS alerts the flight crew to possible collisions with other transponder airplanes in the same airspace. One type of advisory is the traffic advisory (TA), which tells of other airplanes in the area. The other type of advisory, resolution advisory (RA) provides flight path guidance to the flight crew to change or maintain the flight path to avoid a possible collision.

If a tracked airplane is a collision threat, TCAS selects the best maneuver to avoid a collision.

Dual integrated surveillance systems (ISS) include TAWS, PWS, WXR, ATC, TCAS functions. Failure of each function is separately annunciated. Left ISS is the primary source for these functions, and switching between L and R ISS is automatic for each function. Each function source can also be manually selected by the flight crew via the tuning and control panel (TCP).

Consequences of Failure

TCAS failures are annunciated by the TCAS L or R Status message.

Fault in a single ISS TCAS function: the alternate system is automatically selected and performs all TCAS functions. Deactivation of the inoperative unit is not required.

Both ISS TCAS functions inoperative: flight must be planned for a route and approach not requiring TCAS. Deactivation of the inoperative units is not required.

Policy Letter 32 considerations:

PL-32 provides MMEL guidance for Traffic Alert and Collision Avoidance Systems. MMEL relief is based on PL-32 for TCAS II with the exception that the proviso requiring the system to be deactivated and secured is not included. TCAS is part of the ISS functions. Inoperative TCAS is indicated by dedicated Status message, however, the individual TCAS function cannot be individually disabled.

Failure of RA or TA capability: There is no known dispatchable failure which renders only RA or TA capability inoperative. Loss of voted attitude or air data, or loss of inboard/outboard display units, will cause the TCAS RA INOP CAPT or TCAS RA INOP F/O Advisory message will be displayed. PL-32 sub-item entries for these and other TCAS functions are not meaningful and are not proposed for 777X MMEL.

Consequences of Next Critical Failure

Fault in a single ISS TCAS function at dispatch: failure of the remaining TCAS system. The TCAS FAIL Advisory message will be displayed to alert the flight crew. This scenario is the same as inflight failure of the single TCAS system on previous airplanes.

Both systems inoperative at dispatch: none.

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34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01A

Interval	Installed	Required	Procedure
C	2	1	

34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01B

Interval	Installed	Required	Procedure
A	2	0	(O)

May be inoperative provided:

- Predictive Windshear Alert Mode operates normally,
- Alternate procedures are established and used, and
- Repairs are made within 2 flight-days.

34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01C

Interval	Installed	Required	Procedure
A	2	0	(O)

May be inoperative provided:

- Alternate procedures are established and used, and
- Repairs are made within 2 flight-days.

NOTE: Operator's alternate procedures should include reviewing windshear avoidance and windshear recovery procedures.

34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01-01 Advisory Callouts (Mode 6)

34-46-01-01A

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided alternate procedures are established and used.

34-46-01 Ground Proximity Warning Systems (GPWS)**34-46-01-01 Advisory Callouts (Mode 6)****34-46-01-01B**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Advisory callout not required by 14 CFR, and
- Alternate procedures are established and used.

34-46-01 Ground Proximity Warning Systems (GPWS)**34-46-01-02 Windshear Alert Mode (Reactive) (Mode 7)****34-46-01-02A**

Interval	Installed	Required	Procedure
C	2	1	

34-46-01 Ground Proximity Warning Systems (GPWS)**34-46-01-02 Windshear Alert Mode (Reactive) (Mode 7)****34-46-01-02B**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Predictive Windshear Alert Mode operates normally, and
- Alternate procedures are established and used.

34-46-01 Ground Proximity Warning Systems (GPWS)**34-46-01-02 Windshear Alert Mode (Reactive) (Mode 7)****34-46-01-02C**

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided alternate procedures are established and used.

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NOTE: Operator's alternate procedures should include reviewing windshear avoidance and windshear recovery procedures.

34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01-03 Terrain Awareness Function

34-46-01-03A

Interval	Installed	Required	Procedure
D	2	1	

34-46-01 Ground Proximity Warning Systems (GPWS)

34-46-01-03 Terrain Awareness Function

34-46-01-03B

Interval	Installed	Required	Procedure
B	2	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 34-42-05.

Proposal based on PL-54.

The ground proximity warning system (GPWS) alerts or warns the flight crew of potentially dangerous conditions. GPWS uses inputs from the common core system (CCS), ILS and two radio altimeters. MMEL policy letter 54 allows dispatch relief for different modes of the GPWS. This relief is predicated on the air carrier's development and use of a flight crew operational procedure for aircraft altitude and performance awareness.

GPWS includes reactive windshear detection (Mode 7) and the terrain awareness function.

Dual integrated surveillance systems (ISS) include GPWS, TAWS, PWS, WXR, ATC, TCAS functions. Failure of each function is separately annunciated. Left ISS is the primary source for these functions, and switching between L and R ISS is automatic for each function. Each function source can also be manually selected by the flight crew via the tuning and control panel (TCP).

Consequences of Failure

Failure of the GPWS function is annunciated by the GROUND PROXIMITY SYS L or R Status message. Failure of the advisory callouts (Mode 6) function is annunciated by the ALT CALLOUTS FAIL Advisory message. Failure of the reactive windshear warning (Mode 7) function is annunciated by the WINDSHEAR REACTIVE L or R Status message. Failure of the terrain Awareness Function is annunciated by the TERR SYS L or R Status message.

One ISS GPWS function inop: None - remaining ISS performs all GPWS functions.

Both ISS GPWS functions inop

Modes 1 - 4, test mode, and mode 5 - (These functions have no dispatchable failure mode independent of GPWS itself; PL-54 sub-items not included). Alternate procedures established and used to maintain flight crew awareness of airplane altitude and flight path.

Mode 6 - advisory callouts will not be available. Alternate procedures must be established and used.

Mode 7 - windshear alerting will not be available, so alternate procedures must be established and used.

Terrain awareness function - enhanced ground proximity warning is not available.

Consequences of Next Critical Failure

Dispatch with one ISS GPWS function inop: Failure of remaining ISS GPWS function results in loss of all GPWS functions. Equivalent to failure of single GPWS box on previous models. The GND PROX SYS FAULT Advisory message will be displayed.

Dispatch with both ISS GPWS functions, or individual GPWS modes inop:

All functions except mode 7 and terrain awareness function:

Alternate procedures provide adequate flight crew awareness of terrain.

Mode 7:

Predictive windshear system and one weather radar system operative, and windshear occurs: predictive windshear system provides alternate windshear alerting function.

Predictive windshear system inoperative, or all weather radar systems inoperative; and windshear occurs: alternate procedures provide adequate safety margin to prevent potentially dangerous condition from escalating to an actual dangerous condition.

Terrain awareness function:

Alternate procedures provide adequate flight crew awareness of terrain. GPWS (if available) provides reactive terrain avoidance information.

34-51-01 VOR Navigation Systems

Interval	Installed	Required	Procedure
D	2	-	

Any in excess of those required by 14 CFR may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-31-04.

The very high frequency omnidirectional range (VOR) navigation system provides bearing and deviation information relative to ground stations to the flight management function (FMF) and navigation displays (NDs).

Two VOR receivers are installed, one in each multi-mode receiver (MMR) unit. For position updating, the VORs are tuned automatically by the FMF. For display on the ND, the VORs can be tuned automatically, or may be tuned manually on the CDU NAV RADIO page. When manually tuned, a radial can be entered for display on the ND map. The respective (left or right) tuned VOR frequency and DME distance are displayed in the lower corner of the ND when the associated pointer is selected ON. When the identification signal (Morse code) is received, the decoded identifier is displayed in place of the frequency. The crew can inhibit specified VOR nav aids from being used for FMC updating by entries on the REF NAV DATA page of the CDU.

Consequences of Failure

VOR failure is annunciated by associated status message VOR L, R.

In case of VOR failure or power loss, the amber "VOR" flag, inside an amber box, appears on the NDs. Navigation equipment must be appropriate for the route being flown.

MMR failures:

MMR unit inop: associated ILS, GPS, GLS, VOR, MB receivers inoperative. Each of these functions has independent MMEL coverage. Flight planning must take nav and approach capabilities into account.

Both MMR units inop: Flight planning must take nav and approach capabilities into account.

Consequences of Next Critical Failure

Failure of VOR function on opposite MMR unit. ILS and GLS functions remain available, as well as GPS functions. Navigation based on remaining capabilities which may include (depending on dispatch condition): single GPS, DME/DME, ADF (if installed), inertial coasting, radar vectors, etc.

34-53-01 ATC Transponders/Automatic Altitude Reporting Systems**34-53-01A**

Interval	Installed	Required	Procedure
D	2	1	

Any in excess of those required by 14 CFR may be inoperative.

34-53-01 ATC Transponders/Automatic Altitude Reporting Systems**34-53-01B**

Interval	Installed	Required	Procedure
B	2	0	

May be inoperative provided:

- Operations do not require its use,
 - Prior to flight, approval is obtained from ATC facilities having jurisdiction over the planned route of flight, and
 - Automatic Dependent Surveillance-Broadcast (ADS-B) System is considered inoperative.
-

34-53-01 ATC Transponders/Automatic Altitude Reporting Systems**34-53-01-01 Elementary and Enhanced Downlink Aircraft Reportable Parameters Not Required By 14 CFR**

Interval	Installed	Required	Procedure
A	-	0	

May be inoperative provided:

- Operations do not require its use, and
 - Repairs are made prior to completion of next heavy maintenance visit.
-

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-42-03.

Proposal based on PL-76.

The air traffic control transponder system allows ground facilities to track airplane movement through controlled airspace. The ATC altitude reporting function reports airplane altitude. The ATC transponders operate in the same frequency range as the DME interrogators and TCAS.

The left and right transponders receive voted altitude from the flight controls air data reference function (ADRF). If the AIR DATA SYS FAULT Caution message is displayed, neither transponder receives data from the ADRF since the altitude may be suspect. In this case, the TCAS FAIL Advisory message will also be displayed. The transponders continue to operate in Mode A (airplane ID only), Mode C (excluding altitude information), and Mode S (excluding altitude information).

Dual integrated surveillance systems (ISS) include TAWS, PWS, WXR, ATC, TCAS functions. Failure of each function is separately annunciated. Left ISS is the primary source for these functions, and switching between L and R ISS is automatic for each function. Each function source can also be manually selected by the flight crew via the tuning and control panel (TCP).

Consequences of Failure

Transponder failure is annunciated by the TRANSPONDER L or R Status message.

Navigation equipment must be appropriate for the route being flown. Where this equipment is excess or not required, it may be inoperative for an extended time.

For both transponders inoperative, the TRANSPONDER FAIL Advisory message will be displayed. The ADS-B Out function will also be inoperative.

Consequences of Next Critical Failure

For dispatch with one transponder inoperative, failure of remaining transponder will result in the TRANSPONDER FAIL Advisory message being displayed. Flight crew coordinates with ATC as appropriate.

There is no next critical failure identified for dispatch with both transponders inoperative.

34-55-01 Distance Measuring Equipment (DME) Systems

Interval	Installed	Required	Procedure
D	2	-	

Any in excess of those required by 14 CFR may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-55-01.

Refer to FAA MMEL policy letter 3.

The distance measuring system provides the pilots with line-of-sight distance between the airplane and a ground station. DME information is displayed on the NDs and PFDs. (Reference MMEL Policy Letter #3)

The 777X DME operates the same as the 777 scanning DME. Each DME can be tuned up to 5 direct channels: Direct channel 1 and 2 are used to tune best DME/DME pair, direct channel 3 is paired with VOR-L, direct channel 4 is paired with VOR-R, and direct channel 5 is paired with ILS.

Consequences of Failure

DME failure is annunciated by the DME L or R Status message.

The DME FAIL L+R Caution message may be displayed with loss of both left and right DMEs.

The 777X earth reference system (ERS) relies on GPS for primary means navigation. In case of DME failure or power loss the amber "DME" flag, inside an amber box, appears on the NDs. Navigation equipment must be appropriate for the route being flown. Where this equipment is excess or not required, it may be inoperative for an extended time.

Consequences of Next Critical Failure

None.

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34-57-01

Automatic Direction Finder (ADF) Systems

Interval	Installed	Required	Procedure
D	2	-	

Any in excess of those required by 14 CFR may be inoperative.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 34-57-01.

The automatic direction finding System is an airborne system used to determine the relative bearing from the aircraft to a ground based transmitter. There are two ADF antennas and two ADF receivers installed.

ADF is optional on the 777X.

Consequences of Failure

ADF failure is annunciated by the ADF L or R Status message.

ADF failure will result in EICAS message annunciation. In case of ADF failure or power loss, an "ADF" flag, inside an amber box, appears on the mini map and the other ADF information is removed. Navigation equipment must be appropriate for the route being flown. Where this equipment is excess or not required, it may be inoperative for an extended time.

Consequences of Next Critical Failure

None.

34-58-01 Global Positioning Systems (GPS)**34-58-01-01 Left GPS**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Right GPS operates normally,
- Enroute operations do not require its use, and
- Left TCP Backup Navigation Function is considered inoperative.

34-58-01 Global Positioning Systems (GPS)**34-58-01-02 Right GPS**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Left GPS operates normally, and
- Enroute operations do not require its use.

34-58-01 Global Positioning Systems (GPS)**34-58-01-03 Both GPS**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided:

- Both IRUs operate normally,
- Operations do not require their use,
- Left TCP Backup Navigation Function is considered inoperative,
- GPWS Terrain Awareness Function is considered inoperative,
- ADS-B Out Extended Squitter Function is considered inoperative, and
- [For Brake to Exit Function installed:](#)
- Brake to Exit Function is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 34-31-05.

The global positioning system (GPS) uses navigation satellites to supply accurate airplane position to the flight management function (FMF), Earth Reference System (ERS), and the flight crew. The GPS uses four position satellites to verify the initial aircraft position selected by the flight crew, aid in the automatic update of the inertial sensors in the ERS (hybrid GPS/inertial navigation system, see discussion under item 34-21-01), and aid the FMF in calculation of airplane position. Navigation accuracy is not affected by failure of one GPS system, since the two GPS systems are independent. Two operative GPS systems provide additional redundancy (availability) but no additional accuracy.

Two FMFs and two sensors capable of meeting a selected RNP are required for primary means RNP navigation.

Dual multi-mode receiver (MMR) units include ILS receivers, LOC receivers, GNSS (GPS)/GLS receivers, and VOR. Switching between L and R MMR is automatic for all functions.

Consequences of Failure

GPS failures are indicated by the GPS L, R Status message. Single GPS failure is annunciated by the NAV SINGLE GPS Advisory message and associated GPS FAIL L, R Advisory message. Dual GPS failure is annunciated by the GPS FAIL L+R Advisory message.

One GPS system inoperative, non-RNP routing or RNP routing not requiring GPS accuracy (other sensors meet RNP accuracy requirements):

FMF position accuracy is unaffected, as it will be based on the remaining GPS system.

For left GPS inoperative, the tuning and control panel (TCP) backup navigation function will also be inoperative (Ref MMEL item 23-24-01-01).

Both GPS systems inoperative, non-RNP routing or RNP routing not requiring GPS accuracy (other sensors meet RNP accuracy requirements):

FMF position accuracy may be reduced, however, other sensors must meet routing position accuracy requirements. Aircraft position can be updated by another means, such as by DME/DME, VOR/DME or inertial. The GPA FAIL L+R Advisory message is displayed if both GPS systems have failed.

Both GPS systems inoperative, ADS-B Out data is inoperative Ref MMEL 34-42-06-01.

One or both GPS systems inoperative, RNP routing (RNP < 0.3 nm) requiring GPS accuracy or availability of 2 GPS systems: dispatch may not be allowed.

MMR failures:

MMR unit inoperative: associated ILS, GPS, GLS, VOR, MB receivers will be inoperative. Each of these functions has independent MMEL coverage. Flight planning must take nav and approach capabilities into account.

Both MMR units inoperative: Flight planning must take nav and approach capabilities into account.

Hybrid GPS/inertial system inoperative: less than two independent valid hybrid GPS/inertial data sources are available, due to any combination of GPS receiver, inertial unit, hybrid GPS processing, or interface failures. This condition is equivalent to single GPS system failed and the advisory message NAV SINGLE GPS is displayed. GPS/inertial based primary means RNP operations (RNP < 0.3 nm) are not supported. Flight planning must assume navigation by DME, VOR and/or pure inertial navigation sources.

NOTE 1: GPS altitude is used as a backup for air data reference function (ADRF) altitude derived from the static air data modules (ADMs). If both GPS receivers are inoperative, this backup source is not available.

NOTE 2: GPS is used as a UTC reference for reset purposes when airplane is powered up from a secured state. If both GPS receivers are inoperative, and airplane power (including main battery) is interrupted, clocks will reset to midnight. The FMF can be used to manually set date and time using the TIME/DATE INIT page.

Both GPS systems inoperative:

Brake to Exit function will be inoperative. Brake to Exit function requires the Airport Map function to operate normally. Airport Map function requires GPS.

Consequences of Next Critical Failure

Dispatch with one GPS inoperative, non-RNP routing or RNP routing not requiring GPS accuracy (other sensors meet RNP accuracy requirements):

Remaining GPS fails: FMF position accuracy may be reduced, however, other sensors must meet routing position accuracy requirements. Aircraft position can be updated by another means, such as by DME/DME, VOR/DME or inertial. The EICAS advisory message GPS is displayed if both GPS systems have failed.

Failure of opposite MMR unit (remaining GPS and other functions): ILS autoland or approach not available, depending on dispatch condition. GLS autoland or approach not available, depending on dispatch condition. Navigation based on remaining capabilities which may include (depending on dispatch condition): VOR/DME, DME/DME, ADF (if installed), inertial coasting, radar vectors, etc.

Dispatch with hybrid GPS/inertial system inoperative: failure of remaining GPS receiver requires inertial navigation with radio updating (if available). Flight planning is not based on RNP capability which requires hybrid GPS/inertial data sources.

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Section 2

34-61-01 Flight Management Function

34-61-01-01 FMC C & FMC L

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided FMC R operates normally.

34-61-01 Flight Management Function

34-61-01-02 FMC R

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Both FMC C and FMC L operate normally, and
- Left TCP backup navigation function operates normally.

34-61-01 Flight Management Function

34-61-01-03 Navigation Databases

Interval	Installed	Required	Procedure
A	3	0	

May be inoperative provided:

- Operations do not require its use,
- It is not used in a primary navigation system required by 14 CFR,
- Alternate procedures are developed and used,
- The ICAO Flight Plan is updated (as required) to notify ATC of the navigation equipment status of the aircraft, and
- Repairs are made within 10 flight-days.

NOTE: An out-of-currency or out-of-date navigation database is not authorized MMEL relief per 14 CFR.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 34-61-01.

FAA Proposal consistent with PL-98.

The 777X flight management function (FMF) resides in the common core system (CCS). Three copies of the FMF application are hosted in three separate general processing modules: L1, L4, and R4. The FMF computes a navigation solution in addition to the hybrid GPS/inertial solution determined by the earth reference system (ERS) (see ERS and GPS descriptions under items 34-21-01 and 34-31-05, respectively.) Service history on several airplane types has shown that flight management system software faults may occur which cause one FMF software application to halt, so this type of fault is annunciated by status message.

The role and function of the FMF navigation database is similar to previous airplane types. A navigation database, with two cycles, is installed in each of the three CCS general processing modules in which the FMF is loaded (L1, L4, and R4).

Consequences of Failure

Failure of a single FMF is annunciated by the FMC C, L, or R Status message. If failure is due to a failed GPM, the associated GPM Status message will also be displayed.

FMF software application halted: None. Two FMF applications perform all FMF functions.

FMF nav database inoperative:

For FAA: MMEL dispatch for an inoperative navigation database is provided according to FAA Policy Letter (PL) 98.

For EASA: MMEL dispatch for is provided a navigation database that is out of currency.

Consequences of Next Critical Failure

FMF software application halted at dispatch, failure of a second FM application. Remaining FM application performs all FM functions. Condition is annunciated to flight crew by the FMC SINGLE AVAIL Advisory message.

FMF software application halted in GPM R4, or GPM R4 failed, followed by failure of the left Common Computing Resource cabinet: Loss of all FMF capability. This condition is annunciated to the flight crew by the FMC FAIL Caution message. In this improbable scenario, left TCP backup navigation function remains for basic waypoint to waypoint navigation.

FMF nav database inoperative: None.

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35-11-01 Crew Oxygen System

35-11-01-01 Crew Oxygen Pressure Indication System

35-11-01-01-01 Overboard Discharge Indicator Disc

35-21-01 Passenger Oxygen System

35-21-01-01 Oxygen Power

35-21-01-02 Power Channels

35-21-02 Passenger Oxygen Controllers

35-21-02A

35-21-02B

35-21-03 Passenger Oxygen Automatic Presentation System

35-21-04 Passenger Oxygen ON Light

35-21-05 OFCR/OFAR Oxygen Controllers - Seat/Bunk Controllers

35-21-05A

35-21-05B

35-31-01 Portable Oxygen Bottles or Units (Including Masks and Hoses)

35-31-01-01 Tamper Seals or Tags

35-31-02 Portable Protective Breathing Equipment (PBE)

35-31-02-01 Tamper Seals or Tags

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35-11-01 Crew Oxygen System**35-11-01-01 Crew Oxygen Pressure Indication System**

Interval	Installed	Required	Procedure
B	1	0	(M)

May be inoperative provided:

- Oxygen supply is verified to be above minimum required before each departure, and
- Crew oxygen shutoff valve(s) is verified open.

35-11-01 Crew Oxygen System**35-11-01-01 Crew Oxygen Pressure Indication System****35-11-01-01-01 Overboard Discharge Indicator Disc**

Interval	Installed	Required	Procedure
B	1	0	

May be damaged or missing.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 35-11-01.

Crew Oxygen Pressure Indication System

A pressure transducer and gauge are incorporated on the pressure regulator assembly at the oxygen cylinder. Pressure is converted to an electrical signal which is sent to the EICAS system status page through Displays and Crew Alerting, and to a pressure gauge in the remote fill panel if the remote fill option is installed. The transducer is powered by the 28 VDC right main bus. The CREW OXYGEN LOW Advisory message is displayed whenever the crew oxygen cylinder pressure goes below a predetermined customer selectable pressure level.

Overboard Discharge Indicator Disc

A green overboard discharge indicator disc is installed on the exterior of the airplane to prevent dirt, grease, and other foreign debris from entering the discharge line. If an over pressure condition exists, the oxygen is discharged out of the cylinder through the discharge port. This discharge causes the green overboard discharge indicator disc to blow out at approximately 500 psig, providing a visual indication from outside the aircraft that pressure relief has occurred.

Consequences of Failure

Crew Oxygen Pressure Indication System

Flight crew loses status page message providing an indication of the oxygen pressure in the flight crew oxygen system. Oxygen pressure may be checked at the oxygen cylinder gauge or at the remote fill fitting, if it is installed.

Overboard Discharge Indicator Disc

Pressure relief may have occurred and oxygen supply may be insufficient for dispatch. Indicator may also be simply missing with adequate oxygen supply. Either way, oxygen quantity is checked during normal preflight procedures.

Consequences of Next Critical Failure

Crew Oxygen Pressure Indication System

Flight crew oxygen system leak which depletes the oxygen supply following dispatch. Flight crew oxygen is not available. Oxygen supply must be verified to be above the minimum required before each departure. The combined probability of an event requiring oxygen and an oxygen system leak is extremely improbable.

Overboard Discharge Indicator Disc

None identified.

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35-21-01 Passenger Oxygen System**35-21-01-01 Oxygen Power**

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Appropriate portable oxygen supplies are available,
- Both Air Conditioning Packs operate normally,
- Pressurization System operates normally,
- Appropriate altitude adjustments are applied, and
- Passengers are appropriately briefed.

35-21-01 Passenger Oxygen System**35-21-01-02 Power Channels**

Interval	Installed	Required	Procedure
C	12	6	

One channel in each PSU zone may be inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 35-21-01.

The 777X incorporates a pulsed passenger oxygen system similar to the 787. The system supplies emergency oxygen to passenger, lavatory, flight attendant and crew rest locations. The system regulates the flow of gaseous oxygen stored in pressurized cylinder assemblies, distributes oxygen to the passenger masks, and provides small pulses of oxygen on demand during inhalation by the user. Each oxygen cylinder is a single use device, and once activated, the system provides oxygen until the cylinder is depleted. After activation, the cylinder must be replaced. There are three options (small, medium, large) available to size the passenger oxygen system to individual operator's needs.

There are two main portions of the passenger oxygen system: The hosted software in the electrical load management system (ELMS) and distributed oxygen controllers. Two copies of the passenger oxygen system software reside in the P110 and P210 panels for the 777-9 similar to these functions in the P310 ELMS panel on the legacy 777's. The software interfaces with aircraft functions to determine if the distributed passenger oxygen controllers should be deployed. If a deployment condition occurs, the software will activate power to the distributed controllers.

The distributed oxygen controllers dispense oxygen upon demand to the individual masks. The distributed controllers are located above the passenger seating areas, lavatories, and in flight attendant rest and crew rest locations.

Whenever cabin pressure altitude is sensed to be greater than 13,500 feet, ELMS commands redundant oxygen system deployment power by commanding the oxygen system relays in the P110 and P210 panels to close. Once the local electronics units receive power, they deploy the passenger masks and stand ready to start the flow of oxygen. When the controller senses the first user breathing in the mask, a pyrotechnic device starts the flow of oxygen from the bottle to the mask. The pyrotechnic device extends a small pin to make a hole in the oxygen cylinder rupture disk. The controller then releases pulses of oxygen with each breath. When the oxygen flows, the controller illuminates a green LED indication at the PSU.

To reduce the likelihood of inadvertent deployment, the hosted application will suppress automatic passenger oxygen system activation when the airplane is in the ground mode or airspeed indication is below 80 knots. The system may be manually activated by the PASS OXYGEN switch on the overhead panel in the flight deck.

Distributed oxygen controllers are divided up into six power zones in the cabin. Controller boxes within each zone receive power from two sources through two redundant circuits or channels.

Consequences of Failure

If a single power channel is inoperative within one or more of the six zones, there is no effect on operation of the associated oxygen controllers. The remaining channel provides power to operate the associated controllers in that zone. The PASS OXYGEN POWER CHANNEL Status message is displayed.

If both power channels to one or more of the six zones are inoperative, the EICAS PASS OXYGEN POWER Status message is displayed. The entire passenger oxygen system must be considered inoperative in this case, due to zone architecture.

Consequences of Next Critical Failure

If a single power channel within a zone is inoperative at dispatch, in the event of a cabin depressurization, the redundant channel will power the associated oxygen controllers.

For a single power channel inoperative at dispatch, an uncontained rotor burst event may result in the remaining channel inoperative which could prevent oxygen delivery to one or more zone. The resulting airplane level hazard is Hazardous. The probability of a rotorburst is on the order of 5E-8.

If both power channels to one or more of the six zones are inoperative at dispatch, altitude limitations and portable oxygen requirements ensure that passenger oxygen resources meet regulatory requirements.

35-21-02 Passenger Oxygen Controllers**35-21-02A**

Interval	Installed	Required	Procedure
B	-	0	(M)

May be inoperative provided:

- Associated passenger seats are blocked and placarded to prevent occupancy,
- Associated Flight Attendant Seat is considered inoperative,
- Associated lavatory door is locked closed and placarded "INOPERATIVE - DO NOT ENTER", and
- Associated galley area curtain nearest operative oxygen controllers is secured open or removed.

NOTE: These provisions are not intended to prohibit lavatory inspections by crew members.

35-21-02 Passenger Oxygen Controllers**35-21-02B**

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- Appropriate portable oxygen supplies are available,
- Both Air Conditioning Packs operate normally,
- Pressurization System operates normally,
- Appropriate altitude adjustments are applied, and
- Passengers are appropriately briefed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 35-21-02.

The passenger oxygen system stores gaseous oxygen in pressurized cylinder assemblies and distributes oxygen to masks stored over the passenger seats in each of the Passenger Service Units (PSUs), as well as to masks in lavatories, flight attendant rest, and crew rest locations.

Distributed oxygen controllers for each PSU are divided up into six power zones in the cabin. Oxygen controller boxes within each zone receive redundant power from the P110 and P210 electrical load management system (ELMS) panels. Periodic tests of the system are performed using an Initiated/Ground test. If an oxygen controller detects a fault for a specific PSU, it will be indicated by illumination of an LED on that unit.

The distributed oxygen controllers dispense oxygen upon demand to the individual masks. The controllers are normally unpowered and remain dormant until power is applied by ELMS to either perform Built-in-Test (BIT) functions or to deploy and begin providing oxygen.

Whenever cabin pressure altitude is sensed to be greater than 13,500 feet, the system is automatically actuated by the ELMS panel. This signal applies power from the ELMS relays to the oxygen system local electronic units at each oxygen controller box. Once the local electronics units receive power, they deploy the passenger masks and stand ready to start the flow of oxygen. When the controller senses the first user breathing in the mask, a pyrotechnic device starts the flow of oxygen from the bottle to the mask. The pyrotechnic device extends a small pin to make a hole in the oxygen cylinder rupture disk. The controller then releases pulses of oxygen with each breath. When the oxygen flows, the controller illuminates a green LED indication at the PSU.

Consequences of Failure

Passenger oxygen is not available from the inoperative controller. Associated passenger seats are blocked and placarded to prevent seat occupancy or,

Seats do not need to be blocked provided appropriate altitude restrictions are applied, and MMEL provisos identical to the entire passenger oxygen system being inoperative are adhered to (see substantiation under item 35-21-01).

Consequences of Next Critical Failure

Cabin depressurization: sufficient passenger oxygen controllers or portable oxygen supplies are available for all passengers by complying with the provisos.

35-21-03

Passenger Oxygen Automatic Presentation System

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided flight remains at FL 300 or below.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 35-21-03.

The Electrical Load Management System (ELMS) continuously monitors the cabin pressure signals sent by Displays and Crew Alerting (DCA). Two of the cabin pressure sensors send signals over the common data network to DCA. A third remote cabin pressure sensor is hardwired to DCA. When the cabin altitude exceeds 13,500 feet, as determined by two of the three cabin pressure sensors, the ELMS panel energizes the mask deployment relays. Power is applied to oxygen controllers to deploy the oxygen masks.

Consequences of Failure

Oxygen masks are not automatically deployed when cabin pressure altitude exceeds 13,500 feet. Warning devices on the flight deck indicate to the crew when cabin pressure altitude exceeds 10,000 feet. The passenger oxygen system may be manually deployed by the flight deck crew by pressing the PASS OXYGEN switch on the overhead panel.

Consequences of Next Critical Failure

Cabin depressurization: flight deck crew manually deploys passenger oxygen masks by means of the flight deck control.

35-21-04 Passenger Oxygen ON Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 35-21-04.

When the passenger oxygen system has been activated, either manually with the associated switch or automatically by the electrical load management system (ELMS), the Passenger Oxygen ON light is illuminated. The condition which results in illumination of this light also results in the PASS OXYGEN ON Advisory message.

Consequences of Failure

None.

Consequences of Next Critical Failure

If cabin depressurization occurs, the passenger oxygen masks will deploy but the Pass Oxygen switch ON light will not illuminate. This effect will have no significant impact because the PASS OXYGEN ON Advisory message will be displayed to indicate deployment of the passenger oxygen masks to the pilots.

35-21-05 OFCR/OFAR Oxygen Controllers - Seat/Bunk Controllers

35-21-05A

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided associated seat/bunk is blocked and placarded to prevent occupancy.

35-21-05 OFCR/OFAR Oxygen Controllers - Seat/Bunk Controllers

35-21-05B

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative provided:

- Appropriate portable oxygen supplies are available,
- Both Air Conditioning Packs operate normally,
- Pressurization System operates normally,
- Appropriate altitude adjustments are applied, and
- Crewmembers are appropriately briefed.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 35-21-05.

The passenger oxygen system stores gaseous oxygen in pressurized cylinder assemblies and distributes oxygen to masks stored over the passenger seats in each of the Passenger Service Units (PSU) and in lavatories, as well as in flight attendant/flight crew rest locations.

The oxygen controllers are controlled by the electrical load management system (ELMS). If an oxygen controller detects a fault, it will be indicated by illumination of an LED on that unit.

Consequences of Failure

Crew member oxygen is not available from the inoperative oxygen controller in a flight attendant/flight crew rest area. Associated seat/bunk is blocked and placarded to prevent occupancy

or,

Seat/bunk does not need to be blocked provided appropriate altitude restrictions are applied, and MMEL provisos identical to the entire passenger oxygen system being inoperative are adhered to (see substantiation under item 35-21-01), except that briefing of passengers is not required since it is the crew/attendant rest controllers that are affected.

Consequences of Next Critical Failure

Cabin depressurization: sufficient oxygen controller boxes or portable oxygen supplies are available for all crew members by complying with the provisos.

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35-31-01 Portable Oxygen Bottles or Units (Including Masks and Hoses)

Interval	Installed	Required	Procedure
D	-	-	(M)

Any in excess of those required by 14 CFR may be inoperative or removed provided:

- An inoperative or not properly serviced portable oxygen bottle/unit remains in a certified location until removed or serviced at the next suitable maintenance facility,
- Location placarding is removed or obscured, and
- Required distribution is maintained.

NOTE 1: Inoperative portable oxygen bottles or units, removed from a certified location or removed from the aircraft, are subject to 49 CFR dangerous goods regulations.

NOTE 2: Medical equipment installed in the aircraft as part of an EMS operation is not considered part of the normal complement of equipment. No MMEL relief applies to that equipment and 14 CFR maintenance and inspection requirements do not apply.

35-31-01 Portable Oxygen Bottles or Units (Including Masks and Hoses)

35-31-01-01 Tamper Seals or Tags

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper installation and servicing is verified at each preflight.

SUBSTANTIATION

Background

Proposal is based on 777 MMEL item 35-31-01.

Refer to FAA MMEL Policy Letter 132.

FAR 121.329 and 121.333 establish requirements for portable oxygen equipment and the airplane is equipped in compliance with those regulations. Portable equipment may be a portable oxygen bottle containing gaseous oxygen or may be a portable chemical oxygen generating device.

Consequences of Failure

A sufficient number of portable oxygen dispensing units are provided to satisfy the requirements of FAR 121.333 or other applicable regulations.

Consequences of Next Critical Failure

Cabin depressurization: normal passenger oxygen system and portable oxygen dispensing units provide oxygen for passengers and cabin attendants.

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35-31-02 Portable Protective Breathing Equipment (PBE)

Interval	Installed	Required	Procedure
D	-	-	

Any in excess of those required by 14 CFR may be inoperative or removed provided:

- Inoperative PBE remains in a certified location until removed from the aircraft at the next suitable maintenance facility,
- Location placarding is removed or obscured, and
- Required distribution is maintained.

NOTE: Inoperative PBEs, removed from a certified location or removed from the aircraft, are subject to 49 CFR dangerous goods regulations.

35-31-02 Portable Protective Breathing Equipment (PBE)**35-31-02-01 Tamper Seals or Tags**

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative, damaged, or missing provided proper installation and servicing is verified at each preflight.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 35-31-02.

Refer to FAA MMEL Policy Letter 132.

Portable protective breathing equipment is required for use by flight crewmembers and for the use of appropriate crewmembers for fighting fires in accessible compartments other than the flight deck. The equipment must be designed to protect from smoke, carbon dioxide or other harmful gases while on flight deck duty or while combating a fire. The equipment must include masks covering the eyes, nose and mouth (or accessory equipment to cover the eyes). Refer to 14 CFR Part 25, paragraph 25.1439 and Part 121, paragraph 121.337.

Consequences of Failure

The number of excess portable protective breathing equipment units is reduced by the number of failed units. FAR 121.337 requires that portable protective breathing equipment be provided for the flight deck and in each passenger compartment (one for each hand fire extinguisher). Compliance with the proviso ensures that the airplane is equipped with the required number of portable protective breathing equipment.

Consequences of Next Critical Failure

Cabin depressurization/toxic gas on the flight deck: Portable protective breathing equipment is available for use.

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36-00-01 Air Supply and Cabin Pressure Controllers (ASCPC)

36-00-01-01 Primary Controllers

36-00-01-02 Backup Controllers

36-11-01 Pressure Regulating and Shutoff Valve (PRSOV) Systems

36-11-01-01 ENG Bleed Air Switch Lights

36-11-01-01-01 OFF Lights

36-11-01-01-02 ON Lights

36-11-02 High Pressure Shutoff Valves (HPSOV)

36-11-03 Intermediate Pressure Check Valves (IPCV)

36-11-04 Precoolers

36-11-05 Fan Air Modulation Valves (FAMV)

36-12-01 Left and Right Bleed Isolation Systems (Valve and/or Indication)

36-12-01-01 ISLN Switch Lights

36-12-01-01-01 CLOSED Lights

36-12-01-01-02 AUTO Lights

36-12-02 Center Bleed Isolation System (Valve and/or Indication)

36-12-02-01 ISLN Switch Lights

36-12-02-01-01 CLOSED Light

36-12-02-01-02 AUTO Light

36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)

36-12-03-01 Valve Indication

36-12-03-01A

36-12-03-01B

36-12-03-02 APU Switch Light

36-12-03-02-01 OFF Light

36-12-03-02-02 AUTO Light

36-20-01 Air Synoptic Display

36-21-01 Manifold Pressure Sensing Systems

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36-21-01-01A

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36-21-01-02 FCAC Not Installed

36-21-02 Intermediate Pressure Sensing Systems

36-22-01 Manifold Temperature Sensing Systems

36-22-01-01 Primary Sensor Channels - Left

36-22-01-02 Primary Sensor Channels - Right

36-22-01-03 Primary Temperature Sensors

36-22-01-04 Secondary Temperature Sensors

36-22-02 Intermediate Temperature Sensing Systems

36-22-02-01 Temperature Sensor Channels - Left

36-22-02-02 Temperature Sensor Channels - Right

36-22-02-03 Temperature Sensors

36-23-01 Bleed Manifold Flow Sensors

36-00-01 Air Supply and Cabin Pressure Controllers (ASCPC)

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One ASCPC (primary and backup controllers) may be inoperative provided:

- Associated PRSOV is locked closed,
- Associated HPSOV is locked closed,
- Associated ENG BLEED AIR switch remains OFF,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- APU Bleed Air System operates normally,
- APU is operated during takeoff and landing,
- Appropriate minimum N1 is maintained on associated engine while in icing conditions, and
- Appropriate performance adjustments are applied.

NOTE: Opposite ASCPC Primary Controller and Backup Controller must operate normally.

36-00-01 Air Supply and Cabin Pressure Controllers (ASCPC)**36-00-01-01 Primary Controllers**

Interval	Installed	Required	Procedure
C	2	1	

One ASCPC Primary Controller may be inoperative provided:

- Associated ASCPC Backup Controller operates normally,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally, and
- Both Outflow Valves operate normally.

NOTE: Opposite ASCPC Primary Controller and Backup Controller must operate normally.

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36-00-01 Air Supply and Cabin Pressure Controllers (ASCPC) 36-00-01-02 Backup Controllers

Interval	Installed	Required	Procedure
C	2	1	

One ASCPC Backup Controller may be inoperative provided:

- Associated Primary Controller operates normally,
- Opposite Engine Bleed Air System operates normally,
- Left and Right Bleed Isolation Systems operate normally, and
- Center Bleed Isolation System operates normally.

NOTE: Opposite ASCPC Primary Controller and Backup Controller must operate normally.

SUBSTANTIATION

Background

Proposal for item 36-00-01 based on 777 MMEL item 36-11-02-05B.

Proposal for item 36-00-01-01 based on 777 MMEL item 36-00-01-01.

The Air Supply Control System (ASCS) provides pressurized air from the engines, Auxiliary Power Unit (APU), or ground air source to the Cabin Air Conditioning and Temperature Control System (CACTCS), Engine Anti-Ice (EAI), Wing Anti-Ice (WAI), hydraulic Air Driven Pumps (ADP), Nitrogen Generation System (NGS), Aft Cargo Heat, Total Air Temperature (TAT) probe aspiration, and the hydraulic reservoirs. The ASCS also provides air to the engine and APU starters, to start the engines and APU.

The ASCS system is composed of an engine bleed system for each engine, comprised of a high pressure shutoff valve (HPSOV), an intermediate pressure check valve (IPCV), pressure regulating shutoff valve (PRSOV), fan air modulating valve (FAMV), bleed air mixer (BAM), duct vent valve (DVV), Precooler, intermediate pressure sensor (PI), intermediate temperature sensor (TI), manifold pressure sensor (PM), flow sensor (FS), and manifold temperature sensor (TM) for each engine. In addition, three bleed isolation shutoff valves (ISOV) serve the two engines, i.e., the whole ASCS, and a fourth ISOV serves the APU.

The left and right Air Supply Cabin Pressure Controllers (ASCPCs) provide control for all sections of the pneumatic system and for the pressurization system. The controllers also set the amount of air that the air conditioning packs use (flow schedules). They provide backup control to the Cabin Temperature Controllers (CTC) for air conditioning pack flow control and trim air control. The left ASCPC controls the left engine air supply. The right ASCPC controls the right engine air supply. The Isolation and Shutoff Valves (C, L & R ISOV) and Auxiliary Power Unit (APU) Shutoff Valve can be controlled by either the left or right ASCPC.

The ASCPCs have two modes: primary and backup. The ASCPCs use the primary and backup control modes for the following systems: Engine air supply, Air supply distribution, Pressurization, Pack flow schedule and Backup pack flow control. The ASCPCs use backup control mode as a backup to primary mode for the engine air supply system. If the primary and backup modes do not operate, the pneumatic mode controls the engine air supply to a default condition.

The primary left ASCPC provides control for the following systems: left engine air supply, pressurization and pack flow schedule and backup left pack flow control (backup for left CTC).

The backup left ASCPC provides backup control for the left engine air supply.

The primary right ASCPC provides control for the following systems: right engine air supply and backup right pack flow control (backup for right CTC).

The backup right ASCPC provides backup control for the right engine air supply and backup control for the pressurization and pack flow schedule.

Both left and right ASCPCs provide simultaneous control of the air supply distribution system.

Relative to the 777-300ER, differences in the 777X ASCS include the following:

- New engine bleed system that meets the higher engine air pressure and temperature requirements, as well as an increased air supply demand from the downstream bleed air flow user systems.
- Redesigned Air Supply Control System for the new 777-9 engines
- Increased bleed air capacity to support increased bleed flow requirements
- Re-routing of cross-over ducting between Engines 1 and 2 from the Pack Bay to the Main Landing Gear Wheel Well to integrate with the revised keel beam design
- Addition of insulation to the ducting in the wing leading edge
- New Air Supply and Cabin Pressure Controller (ASCPC)
- Addition of Engine Anti-Ice System as an ASCS bleed air consumer instead of using a dedicated Engine Anti-Ice engine bleed port
- Addition of a third Air Driven hydraulic pump (ADP) as an ASCS bleed air consumer

Consequences of Failure

Failure of the left ASCPC is indicated by both the ASCP PRIMARY CTRL L and ASCP BACKUP CTRL L Status messages. Loss of primary and backup control for the left engine air supply. Loss of primary control for pressurization and pack flow. Loss of left CTC backup flow control.

Failure of the right ASCPC is indicated by both the ASCP PRIMARY CTRL R and ASCP BACKUP CTRL R Status messages. Loss of primary and backup control for the right engine air supply. Loss of backup control for pressurization and pack flow. Loss of right CTC backup flow control.

For dispatch, the associated bleed system must be deactivated. The opposite engine and APU bleed systems must operate normally. Isolation valves, packs and outflow valves must also operate normally. Intermediate stage air is only available for engine anti ice from the associated engine bleed system. Therefore, minimum N1 is required in icing conditions to support engine anti-ice capability. Performance penalties must be applied for flight planning fuel.

ASCPC primary channel failure is annunciated by the associated ASCP PRIMARY CTRL L or R Status message. Loss of primary control of associated engine air supply. Backup engine air control remains. Loss of one pressurization and pack flow schedule control. Pressurization and pack flow schedule control remains on opposite side primary controller. Loss of backup pack flow control (backup for associated side CTC).

For dispatch, the associated backup controller must operate normally. The opposite engine bleed system must operate normally. Isolation valves, packs and outflow valves must also operate normally.

ASCPC backup channel failure is annunciated by the associated ASCP BACKUP CTRL L or R Status message. Loss of backup control of associated engine air supply.

For dispatch, the associated primary controller must operate normally. The opposite engine bleed system must operate normally. Isolation valves must also operate normally.

Consequences of Next Critical Failure

ASCPC inoperative at dispatch:

Unannunciated depressurization condition is classified as Catastrophic. Depressurization without indication will compromise crew who may not react to situation, leading to hypoxic crew and passengers. Top event probability is $3.64\text{E-}10$ per flight hour. The top event probability is unchanged when dispatching with ASCPC inoperative.

Failure of the opposite engine or bleed system: Failure of the engine or bleed system will result in loss of all bleed to manifold consumers. Therefore, the APU must be operated during takeoff and landing to ensure adequate bleed air for the center hydraulic system ADPs so that the landing gear can be retracted. 4th stage air is only available to EAI since the PRSOV defaults closed. Bleed system failure is indicated by the BLEED OFF ENG L or R Advisory message. Engine failure is indicated by the ENG FAIL L or R Caution message. Failure of an isolation valve may result in loss of wing anti-ice.

ASCPC primary channel inoperative at dispatch: Failure of associated backup channel: Results in loss of bleed air from associated engine since PRSOV defaults closed. Remaining bleed system will provide bleed to all manifold consumers. 4th stage air for affected engine will be available for EAI on that engine. Failure of the ASCPC backup channel is indicated by the ASCP BACKUP CTRL L or R Status message.

ASCPC backup channel inoperative at dispatch: Failure of associated primary channel: Results in loss of bleed air from associated engine since PRSOV defaults closed. Remaining bleed system will provide bleed to all manifold consumers. 4th stage air for affected engine will be available for EAI on that engine. Failure of the ASCPC primary channel is indicated by the ASCP PRIMARY CTRL L or R Status message..

Loss of Captain's Instrument Bus:

Results in loss of the Left ASCPC Primary Controller, Right ASCPC Backup Controller and Remote Cabin Pressure Sensor. There will also be a loss of power to the left forward Outflow Valve ECU (Ref. S&MF ELEC-14).

Dispatch with any Primary Controller (Primary and Backup or Primary only) inoperative requires both Air Conditioning Packs and Outflow Valves to operate normally which ensures that cabin pressurization control is maintained by at least one Backup Controller. For dispatch with either Backup Control inoperative, the Right Primary Controller will be available.

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36-11-01 Pressure Regulating and Shutoff Valve (PRSOV) Systems

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- APU is operated during takeoff and landing,
- Associated ENG BLEED AIR switch remains OFF, and
- Appropriate performance adjustments are applied.

36-11-01 Pressure Regulating and Shutoff Valve (PRSOV) Systems

36-11-01-01 ENG Bleed Air Switch Lights

36-11-01-01-01 OFF Lights

Interval	Installed	Required	Procedure
C	2	0	

36-11-01 Pressure Regulating and Shutoff Valve (PRSOV) Systems

36-11-01-01 ENG Bleed Air Switch Lights

36-11-01-01-02 ON Lights

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 36-11-01.

The pneumatic system provides air for engine starting, cabin pressurization and environmental control, three air driven hydraulic demand pumps, wing anti-ice, hydraulic reservoir pressurization, cargo conditioning, and TAT probe aspiration. The two engine bleed air systems and the APU load compressor provide air sources for the pneumatic system. On the ground, the system can also be pressurized from a ground air supply.

Engine bleed air comes from the intermediate bleed port of the engine compressor, supplemented when required by the high stage bleed port. Ducting downstream of these ports merge to provide a single bleed air flow path for each engine. A pressure regulating and shutoff valve (PRSOV) regulates the downstream system pressure for each engine bleed system. The PRSOV's are spring loaded closed, and regulate bleed air to maintain an appropriate wing manifold pressure. For 777-9, the PRSOV controller is a remotely located LRU that controls the PRSOV; the valve is capable of higher pressures and temperatures. Air from the engine fan section is used to cool the engine bleed air in the precooler before it enters the pneumatic manifold. If the precooler does not cool the bleed air sufficiently, the PRSOV reduces the airflow to limit the temperature. The PRSOV is automatically closed during engine start and during potential reverse flow conditions. Either PRSOV can be selected closed using the L or R ENG BLEED AIR switch on the overhead panel.

The normal positions of the isolation valves when the switches are set to AUTO and both engine air supply systems are on is: Left isolation valve - open, Center isolation valve - closed, Right isolation valve - open, and APUSOV - closed. The C-isolation valve closed isolates the L and R systems. One condition which causes the ASCPC to automatically open the C-isolation valve is when left or right engine bleed air supply systems are off. So, dispatching with one bleed inoperative per 36-11-01 causes the airplane to be in a cross bleed configuration.

The ENG Bleed Air switch is an alternate action, mechanically latched, push-button switch; each incorporates an amber "OFF" indicator light and a mechanical flag "ON" indicator. The "OFF" indicator light will illuminate whenever the associated engine bleed air PRSOV is latched closed due to bleed system failures, or the engine is not running, or the switch is selected off, or the fire handle is pulled. The light is illuminated by the associated ASCPC.

1. ON Light: The engine bleed valve opens when engine bleed air is available.
2. Transition: On is not visible so the valve is commanded closed.
3. OFF Light: the engine bleed valve is closed. The engine bleed valve is commanded closed and the OFF light is illuminated when: The engine is not running, or a bleed air overheat, overpressure, or bleed control system failure has occurred, or the valve is failed closed, or the L ENG bleed valve is closed during APU to Pack Takeoff procedure, or the ENG fire switch is pulled out, or the switch is off.

NOTE: The 777-300ER bleed system performs a pre-flight built-in test (PFB) after engines are running, which is designed to detect a failed open HPSOV prior to takeoff. Failure of the PFB test results in the BLEED OFF advisory message. The new 777X PFB is designed to detect failed open PRSOV prior to takeoff, and failure will result in a PRSOV status message. This change is enabled by the new 777X HPSOV and PRSOV architecture that integrates the pneumatic controls into the valve and eliminates the potential for pneumatic control freezing and sense line leakage. These changes will reduce the probability of BLEED OFF advisory messages during taxi-out.

Consequences of Failure

Failure of a pressure regulating and shutof valve is indicated by the BLEED PRSOV L or R Status message.

The inoperative PRSOV must be locked closed for dispatch. The following items must operate normally: Opposite bleed system, isolation valves, packs, outflow valves and APU bleed air.

The associated bleed air system is inoperative. The associated BLEED OFF ENG L or R Advisory message will be displayed. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out). With PRSOV locked closed, the associated HPSOV remains available to support engine anti-ice demands.

Switch OFF Light:

The BLEED OFF ENG L (R) advisory message operates normally. The light will not be available for crew notification. For example, prior to engine start these lights are normally illuminated. However, these lights are normally extinguished from engine start to engine shutdown. Also, any manual actuation of the switch to OFF will result in the EICAS advisory level message BLEED OFF ENG L or R, whether the engine is running or not. Therefore, lack of the light will not present a crew operations problem under normal conditions.

Switch ON Light:

The position of the switch can be discerned by being flush with the surrounding light plate.

Consequences of Next Critical Failure

Failure of the opposite engine or opposite engine bleed air system:

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if oppo-

site bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

If HPSOV fails to the open position during takeoff, the bleed isolation valves, air conditioning packs, and center system hydraulic pump will be re-configured to provide required bleed air consumption to manage manifold pressure increase caused by high 11th stage pressure. System re-configuration prevents damage to manifold ducting from overpressurization.

APU failure on takeoff:

ADP air source is lost. Gear retraction will be slow (approximately 17 seconds) and flap retraction will revert to secondary (electric) mode. AFM takeoff performance is not affected since two engine climb out profile with gear down is better.

Cargo fire:

APU is operated during descent when below 17,000 feet to provide an air source for the center hydraulic system ADPs. In the event of a cargo fire, APU air source will also support the increase in cabin pressurization rate limit.

Switch OFF Light:

None. Failure of a Bleed Engine PRSOV to closed with the engine running will be accompanied by the EICAS advisory level message BLEED OFF ENG L or R. Therefore, lack of the Bleed OFF light will not be significant from a crew operations standpoint.

Switch ON Light:

None

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

Dispatch with a Pressure Regulating Shutoff Valve (PRSOV) locked closed, or in a configuration that results in a PRSOV latching closed can result in increased pressure in the core compartment of the opposite engine due to the FAMV being commanded more open.

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However, for dispatch with the PRSOV locked closed on one engine, the APU is used to supply the ADPs during takeoff. Therefore, the the FAMV on the opposite engine will be more closed than normal. Therefore, the pressure limit in the core compartment will not be exceeded which will mitigate the hazard.

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36-11-02 High Pressure Shutoff Valves (HPSOV)

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative HPSOV is locked closed,
- Associated PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- Associated ENG BLEED AIR switch remains OFF,
- Appropriate minimum N1 is maintained on associated engine while in icing conditions,
- APU is operated during takeoff and landing, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 36-11-02.

The HPSOVs are used to control the air supplied by the high stage port in the associated engine bleed system. The valves are spring loaded closed, and commanded open when the downstream pressure is below the set point. The HPSOVs supply pressure regulated air upstream of the PRSOV. The HPSOVs are automatically closed if overpressure or overtemperature is detected, or if the associated engine fire handle is activated. For 777-9, HPSOV control is integrated into the valve instead of being separate; valve is also capable of higher pressures and temperatures.

The PRSOV can be selected closed using the BLEED AIR panel L or R ENG switch. However, bleed switch selected OFF does not ensure that the HPSOV will remain closed. For 777-9, engine anti-ice (EAI) air is provided via the bleed system intermediate duct, and the HPSOV is now used to provide sufficient temperature and pressure. If EAI is on, then the HPSOV could be required to open and will be commanded to do so when necessary. If the HPSOV is inoperative and secured closed, then a minimum N1 setting will be required to ensure EAI capability.

Consequences of Failure

Failure of an HPSOV is indicated by the BLEED HPSOV L or R Status message.

The PRSOV and HPSOV must be locked closed for dispatch. The following items must operate normally: Opposite bleed system, isolation valves, packs, outflow valves and APU bleed air.

The associated bleed air system is inoperative. The associated BLEED OFF ENG L or BLEED OFF R Advisory message will be displayed. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out).

High stage bleed air will not be available on the associated engine to support EAI. Since intermediate bleed air is the only available source for engine anti-ice, a minimum N1 is required in icing conditions to ensure adequate EAI performance.

The dispatch option to use the associated bleed air system, without requiring the APU bleed air system, has been withdrawn from the MMEL proposal due to the associated reduction in safety and increase in pilot workload during takeoff and approach.

Consequences of Next Critical Failure

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if opposite bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

Dispatch with a High Pressure Shutoff Valve (HPSOV) closed, with associated bleed system used, will not result in an increase in core compartment pressure that will exceed the pressure limit.

Dispatch with a High Pressure Shutoff Valve (HPSOV) locked closed, with associated PRSOV closed and APU used can result in increased pressure in the core compartment of the opposite engine due to the FAMV being commanded more open.

However, for dispatch with the PRSOV locked closed on one engine, the APU is used to supply the ADPs during takeoff. Therefore, the the FAMV on the opposite engine will be more closed than normal. Therefore, the pressure limit in the core compartment will not be exceeded which will mitigate the hazard.

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36-11-03 Intermediate Pressure Check Valves (IPCV)

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- a. Inoperative IPCV is open,
- b. Associated HPSOV is locked closed,
- c. Associated PRSOV is locked closed,
- d. Opposite Engine Bleed Air System operates normally,
- e. Both Left and Right Bleed Isolation Systems operate normally,
- f. Center Bleed Isolation System operates normally,
- g. Both Air Conditioning Packs operate normally,
- h. Both Outflow Valves operate normally,
- i. APU Bleed Air System operates normally,
- j. Associated ENG BLEED AIR switch remains OFF,
- k. Appropriate minimum N1 is maintained on associated engine while in icing conditions,
- l. APU is operated during takeoff and landing, and
- m. Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 36-11-03.

The IPCV is located downstream from the intermediate port in each engine bleed air system. It prevents reverse flow of higher pressure air into the intermediate stage of the associated engine compressor when the HPSOV is selected open.

Consequences of Failure

With the intermediate pressure check valve (IPCV) failed open, the PRSOV and HPSOV must be locked closed for dispatch to preclude compressor stall due to reverse flow. The following items must operate normally: Opposite bleed system, isolation valves, packs, outflow valves and APU bleed air.

The associated bleed air system is inoperative. The associated BLEED OFF ENG L or R Advisory message will be displayed. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out).

Since high stage air is not available on the associated engine to support engine anti-ice, a minimum N1 is required in icing conditions to support EAI performance.

Consequences of Next Critical Failure

Failure of the opposite engine or remaining engine bleed air system:

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if opposite bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable.

APU failure on takeoff: ADP air source is lost.

ADP air source is lost. Gear retraction will be slow (approximately 17 seconds) and flap retraction will revert to secondary (electric) mode. AFM takeoff performance is not affected since two engine climb out profile with gear down is better.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is $1.405E-08$.

Dispatch with a Pressure Regulating Shutoff Valve (PRSOV) locked closed, or in a configuration that results in a PRSOV latching closed can result in increased pressure in the core compartment of the opposite engine due to the FAMV being commanded more open.

However, for dispatch with the PRSOV locked closed on one engine, the APU is used to supply the ADPs during takeoff. Therefore, the the FAMV on the opposite engine will be more closed than normal. Therefore, the pressure limit in the core compartment will not be exceeded which will mitigate the hazard.

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36-11-04 Precoolers

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One precooler may have partially blocked airflow or bleed air leakage provided:

- It is verified that precooler airflow is not completely blocked,
- Precooler bleed air leakage is verified within normal limits,
- Opposite Engine Bleed Air System operates normally, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 36-11-04.

Hot engine bleed air is cooled by heat exchange in the precoolers using cooler air extracted from the fan of each engine. The precooler in each engine bleed system is located downstream of the PRSOV. Fan air extraction from each engine is controlled by the Fan Air Modulation Valves (FAMV). Heat contained in the engine bleed air is transferred to the fan air which is then vented overboard.

For 777-9, the precooler is increased in size and capacity.

Consequences of Failure

Engine bleed air cooling capability is reduced for the associated system. No significant impact to system performance.

Verification is required that precooler airflow is not completely blocked and that bleed air leakage is within normal limits. Opposite engine bleed system must operate normally.

Consequences of Next Critical Failure

Failure of the associated FAMV: The associated engine bleed air system may become inoperative. If the FAMV is inoperative, the PRSOV may reduce or shut off the bleed air. The PRSOV automatically shuts off if precooler exit temperature limits are exceeded. The other engine bleed air system remains as the air source for the pneumatic system.

Damage to the opposite precooler:

Damage to the opposite precooler that is within that is not completely blocked and has leakage within normal limits (as required for the for dispatch side) will have no significant impact to the system.

Failure of the opposite engine or bleed system: The pneumatic system is supplied by the engine bleed with a damaged precooler. Demand may exceed capability of the engine with damaged precooler, resulting in temperature topping or bleed system shutdown and loss of pressurization and WAI. The APU can be used as a bleed source for cabin pressurization at altitudes below 22,000 feet. The APU bleed air does not provide sufficient heating for WAI. If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions. Performance adjustments must be applied for ETOPS critical fuel reserves.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is $1.405E-08$.

Dispatch with damage to a Precooler can create additional undercowl flow due to the allowable leakage which could result in an increase in core compartment pressure above the allowable limit. The maximum dispatch time has been calculated to be 56,500 flight hours.

36-11-05 Fan Air Modulation Valves (FAMV)

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative FAMV is locked open,
- Opposite Engine Bleed Air System operates normally,
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 36-11-05.

Hot engine bleed air is cooled by heat exchange in the precoolers using cooler air extracted from the fan of each engine. The FAMV is located downstream of the fan air inlet and upstream of the precooler on each engine. For 777-9, pneumatic control integrated into valve instead of being separate; the valve is capable of higher pressures and temperatures. The valves are spring loaded open. Precooler exit temperature of the engine bleed air is regulated to approximately 380 deg F by controlling the FAMV position. If the precooler does not cool the bleed air sufficiently, the associated PRSOV is automatically controlled to reduce or shutoff engine bleed airflow.

Consequences of Failure

The BLEED FAMV L or R Status message is displayed if the associated engine bleed fan air modulating valve (FAMV) is failed open or closed or the associated air supply and cabin pressure controller has failed.

The FAMV must be locked in the full open position, resulting in maximum cooling of the associated engine bleed air. Opposite engine bleed air system must operate normally. Performance and fuel burn penalties are required due to higher than normal fan air extraction.

Consequences of Next Critical Failure

Associated engine bleed air overtemperature condition: No effect since protective system auto-shutdown capability of the engine bleed system remains operational. Flight crew also has manual shutdown control using the associated engine bleed air switch.

Failure of the opposite engine or engine bleed system: The pneumatic system is supplied by the engine bleed system with FAMV locked open. WAI capability is reduced due to maximum precooling of the bleed air. If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

Dispatch with a FAMV locked open could result in an increase in core compartment pressure above the allowable limit. The maximum dispatch time has been calculated to be 3,950 flight hours.

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36-12-01 Left and Right Bleed Isolation Systems (Valve and/or Indication)

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Inoperative isolation valve is locked open,
- Opposite Bleed Isolation Valve Indication is verified to operate normally,
- Center Bleed Isolation Valve Indication is verified to operate normally,
- APU Bleed Air Shutoff Valve Indication is verified to operate normally,
- Center Bleed Isolation System operates normally,
- Center System Demand ADP C2 operates normally, and
- Appropriate performance adjustments are applied.

36-12-01 Left and Right Bleed Isolation Systems (Valve and/or Indication)

36-12-01-01 ISLN Switch Lights

36-12-01-01-01 CLOSED Lights

Interval	Installed	Required	Procedure
C	2	0	

36-12-01 Left and Right Bleed Isolation Systems (Valve and/or Indication)

36-12-01-01 ISLN Switch Lights

36-12-01-01-02 AUTO Lights

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 36-12-01B.

The pneumatic system manifold has three isolation valves (L, C, and R). Each valve is spring loaded closed. Isolation valve control is provided by the L and R Air Supply and Cabin Pressure Controllers (ASCPC). Each valve is actuated by a dual wound DC solenoid with one winding controlled by the L ASCPC and the other controlled by the R ASCPC. Individual isolation valve switches are provided on the overhead bleed air panel to allow the flight crew to select AUTO control or CLOSED. In AUTO, the ASCPC's control the isolation valve positions in response to normal and non-normal operating conditions.

In normal operation, the L and R isolation valves are commanded open and the C valve is closed. For engine starting, the C and L (or R) valves are opened to provide air from the APU load compressor. During the first 3 minutes of takeoff, loss of an engine closes the associated isolation valve and opens the center isolation valve; after 3 minutes only the center valve is opened. This configuration sustains pneumatic power to the three hydraulic air driven pumps (ADPs).

The Bleed Isolation (ISLN) Valve switches are alternate action, mechanically latched, push-button type switches; each incorporates an amber "CLOSED" indicator light and a mechanical flag "AUTO" indicator. The "CLOSED" indicator light will illuminate whenever the associated bleed isolation valve is latched closed due to bleed system duct leak or failure, the switch is selected off, or the valve fails closed. The lights are illuminated by an ARINC 629 signal from the left ASCPC for the left and center Isolation Valves and from the right ASCPC for the right Isolation Valve.

AUTO Light: The bleed isolation valve is controlled automatically.

CLOSED Light: The valve is closed because a duct leak or bleed loss has occurred, or the valve is failed closed, or the switch is off.

Consequences of Failure

The BLEED ISLN VALVE L or R Status message will be displayed when the left or right isolation valve is not in the commanded position.

The inoperative L or R ISOV must be locked in the open position. The C ISOV will automatically close during takeoff and landing to isolate the pneumatic system. This is the same as for normal operations of the L or R ISOVs.

The associated ECS channel within the ASCPC must be verified to be operating normally. This is done by verifying that a valid status for the remaining isolation valves are displayed on the AIR SUPPLY maintenance page. This ensures that the ASCPC knows that the isolation valve is locked open. If the ASCPC doesn't know the isolation valve is locked open it will not be able to isolate a burst duct condition in the required amount of time.

The center bleed isolation system must operate normally. With the right isolation valve locked open, the center isolation valve will be required to provide engine bleed separation.

The system logic will not allow APU-to-Pack takeoff if there is a isolation valve fault. APU-to-Pack requires the C ISOV to be closed and L and R ISOV closure capability to ensure ADPs receive necessary pressure in the event of an engine or bleed system loss.

AUTO Light: The associated switch position is discernible by the switch flush with the surrounding panel.

CLOSED Light: The associated BLEED ISLN CLOSED L, R and BLEED ISLN OPEN L, R Advisory messages operates normally. The light(s) will not be available for crew notification. These lights are not illuminated during normal operation of the bleed system. Also, any manual actuation of the associated switches to CLOSED will result in the EICAS advisory level message BLEED ISLN CLOSED L, C or R, whether the engine is running or not. Therefore, lack of the light will not present a crew operations problem under normal conditions.

Consequences of Next Critical Failure

Airplane dispatched with L or R valve locked open:

The left and right isolation valves are normally commanded to the open position during dual engine bleed operation. The center isolation valve is normally commanded closed to provide left/right separation. In the event of an engine out or engine bleed failure, the center isolation valve will be commanded open automatically to allow for single bleed operation. For application of the left or right isolation valve MMEL item with the valve locked open, there will be no impact since the valve will already be locked in the open position.

In the event of a duct burst/rotorburst scenario, the isolation valve on the associated side is normally commanded closed and the center isolation valve is commanded open. This preserves bleed air supply to all ADPs to support center hydraulic system performance. However, for application of the left or right isolation valve MMEL item with the valve locked open, in the event of a duct burst/rotorburst scenario on the same side as the locked open isolation valve, the system will not be able to close the locked open isolation valve. Therefore, the bleed air system will command the center isolation valve closed to isolate the opposite engine bleed air source. In this scenario, bleed air will only be supplied to ADP C2 (for left side failure) or ADPs C1 & C3 (for the right side failure). Gear retraction and flap/slat movement will be slower than normal. Performance penalty must be applied.

AUTO Light: None

CLOSED Light: None. Failure of a Bleed Isolation Valve to the closed position when commanded open will be accompanied by the EICAS advisory level message BLEED ISLN OFF L, C or R. Therefore, lack of the Bleed Isolation Valve CLOSED lights will not be significant. If an ASCPC Primary Controller is failed, the associated lights and EICAS advisory messages will not operate. However, the isolation valves will continue to operate normally based on commands from the opposite ASCPC.

36-12-02 Center Bleed Isolation System (Valve and/or Indication)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Center Bleed Isolation Valve is locked open,
- Left and Right Bleed Isolation Valve Indications are verified to operate normally, and
- APU Bleed Air Shutoff Valve Indication is verified to operate normally, and
- Left and Right bleed Isolation Systems operate normally.

36-12-02 Center Bleed Isolation System (Valve and/or Indication)
36-12-02-01 ISLN Switch Lights
36-12-02-01-01 CLOSED Light

Interval	Installed	Required	Procedure
C	1	0	

36-12-02 Center Bleed Isolation System (Valve and/or Indication)
36-12-02-01 ISLN Switch Lights
36-12-02-01-02 AUTO Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION
Background

Proposal based on 777 MMEL item 36-12-02B.

The pneumatic system manifold has three isolation valves (L, C, and R). Each valve is spring loaded closed. Isolation valve control is provided by the L and R Air Supply and Cabin Pressure Controllers (ASCPC). Each valve is actuated by a dual wound DC solenoid with one winding controlled by the L ASCPC and the other controlled by the R ASCPC. Individual isolation valve switches are provided on the overhead bleed air panel to allow the flight crew to select AUTO control or CLOSED. In AUTO, the ASCPC's control the isolation valve positions in response to normal and non-normal operating conditions.

In normal operation, the L and R isolation valves are commanded open and the C valve is closed. For engine starting, the C and L (or R) valves are opened to provide air from the APU load compressor. During the first 3 minutes of takeoff, loss of an engine closes the associated isolation valve and opens the center isolation valve; after 3 minutes only the center valve is opened. This configuration sustains pneumatic power to the three hydraulic air driven pumps (ADPs).

The Bleed Isolation (ISLN) Valve switches are alternate action, mechanically latched, push-button type switches; each incorporates an amber "CLOSED" indicator light and a mechanical flag "AUTO" indicator. The "CLOSED" indicator light will illuminate whenever the associated bleed isolation valve is latched closed due to bleed system duct leak or failure, the switch is selected off, or the valve fails closed. The lights are illuminated by an ARINC 629 signal from the left ASCPC for the left and center Isolation Valves and from the right ASCPC for the right Isolation Valve.

AUTO Light: The bleed isolation valve is controlled automatically.

CLOSED Light: The valve is closed because a duct leak or bleed loss has occurred, or the valve is failed closed, or the switch is off.

Consequences of Failure

The BLEED ISLN VALVE C status message will be displayed when the center isolation valve is not in the commanded position

The inoperative C ISOV must locked in the open position. The bleed will automatically command the R ISOV closed for dual bleed operation to retain L/R system separation.

The associated ECS channel within the ASCPC must be verified to be operating normally. This is done by verifying that a valid status for the remaining isolation valves are displayed on the AIR SUPPLY maintenance page. This ensures that the ASCPC knows that the isolation valve is locked open. If the ASCPC doesn't know the isolation valve is locked open it will not be able to isolate a burst duct condition in the required amount of time.

The system logic will not allow APU-to-Pack takeoff if there is a isolation valve fault. APU-to-Pack requires the C ISOV to be closed and L and R ISOV closure capability to ensure ADPs receive necessary pressure in the event of an engine or bleed system loss.

AUTO Light: The associated switch position is discernible by the switch flush with the surrounding panel.

CLOSED Light: The associated BLEED ISLN CLOSED C and BLEED ISLN OPEN C Advisory messages operate normally. The light(s) will not be available for crew notification. These lights are not illuminated during normal operation of the bleed system. Also, any manual actuation of the associated switches to CLOSED will result in the EICAS advisory level message BLEED ISLN CLOSED L, C or R, whether the engine is running or not. Therefore, lack of the light will not present a crew operations problem under normal conditions.

Consequences of Next Critical Failure

The center isolation valve is normally commanded to the closed position during dual engine bleed operation.

For application of the center isolation valve MMEL item with the valve locked open, the bleed air system retains separation by closing the right isolation valve. In the event of an engine out or bleed air system failure on either side, the right isolation valve will be commanded open to allow for single bleed operation to all bleed air consumers.

For duct burst/rotor burst on either side the associated left or right ISOV will close to allow single bleed operation to supply all center system ADPs.

For duct burst/rotorburst on the left side, the left isolation valve will be commanded closed and the right isolation valve will be commanded open. The center isolation valve will already be locked in the open position.

For duct burst/rotorburst on the right side, the left isolation valve will remain commanded open and the right isolation valve will remain commanded closed. The center isolation valve will already be locked in the open position.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

Dispatch with the Center Isolation Valve locked open will result in the left engine supplying an additional ADP and could result in an increase in core compartment pressure above the allowable limit. The maximum dispatch time has been calculated to be 6,440 flight hours.

AUTO Light: None

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CLOSED Light: None. Failure of a Bleed Isolation Valve to the closed position when commanded open will be accompanied by the EICAS advisory level message BLEED ISLN OFF L, C or R. Therefore, lack of the Bleed Isolation Valve CLOSED lights will not be significant. If an ASCPC Primary Controller is failed, the associated lights and EICAS advisory messages will not operate. However, the isolation valves will continue to operate normally based on commands from the opposite ASCPC.

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36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Bleed Air Shutoff Valve is locked closed,
- Other procedures do not require APU as a pneumatic source,
- APU BLEED AIR switch remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

NOTE: APU may be used for electrical power.

36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)
36-12-03-01 Valve Indication
36-12-03-01A

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Bleed Air Shutoff Valve is verified to operate normally,
- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of the APU, and
- Flight remains within 180 minutes of landing at a suitable airport.

36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)
36-12-03-01 Valve Indication
36-12-03-01B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU Bleed Air Shutoff Valve is verified to operate normally before each departure,
- Other procedures do not require use of APU as a pneumatic source,

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- c. APU BLEED AIR switch remains OFF for flight, and
- d. Flight remains within 180 minutes of landing at a suitable airport.

NOTE 1: APU may be used for electrical power.

NOTE 2: APU pneumatic power may be used for ground operations only.

36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)**36-12-03-02 APU Switch Light****36-12-03-02-01 OFF Light**

Interval	Installed	Required	Procedure
C	1	0	

36-12-03 APU Bleed Air Shutoff System (Valve and/or Indication)**36-12-03 APU Switch Light****36-12-03-02-02 AUTO Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL 36-12-03.

Valve: The APU bleed air shutoff valve is located in the APU pneumatic duct just forward of the APU fire wall. It provides the capability to isolate the APU load compressor from the rest of the pneumatic system. The valve is actuated by a dual wound DC solenoid. Valve position is controlled automatically by the L or R ASCPC when the flight deck APU BLEED AIR switch is selected to AUTO. The valve is commanded closed when the switch is selected OFF.

Valve indications: The APU bleed air shutoff valve position indications are based on an electrical signal received from Hall Effect open/closed position indicators installed in the valve assembly. The position signals are processed by the right ASCPC digital controller and valve indication information is provided to other using systems via ARINC 629 L and R Systems Buses.

AUTO Light: The bleed isolation valve is controlled automatically.

OFF Light: The valve is closed because a duct leak or bleed loss has occurred, or the valve is failed closed, or the switch is off, or the APU fire switch is pulled out.

Consequences of Failure

The BLEED VALVE APU Status message will be displayed when the APU bleed shutoff valve disagrees with the commanded position.

Valve inoperative: APU can not be used as bleed air source. On-ground, a ground air source will be required to start the engines and to power the packs when the engines are not running.

Valve indications inoperative, APU not required as electrical power source: Normal operation of the APU bleed valve must be verified, the flight must remain within 180 minutes of landing at a suitable airport, and the APU cannot be required by other MMEL procedures as an electrical and pneumatic power source. The specific consideration is latent failure of the APU bleed check valve and subsequent failure of the APU bleed air shutoff valve to the open position. Since the valve indication is inoperative, it is impossible to tell if the valve is failed open. If this condition occurs with the engines running, the APU will likely surge and shutdown. By not relying on the APU in-flight, this concern is eliminated.

Valve indications inoperative, APU required as electrical power source: Normal operation of the APU bleed valve must be verified before each departure and the APU bleed switch must be selected off in-flight due to next-critical-failure considerations. Specific concern is for latent failure of the APU bleed check valve and subsequent failure to the open position of the APU bleed shutoff valve. By verifying that the valve operates normally before each departure, the risk is reduced to that of the valve failing open whether the indication is operative or inoperative.

Valve indications inoperative: Incorrect flight deck effects may be observed. For example, if the valve is commanded closed and is actually closed, but the valve indications are inoperative and indicate the valve is open the following effects may be observed:

- The BLEED VALVE APU Status message will be displayed on the Status Page.
- On the Air Synoptic, the APU bleed valve position and/or flow bar indication may be incorrect or missing.
- On the EICAS Air Supply Maintenance Page, the APU ISO VLV readout will be OPEN.

AUTO Light: The associated switch position is discernible by the switch flush with the surrounding panel.

OFF Light: The associated BLEED OFF APU Advisory message operates normally. The light will not be available for crew notification. This light is not illuminated during normal operation of the bleed system. Also, any manual actuation of the associated switch to OFF will result in the EICAS advisory level message BLEED OFF APU whether the APU is running or not. Therefore, lack of the light will not present a crew operations problem under normal conditions.

Consequences of Next Critical Failure

Valve inoperative and one engine bleed air system fails: The other engine bleed system remains as air source for the pneumatic system. Dispatch is not allowed when the APU is required as a pneumatic source, such as when an engine bleed system is inoperative.

Valve indications inoperative: Dispatch is not allowed when the APU is required as a pneumatic source, such as when an engine bleed system is inoperative. The following failure combinations were considered:

Valve fails open and APU not required as electrical power source: The APU is not relied on in-flight for electrical power, including the limit of within 180 minutes of landing at a suitable airfield. Therefore both engine driven IDGs and the backup electrical system must operate normally at dispatch. If an engine driven IDG subsequently fails, and the APU is started and fails or fails to start, only two AC power sources remain available. The APU could fail because the APU bleed shutoff valve failed open after it was verified operating normal before the first departure and APU bleed check valve was failed latently. This condition will likely cause bleed backflow through the APU resulting in a surge condition and APU shutdown. The airplane may be safely recovered on one engine driven IDG and the backup electrical power system, which is the same dispatch restrictions as dispatch with the APU inoperative.

Valve fails open and APU required as electrical power source:

If the APU check valve is latently failed and the APU is running, there will be backflow through the APU causing it to likely surge and shutdown. If this condition occurs, only two AC power sources (IDG or backup electrical stem inoperative at dispatch) remain available. The airplane may be safely recovered on one engine driven IDG and the backup electrical power system (IDG inoperative at dispatch and APU subsequently fails), or both engine driven IDGs (backup electrical system inoperative at dispatch and APU subsequently fails).

If a duct leak occurred in the high pressure pneumatic duct between the APU and the left and center isolation valves, and the APU was running, the bleed leak detection system (DLODS) could not isolate this duct. Therefore, to reduce risk of failure of the APU bleed valve open and a duct leak occurring, normal operation of the valve must be verified before each departure, since the APU may be running to support electrical MMEL procedures.

Closed: For the valve failed closed, in-flight concerns for bleed backflow through the APU and duct leak isolation are eliminated. The APU will not operate as a pneumatic source, which provides an obvious flight deck effect, as the APU bleed valve will not operate properly, preventing the APU from being used as a pneumatic power source on the ground to start the engines or power the packs. Additionally, the APU cannot be started pneumatically. Upon identification, the valve must be locked closed or repaired.

AUTO Light: None.

OFF Light: None. Failure of the APU Bleed Valve to the closed position when commanded open will be accompanied by the EICAS advisory level message BLEED OFF APU. Therefore, lack of the APU Bleed OFF light will not be significant. If the right ASCPC Primary Controller is failed, the APU Bleed Off light and the associated EICAS advisory message will not operate. However, the APU Bleed Valve will continue to operate normally based on commands from the opposite ASCPC.

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36-20-01

Air Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 36-20-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Pneumatic system indications are shown on the bottom half of the air synoptic display. Cabin Air Conditioning and Temperature Control System (CACTCS) indications are shown on the top half of the display. The pneumatic system display shows airflow direction and user systems, valve positions, duct pressure and air source status.

Green flow bars show airflow direction and identify which sources and users are on. Valve positions are indicated by symbols.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

36-21-01 Manifold Pressure Sensing Systems**36-21-01-01 FCAC Installed**

36-21-01-01A

Interval	Installed	Required	Procedure
C	2	1	(O)

One Manifold Pressure Sensing System may be inoperative provided:

- Remaining items of associated Engine Bleed System operate normally,
- Opposite Engine Bleed Air System operates normally,
- Both lower Recirculation Fans operate normally,
- Both Air Conditioning Packs operate normally,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- At least one Auto Cabin Pressure Control operates normally,
- For Right Manifold Pressure Sensing System inoperative, Center Hydraulic System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is selected off during takeoff and climb at FL 260 or below, and
- Appropriate performance adjustments are applied.

36-21-01 Manifold Pressure Sensing Systems**36-21-01-01 FCAC Installed**

36-21-01-01B

Interval	Installed	Required	Procedure
C	2	1	(O)

One Manifold Pressure Sensing System may be inoperative provided:

- Remaining items of associated Engine Bleed Air System operate normally,
- Opposite Engine Bleed Air System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- At least one Auto Cabin Pressure Control operates normally,
- For right Manifold Pressure Sensing System inoperative, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is selected off during takeoff and climb at FL 260 or below, and
- FWD CARGO A/C selector remains off during takeoff and climb below FL 260, and

- i. Appropriate performance adjustments are applied.

36-21-01 Manifold Pressure Sensing Systems

36-21-01-02 FCAC Not Installed

Interval	Installed	Required	Procedure
C	2	1	(O)

One Manifold Pressure Sensing System may be inoperative provided:

- Remaining items of associated Engine Bleed Air System operate normally,
- Opposite Engine Bleed Air System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Cabin Temperature Controllers (CTCs) operate normally,
- At least one Auto Cabin Pressure Control operates normally,
- For right Manifold Pressure Sensing System inoperative, Center System Demand ADP C2 operates normally,
- Associated Air Conditioning Pack is selected off during takeoff and climb at FL 260 or below, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION

Background

A gauge pressure sensor is located in the pneumatic manifold downstream of the precooler in each engine bleed air system. Manifold pressure signals are used by the associated ASCPC in the electronic control of the PRSOV. The pressure signals are also used for display of L and R manifold duct pressure on EICAS primary display. An inlet pressure sensor for the pack Flow Control Valve (FCV) located further downstream in the manifold provides backup pressure data for low manifold pressure bleed shutdown and duct pressure indication if a manifold pressure sensor becomes inoperative.

Consequences of Failure

Failure of a manifold pressure sensor is indicated by the BLEED PRESS MANF SENSOR L or R Status message.

The following must operate normally: Remaining items of associated bleed system and opposite engine bleed system, both packs, both CTCs, at least one auto cabin pressure control, and (for right manifold pressure sensor inoperative) center hydraulic system demand ADP C2.

With a failed BLEED PRESS MANF SENSOR and high engine thrust levels (that occur during climb below 26,000 feet), the associated cooling pack inlet pressure sensor may go out of range which could expose the cooling pack to pressures exceeding certified design limits.

For dispatch, the associated pack must remain off during takeoff and climb below 26,000 feet. When the airplane altitude exceeds 26,000 feet, the pack is selected on. The associated PACK OFF L, R Advisory message will be displayed. If the pack inlet pressure sensor goes out of range with pack on, CACTCS will close the associated FCVs and display a PACK IN STBY MODE L, R Advisory message. When the pack inlet pressure sensor goes back in range, CACTCS will automatically open the appropriate FCV and resume controlling flow. The pack will then operate normally, and the PACK IN STBY MODE L, R message will extinguish.

Consequences of Next Critical Failure

Pack Flow Control Valve Inlet Pressure Sensor:

Failure of the associated pack flow control valve inlet pressure sensor would result in a default value being used to control flow when the pack is selected to AUTO after the airplane climbs above 26,000 feet. The total cabin in-flow may differ from the normal scheduled flow while a default value is used.

Pack Flow Control Valve:

Failure of the associated pack flow control valve to limit pressure and flow could result in the cooling pack being exposed to higher pressures than certified and possibly deform or burst vessels meant to contain the pressure. In addition, higher speeds of the cooling pack air cycle machine than were used for certification of containment of a rotor burst may occur. Failure of both the PRSOV and FCV to limit pressure and flow to the cooling pack is addressed as a hazardous condition in the CACTCS SSA. The FTA predicts a probability for this combination of failures to be extremely remote with an occurrence less than the 1.0 E-07 per flight hour.

Smoke event: During takeoff and climb below FL 260 when the associated pack is selected off, either both of the lower recirculation fans must be operating normally or forward cargo air conditioning (FCAC) must not be used. If these conditions are not met, smoke can penetrate the cabin during a smoke event.

36-21-02 Intermediate Pressure Sensing Systems

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- Associated ENG BLEED AIR switch remains OFF,
- Appropriate minimum N1 is maintained on associated engine while in icing conditions,
- APU is operated during takeoff and landing, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 36-21-02.

A gauge pressure sensor located downstream of the HPSOV monitors the intermediate engine bleed pressure (PI) in each engine bleed air system. The PI pressure signals are used for primary HPSOV control, and for parameter display on the EICAS ECS maintenance page.

Consequences of Failure

Failure of an intermediate pressure sensor is indicated by the BLEED PRESSURE INT SENSOR L or R Status message. Associated HPSOV control is lost and HPSOV will remain closed. Bleed pressure indications are lost on the ECS maintenance page.

The associated bleed air system is inoperative. The associated BLEED OFF ENG L or BLEED OFF R Advisory message will be displayed. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out).

High stage bleed air will not be available on the associated engine to support EAI. Since intermediate bleed air is the only available source for engine anti-ice, a minimum N1 is required in icing conditions to ensure adequate EAI performance.

Consequences of Next Critical Failure

Failure of the opposite engine or bleed system:

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if opposite bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions were encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

However, for dispatch with the PRSOV locked closed on one engine, the APU is used to supply the ADPs during takeoff. Therefore, the the FAMV on the opposite engine will be more closed than normal. Therefore, the pressure limit in the core compartment will not be exceeded which will mitigate the hazard.

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36-22-01 Manifold Temperature Sensing Systems

36-22-01-01 Primary Sensor Channels - Left

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with BLEED TEMP MANF CHAN L Status message displayed.

36-22-01 Manifold Temperature Sensing Systems

36-22-01-02 Primary Sensor Channels - Right

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with BLEED TEMP MANF CHAN R Status message displayed.

36-22-01 Manifold Temperature Sensing Systems

36-22-01-03 Primary Temperature Sensors

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One Primary Temperature Sensor may be inoperative provided:

- Associated PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- Associated ENG BLEED AIR switch remains OFF,
- APU is operated during takeoff and landing, and
- Appropriate performance adjustments are applied.

36-22-01 Manifold Temperature Sensing Systems**36-22-01-04 Secondary Temperature Sensors**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One Secondary Temperature Sensor may be inoperative provided:

- Associated PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- Associated ENG BLEED AIR switch remains OFF,
- APU is operated during takeoff and landing, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 36-22-01-05.

The primary temperature sensor is a dual element temperature sensor located in the manifold just downstream of the precooler exit in each engine bleed air system. The sensors monitor the precooler exit temperatures (TM) for use in electronic control of the associated FAMV and PRSOV. The TM signals are also used for parameter display on the EICAS ECS maintenance page.

The secondary temperature sensor is a dual element sensor that is part of the bleed manifold flow sensor.

Consequences of Failure

Failure of one channel in a bleed temperature manifold primary sensor results in the BLEED TEMP MANF CHAN L or R status message. Loss of redundancy only.

Failure of both channels in a bleed temperature manifold primary sensor results in the BLEED TEMP MANF SNSR PRI L or R Status message.

Due to loss of temperature sensing, the associated Fan Air Modulation Valve (FAMV) is commanded to the full open position. Performance and fuel burn penalties are required due to higher than normal fan air extraction.

The inoperative PRSOV must be locked closed for dispatch. The associated bleed air system is inoperative. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out). With PRSOV locked closed, the associated HPSOV remains available to support engine anti-ice demands.

Failure of one or both channels of a bleed temperature manifold secondary sensor is indicated by the BLEED TEMP MANF SNSR SEC L or R Status message.

Due to loss of temperature sensing, the associated Fan Air Modulation Valve (FAMV) is commanded to the full open position. Performance and fuel burn penalties are required due to higher than normal fan air extraction.

The dispatch option to use the associated bleed air system, without requiring the APU bleed air system, has been withdrawn from the MMEL proposal due to the associated reduction in safety and increase in pilot workload during takeoff and approach.

Consequences of Next Critical Failure

Failure of the opposite engine or opposite engine bleed air system:

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if opposite bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions are encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

If HPSOV fails to the open position during takeoff, the bleed isolation valves, air conditioning packs, and center system hydraulic pump will be re-configured to provide required bleed air consumption to manage manifold pressure increase caused by high 11th stage pressure. System re-configuration prevents damage to manifold ducting from overpressurization.

APU failure on takeoff:

ADP air source is lost. Gear retraction will be slow (approximately 170 seconds) and flap retraction will revert to secondary (electric) mode. AFM takeoff performance is not affected since two engine climb out profile with gear down is better.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors. The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08. Dispatch with an inoperative Manifold Temperature Sensor will result in the FAMV being commanded to the full open position which can result in an increase in core compartment pressure above the allowable limit. The maximum dispatch time has been calculated to be 4,190 flight hours.

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36-22-02 Intermediate Temperature Sensing Systems

36-22-02-01 Temperature Sensor Channels - Left

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with BLEED TEMP INT CHAN L Status message displayed.

36-22-02 Intermediate Temperature Sensing Systems

36-22-02-02 Temperature Sensor Channels - Right

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with BLEED TEMP INT CHAN R Status message displayed.

36-22-02 Intermediate Temperature Sensing Systems

36-22-02-03 Temperature Sensors

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One Temperature Sensor may be inoperative provided:

- Associated PRSOV is locked closed,
- Opposite Engine Bleed Air System operates normally,
- Both Left and Right Bleed Isolation Systems operate normally,
- Center Bleed Isolation System operates normally,
- Both Air Conditioning Packs operate normally,
- Both Outflow Valves operate normally,
- APU Bleed Air System operates normally,
- Associated ENG BLEED AIR switch remains OFF,
- APU is operated during takeoff and landing, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION

Background

New item for 777X.

A new intermediate temperature (TI) sensor is installed for 777X. The TI sensor is the same sensor technology as the manifold temp (TM) sensor, and is located in the intermediate bleed duct downstream of the low and high stage bleed ports but upstream of the EAIV and PRSOV. It is used by ACIPS to control the EAIV and by ASCS to detect HPSOV failure and protect the downstream valves and ducting. It will also be displayed on the maintenance page.

Consequences of Failure

Failure of one channel in a bleed temperature manifold primary sensor results in the BLEED TEMP INT CHAN L or R status message. Loss of redundancy only.

Failure of both channels in a bleed temperature manifold primary sensor results in the BLEED TEMP INT SENSOR L or R Status message.

The inoperative PRSOV must be locked closed for dispatch. The associated bleed air system is inoperative. The other engine bleed air system and the APU remain as air sources for the pneumatic system. The APU is operated during takeoff and landing to ensure there is adequate bleed air available for the center hydraulic system ADPs. The isolation valves are controlled automatically in response to increased demand and in response to subsequent failures (bleed system or engine out). With PRSOV locked closed, the associated HPSOV remains available to support engine anti-ice demands.

The dispatch option to use the associated bleed air system, without requiring the APU bleed air system, has been withdrawn from the MMEL proposal due to the associated reduction in safety and increase in pilot workload during takeoff and approach.

Consequences of Next Critical Failure

Failure of the opposite engine or opposite engine bleed air system:

Both engine bleed sources are inoperative. During takeoff, the APU provides dedicated bleed air to the ADPs to ensure center Hydraulic System pressure is maintained to provide airplane controllability. Inflight, airplane must descend due to loss of pressurization capability. The APU remains as an air source for the pneumatic system below 22,000 feet, and can be used to maintain cabin pressurization. WAI capability will be lost if opposite bleed air fails enroute (APU bleed air does not provide sufficient heating for WAI). If icing conditions are encountered, flight test will show that airplane operation in icing is acceptable, or non-normal checklist will require exiting icing conditions.

If HPSOV fails to the open position during takeoff, the bleed isolation valves, air conditioning packs, and center system hydraulic pump will be re-configured to provide required bleed air consumption to manage manifold pressure increase caused by high 11th stage pressure. System re-configuration prevents damage to manifold ducting from overpressurization.

APU failure on takeoff:

ADP air source is lost. Gear retraction will be slow (approximately 170 seconds) and flap retraction will revert to secondary (electric) mode. AFM

takeoff performance is not affected since two engine climb out profile with gear down is better.

Thrust Reverser Bifurcation Latch Failure during RTO:

A catastrophic failure condition can result from the combination of the following conditions: 1) Exceedance of the pressure limit in the core compartment. 2) Thrust reverser deployment during a rejected takeoff (RTO). 3) Failure of the thrust reverser N1 inhibit function.

The combination of these conditions can result in failure of the Bifurcation Latch Systems in the Nacelle and may result in separation of the inner wall from the Thrust Reverser which will compromise the blocker doors.

The result is sudden asymmetric thrust and potential high speed runway excursion. This failure condition is classified as 'Catastrophic'. The probability of failure of the thrust reverser N1 inhibit function is 1.405E-08.

Dispatch with an Intermediate Manifold Temperature Sensor (High Pressure Shutoff Valve (HPSOV) closed), with associated bleed system used, will not result in an increase in core compartment pressure that will exceed the pressure limit.

Dispatch with an Intermediate Manifold Temperature Sensor inoperative (HPSOV locked closed) will cause the associated PRSOV to close at low N1 speeds which would normally result in increased pressure in the core compartment of the opposite engine due to the opposite FAMV being commanded more open. However, when using the APU to supply the ADPs during takeoff, the opposite FAMV on the opposite engine will be more closed than normal. Therefore, the pressure limit in the core compartment will not be exceeded which will mitigate the hazard.

36-23-01

Bleed Manifold Flow Sensors

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

New proposal for 777X.

The bleed manifold flow sensor consists of an ambient temperature sensing element, a wire-wound heater, and a heated temperature sensing element. The sensor is installed in the left and right manifold ducting on the wing upstream of the same side manifold pressure sensor and provides mass flow rate data for system built-in test purposes.

Consequences of Failure

Failure of a bleed manifold flow sensor is indicated by the BLEED FLOW MANF SENSOR L or R Status message.

Loss of mass flow data used for system built-in test. Loss of flow reading on the display. Pack inlet flow sensor is used as a backup for built in test but does not provide display data.

Consequences of Next Critical Failure

Loss of Pack inlet Flow sensor: Results in loss of bleed flow sensing and display of the associated PACK L or R Status message. System continues normal operation but with degraded system failure detection, isolation, and indication.

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38-10-01 Potable Water Systems**38-10-01A**

Interval	Installed	Required	Procedure
C	-	-	(M)

Individual components may be inoperative provided:

- Associated components are deactivated or isolated, and
- Associated system components are verified not to have leaks.

NOTE: Any portion of system which operates normally may be used.

38-10-01 Potable Water Systems**38-10-01B**

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided:

- System is drained, and
- Procedures are established to ensure that system is not serviced.

38-10-01 Potable Water Systems**38-10-01-01 Potable Water Indication System**

Interval	Installed	Required	Procedure
D	-	-	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 38-10-01.

Items 38-10-01A, 38-10-01B:

See FAA Policy Letter 83, Revision 7, dated January 24, 2013.

The Potable Water System provides servicing facilities, storage, distribution, thermal management, indication and aircraft wide system control of potable water for use in galleys, lavatories and humidification systems.

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Potable water is stored in three water tanks installed in the lower lobe of the airplane aft of the bulk cargo compartment. Three identical water tanks are installed. Each water tank has 130 US gallons useable volume. The airplane's total volume is 390 gallons. The tanks are equipped with fittings to attach the plumbing lines and to mount the level sensors. A level sensor is installed in each tank. During normal use, the tanks are vented to the cabin. The water tanks are new for the 777-9. The level sensing system is the same as the 777-300ER.

The two centrifugal potable water pumps, each capable of delivering approximately 3.5 gallons per minute at 35 pounds per square inch gauge (psig), continuously pressurize the water in the distribution system. Water is gravity fed from the tanks to the water pumps. An orificed line returns a small amount of water to the tanks. Self-draining check valves are installed to permit alternate operation to optimize pump life and still allow complete system drainage. In addition, a pressure switch is installed in the circulation line to monitor system pressure. One pump operates continuously to maintain system pressure. The second pump is used as a backup and to assist in powered drainage of the system. The pumps are switched off if there is no water in the system. The pumps alternate operation on successive flights. The water pressurization system is the same as the 777-300ER.

Consequences of Failure

System inoperative: None. Inoperative components or entire system is deactivated and verified not to leak.

Indication system inoperative: None. The system is not required in operation.

Consequences of Next Critical Failure

None.

38-30-01 Waste Water Systems**38-30-01A**

Interval	Installed	Required	Procedure
C	-	-	(M)

Individual components may be inoperative provided:

- Associated components are deactivated or isolated, and
- Associated system components are verified not to have leaks.

NOTE: Any portion of system which operates normally may be used.

38-30-01 Waste Water Systems**38-30-01B**

Interval	Installed	Required	Procedure
C	-	-	(M)

Associated lavatory system may be inoperative provided:

- Associated components are deactivated or isolated to prevent leaks, and
- Associated lavatory door is secured closed and placarded, "INOPERATIVE - DO NOT ENTER".

NOTE: These provisions are not intended to prohibit inspections by crewmembers.

38-30-01 Waste Water Systems**38-30-01-01 Vacuum Blowers**

Interval	Installed	Required	Procedure
C	2	-	(M) (O)

May be inoperative provided:

- Associated vacuum blower is deactivated, and
 - Lavatories affected by inoperative vacuum blower are not used on the ground or at flight altitudes at 16,000 feet MSL or below.
-

38-30-01 Waste Water Systems**38-30-01-02 Waste Tanks**

Interval	Installed	Required	Procedure
C	2	-	(M)

May be inoperative provided:

- Associated waste tank(s) is deactivated, and
- Associated components are deactivated or isolated to prevent leaks.
- Associated lavatory door(s) is secured closed and placarded, "INOPERATIVE - DO NOT ENTER".

NOTE: These provisions are not intended to prohibit inspections by crewmembers.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 38-30-01 and 787 MMEL item 38-30-01-01. 38-30-01A & 38-30-01B

FAA Policy Letter 83, Revision 8, dated 5/11/2015.

The gray water drain system is used to collect the waste water from the lavatory sinks, galleys and humidifiers and drain it overboard through two heated drain masts. The drain masts are located to minimize impingement of the drained fluid on the airplane's outer surfaces. The forward drain masts is in the same relative position to the wings and fairing panels and the aft drain mast is in the same relative position to the tail as the 777-300ER. The forward drain mast is installed on the wing-to-body fairing which is a flammable leakage zone. The gray water drain lines are sloped to allow gravity drainage. Gray water drain lines in cold areas are heated to prevent freezing. (Inoperative drain mast heaters are addressed in MMEL item 30-71-01.)

The waste water system for the 777-9 is divided into two independent subsystems – balancing the lavatories and galleys to the greatest extent possible to provide even filling of the waste tanks. Each subsystem has a dedicated vacuum generator and waste tank. Vacuum control is independent for each subsystem. This system architecture is different from the 777-300ER which has three waste tanks. With a vacuum generator inoperative, the associated lavatories and sinks must not be used until differential pressure is sufficient. This typically will be at flight altitudes at or above 16,000 feet.

The vacuum waste system is used to collect the waste from the toilets. The vacuum waste system uses differential pressure to move waste water from toilets to common storage tanks. The vacuum waste system is also used to collect waste from the galleys if equipped with the galley waste disposal system. During flight at cruise altitudes, the waste system will use cabin to ambient differential pressure to transport waste from toilets in the lavatories and/or to waste tanks located aft of the cargo compartment. For ground and low altitude operation, vacuum generators will be used to create needed system differential pressure. The vacuum generators are an on demand system only operating when a toilet is flushed.

The following subsystems are included in the waste water systems: gray water drain system, vacuum toilet assembly, waste tank, vacuum blower and filter, vacuum blower barometric switch, vacuum check valve, vacuum waste system tubing, liquid separator, waste tank drain ball-valve, waste drain valve assembly, waste tank rinse fitting assembly, waste tank rinse filter, waste tank rinse nozzle, and waste tank quantity indication.

Consequences of Failure

System inoperative: None. Inoperative components or entire system is deactivated and verified not to leak.

Vacuum Blowers inoperative: Affected lav(s) only used at flight altitudes where differential pressure is sufficient for system operation.

Waste tanks inoperative: Associated waste tanks are deactivated and associated waste water components are deactivated or isolated.

Consequences of Next Critical Failure

None.

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42-21-01 Common Computing Resource (CCR) General Processing Modules (GPM)

42-21-01-01 GPM L1

42-21-01-02 GPMs L2, L3, R1, R2 & R3

42-21-01-03 GPM L4

42-21-01-04 GPM R4

42-21-02 Remote Data Concentrators (RDC)

42-21-02-01 RDC 1

42-21-02-02 RDC 2

42-21-02-03 RDC 3

42-21-02-04 RDC 4

42-21-02-05 RDC 5

42-21-02-06 RDC 6

42-21-03 CCS ARINC 664 Network Remote Switch (ARS)

42-21-04 ARINC 664 Network Cabinet Switch (ACS)

42-21-05 CCS ARINC 664 Fiber Optic Translators (FOX)

42-21-06 CCS Power Conditioning Modules (PCM)

42-21-07 AIRPLANE POWER CYCLE Status message

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42-21-01 Common Computing Resource (CCR) General Processing Modules (GPM)**42-21-01-01 GPM L1**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Remaining GPMs operate normally,
 - Remaining Common Core System (CCS) equipment operates normally, and
 - Center Flight Management Function (FMF) is considered inoperative.
-

42-21-01 Common Computing Resource (CCR) General Processing Modules (GPM)**42-21-01-02 GPMs L2, L3, R1, R2 & R3**

Interval	Installed	Required	Procedure
C	5	4	

One may be inoperative provided:

- Remaining GPMs operate normally, and
 - Remaining Common Core System (CCS) equipment operates normally.
-

42-21-01 Common Computing Resource (CCR) General Processing Modules (GPM)**42-21-01-03 GPM L4**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Remaining GPMs operate normally,
 - Remaining Common Core System (CCS) equipment operates normally,
 - Left Flight Management Function (FMF) is considered inoperative, and
 - Left Communication Management System (Data Link) is considered inoperative.
-

42-21-01 Common Computing Resource (CCR) General Processing Modules (GPM)**42-21-01-04 GPM R4**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Remaining GPMs operate normally,
- Remaining Common Core System (CCS) equipment operates normally,
- Right Flight Management Function (FMF) is considered inoperative, and
- Right Communication Management System (Data Link) is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 42-21-01.

The 777-9 Common Core System (CCS) consists of two Common Computing Resource (CCR) cabinets, four Avionics Remote Switches (ARS), and six Remote Data Concentrators (RDC). Each CCR has two Avionics Cabinet Switches (ACS), two Power Conditioning Modules (PCM), two Fiber Optic Translator Modules (FOX), and four General Processing Modules (GPM).

The CCR, PCM, GPM and RDC parts are new for the 777-9. The ARS, ACS and FOX parts are identical to the equipment in in CCS on the 787.

The CCS is an integrated modular avionics (IMA) architecture that provides a set of shared computing, networking, and input/output resources to support the computing and system interface needs for multiple airplane systems. For functions hosted on CCS, the following services are provided:

- Data load of loadable software parts onto the shared computing resources.
- Reporting of installed software configurations on each shared computing resource.
- Fault detection, isolation, and reporting on shared computing hardware.
- Sufficient redundancy in shared resources to meet any availability requirements.
- Non-volatile memory (NVM) access on shared computing resources.
- Communication services between hosted functions.
- Dedicated physical input/output (I/O) interfaces.

Additionally, CCS provides the means for hosted functions of all criticalities to safely share the same physical resources. The three key architectural design elements of CCS are:

- Common Computing Resource (CCR)
- Common Data Network (CDN)

- Remote Data Concentrators (RDC)

The CCR is a modular and configurable design. The planned configuration consists of two CCR cabinets, each with eight General Processing (computing) Modules (GPM) slots, two Power Conditioning Modules (PCM), two internal CDN switches (ACS), and two Fiber Optic Translators (FOX). For the 777-9, only 4 of the GPM slots are populated. Slots supporting GPMs could also support third party application specific modules (ASM). ASM certification is the responsibility of the ASM supplier, and these will not be certified as part of the CCR platform. One ASM already identified is the graphics generator module (GGM) used by the displays system with two double wide slots provided for it in the CCR.

The CDN consists of ARSs, ACSs, FOXs, and CDN fiber or copper connections. These devices control the movement of data on the network between LRUs, CCR Cabinets and RDCs.

The network communication protocol conforms to ARINC 664, Part 7. This is derived from commercial Ethernet standards (Institute for Electrical and Electronics Engineers (IEEE) 802 & Request for Conformity (RFC) 1122). This is a unified network supporting both high-speed (100 Megabytes per second (Mbps)) connections and low-speed (10 Mbps) connections. High speed data outside the cabinet will be transmitted over fiber optic cable for any switch-to-switch traffic and most LRUs. Copper wire will be used for all low-speed data and for the switch to RDC network connections.

The network is configured in a dual redundant arrangement. Two sets of independent switches provide an A channel and B channel to the network. Only under very limited conditions are messages transmitted on a single channel; however, the majority of the users will be using both channels. Physical separation on the airplane of both the switches and wiring is employed to ensure that at least one channel continues to operate regardless of the occurrence of a non-catastrophic event.

The General Processing Module (GPM) is a fully self-monitored, high integrity computing platform supporting multiple independent software applications. In order to support multiple independent software applications running on this common computing platform, the platform must provide a robustly partitioned environment. This consists of a set of partitioning services and a means of detecting failures of the platform which compromise the partitioning services resulting in corrupted I/O or other malfunctions.

For 777-9, the following avionics functions have applications hosted on the GPMs: communication & audio, crew alerting/warning, flight management & navigation, maintenance & data loading, primary displays, and thrust management & autothrottle.

For 777-300ER, the following avionics applications are hosted in the AIMS cabinet: Displays, engine indicating functions, flight management function, thrust management function, central maintenance function, aircraft monitoring function, and the flight deck communications function.

Consequences of Failure**GPM L1:**

Inoperative GPM L1 is indicated by the CCR GPM L1 Status message. Center Flight Management Function (FMF) will be inoperative. Left and Right FMF remain operative. Remaining consequences result in loss of redundancy only. Hazard condition is 'Minor'.

GPM L2:

Inoperative GPM L2 is indicated by the CCR GPM L2 Status message. Loss of redundancy only. Hazard condition is 'Minor'.

GPM L3:

Inoperative GPM L3 is indicated by the CCR GPM L3 Status message. Loss of redundancy only. Hazard condition is 'Minor'.

GPM L4:

Inoperative GPM L4 is indicated by the CCR GPM L4 Status message. Left Flight Management Function (FMF) will be inoperative. Center and Right FMF remain operative. Left Communication Management System (Data Link) will be inoperative. Right Data Link remains operative. Remaining consequences result in loss of redundancy only. Hazard condition is 'Minor'.

GPM R1:

Inoperative GPM R1 is indicated by the CCR GPM R1 Status message. Loss of redundancy only. Hazard condition is 'Minor'.

GPM R2:

Inoperative GPM R2 is indicated by the CCR GPM R2 Status message. Loss of redundancy only. Hazard condition is 'Minor'.

GPM R3:

Inoperative GPM R3 is indicated by the CCR GPM R3 Status message. Loss of redundancy only. Hazard condition is 'Minor'.

GPM R4:

Inoperative GPM R4 is indicated by the CCR GPM R4 Status message. Right Flight Management Function (FMF) will be inoperative. Left and Center FMF remain operative. Right Communication Management System (Data Link) will be inoperative. Left Data Link remains operative. Remaining consequences result in loss of redundancy only. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

NOTE: 'Central' Computing Resource: The Common Core System provides three functions: Computing, Data Transport, and Input/Output functions. Loss of 'Central' Computing Resource refers to the loss of any one or more of these three functions. This is not to be confused with 'Common' Computing Resource (CCR). Common Computing Resource refers to the two cabinets that hold most of the CCS components (GPMs, GGMs, ACSs, FOXs, PCMs).

Loss of Central Computing Resource:

Loss of Central Computing Resource FTA is impacted by dispatch with one GPM inoperative, however, review of the associated fault tree analysis, assuming dispatch with an inoperative GPM shows that an acceptable level of safety is maintained.

The loss of the central computing resource results in a 'Catastrophic' hazard classification.

When dispatching with an inoperative GPM, the probability of additional failures resulting in loss of Central Computing Resource is extremely improbable (probability is on the order of $8.4E-11$).

Loss of All Computing Resources:

Loss of All Computing Resources FTA is impacted by operation with one GPM inoperative, however, review of the associated fault tree analysis, assuming dispatch with an inoperative GPM shows that an acceptable level of safety is maintained.

The loss of All Computing Resources results in a 'Hazardous' hazard classification.

When dispatching with an inoperative GPM, the probability of additional failures resulting in Loss of All Computing Resources is extremely improbable (probability is on the order of $5.1E-11$).

Loss of Opposite Common Computing Resource (CCR) Cabinet:

Failure of the opposite CCR cabinet results in loss of all the opposite side GPMs.

GPM L1 and Right CCR:

Inoperative GPM L1 and Right CCR is indicated by the CCR GPM L1 and CCR CABINET R Status messages.

Two Flight Management Functions will be inoperative.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Right Forward Audio Gateway Unit results in loss of audio for Right MMR, Right ADF, and Right DME. No impact to HF and VHF.

Loss of right Communications Management Function. ATN CPDLC may be lost.

Hazard condition is 'Major'.

GPM L2 and Right CCR:

Inoperative GPM L2 and Right CCR is indicated by the CCR GPM L2 and CCR CABINET R Status messages.

Loss of both Captain's and First Officer's stick shaker motor functions.

Loss of all configuration warning functionality.

Brake to Exit (BTE) will be inoperative.

Integrated Standby Flight Display (ISFD) heading display will default to

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magnetic heading (NORM) and will not respond to changes in the heading reference FD switch.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Right Forward Audio Gateway Unit results in loss of audio for Right MMR, Right ADF, and Right DME. No impact to HF and VHF.

Loss of right Communications Management Function. ATN CPDLC may be lost.

Hazard condition is 'Major'.

GPM L3 and Right CCR:

Inoperative GPM L3 and Right CCR is indicated by the CCR GPM L3 and CCR CABINET R Status messages.

Loss of both Captain's and First Officer's stick shaker motor functions.

Loss of all configuration warning functionality.

Brake to Exit (BTE) will be inoperative.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Right Forward Audio Gateway Unit results in loss of audio for Right MMR, Right ADF, and Right DME. No impact to HF and VHF.

Loss of right Communications Management Function. ATN CPDLC may be lost.

Loss of SATCOM datalink functionality.

Hazard condition is 'Major'.

GPM L4 and Right CCR:

Inoperative GPM L4 and Right CCR is indicated by the CCR GPM L4 and CCR CABINET R Status messages.

All Communications Management Functions will be inoperative. Loss of all datalinks. Display COMM pages will be blank.

Loss of all SATCOM. SATCOM FAIL Advisory message will be displayed.

Thrust Management Function (TMF) will be inoperative. Autothrottle and thrust limits will not be available.

Two Flight Management Functions will be inoperative.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Right Forward Audio Gateway Unit results in loss of audio for Right MMR, Right ADF, and Right DME. No impact to HF and VHF.

Hazard condition is 'Hazardous', however, the probability of the next critical failure is extremely remote ($<1.0E-07$): Excessive workload due to EICAS associated Non-Normal Checklists accomplishment, manual control of thrust, increased awareness regarding EGT limits and N1 commanded positions during takeoff, manual control of aircraft given LNAV/VNAV mode fail until re-engaging, and re-planning RNP procedures coordinating with ATC, alongside displays' information readjusting given loss of lower MFD, combined with Flight plan update, activation, and execution. This scenario could lead to a go-around during final approach.

GPM R1 and Left CCR:

Inoperative GPM R1 and Left CCR is indicated by the CCR GPM R1 and CCR CABINET L Status messages.

Loss of all P5 overhead panel digital data results in loss of ability to reconfigure airplane using P5 panel switches.

EEC increases flight idle to high idle when not configured for approach/landing and not in icing conditions (flaps <22, gear up).

Two Flight Management Functions will be inoperative.

Integrated Stand by Flight Display (ISFD) heading display will default to magnetic heading (NORM) and will not respond to changes in the heading reference overhead panel switch.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Left Forward Audio Gateway Unit results in loss of audio for left MMR, left ADF, left DME and left VHF.

Loss of left Communications Management Function. ATN CPDLC may be lost.

Hazard condition is 'Major'.

GPM R2 and Left CCR:

Inoperative GPM R2 and Left CCR is indicated by the CCR GPM R2 and CCR CABINET L Status messages.

Captain's side surveillance (GPWS, TAWS, TCAS, WXR) will be inoperative. Loss of WXR using TCP-L.

Captain and First Officer stick shaker motors will be inoperative. PFD indications will still be available.

Loss of all Configuration Warning Functions.

Brake-to-Exit (BTE) will be inoperative.

Two Flight Management Functions will be inoperative.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative.

Loss of Left Forward Audio Gateway Unit results in loss of audio for left MMR, left ADF, left DME and left VHF.

Left Communications Management Function will be inoperative. ATN CPDLC may be lost. SATCOM data link will be inoperative.

Hazard condition is 'Major'.

GPM R3 and Left CCR:

Inoperative GPM R3 and Left CCR is indicated by the CCR GPM R3 and CCR CABINET L Status messages.

Electronic Checklist (ECL) will be inoperative.

FO Weather Radar selections from TCP-C and TCP-R will be inoperative.

Captain and First Officer stick shaker motors will be inoperative.

Loss of all Configuration Warning Functions.

Takeoff, Landing, In-Flight speedbrake and overspeed warnings will be

inoperative.

Master Warning Light (MWL) and Master Caution Light (MCL) functions will be inoperative.

Brake-to-Exit (BTE) will be inoperative.

Two Flight Management Functions will be inoperative.

Both HUDs (if installed) will be inoperative.

Lower Center Display will be blank/inoperative.

Forward Left Audio Gateway Unit (AGU-FWD-L) CDN communication will be inoperative. MMR-L, Loss of Left Forward Audio Gateway Unit results in loss of audio for left MMR, left ADF, left DME and left VHF.

Left Communications Management Function will be inoperative. ATN CP-DLC may be lost.

Hazard condition is 'Major'.

GPM R4 and Left CCR:

Inoperative GPM R4 and Left CCR is indicated by the CCR GPM R4 and CCR CABINET L Status messages.

CAPT Weather Radar selections from TCP-L and TCP-C will be inoperative.

Autothrottle will be inoperative.

SATCOM will be inoperative.

All Flight Management Functions will be inoperative.

All Communications Management Functions will be inoperative. Loss of HF/VHF datalink.

No Tuning data available to DME and ADF.

Loss of means to set fuel quantity in FMC.

Pilot will need to address alternate means of navigation.

WINGTIPS NOT FOLDED indication will be inoperative. No effect unless there is an addition failure in the FWT system.

Loss of TEVC due to gross weight invalid results in increased drag/fuel consumption.

Loss of EEC signals resulting in EEC N1 target transmitted as NCD and no annunciation of T/O THRUST DISAGREE Advisory message.

Loss of LNAV/VNAV mode.

Brake-to-Exit (BTE) will be inoperative.

Both HUDs (if installed) will be inoperative.

Lower Center Display will be blank/inoperative.

Loss of Left Forward Audio Gateway Unit results in loss of audio for left MMR, left ADF, left DME and left VHF.

Hazard condition is 'Major' for all the above consequences.

Hazard condition is 'Hazardous' only for RNP AR operations less than 0.3.

However, the probability of the next critical failure is extremely remote (<1.0E-07).

42-21-02 Remote Data Concentrators (RDC)**42-21-02-01 RDC 1**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- RDC 1 is deactivated,
 - Remaining RDCs operate normally,
 - Remaining Common Core System (CCS) equipment operates normally,
 - Left Hydraulic Engine Driven Pump (EDP) Temperature Indication L1 is considered inoperative,
 - Right Engine Anti-Ice (EAI) Indication Pressure Sensor R3 is considered inoperative, and
 - Total Air Temperature (TAT) Probe Element 1 is considered inoperative.
-

42-21-02 Remote Data Concentrators (RDC)**42-21-02-02 RDC 2**

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- RDC 2 is deactivated,
 - Remaining RDCs operate normally,
 - Remaining Common Core System (CCS) equipment operates normally,
 - Right Tuning and Control Panel (TCP) is considered inoperative,
 - Primary Flight Control System (PFCS) Interface is considered inoperative,
 - Right Hydraulic Engine Driven Pump (EDP) Temperature Indication R1 is considered inoperative,
 - Wing Anti-Ice (WAI) Indication Pressure Sensor R2 is considered inoperative,
 - One Right Wing Anti-Ice (WAI) Temperature Sensor Channel is considered inoperative,
 - Left Engine Anti-Ice (EAI) Indication Pressure Sensor L4 is considered inoperative,
 - Nitrogen Generation System (NGS) is considered inoperative, and
 - Repairs are made within 10 flight-days.
-

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42-21-02 Remote Data Concentrators (RDC)

42-21-02-03 RDC 3

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- RDC 3 is deactivated,
- Remaining RDCs operate normally,
- Remaining Common Core System (CCS) equipment operates normally,
- Left Hydraulic System Temperature Transducer is considered inoperative,
- Wing Anti-Ice (WAI) Indication Pressure Sensor L2 is considered inoperative,
- One Left Wing Anti-Ice (WAI) Temperature Sensor Channel is considered inoperative,
- Left Engine Anti-Ice (EAI) Indication Pressure Sensor L3 is considered inoperative,
- Crew Oxygen Pressure Indication System is considered inoperative,
- Nitrogen Generation System (NGS) is considered inoperative,
- Left Flight Deck Window Indication System (Side - No. 2) is considered inoperative, and
- Repairs are made within 10 flight-days.

42-21-02 Remote Data Concentrators (RDC)

42-21-02-04 RDC 4

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- RDC 4 is deactivated,
- Remaining RDCs operate normally,
- Remaining Common Core System (CCS) equipment operates normally,
- Center Hydraulic System Temperature Transducer is considered inoperative,
- Right Hydraulic System Temperature Transducer is considered inoperative,
- Wing Anti-Ice (WAI) Indication Pressure Sensor L3 is considered inoperative,
- One Left Wing Anti-Ice (WAI) Temperature Sensor Channel is considered inoperative,
- Crew Oxygen Pressure Indication System is considered inoperative,
- Nitrogen Generation System (NGS) is considered inoperative,

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- j. Right Flight Deck Window Indication System (Side - No. 2) is considered inoperative, and
 - k. Repairs are made within 10 flight-days.
-

42-21-02 Remote Data Concentrators (RDC)**42-21-02-05 RDC 5**

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- a. RDC 5 is deactivated,
 - b. Remaining RDCs operate normally,
 - c. Remaining Common Core System (CCS) equipment operates normally,
 - d. Center Tuning and Control Panel (TCP) is considered inoperative,
 - e. Left Hydraulic Engine Driven Pump (EDP) Temperature Indication L2 is considered inoperative,
 - f. Total Air Temperature (TAT) Probe Element 2 is considered inoperative,
 - g. Crew Oxygen Pressure Indication System is considered inoperative,
 - h. One Left Bleed Air Intermediate Temperature Sensor Channel is considered inoperative,
 - i. Nitrogen Generation System (NGS) is considered inoperative, and
 - j. Repairs are made within 10 flight-days.
-

42-21-02 Remote Data Concentrators (RDC)**42-21-02-06 RDC 6**

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- a. RDC 6 is deactivated,
- b. Remaining RDCs operate normally,
- c. Remaining Common Core System (CCS) equipment operates normally,
- d. Right Hydraulic Engine Driven Pump (EDP) Temperature Indication R2 is considered inoperative,
- e. Wing Anti-Ice (WAI) Indication Pressure Sensor R3 is considered inoperative,
- f. One Right Wing Anti-Ice (WAI) Temperature Sensor Channel is considered inoperative,

- g. Right Engine Anti-Ice (EAI) Indication Pressure Sensor R4 is considered inoperative,
- h. Nose Wheel Steering Pressure Sensor is considered inoperative,
- i. Alerting and Transponder Control Panel is considered inoperative,
- j. One Right Bleed Air Intermediate Temperature Sensor Channel is considered inoperative,
- k. Nitrogen Generation System (NGS) is considered inoperative, and
- l. Repairs are made within 10 flight-days.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 42-21-02.

For a general description of the Common Core System, see discussion under item 42-21-01, General Processing Modules (GPM).

The RDC provides I/O processing and data consolidation to minimized wire runs on the airplane. Analog data is converted to digital and transmitted to its hosted function via the CDN. In addition data from ARINC 429, ARINC 629 and CAN buses are converted to CDN data payloads and transmitted to their destinations via the CDN network. The RDC provides a gateway between ARINC 429, ARINC 629 and CAN data buses and the CDN to support communication with non-network devices. In addition the RDC provides a variety of analog I/O to drive hardware owned by a hosted function.

The RDC uses dual microprocessors as well as a high integrity End System. This provides high integrity processing and CDN interface. The analog I/O is grouped into "independent fault zones" or IFZs. The IFZ segregates sets of I/O components such that faults within one zone affect only that zone. The RDC and its IFZs are designed to meet the requirement that the probability rate of undetected corrupted data from two or more IFZs within a single RDC at the same time is less than 1E-10 per flight hour.

With high integrity processing and IFZs, the RDC can be viewed as multiple independent I/O channels. This means multiple critical systems can share a common RDC with the knowledge that having multiple functions experience corrupted data simultaneously is extremely improbable. However, since there are common failure modes that can render the entire RDC inoperative, allocation of functions to RDCs must consider availability issues.

Consequences of Failure

RDC 1:

Inoperative RDC 1 is indicated by the CCS RDC 1 Status message. The following functions will also be inoperative:

TAT Probe Element 1 - TAT ELEMENT 1 Status message will be displayed.

DATALINK LOST Advisory message will be displayed in no other media link is available.

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Right Engine Anti-Ice (EAI) Indication Pressure Sensor R3 - EAI IND PRESS SENSOR R3 Status message will be displayed.
Hazard condition is 'Minor'.

RDC 2:

Inoperative RDC 2 is indicated by the CCS RDC 2 Status message. The following functions will also be inoperative:

Right Tuning and Control Panel (TCP-R) - TCP R Status message will be displayed.

PFCS Interface - PFCS INTERFACE Status message will be displayed.

Wing Anti-Ice (WAI) Indication Pressure Sensor R2 - WAI IND PRESS SENSOR R2 Status message will be displayed.

Wing Anti-Ice (WAI) Right Temperature Sensor Channel - WAI TEMP SENSOR CHAN R will be displayed

Left Engine Anti-Ice (EAI) Indication Pressure Sensor L4 - EAI IND PRESS SENSOR L4 Status message will be displayed.

Nitrogen Generation System - NITROGEN GEN SYS Status message will be displayed.

Repair interval for RDC 2 is Category 'A', 10 flight-days, to match the NGS MMEL item repair interval.

Hazard condition is 'Minor'.

RDC 3:

Inoperative RDC 3 is indicated by the CCS RDC 3 Status message. The following functions will be inoperative:

Wing Anti-Ice (WAI) Indication Pressure Sensor L2 - WAI IND PRESS SENSOR L2 Status message will be displayed.

One Wing Anti-Ice (WAI) Left Temperature Sensor Channel - WAI TEMP SENSOR CHAN L will be displayed.

Left Engine Anti-Ice (EAI) Indication Pressure Sensor L3 - EAI IND PRESS SENSOR L3 Status message will be displayed.

Crew Oxygen Pressure Indication System: For single crew oxygen cylinder installed, CREW OXYGEN LOW Advisory message will be inoperative. 'OXYGEN - CREW PRESS' reading on Status (STAT) display will be blank. For optional second crew oxygen cylinder installed, crew oxygen pressure will be available from optional second cylinder via RDC 4.

Nitrogen Generation System - NITROGEN GEN SYS Status message will be displayed.

Repair interval for RDC 3 is Category 'A', 10 flight-days, to match the NGS MMEL item repair interval.

Left Flight Deck Window System (Side - No. 2) - WINDOW OPEN FD L Advisory message will be inoperative.

HF-L page will not appear on CMCF.

Hazard condition is 'Minor'.

RDC 4:

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Inoperative RDC 4 is indicated by the CCS RDC 4 Status message. The following functions will be inoperative:

Wing Anti-Ice (WAI) Indication Pressure Sensor L3 - WAI IND PRESS SENSOR L3 Status message will be displayed.

One Wing Anti-Ice (WAI) Left Temperature Sensor Channel - WAI TEMP SENSOR CHAN L will be displayed.

Crew Oxygen Pressure Indication System - Oxygen cylinder pressure transducer data from optional second cylinder will not be available. Primary cylinder pressure transducer data will be available via RDC 5.

Nitrogen Generation System - NITROGEN GEN SYS Status message will be displayed.

Repair interval for RDC 4 is Category 'A', 10 flight-days, to match the NGS MMEL item repair interval.

Right Flight Deck Window System (Side - No. 2) - WINDOW OPEN FD R Advisory message will be inoperative.

Hazard condition is 'Minor'.

RDC 5:

Inoperative RDC 5 is indicated by the CCS RDC 5 Status message. The following functions will be inoperative:

Center Tuning and Control Panel (TCP-C) - TCP C Status message will be displayed. TCP FAIL C Advisory messages will be displayed.

TAT Probe Element 2 - TAT ELEMENT 2 Status message will be displayed.

Crew Oxygen Pressure Indication System - For single crew oxygen cylinder installed, CREW OXYGEN LOW Advisory message will be inoperative. 'OXYGEN - CREW PRESS' reading on Status (STAT) display will be blank. Oxygen cylinder pressure transducer data from primary cylinder will not be available. Optional second cylinder (if installed) pressure transducer data will be available via RDC 5.

Nitrogen Generation System - NITROGEN GEN SYS Status message will be displayed.

Repair interval for RDC 5 is Category 'A', 10 flight-days, to match the NGS MMEL item repair interval.

Hazard condition is 'Minor'.

RDC 6:

Inoperative RDC 6 is indicated by the CCS RDC 6 Status message. The following functions will be inoperative:

Wing Anti-Ice (WAI) Indication Pressure Sensor R3 - WAI IND PRESS SENSOR R3 Status message will be displayed.

One Wing Anti-Ice (WAI) Right Temperature Sensor Channel - WAI TEMP SENSOR CHAN R will be displayed.

Right Engine Anti-Ice (EAI) Indication Pressure Sensor R4 - EAI IND PRESS SENSOR R4 Status message will be displayed.

Nose Wheel Steering Pressure Sensor - Loss of nose steering low pres-

sure monitor. Loss of nose wheel steering rate jam isolation SOV monitor.
Loss of nose wheel steering rate jam component monitor.
Alerting and Transponder Control Panel - XPDR PANEL INOP Advisory message will be displayed.
Nitrogen Generation System - NITROGEN GEN SYS Status message will be displayed.
Repair interval for RDC 6 is Category 'A', 10 flight-days, to match the NGS MMEL item repair interval.
Hazard condition is 'Minor'.

Consequences of Next Critical Failure

NOTE: 'Central' Computing Resource: The Common Core System provides three functions: Computing, Data Transport, and Input/Output functions. Loss of 'Central' Computing Resource refers to the loss of any one or more of these three functions. This is not to be confused with 'Common' Computing Resource (CCR). Common Computing Resource refers to the two cabinets that hold most of the CCS components (GPMs, GGMs, ACSs, FOXs, PCMs).

'Loss or Malfunction of Central Computing Resource' is a next critical failure condition. The resulting in hazard condition is 'Catastrophic'. 'Loss or Malfunction of Central Computing Resource' be impacted by operation with one RDC inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative RDC. When dispatching with an inoperative RDC, the probability of additional failures resulting in 'Loss or Malfunction of Central Computing Resource' is extremely remote (probability on the order of $1.28E-8$). The maximum allowable dispatch time is calculated to be 4320 flight hours. Ref. AFHA_6.4.1.1, CCS_PLAT_LOSS_PFH.

'Loss of All I/O Conversion Resources' is a next critical failure condition. The resulting in hazard condition is 'Catastrophic'. 'Loss of All I/O Conversion Resources' may be impacted by operation with one RDC inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative RDC. When dispatching with an inoperative RDC, the probability of additional failures resulting in 'Loss of All I/O Conversion Resources' is extremely remote (probability on the order of $1.28E-8$). The maximum allowable dispatch time is calculated to be 4320 flight hours. Ref. CCS_FHA_3.1.1, CCS_IO_LOSS_PFH.

Failure of an additional RDC is also a next critical failure. The hazard conditions resulting from failure of any one failed RDC is no worse than 'Minor'. The hazard conditions resulting from failure of any two RDCs are generally the combined 'Minor' consequences of the two individual RDCs. However, failure of two RDCs, in some instances, can result failure conditions that may be worse than 'Minor'.

The following are the 'Major' hazard condition that result from the failure of any two RDCs. For failure of any two RDCs, there are no failure conditions that are worse than 'Major'.

Loss of RDC 1 and RDC 2:

Results in loss of interface with APU controller. APU will not start. If APU is supplying bleed air to ECS, ECS-ADP, and main engine start (MES) pneumatic modes are disabled. Loss of ability to respond to ADP pneumatic or electrical load, and inability to perform No Brake Power Transfer. APU status message will be set by DCA after 10 seconds if no communication from the APUC and APU control switch is ON. Hazard condition is 'Major'.

Results in loss of main gear steering takeoff configuration warning. CONFIG MAIN STEERING Warning message will be inoperative. Associated master warning light will not illuminate and aural siren will not sound if takeoff is attempted with main gear steering not locked. Hazard condition is 'Major'.

Results in loss of MMR and IRU data sources received via RDC 1 and 2. Loss of Terrain Awareness and Warning System (TAWS). Transponder Function will report associated ADS-B OUT EICAS messages as it will not have position data available from the GNSS. Loss of TCP-L and TCP-R data. TCP-C is still available via RDC 5. Loss of WXR when in the AUTO mode on the WXR Mode Selection page of any TCP. Manual Mode is not affected.

If AUTO mode is selected on the WXR Mode Control Page of any TCP, AUTOTILT FAIL will be displayed on Display Units currently showing WXR information. ADS-B IN displayed on displays with ADS-B IN (if installed).

TERR FAIL will display on Display Units. Following messages will be displayed:

ADS-B OUT FAIL (A), ADS-B OUT DATA L (S), ADS-B OUT DATA R (S), GND PROX SYS FAULT (A), GROUND PROXIMITY SYS R (S), GROUND PROXIMITY SYS L (S), TERR SYS R (S), TERR SYS L (S), WXR SYS FAULT (A).

Hazard condition is 'Major'.

The Ixx estimate used in P-Beta will default to a safe value. There may be slight control law performance degradation, but no material safety impact. The cold hydraulic function will be lost. All other effects will be limited to loss of redundancy or will only impact maintenance functionality. The following messages will be displayed:

PFCS INTERFACE (S), ELEC BACKUP DISC CTRL L (S).

Hazard condition is 'Major'. (for cold hydraulic function)

Autothrottle will disconnect. The following messages will be displayed: AUTOTHROTTLE INOP L (A), AUTOTHROTTLE INOP R (A), AUTO-

THROTTLE DISC (C).

Hazard condition is 'Major' (In approach and go-around phases). Hazard condition is 'Minor' for all other phases.

Loss of RDC 3 and RDC 4:

Loss of one source of ASCPC bleed temperature data. Redundant data is available through RDC 5.

Hazard condition is 'Minor' as airplane will not dispatch in this configuration.

Loss of RDC 5 and RDC 6:

Loss of brake source (BRAKE ACCUM ONLY) Advisory message. BRAKE SOURCE light is not affected. Loss of CONFIG PARKING BRAKE Warning message, Master Warning Light and Aural Siren. Loss of PARKING BRAKE SET Memo message. Hazard condition is 'Major'.

If center pitot clogs due to icing, ISFD will display erroneous airspeed. Hazard condition is 'Major'.

Loss of RDC 1 and RDC 4:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 1 and RDC 6:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 2 and RDC 3:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 2 and RDC 4:

If AOA SPD is displayed, the minimum maneuver speed (lower amber band) will not show on speedtape. Stick shaker speed (barber pole) will show and be correctly displayed. 'Major'

Loss of RDC 2 and RDC 5:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 2 and RDC 6:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 3 and RDC 6:

All hazard conditions are no worse than 'Minor'.

Loss of RDC 4 and RDC 6:

All hazard conditions are no worse than 'Minor'.

Draft
Feb 26, 2026

42-21-03 CCS ARINC 664 Network Remote Switch (ARS)

Interval	Installed	Required	Procedure
C	4	3	(M)

One may be inoperative provided:

- Inoperative CCS ARINC 664 Network Remote Switch (ARS) is deactivated, and
- Remaining common core system (CCS) equipment operates normally.

SUBSTANTIATION**Background**

For a general description of the Common Core System, see discussion under item 42-21-01, General Processing Modules (GPM).

There are four Network Remote Switches (ARS). Two ARSs are channel A and two ARSs are channel B.

There are four Network Cabinet Switches (ACS). Two ACSs are each CCR cabinet. In each CCR cabinet, one ACS is channel A and one ACS is channel B.

The cabinet switches are functionally identical to the remote switches; however, these cabinet switches are packaged to fit into one of the cabinet slots, share the CCR supplied power, and both high and low speed data buses within the cabinet are copper only. A fiber optic translator module provides the conversion from internal high speed copper to external high speed fiber.

Each switch contains 24 ports and each port can be either 10 Mbps (low speed) or 100 Mbps (high speed) based on the loaded configuration table. Each external switch contains four fiber ports and 20 copper ports. The 20 copper ports will be configured as either low or high speed, while the four fiber ports will be configured as high speed. Three of the fiber ports on each external switch are used for communication with other switches. The remaining fiber port in each switch is for use by other LRUs.

Since the cabinet provides a sufficient electromagnetic shield, the cabinet switch will have 20 of its copper ports configured for high speed and only four configured for either low or high speed. The four configurable speed ports will be made available to external LRUs such as the RDC. Eight of the high speed internal ports are used by the eight GPMs while two are used by the GGs. The remaining ten high speed internal ports go to the FOX module for translation to fiber. Four of these fiber ports are used to communicate with other switches and the remaining six in each cabinet are for use by other external LRUs.

Consequences of Failure

Network Remote Switch (ARS) L1A:

Inoperative CCS A664 Network Switch (ARS) L1A is indicated by the CCS REMOTE SWITCH L1A Status message. Results in loss of redun-

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dancy only. Hazard condition is 'Minor'.

Network Remote Switch (ARS) L2A:

Inoperative CCS A664 Network Switch (ARS) L2A is indicated by the CCS REMOTE SWITCH L2A Status message. Results in loss of redundancy only. Hazard condition is 'Minor'.

Network Remote Network Switch (ARS) R1B:

Inoperative CCS A664 Network Switch (ARS) R1B is indicated by the CCS REMOTE SWITCH R1B Status message. Results in loss of redundancy only. Hazard condition is 'Minor'.

Network Remote Switch (ARS) R2B:

Inoperative CCS A664 Network Switch (ARS) R2B is indicated by the CCS REMOTE SWITCH R2B Status message. Results in loss of redundancy only. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

NOTE: 'Central' Computing Resource: The Common Core System provides three functions: Computing, Data Transport, and Input/Output functions. Loss of 'Central' Computing Resource refers to the loss of any one or more of these three functions. This is not to be confused with 'Common' Computing Resource (CCR). Common Computing Resource refers to the two cabinets that hold most of the CCS components (GPMs, GGMs, ACSs, FOXs, PCMs).

Loss or malfunction of central computing resource is a next critical failure condition. The resulting in hazard condition is 'Catastrophic'. Loss or malfunction of central computing resource may be impacted by operation with one ARS inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative ARS. When dispatching with an inoperative ARS, the probability of additional failures resulting in loss or malfunction of central computing resource is extremely improbable (probability on the order of $2.7E-10$). Ref. AFHA_6.4.1.1, CCS_PLAT_LOSS_PFH.

Loss of all data transport resources is a next critical failure condition. The resulting hazard condition is 'Hazardous'. Loss of all data transport resources may be impacted by operation with one ARS inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative ARS. When dispatching with an inoperative ARS, the probability of additional failures resulting in loss of all data transport resources is extremely improbable (probability is on the order of $2.4E-10$). Ref. CCS_FHA_2.1.1, CCS_TRANSP_LOSS_PFH.

For operation with an inoperative ARINC 664 Remote Switch (ARS), the next critical failure also includes the loss of either an additional ARINC 664 Remote Switch (ARS) or an ARINC 664 Cabinet Switch (ACS). The consequences of any two inoperative ARSs or any ARS+ACS combination results in a hazard condition that is no worse than 'Major'. A summary of consequences for each ARS+ARS and ARS+ACS combination is as follows:

CCS-46: Loss of A664 Remote Switch (ARS) L1A and A664 Cabinet Switch (ACS) LB:

Inoperative Remote Switch L1A and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH L1A and CCR CABINET SWITCH LB Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded Captain ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-L, VHF-R, HF-R, SAT-R Ch#2, and Left Nav functions.

Loss of VHF-C inputs to CMF (loss of RDCs 1 and 5) results in loss of VHF-C for datalink. Loss of HF-L input and could result in loss of all HF datalink if HR-R is not installed.

If master is in left cabinet, APP TUNE DISAGREE message may be displayed.

Loss of ability to transmit/receive data on CDN CH-B. CSS still able to transmit/receive on CH-A.

Loss of left cabinet ability to drive Left Outboard Display (LOB) and Left EFIS/DCP.

Loss of NGS.

Loss of all CDN data to/from RDC 5.

Hazard condition is 'Major'.

CCS-47: Loss of A664 Remote Switch (ARS) L1A and A664 Cabinet Switch (ACS) RB:

Inoperative Remote Switch L1A and Cabinet Switch RB is indicated by the CCS REMOTE SWITCH L1A and CCR CABINET SWITCH RB Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded Captain ACP: Cannot use VHF-C, HF-L, SAT-L Ch#1, SAT-R Ch#1, and Right Nav functions.

Loss of VHF-C inputs to CMF (due to loss of RDCs 1 and 5). Loss of redundant path from RDCs 1 and 5 to right GGM (R1, R2). Loss of all CDN Ch A data to/from RDCs 1 and 5. GPMs R1 thru R4 and GGMs R1 and R2 will lose redundant cross cabinet data on Channel B.

If FMC-R is master: loss of tuning to MMR-L due to loss of FMC-R connection to RDCs 1 and 5. If FMF-R is master, DME-L/ADFS-L tuning inputs will be lost.

Hazard condition is 'Major'.

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CCS-48: Loss of A664 Remote Switch (ARS) L2A and A664 Cabinet Switch (ACS) LB:

Inoperative Remote Switch L2A and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH L2A and CCR CABINET SWITCH LB Status messages.

Loss of VOR/XLS data from MMR-R and loss of overall MMR-R state.

Loss of cabin interphone from TCP-R, PA announcements, and cabin interphone calls from flight interphone phone from FO position.

Degraded First Officer ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-L, VHF-R, HF-R, SAT-R Ch#2, and Left Nav functions.

Complete Loss of Flight Deck Left Window #2 indication data from RDC 3 to GPMs L2, L3, R2 & R3 when not closed/latched.

Loss of all CDN data to/from RDC 3.

Loss of crew oxygen pressure sensor inputs to DCA and fill gauge effector output from DCA.

EICAS messages:

GPS FAIL R (A), on CCR-R driven displays.

CCS-49: Loss of A664 Remote Switch (ARS) L2A and A664 Cabinet Switch (ACS) RB:

Inoperative Remote Switch L2A and Cabinet Switch RB is indicated by the CCS REMOTE SWITCH L2A and CCR CABINET SWITCH RB Status messages.

If primary FMF is in GPM R4: Loss of VOR/XLS data from MMR-R and overall state for MMR-R.

All navigation partitions use MMR-L for VOR/XLS data and GPS data.

Degraded First Officer ACP: Cannot use VHF-C, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Right Nav functions.

Loss of line pressure sensor 1 input to DCA CREW OXYGEN LOW advisory message is not displayed due to no data from RDC. Crew pressure display on STAT synoptic is blank.

Hazard condition is 'Major'.

CCS-50: Loss of A664 Remote Switch (ARS) R1B and A664 Cabinet Switch (ACS) LB:

Inoperative Remote Switch R1B and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH R1B and CCR CABINET SWITCH LB Status messages.

Loss of VOR/XLS data from MMR-L and loss of overall MMR-L state.

Degraded Captain's ACP: Cannot use VHF-C, VHF-L, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Left Nav functions.

Complete Loss of Flight Deck Right Window #2 indication data from RDC 4 to GPMs L2, L3, R2 & R3 when not closed/latched.

Hazard condition is 'Major'.

CCS-51: Loss of A664 Remote Switch (ARS) R1B and A664 Cabinet Switch (ACS) RA:

Inoperative Remote Switch R1B and Cabinet Switch RA is indicated by

the CCS REMOTE SWITCH R1B and CCR CABINET SWITCH RA Status messages.

If FMF Master is in GPM R4: Loss of VOR/XLS data from MMR-L and overall state.

Degraded Captain's ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-R, HF-R, SAT-R Ch#2, and Right Nav functions.

Degraded OBS ACP: Cannot communicate with CAPT on FLT interphone.

Loss of ability to make PA announcements and cabin interphone calls using Flight Interphone system from Captain position.

Cabin Interphone selections using TCP-L will not work as intended.

Hazard condition is 'Major'.

CCS-52: Loss of A664 Remote Switch (ARS) R2B and A664 Cabinet Switch (ACS) LA:

Inoperative Remote Switch R2B and Cabinet Switch LA is indicated by the CCS REMOTE SWITCH R2B and CCR CABINET SWITCH LA Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded First Officer ACP: Cannot use VHF-C, VHF-L, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Left Nav functions.

If FMF Master is in GPM L1 or L4: Input to FMF from Right MFK will be inoperative.

Loss of all CDN data to/from RDC 6.

Loss of EDP R2 temperature indication.

Some exterior lighting remains in last known state.

Hazard condition is 'Major'.

CCS-53: Loss of A664 Remote Switch (ARS) R2B and A664 Cabinet Switch (ACS) RA:

Inoperative Remote Switch R2B and Cabinet Switch RA is indicated by the CCS REMOTE SWITCH R2B and CCR CABINET SWITCH RA Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded First Officer's ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-R, HF-R, SAT-R Ch#2, and Right Nav functions.

Degraded OBS ACP: Cannot communicate with FO on FLT interphone.

Loss of ability to make PA announcements and cabin interphone calls using Flight Interphone system from First Officer position.

Cabin Interphone selections using TCP-R will not work as intended.

If FMF Master is in GPM R4: Input to FMF from Right MFK will be inoperative.

If the master is in the Right Cabinet, APP TUNE DISAGREE (A) message may be displayed.

Hazard condition is 'Major'.

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CCS-54: Loss of A664 Remote Switch (ARS) L1A and A664 Remote Switch (ARS) R2B:

Inoperative Remote Switch L1A and Remote Switch R2B is indicated by the CCS REMOTE SWITCH L1A and CCS REMOTE SWITCH R2B Status messages.

Loss of Flight Deck Interphone communication between Captain and First Officer.

Hazard condition is 'Major'.

CCS-55: Loss of A664 Remote Switch (ARS) L1A and A664 Remote Switch (ARS) R1B:

Inoperative Remote Switch L1A and Remote Switch R1B is indicated by the CCS REMOTE SWITCH L1A and CCS REMOTE SWITCH R1B Status messages.

Captain's Audio Control Panel will be inoperative.

Hazard condition is 'Major'.

CCS-56: Loss of A664 Remote Switch (ARS) L2A and A664 Remote Switch (ARS) R2B:

Inoperative Remote Switch L2A and Remote Switch R2B is indicated by the CCS REMOTE SWITCH L2A and CCS REMOTE SWITCH R2B Status messages.

First Officer's ACP will be inoperative.

Loss of all closed, latched, locked signals/warning from right side passenger doors.

Loss of NGS.

Cabin interphone selection using TCP-R will be inoperative.

HF datalink connections may be delayed.

Hazard condition is 'Major'.

CCS-57: Loss of A664 Remote Switch (ARS) L2A and A664 Remote Switch (ARS) R1B:

Inoperative Remote Switch L2A and Remote Switch R1B is indicated by the CCS REMOTE SWITCH L2A and CCS REMOTE SWITCH R1B Status messages.

Loss of Flight Deck Interphone communication between Captain and First Officer.

Hazard condition is 'Major'.

42-21-04

ARINC 664 Network Cabinet Switch (ACS)

Interval	Installed	Required	Procedure
C	4	3	(O)

One may be inoperative provided:

- Remaining common core system (CCS) equipment operates normally, and
- Appropriate Performance Based Navigation restrictions are applied.

SUBSTANTIATION

Background

New proposal for 777X.

For a general description of the Common Core System, see discussion under item 42-21-01, General Processing Modules (GPM).

There are four Network Remote Switches (ARS). Two ARSs are channel A and two ARSs are channel B.

There are four Network Cabinet Switches (ACS). Two ACSs are each CCR cabinet. In each CCR cabinet, one ACS is channel A and one ACS is channel B.

The cabinet switches are functionally identical to the remote switches; however, these cabinet switches are packaged to fit into one of the cabinet slots, share the CCR supplied power, and both high and low speed data buses within the cabinet are copper only. A fiber optic translator module provides the conversion from internal high speed copper to external high speed fiber.

Each switch contains 24 ports and each port can be either 10 Mbps (low speed) or 100 Mbps (high speed) based on the loaded configuration table. Each external switch contains four fiber ports and 20 copper ports. The 20 copper ports will be configured as either low or high speed, while the four fiber ports will be configured as high speed. Three of the fiber ports on each external switch are used for communication with other switches. The remaining fiber port in each switch is for use by other LRUs.

Since the cabinet provides a sufficient electromagnetic shield, the cabinet switch will have 20 of its copper ports configured for high speed and only four configured for either low or high speed. The four configurable speed ports will be made available to external LRUs such as the RDC. Eight of the high speed internal ports are used by the eight GPMs while two are used by the GGs. The remaining ten high speed internal ports go to the FOX module for translation to fiber. Four of these fiber ports are used to communicate with other switches and the remaining six in each cabinet are for use by other external LRUs.

Consequences of Failure

CCS-27: Loss of Common Data Network (CDN) A664 Cabinet Switch (ACS) LA:
Inoperative CCS A664 Cabinet Switch (ACS) LA is indicated for the CCR CABINET SWITCH LA Status message. A664 Cabinet Switch LA will be

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inoperative results in loss of data transfer in or out of ACS LA. All LRUs connected to ACS LA will lose data from Channel A. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-28: Loss of Common Data Network (CDN) A664 Cabinet Switch (ACS) LB: Inoperative CCS A664 Cabinet Switch (ACS) LB is indicated for the CCR CABINET SWITCH LB Status message. A664 Cabinet Switch LB will be inoperative results in loss of data transfer in or out of ACS LB. All LRUs connected to ACS LB will lose data from Channel B. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-29: Loss of Common Data Network (CDN) A664 Cabinet Switch (ACS) RA: Inoperative CCS A664 Cabinet Switch (ACS) RA is indicated for the CCR CABINET SWITCH RA Status message. A664 Cabinet Switch RA will be inoperative resulting in loss of data transfer in or out of ACS RA. All LRUs connected to ACS RA will lose data from Channel A. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-30: Loss of Common Data Network (CDN) A664 Cabinet Switch (ACS) RB: Inoperative CCS A664 Cabinet Switch (ACS) RB is indicated for the CCR CABINET SWITCH RB Status message. A664 Cabinet Switch RB will be inoperative resulting in loss of data transfer in or out of ACS RB. All LRUs connected to ACS RB will lose data from Channel B. Results in loss of redundancy only. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

NOTE: 'Central' Computing Resource: The Common Core System provides three functions: Computing, Data Transport, and Input/Output functions. Loss of 'Central' Computing Resource refers to the loss of any one or more of these three functions. This is not to be confused with 'Common' Computing Resource (CCR). Common Computing Resource refers to the two cabinets that hold most of the CCS components (GPMS, GGMS, ACSs, FOXs, PCMs).

Loss or malfunction of central computing resource is a next critical failure condition. The resulting in hazard condition is 'Catastrophic'. Loss or malfunction of central computing resource may be impacted by operation with one ACS inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative ACS. When dispatching with an inoperative ACS, the probability of additional failures resulting in loss or malfunction of central computing resource is extremely improbable (probability on the order of $2.3E-10$). Ref. AFHA_6.4.1.1, CCS_PLAT_LOSS_PFH.

Loss of all data transport resources is a next critical failure condition. The resulting hazard condition is 'Hazardous'. Loss of all data transport resources may be impacted by operation with one ACS inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative ACS. When dispatching with an inoperative ACS, the probability of additional failures resulting in loss of all data transport resources is extremely improbable (probability is on the order of $2.0E-10$). Ref. CCS_FHA_2.1.1, CCS_TRANSP_LOSS_PFH.

Loss of data transport between computing resources is a next critical failure condition. The resulting hazard condition is 'Hazardous' only for RNP AR operations with a minima less than 0.3. For all other operations, the hazard condition is 'Major'. Loss of data transport between computing resources may be impacted by operation with one ACS inoperative.

An acceptable level of safety can be shown provided RNP AR operations are not conducted with a minima less than 0.3. Ref. CCS_FHA_2.1.2, CCS_XLINK_LOSS_PFH, CCS-58 thru CCS-63.

For all combinations of an inoperative ACS and ARS, the consequences are no worse than 'Major'. Ref. CCS-46 thru CCS-53.

CCS-46: Loss of A664 Remote Switch (ARS) L1A and A664 Cabinet Switch (ACS) LB:

Inoperative Remote Switch L1A and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH L1A and CCR CABINET SWITCH LB Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded Captain ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-L, VHF-R, HF-R, SAT-R Ch#2, and Left Nav functions.

Loss of VHF-C inputs to CMF (loss of RDCs 1 and 5) results in loss of VHF-C for datalink. Loss of HF-L input and could result in loss of all HF datalink if HR-R is not installed.

If master is in left cabinet, APP TUNE DISAGREE message may be displayed.

Loss of ability to transmit/receive data on CDN CH-B. CSS still able to transmit/receive on CH-A.

Loss of left cabinet ability to drive Left Outboard Display (LOB) and Left EFIS/DCP.

Loss of NGS.

Loss of all CDN data to/from RDC 5.

Hazard condition is 'Major'.

CCS-47: Loss of A664 Remote Switch (ARS) L1A and A664 Cabinet Switch (ACS) RB:

Inoperative Remote Switch L1A and Cabinet Switch RB is indicated by the CCS REMOTE SWITCH L1A and CCR CABINET SWITCH RB Status messages.

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Loss of fail-operational and fail-passive Autoland above alert height.

Degraded Captain ACP: Cannot use VHF-C, HF-L, SAT-L Ch#1, SAT-R Ch#1, and Right Nav functions.

Loss of VHF-C inputs to CMF (due to loss of RDCs 1 and 5). Loss of redundant path from RDCs 1 and 5 to right GGM (R1, R2). Loss of all CDN Ch A data to/from RDCs 1 and 5. GPMs R1 thru R4 and GGMs R1 and R2 will lose redundant cross cabinet data on Channel B.

If FMC-R is master: loss of tuning to MMR-L due to loss of FMC-R connection to RDCs 1 and 5. If FMF-R is master, DME-L/ADFS-L tuning inputs will be lost.

Hazard condition is 'Major'.

CCS-48: Loss of A664 Remote Switch (ARS) L2A and A664 Cabinet Switch (ACS) LB:

Inoperative Remote Switch L2A and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH L2A and CCR CABINET SWITCH LB Status messages.

Loss of VOR/XLS data from MMR-R and loss of overall MMR-R state.

Loss of cabin interphone from TCP-R, PA announcements, and cabin interphone calls from flight interphone phone from FO position.

Degraded First Officer ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-L, VHF-R, HF-R, SAT-R Ch#2, and Left Nav functions.

Complete Loss of Flight Deck Left Window #2 indication data from RDC 3 to GPMs L2, L3, R2 & R3 when not closed/latched.

Loss of all CDN data to/from RDC 3.

Loss of crew oxygen pressure sensor inputs to DCA and fill gauge effector output from DCA.

EICAS messages:

GPS FAIL R (A), on CCR-R driven displays.

CCS-49: Loss of A664 Remote Switch (ARS) L2A and A664 Cabinet Switch (ACS) RB:

Inoperative Remote Switch L2A and Cabinet Switch RB is indicated by the CCS REMOTE SWITCH L2A and CCR CABINET SWITCH RB Status messages.

If primary FMF is in GPM_R4: Loss of VOR/XLS data from MMR-R and overall state for MMR-R.

All navigation partitions use MMR-L for VOR/XLS data and GPS data.

Degraded First Officer ACP: Cannot use VHF-C, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Right Nav functions.

Loss of line pressure sensor 1 input to DCA CREW OXYGEN LOW advisory message is not displayed due to no data from RDC. Crew pressure display on STAT synoptic is blank.

Hazard condition is 'Major'.

CCS-50: Loss of A664 Remote Switch (ARS) R1B and A664 Cabinet Switch (ACS) LB:

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Inoperative Remote Switch R1B and Cabinet Switch LB is indicated by the CCS REMOTE SWITCH R1B and CCR CABINET SWITCH LB Status messages.

Loss of VOR/XLS data from MMR-L and loss of overall MMR-L state.

Degraded Captain's ACP: Cannot use VHF-C, VHF-L, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Left Nav functions.

Complete Loss of Flight Deck Right Window #2 indication data from RDC 4 to GPMs L2, L3, R2 & R3 when not closed/latched.

Hazard condition is 'Major'.

CCS-51: Loss of A664 Remote Switch (ARS) R1B and A664 Cabinet Switch (ACS) RA:

Inoperative Remote Switch R1B and Cabinet Switch RA is indicated by the CCS REMOTE SWITCH R1B and CCR CABINET SWITCH RA Status messages.

If FMF Master is in GPM R4: Loss of VOR/XLS data from MMR-L and overall state.

Degraded Captain's ACP: Cannot use PA/CAB interphone. Cannot communicate with OBS on FLT interphone. Cannot use VHF-R, HF-R, SAT-R Ch#2, and Right Nav functions.

Degraded OBS ACP: Cannot communicate with CAPT on FLT interphone.

Loss of ability to make PA announcements and cabin interphone calls using Flight Interphone system from Captain position.

Cabin Interphone selections using TCP-L will not work as intended.

Hazard condition is 'Major'.

CCS-52: Loss of A664 Remote Switch (ARS) R2B and A664 Cabinet Switch (ACS) LA:

Inoperative Remote Switch R2B and Cabinet Switch LA is indicated by the CCS REMOTE SWITCH R2B and CCR CABINET SWITCH LA Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded First Officer ACP: Cannot use VHF-C, VHF-L, HF-L, SAT-R Ch#1, SAT-L Ch#1, and Left Nav functions.

If FMF Master is in GPM L1 or L4: Input to FMF from Right MFK will be inoperative.

Loss of all CDN data to/from RDC 6.

Loss of EDP R2 temperature indication.

Some exterior lighting remains in last known state.

Hazard condition is 'Major'.

CCS-53: Loss of A664 Remote Switch (ARS) R2B and A664 Cabinet Switch (ACS) RA:

Inoperative Remote Switch R2B and Cabinet Switch RA is indicated by the CCS REMOTE SWITCH R2B and CCR CABINET SWITCH RA Status messages.

Loss of fail-operational and fail-passive Autoland above alert height.

Degraded First Officer's ACP: Cannot use PA/CAB interphone. Cannot

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communicate with OBS on FLT interphone. Cannot use VHF-R, HF-R, SAT-R Ch#2, and Right Nav functions.

Degraded OBS ACP: Cannot communicate with FO on FLT interphone. Loss of ability to make PA announcements and cabin interphone calls using Flight Interphone system from First Officer position.

Cabin Interphone selections using TCP-R will not work as intended.

If FMF Master is in GPM R4: Input to FMF from Right MFK will be inoperative.

If the master is in the Right Cabinet, APP TUNE DISAGREE (A) message may be displayed.

Hazard condition is 'Major'.

CCS-58: Loss of A664 Cabinet Switch (ACS) LA and A664 Cabinet Switch (ACS) RB:

Inoperative Cabinet Switch LA and Cabinet Switch RB is indicated by the CCR CABINET SWITCH LA and CCR CABINET SWITCH RB Status messages. Two ACSs are inoperative and will not transfer data.

Both HUDs (if installed) will be inoperative.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides.

Autopilot will disconnect. TMF may indicate A/T disconnect and INOP on one side but will remain engaged. Decrease in EGT margins may result in limit exceedance.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 1, 4, and 6 to Right CCR:

Left GGMs will drive LOB, LIB, and RIB Display Units (DU); Right GGMs will drive ROB and Lower DUs.

Dual masters may result in several function not synchronized between the two sides: Cursors, ECL, Autobrake Switch, Sel LDG ALT, Fuel to Remain, MFD "Not Available" messages, CDU entered data, Aural.

Both HUDs (if installed) will be inoperative.

VHF-C and HF-L will be inoperative.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-59: Loss of A664 Cabinet Switch (ACS) LB and A664 Cabinet Switch (ACS) RA:

Inoperative Cabinet Switch LA and Cabinet Switch RB is indicated by the CCR CABINET SWITCH LA and CCR CABINET SWITCH RB Status messages. Two ACSs are inoperative and will not transfer data.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides:

Autothrottle will indicate disconnected and INOP on FO side, however it remains engaged until pilot takes over the manual control that discon-

nects the A/T.

Left and Right Nav Displays/FMFs become independent and unsynchronized.

Decrease in EGT margins may result in limit exceedance.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 3, 4, and 5 to Right CCR:

Left GGMs will drive LOB & LIB DUs; Right GGMs drive ROB, RIB, and Lower DUs.

Dual masters may result in several function not synchronized between the two sides: Cursors, ECL, Autobrake Switch, Sel LDG ALT, Fuel to Remain, MFD "Not Available" messages, CDU entered data, Aural.

Both HUDs (if installed) will be inoperative.

VHF-R and HF-R (if installed) will be inoperative.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-60: Loss of ACS LA + FOX LB:

Inoperative Cabinet Switch LA and Fiber Optic Translator LB is indicated by the CCR CABINET SWITCH LA and CCR FOX LB Status messages. The ACS and FOX will not transfer data.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides:

Autothrottle will disconnect. Decrease in EGT margins may result in limit exceedance. Autopilot will disconnect.

First Officer's HUD (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 1, 2, 4, and 6 to Left CCR:

Left GGMs will drive LOB & LIB DUs, and HUD-L; Right GGMs drive ROB & RIB DUs. Loss of synchronization for FMF/TMF, CMF L and CMF R, Cursors, ECL/Maint.

Loss of N1 trim.

ISS data only appears on First Officer's side DUs.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-61: Loss of ACS LB + FOX LA:

Inoperative Cabinet Switch LB and Fiber Optic Translator LA is indicated by the CCR CABINET SWITCH LB and CCR FOX LA Status messages. The ACS and FOX will not transfer data.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides:

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Autothrottle will disconnect. Decrease in EGT margins may result in limit exceedance. Autopilot will disconnect.

Both HUDs (if installed) will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 1, 2, 3, and 5 to Left CCR:

Left GGMs will drive only Lower DU; Right GGMs drive LOB, LIB, ROB & RIB DUs. Loss of synchronization for FMF/TMF, CMF L and CMF R, Cursors, ECL/Maint.

Loss of N1 trim.

ISS data only appears on First Officer's side DUs.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-62: Loss of ACS RA + FOX RB:

Inoperative Cabinet Switch RA and Fiber Optic Translator RB is indicated by the CCR CABINET SWITCH RA and CCR FOX RB Status messages.

The ACS and FOX will not transfer data.

Both HUDs (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules:

Left GGMs will drive LOB, LIB, ROB and RIB DUs; Right GGMs will not drive any displays (therefore no sync issues between displays). Loss of synchronization for CMF L and CMF R.

Loss of First Officer Master Warning/ Caution illumination.

Failure condition is 'Major'.

CCS-63: Loss of ACS RB + FOX RA:

Inoperative Cabinet Switch RB and Fiber Optic Translator RA is indicated by the CCR CABINET SWITCH RB and CCR FOX RA Status messages.

The ACS and FOX will not transfer data.

Both HUDs (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules:

Left GGMs will drive LOB, LIB, ROB and RIB DUs; Right GGMs will not drive any displays (therefore no sync issues between displays). Loss of synchronization for CMF L and CMF R.

Loss of First Officer Master Warning/ Caution illumination.

Failure condition is 'Major'.

42-21-05 CCS ARINC 664 Fiber Optic Translators (FOX)

Interval	Installed	Required	Procedure
C	4	3	(O)

One may be inoperative provided:

- Remaining common core system (CCS) equipment operates normally, and
- Appropriate Performance Based Navigation restrictions are applied.

SUBSTANTIATION**Background**

New proposal for 777X.

For a general description of the Common Core System, see discussion under item 42-21-01, General Processing Modules (GPM).

The Fiber Optic Translator (FOX) is a relatively simple device as its only job is to translate 100BaseX data between copper and optical media. This is accomplished with the use of two Physical Interface Devices (PHYs). Since the standard encoding bitstream for copper 100BaseT is not compatible with the standard 100BaseBX optical transceiver interface, PHYs are used to make that translation. For copper to fiber, the first PHY translates the Multi-Level Transmit (MLT)-3 signal to a media independent interface. This media independent interface is fed into another PHY which translates the information into low voltage pseudo emitter coupled logic (LVPECL) which is the standard interface for optical media. For fiber to copper, the process is simply reversed.

Consequences of Failure

CCS-31: Loss of Fiber Optic Translator (FOX) LA:

Inoperative Fiber Optic Translator LA is indicated by the CCR FOX LA Status message. Results in loss of ARINC 664 data in or out of FOX LA. All LRUs connected to FOX LA will lose data from Channel A. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-32: Loss of Fiber Optic Translator (FOX) LB:

Inoperative Fiber Optic Translator LB is indicated by the CCR FOX LB Status message. Results in loss of ARINC 664 data in or out of FOX LB. All LRUs connected to FOX LB will lose data from Channel B. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-33: Loss of Fiber Optic Translator (FOX) RA:

Inoperative Fiber Optic Translator RA is indicated by the CCR FOX RA Status message. Results in loss of ARINC 664 data in or out of FOX RA. All LRUs connected to FOX RA will lose data from Channel A. Results in loss of redundancy only. Hazard condition is 'Minor'.

CCS-34: Loss of Fiber Optic Translator (FOX) RB:

Inoperative Fiber Optic Translator RB is indicated by the CCR FOX RB

Status message. Results in loss of ARINC 664 data in or out of FOX RB. All LRUs connected to FOX RB will lose data from Channel B. Results in loss of redundancy only. Hazard condition is 'Minor'.

Consequences of Next Critical Failure

NOTE: 'Central' Computing Resource: The Common Core System provides three functions: Computing, Data Transport, and Input/Output functions. Loss of 'Central' Computing Resource refers to the loss of any one or more of these three functions. This is not to be confused with 'Common' Computing Resource (CCR). Common Computing Resource refers to the two cabinets that hold most of the CCS components (GPMs, GGMs, ACSs, FOXs, PCMs).

Loss or malfunction of central computing resource is a next critical failure condition. The resulting in hazard condition is 'Catastrophic'. Loss or malfunction of central computing resource may be impacted by operation with one FOX inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative FOX. When dispatching with an inoperative FOX, the probability of additional failures resulting in loss or malfunction of central computing resource is extremely improbable (probability on the order of $2.3E-10$). Ref. AFHA_6.4.1.1, CCS_PLAT_LOSS_PFH.

Loss of all data transport resources is a next critical failure condition. The resulting hazard condition is 'Hazardous'. Loss of all data transport resources may be impacted by operation with one FOX inoperative.

An acceptable level of safety can be shown using the associated fault tree analysis assuming dispatch with one inoperative FOX. When dispatching with an inoperative FOX, the probability of additional failures resulting in loss of all data transport resources is extremely improbable (probability is on the order of $2.0E-10$). Ref. CCS_FHA_2.1.1, CCS_TRANSP_LOSS_PFH.

Loss of data transport between computing resources is a next critical failure condition. The resulting hazard condition is 'Hazardous' only for RNP AR operations with a minima less than 0.3. For all other operations, the hazard condition is 'Major'. Loss of data transport between computing resources may be impacted by operation with one FOX inoperative.

An acceptable level of safety can be shown provided RNP AR operations are not conducted with a minima less than 0.3. Ref. CCS_FHA_2.1.2, CCS_XLINK_LOSS_PFH, CCS-60 thru CCS-63 and CCS-72.

CCS-60: Loss of ACS LA + FOX LB:

Inoperative Cabinet Switch LA and Fiber Optic Translator LB is indicated by the CCR CABINET SWITCH LA and CCR FOX LB Status messages. The ACS and FOX will not transfer data.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides:

Autothrottle will disconnect. Decrease in EGT margins may result in limit exceedance. Autopilot will disconnect.

First Officer's HUD (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 1, 2, 4, and 6 to Left CCR:

Left GGMs will drive LOB & LIB DUs, and HUD-L; Right GGMs drive ROB & RIB DUs. Loss of synchronization for FMF/TMF, CMF L and CMF R, Cursors, ECL/Maint.

Loss of N1 trim.

ISS data only appears on First Officer's side DUs.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-61: Loss of ACS LB + FOX LA:

Inoperative Cabinet Switch LB and Fiber Optic Translator LA is indicated by the CCR CABINET SWITCH LB and CCR FOX LA Status messages. The ACS and FOX will not transfer data.

Results in dual masters for the Flight Management Function (FMF) and Thrust Management Function (TMF) resulting in unsynchronized data on Captain's and First Officer's sides:

Autothrottle will disconnect. Decrease in EGT margins may result in limit exceedance. Autopilot will disconnect.

Both HUDs (if installed) will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules and loss of RDCs 1, 2, 3, and 5 to Left CCR:

Left GGMs will drive only Lower DU; Right GGMs drive LOB, LIB, ROB & RIB DUs. Loss of synchronization for FMF/TMF, CMF L and CMF R, Cursors, ECL/Maint.

Loss of N1 trim.

ISS data only appears on First Officer's side DUs.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

CCS-62: Loss of ACS RA + FOX RB:

Inoperative Cabinet Switch RA and Fiber Optic Translator RB is indicated by the CCR CABINET SWITCH RA and CCR FOX RB Status messages. The ACS and FOX will not transfer data.

Both HUDs (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Dis-

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play modules:

Left GGMs will drive LOB, LIB, ROB and RIB DUs; Right GGMs will not drive any displays (therefore no sync issues between displays). Loss of synchronization for CMF L and CMF R.

Loss of First Officer Master Warning/Caution illumination.

Failure condition is 'Major'.

CCS-63: Loss of ACS RB + FOX RA:

Inoperative Cabinet Switch RB and Fiber Optic Translator RA is indicated by the CCR CABINET SWITCH RB and CCR FOX RA Status messages.

The ACS and FOX will not transfer data.

Both HUDs (if installed) will be inoperative.

Lower DU will be inoperative.

Loss of cross cabinet communications between Left and Right CCR Display modules:

Left GGMs will drive LOB, LIB, ROB and RIB DUs; Right GGMs will not drive any displays (therefore no sync issues between displays). Loss of synchronization for CMF L and CMF R.

Loss of First Officer Master Warning/Caution illumination.

Failure condition is 'Major'.

CCS-72: Loss of Fiber Optic Translators (FOX) LA + FOX LB:

Results in dual masters for Thrust Management Function (TMF) and Flight Management Function resulting in unsynchronized data on Captain's and First Officer's sides:

Autothrottle will disconnect. Decrease in EGT margins may result in limit exceedance.

Autopilot will disconnect. LNAV/VNAV mode failure.

Both HUDs (if installed) will be inoperative.

Lower Display Unit will be inoperative.

Loss of cross-cabinet communication results in loss of synchronization between Captain and First Officer sides. Affects FMF, TMF, CMF. Left GGMs will drive LOB and LIB DUs. Right GGMs will drive ROB and RIB DUs. ECL/Maint will not be in sync. ISS data will only appear on First Officer's DUs.

Failure condition is 'Hazardous' for Initial Departure, Final Departure, Initial Approach and Final Approach. NOTE: Loss of LNAV is 'Hazardous' for RNP AR with RNP below 0.3.

Failure condition is 'Major' for all other phases.

42-21-06 CCS Power Conditioning Modules (PCM)

Interval	Installed	Required	Procedure
C	4	3	(M)

One may be inoperative provided:

- Inoperative PCM is deactivated, and
- Remaining common core system (CCS) equipment operates normally.

SUBSTANTIATION**Background**

New proposal for 777X.

For a general description of the Common Core System, see discussion under item 42-21-01, General Processing Modules (GPM).

There are two Power Conditioning Modules (PCMs) in each Cabinet. The PCM's primary task is converting the ship's 28 Voltage Direct Current (Vdc) into 12 Vdc to power the modules in the cabinet; however, it also provides the backup clock when the cabinet is turned off. This is the source of time for the airplane clock function at power up until such time as the airplane clock gets updated time from an external source such as GPS. Each PCM has a 28 Vdc input and a battery input. The primary source of power is the 28 Vdc with the battery input providing transient protection during bus switching and powering the clock when the cabinet is turned off. Powering the full cabinet on the battery is limited to eleven seconds. If primary power is removed the PCM will continue to operate on the battery for the one second after which a power down warning will be issued to the hosted applications allowing 10 seconds to save state data to NVM. Finally, eleven seconds after the loss of main power, it will remove the battery power from the power conditioning function and only provide battery power for the clock. Two GPMs in each cabinet communicate with the PCM over an I2C bus. This is used to set and read the clock as well as gather PCM BIT information for the CCS Health Monitor function.

Consequences of Failure

Failure of a PCM is indicated by the CCR PCM L1, L2, R1 or R2 Status message. Loss of redundancy only. Power is removed from failed component to preclude intermittent behavior and ensure system is configured in a known state.

Consequences of Next Critical Failure

For an inoperative PCM in the left CCR cabinet (PCM L1 or PCM L2), the next critical failure is the remaining PCM on the associated side. The result of this failure combination is the loss of the associated CCR cabinet.

The CCR PCM L1 and CCR PCM L2 Status messages will be displayed. The CCR CABINET L Status message will be displayed.

CCS-09: Loss of Left Common Computing Resource (CCR):

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Two Flight Management Functions will be inoperative. FMC SINGLE AVAIL (A) message will be displayed.

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative. DISPLAYS SYS LIMITED (A) message will be displayed.

Loss of Left Forward Audio Gateway Unit results in loss of audio for left MMR, left ADF, left DME and left VHF. NAV AUDIO FAIL L (A) message and VHF AUDIO FAIL L (A) message will be displayed.

Loss of left Communications Management Function. ATN CPDLC may be lost.

Hazard condition is 'Major'.

For an inoperative PCM in the right CCR cabinet (PCM R1 or PCM R2), the next critical failure is the remaining PCM on the associated side. The result of this failure combination is the loss of the associated CCR cabinet.

The CCR PCM R1 and CCR PCM R2 Status messages will be displayed. The CCR CABINET R Status message will be displayed.

CCS-10: Loss of Right Common Computing Resource (CCR):

Both HUDs (if installed) will be inoperative. Lower Center Display will be blank/inoperative. DISPLAYS SYS LIMITED (A) message will be displayed.

Loss of Right Forward Audio Gateway Unit results in loss of audio for right MMR, right ADF and right DME. NAV AUDIO FAIL R (A) message and VHF AUDIO FAIL (A) message will be displayed.

Loss of right Communications Management Function. ATN CPDLC may be lost.

Hazard condition is 'Major'.

42-21-07

AIRPLANE POWER CYCLE Status message

Interval	Installed	Required	Procedure
A	N/A	N/A	

May be dispatched with AIRPLANE POWER CYCLE Status message displayed provided repairs are made within 7 calendar-days.

SUBSTANTIATION**Background**

New proposal for 777X.

The health manager for the Common Core System (CCS) monitors the accumulated time since the airplane power cycle. Operating the airplane for an extended period of time will eventually introduce the potential for adverse effects. The CCS is designed to perform its intended function when continuously powered for up to 760 hours. Airplane testing has verified CCS function for up to 720 hours.

To mitigate the potential for adverse effects, the AIRPLANE POWER CYCLE Status message will be displayed when the health manager for the CCS has detected that greater than 500 hours has elapsed since the last airplane power cycle.

Consequences of Failure

The AIRPLANE POWER CYCLE Status message will be displayed when the CCS has been continuously powered for greater than 500 hours. The airplane may be dispatched for 7 calendar-days in this condition without cycling CCS power without exceeding 720 continuous powered hours.

Consequences of Next Critical Failure

None. The MMEL repair interval ensures that the airplane will not go more than 720 hours without having the power cycled.

If the CCS remains powered for more than 720 hours, the potential hazard that may result is no worse than 'Major'.

Intentionally
Blank

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44-11-01 Cabin Services System (CSS)

44-11-01-01 Cabin Services System Controller (CSSC)

44-11-01-02 Cabin Attendant Panels (CAP)

44-12-01 Passenger Address System

44-12-01-01 Lavatory Speakers

44-12-01-02 Cabin Speakers

44-12-01-02A

44-12-01-02B

44-12-02 Prerecorded Passenger Announcement System

44-12-02A

44-12-02B

44-14-01 Crewmember Interphone Systems

44-14-01-01 Flight Deck to Cabin, Cabin to Flight Deck Functions

44-14-01-01A

44-14-01-01B

44-14-01-02 Cabin to Cabin Functions

44-14-01-03 Flight Deck to Ground/Ground to Flight Deck Function
(Includes Nose Gear Flight Interphone Jack)

44-14-01-03A

44-14-01-03B

44-14-02 Cabin Interphone Alerting Systems

44-14-02-01 Flight Deck Call System

44-14-02-01-01 Flight Deck Cabin Interphone (CAB) CALL Lights
and EICAS Cabin COMM Messages

44-14-02-01-02 Flight Deck Chime

44-14-02-02 Flight Attendant Master Call Lights

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44-14-03-02 Cabin

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44-35-01 Broadband Communication

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44-11-01 Cabin Services System (CSS)**44-11-01-01 Cabin Services System Controller (CSSC)**

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Flight Deck Handset operates normally, and
- Alternate procedures are established and used.

44-11-01 Cabin Services System (CSS)**44-11-01-02 Cabin Attendant Panels (CAP)**

Interval	Installed	Required	Procedure
C	-	1	(M)

May be inoperative provided associated Cabin Attendant Panel (CAP) is deactivated.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 44-11-01.

Cabin Services System Controller (CSSC):

The Cabin Service System Controller (CSSC) coordinates and control the flow of data and signal for all the Cabin Services System (CSS) components. The CSSC control data for the following cabin system primary functions:

- Cabin fault detection and monitoring
- Cabin Interphone System (CIS)
- Cabin Lighting System (CLS)
- Cabin monitoring and control
- Database logic
- Flight deck servicesOnboard Data Load Function (ODLF)
- On-Board Health Management Function (OHMF)
- Passenger Address System (PAS)
- Passenger Service System (PSS).

Cabin Attendant Panel (CAP):

The Cabin Attendant Panels (CAP) are the interface used by the flight attendants to control some of the cabin services system (CSS) functions. The CSS provides passenger address, cabin interphone, general lighting, passenger service, signs, monitoring and control throughout the cabin. The Quantities of CAPs and their location is up to the individual Airline. CSS only requires 1 CAP, the rest are optional. Each panel employs a touch sensitive flat panel screen to control each of the CSS functions. Additional panels, if selected by the airline, operate independently and provide the same functionality.

The CAP lets the flight attendants monitor and control the following during flight operation:

- Cabin Lighting Control
- Lavatory/Passenger Service Call
- Secondary Crew Rest/Lavatory Smoke Indications
- Window shade control (optional)
- Cabin Temperature fine tuning
- Potable Water/Waste Tank Fill Indicators (Status Only)

Consequences of Failure

Cabin Services System Controller (CSSC):

The 777-9 incorporates a redundant feature if the head end CSS controller (CSSC) fails. This backup feature allows for continued essential cabin interphone and PA functionality to be preserved.

If CSSC fails, the Master CAP takes over the cabin services, passenger address and crew interface functions. The CAP will send the chime and 'CABIN' EICAS messages through redundant path. Communication with the crew can be made through the flight deck handset which bypasses the CSSC. Ground crew chime and EICAS messages will be inoperative. Service interphone audio will still be available.

Cabin Attendant Panel (CAP):

Inoperative CAP is unusable. The remaining CAP(s) remain fully functional. Each CAP has a panel override function that when selected, allows the CAP to take over the lighting control of the failed CAP.

Consequences of Next Critical Failure

Cabin Services System Controller (CSSC):

If the CSSC backup feature fails, the Passenger Address System may be used if available, or use of hand-held megaphones may be used.

Cabin Attendant Panel (CAP):

Failure of the only remaining CAP may result in the flight attendants not having the ability to monitor and control the CSS functions through the cabin attendant panel. Cabin lighting control may be lost, which may degrade charging of photoluminescent floor path lighting (if installed). Primary crew rest/lav smoke indications (EICAS) continue to operate. Cabin temperature control from the flight deck is not affected. Cabin interphone functions continue to operate.

44-12-01 Passenger Address System

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Alternate, normal and emergency procedures, and/or operating restrictions are established and used, and
- Flight attendant master call lights operate normally.

NOTE: Any station function(s) that operates normally may be used.

44-12-01 Passenger Address System**44-12-01-01 Lavatory Speakers**

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative provided alternate procedures are established and used.

44-12-01 Passenger Address System**44-12-01-02 Cabin Speakers****44-12-01-02A**

Interval	Installed	Required	Procedure
C	-	-	(M)

May be inoperative provided inoperative speakers are not adjacent to each other.

44-12-01 Passenger Address System**44-12-01-02 Cabin Speakers****44-12-01-02B**

Interval	Installed	Required	Procedure
C	-	-	(M)

No passenger seat, cabin attendant seat or crew rest area bunk may be occupied from which passenger address system is not audible and intelligible; seat must be blocked and placarded "DO NOT OCCUPY".

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 44-12-01 and PL-9, with added functionality for 777X.

The passenger address system broadcasts the attendant calls, voice announcements, prerecorded announcements, boarding music, and the audio from the video programming. The PAS also provides the speaker volume control. Cabin attendant handsets for making announcements on the passenger address system are located near all main cabin doors at the cabin attendant panels. The passenger address system is controlled by a single Cabin Services System (CSS) controller, which also serves as the controller for the cabin interphone system. The passenger address audio inputs go the CSS controller. The CSS controller sends the highest priority audio to the cabin zone units (CZU) and the inflight entertainment system (IFE). The CZUs send audio to speaker drive modules (SDMs). Each SDM sends audio output to a maximum of 4 speakers.

The 777-9 incorporates a redundant feature if the head end CSS controller (CSSC) fails. This backup feature allows for continued essential cabin interphone and PA functionality to be preserved. Passenger address announcements can still be made using the flight deck handset, which bypasses the CSSC and functions independently of the CSS controller. The flight deck handset has a LCD screen that displays all the call/PA functions. The flight interphone will inhibit sidetone in the event that the CSS system controller has failed.

Note that all functions of the passenger seat earphones are considered to fall into the category of "Non-Essential Equipment and Furnishings (NEF)" (Refer to MMEL item 25-20-1). These items have no repair interval and do not affect dispatch except as defined by airline policy. The airplane public address system speakers are considered to be sufficiently loud to gain the attention of passengers using the seat earphones, personal audio players, or simple ear plugs.

Consequences of Failure

1. Passenger Address System:

The PASSENGER ADDRESS Status message will be displayed. The PASS ADDR FAIL Advisory message will be displayed. Passenger address announcements can still be made using the flight deck handset, which bypasses the CSSC and functions independently of the CSS controller. The flight deck handset has a LCD screen that displays all the call/PA functions. If passenger address system function is lost, substitution of function is provided by use of alternate procedures involving hand-held megaphones or the Cabin Interphone System.

NOTE: If the Passenger Address System is inoperative the flight attendant chime will not be available, but the flight attendant Master Call Lights are still operable.

2. Lavatory Speakers:

Speaker is inoperative. Alternate procedures are used for occupant notification.

3. Cabin Speakers:

Speaker is inoperative. Adjacent (forward/aft) speakers must operate normally and will provide coverage for the area normally covered by the inoperative speaker.

Consequences of Next Critical Failure

1. Passenger Address System

Failure of Cabin Interphone System: An adequate number of megaphones (prescribed by FAR) may be used for passenger address.

2. Lavatory Speakers

None identified. Alternate procedures are used for occupant notification.

3. Cabin Speakers

Failure of an adjacent speaker. Other functioning adjacent speaker provides notification to passenger.

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44-12-02 Prerecorded Passenger Announcement System

44-12-02A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

44-12-02 Prerecorded Passenger Announcement System

44-12-02B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 44-12-02.

The prerecorded announcement provides audio to the passenger address system.

Consequences of Failure

Failure of the pre-recorded announcement system requires that the passenger address system be used manually.

Consequences of Next Critical Failure

Subsequent failure of passenger address system would require the use of hand-held megaphones.

44-14-01 Crewmember Interphone Systems**44-14-01-01 Flight Deck to Cabin, Cabin to Flight Deck Functions****44-14-01-01A**

Interval	Installed	Required	Procedure
B	-	-	(O)

May be inoperative provided:

- Flight deck to cabin and cabin to flight deck interphone functions operate normally on at least fifty percent of the cabin handsets,
- Flight deck to cabin and cabin to flight deck interphone function operates normally at one door for each pair of exit doors, and
- Alternate communications procedures between the affected flight attendant's station(s) are established and used.

NOTE: Any station function(s) that operate normally may be used.

44-14-01 Crewmember Interphone Systems**44-14-01-01 Flight Deck to Cabin, Cabin to Flight Deck Functions****44-14-01-01B**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Crewmember interphone system not required by 14 CFR, and
- Alternate, normal and emergency procedures, and/or operating restrictions are established and used.

NOTE: Any station function(s) that operate normally may be used.

44-14-01 Crewmember Interphone Systems**44-14-01-02 Cabin to Cabin Functions**

Interval	Installed	Required	Procedure
B	-	-	(O)

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May be inoperative provided:

- Cabin to cabin interphone functions operate normally on at least fifty percent of the cabin handsets,
- Cabin to cabin interphone function operates normally at one door for each pair of exit doors, and
- Alternate communications procedures between affected flight attendant's station(s) are established and used.

NOTE: Any station function(s) that operate normally may be used.

44-14-01 Crewmember Interphone Systems

44-14-01-03 Flight Deck to Ground/Ground to Flight Deck Function (Includes Nose Gear Flight Interphone Jack)

44-14-01-03A

Interval	Installed	Required	Procedure
C	1	0	(O)

Flight interphone flight deck to ground/ground to flight deck function may be inoperative provided:

- Alternate procedures are established and used, and
- Service Interphone System Nose Gear Jack operates normally.

44-14-01 Crewmember Interphone Systems

44-14-01-03 Flight Deck to Ground/Ground to Flight Deck Function (Includes Nose Gear Flight Interphone Jack)

44-14-01-03B

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 44-14-01 and PL-9.

The cabin interphone system is controlled by a single Cabin Services System (CSS) controller, which also serves as the controller for the passenger address system. The cabin interphone system permits communication between cabin attendants, between cabin attendants and the flight crew, and between the flight crew and the ground crew. Cabin attendant calls are annunciated both visually and aurally with lights and chimes. On the flight deck, the alerting system consists of visual annunciation of an interphone call indicated on the scratch pad of the Tuning and Control Panel, by illumination of the CAB call light on the Audio Control Panel, and by COMM messages on the EICAS display. An aural indication on the flight deck is initiated by a software programmable chime (optional). A CABIN READY message can be sent to the flight deck that causes a chime to sound and the COMM message to appear on the EICAS screen. A Pilot Alert call may be initiated from the cabin by dialing the two-digit code that overrides all other cabin interphone system calls except a pilot Passenger Address call. When a Pilot Alert call is in progress, anyone placing a subsequent Pilot Alert call is automatically joined in a conference with the flight deck crew member.

Consequences of Failure

Failure of the cabin interphone system or associated equipment results in display of the CABIN INTERPHONE Status message and CABIN INT FAIL Advisory message.

Flight Deck to Cabin, Cabin to Flight Deck Functions: MMEL provisos require function is available at every door pair; alternate procedures may use the passenger address system if available.

Cabin to Cabin Functions: MMEL provisos require function is available at every door pair; alternate procedures may use the passenger address system if available.

Flight Deck to Ground/Ground to Flight Deck Function (Includes Nose Gear Flight Interphone Jack): Alternate procedures based on service interphone or hand signals are established and used.

Consequences of Next Critical Failure

Failure of additional interphone functions at specific stations: May require use of the PA system if available, or use of hand-held megaphones which are required by FARs.

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44-14-02 Cabin Interphone Alerting Systems
44-14-02-01 Flight Deck Call System
44-14-02-01-01 Flight Deck Cabin Interphone (CAB) CALL Lights and EICAS Cabin COMM Messages

Interval	Installed	Required	Procedure
B	-	-	(O)

May be inoperative provided:

- a. Flight Deck Chime operates normally, and
 - b. Alternate procedures are established and used to differentiate between normal and emergency calls.
-

44-14-02 Cabin Interphone Alerting Systems
44-14-02-01 Flight Deck Call System
44-14-02-01-02 Flight Deck Chime

Interval	Installed	Required	Procedure
B	1	0	

May be inoperative provided:

- a. Flight deck cabin interphone (CAB) CALL lights operate normally, and
 - b. EICAS cabin COMM messages operate normally.
-

44-14-02 Cabin Interphone Alerting Systems
44-14-02-02 Flight Attendant Master Call Lights
44-14-02-02A

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- a. Passenger Address System operates normally,
- b. Alternate lavatory smoke detector alert(s) operate normally, and
- c. Alternate procedures for contacting flight attendants are established and used.

[For FAA](#)

NOTE 1: Passenger to attendant call system is considered Nonessential Equipment and Furnishing (NEF).

NOTE 2: Any flight attendant call light function that operates normally may be used.

NOTE 3: MMEL relief is not provided for any alternative lavatory smoke detector function.

44-14-02 Cabin Interphone Alerting Systems**44-14-02-02 Flight Attendant Master Call Lights****44-14-02-02B**

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- Flight Attendant Chime operates normally,
- Flight Attendant Chime differentiates between normal and emergency calls,
- Alternate lavatory smoke detector alert(s) operate normally, and
- Alternate procedures for contacting flight attendants are established and used.

For FAA

NOTE 1: Passenger to attendant call system is considered Nonessential Equipment and Furnishing (NEF).

NOTE 2: Any flight attendant call light function that operates normally may be used.

NOTE 3: MMEL relief is not provided for any alternate lavatory smoke detector function.

44-14-02 Cabin Interphone Alerting Systems**44-14-02-03 Flight Attendant Chime****44-14-02-03A**

Interval	Installed	Required	Procedure
B	1	0	(O)

May be inoperative provided:

- Passenger Address System operates normally,
- Alternate lavatory smoke detector alert(s) operate normally, and
- Alternate procedures for contacting flight attendants are established and used.

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For FAA

NOTE 1: Passenger to attendant call system is considered Nonessential Equipment and Furnishing (NEF).

NOTE 2: Any audio alerting system function(s) that operates normally may be used.

NOTE 3: MMEL relief is not provided for any alternate lavatory smoke detector function.

44-14-02 Cabin Interphone Alerting Systems

44-14-02-03 Flight Attendant Chime

44-14-02-03B

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- Flight attendant master call lights operate normally,
- Flight attendant master call lights differentiate between normal and emergency calls,
- Alternate lavatory smoke detector alert(s) operate normally, and
- Alternate procedures for contacting flight attendants are established and used.

For FAA

NOTE 1: Passenger to attendant call system is considered Nonessential Equipment and Furnishing (NEF).

NOTE 2: Any audio alerting system function(s) that operates normally may be used.

NOTE 3: MMEL relief is not provided for any alternate lavatory smoke detector function.

44-14-02 Cabin Interphone Alerting Systems

44-14-02-04 OFCR/OFAR Call Lights

44-14-02-04A

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- Associated OFCR/OFAR address system operates normally, and

- b. Alternate procedures are established and used.

NOTE: Any visual alerting system function(s) that operates normally may be used.

44-14-02 Cabin Interphone Alerting Systems

44-14-02-04 OFCR/OFAR Call Lights

44-14-02-04B

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided associated OFCR/OFAR remains unoccupied.

44-14-02 Cabin Interphone Alerting Systems

44-14-02-05 OFCR/OFAR Chimes

44-14-02-05A

Interval	Installed	Required	Procedure
B	-	0	(O)

May be inoperative provided:

- Associated OFCR/OFAR address system operates normally, and
- Alternate procedures are established and used.

NOTE: Any audio alerting system function(s) that operates normally may be used.

44-14-02 Cabin Interphone Alerting Systems

44-14-02-05 OFCR/OFAR Chimes

44-14-02-05B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided associated OFCR/OFAR remains unoccupied.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 44-14-02.

Proposal based on PL-9. CS-MMEL, item 23-40-2-5.

The cabin interphone alerting system consists of the flight deck call system, the flight attendant call lights and the flight attendant chime.

The flight deck call system consists of the audio control panel CAB (cabin interphone) call switch and indicator, the EICAS COMM messages CABIN ALERT, CABIN CALL and CABIN READY, and the flight deck chime. A cabin interphone call from the passenger cabin is accompanied by illumination of the CAB light on the flight deck audio control panels, display of the appropriate COMM message on EICAS, and annunciation of the flight deck chime. The call indications are cleared by pushing the CAB call switch on any of the three audio control panels.

The flight deck call system also consists of alerts for calls from ground crew. There is no separate sub-item required as is in the 777 MMEL. Ground call alerting consists of the audio control panel FLT (flight interphone) call switch and indicator, the EICAS COMM message GROUND CALL, and the flight deck chime. Any call from ground personnel on the flight interphone is accompanied by illumination of the FLT light on the flight deck audio control panels, display of the GROUND CALL message on EICAS, and annunciation of the flight deck chime. The call indications are reset by pushing the FLT call switch on any of the three audio control panels.

The cabin attendant alerting system consists of a cabin attendant master call light in the passenger cabin, cabin chime via speakers installed throughout the passenger cabin. Master call lights and chime types are configurable by the individual operators.

There is a lavatory call light above each lavatory door that is used to indicate that a lavatory smoke detector has detected smoke. The lavatory call light is covered as part of the lavatory smoke detector MMEL item.

The OFCR has Cabin Attendant Handsets (CAH) located in the crew rest area. The OFAR has a CAH(s) installed in the OFAR. The OFCR/OFAR alerting system consists of handset indication light on an attendant switch panel and chime via speakers in the crew rest areas.

Consequences of Failure

Flight Deck Call System:

Flight deck cabin interphone (CAB) CALL lights and EICAS COMM messages:

Flight deck chime must operate normally.

PL-9 considerations: Flight deck chime does not differentiate between normal and emergency calls. Therefore, alternate procedures must be established and used to differentiate between normal and emergency calls.

Flight deck chime:

Flight deck cabin interphone (CAB) CALL lights and cabin COMM EICAS messages must operate normally.

PL-9 considerations: The cabin COMM EICAS messages differentiate between normal (CABIN CALL) and emergency (CABIN ALERT) calls. Therefore, the system configuration complies with PL-9 b) and no action is required by the operator to comply with PL-9 b).

Flight Attendant Call System:

Flight attendant master call lights - PA system operates normally:

PL-9 considerations - Lavatory Smoke Detection Alerting: The following items are used to indicate smoke in the lavatory: Lavatory smoke detector (aural/visual), lavatory call light (visual), master call lights (visual), continuous cabin chime near lavatory (aural), pop-up window on CAPs (visual), and EICAS Caution message in the flight deck (visual). MMEL relief is not available for all of these items. Therefore, the system configuration includes the installation of an alternate lavatory smoke detector that must operate normally. No additional action is required by the operator to comply with PL-9 b).

Flight attendant master call lights - Chime operates normally:

Flight attendant chime operates normally and differentiates between normal and emergency calls.

PL-9 considerations: Master call lights and chimes are configurable by the customer. Therefore, the operator will need to show that the flight attendant chime can differentiate between normal and emergency calls. [See item above for lavatory smoke detection alerting (PL-9 c)].

Flight attendant chime - PA operate normally:

PL-9 considerations: [See item above for lavatory smoke detection alerting (PL-9 c)].

Flight attendant chime - master call lights operate normally:

Flight attendant master call lights operate normally and differentiate between normal and emergency calls.

PL-9 considerations: Master call lights and chimes are configurable by the customer. Therefore, the operator will need to show that the flight attendant master call lights can differentiate between normal and emergency calls. [See item above for lavatory smoke detection alerting (PL-9 c)].

OFCR/OFAR Rest Call Lights:

PL-9 considerations: Use cargo configuration, courier/supernumerary, relief as the basis of the crew rest relief. Cat B relief if the address system operates normally or Cat D if crew rest remains unoccupied. NOTE has been moved to the 'address system operates normally' option.

OFCR/OFAR Rest Chimes:

PL-9 considerations: Use cargo configuration, courier/supernumerary, relief as the basis of the crew rest relief. Cat B relief if the address system operates normally or Cat D if crew rest remains unoccupied. NOTE has

been moved to the 'address system operates normally' option.

Consequences of Next Critical Failure

Failure of the passenger address system will necessitate use of hand-held megaphones which are required by FAR.

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44-14-03 Cabin Interphone Handset Systems**44-14-03-01 Flight Deck****44-14-03-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Flight deck to cabin communication operates normally, and
- Alternate procedures are established and used.

44-14-03 Cabin Interphone Handset Systems**44-14-03-01 Flight Deck****44-14-03-01B**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

44-14-03 Cabin Interphone Handset Systems**44-14-03-02 Cabin**

Interval	Installed	Required	Procedure
B	-	-	(O)

May be inoperative provided:

- At least fifty percent of cabin handsets operate normally,
- One handset must operate normally at each pair of exit doors, and
- Alternate communications procedures between the affected flight attendant's station(s) are established and used.

NOTE 1: An operative handset at an inoperative flight attendant seat shall not be counted to satisfy the fifty percent requirement.

NOTE 2: Any handset functions that operate normally may be used.

44-14-03 Cabin Interphone Handset Systems**44-14-03-03 OFCR/OFAR**

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 44-14-03.

Proposal based on PL-9.

The flight deck handset and the cabin attendant handsets are part of the cabin interphone system. The cabin interphone system provides voice communications between the flight deck and the flight attendant stations. The passenger address system can also be selected through the cabin interphone system or the flight deck handset. Cabin attendant handsets are located near all main cabin doors at the cabin attendant stations.

EICAS communication alert messages and chimes alert the pilots to incoming cabin calls. Normal priority calls from the cabin display the CABIN CALL EICAS message. Normal priority calls made to the flight deck while another call is in progress will result in a busy signal at the handset, the calling station being displayed in the call queue, and the CABIN CALL communication alert message being set in EICAS. The call queue and memo messages will be cleared when communication is established between that calling station and the flight deck. Priority calls from the cabin display the CABIN ALERT EICAS message. Priority calls automatically disconnect lower priority cabin interphone calls. Priority calls placed while a priority call is in progress are automatically connected as a conference call.

Calls can be answered or placed using the flight deck handset. Desired call locations are entered using the numeric keys on the handset. Pressing the handset reset switch or placing the handset back on the cradle terminates the call.

Consequences of Failure

Flight Deck Handset - Calls and announcements can be made from the other available flight deck headsets/boom mics using the audio control panel and the call destination controlled from the Tuning and Control Panel.

Cabin Attendant Handsets - Alternate communication procedures must be used by those attendants affected by inoperative handsets.

Consequences of Next Critical Failure

Alternate procedures are established and used.

44-35-01 Broadband Communication**44-35-01-01 BROADBAND COMM Switch ON Light**

Interval	Installed	Required	Procedure
C	1	0	

44-35-01 Broadband Communication**44-35-01-02 PASS WI-FI Switch ON Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

New proposal for 777X.

The BROADBAND COMM switch and PASS WI-FI switch are located on the overhead P5 panel. When the alternate action pushbutton switch is depressed, an amber ON nomenclature is illuminated indicating that the broadband communication system is enabled. Both switches are optional equipment. In addition, the BROADBAND COMM switch has an option for either pushbutton alternating switch or a rotary selector switch. Only the pushbutton alternating switch configuration includes an ON light. The rotary switch does not include an ON light.

Consequences of Failure

Switch light will not indicate ON when selected. The flight crew can determine switch position from flush state with panel.

Consequences of Next Critical Failure

None.

44-51-01

Cabin Experience Network (CEN) System

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- Flight Deck Entry Visual Surveillance System - Video Surveillance System is considered inoperative.

[For Cabin Video Monitoring System \(CVMS\) installed:](#)

- Cabin Video Monitoring System is considered inoperative.

[For Cargo Bay Video Monitoring System \(CBVMS\) installed:](#)

- Cargo Bay Video Monitoring System is considered inoperative.

[For Direct View System installed:](#)

- Direct View System is considered inoperative.

SUBSTANTIATION

Background

New proposal for 777X.

The Cabin Experience Network (CEN) is an optional high-speed cabin network that supports the Flight Deck Entry Visual Surveillance System (FDEVSS) and Direct View System (DVS) video surveillance systems. The CEN includes one CEN Server, up to six CEN Switches, and at least one CEN Monitor supporting DVS. The FDEVSS and DVS utilize Internet Protocol (IP) cameras that receive Power over Ethernet (PoE) from their respective CEN Switches. The IP cameras send compressed video streams in H.264 format to the CEN Server via the CEN Switches.

The DVS camera compressed video streams are decoded at the CEN Monitor. A DVS camera video feed is displayed on the CEN Monitors for flight attendants to view the cabin area during taxi, takeoff and landing (TTL). (Reference FAA Issue Paper C-7, Direct View Compliance Method)

The FDEVSS camera video streams are decoded at the CEN Server and delivered to the Ground Maneuvering Camera System (GMCS) Video Management Unit (VMU) in ARINC 818 format. The GMCS VMU sends the video feed to the three Flight Deck Multi-Function Displays (MFD) also in ARINC 818 format. The Flight Deck uses the MFD touch screen menus to select one of the three FDEVSS cameras to be viewed on an MFD.

The Avionics Gateway is utilized to provide Airplane Data information during normal operation and CEN Software Load functions. CEN Software is loaded via the Maintenance Access Terminal (MAT) in the Flight Deck.

Consequences of Failure

No airworthiness effect, but airline maintenance functions and flight crew, cabin crew experience could be impacted. An inoperative CEN or supporting component may render one or more of the following functions inoperative:

- Direct View – would require the cabin crew to establish other procedures to maintain awareness of passenger status during takeoff and landing.

- Flight Deck Entry Visual Surveillance System – alternate procedures must be established and used.

- Cabin/Cargo Video Monitoring System

- Maintenance Access Terminal (MAT) functions, including CEN, Camera, and Projection maintenance menus.

Consequences of Next Critical Failure

If the Direct View or Flight Deck Entry Visual Surveillance systems are required as part of the airline's operational procedures, alternate procedures must be established and used.

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Federal Aviation Administration (FAA)**ATA 44****777-9 Master Minimum Equipment List****Section 2****44-75-01 Flight Deck Entry Video Surveillance Systems***********44-75-01A**

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative and components may be missing provided:

- Alternate procedures are established and used, and
- Repairs are made within 3 flight-days.

NOTE: Any portion of the system which operates normally may be used.

44-75-01 Flight Deck Entry Video Surveillance Systems*********44-75-01B**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative and components may be missing provided:

- Flight Deck Door Viewing Port operates normally, and
- Alternate procedures are established and used.

NOTE: Any portion of the system which operates normally may be used.

44-75-01 Flight Deck Entry Video Surveillance Systems*********44-75-01C**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative and components may be missing provided procedures do not require its use.

SUBSTANTIATION**Background**

Proposal is the based on PL-122.

The Flight Deck Entry Video Surveillance System (FDEVSS) includes three Power over Ethernet (PoE) network cameras with built-in Infrared illuminators to improve camera video capture in low light conditions. The FDEVSS camera views capture the Flight Deck door area. One of the camera views must capture entry into/from the Flight Deck. Flight Deck personnel can view all FDEVSS camera video streams on the three Multi-Function Displays inside the cockpit.

Consequences of Failure

Failure of the video surveillance system will not affect the airworthiness of the aircraft. Failure of an individual camera will not impact other functions of the system. Failure of the CEN server will result in the FDEVSS not being available. Failure of CEN Switch 2 will disable FDEVSS camera video streams. Failure of CEN Switch 3 or any CEN Monitor will not affect operation of the FDEVSS.

If the system is required as part of an airline's operational procedures, alternate procedures must be established and used, which can include use of the flight deck door viewing port.

Consequences of Next Critical Failure

None identified.

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Federal Aviation Administration (FAA)**ATA 44****777-9 Master Minimum Equipment List****Section 2****44-75-02 Cabin Video Monitoring System (CVMS)***********44-75-02A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

44-75-02 Cabin Video Monitoring System (CVMS)*********44-75-02B**

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION**Background**

New proposal for 777X.

The optional Cabin Video Monitoring System (CVMS) installs Power over Ethernet (PoE) network cameras at customer specific locations throughout the cabin area including passenger seating area, galleys and medical bays if equipped. Typically the cameras installed have built-in Infrared illuminators to improve camera video capture in low light conditions. Two camera types, a surround view camera and covert camera are optional. The surround view and covert cameras do not have a built in IR illuminator. Cabin Attendants shall be able to view all CVMS camera video streams on the CEN Cabin Monitor. The Flight Deck shall be able to view all CVMS camera video streams on the Multi Function Displays.

Consequences of Failure

CVMS camera views will not be available to flight crew and cabin crew.

Consequences of Next Critical Failure

None

44-75-03 Cargo Bay Video Monitoring System (CBVMS)

44-75-03A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

44-75-03 Cargo Bay Video Monitoring System (CBVMS)

44-75-03B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION**Background**

New proposal for 777X.

The optional Cargo Bay Video Monitoring System (CBVMS) installs three (3) Power over Ethernet (PoE) network cameras and two (2) IR Illuminators in the Bulk Cargo Bay. The Infrared illuminators are installed to improve camera video capture in low light conditions. One camera captures the Cargo Bay Door and the other CBVMS cameras look FWD and AFT. Cabin Attendants shall be able to view all CBVMS camera video streams on the CEN Cabin Monitor. The Flight Deck shall be able to view all CBVMS camera video streams on the Multi Function Displays.

Consequences of Failure

CVMS camera views will not be available to flight crew and cabin crew.

Consequences of Next Critical Failure

None

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44-75-04 Direct View System

44-75-04A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

44-75-04 Direct View System

44-75-04B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 23-75-02.

The direct view system includes at least one Cabin Experience Network (CEN) monitor and three Power over Ethernet (PoE) cameras. The DVS cameras have built-in infrared illuminator to improve video capture in low light conditions. The CEN Monitor and cameras are required to assist Flight Attendants in viewing Business Class seating during taxi, takeoff and landing. Reference issue paper C-7, 14 CFR part 25 paragraph 25-785.

Consequences of Failure

If operator procedures require use of the direct view system, alternate procedures must be established and used to maintain awareness of passenger status during taxi, takeoff and landing.

Consequences of Next Critical Failure

None.

45-10-01 Central Maintenance Computing Functions (CMCF)

45-11-01 Maintenance Access Terminal (MAT)

45-12-01 Airplane Condition Monitoring Function (ACMF)

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45-10-01 Central Maintenance Computing Functions (CMCF)

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 45-11-01.

The Central Maintenance Computing Function (CMCF) collects, stores and displays maintenance information for most of the systems onboard the 777X. The maintenance information collected from member systems includes fault reports, configuration data, and shop fault data. The CMCF also provides a centralized location for performing LRU initiated tests on the airplane member systems. CMCF airplane member system fault report processing involves fault isolation, fault consolidation, and Flight Deck Effect correlation.

The 777X CMCF is hosted in 2 General Processing Modules on the Common Core System (CCS). The CMCF function can be accessed on Flight Deck Multifunction displays. In addition, the CMCF function can be accessed on Maintenance Access Terminal, and Portable Maintenance Devices through the use of Onboard Network System.

Airplane system faults affecting airworthiness and dispatch are annunciated by status and EICAS alert level messages, or other flight deck effects.

Consequences of Failure

Loss of redundancy if one CMCF is failed.

If both CMCFs are failed, CMCF will not be able to support fault isolation, ground tests and special functions, configuration reporting, or rigging. Degraded ACMF report generation due to loss of CMCF flight phase.

Consequences of Next Critical Failure

None.

45-11-01 Maintenance Access Terminal (MAT)

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 45-11-01.

The Maintenance Access Terminal (MAT) is located in the flight deck and provides access to the Central Maintenance Computing Function (CMCF), Airplane Condition Monitoring Function (ACMF), and Onboard Network System (ONS) functions including data loading. Maintenance personnel are considered the primary users of the MAT.

Consequences of Failure

Portable maintenance devices can be used to access the CMCF, ACMF, and ONS functions. Flight deck displays are also available for CMCF.

Consequences of Next Critical Failure

None.

45-12-01 Airplane Condition Monitoring Function (ACMF)

Interval	Installed	Required	Procedure
D	2	0	

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 45-12-01.

The Airplane Condition Monitoring Function (ACMF) is a CCS hosted application (General Processing Module L1 and R1 with Data Gathering Applications (DGA) in L1 and R1). The ACMF enables the airline to monitor, record, and report engine and airplane systems performance. The collected data also allows the airline to conduct trend analysis of maintenance data. Onboard access to the ACMS functionality is provided through the Maintenance Access Terminal or a Portable Maintenance Display (PMD).

Report recording is initially done on the ACMF client hardware and the Continuous Parameter Logging (CPL) is stored on the Onboard Network System (ONS) mass storage device (MSD). The recorded reports can be displayed on a PMD, Laptop, or printed on the flight deck printer. Additionally, the reports may be downlinked to a ground station, recorded to a portable storage device (USB drive, etc.) from an PMD, or recorded directly to the ONS MSD. The CPL file is designed to be automatically downlinked to the ground station once completed. ACMF and DGA BITE logs are triggered and downlinked to the ground station at ACMF start up. In order to use ACMF, an ACMF AMI must be present to define the collected parameters. The baseline AMI is developed by Boeing. It is designed to collect parametric and report data.

The ACMF AMI is considered User Modifiable Software (UMS). UMS is software designed to be modified (usually by airlines) within the specified modification constraints and with approved modification procedures without any further involvement by the certification authority. UMS includes software generated by a variety of tools including the Ground Based Software Tool (GBST) which is one of the tools associated with ACMF.

Consequences of Failure

For loss of both ACMF functions: Loss of CPL recording. Loss of ACMF data reporting. Loss of CMCF Input Monitoring.

Consequences of Next Critical Failure

None.

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46-11-01 Onboard Network System (ONS)

46-11-01A

46-11-01B

46-11-02 Electronic Flight Bag (EFB) Systems

46-11-02-01 Data Connectivity

46-11-02-01A

46-11-02-01B

46-11-02-02 Power Supply/Power Connection

46-11-02-02A

46-11-02-02B

46-11-02-03 Mounting Device

46-11-02-03A

46-11-02-03B

46-13-02 Aircraft Interface Device (AID)

46-13-02A

46-13-02B

46-13-03 Crew Wireless LAN Unit (CWLU)

46-13-03A

46-13-03B

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46-11-01 Onboard Network System (ONS)**46-11-01A**

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Any function which operates normally may be used.

46-11-01 Onboard Network System (ONS)**46-11-01B**

Interval	Installed	Required	Procedure
D	1	0	(O)

May be inoperative provided procedures do not require its use.

NOTE: Any function which operates normally may be used.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 46-11-01.

The Onboard Network System (ONS) is a network system which provides airplane interfaces for a variety of flight crew and maintenance applications.

The ONS includes the following components and associated interfaces:

- Avionics Gateway for communication with the Common Data Network (CDN)
- Network File Server (including optional dual NFS configuration). As a server, the NFS operates as an Ethernet router between connected devices and as a data storage unit. As a computer, the NFS, with its own operating systems, can host specified Boeing or third-party software applications. The NFS supports a real-time, aircraft-to-ground data network, with interfaces to specified on-board Ethernet devices.

Consequences of Failure

Failure of the onboard network system is indicated by the ONBOARD NETWORK SYS Status message.

No airworthiness effect, but airline maintenance functions, flight crew operations, and passenger services could be impacted. An inoperative Onboard Network System or supporting component may render one or more of the following functions inoperative:

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-
- Maintenance Access Terminal (MAT) functions, including CMCF data collection and loading.
 - Portable maintenance device interfaces (some functions may still be accessed via Flight Deck Multi-Function Displays).
 - All software and database data load functions
 - Broadband off-board communication:
 - Upload of parts via Boeing Electronic Distribution of Software (BEDS)
 - Download of recorded data (ACMF, engine, etc.) via BEDS
 - Communication to or from portable EFBs, cabin crew and maintenance devices.
 - Flight deck printer
 - Flight Deck Entry Video Surveillance system
 - Cabin video monitoring system (CVMS)
 - Engine trim balance application

Consequences of Next Critical Failure

No specific next critical failure identified.

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46-11-02 Electronic Flight Bag (EFB) Systems

46-11-02-01 Data Connectivity**46-11-02-01A**

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative provided alternate procedures are established and used.

46-11-02 Electronic Flight Bag (EFB) Systems

46-11-02-01 Data Connectivity**46-11-02-01B**

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require its use.

46-11-02 Electronic Flight Bag (EFB) Systems

46-11-02-02 Power Supply/Power Connection**46-11-02-02A**

Interval	Installed	Required	Procedure
C	-	-	(O)

May be inoperative provided alternate procedures are established and used.

46-11-02 Electronic Flight Bag (EFB) Systems

46-11-02-02 Power Supply/Power Connection**46-11-02-02B**

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require its use.

Federal Aviation Administration (FAA)**ATA 46****777-9 Master Minimum Equipment List****Section 2****46-11-02 Electronic Flight Bag (EFB) Systems***********46-11-02-03 Mounting Device****46-11-02-03A**

Interval	Installed	Required	Procedure
C	-	0	(M) (O)

May be inoperative provided:

- Associated EFB and hardware is stowed, secured by an alternate means, or removed from the aircraft, and
 - Alternate procedures are established and used.
-

46-11-02 Electronic Flight Bag (EFB) Systems*********46-11-02-03 Mounting Device****46-11-02-03B**

Interval	Installed	Required	Procedure
D	-	0	(M)

May be inoperative provided:

- Associated EFB and hardware is stowed, secured by an alternate means, or removed from the aircraft, and
 - Procedures do not require its use.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 46-11-02 and PL-121.

The Electronic Flight Bag (EFB) devices reduce the need for paper and other reference materials in the cockpit. They are approved for use in conjunction with, or to replace, some of the hard copy material that pilots typically carry in their flight bags. The EFB devices can display a variety of aviation data or perform basic calculations (e.g., performance data, etc.). Some of these functions have been traditionally accomplished using paper references or were based on data provided to the flight crew by an airline's flight dispatch function. EFBs can electronically store and retrieve documents required for flight operations, such as the Operations Manual, Airplane Flight Manual, Navigation data and Maps, Minimum Equipment Lists, and airline operations and control documents. EFBs may also host applications such as the Onboard Performance Tool (OPT) or 3rd party applications.

Unlike 777 and 787, the 777X does not offer an installed EFB option. This item includes provisions for portable EFBs in accordance with FAA Policy Letter 121.

Consequences of Failure

When applicable, operator must establish alternate procedures to be used when specified EFB interface is inoperative.

Consequences of Next Critical Failure

None.

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46-13-02 Aircraft Interface Device (AID)

46-13-02A

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

46-13-02 Aircraft Interface Device (AID)

46-13-02B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 46-11-02-05-04.

The Aircraft Interface Device (AID) functions as a Wireless Wide Area Network (WAN) Unit (WWU). It includes a cellular radio and a WiFi radio to enable on ground connectivity. It is used for both wireless uploading and downloading of files and/or data for support of ONS-hosted applications, airplane systems and systems analysis, and software part loading.

Consequences of Failure

None identified.

Consequences of Next Critical Failure

None identified.

46-13-03 Crew Wireless LAN Unit (CWLU)

46-13-03A

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided alternate procedures are established and used.

NOTE: Any Wi-Fi Function that operates normally may be used.

46-13-03 Crew Wireless LAN Unit (CWLU)

46-13-03B

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require its use.

NOTE: Any Wi-Fi Function that operates normally may be used.

SUBSTANTIATION**Background**

New proposal for 777X.

The Crew Wireless Local Area Network (LAN) Unit (CWLU) provides the onboard Wi-Fi connection point connecting flight/cabin/maintenance crew devices to the Onboard Network System (ONS). The CWLU is optional equipment which may consist of 1 or 3 wireless access points (WAPs) when installed.

Consequences of Failure

Portable devices (Flight (EFB), Cabin Crew, Maintenance) may not be able to access airplane data via the CWLU to ONS.

- Consequences for loss of EFB or Cabin Crew connectivity depend on airline-specific applications and procedures.

- Consequences for loss of portable maintenance device connectivity require use of alternate connection methods (wired) or use of MAT or UMDs (wired).

Consequences of Next Critical Failure

None identified.

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47-11-01 Nitrogen Generation System (NGS)

47-11-01-01 Nitrogen Generation Performance

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47-11-01 Nitrogen Generation System (NGS)

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- NGS shutoff valve is locked closed, and
- Repairs are made within 10 flight-days.

47-11-01 Nitrogen Generation System (NGS)**47-11-01-01 Nitrogen Generation Performance**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 47-11-01.

The Flammability Reduction System (FRS) consists of the Nitrogen Generation System (NGS) and the Nitrogen Enriched Air Distribution System (NEADS). The purpose of the FRS is to send Nitrogen Enriched Air (NEA) to the fuel tanks in order to reduce the fuel tank flammability.

The 777X FRS has been expanded from the legacy 777 design to inert the main wing tanks in addition to the center tank.

The NGS is installed in the unpressurized underwing/body fairing compartment of the airplane. The NGS receives bleed air from the pneumatic system and separates the air into nitrogen enriched air (NEA) and oxygen enriched air (OEA). The NEA is ducted to the left and right main fuel tanks and the center wing tank through the nitrogen enriched air distribution system (NEADS). The OEA is a waste gas that is dumped overboard through a dedicated exhaust port.

The NGS shutoff valve controls the pressure that comes into the system. Bleed air goes through the primary ozone converter which reduces the ozone to protect the air separation modules (ASMs).

The NGS thermal control unit (TCU) uses a dedicated ram air cooling system for thermal exchange. Ram air is drawn through a dedicated air inlet to the integrated main and precooler heat exchangers before being discharged overboard. An AC-powered, motor-driven fan integral to the ram air circuit provides forced air cooling to the heat exchangers during system on-ground or low-altitude hot day flight operations. A temperature control valve (TCV) modulates to bypass bleed air around or through the heat exchangers to target 170 degrees F conditioned air temperature for air separation. Conditioned air is then passed through a high efficiency filter/secondary ozone catalyst assembly to further remove ozone and particulate or aerosol contaminants before entering the air separation modules (ASMs). The resultant product gas is ducted to the fuel tanks to displace fuel vapor rich ullages overboard via the fuel tank vent system to ensure ullage spaces oxygen content is below the amount to support ignition or combustion. Depending on aircraft conditions and system operating mode, the total amount of inert gas available for inerting is determined by the state of the NGS high/low flow valve and the super low flow valve. The distribution of the inert gases to different fuel tanks may also vary based on the control of the left main tank, right main tank, and the center wing tank NEADS isolation valves, which are controlled by the fuel quantity processor unit (FQPU).

Connecting the NGS air separation unit (ASU) outlet to the fuel tanks are the NEADS and the fuel tank vent system. This system consists of a series of tubes, ducts, isolation valves, check valves, flame arresters, float valves, and cross-ventilation check valves for the proper distribution the inert gas to the various tank compartments, and to allow the fuel tanks to communicate to the atmosphere while preventing the overboard spillage of fuel.

In addition to NEADS isolation valves and super low flow valve control, the fuel quantity processor unit (FQPU) has primary responsibility for fuel tank structure and tank elements over-pressurization by actively monitoring the amount of NEA flow delivered to the fuel tanks under all airplane conditions or system operations, as well as for providing active fuel tanks & tank elements over-temperature protection by monitoring the NEA stream for excessive high temperature condition. A potential over-pressurization or over-temperature condition will result in a NGS shutdown (latching) by the FQPU. Loss of valid fuel quantity data or loss of communication between the NGS and FQPU will also result in NGS shutdown (non-latching).

Consequences of Failure

The NITROGEN GEN SYS Status message will be displayed when NGS has detected a critical fault resulting in FRS being latched in the shut down state. For dispatch the NGS shutoff valve (SOV) must be locked closed. This results in loss of fuel tank inerting capability. Minor effect at airplane level.

The NITROGEN GEN PERF Status message indicates the system has detected a fault affecting redundancy, reliability or performance.

Consequences of Next Critical Failure

Hot surface in fuel leakage zone: There is a next critical failure of the mass flow sensor that can result in excessive surface temperature of the sensor. This hazard is mitigated by removing power from the sensor by opening the NGS valves circuit breaker.

Loss of fuel tank inerting is minor because the 777-9 is designed to be compliant to the FRS reliability requirements of Appendix M25.1(a)(2), as well as 25.981(a) and 25.954. The existence of non-lightning related ignition sources in the fuel tank is extremely improbable, and the probability of catastrophic fuel vapor ignition due to lightning is also extremely improbable, taking into account flammability, critical lightning strikes, and failures within the fuel system.

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49-11-01 Auxiliary Power Unit (APU)

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU selector remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-11-01.

The APU supplies electrical and pneumatic power to the airplane to enable independent ground operation. It provides electrical power from a 150 kVA oil-cooled APU generator. Pneumatic power is provided by the APU load compressor. The APU is also available for use in flight. Starting capability is provided throughout the airplane flight envelope. Full electrical power is available up to 39,000 ft. Above 39,000 ft., 140 kVA is available. Pneumatic power is available up to an altitude of approximately 22,000 feet.

The APU provides bowed rotor motoring (BRM) capability. BRM is a new, additional main engine start (MES) pneumatic mode that supplies reduced bleed air for up to three minutes in order to eliminate any shaft bow that may have set in while the engine was shut down. During BRM, the EECs will transmit a signal to indicate that a BRM condition exists. The APUC will respond by reducing the pneumatic output to the main engines allowing the main engines to dry motor before a normal start.

Although there are some exceptions, the MMEL/DDG generally does not grant authority to operate with equipment missing or removed. However, the APU can be removed by an approved procedure, such as an engineering order. Operationally, the weight & balance effects of the removed APU would need to be accounted for, and operation would be under MMEL 49-11-1 for APU inop (which includes ETOPS restrictions).

Consequences of Failure

The APU Status message will be displayed when the APUC has detected a fault that would cause automatic shutdown of APU or complete loss of APUC bus activity (both L and R A429) for 10 seconds after the APU Selector has been in the ON position for ten seconds.

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The APU REMOTE SHUTDOWN message indicates that the remote shutdown switch on the nose landing gear panel has been activated. The message is latched and the APU cannot be started. The message may be cleared and the system reset by running the fire/overheat test.

APU electrical and pneumatic power is not available on ground or in-flight. Ground operations support can be supplied by pneumatic and electrical carts. The APU is not required for any normal in-flight procedures. The MMEL remarks preclude dispatch with other inoperative equipment that require operation of the APU in-flight. The DDG will list all MMEL items that require APU availability. FAR 121 Appendix P prescribes that the airplane must remain with 180 minutes of a suitable airport.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27E-10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67E-10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

Engine or IDG failure: Airplane electrical power is supplied by the main and backup generator systems on the remaining engine or the engine with remaining operative IDG. Airplane pneumatic power is supplied by bleed air from the remaining engine.

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Federal Aviation Administration (FAA)**ATA 49****777-9 Master Minimum Equipment List****Section 2****49-15-01 APU Air Inlet Door Actuation System****49-15-01A**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative with door in any position provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of APU,
 - APU selector remains OFF,
 - Flight remains within 180 minutes of landing at a suitable airport, and
 - Appropriate performance adjustments are applied.
-

49-15-01 APU Air Inlet Door Actuation System**49-15-01B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- APU air inlet door is deactivated in the full open position, and
 - Appropriate performance adjustments are applied.
-

49-15-01 APU Air Inlet Door Actuation System**49-15-01-01 APU Air Inlet Door Actuator Position Indication Switch**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- APU inlet door is verified to operate normally before each departure, and
 - Both ELMS P310 channels operate normally.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-15-01.

The APU inlet door is located on the upper right side of the tail cone just aft of the firewall. The outward opening inlet door is hinged along its aft edge. Door actuation is provided by a 28 VDC motor actuator which is connected directly to the door. Control is provided by the Electrical Load Management System (ELMS). The door is commanded open when APU is selected on, and closed when APU has been shutdown.

The APU Inlet Door Position Switch is located near the hingeline of the APU Inlet Door. The position switch provides indication when the inlet door is fully open and when the inlet door is not fully open. The APU Inlet Door position indication on the APU Maintenance page is based on the APU Inlet Door position switch.

The APU Inlet Door Actuator includes a switch that indicates when the actuator is in the closed position, or the not-closed position.

Consequences of Failure

The APU DOOR Status message will be displayed when ELMS has detected either one of the following conditions: 1) Door actuator has been commanded to open and the door actuator switch indicates 'closed' or the door position switch indicates 'not open'. 2) Door actuator has been commanded to close and the door position switch indicates 'open' or the door actuator switch indicates 'not closed'.

If the door position switch does not indicate 'open' when the APU is starting, the APU will automatically shut down.

There are two options for dispatch:

APU not used: Dispatch is allowed provided the APU is not used. Fuel burn penalty is applied if the inlet door is not in the closed position. The APU can windmill indefinitely without damage with the inlet door open.

APU required: Dispatch is allowed provided the APU inlet door is deactivated in the full open position. Fuel burn penalty is applied due to increased aerodynamic drag with the inlet door deactivated in the full open position.

Inlet Door Actuator Switch:

If the inlet door actuator switch is failed (i.e., indicating a closed status when the door is open or indicating a not closed status when the door is closed), the APU DOOR Status message will be displayed but the inlet door will operate normally.

Dispatch is allowed provided that the APU inlet door is verified to operate normally before each departure. Both ELMS P310 channels must operate normally.

Verification of the APU inlet door is accomplished using the APU Maintenance page. The APU inlet door status on the APU Maintenance page is based on the APU door position switch (OPEN or NOT OPEN).

Consequences of Next Critical Failure

Inlet Door System:

Dispatch with inlet door failed closed or partially open: Dispatch is made with all APU inoperative restrictions imposed so that a subsequent single failure does not compromise safety.

Dispatch with inlet door deactivated open: APU operates normally so it is available as an alternate AC electrical power source or bleed source (FL

220 and below). Therefore there are no subsequent failure concerns.

Inlet Door Actuator Switch:

If the inlet door or the inlet door position switch subsequently fails closed (i.e., the switch indicates a not open condition when the door is actually open) when the APU is running, the APU may shutdown, which will result in the APU SHUTDOWN Advisory message and illumination of the APU FAULT light. If the inlet door or the inlet door position switch subsequently fails closed with the APU not running, the APU will not start. However, an inoperative inlet door actuator position switch has no effect on failures that can cause the APU door to not operate normally, other than display of the APU DOOR message due to a failed door actuator position switch which could mask a subsequently failed open door.

If the inlet door subsequently fails open, the door will remain open after the APU is shutdown, however, there is no other flight deck effect other than the APU DOOR Status message. Since the APU DOOR Status message is already displayed due to the inlet door actuator position switch failure, the failed open door would not be identified by the crew. Although crews are not required to check Status messages after engine start, under normal circumstances display of the status cue 30 minutes after takeoff would likely cause the crew to review the Status messages. A failed open APU door increases fuel burn, but exposure will be limited to one flight since the door operation is verified normal before each departure. For that single flight, fuel usage monitoring by the flight crew should provide indication of the additional fuel burn and allow flight plan adjustment when required.

Inlet door position switch: If the inlet door position switch fails open while the APU is running, the APU will continue running. If the inlet door position switch fails open and the APU is not running and an APU start is initiated, then the APU will not start and after 60 seconds the APU SHUTDOWN Advisory message will be displayed.

49-42-01 APU Starting System (Including Electric Starter)**49-42-01A**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be dispatched with APU START SYS Status message displayed provided:

- APU chip collector contaminants are verified to be acceptable,
 - APU is verified to turn freely,
 - APU is started before departure and operated continuously throughout the flight, and
 - Appropriate performance adjustments are applied.
-

49-42-01 APU Starting System (Including Electric Starter)**49-42-01B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be dispatched with APU START SYS Status message displayed provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
 - Other procedures do not require use of APU,
 - APU selector remains OFF, and
 - Flight remains within 180 minutes of landing at a suitable airport.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-42-01.

The APU starting system includes two independent starters: an electric starter and an Air Turbine Starter (ATS). The starting sequence is automatically controlled by the APU controller (APUC). The ATS is the primary means of starting when pneumatic power is available. If pneumatic power is not available, the APUC defaults to the electric starter. The APU START SYS message is set if the APUC detects a failure in the electric starter, fuel scheduling, ignition, or lube deprime systems or if there is no signal from ELMS to the APUC. It is assumed that in the normal course of operations the electric starter will be used once a day.

Consequences of Failure

The APU START SYS Status message is displayed when the APUC has detected failure in the Electric Starter, Fuel Scheduling, Ignition, or De-oil/Deprime systems or there is no signal from ELMS to the APUC.

APU starting capability is degraded. It may be impossible to start the APU for some of the failures indicated by the APU START SYS Status message. APU running capability is not affected if the APU start is successful. For dispatch, the APU must be started before departure and operated continuously during the flight. If the APU cannot be started, dispatch per the provisions of an inoperative APU is required.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27E-10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67E-10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

APU shutdown: Loss of APU as source of electrical and pneumatic power. Electrical power needs are supplied by engine driven generator(s) and backup electrical power system, if required. Pneumatic power is supplied by engine bleed air system. Uncommanded shutdown of the APU is indicated by the APU SHUTDOWN Advisory message.

For APU not used: Subsequent failure of either an IDG or an engine would leave one operative 150 kVA AC power source. The Backup AC Electrical Power System would then assume the load on one AC Transfer Bus. Additionally, load shedding of non-essential loads would occur to ensure sufficient power is available for essential loads.

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49-43-01 APU Air Turbine Starter

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided APU Starting System (including electric starter) operates normally.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-43-01.

The APU starting system includes two independent starters: an electric starter and an Air Turbine Starter (ATS). The starting sequence is automatically controlled by the APU controller (APUC). The ATS is the primary means of starting when pneumatic power is available. If pneumatic power is not available, the APUC defaults to the electric starter. The status message APU AIR STARTER is set when the APUC detects loss of air starter function. Failure of the electrical starter is signaled by the status message APU START SYS. It is assumed that in the normal course of operations the electric starter will be used once a day.

Consequences of Failure

The APU AIR STARTER Status message is set when the APUC detects loss of the air starter function.

APU cannot be started with pneumatic power. Use of the APU is not affected since starting capability is retained throughout the flight envelope. The APU controller defaults to the electric starter in the same way as when pneumatic power is not available.

Consequences of Next Critical Failure

Failure of APU controller and/or electric starter resulting in loss of APU starting functionality. Failure of the electrical starter is indicated by the APU START SYS Status message. Loss of APU as a source of electrical and pneumatic power. Electrical power needs are supplied by engine driven generator(s) and backup electrical power system, if required. Pneumatic power is supplied by engine bleed air system(s).

49-52-01 APU Bleed Air System

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Other procedures do not require use of the APU as a pneumatic source,
- APU BLEED AIR switch remains OFF except for ground operations, and
- Flight remains within 180 minutes of landing at a suitable airport.

NOTE: The APU may be used for electrical power.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-52-01.

The APU bleed air system supplies pressurized air to the airplane pneumatic system. Prior to engine start, APU bleed air can be used to supply pneumatic power to the environmental control system, the air driven hydraulic pumps, and for main engine starting. The system is composed of a centrifugal load compressor, variable inlet guide vanes (IGV) and a surge control valve (SCV). Control of the IGVs and SCV is provided by the APU Controller.

The APU provides bowed rotor motoring (BRM) capability. BRM is a new, additional main engine start (MES) pneumatic mode that supplies reduced bleed air for up to three minutes in order to eliminate any shaft bow that may have set in while the engine was shut down. During BRM, the EECs will transmit a signal to indicate that a BRM condition exists. The APUC will respond by reducing the pneumatic output to the main engines allowing the main engines to dry motor before a normal start.

Consequences of Failure

The APU BLEED AIR Status message will be displayed when the APUC has detected the loss of ability to pneumatically load the APU. The message is triggered by inlet guide vane (IGV) or surge control system faults or if bleed air duct overheat is detected

APU is not capable of supplying pneumatic power because of problems in the APUC with control of the inlet guide vanes or with surge control. On ground, air can be supplied by a pneumatic cart before engine start. In-flight, pneumatic power is supplied by the two engine bleed air systems. The MMEL remarks prohibit dispatch in a configuration where APU bleed air is required. There are no Normal or Non-Normal procedures that require use of APU as a pneumatic air source. However, several MMEL items require the APU as a second pneumatic source during takeoff and landing. The DDG lists all the MMEL items that require APU bleed air as a pneumatic source. APU can still be used for electrical power. Air Turbine Starter is not affected provided the APU BLEED AIR switch remains in the AUTO position.

Consequences of Next Critical Failure

Engine failure, or failure of engine bleed air system: pneumatic power is supplied by the remaining engine bleed air system.

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49-52-02 APU Bleed Air Check Valve

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Other procedures do not require use of APU as a pneumatic source,
- APU BLEED AIR switch remains OFF except for main engine start, and
- Flight remains within 180 minutes of landing at a suitable airport.

NOTE: The APU may be used for electrical power. Air Turbine Starter is not available with APU Bleed Air Shutoff Valve closed.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-52-02.

The APU bleed air check valve prevents reverse flow of pneumatic air into the APU bleed air system. A reverse flow condition would exist if the air supply system were pressurized by either main engine bleed system, the APU bleed air shutoff valve (SOV) were open, and the APU bleed air check valve were inoperative. An inoperative check valve may be detected when attempting an APU air turbine start by not enough air being supplied to the APU air turbine starter.

Consequences of Failure

The APU bleed air system is not protected against reverse air flow by the bleed air check valve. The MMEL requires the bleed air SOV to remain in the OFF position after main engine start to preclude any reverse flow condition. APU pneumatic air is not available to the air supply system when the SOV is OFF. The BLEED OFF APU Advisory message will be displayed. Other MMEL items requiring APU pneumatic air are listed in the Operations procedures.

Consequences of Next Critical Failure

Engine failure or failure of engine bleed air system: pneumatic power is supplied by the remaining engine bleed air system.

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49-61-01 APU Controller (APUC)

Interval	Installed	Required	Procedure
C	1	0	

May be dispatched with APU CONTROL Status message displayed.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 49-61-01.

The APU Controller (APUC) is a Full Authority Digital Electronic Control (FADEC) system. It controls and monitors the APU starting sequence, normal operation, and shutdown. It also controls protective APU auto shutdown if necessary to prevent damage to the APU. The APUC will perform the same functions as the baseline 777-300ER APUC. New functions will be added for new APU LRU's, Bowed Rotor Motoring (BRM), APU Load compressor temperature monitoring and control, and Built-In Test Equipment (BITE).

Consequences of Failure

The APU CONTROL Status message will be displayed there is a failure in the APU control system. This message indicates a loss of redundancy or of non-essential functions only. The APU is fully functional with the APU CONTROL Status message displayed.

Consequences of Next Critical Failure

Failure of APU controller: Loss of APU control functions. APU cannot be started. If APU is running, APU will perform a protective shutdown and display the APU Status message and APU SHUTDOWN Advisory message.

49-61-02 APU Shutdown Panel (P40)**49-61-02A**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided:

- APU Fire Detection System operates normally,
- APU Fire Warning Speakers operate normally if APU is used for airplane electrical power up, and
- At least one APU Fire Detection Loop operates normally.

NOTE: APU Fire Warning Speakers may be inoperative provided external electrical power is used for airplane power up.

49-61-02 APU Shutdown Panel (P40)**49-61-02B**

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided APU is considered inoperative.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-61-02.

The Ground Control Panel (P40) is located on the aft side of the nose landing gear. The panel is for use by the ground crew in the event that APU shutdown is required for a normal or fire condition. The panel includes a fire warning horn and fire warning light. Both are activated by the APU fire detection system. The panel also provides switches for APU fire shutdown and APU bottle discharge. The panel also provides a fire bottle armed light and bottle discharge light. The panel does not provide APU starting capability or parameter displays.

Consequences of Failure

Manual APU shutdown and fire bottle discharge cannot be accomplished at the ground control panel. APU shutdown and fire bottle discharge must be accomplished from the flight deck.

For dispatch, the APU may be used if the APU fire detection system operates normally. If the APU fire warning speakers are inoperative, the APU may not be used for airplane electrical power up (external power must be used for power up).

Consequences of Next Critical Failure

APU Fire:

Remote panel (P40) will not annunciate the fire. Flight deck annunciations will be made by the APU fire detection system.

Upon detection of an APU fire, the APU FIRE Warning message will be displayed. The APU automatic shutdown feature will activate in both attended and unattended mode. The APU SHUTDOWN Advisory message will be displayed upon APU shutdown. Upon fire bottle discharge, the BOTTLE DISCH APU Advisory message will be displayed. Similarly, the BOTTLE APU Status message will also be displayed if fire bottle discharges.

In attended mode (one or both main engines running), the APU automatically shuts down and the flight crew will determine whether or not to use the fire extinguishing system.

In unattended mode (no main engines running), the APU automatically shuts down and the APU fire extinguishing system will discharge the fire bottle 10 seconds after fire detection.

Loss of APU as source of electrical and pneumatic power. Electrical power needs are supplied by engine driven generator(s) and backup electrical power system, if required. Pneumatic power is supplied by engine bleed air system.

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Feb 26, 2019

49-61-03 APU Temperature Sensors**49-61-03-01 APU Bleed Temperature (TAPU) Sensor**

Interval	Installed	Required	Procedure
C	1	0	

May be dispatched with APU BLEED TEMP SNSR Status message displayed.

49-61-03 APU Temperature Sensors**49-61-03-02 APU Engine Manifold Temperature Sensors**

Interval	Installed	Required	Procedure
C	2	0	

May be dispatched with one or both of the following Status messages displayed:

- APU L ENG MANF TEMP SNSR
 - APU R ENG MANF TEMP SNSR
-

49-61-03 APU Temperature Sensors**49-61-03-03 APU Pack Inlet Temperature Sensors**

Interval	Installed	Required	Procedure
C	2	0	

May be dispatched with one or both of the following Status messages displayed:

- APU L PACK INLET TEMP SNSR
 - APU R PACK INLET TEMP SNSR
-

SUBSTANTIATION**Background**

The APU control system includes logic to limit the maximum steady state compressor bleed air temperature to 450 degrees F. In addition to dedicated APU Temperature (TAPU) sensors located in the Environmental Control System (ECS) duct forward of the aft cargo door, the system makes use of existing temperature sensors used in other airplane systems. For Main Engine Start (MES) and Bowed Rotor Motoring (BRM) modes, the APU control system will use temperature manifold sensors located in the ECS ducts in the engine struts. For ECS, and ADP/ECS modes, the system will use the pack inlet temperature sensors located upstream of the packs.

To ensure that compressor discharge temperatures remain below 450 degrees F, the APU Controller (APUC) will bias the inlet guide vanes (IGV) towards the closed position to reduce the duct temperatures when in MES, ECS and ECS/ADP modes. By closing the IGVs, compressor discharge pressure is reduced which provides a corresponding compressor discharge temperature reduction. Closed loop feedback using existing airplane duct temperatures will be used to adjust the IGVs as needed to accommodate APU performance changes due to changes in outside air temperature. If the APU bleed temperature exceeds 450 degrees F, the APU Controller (APUC) enters duct protection mode (TEMP PROT) and disables bleed air by driving the IGVs full closed and requesting the Air Supply Control System (ASCS) to close the APU bleed valve. Bleed air cannot be restored until duct temperature remains below 390 degrees F for a minimum of 30 seconds.

Consequences of Failure

The APU BLEED TEMP SNSR Status message will be displayed when there is a failure of APU bleed temperature (TAPU) sensor element 1 or 2. Loss of redundancy only.

The APU L, R ENG MANF TEMP SNSR Status message will be displayed when the APU controller has detected that an associated left or right engine manifold temperature sensor element has failed. Loss of redundancy only.

The APU L, R PACK INLET TEMP SNSR Status message will be displayed when the APU controller has detected that an associated left or right pack inlet temperature sensor element has failed. Loss of redundancy only.

Consequences of Next Critical Failure

For APU L, R ENG MANF TEMP SNSR Status message, failure of TAPU sensor element 1 and 2 will result in the associated APU L, R MANF TEMP CTRL Status message.

For APU L, R PACK INLET TEMP SNSR Status message, failure of TAPU sensor elements 1 and 2 will result in the associated APU L, R PACK INLET CTRL Status message. Due to the proximity of the pack sensors, 2 pack operation is available as long as one pack sensor is valid.

49-61-04 APU Temperature Control Sensors - Engine Manifold

49-61-04A

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Associated engine does not use APU as a pneumatic source for engine start, and
- Alternate procedures are established and used.

NOTE: Inoperative engine manifold temperature control for APU supplied bleed air is indicated by either of the following Status messages:

APU L ENG MANF TEMP CTRL
APU R ENG MANF TEMP CTRL

49-61-04 APU Temperature Control Sensors - Engine Manifold

49-61-04B

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided:

- Both engines do not use APU as a pneumatic source for engine start, and
- Alternate procedures are established and used.

NOTE: Inoperative engine manifold temperature control for APU supplied bleed air is indicated by either of the following Status messages:

APU L ENG MANF TEMP CTRL
APU R ENG MANF TEMP CTRL

SUBSTANTIATION

Background

The APU control system includes logic to limit the maximum steady state compressor bleed air temperature to 450 degrees F. In addition to dedicated APU Temperature (TAPU) sensors located in the Environmental Control System (ECS) duct forward of the aft cargo door, the system makes use of existing temperature sensors used in other airplane systems. For Main Engine Start (MES) and Bowed Rotor Motoring (BRM) modes, the APU control system will use temperature manifold sensors located in the ECS ducts in the engine struts. For ECS, and ADP/ECS modes, the system will use the pack inlet temperature sensors located upstream of the packs.

To ensure that compressor discharge temperatures remain below 450 degrees F, the APU Controller (APUC) will bias the inlet guide vanes (IGV) towards the closed position to reduce the duct temperatures when in MES, ECS and ECS/ADP modes. By closing the IGVs, compressor discharge pressure is reduced which provides a corresponding compressor discharge temperature reduction. Closed loop feedback using existing airplane duct temperatures will be used to adjust the IGVs as needed to accommodate APU performance changes due to changes in outside air temperature. If the APU bleed temperature exceeds 450 degrees F, the APU Controller (APUC) enters duct protection mode (TEMP PROT) and disables bleed air by driving the IGVs full closed and requesting the Air Supply Control System (ASCS) to close the APU bleed valve. Bleed air cannot be restored until duct temperature remains below 390 degrees F for a minimum of 30 seconds.

Consequences of Failure

The APU L, R ENG MANF TEMP CTRL Status message will be displayed when all temperature sensors required to monitor APU bleed air temp during the associated left or right main engine start have failed.

The message is set when the airplane is on the ground.

One Inoperative:

Associated engine cannot be started using APU bleed air. Associated engine can be started using cross-bleed or ground cart.

Both Inoperative:

Both engines cannot be started using APU bleed air.

Consequences of Next Critical Failure

None.

49-61-05 APU Temperature Control Sensors - Pack Inlet**49-61-05A**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided:

- Both Engine Bleed Air Systems operate normally, and
 - Opposite Air Conditioning Pack operates normally.
-

NOTE 1: Inoperative pack inlet temperature control for APU supplied bleed air is indicated by either of the following Status messages:

APU L PACK INLET TEMP CTRL

APU R PACK INLET TEMP CTRL

NOTE 2: An engine bleed system is not operating normally if certain items associated with that system are inoperative. See DDG item 36-00-01 for a listing of those items. If any of these items are inoperative, dispatch is not allowed.

NOTE 3: An air conditioning pack is not operating normally if certain items associated with that system are not operating normally. See DDG item 21-51-01 for a listing of these items. If any of these items are inoperative, dispatch is not allowed.

49-61-05 APU Temperature Control Sensors - Pack Inlet**49-61-05B**

Interval	Installed	Required	Procedure
C	2	0	

May be inoperative provided:

- Both Engine Bleed Air Systems operate normally, and
 - For ground operations with both engines off, airplane is supplied with conditioned air.
-

NOTE 1: Inoperative pack inlet temperature control for APU supplied bleed air is indicated by either of the following Status messages:

APU L PACK INLET TEMP CTRL

APU R PACK INLET TEMP CTRL

NOTE 2: An engine bleed system is not operating normally if certain items associated with that system are inoperative. See DDG item 36-00-01 for a listing of those items. If any of these items are inoperative, dispatch is not allowed.

SUBSTANTIATION

Background

The APU control system includes logic to limit the maximum steady state compressor bleed air temperature to 450 degrees F. In addition to dedicated APU Temperature (TAPU) sensors located in the Environmental Control System (ECS) duct forward of the aft cargo door, the system makes use of existing temperature sensors used in other airplane systems. For Main Engine Start (MES) and Bowed Rotor Motoring (BRM) modes, the APU control system will use temperature manifold sensors located in the ECS ducts in the engine struts. For ECS, and ADP/ECS modes, the system will use the pack inlet temperature sensors located upstream of the packs.

To ensure that compressor discharge temperatures remain below 450 degrees F, the APU Controller (APUC) will bias the inlet guide vanes (IGV) towards the closed position to reduce the duct temperatures when in MES, ECS and ECS/ADP modes. By closing the IGVs, compressor discharge pressure is reduced which provides a corresponding compressor discharge temperature reduction. Closed loop feedback using existing airplane duct temperatures will be used to adjust the IGVs as needed to accommodate APU performance changes due to changes in outside air temperature. If the APU bleed temperature exceeds 450 degrees F, the APU Controller (APUC) enters duct protection mode (TEMP PROT) and disables bleed air by driving the IGVs full closed and requesting the Air Supply Control System (ASCS) to close the APU bleed valve. Bleed air cannot be restored until duct temperature remains below 390 degrees F for a minimum of 30 seconds.

Consequences of Failure

The APU L, R PACK INLET TEMP CTRL Status message will be displayed when both TAPU sensors are inoperative and the associated left or right pack inlet heat exchanger temperature sensor is inoperative.

One Inoperative:

Both packs will operate normally, however, APU to Pack takeoff is not available if the left inlet temperature control is inoperative.

Both Inoperative:

Both packs will be inoperative if the APU is the only bleed air source. Airplane must be supplied with conditioned air when both engines are off.

Consequences of Next Critical Failure

Loss of one engine bleed system or engine out: None. Remaining engine bleed system will provide bleed air for associated pack.

49-70-01 APU FAULT Light

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-70-01.

The APU FAULT light is located directly below the APU Master Control Selector. It illuminates when a fault condition is detected in the APU. It also will illuminate when the APU LIMIT EXCEED Caution, APU SHUTDOWN Advisory, or APU Status message is displayed.

Consequences of Failure

FAULT light will not illuminate when APU limit exceedence or APU shutdown occurs. However, the APU LIMIT EXCEED Caution message, APU SHUTDOWN Advisory message and APU Status message will display. APU faults prior to APU start will be displayed on the Status page. The auto shutdown function still operates normally.

Consequences of Next Critical Failure

APU limit exceedence: in the attended mode, the APU LIMIT EXCEED Caution message alerts crew to exceedence condition. In attended mode, other automatic shutdown functions still operate normally. In unattended mode, the APU limit exceedence initiates automatic shutdown.

49-71-01 APU EGT Indication

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-71-01.

APU EGT (°C) is displayed in the APU parameters block on the EICAS status page. The APU uses two pairs of EGT sensors (thermocouples) mounted on the exhaust case. Each pair of sensors provides a separate signal input to the APU Controller. The APUC uses the highest EGT input for controlling fuel based on acceleration and to prevent over-temperature conditions. EGT is also used by the APUC for the APU LIMIT EXCEED Caution message and APU SHUTDOWN Advisory message.

Consequences of Failure

Flight crew will have no indication of APU EGT. EGT indication is not required for any normal or non-normal procedures.

There are crew procedures that are initiated by the APU LIMIT EXCEED Caution and APU SHUTDOWN Advisory messages. However, those procedures are not initiated by the EGT indication, nor are they dependent on the indication for their performance. Loss of indication does not affect the display of the APU LIMIT EXCEED Caution, APU SHUTDOWN Advisory, APU RUNNING Memo and APU COOLDOWN Memo messages.

Consequences of Next Critical Failure

EGT exceeds specified limit:

In the unattended mode, high EGT will trigger a protective shutdown of the APU. APU SHUTDOWN Advisory and APU Status messages will be displayed. In the attended mode, APU LIMIT EXCEED Caution message will be displayed. In both attended and unattended modes the APU Status message will be displayed.

Failure of one pair of EGT sensors will not affect APU operation.

Failure of both pairs of EGT sensors:

In the unattended mode, loss of both pairs of EGT sensors results in a protective shutdown. The APU SHUTDOWN Advisory message and APU Status message will be displayed.

In the attended mode, loss of both pairs of EGT sensors will result in the APU controller disabling bleed air but the APU will continue to run and provide generator capability. The APU Status message will be displayed. The APU will continue to operate but will not start once shut down with both pairs of sensors failed.

49-73-01 APU RPM Indication

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-73-01.

APU RPM (%) is displayed in the APU parameters block on the EICAS status page. RPM is sensed by dual redundant electronic speed sensors. RPM is used by the APU Controller in the logic for display of the following messages: APU LIMIT EXCEED Caution, APU SHUTDOWN Advisory, APU CONTROL Status, APU RUNNING Memo and APU COOLDOWN Memo.

Consequences of Failure

Flight crew has no indication of APU RPM. RPM indication is not required for any normal or non-normal procedures. There are crew procedures that are initiated by the APU LIMIT EXCEED and APU SHUTDOWN messages. However, those procedures are not initiated by the RPM indication, nor are they dependent on the indication for their performance. Loss of indication does not affect the display of the APU LIMIT, APU SHUTDOWN, APU CONTROL, APU RUNNING and APU COOLDOWN messages.

Consequences of Next Critical Failure

RPM exceeds specified limit: APU will perform a protective shutdown and generate the APU SHUTDOWN Advisory message and APU Status message in both attended and unattended operating modes.

Federal Aviation Administration (FAA)

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777-9 Master Minimum Equipment List

Section 2

49-94-01 APU OIL QTY Indication

49-94-01A

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided APU oil quantity is verified adequate once each flight-day.

49-94-01 APU OIL QTY Indication

49-94-01B

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Backup AC Electrical Power System is verified to operate normally before each departure,
- Other procedures do not require use of APU,
- APU selector switch remains OFF, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 49-94-01.

APU OIL QTY is displayed in the APU parameters block on the EICAS Status page. OIL QTY is sensed by a capacitive-type oil level sensor. Sensed oil quantity is used by the APU controller in the logic for display of the APU OIL QTY Status message. The oil tank is sized for 9.0 quarts of oil providing a minimum of 250 hours of APU operation. The APU OIL QTY Status message is displayed when the oil level in the AGB reaches ADD Level marking on the AGB sight glass or if the sensor circuit is failed. The low oil Status message is normally displayed when the oil level is 64% or less. A low oil condition (64%) provides a minimum of 28.9 hours of APU operation. A sight glass provides a visual indication of the maximum and minimum oil levels.

Consequences of Failure

Flight crew has no indication of APU OIL QTY. Oil quantity indication is not required for any normal or non-normal procedures.

CONSIDERATIONS FOR ETOPS, FAA MMEL Policy Letter 40 (PL-40)

The 777-9 Electrical Power System includes four independent power sources. The primary AC Electrical Power System includes two Engine Driven Generator Systems (Integrated Drive Generator, General Control Breaker). There is one Integrated Drive Generator (IDG) on each engine. Each IDG is rated at 150 KVA. The third independent power source is the Auxiliary Power Unit (APU) AC generator which is rated at 150 kVA. The fourth independent power source is the Backup AC Electrical Power System which is rated at 50 kVA. The Backup AC Electrical Power System (BEPS) includes a Backup Generator on each engine. Each Backup Generator is capable of powering the Backup AC Electrical Power System.

All essential loads, including ETOPS loads, can be powered from a single Main AC Electrical System generator (IDGs, APU). Load shed of nonessential AC loads is accomplished to ensure remaining sources remain within rated power. In the event of loss of both IDGs and APU, the BEPS is capable of providing all the minimum required ETOPS and DC loads.

Therefore, for up to 120 minute ETOPS, the 777-9 is compliant with the ATA 24 ELECTRICAL requirement of three independent sources of electrical power with any one of the four AC electrical power systems inoperative.

For an inoperative Engine Driven Generator (IDG), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. One IDG, APU and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.27\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Auxiliary Power Unit (APU), MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Backup AC Electrical System which includes a full capability Backup Generator on each engine. Two IDGs and Backup AC Electrical Power System will be available at dispatch. Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $2.67\text{E-}10$ (19.1 FH, 330 minutes ETOPS).

For an inoperative Backup AC Electrical Power System, MMEL relief for 180 minutes ETOPS is proposed. Proposal is based on the availability of the Main AC Electrical Power sources (two IDGs and APU). Probability of loss of AC Electrical Power in this configuration is extremely improbable. Probability of loss of AC Electrical Power is $1.73\text{E-}09$ (19.1 FH, 330 minutes ETOPS).

Electrical system available probabilities assume 19.1 FH Exposure Time for ETOPS (330 minutes ETOPS).

Consequences of Next Critical Failure

Low oil quantity: MMEL remarks require a daily check of APU oil quantity when indication is not available. If oil quantity is not checked, APU cannot be used.

Federal Aviation Administration (FAA)**ATA 49****777-9 Master Minimum Equipment List****Section 2****49-94-02 APU OIL PRESS Indication**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 49-94-02.

APU OIL PRESS is sensed by a pressure transducer and by a low oil pressure switch, both located on the APU lube cluster. Pressure sensed by the transducer is displayed in the APU parameters block on the EICAS status page and is transmitted to Displays and Crew Alerting by the APU Controller (APUC). A low oil pressure signal is sent to the APUC by the low oil pressure switch when pressure is determined to be below 30-40 psi. A low oil pressure signal from the low oil pressure switch or the oil pressure transducer is used by the APUC to initiate an auto-shutdown when the APU is operating in the unattended mode. In the attended mode, a low oil pressure condition detected by either sensor is annunciated by the APU LIMIT EXCEED Caution message.

Consequences of Failure

Failure of the APU OIL PRESS indication is caused by failure of the APU oil pressure transducer. The condition is indicated by loss of the oil pressure indication on the EICAS Status Page. Oil pressure indication is not required for any flight crew procedures. Low oil pressure would be detected by the low oil pressure switch.

Consequences of Next Critical Failure

Low oil pressure: Low oil pressure switch would detect the condition and signal the APUC.

Failure of low oil pressure switch: The APUC would initiate an auto shutdown in the unattended mode and would annunciate the APU LIMIT EXCEED Caution message in the attended mode.

52-00-01 Doors Synoptic Display

52-11-01 Main Entry Doors/Slides

52-11-01-01 Passenger Configuration (777-9)

52-11-01-02 Door Slides - Passenger Configuration (No Passengers Carried)

52-11-02 Passenger Entry Door Pressure Stop Assemblies

52-11-02-01 Pressure Stops 1, 2, 7 or 8

52-11-02-02 Pressure Stops 3, 4, 5 or 6

52-11-03 Passenger Entry Door Hold-Open Mechanisms

52-11-04 Passenger Entry Door Hold-Open Release Handles

52-11-05 Passenger Entry Door Flight Lock Systems

52-11-06 Passenger Entry Door Locked Indicator Lights

52-21-01 Service Exit Doors

52-21-01-01 Service Exit Doors/Slides - Passenger Configuration

52-21-01-02 Door Slides - Passenger Configuration (No Passengers Carried)

52-21-02 Service Exit Door Pressure Stop Assemblies

52-21-02-01 Pressure Stops 1, 2, 6 or 7

52-21-02-02 Pressure Stops 3, 4 or 5

52-21-03 Service Exit Door Hold-Open Mechanisms

52-21-04 Service Exit Door Hold-Open Release Handles

52-21-05 Service Exit Door Flight Lock Systems

52-21-06 Service Exit Door Locked Indicator Lights

52-34-01 Forward Cargo Door Hook/Latch System (Electric Mode)

52-34-02 Forward Cargo Door Lift System (Electric Mode)

52-34-03 Forward Cargo DOOR LATCHED Light

52-36-01 Bulk Cargo Door Counterbalance Mechanism

52-37-01 Aft Large Cargo Door Hook/Latch System (Electric Mode)

52-37-02 Aft Large Cargo Door Lift System (Electric Mode)

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52-71-01	Door Indication Systems
52-71-01-01	Passenger Entry Doors
52-71-01-02	Service Exit Doors
52-71-01-03	Large Cargo Doors - Forward and Aft
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**52-71-02 Passenger Entry Door & Service Exit Door (if installed)
Status Annunciation and Alerting Systems (Flight
Attendant)**

52-71-02A

52-71-02B

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52-00-01 Doors Synoptic Display

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided DOORS AUTO, DOORS AUTO/MANUAL & DOORS MANUAL Memo messages operate normally.

SUBSTANTIATION**Background**

Proposal is based on 777 MMEL item 52-00-01.

The Synoptic Displays provide a graphic presentation of airplane system operational status and are available for several airplane systems. (Electrical Power, Fuel, Air, Flight Controls, Hydraulic, Doors and Landing Gear) The synoptic pages are displayed on the multi-function display (MFD) by pressing the SYS button on the display select panel or the multi-function keypad. The lower and two inboard display units can display the MFD format.

A system failure external to Displays and Crew Alerting (DCA) can result in network communication losses which may result in missing data on the associated system synoptic. The system failure will normally be annunciated by an EICAS message(s). In this case, the data for the associated synoptic will typically be missing on all three MFDs. The synoptic display is "operating normally" in these cases and not subject to MMEL conditions. DCA hosted App may process data through its own logic before displaying on the synoptic page. Therefore, DCA logic issues could also cause information not to display on the synoptic page.

Consequences of Failure

None. In general, more detailed information on system status is available through the Maintenance Displays.

Flight crew procedures are not predicated on using the Synoptic pages. If an airplane system fault occurs EICAS will continue to alert the flight crew.

Consequences of Next Critical Failure

Not applicable.

Federal Aviation Administration (FAA)**ATA 52****777-9 Master Minimum Equipment List****Section 2****52-11-01 Main Entry Doors/Slides****52-11-01-01 Passenger Configuration (777-9)**

Interval	Installed	Required	Procedure
A	8	7	(M) (O)

One door/slide may be inoperative or one slide missing provided:

- a. All other Passenger Entry Doors/Slides are fully operational,

For Service Exit Doors installed:

- b. Both Service Exit Doors/Slides operate normally,
- c. Affected door is not used for passenger loading,
- d. Affected door is closed, latched, and locked,
- e. A conspicuous barrier strap or rope and a placard stating that the door is inoperative shall be placed across the inoperative door,
- f. Emergency exit sign and floor proximity lights associated with the inoperative exit must be covered to obscure the signs and lights,
- g. Passengers must be briefed not to use affected door,
- h. All passenger seats halfway to the next exit in each direction from the inoperative door, across the entire width of the airplane, shall be blocked off with conspicuous tapes or ropes that contrast with the airplane interior prior to loading passengers. Only the seats in these areas shall be blocked; main passenger aisles, cross aisles, and exit areas must not be blocked. (For an inoperative forward door/slide, the blocked seating area shall extend from the forward cabin end, rearward to a line halfway between the inoperative forward door and the next set of doors aft of the inoperative one. For an inoperative rear door/slide, the blocked seating area shall extend forward from the aft cabin end to a line halfway between the inoperative door and the next set of doors forward of the inoperative one),
- i. Conspicuous signs and placards shall be placed in appropriate locations indicating these seats are not to be occupied by passengers,
- j. Seated capacity must not exceed rated capacity of remaining pairs of exits,
- k. For extended overwater operations, occupancy shall not exceed the normal rated capacity of the slide/rafts, or the remaining slide/rafts, or the rated overload capacity of the slide/rafts remaining after loss of one additional slide/raft of greatest capacity, whichever is least,
- l. Blocked seating layouts and evacuation procedures must be developed and approved by the FAA certificate holding office for inclusion in the operator's manual, and
- m. Repairs are made within 1 flight-day.

NOTE 1: Weight and Balance Manifest must be revised as necessary to ensure proper loading limits are observed.

NOTE 2: Cabin attendants may be stationed in the vicinity of each door within blocked areas.

NOTE 3: A door with an inoperative EPAS must be considered inoperative.

52-11-01**Main Entry Doors/Slides****52-11-01-02****Door Slides - Passenger Configuration (No Passengers Carried)**

Interval	Installed	Required	Procedure
C	8	1	(M) (O)

May be missing or inoperative provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger carrying operations,
- Each person has unobstructed access from their seat to an operative exit, either regular or emergency,
- Inoperative exits are conspicuously identified as inoperative,
- Any Emergency Exit sign and floor proximity lights associated only with the inoperative exits are covered to obscure the sign and lights,
- Safety briefing includes the location of the inoperative exit(s) and instructions not to use the inoperative exit(s), and
- Alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-01.

Refer to FAA policy letters 1 and 125.

The 777-9 is a wide-body, twin aisle airplane equipped with 4 pairs of passenger doors. The doors are identified as 1 through 4 left and 1 through 4 right. Each door is a translating door that can be rated as Type A or Type C, with an emergency escape slide/raft installed on the inboard lower face. The doors can be operated manually from the inside or outside. Each door is also equipped with an Emergency Power Assist System (EPAS) which rapidly powers the door full open and automatically deploys the escape slide/raft for emergency evacuation.

The doors can be operated manually from the inside or outside with an inoperative EPAS. However, MMEL criteria require consideration of the next critical failure or event, which in this case is a passenger evacuation scenario from an unusual airplane attitude. To address this contingency, it was determined that the EPAS is required to ensure the door is opened fully and the escape slide/raft is deployed for emergency evacuation. Each EPAS is equipped with a battery pack and reservoir. The battery packs have two built-in-test (BIT) functions; a battery pack test and squib circuit continuity test.

Consequences of Failure

The affected door is not usable for passenger entry or exit, including emergency egress. Passenger load and distribution must be adjusted to account for the unusable door in the event of an emergency evacuation. No passengers will be allowed to sit in the seats within the evacuation zone of the affected door and its symmetric pair.

For dispatch with passengers, MMEL relief is consistent with PL-1.

For dispatch without passengers, MMEL relief is consistent with PL-125.

Consequences of Next Critical Failure

Emergency evacuation: Passenger evacuation will be accomplished via the remaining doors. The MMEL passenger seating restrictions ensure that the ratio of passengers per exit remains within certified limits.

52-11-02 Passenger Entry Door Pressure Stop Assemblies**52-11-02-01 Pressure Stops 1, 2, 7 or 8**

Interval	Installed	Required	Procedure
C	-	-	(M)

One forward or aft pressure stop per door (total of 8 Passenger Entry Door Stops per airplane) may be inoperative or missing provided:

- There are no visible defects on remaining stops for the affected door(s), and
- Both Outflow Valves are considered inoperative.

NOTE: There are a total of 16 pressure stop assemblies installed per each Passenger Entry Door.

52-11-02 Passenger Entry Door Pressure Stop Assemblies**52-11-02-02 Pressure Stops 3, 4, 5 or 6**

Interval	Installed	Required	Procedure
C	-	-	(M) (O)

One forward or aft pressure stop per door (total of 8 Passenger Entry Door Stops per airplane) may be inoperative or missing provided:

- There are no visible defects on remaining stops for the affected door(s),
- Both Air Supply and Cabin Pressure Controllers (ASPC) operate normally, and
- Maximum cabin differential pressure is limited to 6.0 psi.

NOTE: There are a total of 16 pressure stop assemblies installed per each passenger door.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-02.

Each door and its surrounding structure has a total of 16 pin-to-pad type pressure stops, 8 each distributed along the forward and aft sides of each door. Cabin pressurization loads on the closed, latched, and locked door are transmitted to the surrounding structure by the pressure stops.

Consequences of Failure

Pressurization loads are transmitted to the door surround structure by the remaining 15 pressure stops.

For dispatch with an inoperative pressure stop 1, 2, 7 or 8, the flight must be conducted unpressurized.

For dispatch with an inoperative pressure stop 3, 4, 5 or 6, altitude is restricted to limit cabin differential pressure. Altitude restriction varies depending upon pressure stop missing or inoperative.

Consequences of Next Critical Failure

Failure of another pressure stop: No effect since the operational restriction on cabin differential pressure precludes excessive loads on the remaining 14 pressure stops.

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Feb 26, 2026

52-11-03

Passenger Entry Door Hold-Open Mechanisms

Interval	Installed	Required	Procedure
C	8	4	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-03.

Each passenger door has a hold-open mechanism to secure the door against a bumper on the airplane body when the door is in the full open position. The mechanism consists of a hook, linkage, and release handle. It ensures that a door exposed to wind loads does not move from the full open position. The hold-open mechanism is not required for an emergency evacuation since the Emergency Power Assist System (EPAS) is designed to power the door open and hold it against the bumper in the full open position.

Consequences of Failure

An open passenger door can move under wind loads but the snubber will control the velocity of the closure. "Jetways" commonly used for passenger loading provide wind protection around an open passenger door.

Consequences of Next Critical Failure

If the snubber were to fail there would be degraded control of door velocity which may pose a potential personal safety risk.

In the case of emergency evacuation, EPAS provides enough force to hold the door in its full open position for an adequate span of time to allow evacuation.

52-11-04 Passenger Entry Door Hold-Open Release Handles

Interval	Installed	Required	Procedure
C	8	4	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-11-04-02-01.

The hold-open mechanism installed on each passenger door is a mechanical device consisting of a hook, linkage, and release handle. When the door is fully open, the hook engages a catch to secure the door against a rubber bumper. Pulling the release handle disengages the hook from the catch, allowing the door to be manually translated to the closed position.

Consequences of Failure

The door cannot be released from the full open position using the release handle. There is no operational effect on manual or power assisted opening of the passenger doors.

Consequences of Next Critical Failure

None identified.

52-11-05 Passenger Entry Door Flight Lock Systems

Interval	Installed	Required	Procedure
B	8	0	(M) (O)

May be inoperative provided:

- Each affected door is verified to be capable of being unlatched and opened before each departure,
- Associated Flight Attendant Seat operates normally, and
- A person employed by the operator is designated to monitor the affected door handle(s) when cabin differential pressure is less than 1.5 psi.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-05.

The flight lock systems prevent operation of the passenger door handles when the airplane is in flight. Each flight lock is automatically engaged when the airplane exceeds 80 KCAS. The flight lock mechanism on each door consists of a DC motor driven actuator and lever. The lever engages a cam on the door latch torque tube which prevents rotation of the torque tube to the unlatched position, thus preventing door opening. Flight lock commands for left side door are processed by the Proximity Sensor Data Concentrator (PSDC) #1. Flight lock commands for right side doors are processed by PSDC #2. Power for the flight lock actuators on the left and right doors is supplied by the left and right main 28 VDC buses, respectively. For clarification, the flight lock status messages are not inhibited in flight.

Consequences of Failure

The DOOR FLIGHT LOCK 1L, 1R, 2L, 2R, 3L, 3R, 4L or 4R Status message will be displayed for the associated passenger door when the flight lock for that door is in an uncommanded or unknown position.

The flight lock on the affected door(s) will not engage or will not indicate properly. There are faults that may affect in individual door. However, if a left or right power enable relay is inoperative, the four passenger doors (and service exit door, if installed) on the corresponding side of the airplane will be affected. For MMEL dispatch, the associated door(s) must be verified to unlock, unlatch, and open normally before each departure. In addition, the door handle must be monitored by a cabin attendant when cabin differential pressure is less than 1.5 psi to prevent a passenger from opening the door.

Consequences of Next Critical Failure

Passenger attempts to open door inflight: Passenger door handle cannot be moved to the open position when cabin differential pressure exceeds 1.5 psi. Dispatch procedure requires cabin attendant monitoring of the affected door(s) to ensure passengers do not attempt to open the door when delta P is less than 1.5 psi. In normal (automatic) operation of the pressurization system, 1.5 psi is reached within 1 minute of takeoff.

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Feb 26, 2026

52-11-06

Passenger Entry Door Locked Indicator Lights

Interval	Installed	Required	Procedure
C	8	0	(M)

May be inoperative provided associated Passenger Entry Door is verified to be closed, latched, and locked before each departure.

SUBSTANTIATION**Background**

New proposal for 777X.

Each passenger door has a green door locked indicator light located on the door upper interior liner. The light is a component of the door operator indication system and is controlled based on input from the sensors which provide door indications to the flight deck. The door locked indicator light will only illuminate when targets attached to the latch and lock mechanisms, respectively, rotate in front of their corresponding sensors.

Illumination of the door locked indicator light indicates to the door operator that they have performed all the necessary steps to close, latch, and lock the door and that the door is safe for flight. If the door locked indicator light is extinguished, it indicates to the door operator that the door is not fully closed, latched, and locked, and that the door is not prepared for flight.

Consequences of Failure

Associated passenger door locked indicator light will not illuminate when the door has been fully closed, latched, and locked. Alternatively, the door locked indicator light remains illuminated when the door is not closed, latched, and locked.

For dispatch, the associated door must be verified to be closed, latched, and locked by visual inspection.

Consequences of Next Critical Failure

None identified.

52-21-01 Service Exit Doors

52-21-01-01 Service Exit Doors/Slides - Passenger Configuration

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One door/slide may be inoperative or one slide missing provided:

- a. All Passenger Entry Doors operate normally,
- b. Affected Service Exit Door is not used for passenger loading,
- c. Affected Service Exit Door is closed, latched, and locked,
- d. A conspicuous barrier strap or rope and a placard stating that the door is inoperative shall be placed across the inoperative door,
- e. Emergency exit sign and floor proximity lights associated with the inoperative exit must be covered to obscure the signs and lights,
- f. Passengers must be briefed not to use affected door,
- g. All passenger seats halfway to the next exit in each direction from the inoperative door, across the entire width of the airplane, shall be blocked off with conspicuous tapes or ropes that contrast with the airplane interior before loading passengers. Only the seats in these areas shall be blocked; main passenger aisles, cross aisles and exit areas must not be blocked,
- h. Conspicuous signs and placards shall be placed in appropriate locations indicating these seats are not to be occupied by passengers,
- i. Seated capacity must not exceed rated capacity of remaining pairs of exits,
- j. For extended overwater operations, occupancy shall not exceed the normal rated capacity of the slide/rafts, or the remaining slide/rafts, or the rated overload capacity of the slide/rafts remaining after loss of one additional slide/raft of greatest capacity, whichever is least,
- k. Blocked seating layouts and evacuation procedures must be developed and approved by the FAA certificate holding office for inclusion in the operator's manual, and
- l. Repairs are made within 1 flight-day.

NOTE 1: Weight and Balance Manifest must be revised as necessary to ensure proper loading limits are observed.

NOTE 2: Cabin attendants may be stationed in the vicinity of each door within blocked areas.

NOTE 3: A door with an inoperative EPAS must be considered inoperative.

52-21-01 Service Exit Doors

52-21-01-02 Door Slides - Passenger Configuration (No Passengers Carried)

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative or slides missing provided:

- No passengers are carried,
- A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger-carrying operations,
- Each person has unobstructed access from their seat to an operative exit, either regular or emergency,
- Inoperative exits are conspicuously identified as inoperative,
- Any Emergency Exit sign and floor proximity lights associated only with the inoperative exits are covered to obscure the sign and lights,
- Safety briefing includes the location of the inoperative exit(s) and instructions not to use the inoperative exit(s), and
- Alternate procedures are established and used.

SUBSTANTIATION**Background**

Proposal is similar to 777 MMEL item 52-11-01.

Refer to FAA policy letters 1 and 125.

The 777-9 is a wide-body, twin aisle airplane equipped with 1 pair of optional service exit doors (SED). The doors are identified as SED left and SED right. Each door is a translating Type B or Type C door, with an emergency escape slide/raft installed on the inboard lower face. The doors can be operated manually from the inside or outside. Each door is also equipped with an Emergency Power Assist System (EPAS) which assists the door to the full open position and automatically deploys the escape slide/raft for emergency evacuation.

Consequences of Failure

The affected door is not usable for passenger exit. Passenger load and distribution must be adjusted to account for the unusable door in the event of an emergency evacuation. No passengers will be allowed to sit in the seats within the evacuation zone of the affected door and its symmetric pair.

Consequences of Next Critical Failure

Emergency evacuation: Passenger evacuation will be accomplished via the remaining doors. The MMEL passenger seating restrictions ensure that the ratio of passengers per exit remains within certified limits.

Federal Aviation Administration (FAA)**ATA 52****777-9 Master Minimum Equipment List****Section 2****52-21-02 Service Exit Door Pressure Stop Assemblies****52-21-02-01 Pressure Stops 1, 2, 6 or 7*********

Interval	Installed	Required	Procedure
C	-	-	(M)

One forward or aft pressure stop per door (total of 2 service exit door pressure stops per airplane) may be inoperative or missing provided:

- There are no visible defects on remaining stops for the affected door(s), and
- Both Outflow Valves are considered inoperative.

NOTE: There are a total of 14 pressure stop assemblies installed per each Service Exit Door.

52-21-02 Service Exit Door Pressure Stop Assemblies**52-21-02-02 Pressure Stops 3, 4 or 5*********

Interval	Installed	Required	Procedure
C	-	-	(M) (O)

One forward or aft pressure stop per door (total of 2 service exit door pressure stops per airplane) may be inoperative or missing provided:

- There are no visible defects on remaining stops for the affected door(s),
- Both Air Supply and Cabin Pressure Controllers (ASPC) operate normally, and
- Maximum cabin differential pressure is limited to 6.0 psi.

NOTE: There are a total of 14 pressure stop assemblies installed per each Service Exit Door.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-02.

Each door and its surrounding structure has a total of 14 pin-to-pad type pressure stops, 7 each distributed along the forward and aft sides of each door. Cabin pressurization loads on the closed, latched, and locked door are transmitted to the surrounding structure by the pressure stops.

Consequences of Failure

Pressurization loads are transmitted to the door surround structure by the remaining 13 pressure stops.

For dispatch with an inoperative pressure stop 1, 2, 6 or 7, the flight must be conducted unpressurized.

For dispatch with an inoperative pressure stop 3, 4 or 5, altitude is restricted to limit cabin differential pressure. Altitude restriction varies depending upon pressure stop missing or inoperative.

Consequences of Next Critical Failure

Failure of another pressure stop: No effect since the operational restriction on cabin differential pressure precludes excessive loads on the remaining 12 pressure stops.

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Feb 26, 2026

52-21-03 Service Exit Door Hold-Open Mechanisms

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-11-03-02.

Each service exit door has a hold-open mechanism to secure the door against a bumper on the airplane body when the door is in the full open position. The mechanism consists of a hook, linkage, and release handle. It ensures that a door exposed to wind loads does not move from the full open position. The hold-open mechanism is not required for an emergency evacuation since the Emergency Power Assist System (EPAS) is designed to power the door open and hold it against the bumper in the full open position.

Consequences of Failure

An open service exit door can move under wind loads but the snubber will control the velocity of the closure. “Jetways” commonly used for passenger loading provide wind protection around an open service exit door.

Consequences of Next Critical Failure

If the snubber were to fail there would be degraded control of door velocity which may pose a potential personal safety risk.

In the case of emergency evacuation, EPAS provides enough force to hold the door in its full open position for an adequate span of time to allow evacuation.

52-21-04**Service Exit Door Hold-Open Release Handles**

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-11-04-02-01.

The hold-open mechanism installed on each service exit door is a mechanical device consisting of a hook, linkage, and release handle. When the door is fully open, the hook engages a catch to secure the door against a rubber bumper. Pulling the release handle disengages the hook from the catch, allowing the door to be manually translated to the closed position.

Consequences of Failure

The door cannot be released from the full open position using the release handle. There is no operational effect on manual or power assisted opening of the passenger doors.

Consequences of Next Critical Failure

None identified.

52-21-05 Service Exit Door Flight Lock Systems

Interval	Installed	Required	Procedure
B	2	0	(M) (O)

May be inoperative provided:

- a. Each affected door is verified to be capable of being unlatched and opened before each departure,
- b. Associated Flight Attendant Seat operates normally, and
- c. A person employed by the operator is designated to monitor the affected door handle(s) when cabin differential pressure is less than 1.5 psi.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-11-05-01.

The flight lock systems prevent operation of the service exit door (SED) handles when the airplane is in flight. Each flight lock is automatically engaged when the airplane exceeds 80 KCAS. The flight lock mechanism on each door consists of a DC motor driven actuator and lever. The lever engages a cam on the door latch torque tube which prevents rotation of the torque tube to the unlatched position, thus preventing door opening. Flight lock commands for the left SED are processed by the Proximity Sensor Data Concentrator (PSDC) #1. Flight lock commands for right SED are processed by PSDC #2. Power for the flight lock actuators on the left and right SEDs is supplied by the left and right main 28 VDC buses, respectively. For clarification, the flight lock status messages are not inhibited in flight.

Consequences of Failure

The DOOR FLT LOCK SVC EXIT L or R Status message will be displayed for the associated SED when the flight lock for that door is in an uncommanded or unknown position.

The flight lock on the affected SED(s) will not engage or will not indicate properly. There are faults that may affect in individual SED. However, if a left or right power enable relay is inoperative, the SED and the four passenger doors on the corresponding side of the airplane will be affected. For MMEL dispatch, the associated door(s) must be verified to unlock, unlatch, and open normally before each departure. In addition, the door handle must be monitored by a cabin attendant when cabin differential pressure is less than 1.5 psi to prevent a passenger from opening the door.

Consequences of Next Critical Failure

Passenger attempts to open door inflight: SED handle cannot be moved to the open position when cabin differential pressure exceeds 1.5 psi. Dispatch procedure requires cabin attendant monitoring of the affected door(s) to ensure passengers do not attempt to open the door when delta P is less than 1.5 psi. In normal (automatic) operation of the pressurization system, 1.5 psi is reached within 1 minute of takeoff.

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52-21-06

Service Exit Door Locked Indicator Lights

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided associated Service Exit Door is verified to be closed, latched, and locked before each departure.

SUBSTANTIATION**Background**

New proposal for 777X.

Each service exit door has a green door locked indicator light located on the door upper interior liner. The light is a component of the door operator indication system and is controlled based on input from the sensors which provide door indications to the flight deck. The door locked indicator light will only illuminate when targets attached to the latch and lock mechanisms, respectively, rotate in front of their corresponding sensors.

Illumination of the door locked indicator light indicates to the door operator that they have performed all the necessary steps to close, latch, and lock the door and that the door is safe for flight. If the door locked indicator light is extinguished, it indicates to the door operator that the door is not fully closed, latched, and locked, and that the door is not prepared for flight.

Consequences of Failure

Associated service exit door locked indicator light will not illuminate when the door has been fully closed, latched, and locked. Alternatively, the door locked indicator light remains illuminated when the door is not closed, latched, and locked.

For dispatch, the associated door must be verified to be closed, latched, and locked by visual inspection.

Consequences of Next Critical Failure

None identified.

52-34-01 Forward Cargo Door Hook/Latch System (Electric Mode)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Manual mode operates normally,
 - There is no damage to the hook/latch mechanism, and
 - Door is manually latched and locked using the maintenance manual procedure.
-

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-34-01.

A large cargo door is installed in the lower compartment forward of the wing on the right side. The door is held in the closed, latched, and locked position by eight cam latches located near the bottom of the door, and by eight latch pins located on the lower sill. The door rotates outward about a piano-type hinge along the upper edge. It can be operated electrically from the inside or outside of the airplane, or manually from the outside only.

Consequences of Failure

Forward cargo door cannot be latched/unlatched electrically. Access to the cargo compartment is available by manual operation of the forward cargo door. Instructions for manual operation of the hook/latch mechanism are printed on decals located near the manual drive access port and detailed in the Maintenance Manual.

Consequences of Next Critical Failure

None identified. When the door is manually closed, latched, and locked, it is configured exactly the same as in electric mode. All door indications on the flight deck remain operational.

52-34-02 Forward Cargo Door Lift System (Electric Mode)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- a. Manual mode operates normally,
- b. There is no damage to the door lift system, and
- c. Door is manually closed, latched, and locked using the maintenance manual procedure.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-34-02.

A large cargo door is installed in the lower compartment forward of the wing on the right side. The door is held in the closed, latched, and locked position by eight cam latches located near the bottom of the door, and by eight latch pins located on the lower sill. The door rotates outward about a piano-type hinge along the upper edge. It can be operated electrically from the inside or outside of the airplane, or manually from the outside only.

Consequences of Failure

Forward cargo door lift system cannot be operated electrically. Access to the cargo compartment is available by manual operation of the forward cargo door. Instructions for manual lift operation are printed on decals located near the manual drive access ports and detailed in the Maintenance Manual.

Consequences of Next Critical Failure

None identified. When the door is manually closed, latched, and locked, it is configured exactly the same as in electric mode. All door indications on the flight deck remain operational.

52-34-03 Forward Cargo DOOR LATCHED Light

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided the forward cargo door is verified to be closed, latched, and locked before each departure.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-34-03.

The forward cargo door has a green DOOR LATCHED light located on the external door control panel. The light is a component of the cargo door control system and is independent of the door indication system which provides door indications on the flight deck. The DOOR LATCHED light illuminates when the following three sensors indicate a target near (true) state: (1) Door Latch Range Sensor, (2) Door Latched Sensor, and (3) Door Handle Unlocked Sensor. The green light indicates to the operator that the door is fully closed and latched. The green light extinguishes when the operator locks the door by closing the lock handle.

Consequences of Failure

Forward cargo door latched light will not illuminate when the cargo door has been fully closed and latched. Forward cargo door must be verified to be closed, latched, and locked before each departure.

Consequences of Next Critical Failure

None identified, since MMEL procedure ensures door is correctly closed, latched, and locked without the use of the DOOR LATCHED light.

52-36-01 Bulk Cargo Door Counterbalance Mechanism

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Bulk cargo door snubber system is verified to operate normally, and
- A safety hold open device is used when door is in the open position.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-36-01.

The bulk cargo door is a plug type door located aft of the aft cargo door. It is inward opening and manually operated. Door operation is assisted by a counterbalance mechanism which compensates the door weight for ease of operation. The counterbalance mechanism self-opens the door once it is unlatched. A strap loop is mounted inside the bulk compartment for securing the door in the open position as a supplement to the counterbalance mechanism.

Consequences of Failure

Failure of the counterbalance mechanism will result in additional physical force required to operate the bulk cargo door. The counterbalance mechanism will not be available to hold the door open. Unless the strap loop is used to hold the door open, the door will move towards the closed position.

Consequences of Next Critical Failure

None while in flight. On ground, in the unlikely event that the bulk cargo door snubber system fails, the door closure rate will no longer be controlled resulting in the possibility of personal injury to ground operations personnel.

52-37-01 Aft Large Cargo Door Hook/Latch System (Electric Mode)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Manual mode operates normally,
- There is no damage to the hook/latch mechanism, and
- Door is manually latched and locked using the maintenance manual procedure.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-37-01.

An optional large cargo door may be installed (in place of the standard smaller door) in the lower compartment aft of the wing on the right side. The aft large cargo door is essentially the same as the forward cargo door. The door is held in the closed, latched, and locked position by eight cam latches located near the bottom of the door, and by eight latch pins located on the lower sill. The door rotates outward about a piano-type hinge along the upper edge. It can be operated electrically from the inside or outside of the airplane, or manually from the outside only.

Consequences of Failure

Aft large cargo door cannot be latched/unlatched electrically. Access to the cargo compartment is available by manual operation of the aft cargo door. Instructions for manual operation of the hook/latch mechanism are printed on decals located near the manual drive access port and detailed in the Maintenance Manual.

Consequences of Next Critical Failure

None identified. When the door is manually closed, latched, and locked, it is configured exactly the same as in electric mode. All door indications on the flight deck remain operational.

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52-37-02

Aft Large Cargo Door Lift System (Electric Mode)

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Manual mode operates normally,
- There is no damage to the door lift system, and
- Door is manually closed, latched, and locked using the maintenance manual procedure.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-37-02.

An optional large cargo door may be installed (in place of the standard smaller door) in the lower compartment aft of the wing on the right side. The aft large cargo door is essentially the same as the forward cargo door. The door is held in the closed, latched, and locked position by eight cam latches located near the bottom of the door, and by eight latch pins located on the lower sill. The door rotates outward about a piano-type hinge along the upper edge. It can be operated electrically from the inside or outside of the airplane, or manually from the outside only.

Consequences of Failure

The aft large cargo door lift system cannot be operated electrically. Access to the cargo compartment is available by manual operation of the aft cargo door. Instructions for manual lift operation are printed on decals located near the manual drive access ports and detailed in the Maintenance Manual.

Consequences of Next Critical Failure

None identified. When the door is manually closed, latched, and locked, it is configured exactly the same as in electric mode. All door indications on the flight deck remain operational.

52-37-03**Aft Large Cargo DOOR LATCHED Light**

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided the aft large cargo door is verified to be closed, latched, and locked before each departure.

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 52-37-03.

The aft large cargo door has a green DOOR LATCHED light located on the external door control panel. The light is a component of the cargo door control system and is independent of the door indication system which provides door indications on the flight deck. The DOOR LATCHED light illuminates when the following three sensors indicate a target near (true) state: (1) Door Latch Range Sensor, (2) Door Latched Sensor, and (3) Door Handle Unlocked Sensor. The green light indicates to the operator that the door is fully closed and latched. The green light extinguishes when the operator locks the door by closing the lock handle.

Consequences of Failure

Aft large cargo door latched light will not illuminate when the cargo door has been fully closed and latched. Aft large cargo door must be verified to be closed, latched, and locked before each departure.

Consequences of Next Critical Failure

None identified, since MMEL procedure ensures door is correctly closed, latched, and locked without the use of the DOOR LATCHED light.

**52-50-01 Main Equipment Center Access Hatch - Flight Deck
Unlock Function**

Interval	Installed	Required	Procedure
D	1	0	

SUBSTANTIATION

Background

New proposal for 777X.

The main equipment center (MEC) access hatch provides access between the MEC and the passenger compartment. The MEC access hatch is intended to be used during maintenance only.

The MEC access hatch may be unlocked by the E/E ACCESS HATCH switch located on the P61 overhead maintenance panel. An actuator in the latch assembly is used to lock and unlock the access hatch. Electrical power for the lock/unlock actuator is provided by the P320 ground service/handling distribution panel. Power is not supplied to the actuator when the airplane is in-air. A manual unlatch handle can also be used to unlock the door from the MEC if the latch access hatch is locked.

Consequences of Failure

The MEC access hatch cannot be unlocked from the flight deck using the switch on the P61 panel. The MEC access hatch must be unlocked from the MEC using the manual unlatch handle.

Consequences of Next Critical Failure

None.

52-51-01 Flight Deck Door Automatic Locking System**52-51-01A**

Interval	Installed	Required	Procedure
A	1	0	(M) (O)

May be inoperative provided:

- Automatic locking system is deactivated,
 - Flight Deck Door Dead Bolt operates normally and is used to lock door,
 - Alternate procedures are established and used for locking and unlocking door using dead bolt, and
 - Repairs are made within 2 flight-days.
-

52-51-01 Flight Deck Door Automatic Locking System**52-51-01B**

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Automatic locking system is deactivated,
 - No passengers are carried,
 - A maximum of 19 persons are carried as authorized by 14 CFR for non-passenger carrying operations , and
 - Alternate procedures are established and used.
-

52-51-01 Flight Deck Door Automatic Locking System**52-51-01-01 Flight Deck Access System (Keypad, Chime Module)**

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Keypad is deactivated, and
 - Alternate procedures are established and used.
-

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52-51-01 Flight Deck Door Automatic Locking System

52-51-01-01 Flight Deck Access System (Keypad, Chime Module)

52-51-01-01-01 LEDs

Interval	Installed	Required	Procedure
C	3	0	(O)

May be inoperative provided alternate procedures are established and used.

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-01 Flight Deck Access System (Keypad, Chime Module)

52-51-01-01-02 Door Bell Mode

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided alternate procedures are established and used.

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-01 Flight Deck Access System (Keypad, Chime Module)

52-51-01-01-03 Switch Guard

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided FD DOOR LOCK FAIL Advisory message operates normally.

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-02 Flight Deck Door Lock Control Selector Switch

Interval	Installed	Required	Procedure
B	1	0	(M) (O)

May be inoperative provided:

- Keypad is deactivated,
- Electric strike is verified to operate normally,
- FLIGHT DECK ACCESS SYSTEM switch is set OFF (guard is extended) when flight deck door is closed and flight deck not occupied, and

d. Alternate procedures are established and used.

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-03 FD DOOR LOCK FAIL Indication

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Automatic locking controls are verified to operate normally, and
 - Door chime is verified to operate normally.
-

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-04 FD DOOR AUTO UNLOCK Indication

Interval	Installed	Required	Procedure
C	1	0	(M)

May be inoperative provided:

- Automatic locking controls are verified to operate normally, and
 - Door chime is verified to operate normally.
-

52-51-01 Flight Deck Door Automatic Locking System

52-51-01-05 Pressure Rate-of-Change Sensing Module

Interval	Installed	Required	Procedure
A	1	0	(M)

May be inoperative provided:

- Pressure sensor is deactivated, and
 - Repairs are made within 2 flight-days.
-

SUBSTANTIATION

Background

Proposal for 52-51-01A/B based on 787 MMEL item 52-51-01-02.

Proposal for 52-51-01-01 based on 777 MMEL item 52-51-02-01.

Proposal for 52-51-01-02 based on 777 MMEL item 52-51-02-04.

Proposal for 52-51-01-03, -04 based on 787 MMEL item 52-51-01-02.

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Proposal for 52-51-01-05 based on 777 MMEL item 52-51-02-05.

Refer to FAA policy letter PL-112.

Refer to FAA policy letter PL-125.

The 777X Flight Deck Door and Bulkhead are the main barriers between the pilot's flight compartment and the passenger compartment. The bulkhead spans the entire width of the upper fuselage, and runs from floor to ceiling. The Flight Deck Door allows crew members access between the flight deck and the passenger compartment by use of the Flight Deck Access System (FDAS). The Flight Deck Door uses a piano style hinge along the left hand side of the door, to distribute intrusion loads over the length of the hinge post. The latch side door post features a door jamb that is designed to distribute intrusion loads over its entire length. The door latch and strike post will resist aft decompression loads and 250 pound pull loads applied to the aft door pull handle. The flight deck door features an inset emergency egress panel that may be used if the flight deck door becomes jammed.

In the event of a Flight Deck rapid decompression the flight deck door is released and allowed to swing open. In addition the door incorporates an upper decompression panel that opens aft in the event of the main cabin decompression.

The upper decompression panel also features a view port, which allows the crew to identify personnel requesting access to the Flight Deck.

The latching system incorporates an intrusion-resistant strike and solenoid, and a manual door knob release on the flight deck side. Power to the solenoid system is controlled by the FLIGHT DECK ACCESS SYSTEM power cutoff switch on the chime module, located on the flight deck side of the strike post assembly, and by the door lock control panel, located in the P8 panel, also within reach of the seated pilot.

In the event of a passenger cabin decompression, the upper flight deck door decompression panel is allowed to open, permitting flight deck air to vent into the passenger cabin.

The Flight Deck Access System (FDAS) is powered from the 28V DC Main power bus. When the FLIGHT DECK ACCESS SYSTEM power cutoff switch is in the NORM position, the Flight Deck Door is mechanically locked on the passenger side, but can be opened manually from the flight deck side. When the FLIGHT DECK ACCESS SYSTEM power cutoff switch is in the OFF position, the Flight Deck Door can be opened with minimal forward load; just enough to overcome the spring loaded catch assembly. Similar to other current Boeing commercial aircraft models, access to the flight deck when power is on can only be attained by entering the correct emergency access code into the keypad or by having a crew member open the door from the flight deck side.

The Flight Deck Door Access selector switch that is installed on the aft aisle stand (P8 panel) has a 3-position rotary selector accessible to both pilots. The selector functions are UNLKD, AUTO and DENY. UNLKD is a counterclockwise push-to-rotate momentary position that unlocks the door for up to 45 seconds as long as the switch is held in UNLKD. When UNLKD is selected the DENY function will be reset. AUTO is the normal, maintained switch position that enables the auto door unlock sequence provided the correct demand access code is entered using the keypad and after the time delay (programmable) has expired. DENY is a clockwise momentary position which rejects a demand access entry request and cancels the aural alert and the FD DOOR AUTO UNLOCK Warning message. DENY also keeps the door locked and rejects demand access codes from the keypad for a predetermined number of minutes (programmable). DENY mode will only function after the proper access code has been entered.

The FLIGHT DECK ACCESS SYSTEM power cutoff switch is located on the Chime Module and is used to remove power from the electrically-operated door lock assembly. In addition to the FD DOOR LOCK FAIL Advisory message, the switch clearly indicates when it is in the power OFF position. Setting the FLIGHT DECK ACCESS SYSTEM power cutoff switch to OFF, the FDAS chime module (when selector is in AUTO MODE) will still attempt to command the lock closed, but with no power provided to the lock, the locking pin will not extend. This feature causes the FD DOOR LOCK FAIL Advisory message to be displayed (tested) while also allowing the Flight Deck door to be left unlocked for maintenance activities.

Authorized crewmember can request access to the flight deck by entering a 3 to 8 digit code. The following occur simultaneously: MASTER CAUTION Light on, steady Master Caution Aural Siren and FD DOOR AUTO UNLOCK warning message.

A customer-enabled Doorbell Mode is provided that does not unlock the door or produce any other flight deck effects other than the Comm Medium Message F/D DOOR CALL and an associated High/Low aural chime. The doorbell is initiated by selecting 1 on the keypad followed by selecting the ENT key.

Flight Deck Door - Decompression Sensing Module:

The flight deck door pressure sensor detects rapid pressure changes to unlock the door during a flight deck decompression event.

The pressure sensor has an internal dual-channel solid-state pressure sensor. The pressure sensors are normally closed switches that open if a rapid decompression event occurs in the flight deck. Either redundant channel in the pressure sensor will open a switch that removes power from the electric strike and allow the door to open.

Consequences of Failure

The FD DOOR LOCK FAIL Advisory message will be displayed when the flight deck door solenoid lock pin fails to extend to the locked position commanded by the chime module and pressure sensor.

Flight Deck Door Automatic Locking System:

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Flight deck door automatic locking system (primary system) must be deactivated. The flight deck door is locked using the flight deck door dead-bolt (secondary system).

Flight Deck Access System:

FDAS keypad is deactivated.

FDAS LEDs, Door Bell Mode, Switch Guard:

Alternate procedures are established and used.

Flight Deck Door Lock Control Selector Switch:

Keypad is deactivated and automatic lock is verified to operate normally.

FD DOOR LOCK FAIL Indication:

Automatic locking controls are verified to operate normally.

FD DOOR AUTO UNLOCK Indication:

Automatic locking controls are verified to operate normally.

Decompression Sensing Module:

Pressure sensor must be deactivated.

FAA Policy Letter 112 (PL-112) Considerations:

The decompression function is dependent on the primary locking system.

Therefore, PL-112 guidance for decompression function dependent on primary locking system applies. During a decompression event, the door is automatically electrically unlocked. The door decompression sensing module will unlock the door allowing the door to open when sufficient force is applied. Flight Deck Door Automatic Locking System is the 'primary' locking system. Flight Deck Door Deadbolt is the 'secondary' locking system.

Consequences of Next Critical Failure

Flight Deck Door Automatic Locking System:

In the event of rapid decompression of the flight deck, the door will not automatically unlock because it will be locked with the flight deck door deadbolt. Failure of the flight deck door not to unlock during a rapid flight deck decompression is considered a 'Catastrophic' hazard. The resulting condition may result in potential structural failures or forward hull loss which may result in fatalities or incapacitation of flight crew.

The probability of a rapid flight deck decompression (RFDD) event is 4.64E-08.

The maximum allowable dispatch time is calculated to be 209 flight-hours.

Flight Deck Access System: None.

FDAS LEDs, Door Bell Mode, Switch Guard: None.

Flight Deck Door Lock Control Selector Switch: None.

FD DOOR LOCK FAIL Indication: None.

FD DOOR AUTO UNLOCK Indication: None.

Decompression Sensing Module:

In the event of rapid decompression of the flight deck, the door will not automatically unlock because it will be locked with the flight deck door deadbolt. Failure of the flight deck door not to unlock during a rapid flight deck decompression is considered a 'Catastrophic' hazard. The resulting condition may result in potential structural failures or forward hull loss which may result in fatalities or incapacitation of flight crew.

The probability of a rapid flight deck decompression (RFDD) event is 4.64E-08.

The maximum allowable dispatch time is calculated to be 83,500 flight-hours.

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52-51-02 Flight Deck Door Dead Bolt

Interval	Installed	Required	Procedure
C	1	0	

May be inoperative provided Flight Deck Door Automatic Locking System operates normally.

SUBSTANTIATION

Background

Proposal based on 787 FAA MMEL item 52-51-02.

The deadbolt system consists of a passenger side key lock, a locking bolt, lock housing, and a knob/indicator on the flight deck side. The deadbolt is located in the door. The locking bolt extends into the door post for positive lock engagement. The deadbolt will retract and engage by the key and/or knob only. The deadbolt will have a lockout feature in the flight deck so that an intruder with the key would not be able to unlock the door. The knob will clearly indicate the status of the lock whether it is unlocked, in an intermediate position showing it has been locked with a key from the passenger cabin, or fully locked out from the flight deck overriding the passenger side key.

Consequences of Failure

Relief as allowed by FAA Policy Letter 112.

Consequences of Next Critical Failure

None.

52-51-03 Flight Deck Door Viewing Port[Flight Deck Entry Video Surveillance Not Installed](#)**52-51-03-01 Flight Deck Entry Video Surveillance System Not Installed**

52-51-03-01A

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative provided:

- Alternate procedures are established and used, and
- Repairs are made within 3 flight-days.

52-51-03 Flight Deck Door Viewing Port**52-51-03-01 Flight Deck Entry Video Surveillance System Not Installed**

52-51-03-01B

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

[Flight Deck Entry Video Surveillance Installed](#)**52-51-03 Flight Deck Door Viewing Port****52-51-03-02 Flight Deck Entry Video Surveillance System Installed**

52-51-03-02A

Interval	Installed	Required	Procedure
A	1	0	(O)

May be inoperative provided:

- Alternate procedures are established and used, and
- Repairs are made within 3 flight-days.

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52-51-03 Flight Deck Door Viewing Port

52-51-03-02 Flight Deck Entry Video Surveillance System Installed

52-51-03-02B

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- Flight Deck Entry Video Surveillance System operates normally, and
- Alternate procedures are established and used.

52-51-03 Flight Deck Door Viewing Port

52-51-03-02 Flight Deck Entry Video Surveillance System Installed

52-51-03-02C

Interval	Installed	Required	Procedure
D	1	0	

May be inoperative provided procedures do not require its use.

SUBSTANTIATION

Background

Proposal based on PL-122.

An optical viewing port is installed in the flight deck door to enable visual identification of personnel who may be requesting entry.

Consequences of Failure

Alternate procedures must be established and used to identify personnel requesting flight deck entry. This may involve use of the visual surveillance system (if installed), or voice communication.

Consequences of Next Critical Failure

None.

52-71-01 Door Indication Systems**52-71-01-01 Passenger Entry Doors**

Interval	Installed	Required	Procedure
C	8	0	(M)

May be inoperative provided:

- Door sensors for each associated door are deactivated, and
 - Each associated door is verified closed, latched, and locked before each departure.
-

52-71-01 Door Indication Systems**52-71-01-02 Service Exit Doors**

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Door sensors for each associated door are deactivated, and
 - Each associated door is verified closed, latched, and locked before each departure.
-

52-71-01 Door Indication Systems**52-71-01-03 Large Cargo Doors - Forward and Aft**

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Door sensors for each associated door are deactivated, and
 - Each associated door is verified closed, latched, and locked before each departure.
-

52-71-01 Door Indication Systems**52-71-01-04 Bulk Cargo Door**

Interval	Installed	Required	Procedure
C	1	0	(M)

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May be inoperative provided:

- Bulk cargo door switch is deactivated, and
- Bulk cargo door is verified closed and latched before each departure.

52-71-01 Door Indication Systems

52-71-01-05 Access Doors - Forward and Main Equipment Center (E/E Bay)

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided:

- Door sensor for each associated door is deactivated, and
- Each associated door is verified closed and latched before each departure.

SUBSTANTIATION

Background

The door warning system provides door status information and indications for the flight deck and cabin attendant panel (CAP). The door warning system interfaces include proximity sensors and switches. The proximity sensors and switches in the door warning system send data to the proximity sensing data concentrators (PSDCs). The PSDCs send the data through the common data network (CDN) to the display crew alerting system (DCA) in the common computing resource (CCR). DCA shows indication information on the display, and sends indication information through the CDN, cabin service system controller (CSSC), and cabin zone unit (CZU) to the CAP.

Passenger Doors/Service Exit Doors (if installed):

The warning system for each passenger door, and service exit door (SED) (if installed), includes two proximity sensors. One proximity sensor indicates door locked and one proximity sensor indicates closed and latched. The door locked proximity sensor is on the aft edge of the door's vent door. The door closed and latched proximity sensor is on the door latch mechanism aft latch crank. The door proximity sensors sense when the target is near the sensor. When the target is not near the sensor, the associated status will not be indicated. The door locked proximity sensor determines when the door is locked using the door's vent door position. The door closed and latched proximity sensor determines when the PED/SED is closed and latched using the door latch mechanism latch track target position.

Each PED/SED also includes two flight lock sensors. Dispatch relief for these sensors is addressed in a separate MMEL item. Each PED/SED also includes a door locked indicator light. Dispatch relief for the indicator lights is addressed in a separate MMEL item.

Forward/Aft Large Cargo Doors:

The warning system for each forward and aft large cargo door includes three proximity sensors. One proximity sensor indicates door locked, one proximity sensor indicates door closed, and one proximity sensor indicates door latched. The door locked proximity sensor is behind one of the large cargo door lock mechanism lock pawls. The door closed proximity sensor is on the bottom inboard edge of the large cargo door, forward of the large cargo door cam latch. The large cargo door latched proximity sensor is next to the door cam latch near the bottom center of the door. When the target is not near the sensor, the associated status will not be indicated. The large cargo door locked proximity sensor determines when the door is locked using the door lock mechanism lock pawl position. The large cargo door closed proximity sensor determines when the door is closed using the position of the lower edge of the door relative to the lower edge of the door cutout. The large cargo door latched proximity sensor determines when the door is latched using the position of the door cam latch.

Bulk Cargo Door:

The warning system for the bulk cargo door includes a switch to indicate that the bulk cargo door is closed and latched. The bulk cargo door closed and latched switch is in the bulk cargo door latch mechanism forward latch on the forward side of the bulk cargo door cutout. The bulk cargo door closed and latched switch is a mechanical device that closes a circuit when the switch is moved. When the bulk cargo door latch mechanism extends its latch probe into the door latch mechanism forward latch, the latch probe moves the plunger switch which closes a circuit. The bulk cargo door closed and latched switch determines when the bulk cargo door is closed and latched.

Forward Access Door:

The warning system for the forward access door includes the forward access door closed and latched proximity sensor. The forward access door closed and latched proximity sensor is forward of the forward access door. The forward access door closed and latched proximity sensor senses when the target is near the sensor. When the target is not near the sensor, the door is not closed and latched. The forward access door closed and latched proximity sensor determines when the door is closed and latched using the door latch position.

Main Equipment Center (E/E Bay) Access Door:

The warning system for the main equipment center (MEC) access door includes the MEC access door closed and latched proximity sensor. The MEC access door closed and latched proximity sensor is forward of the MEC access door. The MEC access door closed and latched proximity sensor senses when the target is near the sensor. When the target is not near the sensor, the MEC access door is not closed and latched. The MEC access door closed and latched proximity sensor determines when the door is closed and latched using the door latch pin.

EICAS and Status messages:

Door warning system indications are shown on engine indication and crew alerting system (EICAS) display and Status message display, maintenance access terminal (MAT), and door synoptic display. The EICAS display shows Warning, Caution, Advisory, and Memo messages for the door warning system.

The CONFIG DOOR Warning shows when any of the passenger doors, Service Exit Doors (SEDs) (if installed), or cargo doors are not closed and latched while the engine thrust is in takeoff range on the ground. The CONFIG DOOR Warning will show for any one PED/SED or large cargo door sensor failed or indicating FAR when engine thrust is applied up to 40 knots and will show above 40 knots if two sensors are failed or indicate FAR.

The DOOR OPEN FWD CARGO Caution message shows when the forward large cargo door is not closed, latched, and locked. The DOOR OPEN AFT CARGO Caution message shows when the large aft cargo door is not closed, latched, and locked.

The DOOR OPEN BULK CGO Advisory message shows when the bulk cargo door is not closed and latched. The DOOR OPEN E/E ACCSS Advisory message shows when the Main Equipment Center (MEC) access door is not closed and latched. The DOOR OPEN FWD ACCSS Advisory message shows when the forward access door is not closed and latched.

The associated DOOR OPEN ENTRY (1L, 1R, 2L, 2R, 3L, 3R, 4L or 4R) Advisory message shows when the associated PED is not closed, latched, and locked. For Service Exit Doors installed, the associated DOOR OPEN SERVICE L or R Advisory message shows when the associated SED is not closed, latched, and locked.

The DOORS OPEN Advisory message will be displayed when two or more passenger, cargo, access, or bulk doors are not closed, latched, and locked while on the ground and engines not running.

Consequences of Failure

The DOOR ENTRY IND (1L, 1R, 2L, 2R, 3L, 3R, 4L or 4R) Status message will be displayed when there is a failure of one or both of the sensors for the associated Passenger Door. (For Service Exit Doors, the associated DOOR SERVICE EXIT IND L or R Status message will be displayed.) A failed sensor or a sensor indicating FAR will result in display of the associated DOOR OPEN ENTRY (1L, 1R, 2L, 2R, 3L, 3R, 4L or 4R) Advisory message. (For Service Exit Doors, the SERVICE DOOR EXIT L or R Advisory message will be displayed.) For a PED (or SED) sensor failed or indicating FAR, the CONFIG DOOR Warning message will also be displayed when takeoff thrust is applied. For dispatch, the associated door must be verified to be closed, latched, and locked prior to each departure. Both door sensors must be deactivated to prevent the CONFIG DOOR Warning.

The DOOR AFT CARGO IND Status message will be displayed when there is a failure of one or more of the associated three aft cargo door sensors. The DOOR FWD CARGO IND Status message will be displayed when there is a failure of one or more of the associated three forward cargo door sensors. A failed sensor or a sensor indicating FAR will result in display of the associated DOOR OPEN AFT CARGO or DOOR OPEN FWD CARGO Caution message. For a cargo door sensor failed or indicating FAR, the CONFIG DOOR Warning message will also be displayed when takeoff thrust is applied. For dispatch, the associated door must be verified to be closed, latched, and locked prior to each departure. All three door sensors must be deactivated to prevent the CONFIG DOOR Warning.

The DOOR OPEN BULK CGO Advisory message will be displayed if the bulk cargo door switch has failed. For dispatch, the bulk cargo door switch must be deactivated. The door must be verified to be closed and latched prior to each departure.

The DOOR OPEN FWD ACCSS Advisory message will be displayed if the forward access door sensor has failed or indicates FAR. For dispatch, the forward access door sensor must be deactivated. The door must be verified to be closed and latched prior to each departure.

The DOOR OPEN E/E ACCSS Advisory message will be displayed if the main equipment center (E/E Bay) access door sensor has failed or indicates FAR. For dispatch, the main equipment center access door sensor must be deactivated. The door must be verified to be closed and latched prior to each departure.

Consequences of Next Critical Failure

None identified.

52-71-02 Passenger Entry Door & Service Exit Door (if installed) Status Annunciation and Alerting Systems (Flight Attendant)

52-71-02A

Interval	Installed	Required	Procedure
C	-	0	(O)

May be inoperative provided alternate procedures are established and used.

52-71-02 Passenger Entry Door & Service Exit Door (if installed) Status Annunciation and Alerting Systems (Flight Attendant)

52-71-02B

Interval	Installed	Required	Procedure
D	-	0	

May be inoperative provided procedures do not require their use.

SUBSTANTIATION

Background

Proposal based on 777 MMEL item 52-71-02.

The annunciation provides an indication of the status of the door power opening and slide inflation systems. The annunciation is either AUTO or ARM, which indicates the status of the associated door power opening and slide inflation systems. When indicating AUTO or ARM and the associated door is opened, the door will be power assisted open and the door slide will deploy and inflate.

An additional optional configuration installs a door armed warning module on each passenger door and optional service/exit door. If an attempt is made to open a passenger door or optional service/exit door that is armed (annunciation AUTO or ARM) by moving the handle toward OPEN, a horn sounds warning that the door is armed.

Both of these systems are optional and not required for the certification of the airplane.

Consequences of Failure

For an inoperative door status annunciation, a flight attendant must ensure the door is armed or disarmed as appropriate by using the normal door status indications on the door.

For an inoperative door armed warning module, no warning will be sounded when an attempt is made to open an armed door. Therefore, an inadvertent door power opening and evacuation slide deployment and inflation is somewhat more likely.

Consequences of Next Critical Failure

None identified.

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56-11-01 Flight Deck Window Indication Systems (Side - No. 2)

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56-11-01 Flight Deck Window Indication Systems (Side - No. 2)

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

Proposal based on 777 MMEL item 56-11-01.

The architecture of the flight deck openable window indication system is consistent with the quiet, dark cockpit philosophy. Accordingly the system monitors the physical position of a latch cam and provides annunciation to the flight crew only when the element is not in the proper position for flight.

An alert switch is mounted to the top part of the window via a bracket. The switch plunger contacts a cam, which is attached to the upper latch cam. When the window is closed and latched, the plunger contacts the flat part of the cam. When the window is unlatched, the latch cam rotates 180°, and the curved part of the cam depresses the plunger. Depressing the plunger closes the circuit and sends a signal via hard wires to Remote Data Concentrators (RDC). The RDCs receive signals from both windows and put out the appropriate signals on the ARINC 664 system buses. The Core Computer System (CCS) reads the signals and displays the appropriate message.

If one window is open, the associated WINDOW OPEN FD L, R Advisory message will be displayed. If both windows are open, the WINDOW OPEN FD L+R Advisory message is displayed.

Consequences of Failure

Associated flight deck window alert switch indicates that window is open when window is actually closed and latched. No impact to dispatch. Flight deck windows are verified closed and latched as part of FCOM "Before Start" Normal Procedures.

Consequences of Next Critical Failure

None.

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57-91-01 Folding Wing Tip Control Channels

57-91-01-01 Left Wing

57-91-01-02 Right Wing

57-91-02 Folding Wing Tip Control Relays

57-91-02-01 Left Wing

57-91-02-02 Right Wing

57-91-03 Folding Wing Tip Preload Monitors

57-91-03-01 Over-Preload Level 1 Condition Detected

57-91-03-02 Under-Preload Level 1 Condition Detected

57-91-04 Flight Deck Control Channels

57-91-04A

57-91-04B

57-91-05 Automatic Fold Function

57-91-06 WINGTIPS AUTO/FOLD Switch Lights

57-91-06-01 MAN Light

57-91-06-02 AUTO Light

57-91-07 WINGTIPS Selector Switch

57-94-01 Folding Wing Tip Latch Pin Actuators

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57-91-01 Folding Wing Tip Control Channels**57-91-01-01 Left Wing**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated Remote Electronics Unit (REU) is deactivated.

57-91-01 Folding Wing Tip Control Channels**57-91-01-02 Right Wing**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated Remote Electronics Unit (REU) is deactivated.

SUBSTANTIATION**Background**

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

If takeoff is attempted while the FWTs are not fully extended, latched, and locked, the configuration warning tone will sound and EICAS will show the CONFIG WINGTIPS Warning message. If the flight crew continues the takeoff with the CONFIG WINGTIPS warning shown, a time critical warning shows when the airplane reaches 50 Kts (Knots) and the takeoff thrust remains set. These warnings show in the event of the configuration time critical warning:

- Aural REJECT, REJECT
- REJECT on the Primary Flight Display (PFD), in red text
- REJECT on the Head-Up Display (HUD) (if installed).

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

The pilot can enable manual fold operation of the FWT by setting the AUTO/FOLD switch on the P5 panel to MAN. The auto fold switch button will show a MAN light to indicate that automatic wing tip folding is disabled. The EICAS display will show the WINGTIPS IN MANUAL Advisory message when the automatic wing tip folding is disabled.

When auto fold is disabled (AUTO/FOLD switch in MAN), the rotary selector switch can be moved to FOLD at any time, but the FWT system will only operate only if the airplane is on the ground and ground speed is less than 50 knots.

For manual fold operation, EICAS will show the WINGTIPS NOT FOLDED Caution message to alert the flight crew if the airplane exits the runway with the FWTs extended.

REJECTED TAKEOFF

Auto fold will function after a RTO situation. If an RTO is performed and ground speed exceeds 85 knots, auto fold will begin to fold the wingtips once the groundspeed is below 50 knots. If an RTO is started before the airplane achieves 85 knots ground speed, auto fold will not function and the wingtips will be in extended position until manually commanded by the pilot to fold. The pilot has to move the fold/extend selector to the fold position.

POWER AND CONTROL

The Folding Wing Tip (FWT) System uses hydraulic power to move the FWTs. The power is provided by the center hydraulic system. Control of the FWT System is provided by the IFCE through Remote Electronic Units (REU). Sensors provide feedback to the IFCEs through the REUs. The FWT System, Power, and Control consists of the following sub-systems:

- Monitor and control
- Fold Subsystem (FSS)
- Latch and Lock Subsystem (LLS)

The Folding Wing Tip (FWT) System uses an active/standby method to provide redundancy and maximum availability of the system. Two separate channels are used for monitoring and controlling the system.

Each control channel (A and B) consists of the following components:

- Remote Electronics Unit (REU)
- Fold brake
- Electro-Hydraulic Servo Valve (EHSV)
- Hydraulic motor
- Secondary Lock Actuator (SLA) sensor channel
- Secondary lock driveline sensor channel

- Wing tip position sensor channel
- Fold Subsystem (FSS) sensor channel

Actuation of the FWT system is done using either one of the two channels in each wing, but not both simultaneously. At any point in the flight cycle, one channel is in use (active) and the other remains in standby mode.

If a component within the active channel fails, the FWT system switches to the channel that is in standby mode. If a component in the new active channel fails after switching channels, the FWT System will be made inoperative.

The IFCE alternates the active channels between channel A and B every Air/Ground cycle. On airplane power-up, the active channel is switched from the last used channel.

The REUs continuously monitor the valves and sensors and relay the information to the IFCE. If a fault is detected, control is transferred to the standby channel and the fault is indicated on EICAS. If the standby channel is not available, the system shuts down, applies the brakes, and isolates the hydraulic system.

The two FWT Isolation Valves isolate the FWT system from the center hydraulic system when the FWT system is not in use.

The FWT Isolation Valves are normally closed when electrical power or the ground is removed. This separates the FWT system from the rest of the center hydraulic system. The electrical power and ground paths are controlled by the IFCE. Actuator Control Electronics (ACE) L1 and ACE L2 send analog signals to the Isolation Valve solenoid coils. The solenoid coils cannot be energized during flight. ACEs L1 and L2 energize the solenoid coils in the Isolation Valves when the airplane is on the ground and the ground speed is less than 50 knots (58 mph).

Hydraulic power is then supplied to the FWT system to allow the wing tips to be folded.

CONTROL CHANNELS

There are two control channels per wing tip.

REU A provides control and monitoring from IFCE C to control hydraulic motor A and Fold Brake A via Hydraulic Control Module (HCM) A. REU B provides control and monitoring from IFCE R to control hydraulic motor B and Fold Brake B via HCM B.

HCM A does not control the Latch Pin Actuators. Only HCM B is used to control the Latch Pin Actuators. Therefore, when Channel A (IFCE C, REU A) is the active channel, REU A also provides commands to HCM B to control the Latch Pin Actuators.

Consequences of Failure

Failure of one Folding Wing Tip Control Channel is indicated by any of the following Status messages:

- WINGTIPS L CHAN A
- WINGTIPS L CHAN B
- WINGTIPS R CHAN A
- WINGTIPS R CHAN B

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The FWT System monitors will detect the failure and automatically switch to the remaining channel. Failure of one control channel (A or B) will result in a loss of redundancy only. The inoperative control channel will not be available to operate the associated folding wing tip, however, the remaining control channel is still available to provide full function to the associated folding wing tip.

For MMEL dispatch the associated control channel is deactivated by deactivation of the associated REU.

Consequences of Next Critical Failure

Failure of the remaining control channel will result in loss of ability to extend or fold the associated folding wing tip.

If failure of the remaining control channel occurs during a subsequent flight, the associated folding wing tip will remain in the extend position and will not automatically fold after landing. The flight crew will not be able to fold the wing tip using the manual command. The WINGTIPS SYS INOP Advisory message will be displayed.

If failure of the remaining control channel occurs while on-ground, the flight crew will not be able to extend the associated folding wing tip. The WINGTIPS DRIVE FAULT Caution message will be displayed.

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Feb 26, 2026

57-91-02 Folding Wing Tip Control Relays**57-91-02-01 Left Wing**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated Remote Electronics Unit (REU) is deactivated.

57-91-02 Folding Wing Tip Control Relays**57-91-02-02 Right Wing**

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided associated Remote Electronics Unit (REU) is deactivated.

SUBSTANTIATION**Background**

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

If takeoff is attempted while the FWTs are not fully extended, latched, and locked, the configuration warning tone will sound and EICAS will show the CONFIG WINGTIPS Warning message. If the flight crew continues the takeoff with the CONFIG WINGTIPS warning shown, a time critical warning shows when the airplane reaches 50 Kts (Knots) and the takeoff thrust remains set. These warnings show in the event of the configuration time critical warning:

- Aural REJECT, REJECT
- REJECT on the Primary Flight Display (PFD), in red text
- REJECT on the Head-Up Display (HUD) (if installed).

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

The pilot can enable manual fold operation of the FWT by setting the AUTO/FOLD switch on the P5 panel to MAN. The auto fold switch button will show a MAN light to indicate that automatic wing tip folding is disabled. The EICAS display will show the WINGTIPS IN MANUAL Advisory message when the automatic wing tip folding is disabled.

When auto fold is disabled (AUTO/FOLD switch in MAN), the rotary selector switch can be moved to FOLD at any time, but the FWT system will only operate only if the airplane is on the ground and ground speed is less than 50 knots.

For manual fold operation, EICAS will show the WINGTIPS NOT FOLDED Caution message to alert the flight crew if the airplane exits the runway with the FWTs extended.

REJECTED TAKEOFF

Auto fold will function after a RTO situation. If an RTO is performed and ground speed exceeds 85 knots, auto fold will begin to fold the wingtips once the groundspeed is below 50 knots. If an RTO is started before the airplane achieves 85 knots ground speed, auto fold will not function and the wingtips will be in extended position until manually commanded by the pilot to fold. The pilot has to move the fold/extend selector to the fold position.

POWER AND CONTROL

The Folding Wing Tip (FWT) System uses hydraulic power to move the FWTs. The power is provided by the center hydraulic system. Control of the FWT System is provided by the IFCE through Remote Electronic Units (REU). Sensors provide feedback to the IFCEs through the REUs. The FWT System, Power, and Control consists of the following sub-systems:

- Monitor and control
- Fold Subsystem (FSS)
- Latch and Lock Subsystem (LLS)

The Folding Wing Tip (FWT) System uses an active/standby method to provide redundancy and maximum availability of the system. Two separate channels are used for monitoring and controlling the system.

Each control channel (A and B) consists of the following components:

- Remote Electronics Unit (REU)
- Fold brake
- Electro-Hydraulic Servo Valve (EHSV)
- Hydraulic motor
- Secondary Lock Actuator (SLA) sensor channel
- Secondary lock driveline sensor channel

- Wing tip position sensor channel
- Fold Subsystem (FSS) sensor channel

Actuation of the FWT system is done using either one of the two channels in each wing, but not both simultaneously. At any point in the flight cycle, one channel is in use (active) and the other remains in standby mode.

If a component within the active channel fails, the FWT system switches to the channel that is in standby mode. If a component in the new active channel fails after switching channels, the FWT System will be made inoperative.

The IFCE alternates the active channels between channel A and B every Air/Ground cycle. On airplane power-up, the active channel is switched from the last used channel.

The REUs continuously monitor the valves and sensors and relay the information to the IFCE. If a fault is detected, control is transferred to the standby channel and the fault is indicated on EICAS. If the standby channel is not available, the system shuts down, applies the brakes, and isolates the hydraulic system.

The two FWT Isolation Valves isolate the FWT system from the center hydraulic system when the FWT system is not in use.

The FWT Isolation Valves are normally closed when electrical power or the ground is removed. This separates the FWT system from the rest of the center hydraulic system. The electrical power and ground paths are controlled by the IFCE. Actuator Control Electronics (ACE) L1 and ACE L2 send analog signals to the Isolation Valve solenoid coils. The solenoid coils cannot be energized during flight. ACEs L1 and L2 energize the solenoid coils in the Isolation Valves when the airplane is on the ground and the ground speed is less than 50 knots (58 mph).

Hydraulic power is then supplied to the FWT system to allow the wing tips to be folded.

CONTROL RELAYS

There are two Control Relays for each Folding Wing Tip. Each Control Relay connects electrical power to the associated Left and Right Wing Tip REUs and is controlled by the IFCEs. Each Control Relay A (Left and Right) connects 28V DC from the P130 panel to the associated Left REU A and Right REU A. Both Control Relay A (Left and Right) are controlled by IFCE C.

Each Control Relay B (Left and Right) connects 28V DC from the P230 panel to the associated Left REU B and Right REU B. Both Control Relay A (Left and Right) are controlled by IFCE R.

Both Control Relays are normally closed so that electrical power is supplied to both REUs. If there is a fault in the system, the associated IFCE will disconnect power from the associated REU by opening the Control Relay.

FWT Control Relays are automatically tested in a post-flight BIT every 1000 flight hours.

Consequences of Failure

Failure of a Folding Wing Tip Control Relay is indicated by any one of the following Status messages:

WINGTIPS L RELAY A
WINGTIPS L RELAY B
WINGTIPS R RELAY A
WINGTIPS R RELAY B

Failure of a Control Relay will be detected during the post-flight BIT. The associated Control Relay will not be capable of removing electrical power when commanded to do so. Therefore, subsequent MMEL dispatch requires that the associated REU is deactivated. The associated control channel will not be available to operate the folding wing tip, however, the remaining control channel is still available to provide full functionality to the associated folding wing tip.

Consequences of Next Critical Failure

Failure of the remaining control channel:

Results in loss of ability to extend or fold the associated folding wing tip.

If failure of the remaining control channel occurs during a subsequent flight, the associated folding wing tip will remain in the extend position and will not automatically fold after landing. The flight crew will not be able to fold the wing tip using the manual command. The WINGTIPS SYS INOP Advisory message will be displayed.

If failure of the remaining control channel occurs while on-ground, the flight crew will not be able to extend the associated folding wing tip. The WINGTIPS DRIVE FAULT Caution message will be displayed.

Failure of the remaining control relay:

The FWT control system will not be able to remove electrical power from the Fold Subsystem by opening the control relay.

Folding of one or both wing tips in flight due to uncommanded motion is classified as catastrophic. The top event probability of this condition is $2.3E-10$. Assuming MMEL dispatch with one REU deactivated on one or both wing tips, the top event probability is unchanged.

57-91-03 Folding Wing Tip Preload Monitors**57-91-03-01 Over-Preload Level 1 Condition Detected**

Interval	Installed	Required	Procedure
C	2	0	

May be dispatched with one or both of the following Status messages displayed:

- WINGTIPS PRELOAD LV1 L
- WINGTIPS PRELOAD LV1 R

57-91-03 Folding Wing Tip Preload Monitors**57-91-03-02 Under-Preload Level 1 Condition Detected**

Interval	Installed	Required	Procedure
C	2	0	

May be dispatched with one or both of the following Status messages displayed:

- WINGTIPS UNDERPRELOAD 1 L
- WINGTIPS UNDERPRELOAD 1 R

SUBSTANTIATION**Background**

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

The Fold Subsystem (FSS) is the part of the Folding Wing Tip (FWT) system that controls the motion of the FWT between the extended and the folded position. The FSS includes the Actuation and Preload functions.

The FSS moves the FWT from the EXTEND to the FOLD position and back to EXTEND by the application of torque at the hinge line. The torque is provided by the Power Drive Unit (PDU), which is controlled by hydraulic inputs from either Hydraulic Control Module (HCM) A or HCM B. The torque output from the PDU is transmitted to the Rotary Fold Actuator (RFA) using torque tubes and the Angle Gear Box (AGB) to apply the torque along the hinge line.

PRELOAD:

When the Folding Wing Tip (FWT) reaches the fully extended position, the Fold Subsystem (FSS) applies a preload. The preload holds the FWT firmly against the structural extend stops to keep it stable and to let the latch pins insert smoothly into the movable lugs. At the beginning of the fold sequence, the FSS again preloads against the extend stops to enable smooth retraction of the latch pins. Preload cannot be directly measured in the FWT system. The differential between the wing tip position sensor and the FSS sensor, on the Angle Gear Box (AGB), is used. As the preload is applied, the FSS sensor will continue to rotate, while the wing tip sensor will remain stationary. This sensor delta is then correlated to the required preload.

PRELOAD MONITOR:

The Folding Wing Tip Preload monitor monitors the amount of preload applied into structure from the fold subsystem during Extending and Folding. The monitor will count each time that either the preload has exceeded a predetermined limit (Over-Preload) or failed to provide a minimum value of preload (Under-Preload). The FWT system is designed to withstand 500 Over-Preload events and/or 500 Under-Preload events before requiring structural inspection, replacement and/or repair of structure and system components, and re-rigging of structure and systems.

Consequences of Failure

Over-Preload Monitor:

The Over-Preload monitor will detect when the structural preload exceeds a predetermined load limit. There is no consequence provided the number of Over-Preload occurrences is limited to less than the allowable number.

The Over-Preload monitor has three levels:

Level 1 trip will occur if an Over-Preload condition has occurred 20 times. The associated WINGTIPS PRELOAD LV1 L or R Status message will be displayed. MMEL dispatch is allowed with this condition.

Level 2 trip will occur if a Level 1 trip occurs two times. The associated WINGTIPS PRELOAD LV2 L or R Status message will be displayed. MMEL dispatch is not allowed in this condition.

Level 3 trip will occur if an Over-Preload condition has occurred 300 times. The level 3 counter accumulates all level 1 and level 2 occurrences. The associated WINGTIPS OVERLOAD L or R Status message will be displayed. MMEL dispatch is not allowed in this condition.

The Under-Preload monitor will detect when the structural preload is less than a pre-determine minimum load. This condition results in additional side loading of the latch pins. There is no consequence provided the number of Under-Preload occurrences is limited to less than the allowable number.

The Under-Preload monitor has two levels:

Level 1 trip will occur if an Under-Preload condition has occurred 5 times. The WINGTIPS UNDERPRELOAD 1 L or R Status message will be displayed. MMEL dispatch is allowed with this condition.

Level 2 trip will occur if a Level 1 trip occurs two times. The WINGTIPS UNDERPRELOAD 2 L or R Status message will be displayed. MMEL dispatch is not allowed in this condition.

Consequences of Next Critical Failure

The FWT system is designed to withstand 500 Over-Preload events and/or 500 Under-Preload events before requiring structural inspection, replacement and/or repair of structure and system components, and re-rigging of structure and systems. Therefore, the Preload monitor ensures that the allowable 500 occurrences will not be exceeded with a 200 count margin. There are no consequences provided the required maintenance actions are accomplished to correct the fault conditions.

57-91-04 Flight Deck Control Channels

57-91-04A

Interval	Installed	Required	Procedure
C	2	1	

May be dispatched with WINGTIPS FD CTRL CHANNEL Status message displayed.

57-91-04 Flight Deck Control Channels

57-91-04B

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- a. Both Wing Tips are deactivated in extended position, and
- b. Airport operations do not require its use.

SUBSTANTIATION

Background

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

The pilot can enable manual fold operation of the FWT by setting the AUTO/FOLD switch on the P5 panel to MAN. The auto fold switch button will show a MAN light to indicate that automatic wing tip folding is disabled. The EICAS display will show the WINGTIPS IN MANUAL Advisory message when the automatic wing tip folding is disabled.

When auto fold is disabled (AUTO/FOLD switch in MAN), the rotary selector switch can be moved to FOLD at any time, but the FWT system will only operate only if the airplane is on the ground and ground speed is less than 50 knots.

For manual fold operation, EICAS will show the WINGTIPS NOT FOLDED Caution message to alert the flight crew if the airplane exits the runway with the FWTs extended.

FLIGHT DECK CONTROL CHANNELS

There are two Flight Deck Control Channels for the WINGTIPS FOLD/EXTEND lever switch. These channels transmit commands from the WINGTIPS FOLD/EXTEND switch to both ACE C (IFCE C) and ACE R (IFCE R).

Consequences of Failure

One Channel Inoperative:

Failure of one flight deck control channel results in the associated ACE/IFCE being declared invalid. The other ACE/IFCE will be used to control the Folding Wing Tip (FWT) System. Loss of redundancy only. The WINGTIPS FD CTRL CHANNEL Status message will be displayed.

Both Channels Inoperative:

Failure of both flight deck control channels results in loss of the ability to control the Folding Wing Tip (FWT) System on both channels. The flight crew will not be able to extend the folding wing tips using the EXTEND/FOLD lever switch. The flight crew will not be able to extend the folding wing tips for takeoff.

For dispatch, the folding wing tips must be deactivated in the extended position. A special maintenance function is accomplished to deactivate the system with the wing tips extended, resulting in annunciation of the WINGTIPS IN MANUAL Advisory message and WINGTIPS DISABLED Status message. For airport operations, airplane is ICAO Aerodrome Reference Code F. With the wing tips disabled, the WINGTIPS NOT FOLDED Caution message will not be displayed when exiting the runway with wing tips extended.

Consequences of Next Critical Failure

One Channel Inoperative:

Failure of the remaining flight deck control channel will result in loss of ability to extend or fold (manually) both folding wing tips.

If failure of the remaining control channel occurs during a subsequent flight, the WINGTIPS SYS INOP Advisory message will be displayed. The wing tips will automatically fold after landing provided the WINGTIPS AUTO/FOLD switch is set AUTO, however, the flight crew will not be able to fold the wing tips using the manual command.

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On-ground, the WINGTIPS DRIVE FAULT Caution message will be displayed. The flight crew will not be able to control the folding wing tips. .

Both Channels Inoperative:

No next critical failures have been identified. Airplane will be operated with the folding wing tips deactivated in the extended position.

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57-91-05

Automatic Fold Function

Interval	Installed	Required	Procedure
C	1	0	(O)

May be inoperative provided:

- WINGTIPS AUTO/FOLD switch remains in manual position, and
- When required, wing tips are manually set to fold when exiting active runway.

SUBSTANTIATION**Background**

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

The pilot can enable manual fold operation of the FWT by setting the AUTO/FOLD switch on the P5 panel to MAN. The auto fold switch button will show a MAN light to indicate that automatic wing tip folding is disabled. The EICAS display will show the WINGTIPS IN MANUAL Advisory message when the automatic wing tip folding is disabled.

When auto fold is disabled (AUTO/FOLD switch in MAN), the rotary selector switch can be moved to FOLD at any time, but the FWT system will only operate only if the airplane is on the ground and ground speed is less than 50 knots.

For manual fold operation, EICAS will show the WINGTIPS NOT FOLDED Caution message to alert the flight crew if the airplane exits the runway with the FWTs extended.

Consequences of Failure

For failure of the Automatic Fold Function, the Folding Wing Tips will not automatically fold after landing or rejected takeoff. For dispatch the WINGTIPS AUTO/FOLD switch must be set to MAN. Flight crews must manually fold the wing tips after landing. The WINGTIPS IN MANUAL Advisory message will be displayed with the AUTO/FOLD switch set to MAN.

Consequences of Next Critical Failure

None identified.

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57-91-06 WINGTIPS AUTO/FOLD Switch Lights**57-91-06-01 MAN Light**

Interval	Installed	Required	Procedure
C	1	0	

57-91-06 WINGTIPS AUTO/FOLD Switch Lights**57-91-06-02 AUTO Light**

Interval	Installed	Required	Procedure
C	1	0	

SUBSTANTIATION**Background**

New proposal for 777X.

(See item 57-91-01 for a description of folding wing tip system)

The WINGTIPS AUTO/FOLD switch is an alternate action, mechanically latched, push-button switch that incorporates an amber "MAN" indicator light and a mechanical shuttered "AUTO" indicator.

WINGTIPS AUTO/FOLD Switch MAN Light:

When the WINGTIPS AUTO/FOLD switch is set to MAN, the automatic fold function of the folding wing tip system is disabled. The wing tips must be manually commanded to fold using the WINGTIPS EXTEND/FOLD selector. AUTO is extinguished when switch is out (MAN).

WINGTIPS AUTO/FOLD Switch AUTO Light:

When the WINGTIPS AUTO/FOLD switch is set to AUTO, the fold function of the folding wing tip system is controlled automatically. Fold is automatically commanded following a landing or a high-speed rejected takeoff. MAN is extinguished when switch is pressed (AUTO).

Consequences of Failure

WINGTIPS AUTO/FOLD Switch MAN Light:

The folding wing tip system WINGTIPS IN MANUAL Advisory message operates normally and is displayed when switch is in the out or MAN position.

WINGTIPS AUTO/FOLD Switch AUTO Light:

The switch position is discernible by the switch flush with the surrounding panel. The automatic fold function of the folding wing tip operates normal-

ly.

Consequences of Next Critical Failure

WINGTIPS AUTO/FOLD Switch MAN Light:

None.

WINGTIPS AUTO/FOLD Switch AUTO Light:

None.

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Feb 26, 2026

57-91-07

WINGTIPS Selector Switch

Interval	Installed	Required	Procedure
C	1	0	(M) (O)

May be inoperative provided:

- Both Wing Tips are deactivated in extended position, and
- Airport operations do not require its use.

SUBSTANTIATION**Background**

New proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

Consequences of Failure

Failure of the WINGTIPS Selector Switch results in loss of the ability to control the Folding Wing Tip (FWT) System. The flight crew will not be able to extend the folding wing tips for takeoff.

For dispatch, the folding wing tips must be deactivated in the extended position. A special maintenance function is accomplished to deactivate the system with the wing tips extended, resulting in annunciation of the WINGTIPS IN MANUAL Advisory message and WINGTIPS DISABLED Status message. For airport operations, airplane is ICAO Aerodrome Reference Code F. With the wing tips disabled, the WINGTIPS NOT FOLDED Caution message will not be displayed when exiting the runway with wing tips extended.

Consequences of Next Critical Failure

No next critical failures have been identified. Airplane will be operated with the folding wing tips deactivated in the extended position.

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Feb 26, 2026

57-94-01

Folding Wing Tip Latch Pin Actuators

Interval	Installed	Required	Procedure
C	8	7	(M) (O)

One may be inoperative provided:

- Inoperative Latch Pin Actuator is replaced with flyaway pin,
- Both Wing Tips are deactivated in extended position, and
- Airport operations do not require its use.

SUBSTANTIATION**Background**

New MMEL proposal for 777X.

The 777-9 includes folding wing tips that allow the airplane to operate within the Code E Airport limitation by reducing the on-ground wing span with the wing tips folded to less than 213 feet. The wing span with the wing tips extended is 236 feet. The Folding Wing Tip (FWT) System is used to move the FWTs before takeoff and landing.

NORMAL TAKEOFF

For a normal takeoff, the FWTs remain folded until the airplane reaches the departure runway. When the airplane reaches the hold short line before the departure runway, the pilot manually commands the FWTs to extend by moving the WINGTIPS Selector switch to the EXTEND position. The FWTs move from the folded position to the extended position within 20 seconds. The EICAS display shows when the FWTs have reached the fully extended position.

NORMAL LANDING

For a normal landing, the FWT system defaults to auto fold. The pilot does not need to make any inputs for the FWT system to operate. The FWTs will fold automatically when the WINGTIPS AUTO/FOLD switch is set to AUTO, the airplane is on-ground and ground speed is less than 50 knots. The FWT system will automatically move the WINGTIPS Selector switch (EXTEND/FOLD) to FOLD during landing rollout.

ACTUATION

Each Folding Wing Tip is actuated by a Power Drive Unit (PDU) which transmits torque to a Rotary Fold Actuator (RFA) to extend or fold the Folding Wing Tip. The PDU received hydraulic pressure from either Hydraulic Control Module. Two torque tubes in each FWT system transmit torque from the PDU to the Rotary Fold Actuator (RFA) through the Angle Gear Box (AGB). The AGB allows a change of axis direction for the torque transmitted from the PDU to the RFA.

LATCH AND LOCK SUBSYSTEM

The FWT Latch and Lock Subsystem (LLS) controls the operation of the latch pins, primary, and secondary locking devices to ensure that the FWT is held securely in the extended position. The LLS consists of these components on each wing:

- Latch Pin Actuator (LPA)s (4)
- Secondary Lock Actuator (SLA)
- Secondary lock driveline

LOCK/UNLOCK

The FSS uses HCM B to control the hydraulic flow to the Latch and Lock Subsystem (LLS) Latch Pin Actuator (LPA)s on both wing tips to lock or unlock the latch pins.

LATCH PIN ACTUATOR

The Latch Pin Actuator (LPA) inserts and removes structural latch pins in the wing structure. There are four LPAs on each Folding Wing Tip (FWT). The latch pin, which is an integral part of the LPA, carries flight loads across the hinge line.

The LPA is a hydraulically powered, dual acting, linear actuator. The LPA contains two integral and independently operated locking mechanisms (primary lock and secondary lock) to positively lock the latch pin in the extended position.

The primary lock is actuated and retained in the locked position by spring force when the latch pin is extended. The latch and primary lock solenoid valve in Hydraulic Control Module (HCM) B hydraulically commands the primary lock to unlock for latch pin retraction.

The secondary lock mechanism is operated by a rotary shaft mechanism driven by the Secondary Lock Actuator (SLA). The four secondary lock rotary shafts are connected in series by the swing link assembly. An inhibit post is fitted in the LPA to restrict the movement of the secondary lock mechanism. The secondary lock can move to the fully unlocked position only when the latch pin fully retracts and moves the inhibit post out of engagement with the secondary lock mechanism.

When the FWT moves to the fully extended position, the latch and primary lock solenoid valve in HCM B sends hydraulic pressure to the LPA to extend the latch pin into structural lugs on the FWT. The primary lock in the LPA moves to its locked position under spring pressure. The secondary lock is moved to its locked position by the rotary shaft, which is driven by the SLA.

The secondary lock cannot fully move into its locked position until the latch pin is engaged and the primary lock is locked. When the secondary lock driveline position sensor signals that all four LPA secondary locks are engaged, pressure is removed from the FWT system and the primary and secondary locks hold the latch pins in place mechanically.

When the FWT system is commanded to fold, the SLA moves the LPA secondary lock to partially disengage. The latch and primary lock solenoid valve, in HCM B, sends hydraulic pressure to the primary lock to unlock it.

The latch pin is retracted by hydraulic pressure from the latch and primary lock solenoid valve. When the latch pin fully retracts, it moves the inhibit post and allows the secondary lock to complete its movement to fully unlocked. When the secondary lock driveline position sensor signals that all four LPA secondary locks are fully retracted, the FWT is commanded to fold.

Consequences of Failure

Failure of a Folding Wing Tip Latch Pin Actuator is indicated by the WINGTIPS DRIVE L or WINGTIPS DRIVE R Status message.

For dispatch, the inoperative Latch Pin Actuator must be replaced with a flyaway pin. The Folding Wing Tips must be deactivated in the extended position using the special maintenance function. The WINGTIPS DISABLED Status message and WINGTIPS IN MANUAL Advisory message will be displayed.

For airport operations, airplane is ICAO Aerodrome Reference Code F. With the wing tips disabled, the WINGTIPS NOT FOLDED Caution message will not be displayed when exiting the runway with wing tips extended.

Consequences of Next Critical Failure

No next critical failures have been identified. Airplane will be operated with the folding wing tips deactivated in the extended position.

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- 73-11-01 Engine Main Fuel Pump (MFP)**
 - 73-11-01-01 Engine MFP Fault
- 73-11-02 Engine Fuel Strainer Bypass Sensors**
- 73-21-01 Electronic Engine Controls (EEC) Normal Mode**
- 73-21-02 EEC MODE Switch Lights - NORM/ALTN**
- 73-21-03 EEC C1 Faults**
- 73-21-05 ENG DIGITAL INPUT FAULT Status Message**
- 73-31-01 Fuel Flow Indications**
- 73-34-01 Engine Fuel Filter Bypass Sensors**

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73-11-01 Engine Main Fuel Pump (MFP)**73-11-01-01 Engine MFP Fault**

Interval	Installed	Required	Procedure
C	2	1	(O)

May be dispatched with ENG FUEL PUMP L or ENG FUEL PUMP R Status message displayed provided:

- All Main Tank Fuel Pumps operate normally,
- Both Center Tank Fuel Override/Jettison Pumps operate normally, and
- Flight remains within 120 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

New proposal for 777X.

Fuel is supplied under pressure to the Engine Main Fuel Pump (MFP) from the airplane fuel system. The airplane fuel system includes pumps located in the main and center fuel tanks.

The MFP pressurizes the fuel and sends it through a fuel strainer that is mounted within the MFP assembly. After the fuel goes through the strainer, it flows through the Integrated Drive Generator (IDG) Fuel/Oil Heat Exchanger (FOHE) and then the main FOHE. After the fuel goes through the two FOHEs, it flows back to the MFP and through the main fuel filter, which is mounted on the MFP assembly. In the MFP is a gear stage that further increases the fuel pressure before it leaves the MFP assembly and goes to the Fuel Metering Unit (FMU).

Consequences of Failure

In the event of loss of pressurized fuel from the airplane fuel system, the associated MFP will operate on suction feed. If an MFP operates on suction feed for more than 30 minutes, the associated ENG FUEL PUMP L or ENG FUEL PUMP R Status message will be displayed. The Status message is an indication that the MFP may be in a degraded state and may no longer meet all of its performance requirements.

Engine main fuel pumps have demonstrated suction feed capability for 60 minutes at climb power and 600 minutes at cruise power. Operation under suction feed may degrade the pump capability, however, the fuel pump will still operate normally under non-suction feed conditions.

One MFP may be inoperative for MMEL dispatch. Dispatch with an MFP that indicates the ENG FUEL PUMP L, R Status message requires that the airplane fuel system Main Tank Fuel Pumps and Center Tank Fuel Override Jettison Pumps operate normally.

PL-40 CONSIDERATIONS:

Considering that suction feed capability on the associated MFP may possibly be compromised, ETOPS is limited to 120 minutes.

Consequences of Next Critical Failure

Loss of pressurized fuel feed from the airplane fuel system:

Loss of all pressurized fuel feed (affecting to both engines) is classified as 'Hazardous'. The probability of loss of all pressurized fuel feed is extremely improbable (on the order of $4.01\text{E}-10$). In this event, both engines would operate on suction feed. The engine with the MFP in the faulted condition may not be able to meet the full suction feed capability. If the MFP were to fail, an engine shutdown would occur.

Loss of pressurized fuel feed from the airplane fuel system to one engine:

Loss of pressurized fuel feed (affecting one engine) is classified as 'Major'. In this event, the associated engine would operate on suction feed. An engine with the MFP in the faulted condition may not be able to meet the full suction feed capability. If the MFP were to fail, an engine shutdown would occur.

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73-11-02

Engine Fuel Strainer Bypass Sensors

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both left and right Engine Fuel Filter Bypass Sensors operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 73-11-01, applicable to 777X/GE-9X.

Fuel is delivered from the airplane fuel system to the main fuel pump (MFP). Within the MFP, the fuel flows from the low pressure pump, through a strainer, which removes any larger contaminants. After passing through the integrated drive generator (IDG) and main fuel/oil heat exchanger (FOHE), the fuel flows through a fuel filter before it returns to the MFP. This filter removes smaller contaminants, before the fuel is further pressurized by the gear stage of the MFP and delivered to the fuel metering unit (FMU).

The fuel pump strainer is a metal mesh strainer. If the strainer becomes clogged, a bypass valve will open due to increased differential pressure allowing fuel to flow past the strainer. The fuel strainer bypass sensor provides indication when there is an impending or actual bypass condition. The EEC monitors the bypass indication.

When an impending or actual strainer bypass condition exists, the associated ENG FUEL STRAINER L or R Status message is displayed as long as the associated fuel strainer bypass sensor is valid. Dispatch is not allowed with the ENG FUEL STRAINER L or R Status message displayed.

Similar to the strainer, if the fuel filter becomes clogged, a bypass valve will open due increased differential pressure allowing fuel to flow past the filter. The fuel filter bypass sensor provides indication when there is an impending or actual bypass condition. The EEC monitors the bypass indication.

When an impending or actual filter bypass condition exists, the associated ENG FUEL FILTER L or R Status message is displayed as long as the associated fuel filter bypass sensor is valid. Dispatch is not allowed with the ENG FUEL FILTER L or R Status message displayed.

Consequences of Failure

Failure of a fuel pump strainer bypass sensor is indicated by the ENG FUEL STRAINER SENSOR L or R Status message. This message is displayed when both elements of the strainer pressure sensor have failed. The sensor will not detect a fuel strainer bypass condition. Dispatch requires that the fuel filter bypass sensor operates normally on both engines.

Consequences of Next Critical Failure

None. Fuel would bypass a clogged strainer, but would still be filtered by the engine fuel filter. Fuel contamination would still be detected by the engine fuel filter bypass sensors indicated by the ENG FUEL BYPASS L, R Advisory message or ENG FUEL BYPASS L+R Caution message if contamination occurs in both engines.

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73-21-01 Electronic Engine Controls (EEC) Normal Mode

Interval	Installed	Required	Procedure
C	2	0	(O)

Normal (NORM) mode may be inoperative provided:

- All required autothrottle system equipment items operate normally,
- Both High Pressure Turbine Active Clearance Control (HPTACC) Valves operate normally,
- Both Low Pressure Turbine Active Clearance Control (LPTACC) Valves operate normally,
- Both Engine Anti-Ice (EAI) Valves operate normally, or inoperative EAI Valve is locked closed,
- Both Engine Anti-Ice (EAI) Cards operate normally, or associated inoperative EAI Valve is locked closed,
- Both engines are operated in alternate (ALTN) mode, and
- Appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 73-21-01-02, applicable to 777X/GE-9X.

Alternate mode means the EEC cannot calculate a thrust rating for the given flight condition and instead the full thrust rating is used. The potential for over-thrusting the engine is possible. Selecting both EEC's to ALTN mode eliminates possible throttle stagger. Selecting both EEC's to alternate mode will ensure that the thrust performance of both engines will be accordance with the alternate mode dispatch thrust calculations. When the engines are operated in the alternate mode the N1 EICAS display has a reference/target and command displayed. The autothrottle is designed to operate with the engines in alternate mode (including takeoff).

Consequences of Failure

The ENG EEC IN ALTN L or R Advisory message is set either due to a control failure or if alternate mode is manually selected. The ENG EEC MODE L or R Status message is set for a control system fault.

Both EEC's must be operated in the ALTN mode with N1 used as the thrust setting parameter. The ENG EEC IN ALTN L and R Advisory messages will be displayed. Thrust rating protection is not available for manual thrust settings, however, the associated ENG N1 OVER MAX L or R Caution message will be displayed if the engine is operated at 2% or greater than maximum N1. The autothrottle is available (including takeoff). Use of derates and reduced thrust is not allowed (AFM Appendix Section 1 Limitations).

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Performance adjustment to increase flight planning fuel is required in alternate mode because the EEC uses default turbine case cooling schedules that are not optimum.

Engine Anti-Ice (EAI) Valves - Valve Locked in Mid Position MMEL item requires EEC normal mode to operate normally. Therefore, associated EAI valve must not be locked in the mid position.

Consequences of Next Critical Failure

If taking off in EEC alternate mode, synthetic airspeed (AOA speed) will not be available if there is a loss of voted air data.

Loss of both voted air data and AOA speed is considered a catastrophic failure condition.

Quantitative Assessment:

The probability of misleading voted airspeed is $8.94\text{E-}9$ per flight hour (per the SSA, loss of voted air data is addressed by misleading voted air-speed).

Alternate mode maintains the same level of redundancy as normal mode for all parameters required to control the engine.

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73-21-02

EEC MODE Switch Lights - NORM/ALTN

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided associated switch(es) is verified to operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 73-21-02, applicable to 777X/GE-9X.

The EEC mode lights allow verification of switch position during use. There are indications on EICAS that provide the same information. The ENG EEC IN ALTN L, R Advisory message will be displayed when an engine is in the Alternate mode.

NORM illuminated (ALTN extinguished): EEC is operating in normal mode.

ALTN illuminated (NORM illuminated): EEC has automatically switched to alternate mode.

ALTN illuminated (NORM extinguished): EEC alternate mode manually selected.

Consequences of Failure

None. The EEC mode switch position can be verified using the associated ENG EEC IN ALTN L, R Advisory message which remains operative.

Consequences of Next Critical Failure

None. If an engine went into alternate mode, the ENG EEC IN ALTN Advisory message is displayed.

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73-21-03

EEC C1 Faults

Interval	Installed	Required	Procedure
A	2	0	

May be dispatched with ENG EEC C1 L and/or ENG EEC C1 R Status message displayed provided repairs are made within 150 flight-hours.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 73-21-03, applicable to 777X/GE9X.

This condition is indicated by the ENG EEC C1 L or R status messages.

The EEC C1 message means that for some aspect of the EEC control system, the system has had a loss of redundancy (single channel fault), but there is no loss of functionality. The engines have been approved (reference appropriate engine manufacturer's documents) to operate with certain faults present in the control system. The MMEL restates this relief for clarification.

Consequences of Failure

The ENG EEC C1 L or R Status message will be displayed when there is a fault in the engine control system that allows for time limited dispatch before repairs are made. The engine control system will continue to operate normally but will be operating with reduced redundancy.

Consequences of Next Critical Failure

Engine may operate erratically or shutdown. If the engine were to surge multiple times due to erratic operation, the associated ENG SURGE L or R Caution message may be displayed. If the associated engine were to shutdown, the associated ENG FAIL L or R Caution message would be displayed.

NOTE: At the time of publication of Draft 4, this MMEL item has not been fully validated by engineering.

73-21-05 ENG DIGITAL INPUT FAULT Status Message

Interval	Installed	Required	Procedure
C	2	0	

May be dispatched with ENG DIGITAL INPUT FAULT L and/or ENG DIGITAL INPUT FAULT R Status message displayed.

SUBSTANTIATION**Background**

To be developed.

Consequences of Failure

To be developed.

[From CAMT: Reduced redundancy or loss of integrity on critical aircraft inputs to the EEC.]

Consequences of Next Critical Failure

To be developed.

[From CAMT: Multiple erroneous critical aircraft inputs to the EEC could cause loss of thrust control to one or both engines.

MMEL dispatch interval TBD, based on required exposure time of fault tree analysis within the Propulsion Control System Safety Assessment.]

73-31-01 Fuel Flow Indications

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided:

- Center tank Fuel Quantity Indication System operates normally, or center fuel tank remains empty,
- Both main tank Fuel Quantity Indication systems operate normally, and
- Flight remains within 180 minutes of landing at a suitable airport.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 73-31-01, applicable to 777X/GE9X.

The fuel flow meter supplies fuel flow data to the electronic engine control (EECs), which send the data to the common computing system (CCS). The EECs calculate the fuel flow rate, and the CCS calculates fuel used. The fuel flow data shows on the engine indication and crew alerting system (EICAS) display. The CCS also uses the data to calculate the fuel-used data for the flight management function (FMF), which is shown on the control display unit (CDU) progress page.

Consequences of Failure

The associated engine's fuel used indication, the FMC calculated fuel quantity, and the total fuel used indication will be inoperative. The total fuel indication and FMC totalizer fuel quantity are not affected by loss of fuel flow indication. FQIS must operate normally.

The FUEL QTY DISAGREE, FUEL FLOW HI ENG L and FUEL FLOW HI ENG R Advisory messages will be inoperative. Fuel flow lines may be missing from the fuel synoptic display.

Updated ETOPS rules require an alert to be displayed when abnormal fuel management or transfer between tanks or possible loss of fuel has occurred (FAR K25.1.4(a)(3)) when beyond 180 minutes (FAR 25.3(b)(ii)).

Consequences of Next Critical Failure

Failure of FQIS will result in total fuel indication and FMC totalizer fuel quantity to be inoperative. The estimated fuel remaining at waypoint or destination on the Progress Page and the FMC gross weight indication will be available and predicted on totalizer fuel quantity.

For fuel leakage, higher than normal fuel usage or leakage would be detected by difference in the associated fuel tank indications and flight plan fuel.

Loss of FQIS in combination with a fuel leak in the dispatch configuration results in a catastrophic hazard condition. The probability of these failures is extremely improbable.

73-34-01**Engine Fuel Filter Bypass Sensors**

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both left and right Engine Fuel Strainer Bypass Sensors operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 73-34-01-01, applicable to 777X/GE9X.

Fuel is delivered from the airplane fuel system to the main fuel pump (MFP). Within the MFP, the fuel flows from the low pressure pump, through a strainer, which removes any larger contaminants. After passing through the integrated drive generator (IDG) and main fuel/oil heat exchanger (FOHE), the fuel flows through a fuel filter before it returns to the MFP. This filter removes smaller contaminants, before the fuel is further pressurized by the gear stage of the MFP and delivered to the fuel metering unit (FMU).

The fuel pump strainer is a metal mesh strainer. If the strainer becomes clogged, a bypass valve will open due to increased differential pressure allowing fuel to flow past the strainer. The fuel strainer bypass sensor provides indication when there is an impending or actual bypass condition. The EEC monitors the bypass indication.

When an impending or actual strainer bypass condition exists, the associated ENG FUEL STRAINER L or R Status message is displayed as long as the associated fuel strainer bypass sensor is valid. Dispatch is not allowed with the ENG FUEL STRAINER L or R Status message displayed.

Similar to the strainer, if the fuel filter becomes clogged, a bypass valve will open due increased differential pressure allowing fuel to flow past the filter. The fuel filter bypass sensor provides indication when there is an impending or actual bypass condition. The EEC monitors the bypass indication.

When an impending or actual filter bypass condition exists, the associated ENG FUEL FILTER L or R Status message is displayed as long as the associated fuel filter bypass sensor is valid. Dispatch is not allowed with the ENG FUEL FILTER L or R Status message displayed.

Consequences of Failure

Failure of a fuel pump filter bypass sensor is indicated by the ENG FUEL FILTER SENSOR L or R Status message. This message is displayed when both elements of the filter pressure sensor have failed. The sensor will not detect a fuel filter bypass condition. Dispatch requires that the fuel strainer bypass sensor operates normally on both engines.

The associated ENG FUEL BYPASS L, R Advisory message and ENG FUEL BYPASS L+R Caution message may be inoperative depending on the type of contaminant.

Consequences of Next Critical Failure

None. Fuel would bypass a clogged filter and unfiltered fuel will be delivered to fuel control system and engine systems. Opposite engine fuel filter bypass warning would detect contaminated fuel as long as the contamination is in both main tanks, the center tank, or the airplane is in a crossfeed configuration. The upstream fuel strainer bypass sensor on the associated engine will still operate normally, however, for single-tank contamination with debris smaller than the fuel strainer mesh size, the condition would not be detected. Clogging of both left and right engine fuel strainers will result in the ENG FUEL BYPASS L+R Caution message.

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74-00-01 Ignition Systems

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74-00-01 Ignition Systems

Interval	Installed	Required	Procedure
B	4	3	

One may be inoperative provided associated Engine Anti-Ice (EAI) Valve and EAI Card operate normally, or associated EAI Valve is deactivated in mid position.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 74-00-01-02, applicable to 777X/GE9X.

There are two ignitors on each engine and each ignitor is capable of starting the engine by itself. The Electronic Engine Control (EEC) controls the selection of the ignition system. The control is automatic on engine start without flight crew input. Ignition power goes to the EEC when the FUEL CONTROL switch is set to the RUN position. The EEC then supplies power to the ignition systems independently during the engine start sequence. Each of the two independent ignition systems can be controlled by either EEC channel. When a single igniter is commanded at normal ground start, the igniter gets power from relays in the EEC channel in control. When dual ignition is commanded, both ignitors get power from relays in both EEC channels. If both channels are healthy, the EEC alternates ignitors every two starts to make sure that each igniter gets power from each channel twice for every four starts with a normal system.

A single igniter is used for all ground starts. Dual ignitors are used for automatic restart attempts on the ground and all in-flight start attempts. The EEC selects both ignitors for the following conditions:

- Loss of igniter power to the EEC for the selected igniter
- Second or third start attempt on the ground when a no-light-off condition or failed start attempt has occurred
- In-flight start attempt
- An automatic relight

The EEC can detect certain failures such as loss of igniter power before a light-off attempt has been made. For these failures, the EEC commands dual ignition before the first start attempt. If the EEC detects that a light-off did not occur after ignition command and FUEL CONTROL switch set to RUN, the EEC will turn off fuel and ignition. The EEC will motor the engine and attempt a second light-off attempt with dual ignitors. If the second attempts fails, it will make a third attempt with dual ignition. If the engine fails to start on the third attempt with dual ignitors, a Failed Start Sequence will be initiated and a message will show on Engine Indication and Crew Alerting System (EICAS)

This item provides MMEL relief with no ETOPS restriction by only allowing one igniter to be inoperative and restricting repair interval to a B.

Consequences of Failure

The ENG IGNITOR L1, L2, R1 or R2 Status message will be displayed when the engine fails to ignite using the associated ignitor or there is no power to the associated ignitor.

Engine will not start with failed Ignitor, EEC will use other Ignitor to start the engine. For dispatch, the associated engine anti-ice system must operate normally.

Consequences of Next Critical Failure

Engine will not start if both associated ignitors have failed.

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75-23-01 Core Compartment Cooling (CCC) Valves

75-24-01 Turbine Case Cooling Air Flow Systems

75-24-01-01 High Pressure Turbine Active Clearance Control (HPTACC) Valves

75-24-01-02 Low Pressure Turbine Active Clearance Control (LPTACC) Valves

75-24-02 Modulated Turbine Cooling Systems

75-24-03 Reverse Bleed System

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75-23-01 Core Compartment Cooling (CCC) Valves

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided associated CCC valve(s) is locked open.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 75-23-01, applicable to 777X/GE-9X.

The Core Compartment Cooling (CCC) Valve is on the top of the engine and directs fan air to various engine accessories for cooling. The primary purpose of this cooling is to reduce accessory heat to extend component life. The CCC valve is open at high thrust settings and closed at low thrust settings. CCC valve position is based on thrust and altitude. The valve is designed to fail in the open position.

Consequences of Failure

ENG CCC VALVE L or R Status message is indicated when the engine core compartment cooling (CCC) valve has failed closed or both of the dual feedback channels have failed. This may result in insufficient cooling of nacelle compartment surrounding the engine core.

For dispatch, the associated CCC valve must be locked in the open position.

Consequences of Next Critical Failure

None. Locking the associated CCC valve open ensures that powerplant components attached to the core will not exceed their design temperature limits.

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75-24-01 Turbine Case Cooling Air Flow Systems

75-24-01-01 High Pressure Turbine Active Clearance Control (HPTACC) Valves

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative HPTACC valve(s) is locked closed,
- Associated engine CCC valve is locked open,
- Associated engine LPTACC valve operates normally,
- EEC Normal Mode operates normally on both engines,
- Appropriate takeoff thrust settings are applied, and
- Appropriate performance adjustments are applied.

NOTE: Dispatch is not allowed with the associated Engine Anti-Ice (EAI) Valve locked in mid-position.

75-24-01 Turbine Case Cooling Air Flow Systems

75-24-01-02 Low Pressure Turbine Active Clearance Control (LPTACC) Valves

Interval	Installed	Required	Procedure
C	2	0	(M) (O)

May be inoperative provided:

- Inoperative LPTACC valve(s) is locked closed,
- Associated engine CCC valve is locked open,
- Associated engine HPTACC valve operates normally,
- EEC Normal Mode operates normally on both engines,
- Appropriate takeoff thrust settings are applied, and
- Appropriate performance adjustments are applied.

NOTE: Dispatch is not allowed with the associated Engine Anti-Ice (EAI) Valve locked in mid-position.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 75-24-01-02, applicable to 777X/GE9X.

Condition indicated by ENG HPTACC VALVE L or R and ENG LPTACC VALVE L or R status messages.

The turbine case cooling system optimizes engine efficiency by controlling the turbine blade tip clearances through the expansion/contraction of the turbine case. The engine fuel system will slew the valves closed in the event of loss of electrical power (fuel/pneumatic bias in the EHSV to slew closed). Closed valves would result in higher turbine blade tip clearances than needed leading to a decrease in EGT margin and an increase in fuel burn during cruise.

Consequences of Failure

Failure of the high pressure turbine active cooling control (HPTACC) valve is indicated by the ENG HPTACC VALVE L or R Status message. Failure of the low pressure turbine active cooling control (LPTACC) valve is indicated by the ENG LPTACC VALVE L or R Status message. The associated Status message will be displayed if the valve is not in its commanded position or position feedback is lost.

For dispatch, the inoperative valve must be locked closed. A valve that is failed open may result in engine deterioration due to turbine blade rub. Operation with valve locked closed results in increased fuel consumption for the associated engine and in a reduction in EGT margin.

The other associated active cooling control valve (HPTACC or LPTACC) must operate normally. The associated CCC valve must be locked in the open position. The EEC normal mode must operate normally. Appropriate adjustments to takeoff thrust settings are required to mitigate the decrease in EGT margin. Fuel planning penalties are required to mitigate the increase in fuel consumption.

Engine Anti-Ice (EAI) Valves - Valve Locked in Mid Position MMEL item requires associated turbine case cooling air flow systems to operate normally. Therefore, associated EAI valve must not be locked in the mid position.

Consequences of Next Critical Failure

Remaining active cooling control valve fails in the closed position (on associated engine): The engine will operate with higher EGT, higher fuel flow and reduced operability margins. However, these effects are not severe enough to result in a hazard to the airplane.

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75-24-02

Modulated Turbine Cooling Systems

Interval	Installed	Required	Procedure
C	2	0	(M)

May be inoperative provided associated Modulated Turbine Cooling Valve(s) is locked open.

SUBSTANTIATION

Background

New proposal for 777X/GE9X.

The modulated turbine cooling (MTC) system regulates cooling air to the first-stage high pressure turbine blades in order to optimize fuel burn and extend component life.

Consequences of Failure

The ENG MTC VALVE L or R Status message will be displayed when the associated modulated turbine cooling (MTC) valve has failed closed or sensor feedback is failed.

A MTC valve that is failed closed may result in loss of cooling to the first-stage high pressure turbine blades which may cause increased fuel burn and may shorten turbine blade life. The associated inoperative MTC valve must be locked in the open position for dispatch.

Consequences of Next Critical Failure

None.

75-24-03 Reverse Bleed System

Interval	Installed	Required	Procedure
D	2	0	

SUBSTANTIATION**Background**

New proposal for 777X/GE9X.

After engine shutdown, residual engine heat can heat fuel that remains in the fuel nozzles to temperatures that may result in carbon deposits (coking). Eventually, a buildup of carbon deposits may impact fuel nozzle performance.

The reverse bleed system operates after engine shutdown and provides cooling air flow from the bleed port into the high pressure compressor. This allows air to pass of the fuel nozzles which will reduce the temperature and reduce or prevent coking.

Consequences of Failure

The ENG RBS L or R Status message will be displayed when there is an electrical fault in the associated reverse bleed system.

Reverse bleed air will not be supplied to the associated engine after shutdown. This will have no impact on airworthiness or safety.

Consequences of Next Critical Failure

None.

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77-31-01 Engine Vibration Monitoring Functions

77-31-02 Accessory Gearbox (AGB) Vibration Faults

77-31-02-01 Tracked Vibration Threshold Function

77-31-02-02 Replacement Vibration Threshold Function

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77-31-01 Engine Vibration Monitoring Functions

Interval	Installed	Required	Procedure
C	2	1	

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 77-31-01, applicable to 777X/GE9X.

The Engine Vibration Monitor (EVM) system supplies N1 and N2 rotor vibration data for flight crew display and engine trim balancing. The engine vibration indication shows on the engine indication and crew alerting system (EICAS) display as a secondary engine parameter. The EVM system calculates the vibration for each engine rotor (N1 and N2), selects the highest value for each engine, and shows the values on the displays.

Vibration signals are sent from two accelerometers on the engine to the two electronic engine control (EEC) units (channel A and channel B). The two accelerometers are the turbine center frame accelerometer and the No. 1 bearing accelerometer. The EVM system also uses the data from the N1 and N2 speed sensors to calibrate the accelerometer data.

Consequences of Failure

The ENG VIB MONITOR L or R Status message will be displayed when there is a failure of the associated engine accelerometers used to measure engine vibrations.

When the EEC detects faults that invalidate the readings of both engine vibration monitoring accelerometers, the vibration indication on the secondary EICAS display will be blank. There is no certified engine vibration level limit. There are no flight crew procedures for vibration indications.

Consequences of Next Critical Failure

None. Vibration problem that required crew action would be detected by remaining engine parameters.

Federal Aviation Administration (FAA)

ATA 77

777-9 Master Minimum Equipment List

Section 2

77-31-02 Accessory Gearbox (AGB) Vibration Faults

77-31-02-01 Tracked Vibration Threshold Function

Interval	Installed	Required	Procedure
A	2	0	

May be dispatched with ENG AGB VIB L and/or ENG AGB VIB R Status message displayed provided associated Accessory Gearbox (AGB) is replaced within 5000 flight-cycles.

77-31-02 Accessory Gearbox (AGB) Vibration Faults

77-31-02-02 Replacement Vibration Threshold Function

Interval	Installed	Required	Procedure
A	2	1	

May be dispatched with ENG AGB L or ENG AGB R Status message displayed provided:

- Associated Backup Generator Input Shaft is either disconnected, or an appropriate dispatch kit is installed, and
- Repairs are made within 10 calendar-days.

SUBSTANTIATION

Background

The GE9X engine has an additional accelerometer on the accessory gearbox (AGB) to support advanced vibration health management and the airplane back-up generator (BUG) disconnect system. The AGB accelerometer is centrally mounted on the surface of the AGB, close to the BUG.

Consequences of Failure

Vibrations resulting in a disconnect of the backup generator (BUG) may also affect the life limit of the accessory gearbox. The ENG AGB VIB L or R status message will be displayed when the EEC has detected that the accessory gearbox low vibration limit has been exceeded. MMEL dispatch is allowed provided the accessory gearbox is replaced within 5000 flight cycles.

The ENG AGB L or R status message will be displayed when the EEC has detected that the accessory gearbox high vibration limit has been exceeded. MMEL dispatch is allowed provided the associated BUG input shaft is either disconnected or the disconnected BUG is removed and the dispatch kit is installed. After the MMEL deferral, the AGB must be replaced.

Consequences of Next Critical Failure

For subsequent events exceeding the low vibration limit, the AGB has adequate life provided it is replaced before 5000 flight cycles are completed.

For the high vibration event, the associated BUG will either be disconnected or the BUG dispatch kit installed which will mitigate the possibility of further damage to the AGB until it can be replaced.

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78-31-01 Thrust Reversers

78-34-01 Reverse Thrust Lever Interlocks

78-34-01-01 Lock Function - Interlock Released

78-34-01-02 Release Function - Interlock Not Released

78-36-01 Thrust Reverser Locking Actuator Indication System

78-36-01-01 Left Engine

78-36-01-02 Right Engine

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78-31-01

Thrust Reversers

Interval	Installed	Required	Procedure
A	2	1	(M) (O)

One may be inoperative provided:

- Inoperative Thrust Reverser is deactivated and secured in forward thrust position,
- Both Sync Locks are verified locked,
- At least one Locking Actuator on each sleeve is verified locked,
- Appropriate performance adjustments are applied, and
- Repairs are made within 10 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 78-31-01, applicable to 777X/GE9X.

The Thrust Reverser (T/R) system controls the direction of the fan exhaust. It makes forward thrust or reverse thrust. The T/R system has left and right T/R halves that attach to the engine strut. When the T/R translating sleeves are in the forward (retracted) position, the fan air goes through the fan duct and comes out at the rear of the fan duct. This makes forward thrust. When the T/R translating sleeves move to the aft (extended) position, the blocker door drag links move the blocker doors into the fan duct. This makes the fan air flow through the cascade segments. The segments turn the fan air and cause it to come out the sides of the T/R in a forward direction. This makes reverse thrust.

Consequences of Failure

The ENG REVERSER L, R Status and ENG REV FAULT L, R Advisory messages indicates that the thrust reverser system may not operate properly or has a reduced level of safety or has a loss of position indication.

For dispatch, the associated thrust reverser must be deactivated and secured in the forward thrust position. The associated ENG REV LIMITED L, R Advisory message will be displayed. Performance adjustments must be applied.

Asymmetric reverse thrust is available.

Airplanes certificated to Amendment 25-92 of Part 25 (effective March 20, 1998) or Change 15 of JAR-25 (effective October 1, 2000) or later are required to have wet runway takeoff performance data provided in their Airplane Flight Manuals (AFM). FAA policy only allows one of the two airplane's reversers to be inoperative for dispatch. This item provides MMEL relief as allowed on other model airplanes (757/767/777/787). Use of reverse thrust is left to the discretion of the operator. Techniques for controlling the airplane with asymmetrical reverse thrust are developed and used in training.

Consequences of Next Critical Failure

Failure of the remaining reverser or associated engine would leave the airplane with no reverse thrust. FAA/EASA AFM performance adjustments for wet runway with reverser inoperative account for this condition.

Failure of the engine opposite the inoperative thrust reverser at or before V1 would result in an RTO. This could result in a runway excursion at a speed that is considered hazardous. The probability of this failure occurring during the takeoff window which would lead to a hazardous excursion is less than $1.0E-09$.

Mechanical failure resulting in a misaligned nose gear in the direction that most limits nose wheel steering combined with asymmetric reverse thrust on landing may result in a lateral departure from the runway. The potential lateral departure speeds on a wet runway are considered 'Hazardous'.

Quantitative assessment:

The probability of a mechanical failure resulting in a misaligned nose gear in the direction that most limits nose wheel steering is $2.6E-06$ / FH.

The probability of a failure resulting in an inoperative thrust reverser is $1.67E-04$ / FH.

Based on the probabilities listed above, the maximum dispatch time is 230 flight hours (FH).

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78-34-01 Reverse Thrust Lever Interlocks**78-34-01-01 Lock Function - Interlock Released**

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative provided associated Interlock is released.

78-34-01 Reverse Thrust Lever Interlocks**78-34-01-02 Release Function - Interlock Not Released**

Interval	Installed	Required	Procedure
C	2	1	(O)

One may be inoperative with Interlock not released provided appropriate performance adjustments are applied.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 78-34-01, applicable to 777X/GE9X.

The reverse thrust lever interlock is an electrical solenoid with an interlock arm assembly attached to it. The interlock blocks the thrust reverse link to stop the reverse thrust lever from moving beyond idle until the Thrust Reverser (T/R) sleeves have deployed 60 percent of their travel.

The pilot commands reverse thrust by moving the forward thrust levers back to idle and lifting the reverse thrust levers. The reverse thrust levers are mounted on the front of the forward thrust levers. The reverse thrust levers have a linkage, which engages with the interlock arm within the Thrust Control Module (TCM). This prevents the lever from moving beyond the idle position. The Electronic Engine Control (EEC) gets Thrust Resolver Angle (TRA) from the resolvers, and a position signal from the Linear Variable Differential Transducer (LVDT) on the upper, non-locking, T/R hydraulic actuators. When the LVDT indicates that the T/R sleeves have extended by more than 60 percent, logic in the EEC closes an internal relay and sends a signal to energize the interlock solenoid in the TCM. The solenoid moves the interlock arm out of contact with the reverse thrust lever linkage and the pilot is allowed to command maximum reverse thrust. The T/R is stowed by moving the reverse thrust lever back to the full down position. There is no interlock restriction when commanding stow, but there is a reverse idle detent at the reverse idle position to let the pilot know that continued movement downward of the lever will stow the T/R.

Airplanes certificated to Amendment 25-92 of Part 25 (effective March 20, 1998) or Change 15 of JAR-25 (effective October 1, 2000) or later are required to have wet runway takeoff performance data provided in the Airplane Flight Manuals (AFM). When dispatching on a wet runway, performance adjustments for one thrust reverser inoperative must be applied. FAA policy only allows one of the two airplane's reversers to be inoperative for dispatch. This item provides MMEL relief as allowed on other model airplanes (777/767/747).

Consequences of Failure

The ENG REV INTERLOCK OPEN L or R Status message indicates that interlock has failed in the non-blocking position. For interlock inoperative in the non-blocking position, there is no physical stop for that reverse thrust lever to prevent it from being moved to the reverse thrust position, however, the EEC will not allow the engine reverse thrust to increase above idle until the thrust reverser sleeves are sufficiently deployed. Dispatch is allowed with one interlock failed in the non-blocking position. For application of reverse thrust, the will operate both reverse thrust levers together up to the interlock position of the operative lever. Once the operative interlock has released, both reverse thrust levers may be moved to command reverse thrust as needed.

The ENG REV INTERLOCK L or R Status message indicates that interlock has failed in the blocked position or that the interlock relay indication has failed. For interlock inoperative in the blocked position, it will not be possible to move the associated reverse thrust lever beyond reverse idle, even when the reverser sleeves are fully deployed. Dispatch is allowed with one interlock failed in the blocked position. Affected side will only allow reverse idle thrust. Asymmetric reverse thrust can be applied if required using the reverse thrust lever with the operative interlock. Performance penalties must be applied if landing on a wet runway. The ENG REV LIMITED L or R Advisory message may be displayed when the reverser interlock is inoperative retracted.

Consequences of Next Critical Failure

For one interlock not blocked: Failure of one reverser would result in reverse thrust available on only one engine.

For one interlock failed blocked: Failure of the opposite reverser would leave the airplane with only reverse idle thrust on one engine. Full reverse thrust would not be available to slow the airplane during landing or RTO.

78-36-01 Thrust Reverser Locking Actuator Indication System
78-36-01-01 Left Engine

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be dispatched with ENG REVERSER SNSR L Status message displayed.

78-36-01 Thrust Reverser Locking Actuator Indication System
78-36-01-02 Right Engine

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be dispatched with ENG REVERSER SNSR R Status message displayed.

SUBSTANTIATION

Background

Proposal based on 787 MMEL item 78-36-01, applicable to 777X/GE-9X.

Two proximity sensors are installed onto each thrust reverser half, one on the center locking actuator and one on the lower locking actuator. Each sensor contains its own internal processor and bite capability and provides a discrete output current directly to the EEC to indicate actuator lock state. Each sensor is installed into the housing of the locking actuators, with its associated target installed on the target arm assembly. When the actuator is locked, the target is near the sensor in a "target near" condition. When the actuator unlocks the lever rotates causing the target to move away from the face of the sensor to a "target far" position.

Both sync locks on each engine are controlled via a sync lock control relay. The sync lock control relay contains one contact for the left sync lock, a second for the right sync lock, and a third contact for position monitoring. This third contact is monitored by the Sensor Interface Unit (SIU). The SIU converts the analog signal to a digital format and sends it along to RDC 5 for the left engine or RDC 6 for the right engine. The RDC converts the data to a format that is compatible with the CDN. Once the signal is output to the CDN, the EEC will use the sync lock control relay status in fault message logic.

Consequences of Failure

The ENG REVERSER SNSR L or R Status message indicates a failure in the thrust reverser indication system. The message will be displayed when there is a fault or failure of a proximity switch, an RDC indication fault, or sync lock relay indication fault.

Loss of redundancy only. Thrust reverser system will operate normally.

Consequences of Next Critical Failure

If there is an additional proximity switch wiring fault, internal proximity switch failure, simultaneous RDC indication faults, or sync lock relay indication failures in combination with an RDC indication failure the associated ENG REVERSER SNSR L, R Status message will be inhibited and the ENG REV FAULT L, R Advisory ENG REVERSER L, R Status message will be displayed. Thrust reverser system will operate normally.

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79-21-01 Engine Oil Debris Monitoring System (DMS) Sensor

79-31-01 Engine Oil Quantity Indicating Systems

79-35-01 Engine Oil Filter Bypass Warning Systems

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79-21-01 Engine Oil Debris Monitoring System (DMS) Sensor

Interval	Installed	Required	Procedure
C	2	1	(M)

One may be inoperative provided:

- Inoperative DMS Sensor is checked for contaminants within 150 flight hours, and
- Associated Engine Oil Filter Bypass Warning System operates normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 79-21-02, updated for 777X/GE9X.

The oil Debris Monitoring System (DMS) sensor detects metallic chips in the oil system and provides early detection of rotor bearing failures. The oil filter bypass warning system is independent of the DMS and provides EICAS messages prior to an oil filter bypass. An approaching or actual oil filter bypass is indicated by the ENG OIL FILTER Status message. Oil bypassing a filter is indicated by the ENG OIL BYPASS L, R Caution message. These messages are no dispatch.

Consequences of Failure

Early detection of emerging rotor bearing failure is inoperative. Condition is indicated by ENG OIL DMS SENSOR L or R status messages. Inspection is done to detect oil debris within 150 flight hours. (For reference, 777/GE90 without electronic chip detection performed a manual check every 600 flight hours.) Associated engine oil filter bypass warning system must operate normally.

Consequences of Next Critical Failure

In the event of bearing failure, increased engine vibration will be evident.

79-31-01 Engine Oil Quantity Indicating Systems

Interval	Installed	Required	Procedure
A	2	1	(M)

One may be inoperative provided:

- Before each departure, verify associated engine oil tank is filled to recommended capacity,
- Oil consumption is within limits,
- There is no evidence of above normal oil leakage, and
- Repairs are made within 3 flight-days.

SUBSTANTIATION**Background**

Proposal based on 787 FAA MMEL item 79-31-01, applicable to 777X/GE-9X.

The Engine Oil Indicating System (EOIS) shows the oil quantity data on the Engine Indication and Crew Alerting System (EICAS) Multi-Function Display (MFD). The oil quantity level is measured from the Oil Level/Temperature Sensor (OLTS) and the measurement data is transmitted by the Remote Data Concentrator (RDC) and Common Computing Resource (CCR) to the EICAS MFD. The engine oil quantity is measured in quarts (liters) and shows on the Secondary Engine Display (SED) page on Engine Propulsion Control System (EPCS) page 2 and the performance maintenance page on EICAS. The oil quantity low limit is 4 qt (4 l). When the oil level is less than the low limit, the oil quantity readout on the EICAS SED page will change to reverse video, showing black numbers on a white background. The letters LO will also show adjacent to the oil quantity display.

Oil quantity is not monitored by the flight crew. Oil consumption is monitored as part of an airline's approved engine monitoring program. There is no low oil quantity level flight crew procedure. Not having an ETOPS restriction is based on limiting exposure time (repair category A) and that operators use ETOPS predeparture checks and maintenance procedures (human factors and verification flights) to prevent oil leaks.

Consequences of Failure

An engine oil quantity transmitter fault detected by both EEC and the Remote Data Concentrators (RDC) is indicated by the associated ENG OIL QTY SENSOR L or R Status message. Associated engine oil quantity is unknown during the flight. The associated engine oil tank must be verified to be filled to recommended capacity before each departure. Oil consumption and leakage must be within normal limits.

Consequences of Next Critical Failure

Loss of oil would not be indicated until the OIL PRESS LOW L, R Caution message and/or OIL TEMP CAUTION L, R Caution message is displayed. Low oil pressure may result in engine shutdown.

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79-35-01 Engine Oil Filter Bypass Warning Systems

Interval	Installed	Required	Procedure
C	2	1	

One may be inoperative provided both Engine Oil Debris Monitoring System (DMS) Sensors operate normally.

SUBSTANTIATION**Background**

Proposal based on 787 MMEL item 79-35-02, applicable to 777X/GE-9X.

The Oil Filter Differential Pressure Sensor (OFDPS) monitors the pressure differential across the inlet and outlet ports of the oil filter. The monitored data is used for fault monitoring and to show Engine Indication and Crew Alerting System (EICAS) indications. The data signal from one element is transmitted to channel A of the Electronic Engine Control (EEC). The second signal is transmitted to channel B of the EEC. The differential of the oil filter inlet and outlet pressures is measured by a strain gauge. The filter differential pressure increases due to collection of particles within the filter. The EEC calculates when there is an impending or actual bypass.

When the oil filter differential pressure indicates an impending bypass, the associated ENG OIL FILTER L or R Status message is displayed.

When the oil filter differential pressure indicates an actual bypass, the associated ENG OIL BYPASS L, R Caution and ENG OIL FILTER L, R Status messages are displayed.

Consequences of Failure

The associated ENG OIL FILTER SENSOR L or R Status message will be displayed when both channels of the associated engine delta pressure sensor for detecting oil filter blockage have failed. Oil filter bypass warning will not be available. Both engine oil debris monitoring system (DMS) sensors (left and right) must operate normally for dispatch.

Consequences of Next Critical Failure

A clogged filter will open the bypass valve and the engine would be using unfiltered oil. Contaminated oil would cause long term reduction in life of the associated engine parts.

Failure of the engine oil debris monitoring system will result in loss of early detection of engine bearing failure and allow circulation of the associated metallic debris in a bypass condition.

80-11-01 Engine Start Valves

80-11-01A

80-11-01B

80-11-02 Engine Start Switches

80-11-02-01 Engine Start Switch Faults

80-11-02-02 Start Selector Holding/Cutout Systems

80-12-01 Engine Turning System (ETS)

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80-11-01 Engine Start Valves**80-11-01A**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Engine Start Valve is manually operated during engine start,
 - APU operates normally,
 - APU is used as a pneumatic source for engine start, and
 - Alternate procedures are established and used.
-

80-11-01 Engine Start Valves**80-11-01B**

Interval	Installed	Required	Procedure
C	2	1	(M) (O)

One may be inoperative provided:

- Associated Engine Start Valve is manually operated during engine start,
 - Associated Engine Turning System (ETS) operation is verified, and
 - Alternate starting procedures are established and used.
-

SUBSTANTIATION**Background**

Proposal for option A based on 777 MMEL item 80-11-01 with revision to require APU bleed for start.

Proposal for option B new for 777X.

The engine start valve, or starter air valve (SAV) is an internally piloted, air actuated, spring loaded normally closed butterfly valve, whose function is to initiate and terminate a start sequence by controlling the airflow directed to the air turbine starter (ATS) inlet. The open position provides for airflow to the ATS while the closed position provides a controlled restriction to terminate the airflow to the ATS. The valve is provided an electric signal via the EEC, in conjunction with upstream pressure to open the valve airflow. A dual-channel pressure transducer is used for SAV butterfly valve position monitoring and fault detection. The SAV is mounted to the forward face of the ATS upstream of the starter in the starter air supply duct. The SAV has an interface to allow manual opening and closing by ground maintenance in the event of valve failure. The design for the GE9X SAV is based on the GE90 SAV design.

The EEC provides a discrete signal to the aircraft that is used by software within the flight deck control panel to unlatch the engine start switch once the engine reaches idle. The flight deck control panel start switch unlatching software allows the start switch to transition from START to NORM. The EEC receives the start command from the start switch in the flight deck and requests the APU to provide bleed air for either normal main engine start or bowed rotor mitigation start.

Starting will be accomplished by auto-start operation only. To initiate auto-start, the pilot will move the start switch from NORM to START and then move the Fuel Control Switch from CUTOFF to RUN. Moving the Fuel Control Switch from RUN to CUTOFF at any time in the process will abort the start sequence. The pilot will monitor N2, fuel flow, Exhaust Gas Temperature (EGT), and N1 to ensure nominal engine progression. During a failed auto-start, the EEC will set an ENG AUTOSTART FAIL L, R Caution message alerting the flight crew. Additionally the EEC will motor the engine for 30 seconds before releasing the start switch and closing the SAV.

Engine fuel flow is controlled by three different valves:

- Fuel system shutoff valve at the aircraft wing spar
- Engine fuel high pressure shutoff valve (HPSOV)
- Engine fuel metering valve (FMV)

Engine start valve is allowed to be inoperative provided the AFM Inflight Restart Envelope shows that the engine can be restarted using windmilling at airplane speeds near 270 knots.

For 777X/GE9X, the SAV plays a backup role in bowed rotor mitigation. See item 80-11-03 for a full description.

Consequences of Failure

The START VLV CLOSED L, R Advisory message will be displayed when the starter air valve is failed closed or the EEC is unable to control the valve. The ENG START VALVE L, R Status message will be displayed when the starter air valve is not in its commanded position or the EEC is unable to control the valve.

The associated engine start valve will not support the auto-start operation.

For dispatch, the inoperative engine start valve must be manually opened and closed during engine start.

There are two available dispatch options:

Option A requires use of the APU as an air source for engine start. This option may be used for both normal starts and extended motor starts. The APU will automatically modulate the engine start air flow to support an extended motor start.

Option B may be used if an extended motor start is not required. This option allows for additional air sources options to be used such as cross bleed or ground cart. The engine turning system operation must be verified or engine cool down time must be observed.

Inflight starter assisted starts are not available.

For dispatch, the connector on the SAV sensor must remain connected to the SAV. Disconnecting the connector will disable the START CUTOUT FAIL L, R Caution message. The START CUTOUT FAIL L, R Caution message must continue to operate normally in order to alert the flight crew if an SAV remains open after engine start up or opens in flight. Operating the engine with the SAV open can cause the starter to fail destructively resulting in substantial amount of secondary economic damage to the engine and thrust reverser hardware. The START CUTOUT FAIL L, R Caution message will display when the SAV is open above the starter cutout RPM.

Consequences of Next Critical Failure

If engine were to go sub-idle, engine can be restarted using windmilling.

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Federal Aviation Administration (FAA)**ATA 80****777-9 Master Minimum Equipment List****Section 2****80-11-02 Engine Start Switches****80-11-02-01 Engine Start Switch Faults**

Interval	Installed	Required	Procedure
C	N/A	N/A	

May be Dispatched with ENG START SWITCH L and/or ENG START SWITCH R Status message displayed.

80-11-02 Engine Start Switches**80-11-02-02 Start Selector Holding/Cutout Systems**

Interval	Installed	Required	Procedure
C	2	0	(O)

May be inoperative provided alternate start procedures are used.

SUBSTANTIATION**Background**

Engine Start Switch faults is a new proposal for 777X/GE9X.

Start Selector Holding/Cutout Systems proposal based on 777 MMEL item 80-11-03, applicable to 777X/GE9X.

Engine Start Switch faults:

Two rotary engine Start Switches, one for each engine located on the flight deck P5 overhead panel. The engine start switch includes the NORM and START positions. Rotating the switch to the START position applies aircraft power to the Electronic Engine Control (EEC) and commands the EEC to open the starter air valve and demand Main Engine Start or Bowed Rotor Motoring mode from the APU Controller via digital signal on the common data network (CDN). The Engine Start Switch is magnetically latched in the START position until commanded by the EEC via digital signal on the CDN to release to NORM position when the Engine achieves idle or aborts the autostart function. The flight crew can manually select NORM to terminate the engine start or in the event of a failure of the automatic release feature.

Start Selector Holding/Cutout Systems:

During engine start, the EEC determines when to command the starter air valve closed. The EEC also sends a signal to the Flight Deck Control Panel application in the Common Core System (CCS) to release the start selector switch to the NORM position.

Consequences of Failure

Engine Start Switch faults:

The associated ENG START SWITCH L, R Status message will be displayed when the associated engine start switch signals a fault to the EEC. The switch input could be invalid in either the NORM or START position. If the invalid signal is in the NORM position there is no effect. If the invalid signal is in the START position, ground start function will not be available on the associated engine. Dispatch is allowed if the start function operates normally.

Start Selector Holding/Cutout Systems:

The associated START CUTOUT FAIL L, R Caution message will be displayed if the engine start switch remains in the START position after the EEC commands the Start Switch to NORM position (unlatching function fails), or if the starter air valve is failed in the open position.

For failure of the engine start switch, the flight crew must position the start selector in START, hold if required and, also if required, move start selector to NORM when engine is at idle speed.

Failure of the starter air valve will be indicated by the ENG START VALVE L, R Status message. The starter air valve MMEL item may be applied if the valve has failed in the closed position. A valve failure in the open position is not dispatchable.

Consequences of Next Critical Failure

None.

80-12-01 Engine Turning System (ETS)

Interval	Installed	Required	Procedure
C	2	0	

SUBSTANTIATION**Background**

New proposal for 777X/GE9X.

The 777-9 starter, starter duct, and igniters are similar in function to the baseline 777-300ER starter, starter duct and igniters. These items generate the necessary rotor torque and ignition for engine starting and continued operation. Additionally, the Autostart logic and Automatic relight logic in the EEC are integral components that control engine starting and ignition.

New starting hardware, new functionality, and new indication has been added due to a sub-idle asymmetric thermal condition known as bowed rotor. This condition causes the high-pressure rotor to "bow" due to heat stratification at the top of the gas path for a period following engine shut down until the rotor can thermally stabilize.

During some shut-down conditions, the GE9X high-pressure rotor may experience thermal bowing due to uneven cooling of the high-pressure shaft. This bowed rotor condition must be mitigated to prevent excess vibration and potential damage to the HPC upon subsequent startup. The 777-9/GE9X will accomplish Bowed Rotor Start (BRS) mitigation through the use of an Engine Turning System (ETS).

An engine turning system (ETS) will rotate the high-pressure rotor a partial turn (160 degrees) every 12 minutes for up to 14 hours while the ground handling bus is powered to prevent a bow from forming. The ETS will operate on aircraft power (100 watts continuous, 115v AC), via the Ground Handling Bus (GHB). ETS will turn the HP rotor upon receiving GHB power after engine shutdown. In the event a thermal bow forms, the ETS will fully clear the bow within 45 minutes.

In the highly unlikely event that the ETS, the APU, and SAV are all inoperative, a minimum engine cool down time of 14 hours must be observed to ensure elimination of a potential bowed rotor condition.

Consequences of Failure

The ENG TURNING SYS L, R Status message will be displayed when the Engine Turning System (ETS) has failed to complete its mission due to a failure with the aircraft provided power, turning system controller, motor, mechanical failure or a disagreement in EEC monitored status.

The ENG TURNING DRIVE L, R Status message will be displayed if the Engine Turning System (ETS) motor's drive shaft has failed.

In the event of an ETS failure, the engine may have a bowed rotor at engine start. The EEC will recognize the potential for rotor bow and commence engine slow motoring. This condition is annunciated to the flight crew prior to engine start by an EXTEND MOTOR indication above the EICAS N2 display. MOTORING will be displayed while in extended motoring mode.

For engine starts using the APU as a pneumatic source, slow motoring will be accomplished by regulation of the air by the APU to a lower setting to achieve the desired motoring RPM.

If the APU or APU bleed air is inoperative, extended motoring will be accomplished through the pulse width modulation (PWM) of the starter air valve with either the ground cart or cross engine bleed supplying the pneumatic power. In both cases, motoring will continue until the bow is cleared.

If APU and starter air valve are inoperative, bowed rotor can be mitigated by allowing engine to cool for a minimum time of 14 hours.

Consequences of Next Critical Failure

Failure of the engine start valve may result in an overspeed condition during extended motoring. The EEC monitors for a bowed rotor start overspeed condition during extended motoring and will abort an engine start if the overspeed threshold is exceeded. The associated ENG AUTOSTART FAIL L, R Caution message will be displayed. An overspeed condition will not impact safety but could result in economic damage to the engine.

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