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B	Sections Revised as Indicated		P.S. Ness J.W. Van Horne

IMPORTANT - PLEASE READ

The purpose of this document is to describe certain characteristics of the operational environment and the safety and interoperability requirements for the systems and functions that support Air Traffic Services (ATS). This document also allocates the safety and interoperability requirements to the aircraft, communication network, ATS ground systems and the procedures used by the controller and the flight crew. This document will be used by the Boeing Company in its development of the FANS 1 upgrade for the 757 and 767. It will be used by the certification authorities to validate the safety and interoperability requirements for airworthiness approval of the airborne data link system and the applications and operational authorization to use the datalink applications. It will be used by ATS Service Providers and ATS applications developers to ensure safety and interoperability. It will be used by the airlines as substantiating data in order to obtain operational changes. This document will also be used to evaluate the modifications to any part of the system or procedures by providing guidance for the extent of validation required to substantiate continued safety and interoperability.

The airworthiness approval of the FANS 1 data communication functions that support Air Traffic Services is based on the operational environment as defined in the 757/767 Air Traffic Services Systems Requirements and Objectives - Generation 2 (ATS SR&O), document number D926T0280. As such, the ATS SR&O and any revisions must be FAA approved through the Seattle Aircraft Certification Office prior to its use.

At the time of the airworthiness approval of the 757/767 (Pegasus '00) FANS 1 FMC, the operational requirements described in revision A of the ATS SR&O were based on using the CPDLC message set to provide primary ATS communication in oceanic airspace as it is currently defined. The operational requirements for providing reduced separation minima and dynamic airborne route planning (DARP) based on FANS 1 communication capability were not determined. Therefore, there was no basis for qualifying the aircraft to any operational requirements. At such time when operational requirements have been determined, it may be necessary to incorporate into the ATS SR&O appropriate functionality or performance necessary to meet operational requirements and qualify the aircraft through the airworthiness approval process. Airspace planners must coordinate with the Boeing Company any functionality or performance that is not specifically defined in revision - of the ATS SR&O that is needed for operational capabilities not addressed in this document. The procedures delineated in Chapter 6 of this document and the procedures defined in the South Pacific Operations Manual may be used for this coordination.

Certain safety and interoperability requirements could not be evaluated as part of the airworthiness approval of the 757/767 (Pegasus '00) FANS 1 FMC. Appendix D provides the requirements for validating safety and interoperability and indicates which of those requirements were satisfied as part of the commissioning of the ATS ground system or as part of the operational authorization to adequately ensure safety and interoperability of the FANS 1 data communication capabilities.

To ensure the continued operational safety of FANS 1, it is important that airspace users and airspace managers report any problems to the Boeing Company. This would include any unintentional differences between aircraft types that may affect interoperability with the ATS ground systems or the communication network. ISPACG has established a problem reporting procedure contained in the South Pacific Operations Manual for this purpose[1].

[1] Note that the ISPACG problem reporting procedure applies to operation in the South Pacific. Other operating regions may choose to define their own reporting procedures.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

ACARS	Aircraft Communications Addressing and Reporting System
ACF	ACARS Convergence Function
ACP	ACARS Convergence Process
ACK	Acknowledgment
ACMS	Aircraft Condition Monitoring System
ADS	Automatic Dependent Surveillance
AEIT	Aircraft Equipment Interoperability Test
AES	Airborne Earth Station
AFM	Airplane Flight Manual
AFN	ATS Facilities Notification
AFTN	Aeronautical Fixed Telecommunication Network
AGL	Above Ground Level
AMI	Airline Modifiable Information
ANP	Actual Navigation Performance
AOC	Airline Operational Communication
AOC DL	Airline Operational Communication Datalink
APF	Airline Policy File
ARINC	Aeronautical Radio, Inc.
ATA/IATA	Air Transport Association/ International Air Transport Association
ATC	Air Traffic Control
ATC DL	ATC Datalink
ATS	Air Traffic Services
ATIS	Air Terminal Information Service
BCS	Block Check Sequence
BFE	Buyer Furnished Equipment
CDU	Control Display Unit
CPDLC	Controller/Pilot Datalink Communications (ICAO)
CRC	Cyclic Redundancy Check
CSMA	Carrier Sensed Media Access
DBI	Downlink Block Identifier
DSP	Datalink Service Provider
EICAS	Engine Indicating & Crew Alerting System
ETA	Estimated Time of Arrival
ETG	Estimated Time-to-Go
EFIS	Electronic Flight Instrument System
EADI	Electronic Attitude Director Indicator
EHSI	Electronic Horizontal Situation Indicator
FAA	Federal Aviation Administration
FANS 1	Future Air Navigation System 1
FHA	Functional Hazard Assessment
FIR	Flight Information Region
FIT	FANS Interoperability Team
FMC	Flight Management Computer
FMCS	Flight Management Computer System
GES	Ground Earth Station
GMT	Greenwich Mean Time
GPIRU	Global Positioning Inertial Reference Unit
GPS	Global Positioning System
GNSSU	Global Navigation System Sensor Unit
HF	High Frequency
HCDU	Hybrid Multipurpose Control Display Unit
HGA	High Gain Antenna
HPA	High Power Amplifier

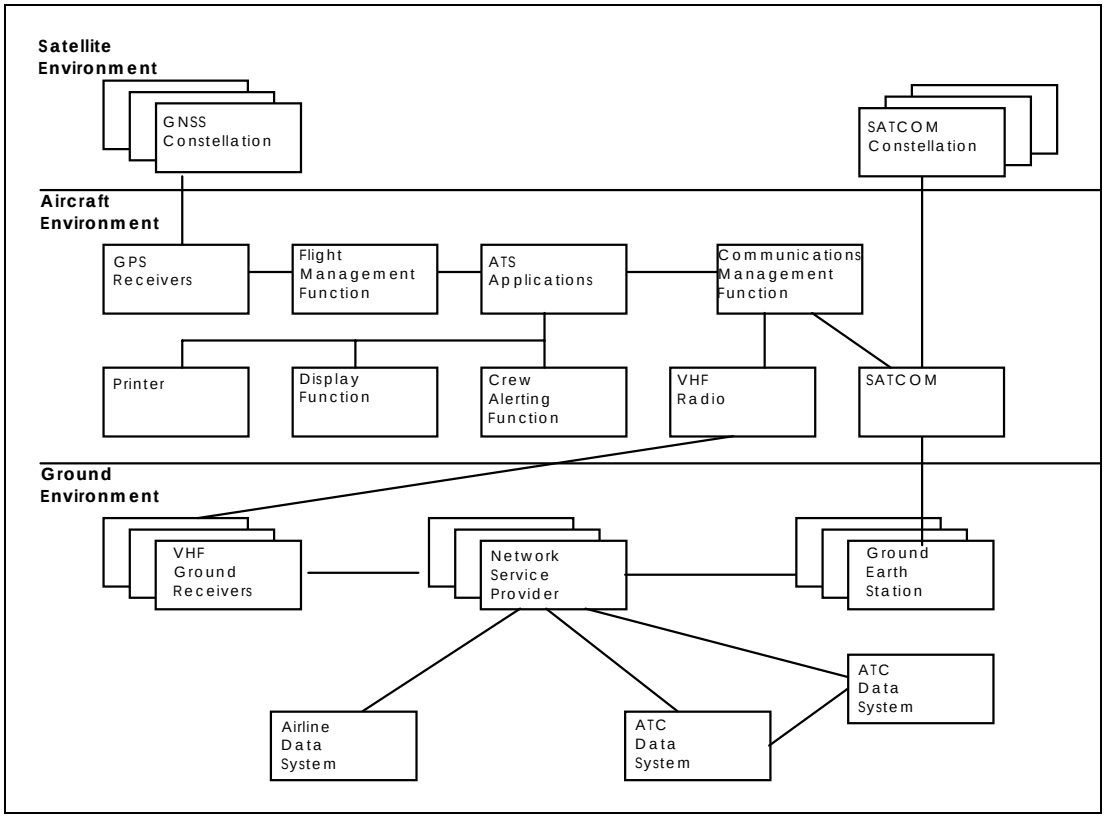
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organization
IMI	Imbedded Message Identifier
INMARSAT	International Maritime Satellite
ISPACG	Informal South Pacific Air Traffic Controllers Coordinating Group
LDU	Link Data Unit
LGA	Low Gain Antenna
LRU	Line Replaceable Unit
MCDU	Multipurpose Control Display Unit
MFI	Message Format Identifier
MMEL	Master Minimum Equipment List
MOPS	Minimum Operational Performance Standards
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
MU	(ACARS) Management Unit
NAK	Negative Acknowledgment
NDB	Navigation Data Base Non-Directional Beacon
NOTAM	Notice to Airmen
OPC	Operational Program Configuration
RFU	Radio Frequency Unit
RGS	Remote Ground Station
RTA	Required Time of Arrival
RTCA	RTCA, Inc.
SATCOM	Satellite Communications System
SDU	Satellite Data Unit
SFE	Seller Furnished Equipment
SITA	Societe Internationale de Telecommunication Aeronautique
SMI	Standard Message Identifier
SP	Service Provider
TBC	The Boeing Company
TCAS	Traffic Alert and Collision Avoidance System
TDM	Track Detail Message
TSO	Technical Standard Order
TWDL	Two-Way Datalink (for Pilot/Controller Communications)
UBI	Uplink Block Identifier
UTC	Universal Time Code
VHF	Very High Frequency
WEU	Warning Electronics Unit

1.0 PURPOSE AND SCOPE

The purpose of this document is three-fold. First, it supports the development of an end-to-end Air Traffic Services (ATS) data communications system by documenting and allocating the requirements, ground rules, and constraints which are necessary for interoperability and which result from the safety assessment as delineated in Paragraph 9.0 of FAA notice 8110.50. The airborne environment considered will be the 757/767 (Pegasus '00) Flight Management Computer System (FMCS) Future Air Navigation System 1 (FANS 1) system, but the requirements documented herein are not intended to preclude FANS 1 implementations on other aircraft. The second purpose of this document is to support the Part 25 certification and Part 121 operational approval of the 757/767 (Pegasus '00) FMCS FANS 1 implementation. The third purpose of this document is to provide a means for substantiation of interoperability after changes to the end-to-end system.

The Air Traffic Services Function transcends the scope of airplane systems as both ground and satellite systems participate in the function. Figure 1 provides an overview of the ATS participants.

Figure 1 - FANS 1 ATS System



Many references will be made concerning the "End-to-End ATS Function". This refers to the entire function and encompasses message processing by the airplane applications, datalink (air, satellite, and ground) and the ground applications.

This document will support the development of an end-to-end ATS system by:

- Defining interfaces between airborne, satellite, and ground environments;
- Becoming a repository for interface decisions made during development;
- Documenting necessary changes or clarifications to existing industry requirements (until they can be folded into the industry documents); and
- Documenting limitations/exceptions of the 757/767 FANS 1 implementations.

This document will support Part 25 certification by:

- Describing the overall requirements for the ATS function as they relate to the 757/767 FANS 1 implementations;
- Supporting Safety/Failure Analysis by identifying those requirements which substantiate assumptions in the analysis;
- Allocating the requirements to the airplane systems environment and non-airplane systems environment; and
- Allocating the airplane systems requirements to the functional subsystems.

The scope of this document shall be limited to the description of the Air Traffic Services Function as it relates to the implementation in the 757/767 (Pegasus '00) FMC FANS 1 Package. The functions of FANS 1 to be considered are:

- ATS Facilities Notification Function (AFN) per ARINC 622-1;
- Automatic Dependent Surveillance (ADS) per ARINC 745-2;
- Two Way ATC Datalink (ATC DL) per RTCA DO-219; and
- Datalink Function per ARINC 429 Supplement 13, ARINC 619, ARINC 724B, ARINC 741, ARINC 716, ARINC 618, ARINC 622-1, and ARINC 620

This document will not cover the requirements associated with the Airline Operational Communications Datalink (AOC DL). This document will also not cover the requirements or integration of the Global Navigation Satellite System (GNSS) as it does not participate directly in the ATS function. Ground-to-ground ATS communications are also beyond the scope of this document.

Industry has recognized that the development of the ATS Function requires significant standards development. It is not the intent of this document to replace or supersede those standards. This document will make reference to existing standards wherever possible. However, it is recognized that some requirements are not yet documented. It is also recognized that the initial implementation of an ARINC 622 datalink system might require additions or changes to such standards. This document will contain any such changes or additions to the existing standards necessary for implementation.

This document assumes previous knowledge of AFN, ATC DL and ADS message sets and functional requirements.

2.0 DELETED

3.0 ORGANIZATION

The organization of this document is described below.

4.0 Industry Standards

This section lists the industry standards which are related to the ATS functions and the ACARS datalink.

5.0 ATS Functions

This section provides a description of the ATS functions and the specific sections of the industry standards which apply to the FANS 1 ATS functions. It also describes the additions, changes, deviations, or limitations made necessary by this development with respect to the industry standards.

6.0 Operations

This section describes how the ATS functions will be used operationally.

7.0 Description of Environments

This section describes the airplane, satellite, and ground environments.

8.0 Allocation of Requirements to Environments

This section will document the safety and interoperability requirements of the ATS functions. This section also allocates each requirement to an environment or to environments.

9.0 Post-Certification Activity

This section describes the methods for reporting problems found in service and for assuring continued interoperability of the end-to-end systems after some portion of the system has been modified.

App A FANS 1 ATC DL Message Implementation

This appendix contains specifics on the FANS 1 FMC implementation of the DO-219 message set.

App B ADS Report Data

This appendix contains specifics on the FANS 1 FMC implementation of the DO-219 message set.

App C Traceability of Safety Assumptions to SR&O Requirements

This appendix will provide the traceability between the safety requirements contained in this document and the FANS 1 Safety Assessments. This appendix also provides traceability between this document and FAA Notice N 8110.50.

App D Validation Requirements for Assurance of Continued Interoperability

This appendix provides guidance on how modifications to the end-to-end system must be validated in order to substantiate continued interoperability. This appendix also provides traceability between the section 8.0 requirements and the validation of those requirements.

App E Differences Between ARINC 745-2, RTCA DO-212 and ADSP ATC/ADS Guidelines

This appendix provides a comparison of the requirements for the ADS function as specified by ARINC 745-2, RTCA DO-212, and the

ADS/ATS Data Link Applications Guidance Material prepared by the ICAO ADS Panel.

App F Differences Between the Desired FANS 1 Requirements and the Actual Implementation

This appendix provides a list of the differences between the desired FANS 1 requirements and the actual implementation.

App G ATC DL Error Processing

This appendix provides a list of the ATC DL [errorinformation] error codes and the conditions under which each will be transmitted by the FMC.

4.0 INDUSTRY STANDARDS

This section lists the industry standards which define the baseline for the ATS functions, including the ACARS datalink.

a) ARINC 429, Mark 33 Digital Information Transfer System
b) ARINC 429, Supplement 13, Williamsburg Protocol
c) ARINC 618, Air-Ground Character Oriented Protocol Specification
d) ARINC 619, ACARS Protocols for Avionics End Systems
e) ARINC 620, Supplement 1, Datalink Ground System Standard and Interface Specification
f) ARINC 622, Supplement 1 and 2, ATS Datalink Applications over ACARS Air-Ground Network
g) ARINC 702, Flight Management Computer System
h) ARINC 724B, Aircraft Communications Addressing and Reporting System
i) ARINC 741, Aviation Satellite Communications System: Part 1 Supplement 6, Aircraft Installation Provisions and Part 2 Supplement 3, System Design and Equipment
j) ARINC 716, Supplement 2, Aircraft VHF Communications Transceiver
k) ARINC 745, Supplement 2, Automatic Dependent Surveillance
l) RTCA DO-212, MOPS for ADS (developed by RTCA SC-170)
m) RTCA DO-219, MOPS for ATC Comm Application (developed by RTCA SC-169)
n) ADS/ATS Data Link Applications Guidance Material, ICAO ADS Panel

5.0 ATS FUNCTIONS

The purpose of this section is to provide a description of the FANS 1 ATS functions. The interoperability, performance and safety requirements as allocated to the aircraft, another system or environment are stated in section 8.0.

A table for each function specifies interoperability requirements by identifying portions of industry specifications that are applicable to the FANS 1 aircraft. When the industry specification states that a requirement is optional, then this section indicates whether or not the option is implemented. This section also identifies any deviations from or additions to the identified portions of the industry specifications.

Figure 2 depicts the ATS functional relationships.

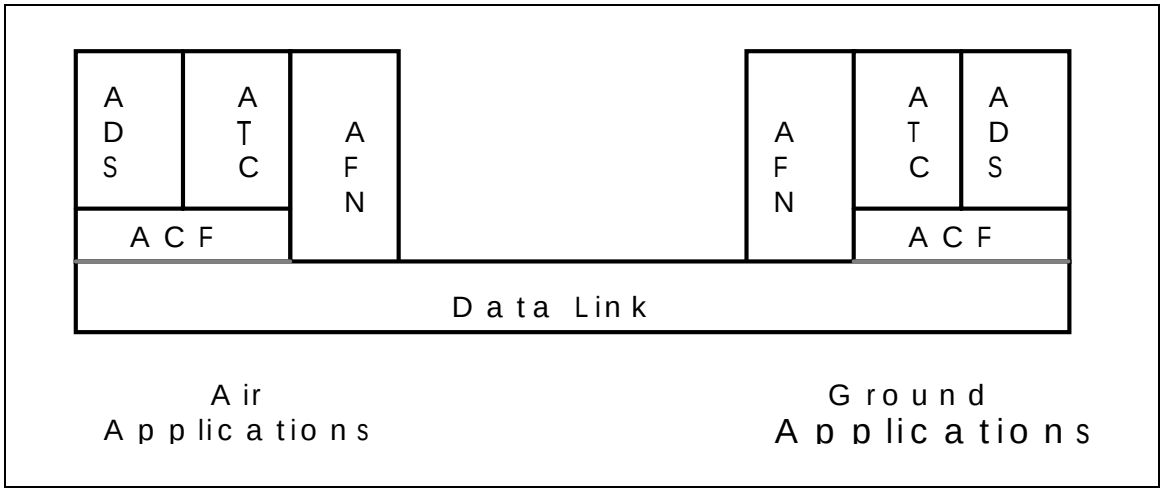


Figure 2 - ATS Functional Relationship

There are four functions in Air Traffic Services: the AFN Function, the Datalink Function, the ADS Function and the ATC DL Function. The AFN Function provides the necessary information to the ground end system such that the ground ATC DL and ADS applications can establish communications links with the aircraft applications. The Datalink Function provides the data communications pathway for the AFN, ADS, and ATC DL Functions. The aircraft ADS Function provides surveillance information to the ground ADS function. The ATC DL Function provides a message set and allows data communications between the aircraft/flight crew and the ground systems/controller.

The AFN, ADS, and ATC DL applications are end-system applications. This means that they are resident at each end of the end-to-end system. The Datalink Function is in each of the end systems and intermediate systems in the data communication pathway. The ACARS Convergence Function, which converts binary-oriented data to/from character-oriented data, is considered to be a sub-function of the Datalink Function and resides in the end systems.

5.1 ATS FACILITIES NOTIFICATION FUNCTION

The AFN function, described by ARINC 622-1 section 3.0, provides the transfer of information required to support the initiation of datalink connectivity between an airplane and an ATC Facility. The airborne AFN Function communicates with a peer AFN Function at an ATC Facility to notify the ground that the aircraft is ready for datalink services (and which datalink applications are supported by the aircraft) and to provide flight identifier, airplane address and application version numbers. The AFN is a character-oriented application, which does not require conversion by the ACARS convergence function as shown in Figure 2.

Table 1 - AFN Clarifications/ Options/ Additions/ Deviations

622-1 Section	Clarification/ Option/ Addition/ Deviation	Description
3.2.3.1 AFN Message Header	Addition	The AFN message header format will be modified from that shown in section 3.2.3.1. The header format, as shown in the downlink example below, will include an optional time stamp. /B0 ctr_address.AFN/FMHflt_no,tail_no,,time_stamp ... CRCX. This time stamp allows the time that a message was formulated to be determined from ATS message recordings at the opposite end system.
	Clarification	A valid time stamp which is included in an AFN uplink message header will be ignored.
	Clarification	Only the overall response, not the individual application responses, found in AFN Acknowledgment uplinks will be used to determine whether the response is positive or negative. The flight crew is not made aware of the individual application responses.
	Clarification	The AFN application is hosted in an ACARS peripheral, i.e., the FMC. Therefore, the AFN message format uses an MFI.
	Option	The 24-bit ICAO Identifier, which is optional in AFN downlink messages, is not provided. A valid 24-bit ICAO identifier included in an AFN uplink will be ignored.

<table>
<tr><th>622-1 Section</th><th>Clarification/ Option/ Addition/ Deviation</th><th>Description</th></tr>
<tr><td rowspan="2">3.2.3.1.2 AFN Acknowledge Message</td><td>Clarification</td><td>The ICAO code in an AFN Acknowledgment message must always contain the 4-character code of the ATC Facility sending the message. This is true even if the corresponding AFN Contact message contained the 7-character network address of the ATC Facility.</td></tr>
<tr><td>Deviation</td><td>An active center address will not be stored. See deviation to 3.2.3.1.3 below.</td></tr>
<tr><td>3.2.3.1.3 AFN Contact Advisory Message</td><td>Deviation</td><td>An active center will not be tracked and as such, AFN Contact Advisory uplinks will not be restricted to the active ATC Facility as defined in section 3.2.3.1.3. This means that an FN_CON will be generated in response to any FN_CAD message which is received unless an FN_ACK is already outstanding. The Active Flag in the downlink will be set to 1 if the Active Flag in the FN_CAD message is set to 1.This implementation was suggested at the first FANS 1 Interoperability Meeting and was adopted as a recommendation. The drawback of this implementation is that any ATC Facility can tell the aircraft to perform a transfer of address.</td></tr>
<tr><td>Attachment 2 ACF IMI Table 2-1</td><td>Deviation</td><td>The version number for the ARINC 745-2 ADS application is 01, not 02 as documented in Attachment.</td></tr>
<tr><td rowspan="2">Attachment 3 ATS Table 3-1</td><td>Addition</td><td>Following the syntax of Table 3-1, the time stamp parameter, will be defined as follows:
<table>
<tr><th>Parameter</th><th>Symbolic</th><th>Length</th><th>Format</th><th>Note</th></tr>
<tr><td>Time stamp</td><td>time_stamp</td><td>6</td><td>HHMMSS</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Deviation</td><td>The message format for FANS 1 will allow alpha and/or numeric characters in ground addresses within AFN messages. This is because ground addresses today include the use of alpha characters and numeric. The standard is assumed to be in error.</td></tr>
<tr><td>Attachment 3 ATS Table 3-2</td><td>Addition</td><td>The elements for the FMH MTI are as follows: Flight number, Aircraft tail number, ICAO ID (optional), time stamp (optional).</td></tr>
</table>

622-1 Section	Clarification/ Option/ Addition/ Deviation	Description
Attachment 3 ATS Table 3-3	Deviation	The AFN application will use a 10 minute value for T_1 versus the 5 minute value specified in Attachment 3 Table 3-3 of ARINC 622-1. Accordingly, T_2 and T_3 will be changed to 10 minutes and 15 minutes respectively.

5.2 DATALINK FUNCTION

The datalink function allows for the exchange of data among the various parts of the datalink applications, which are distributed among the aircraft and the ground host computers. (It allows the aircraft application and the associated peer ground application to communicate). The datalink function is generally described in ARINC 429 Supplement 13 (airborne), ARINC 619 (airborne), ARINC 724B (ACARS MU), ARINC 741 (SATCOM), ARINC 716 (VHF), ARINC 618 (air-to-ground), ARINC 622-1 (end-to-end), and ARINC 620 (ground-to-ground).

The datalink function and its relationship to system components is depicted in Figure 3 below:

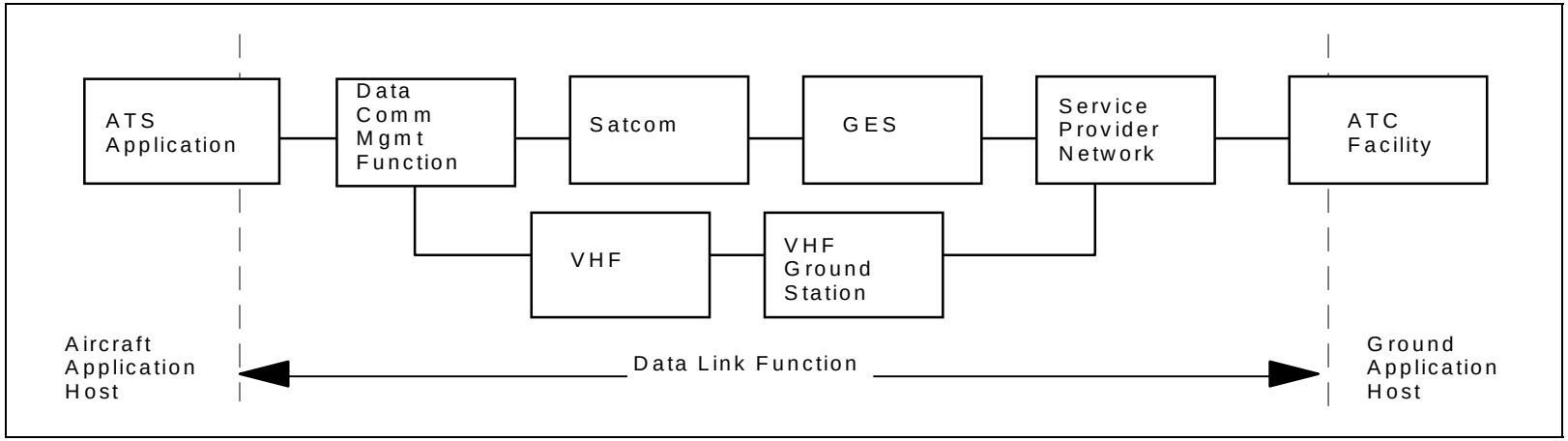


Figure 3 - Datalink Function

As seen in Figure 3, the datalink function is implemented in all environments. The majority of the datalink function is implemented in what is referred to as the ACARS Air-Ground Network. There are multiple air-ground networks, each operated by a service provider (SP). The primary networks are owned by ARINC and SITA. Internetworking between these service providers will be required for full operational benefits from these functions.

A more detailed look at the ATS datalink message exchange process is contained in section 7.

5.2.1 ACARS CONVERGENCE PROCESS

The ACARS Convergence Process, defined by ARINC 622-1, is used to conform the ADS and ATC DL messages to the ACARS message format and to perform the CRC calculation and verification.

Table 2 - ACP Clarifications/ Options/ Additions/ Deviations

622-1 Section	Clarification/ Option/ Addition/ Deviation	Description
2.3 ACARS Convergence Message Formatting and Addressing	Addition	An uplink message up to the maximum ACARS message size limit will be accepted. The ACARS message size limit is 16 blocks, minus the ACARS sub-label field, the 622 message header and CRC, which is equivalent to 1709 octets of DO-219/DO-212 data.
	Clarification	The ADS and ATC DL applications are hosted in an ACARS peripheral, i.e., the FMC. Therefore, the ADS and ATC DL message formats include an MFI.
2.3.1 ADS Contracts	Addition	Only one address is allowed in the User Address Field of each ADS message. If there is more than one address in the User Address Field of an uplink ADS message, the message is considered invalid and is ignored.

622-1 Section	Clarification/ Option/ Addition/ Deviation	Description
2.3.1 thru 2.3.1.4.1, ACARS Convergence Function Message Format		For FANS 1, the ACARS Convergence Process message format, defined in section 2.3.1, is modified to include the aircraft registration[2] (aircraft tail number) in each ADS and ATC DL downlink and uplink message, including the connection management related messages, as shown below. This is necessary to preclude the event where a datalink component could modify the addressing header and send a message to an airplane for which the message was not intended. • /MFI ATC_address.IMItail_numberATS_messageCRCX. The CRC calculation, defined in section 2.3.1.1, is modified to be performed over the IMI and the tail number (both with the eight bit of each character set to zero) and the bit-oriented application data.

[2] The ATS Data Link functions require an aircraft registration (tail number) which is provided by a DO-178B Level C or better system. The FMC does not have access to such an aircraft registration on the 757/767. The ACARS MU has access to a tail number through program pins, but the ACARS MU is a level D system. The following has been implemented in the 757/767 (Pegasus '00) FANS 1 system in order to ensure the integrity of the aircraft registration transmitted in ATS messages.

Upon power-up, the FMC queries the ACARS MU for the aircraft registration via transmission of a documentary data request. If the MU responds with a documentary data response, the FMC uses the aircraft registration included in the documentary data response as follows: The first time a logon is attempted after installation of the FMC on a particular aircraft, the pilot is required to enter the aircraft registration on the ATC LOGON/STATUS page. The pilot entry is compared to the aircraft registration received from the ACARS MU. If the values match, then the entry is considered valid and is stored in the FMC's memory. Each time the FMC is powered up thereafter, the aircraft registration received from the MU is compared to that stored in the FMC's memory. If the two values match, then the aircraft registration is displayed on the ATC LOGON/STATUS page and no pilot entry is required.

If the MU does not respond to the documentary data request, then the pilot is required to enter an aircraft registration, and any value that meets the format requirements is considered valid.

Boeing has recommended that new ACARS software to support FANS 1 ATS Communications be able to support requests for documentary data, and be able to provide documentary data reports to the FMC. The format of the Documentary Data report should be as detailed in Table 5-2 of ARINC 619. (See 2.2.1.4 and 3.3.3 for further detail on how this data is used).

622-1 Section	Clarification/ Option/ Addition/ Deviation	Description
2.4.1 ADS Provisions	Clarification	The IMI used is “ADS”.
	Addition	At flight completion the ADS application clears its tables and generates a (T_disconnect.req) primitive. (Disconnect reason 8).
2.4.2 ATCComm Connection Establishment	Clarification	The IMIs are “CR1”, “CC1”, “AT1” and “DR1”.

5.3 AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

ADS is a means of airborne surveillance in which an airplane function reports its current position, intent, and other pertinent information via the datalink function to an ATC Facility. ADS is defined by ARINC 745-2. This definition includes specification that the ADS reporting rate and the types of data to report are determined via uplink ADS contract requests from an ATC Facility and that a minimum of four ATC Facilities can be supported simultaneously.

Table 3 - ADS Clarifications/ Options/ Additions/ Deviations

745-2 Section	Clarification/ Option/ Addition/ Deviation	Description
ADS Downlink Message Buffering	Addition	The last 2 periodic reports, the last 2 on-demand reports and the last three event reports per connection are buffered. Messages generated beyond these capacities are lost. Note that under the remote condition in which there are 5 connections and at least one of the connections has a queued disconnect, upon a request from an ATS facility for a new connection, the queued disconnect, along with any other downlinks for that connection, will be erased to allocate resources for the new connection.
3.2.2, ADS Request Processing and Supervisory Functions	Deviation	The ADS application does not support at least one connection with a periodic reporting interval of 4 seconds. A minimum periodic reporting interval of 64 seconds on any or all connections is supported. If a periodic reporting interval which is less than 64 seconds is requested, a Noncompliance Notification is issued and that connection is assigned a reporting interval of 64-seconds instead. This 64 second minimum reporting interval is controlled by a Boeing controlled Operational Program Configuration (OPC)[3].
	Option, not provided	The (24-bit ICAO) Airframe Identification group is not provided.

[3] The OPC is a loadable file that is controlled by the Boeing Drawing System

745-2 Section	Clarification/ Option/ Addition/ Deviation	Description
3.2.2, ADS Request Processing and Supervisory Functions (cont'd)	Option, provided	5 ADS connections are provided. The airlines may choose to negotiate with ATS Service Providers to use one of these for company ADS reporting.
3.2.2.1 ADS Periodic Contract Request	Clarification	If the aircraft is flying an offset path, the predicted TTG and altitude will be reported based on the original path.
	Clarification	Predicted Aircraft Intent data are available in response to an ADS demand contract which requests Aircraft Intent and to the first periodic contract requesting the Aircraft Intent on a given connection if performance data are initialized.
3.2.2.2 ADS Event Contract Request	Clarification	There has been some confusion as to the relationship of positive/negative climb rate versus the vertical rate thresholds. The following rules apply: • A positive vertical rate threshold can only be triggered during climbing flight; and • A negative vertical rate threshold can only be triggered during descending flight.
3.2.3, ADS Report Assembly Functions	Deviation	The difference between the time stamp and position of the aircraft shall not exceed 1 second. The difference between the time stamp and the actual periodic or event trigger shall not exceed 2.5 seconds in a periodic or event report. The FMS formulates and attempts to send the appropriate NAK response within 2 seconds.

745-2 Section	Clarification/ Option/ Addition/ Deviation	Description
3.2.5, Emergency Mode Operation	Deviation	The FMC complies with section 3.2.5 with the exception of the automatic change to a 64 second reporting interval. The FMC retains the current contract specified reporting interval when Emergency Mode Operation is initiated. If a reporting rate must be assigned for a default emergency mode contract (i.e., a periodic contract did not already exist on the connection), a 304 second reporting interval is used. This default emergency mode contract is not established when a new connection is established via an event request.
3.3, Figure-of-Merit	Addition	The position determination accuracy portion of the Figure-of-Merit (FOM) does not take the accuracy of time into consideration, except when GPS is unavailable. The flight management function calculates the position determination accuracy as follows when GPS is being used as the time source: Calculated position uncertainty term (UT); The position determination accuracy is calculated as follows when the manually set flight deck clock is used as a backup time source: SQRT(UT^2 + (UTC error * Current Ground Speed)^2),
3.4, ADS Messages	Addition	There is no minimum or maximum number of Intermediate Projected Intent groups specified in section 3.4. To provide a reasonable message size limitation, the FMC will send a maximum of 10 Intermediate Projected Intent groups in a given periodic report.
Attachment 4-8, ADS Output Message Parameters	Clarification	The ETA field in the Predicted Route Group and the Projected Time field in the Intermediate Projected Intent Group will be reported as the estimated time-to-go (ETG). This is because the field definition does not encompass the 24-hour range necessary for an ETA. The use of ETA is assumed to be a misnomer in the standard.
	Deviation	The valid range for distance is 0 - 8191.750 nm; The default value for distance is 8191.875 nm. These modifications are assumed to be errors in the standard.
	Deviation	The valid range for ETA and Projected Time is 0 -16382 seconds; The default value for ETA and Projected Time is 16383 seconds. These modifications are assumed to be errors in the standard.

745-2 Section	Clarification/ Option/ Addition/ Deviation	Description
Attachment 4-9, ADS Intput Message Parameters	Clarification	Zero is not a valid value for aircraft intent projected time. The aircraft intent projected time must always be valid even when the aircraft intent group modulus is zero.
Attachment 8-2, ADS Message Bit Map Representations	Deviation	In Figure 6, the MSB of the Vertical Rate Change Threshold field, and the Altitude Range Ceiling and Floor fields, should be marked as a sign bit. These bits will be set as such. This is assumed to be an error in the standard.
	Deviation	In Figure 18a, the Intermediate Intent Group True Track field definition, the validity and sign bits are in the reverse order (from other validity and sign bits). These bits will be set in a manner which is consistent with the other on-request groups. This is assumed to be an error in the standard.
Attachment 9, 7-Bit Format of Figure of Merit	Deviation	If GNSSUs are installed, the navigation Redundancy bit is set to one when at least one flight management computer's position is valid. Otherwise, the navigation Redundancy bit is set to one when the position from more than one IRU is being used by the flight management computer.

5.4 ATC DATALINK (ATC DL)

The ATC Datalink function enables the flight crew and ATS to interact using digital communication. The ATC DL requirements are defined by DO-219, the RTCA SC-169 MOPS for ATC Two-Way Data Link Communications. This functionality uses pre-defined ATS-to-pilot uplink and pilot-to-ATS downlink message element formats. Appendix A contains information about the FANS 1 FMC ATC DL message set implementation.

Table 4 - ATC DL Clarifications/ Options/ Additions/ Deviations

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description
	Clarification	A message which is larger than 1627 octets will not be generated.
	Clarification	Default data are provided for downlink ATC DL reports where possible. The flight crew is allowed to enter over the provided defaults, unless the data in the report is from the corresponding uplink request (e.g., the [altitude] in the REACHING [altitude] downlink element is the same as the [altitude] in the corresponding uplink request, REPORT REACHING [altitude]), the data are not over-writeable. (See Appendix A for specifics on default data.)
	Clarification	Metric altitude entries for downlink reports and requests are accepted, but all default vertical data and position report altitude data provided will be in feet or English flight levels. However, if a report request, such as REPORT LEAVING [altitude] is received, the corresponding report downlink will contain the same [altitude] data type as the uplink.
	Clarification	As the definition of the [publishedidentifier] variable provides no means to limit the flight management function's search for matching identifiers in its NDB, all NDB records are searched for a matching identifier.

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description
	Clarification	If a duplicate named waypoint (i.e., a 'fixname', 'navaid', or 'publishedidentifier' for which duplicates exist in the FMC's Navigation Data Base) is received, the FMC will select the waypoint closest to the latitude and longitude of the flight plan fix after which the waypoint is loaded, the preceding [routeinformation] item, or current aircraft position, as appropriate for the element being loaded. Note that if the waypoint is defined as a [publishedidentifier] or [placebearingdistance] and the optional [latitudelongitude] is included with the [fixname], then the flight management computer will use that data to resolve the duplicate waypoint's position.
2.2.2, Connection Management	Addition	ATC DL connectivity requires initial contact establishment via AFN logon (to the initial ATC Facility). ATC DL connectivity is transferred as defined in DO-219 thereafter. The initial connection flow is basically as follows: **AIRCRAFT** **GROUND** AFN Contact ----------> <---------- AFN Acknowledgment <---------- ATC DL Connect Request ATC DL Connect Confirm ---------->
	Deviation	The requirements related to the setting of TP4 timer values will not be met. Valid [tp4Table] data will be ignored.
2.2.3.1, Message Attribute Tables	Clarification	A pending ATC DL message is defined to be an uplink or downlink message which has been transmitted and requires a closure response, as specified by the Response Attributes in section 2.2.3.1, but for which a response has not yet been received by or transmitted from the airborne ATC DL application.
2.2.3.3, Message Structure and Content	Deviation	The uplink message element [track detail msg] (#178), defined in section 2.2.3.3, will be considered to be undefined. The uplink will be discarded and a downlink ERROR message (#62) with the 'invalid data' reason will be sent in the reply.
	Deviation	An uplink message containing a [routeclearance] variable larger than 918 bytes will not be accepted. The uplink will be discarded and a downlink ERROR message (#62) with the 'insufficient Msg Storage Capacity' will be sent in reply.

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description

2.2.3.3, Message Structure and Content (cont'd)	Deviation	An optional time stamp field is defined in the header of each ATC DL message as shown below. This definition syntax is consistent with that used in DO-219.
		ATCmessageheader ::= SEQUENCE
		{
		Msgidentificationnumber,
		Msgreferencenumber OPTIONAL,
		Timestamp OPTIONAL
		}
		Timestamp ::= SEQUENCE
		{
		Timehours,
		Timeminutes,
		Timeseconds
		}
		Timeseconds ::= INTEGER (0 .. 59)
		--Units = 1 Second, Range (0 .. 59)

	Correction	The units for [frequencyvhf] and [frequencyuhf] are stated as .025. The units for these two variables should be .001. DO-219 is presumed to be in error.
	Addition	The following ATC DL downlink message element (#80) will be defined in addition to the defined message set. The message structure and content will be as follows, per the abstract syntax defined in section 2.2.3: -- DEVIATING [distanceoffset][direction] OF ROUTE Resp(N) dm80DistanceoffsetDirection [80] DM80DistanceoffsetDirection DM80DistanceoffsetDirection ::= DistanceoffsetDirection The alert attribute for this message is medium. The urgency attribute for this message is normal.

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description

2.2.3.3, Message Structure and Content (Cont'd)	Addition	The downlink variable [positionreport] which is sent in the downlink message element POSITION REPORT (#48), will be defined as follows, per the abstract syntax defined in section 2.2.3.
		Positionreport ::= SEQUENCE
		{
		positioncurrent [0] Positioncurrent,
		timeatpositioncurrent [1] Timeatpositioncurrent,
		altitude [2] Altitude,
		fixnext [3] Fixnext OPTIONAL,
		timeetaatfixnext [4] Timeetaatfixnext OPTIONAL,
		fixnextplusone [5] Fixnextplusone OPTIONAL,
		timeetadestination [6] Timeetadestination OPTIONAL,
		remainingfuel [7] Remainingfuel OPTIONAL,
		temperature [8] Temperature OPTIONAL,
		winds [9] Winds OPTIONAL,
		turbulence [10] Turbulence OPTIONAL,
		icing [11] Icing OPTIONAL,
		speed [12] Speed OPTIONAL,
		speedground [13] Speedground OPTIONAL,
		verticalchange [14] Verticalchange OPTIONAL,
		trackangle [15] Trackangle OPTIONAL,
		trueheading [16] Trueheading OPTIONAL,
		distance [17] Distance OPTIONAL,
		supplementaryinformation [18] Supplimentaryinformation OPTIONAL,
		reportedwaypointposition [19] Reportedwaypointposition OPTIONAL,
		reportedwaypointtime [20] Reportedwaypointtime OPTIONAL,
		reportedwaypointaltitude [21] Reportedwaypointaltitude OPTIONAL
		}
		reportedwaypointposition ::= Position
		reportedwaypointtime ::= Time
		reportedwaypointaltitude ::= Altitude

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description
2.2.3.3, Message Structure and Content (Cont'd)	Deviation	The following downlink message elements, defined in section 2.2.3, will not be generated: • REQUEST [speed] TO [speed] (#19) • REQUEST VOICE CONTACT [frequency] (#21) • REQUEST WEATHER DEVIATION TO [position] VIA [route clearance] (#26) • WHEN CAN WE EXPECT [speed] TO [speed] (#50) • REQUEST VMC DESCENT (#69)
	Deviation	FANS 1 ATC DL application will not consider aircraft type and equipment code data (airplane equipage) included in uplink message element 73, PREDEPARTURE CLEARANCE, to be loadable, printable, or displayable.
	Addition	A message containing any IA5 string character not in the following set will be considered to be in error: (0..9), (A..Z), (,), (.), ( ), (/), (+), and (-). This applies to all message elements which contain IA5 string variables defined in section 2.2.3.3. The uplink message will be discarded and a downlink ERROR message (#62) with the 'application error' reason will be sent in reply.

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description
2.2.3.3, Message Structure and Content (Cont'd)	Option	When a standard POSITION REPORT message element (#48) is transmitted from the aircraft, the following variables will contain data, when such data are available. All other variables will contain no data. Positioncurrent timeatpositioncurrent altitude fixnext timeetaatfixnext fixnextplusone timeetadestination temperature winds speed reportedwaypointposition reportedwaypointtime reportedwaypointaltitude When a downlink message which contains the MAYDAY element (#56) is transmitted, an abbreviated position report containing the following data is included in the downlink. Positioncurrent timeatpositioncurrent altitude speed

DO-219 Section	Clarification/ Option/ Addition/ Deviation	Description
2.2.4.2b Message Reference Number	Addition	A Message Reference Number shall be assigned for each ATC Comm message initiated for transmission with an [errorinformation] message element with the exception as indicated. The Message Reference Number shall be the Message Identification Number for the associated up-link message. If the message header of the associated up-link message does not contain enough bits to constitute a Message Identification Number, then no Message Reference Number shall be assigned for the corresponding ATC Comm message with the [errorinformation] element.
2.2.5.4, Recall (para. b-e only)	Option	Message storage is done purely by time of arrival for uplinks, and time the message was selected for transmission for downlinks, and does not take into account the Recall types defined in section 2.2.5.4.
	Clarification	The storage capability provided is as follows: 75 non-pending uplinks and downlinks (5 of which can contain a [routeclearance] variable) and 10 pending uplinks (2 of which can contain a [routeclearance] variable) can be stored. When an uplink is received which would cause the pending uplink storage capacity to be exceeded, the uplink is discarded and a downlink ERROR message (#62) with the 'insufficient storage capacity" reason is sent in reply.
	Clarification	Non-pending uplinks and non-pending downlinks are automatically deleted when storage space is needed. The flight crew is also provided with the capability to delete any stored ATC DL message.
2.2.6.3b Message Display	Deviation	If a message is received with an ERROR [errorinformation] or SERVICE UNAVAILABLE message element, the ATC DL function does not attempt to locate a pending downlink message, even if a Message Reference Number is included. The received message is displayed as an independent uplink message. (Refer to Appendix A.1, UPLINK MESSAGE ELEMENT TABLE).

<table>
<tr><th>DO-219 Section</th><th>Clarification/ Option/ Addition/ Deviation</th><th>Description</th></tr>
<tr><td rowspan="3">2.2.6.4, Pending Messages</td><td>Deviation</td><td>Outstanding pilot requests are aborted when an END SERVICE message element is received, regardless of whether a transfer of data authority occurs. A subsequent uplink with a message reference number equal to the message identification number of an aborted downlink message will be rejected. A downlink ERROR message (#62) with the ‘unrecognized message reference number” reason will be sent in reply.</td></tr>
<tr><td>Deviation</td><td>Message identification numbers are allowed to be reused under the conditions listed in section 2.2.6.4c and when the downlink message has been deleted from message storage. The FANS 1 ATC DL application cycles through all message identification numbers before re-using any numbers.</td></tr>
<tr><td>Clarification</td><td>Downlink messages are not allowed to be generated when the storage for pending downlink messages is full (30 single block messages or 3300 octets).</td></tr>
<tr><td>A.4.0 Downlink Messages</td><td>Addition</td><td>The table below defines the correlation between uplink report/confirmation requests (UL#) and the appropriate report downlink (DL#). When a report/confirmation request is received by the Airborne ATS Function, the Airborne ATS Function shall provide the flight crew the capability to formulate and transmit the corresponding report downlink as defined in the table below:
<table>
<tr><th>UL#</th><th>DL#</th><th>UL#</th><th>DL#</th><th>UL#</th><th>DL#</th></tr>
<tr><td>127</td><td>41</td><td>136</td><td>39</td><td>144</td><td>47</td></tr>
<tr><td>128</td><td>28</td><td>137</td><td>40</td><td>145</td><td>35</td></tr>
<tr><td>129</td><td>37</td><td>138</td><td>46</td><td>146</td><td>36</td></tr>
<tr><td>130</td><td>31</td><td>139</td><td>45</td><td>147</td><td>48</td></tr>
<tr><td>131</td><td>57</td><td>140</td><td>42</td><td>175</td><td>72</td></tr>
<tr><td>132</td><td>33</td><td>141</td><td>43</td><td>180</td><td>76</td></tr>
<tr><td>133</td><td>32</td><td>142</td><td>44</td><td>181</td><td>78</td></tr>
<tr><td>134</td><td>34</td><td>143</td><td>mult</td><td>182</td><td>79</td></tr>
<tr><td>135</td><td>38, 77</td><td></td><td></td><td></td><td></td></tr>
</table></td></tr>
</table>

<table>
<tr><th>DO-219 Section</th><th>Clarification/ Option/ Addition/ Deviation</th><th>Description</th></tr>
<tr><td rowspan="2">A.4.0 Downlink Messages</td><td>Option</td><td>When encoding a [placebearingdistance] or [publishedidentifier] for which duplicates exist in the NDB for the associated [fixname], the optional [latitudelongitude] will be included with the [placebearingdistance] or [publishedidentifier] in the downlink.</td></tr>
<tr><td>Option</td><td>Boeing aircraft will include DL#'s 29,30, and 80 in report downlink messages as defined in the table below.
<table>
<tr><th>DL#</th><th>Additional Information</th></tr>
<tr><td>32,29,30</td><td>DL#'s 29 or 30 sent with 32 if MCP alt more than 150 ft above/below baro-corrected alt</td></tr>
<tr><td>40,80</td><td>DL# 80 sent with 40 if offset active</td></tr>
<tr><td>42,80</td><td>DL# 80 sent with 42 if offset active</td></tr>
<tr><td>44,80</td><td>DL# 80 sent with 44 if offset active</td></tr>
<tr><td>48</td><td>DL#'s 29 and 30 sent with 48 if MCP alt more than 150 ft above/below baro alt.
DL# 80 sent with 48 if offset active</td></tr>
</table></td></tr>
</table>

5.5 TIME STAMPING

The units and source of time used in the FANS 1 ATS system are as follows:

Table 5 - Time Stamping

Function	Time Stamp Units	Time Stamp Source
ADS	seconds from most recent hour	The time source is GPS time referenced to UTC (reverts to Flight Deck Clock)
ATC DL	ETAs and RTAs use hours/minutes; Time stamp uses hours/minutes/ seconds	The time source is GPS time referenced to UTC (reverts to Flight Deck Clock)
AFN	Hours/minutes/seconds	The time source is GPS time referenced to UTC (reverts to Flight Deck Clock)
ACARS Air-Ground Message Header	Some use minutes/seconds from most recent hour as multi-block message #.[4]	Flight Deck Clock
Service Provider Time Stamp	Hours/minutes/seconds	ARINC - WWVS[5] SITA - [6]

6.0 OPERATIONS

This section describes how the ATS functions are intended to be used operationally[7] and describes the basis for operational assumptions made during the safety assessment.

Some operations use multiple functions, but it is important to understand the operation of the individual functions. This section provides a description of the operation of each function, including exceptional operations for probable airborne system failures.

Loss of datalink can occur at any point in the datalink chain (as depicted in Figure 3). This section discusses probable failures together with the crew notification and corrective actions.

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4 Not recommended for FANS 1. It is recommended that true message sequence numbers be used instead of the time stamps to ensure detection of incomplete multi-block messages.

5 WWVS is a NIST-approved stable signal standard accurate to +/- 5 msec.

6 The SITA network will provide a time stamp within 2 seconds of UTC.

7 Part 1 of the South Pacific Operations Manual defines detailed procedures for the use of ATC DL in the South Pacific.

The airborne failure discussion is specific to the 757/767 FANS 1 implementation. Failures can be caused by equipment failures or message transmission failures, and can occur during operation or prior to dispatch. The phase of operation and the type of failure determine the annunciation philosophy used.

6.1 GENERAL OPERATIONS

The ATS functions, being discussed herein, are resident in the FMCS. Before any discussion of failure modes, it is important to understand some of the architecture of the FMCS installation in the 757 and 767.

While there are two FMCs installed in the airplane, only one of them provides guidance and control at any given time, as determined by the selected autopilot (Left or Center A/P in CMD will make the left FMC master, Right A/P in CMD will make the R-FMC the master) or the Navigation source select switches. Failure of either FMC is annunciated by an EICAS advisory message. The selected FMC is known as the Master FMC and the other is referred to as the Spare. If the Master FMC fails, the crew then selects the offside FMC by changing engaged autopilots, or via the navigation source selector and it becomes the Master.

For the 757/767 (Pegasus '00) FMC, the datalink master follows the normal FMC master switching logic as described above. This assumes that the airplane has the ACARS wired into both FMCs.

Failure of the Slave FMC has no impact on the datalink connections. If the Master FMC fails, the spare FMC which has been kept updated concerning the ATS functions and status, takes over the ATS functions when the crew selects the other FMC, as described above. Messages in the process of being sent to the MU at the time of Master switch are reinitialized. Messages in the process of being received from the MU are not acknowledged and the MU re-sends the message.

ACARS equipment failures are annunciated on the EICAS system as an advisory message. If an ACARS MU should fail, all messages in the process of being transmitted to the FMC at the time of failure are lost.[8] If the FMC was transmitting a downlink at the time of an MU failure, the FMC detects the failure via the lack of positive status from the MU.

There is no direct annunciation of VHF failures. If the MU detects lack of activity on the VHF (no ACKs) then it will switch to SATCOM.

The SATCOM system has EICAS messages which alert the crew to an equipment failure

The pre-flight state and condition of the airborne datalink and application system are ascertained by the crew by review of the EICAS Alert and Status messages prior to dispatch.

Failures in the non-airplane portion of datalink are detected by the MU through protocol timers. This means that if the Service Provider or ATC Facility does not respond in a certain amount of time or in the proper manner, the ACARS MU or FMC, respectively, detects the lack of the specified response and annunciates this fact.

The MU also provides status of the SATCOM and VHF sub-networks to the FMC and EICAS. The FMC and EICAS use these inputs to provide 'datalink' status to the crew.

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[8] This assumes a single MU installation.

6.2 PREFLIGHT AND DISPATCH

The status of the airborne equipment associated with ATS functions is available. The Airplane Flight Manual (AFM) and Mandatory Minimum Equipment List (MMEL) are used with the crew alerting displays to ascertain dispatchability of the aircraft.

6.2.1 INITIAL CONNECTION

Under normal operations, the flight crew performs the pre-flight logon using the 4-character ICAO identifier of the initial ATC Facility with whom they wish to communicate. This datum is available from the onboard Jeppesen charts or provided by the airline dispatch office. The logon provides aircraft and avionic end system addressing information, and ATS application version numbers, which the ground applications need to initiate communication. The ATC Facility ensures that the ground application versions are compatible with the airborne versions.

If the FMC indicates that the logon is successful (i.e., the ICAO code matches and the AFN acknowledgment reason is set equal to 0), the flight crew assumes that the ATC Facility has the ADS and/or ATC DL functions active unless a current NOTAM notifies them of the unavailability of one of those functions. The ATC Facility then initiates ATC DL and/or ADS communication with the aircraft. The logon must be successful in order to establish the ATC DL communication. From the FMC's point of view, the activation of the ADS function is not directly dependent on previous activation of the AFN function to establish the communications link. However, operationally, AFN notification to the initial ATC Facility may be required to provide the appropriate addressing and status information.

The ATC Facilities forward the logon information along the filed flight route (from sector to sector, facility to facility, or FIR to FIR) using ground network communications. The ATC Facilities may use the AFN function to transfer logon information if ground to ground communication is not available.[9] (See section 6.7.2 for more on Switching ATS Facilities.)

No response within 10 minutes or a response indicating other than a successful logon (AFN acknowledgment reason is not equal to 0), is considered to be a negative response. The crew is notified of a negative response via CDU scratch pad/EICAS messages and assumes that ATS applications are not active at the selected facility. If the ATC Facility attempted to initiate ATC DL communication at this time, the aircraft would not respond.

The crew may initiate AFN logon activity at any time, e.g. if datalink connectivity is lost, to attempt to establish datalink connectivity.

6.3 SURVEILLANCE

Surveillance of the aircraft in the non-radar environment uses both the ADS Function and the ATC DL Function. The primary surveillance vehicle is ADS, but ATC DL can be used in tactical situations when needed.

6.3.1 SURVEILLANCE USING ADS

The ATC Facility has the information necessary to establish ADS reporting with airplanes in or near their FIR, via the logon process discussed in 6.2.1 or through other means as discussed in 6.7.2.

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[9] MITRE (for the FAA) and the CAA Australia stated that the AFN process will not affect current procedures governing exchanges of logon information, including the Flight Plan. Ground-Ground Communication interfaces are defined in ADSP Guidance Material.

The ATC Facility has the capability to request periodic reports, event driven reports and immediate on-demand reports.

The flight crew is not required to interact with ADS to provide reporting, but the crew does have the ability to enable/disable ADS reporting via the CDU. When ADS is enabled (default state upon power-up), ADS responds automatically to requests from up to five ATC Facilities.[10] The airlines may choose to negotiate with ATS Service Providers to use one of these for company ADS reporting. The flight crew has access to ADS connection status through the CDU. Active status is displayed to the crew while at least one ADS connection is established.

6.3.1.1 ADS PERIODIC REPORTS

The ATC Facility initiates a periodic report using an uplink periodic contract request which defines the contract and the reporting frequency. The periodic contract remains in effect until the contract is canceled by the ATC Facility or flight completion is achieved.

The ATC Facility may request that optional data groups be added to the basic ADS report (see Appendix B) and specifies the frequency at which those groups should be added to the basic report. The ATC Facility also has the capability to add new optional groups, change optional group reporting frequency, and stop reporting of individual optional groups.

6.3.1.2 ADS WAYPOINT POSITION REPORTS

One event driven report causes an ADS position report to be generated when the airplane sequences a waypoint. This report refers to the ADS Waypoint Change report as defined in ARINC 745 and is similar to, but distinct from, the position report defined in ARINC 702. The Waypoint Change report by definition includes the basic ADS report and the Predicted Route group. Such a report is sent for each waypoint sequence (individual waypoints are not selected by the ATC Facility) and the reporting does not affect the frequency of the periodic reports. It should be noted that the ADS waypoint position report downlinks do not include waypoint identifiers (i.e., all positions are in latitude/longitude format).

The flight management computer does not distinguish between compulsory waypoints and any other waypoint type. This means that the ADS position reports will be generated when any waypoint is sequenced. Any pilot modifications to the filed flight plan which add or delete waypoints will affect the position reports. The flight crew procedurally assures that they do not modify or delete compulsory waypoints. ATS must recognize that position reports may be received for waypoints which do not exist on the filed flight plan. It should also be noted that the ADS position report downlinks for the 757/767 (Pegasus '00) FANS 1 implementation contain the current airplane information at the time of the waypoint sequence.

6.3.2 SURVEILLANCE USING ATC DL

The ATC Facility has the information necessary to establish ATC DL communication, but because the ATC DL application only supports one ATC Facility at a time (except for transfer of service purposes), this communication is limited to the aircraft actually in the ATC Facility's control.

The ATC DL Message set (see Appendix A) contains many messages which help the ATC Facility establish tighter surveillance over aircraft. These messages are in the following classes:

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[10] The industry definitions and the 757/767 (Pegasus '00) FANS 1 implementation of ADS do not allow the airborne system to *know* which of the five contracts is from the controlling center. Established procedures, as defined in Section 7 of the South Pacific Operations Manual ensure that the controlling ATC center gets one of the connections.

- Uplink Contact/Monitor/Surveillance Requests;
- Uplink Report/Confirmation Requests; and
- Downlink Reports, including position reports.

It should be noted that an ATC DL position report contains similar information to the ARINC 702, ADS, and ICAO position reports; but is distinct and is defined in DO-219.

6.3.3 EXCEPTIONAL OPERATIONS

Invalid uplinks are recognized by the airborne application. If the error is found during the ARINC 622 processing (e.g., a CRC failure), no response is sent and the ground views this as an outstanding message. If the error is found during the ADS decoding, the appropriate ADS response is sent back via the network.

ADS reporting is controlled by the ATC Facilities without crew interaction. Therefore failure annunciation to the crew of specific failures of ADS connections is not possible. The loss of the datalink function is the only failure annunciation required for this function and is discussed in section 6.2.1.

After 16 consecutive minutes of NOCOMM, VOICE only, or FAIL, the FMC terminates all ADS contracts and connections. The ADS status is changed to inform the crew that there are no ADS connections currently established. The FMC considers NOCOMM to be true when the MU asserts that all available datalink media are NOCOMM (see section 7.1).

If the loss of the datalink function or the ADS function is due to an aircraft failure, the crew initiates voice contact via the established procedures using direct or third party HF Radio, VHF Radio or SATCOM voice[11]. Verbal position reports are used to establish contact. If the datalink loss is due to a localized ground problem, the aircraft systems may not be able to detect this, and the crew may not be informed that the ADS connection is effectively lost.

The ground ADS application has a timer installed which is started when an uplink ADS message is sent and waits for the appropriate ADS response. If the timer expires, the ATC Facility can re-generate the uplink.

The loss of an ADS periodic or event report can be recognized by various means (e.g., by no periodic report for 1 and 1/2 times the report period). Once alerted by automation or ATS procedures to a possible loss of ADS connectivity, the ATC Facility initiates a one-time demand request. If the demand request is not responded to by the aircraft, the controller should revert to established procedures, such as voice communications with the aircraft.

If the situation arises where there are no contracts on a given connection for 16 consecutive minutes, the ADS function will automatically terminate the connection by sending a Disconnect Request. This will not affect the operation of any other ADS connection. Note that this Contract Inactivity Timer is part of the ADS application and is independent of the 16 minute NO COMM timer.

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11 SATCOM voice is not a requirement for FANS 1 implementation.

6.4 GENERAL PILOT CONTROLLER COMMUNICATIONS

After the ATC Facility responds to the aircraft logon and when the ATC Facility is ready, the ATC Facility sends an ATC DL uplink connection request (contains message element #163 [ICAO facility designation]) to the aircraft to initiate ATC DL connectivity. When the airborne ATC DL application receives the message, it responds automatically with a downlink connection confirm (contains message element #73 [version number]). After this exchange, the flight crew can exchange general ATC DL messages with the ATC Facility.[12] The airborne ATC DL application will only accept messages for the flight crew (some connection establishment and system management type messages can be exchanged) from a single ATC Facility.

There are procedural constraints on ATC DL communication as it is possible for communication to be established with an ATC Facility other than the controlling facility. The flight crew does not select with whom they communicate, but the code of the ATC Facility to which they are communicating should be displayed. These procedures will constrain ATC Facilities' ability to establish connections with aircraft that are not being provided separation service, limit the type of communication (i.e. no active clearances) with other than the active center, or formalize communication termination procedures (i.e., pilot should turn ATC DL off).

6.4.1 EXCEPTIONAL OPERATIONS

There are error conditions defined in RTCA DO-219 which cause termination of the active, and thereby the inactive if it exists, ATC DL connections.

A change of aircraft addressing information in the ATS application system causes a loss of ATC DL communication. On the 757 and 767, the specific conditions which would result in loss of ATC DL communication are pilot entry of a different flight number, pilot entry of a different aircraft registration number (tail number), or the automatic clearing of flight number at flight completion.

After 16 consecutive minutes of NOCOMM, VOICE only, or FAIL, ATC DL connection(s) are terminated by the airborne application. The FMC considers NOCOMM to be true when the MU asserts that all available datalink media are NOCOMM (see section 7.1). The flight crew will be notified of the loss of ATC DL connectivity via CDU scratch pad/EICAS messages. In the case that an ATC DL failure is annunciated to the pilot, the flight crew may reinitiate connectivity by repeating the logon scenario described in section 6.2.1. When an ATC Facility receives a logon when an ATC DL connection appears to already exist with the aircraft, the ATC Facility may conclude that a failure recovery has occurred in the aircraft ATC DL application. Any pending uplink messages which exist between the ATC Facility and that aircraft at the time of the logon receipt would be considered to have failed. The ATC Facility would then respond to the logon in the normal fashion.

Similarly, in the case of a ground ATC DL application restart after unexpected shutdown, the aircraft accepts a connection request from an ATC Facility to which it appears to already be connected. The FMC, however, should handle the transaction transparent to the flight crew; there should be no flight deck effect.[13]

In the case of a failure which does not cause loss of the ATC DL function, but which warrants termination of the function, the pilot may select ATC DL off, thus terminating all connections.

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12 Comprehensive connection establishment procedures and criteria are contained in DO-219 and Part 1 of the South Pacific Operations Manual.

13 Part 1 of the South Pacific Operations Manual specifies procedures for handling a failure of the ATC DL connection.

If the aircraft receives an ATC DL connection request from a new ATC Facility while an ATC DL connection is already established, the airborne ATC DL application will send a Disconnect Request in response, except for the case of a valid communication transfer. The Disconnect Request will contain the identifier of the active ATC Facility (message element #64). (See section 6.7.2.2 for ATC DL communication transfer process).

Procedures accommodate non-delivery of ATC DL messages which specifically require a closure response (e.g., WILCO). Impact for non-delivery of uplink and downlink messages (by individual elements) which do not specifically require a closure response is shown in the table below. The referenced section contains additional exceptional operations description for the message element(s).

Uplink Message Elements	**Description**	**Impact**	**Ref. Section**
0-5	Responses	Acceptable. Uplink expected by crew.	6.6.2
131-147, 181-182	Requests for Reports	Acceptable. Corresponding downlink report expected by ATS.	6.3.3
148, 152	When Can You...	Acceptable. Corresponding response expected by ATS.	6.5.3
159, 162	System Management	Acceptable. Minor effect on operations.	6.5.3, 6.6.2, 6.7.4
160, 161, 163	Connection Management	Acceptable. Minor effect on operations.	6.7.4
165-167	Additional Messages	N/A. These message elements will only be sent with other message elements.	-

Downlink Message Elements	**Example**	**Impact**	**Ref. Section**
0-5	Responses	Acceptable. Downlink expected by ATS.	6.5.3
28-48, 72, 76-79	Reports	Acceptable. Downlink expected by ATS	6.3.3
55-61	Emergency Messages	Acceptable. Uplink response expected by crew.	6.9
62-64	System Management	Acceptable. Minor effect on operations.	6.4.1, 6.5.3, 6.7.4
73	Connection Management	Acceptable. Minor effect on operations.	6.4.1
65-66, 74-75	Additional Messages	N/A. These message elements will only be sent with other message elements.	-
67	Free Text with Normal Urgency	Acceptable. If delivery needs to be assured, use Free Text with distress urgency (#68).	6.5.3, 6.6.2

6.4.2 MESSAGE STORAGE

ATC DL messages are stored in the order received or created. The pilot has the ability to recall the messages for review and to print them on the onboard printer. The 757/767 (Pegasus '00) FMC can store 75 non-pending uplinks and downlinks (5 of which can contain a [route clearance] variable), 10 pending uplinks, (2 of which can contain a [route clearance] variable) and 30 blocks (3300 octets) of pending downlinks. The FMC will automatically delete the oldest uplink or downlink when storage space is needed for new messages. (New downlinks cannot be generated when the storage for pending downlinks is full. The flight crew can delete stored messages. The ATC log clears 10 minutes after flight completion.

The ATC DL messages both ground initiated and crew initiated, are recorded by the network service provider (see section 8.2.3.2.2). It is also the intention of several ATC Facilities to record ATC DL messages.

6.5 TACTICAL INTERVENTION INITIATED BY ATS

ATS uses the ATC DL message set to initiate/negotiate tactical changes via uplinks to the aircraft. When an uplink is received and is available for review, the pilot is alerted. The pilot should display the message and act accordingly. Some messages contain flight plan data which can be loaded into the FMC, reviewed, and executed. Some messages contain flight plan data which can be loaded into the flight management function, reviewed, and executed. See Appendix A for loadable uplink message elements.

6.5.1 FLIGHT PLAN CHANGE LIMITATIONS

Portions of the predeparture clearance and route clearance uplink messages are not reviewable except on the flight deck printer (see section 7.1.7).

6.5.2 NEGOTIATIONS

The airborne ATC DL application provides the flight crew with response prompts for uplink messages, as appropriate, for the received uplink. The potential response prompts are:

- Accept
- Standby
- Reject

If the pilot selects reject, the pilot may then add rationale (reject due to performance or weather) and free text to the message for negotiation purposes. The crew decision is sent in a downlink message to the ground ATC DL application using the appropriate response message (e.g., WILCO or UNABLE). ATS and the pilot can then exchange messages until suitable procedures have been established.

6.5.3 EXCEPTIONAL OPERATIONS

The abnormal operations involving loss of datalink or the ATC DL application are handled the same as described in section 6.4.1. Refer to Figure 5 for an illustration of detection and handling of uplink datalink errors.

For uplink messages which require a crew response (as defined by DO-219), the ground ATC DL application has a timer installed which waits for the appropriate crew response. If the timer expires, the ATC Facility can initiate another message or contact the aircraft via voice. For uplink messages which do not require a crew response, the table in section 6.4.1 shows the impact of message non-delivery.

Invalid uplinks are recognized by the airborne application. If the error is found during the ARINC 622 processing (e.g., a CRC failure), no response is sent and the ground views this as an outstanding message. If the error is found during the ATC DL decoding, an ATC DL error response is sent back via the network. Again, ATS can choose to uplink another message or initiate voice contact.

6.6 TACTICAL MODIFICATION REQUESTED BY CREW

The flight crew can request route modifications, route replacements, lateral path modifications (offset, Direct To), and vertical path modifications.

A route request may either be a route modified[14] by the crew, or a route which has been sent to the airplane from the Airline Data System.[15] The active route, modified active route, or inactive route may be used to hold a requested route. The entire route (if en route, only the current waypoint and on) including arrival, and departure procedures (if applicable)[16] will be sent. The crew can also separately request departure/arrival or transition procedures, offsets, vertical clearances, or 'direct to' clearances.

6.6.1 NEGOTIATIONS

If an ATC Facility receives a path modification request and the request is acceptable, the ATC Facility uplinks the requested route as an appropriate clearance. The crew can then load and execute the path modification uplink, if such functionality is provided for the particular airplane model. If the request is not acceptable, the ATC Facility sends a rejection message and/or an alternative path modification.

If the ATC Facility does not support the particular pilot request, the ATC Facility responds accordingly with the uplink 'SERVICE UNAVAILABLE'.

ATS may send 'REQUEST DEFERRED' or 'STANDBY' as a temporary response to a request. The flight crew will expect a further response for the request.

6.6.2 EXCEPTIONAL OPERATIONS

Refer to Figure 6 for an illustration of downlink error detection.

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14 The following terms defined here for information: The 'active route' is the route to which the flight management function is guiding the aircraft; a 'modified active route' exists if the flight crew has made changes to the active route which have not been executed, the modifications are not being used for control; the 'inactive route' is a standby route which can be empty or may contain a route which can be activated at any time; a fixed location 'waypoint' is a named fix (navaid, airport, other geographic location) in the Navigation Database, a latitude/longitude, or a bearing and distance from a named fix. A route is flown by guiding to reach the active waypoint, then 'sequencing a waypoint' by satisfying the conditions for reaching the waypoint, and then guiding to reach the next waypoint in the route.

15 The route can be sent by airline operations directly to the ATC Facility via AIDC, for example, for review and uplink to the aircraft.

16 Departure airport and runway are always sent if entered. The arrival airport will be sent if entered. Airways and planned holds will be sent if they exist.

Invalid downlinks are recognized by the ATC Facility. If the error is found during the ARINC 622 processing (e.g., a CRC failure), no response is sent and the flight crew views this as an outstanding message. If the error is found during the ATC DL decoding, an ATC DL error response is sent back via the network and the flight crew is so notified. The flight crew can choose to downlink another message or initiate voice contact.

The ATC DL application starts a network acknowledgment timer[17] when the pilot initiates a downlink message. While the network acknowledgment timer is running, the pilot cannot retransmit the corresponding message. Once the timer expires, the corresponding message remains open, if a response is expected. However, the pilot can still choose to resend or initiate voice contact.

When the network Acknowledgment is received for the downlink message, the message status transitions from SENDING to SENT or OPEN. The status is OPEN if a response is expected (by the FMC as defined in DO-219) from the ATC Facility. The OPEN status will remain until a response is received for that message from the ATC Facility. The table in section 6.4.1 shows the impact of message non-delivery for downlink messages which do not require an ATS response.

6.7 SWITCHING ATS FACILITIES OR VHF VOICE TO DATALINK

6.7.1 VHF VOICE TO DATALINK

There are no messages defined which relate to specific types of clearances such as tower, en route, oceanic, etc. Therefore, such clearances are procedurally handled using other messages. For example, an ATC DL route clearance uplink with a "cross position at time" message fulfills the intent of a pre-departure clearance used for oceanic/remote applications. The crew establishes their initial link with the departure ATS authority and receives their pre-departure clearance including pertinent oceanic/remote area elements. The aircraft uses applicable VHF communications until it exits the area where VHF voice is used and enters the area where datalink usage is necessary (e.g., an oceanic FIR). The departure ATC Facility would have transferred communications in order to establish datalink communications.

6.7.2 ATC FACILITY TO FACILITY, OR FIR TO FIR

The FIRs, with their associated ATC Facilities, coordinate (between themselves) for transfer of control via ground networks. They accomplish transfer of communication via uplink to the airborne end system when both facilities have established datalink communication. Aircraft addresses can be forwarded from ATC Facility to ATC Facility if ground connectivity is available. If ground connectivity is not available, an ATC Facility may request the aircraft to forward its addresses to another ATC Facility through the AFN Function.

The controlling ATC Facility uses the AFN application to automatically (i.e., without pilot interaction) transfer logon information by sending an uplink AFN Contact Advisory message. The Contact Advisory contains the next ATC Facility's network address. The AFN application automatically responds with a downlink AFN Response message indicating intent to perform the logon and then automatically goes through the same process as an initial logon. The AFN application sends a downlink AFN Complete message to the requesting ATC Facility with the result of the logon to the next facility.

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17 The Network Acknowledgment timer in the 757/767 (Pegasus '00) FMC is set to 5 minutes. This value is contained in the FMC's Operational Program Configuration (OPC) file.

6.7.2.1 ADS SWITCHING

The ground ATC Facilities wishing ADS data coordinate amongst themselves to assure that no more than five ATC Facilities are attempting to request ADS data from the aircraft and that the controlling facility is one of the five which is receiving ADS data. This requires that the ATC Facilities terminate their contracts when data are no longer needed to assure that the next ground facility can initiate contracts. Ground to ground communications can be used to forward ADS reports from one ATC Facility to the next.[18]

6.7.2.2 ATC DL SWITCHING

ATC DL is transferred by designating a NEXT DATA AUTHORITY who is allowed to establish an ATC DL connection with the aircraft. This connection does not allow pilot-controller dialogue until the switch is complete. Once this connection is established, the ATC Facility allows termination of the active ATC DL connection by sending up one of the following:

- Message 5, as shown below in Figure 4, or
- Message 5 without the instruction to pilot regarding transfer (see Section 6.8).

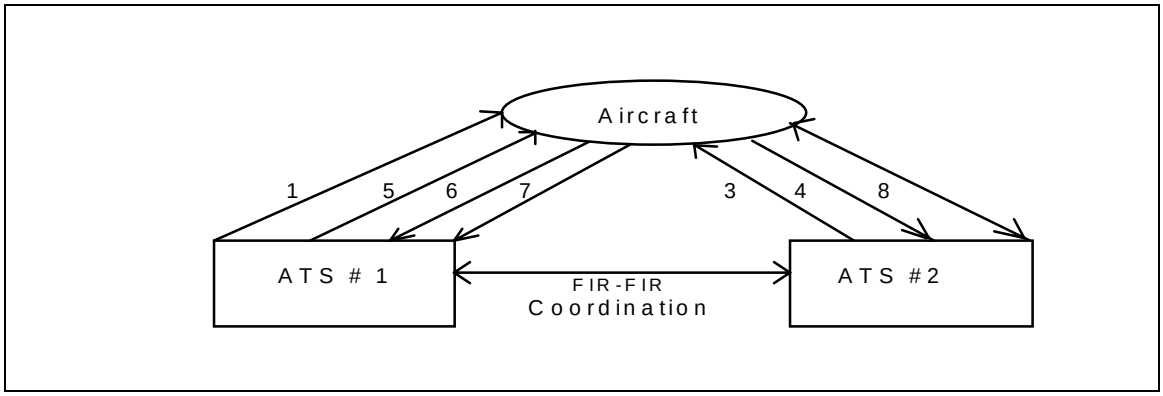

Figure 4 - ATC DL Transfer

[18] Part 7 of the South Pacific Operations Manual specifies procedures for establishing and prioritizing ADS connections.

Label	Message
1	Next Data Authority
2	DELETED
3	Connection Request (with user data)
4	Connection Confirm (with user data)
5[19]	Contact or Monitor instruction[20] + End Service
6	WILCO
7	Disconnect Request
8	Normal message traffic

The scenario in Figure 4 was originally developed by the ICAO ADS Panel. Message 7 has been added to show the Disconnect Request. If the aircraft is transferring from a region without data link capability to a region with data link capability, messages 1, 5, 6, and 7 are not transmitted. If the aircraft is transferring from a region with data link capability to a region without data link capability, messages 3, 4, and 8 are not transmitted. Message triggering mechanisms for associated messages are designed to accommodate these scenarios. Note that the ground-to-ground messages do not necessarily imply data communications.

6.7.3 DATALINK TO VHF VOICE

There is no automatic sequencing of ATS functions when the aircraft transits from datalink communication to voice communication (e.g., datalink equipped ATC Facility to non-datalink equipped ATC Facility). The crew procedurally transfers to voice contact and uses current applicable procedures. (See section 6.8 for terminating datalink communication.)

6.7.4 EXCEPTIONAL OPERATIONS

For crew annunciated datalink or application failures, the crew can re-initiate the AFN logon function. Other failures are handled procedurally.

Any abnormal condition which causes termination of the active ATC DL connection causes termination of the connection awaiting transfer of communication, if it exists.

If the result of either the AFN Response or the AFN Complete (discussed in section 6.7.2) is negative, the ATC Facility can either re-attempt the Contact Advisory or contact the aircraft and instruct the crew to perform a manual logon.

In the event that the controlling ATC Facility cannot establish an ADS connection (due to the aircraft already having five ATC Facility connections in place), but the facility has an ATC DL connection, a free text message can be sent to the flight crew to notify them of the problem. The flight crew can then turn off ADS and re-enable it via the CDU. This will allow the controlling ATC Facility to establish an ADS contract.

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19 Some FIRs send Contact or Monitor instructions and the END SERVICE element as separate messages. Refer to Part 1 of the South Pacific Operations Manual.

20 Note that technically any message element which requires a WILCO can legally be combined with the END SERVICE message element.

In the event that the ATC Facility which will be accepting control, cannot establish an ADS connection (due to the aircraft already having five ATC Facility connections in place), voice contact can be used for the same purpose.

6.8 TERMINATION

If the End Service (message 5 in Figure 4, section 6.7.2) is sent up without the Contact or Monitor instruction, the ATC DL application sends the Disconnect Request immediately and without pilot notification.

The controlling ATC Facility may, as an alternative, inform the pilot, through voice or data communication, to terminate the connection.

There is an uplink disconnect request defined in ARINC 622-2. This uplink disconnect request was designed to be used by an ATC Facility to terminate service in the event of an orderly failure or service termination whereby a transfer is not intended even though a NEXT DATA AUTHORITY message was sent.

An ATC Facility may send an ATC DL uplink message with END SERVICE and an error message to gain the same effect as the uplink disconnect request. This uplink is an invalid uplink, and thus will cause the aircraft ATC DL application to terminate all connections (and thereby not transfer communications) as desired.[21]

The aircraft terminates the active, and thereby the inactive if it exists, ATC DL connections under the following abnormal circumstances:

- Loss of data link communication for 16 minutes (section 6.4.1);
- Pilot initiated termination, including a change of flight number or aircraft registration (tail number) (section 6.4.1);
- Receipt of an uplink disconnect request, and
- Error conditions defined in RTCA DO-219.

ADS and ATC DL connections are terminated automatically at flight completion.

6.9 EMERGENCY OPERATIONS

The aircraft or ATS can initiate emergency operations.[22] There are no specific procedures associated with datalink communications for the initiation or termination of those operations by ATS. ATS would use the general/tactical ATC DL messages to handle the emergency.

Using ATC DL, the flight crew can send a MAYDAY message and also inform ATS of the aircraft's immediate intent. The aircraft ATC DL application includes current position information with the MAYDAY report. The sending of MAYDAY automatically causes ADS to be put into the Emergency mode. The flight crew may also put ADS into Emergency mode independent of transmission of an ATC MAYDAY Report.

The flight crew can also send a PAN PAN PAN message.

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21 This paragraph describes the implementation to be used by the FAA ODL.

22 This is not to say that the ATC Facility can initiate the ADS Emergency mode of operation.

When the ADS emergency mode is activated, all existing connections will be assigned emergency periodic contracts. The reporting interval of an existing periodic contract is maintained; new default periodic contracts receive an interval of 304 seconds. Periodic reports are tagged as emergency reports and the only on-request groups which are sent are the Flight Identification and Earth Reference groups in every fifth report

The ATC Facility can cancel or modify the emergency contract reporting interval and data. The ATC Facility may also cancel the emergency mode for its own connection; this in itself does not change the reporting rate or report contents. Each ATC Facility should maintain its ADS reporting rate at the minimum rate which is necessary.

6.10 FANS 1 OPERATIONAL ASSUMPTIONS FOR FUNCTIONAL HAZARD ANALYSIS

The 757/767 Functional Hazard Analysis (FHA) has made certain assumptions about the environment in which FANS 1 is to be operated. These assumptions are contained here as requirements which should be verified (in systems or procedures) before operational approval of this FANS 1 System. The following table lists the safety requirements which were considered as assumptions in developing the FHA.

1. All voice communication capability will be retained (HF, VHF, SATCOM) and would be considered as a backup to the data link functionality. There will be no proposed change to the Master Minimum Equipment List (MMEL) for HF or VHF communication equipment based on the initial FANS 1 certification.

2. There will be established procedures for each communication failure condition. The procedures must account for possible loss of messages and indicate how long a pilot or controller should wait before deciding a message has been lost. The time-out value must be small enough to assure adequate reaction time based on the separation minima.

3. Air Traffic Control procedures will use ADS periodic reporting or manual ATC DL position reports in addition to ARMed reports and/or ADS Event reports.

4. ATC procedures will be established which will not allow the controller to issue clearances to a plane which is not in his area of control.

5. ATC procedures, systems and personnel will not use AOC DL.

6. If the printer is certified to DO-178B, level D or is non-essential, confirm print-only data using some other means, or do not use print-only data for those data which could contribute to a MAJOR failure effect.

7. If the printer is certified to DO-178B, level D or is non-essential, ATC clearance data received through the ATC DL Application which can only be viewed on the cockpit printer must be independently verified per approved operational procedures.

8. The crew shall reject clearances with which they cannot comply and current air traffic procedures will be used to resolve any resultant conflicts.

9. The ATC Facility shall have the means to detect an erroneous flight identifier or tail number (aircraft registration) received in the end system (CRC'd) portion of the AFN logon message.

7.0 DESCRIPTION OF ENVIRONMENTS

The purpose of this section is to provide a description of the environments (Figure 1) in which this end-to-end system will be operating. Sections 7.1, 7.2, and 7.3 describe the airplane, satellite and ground environments into which the ATS functions will be integrated.

7.1 AIRPLANE ENVIRONMENT

The 757 and 767 airplanes contain a digital network based on the ARINC 429 protocol. Several airplane systems are directly involved with the ATS datalink function.

A description is provided of the number of systems installed, their procurement type (SFE - Seller Furnished Equipment built to a Boeing Specification or BFE - Buyer Furnished Equipment procured directly by the airline), criticality, and whether they have an operational interface to systems outside of the airplane environment. Then a high level description of each piece of equipment is provided including any crew annunciations which the equipment provides.

It should be noted that there are differences between airline configurations. These differences are due to airline options with:

- Cockpit switching
- Multiple equipment installation (e.g., 1 versus 2 ACARS MUs)
- BFE Equipment selection

The BFE equipment selection probably has the most impact, as the airline is in control of the specification and can customize the unit to closely meet its needs. There are variations in the levels of conformance or interpretation of the industry standards (i.e., ARINC Characteristics).

The following systems on 757 and 767 airplanes are involved with the ATS Functions:

System	Number Installed	BFE/ SFE	Criticality	External Interface
Flight Management Computer	2	SFE	Essential	None
Multipurpose Control Display Unit	2	SFE	Essential	None
Aircraft Communication Addressing and Reporting System Management Unit	1 or 2	BFE	Non-Essential	None
VHF Radio	3	BFE	Essential	Antenna
SATCOM	1 or 2	BFE	Non-Essential	Antenna
Printer	1	BFE	Non-Essential	Paper
Warning Electronics Unit	1	SFE	Essential	Aural
Engine Indicating and Crew Alerting System	2	SFE	Critical	None

7.1.1 FLIGHT MANAGEMENT COMPUTER SYSTEM

The Flight Management Computer System (FMCS) hardware consists of two Flight Management Computers (FMCs) and two Control Display Units (CDUs). The FMCs are the main computer processors; the CDUs are the interface between the pilot and the FMC.

The FMCS integrates information from the air data system, inertial reference system, GNSSUs, ACARS MU, radio navigation system, mode control panel, engine and fuel sensors, Thrust Management Computer (TMC), digital clocks, and crew-entered data to perform the following functions:

- Navigation
- Flight Plan Management
- Guidance and Control
- Optimized Performance Management
- Throttle Control
- Navigation Display
- Alternate Navigation via the CDU
- Fault and Configuration Management
- Airline Operational Communication (AOC) [FANS 1]
- ATC Datalink [FANS 1]
- Automatic Dependent Surveillance [FANS 1]
- ATS Facilities Notification [FANS 1]

The FMC also utilizes two internal data bases: navigational and performance/engine. ARINC 702 is used as a guide for design.

While there are two FMCs installed in the airplane, only one of them provides guidance and control at any given time, as determined by the autopilot selection (Left or Center A/P in CMD will make the left FMC master, Right A/P in CMD will make the R-FMC the master) or the Navigation source select switches. Independent navigation stations from both FMCs are generated for the map display. Failure of either FMC is annunciated by an EICAS advisory message

Failure of the Spare FMC has no impact on the datalink connections. If the Master FMC fails, the other FMC which has been kept updated concerning the ATS functions and status, automatically takes over the ATS functions with no crew intervention. Messages in the process of being sent to the MU at the time of Datalink Master substitution are re-processed by the new master. Messages in the process of being received from the MU are not acknowledged and the MU re-sends the message.

A modification was made to the CDUs to add an ATC mode key which provides access to the FMC ATS functions.

7.1.2 AIRCRAFT COMMUNICATIONS ADDRESSING AND REPORTING SYSTEM (ACARS) MANAGEMENT UNIT (MU)

The airborne ACARS system is comprised of an ACARS BFE management unit (MU). Implementations generally conform to ARINC 724B, 618 and 619. Typically, the MU is connected to the following devices:

- Multipurpose Control Display Units
- Multi-Input Printer
- Center VHF
- SATCOM Satellite Data Unit
- Aircraft Condition and Monitoring System (ACMS)
- Central Maintenance Computer
- Crew Alerting System
- Flight Management Computer System
- Airborne Data Loader

Some airplanes may be configured with two MUs. Some airplanes may be configured with a switch to allow use of the center or right VHF radio. It is possible that some airplanes will have dual SATCOM as well. In any case, the redundant architecture may contribute to the availability of the ACARS.

The ACARS MU can interface with the pilot directly through an CDU interface, or through the printer interface. Other messages can be exchanged with the ACMS, CMC and FMCS. Some messages require pilot interaction, but automatically triggered messages and ground initiated messages are possible as well.

ACARS equipment failures are annunciated on the EICAS system as an advisory message. If an ACARS MU should fail, all messages in the process of being transmitted to the FMC at the time of failure are lost.[23] If the FMC was transmitting a downlink at the time of an MU failure, the FMC detects the failure via the lack of positive status from the MU.

Each unique ACARS part number is considered a different configuration and as such, performance of each unique combination needs to be established.

7.1.3 WARNING ELECTRONICS UNIT (WEU)

The Warning Electronic Unit (WEU) is a single cardfile that contains electronic cards which perform the following essential functions: Stall warning, configuration warning (takeoff and landing), altitude alert, speed brake alert, illumination of the master warning lights, generation of all aurals in the flight deck, and activation of the stick shaker motors.

The cards installed in the WEU cardfile are:1 takeoff configuration warning card, 1 landing configuration warning card, left and right stall warning cards, 1 altitude alert card, left and right power supply cards, left and right siren/owl aural warning cards, 1 bell/chime aural warning card, 1 signal consolidation card, 1 WEU BITE module, and 1 master warning card.

7.1.4 VHF RADIO

Three independent VHF systems (radios and antennas) are installed on the airplane to provide line of sight voice and data communication. Typical enroute range of 200 nm can be expected. The left and right VHF radios are typically reserved for voice communications, while the center radio is typically shared between voice and data communications.

The MU interfaces with an ARINC 716 radio using the following signals:

- AUDIO DATA IN
- AUDIO DATA OUT
- DATA FREQUENCY
- DATA KEYLINE
- VOICE/DATA DISCRETE
- PORT SELECT DISCRETE

When the MU is in data mode, the VOICE/DATA and PORT SELECT discretes are grounded and the VHF radio is tuned by MU ARINC 429 broadcast data. The radio is keyed by the MU closing the data keyline. MSK modulated data received on the selected data frequency is sent to the MU. The MU demodulates the data to determine whether a valid uplink is present (UBI present), and if an uplink is intended for that MU (matching flight ID or registration number). The MU modulates the data prior to presenting the MSK modulated audio signal to the radio. The VHF system does not assert possible failure conditions. Therefore, crew alerting for VHF system related failures is not possible.

7.1.5 SATCOM

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[23] This assumes a single MU installation.

Satellite communications (SATCOM) may be provided for remote communications where terrestrial contact is unavailable, or by airline policy regardless of the state of other communication capabilities. SATCOM offers packet data services capable of processing ACARS messages. INMARSAT ACARS packet data services are described as data level 2. SATCOM may provide other services such as cockpit voice, cabin telephone services, and even passenger facsimile services. Each of these services is provided in a manner such that safety services are processed in priority over other traffic. However, all ACARS messages are processed equally over SATCOM. Once a message is accepted from the MU, no further messages are accepted until the satellite ground earth station (GES) acknowledges receipt of the message (which should not be confused with the ACARS network acknowledgment).

Some typical messages that have priority over ACARS messages are listed below:

- System essential signaling (logon)
- T channel request and assignment signaling
- C channel request and assignment signaling

The transmission of higher priority information over ACARS is necessary to provide a balanced service to all the users of the SATCOM system. The ATS ACARS messages are handled interchangeably with AOC or AAC ACARS messages. In addition, adequate system bandwidth assures rapid transmission of data without excess delay in any case.

The airborne earth station (AES) is made up of some or all of the following components:

- Satellite Data Unit (SDU)
- Radio Frequency Unit (RFU)
- Class C High Power Amplifier (HPA-C)
- Class A High Power Amplifier (HPA-A)
- Low gain antenna (LGA)
- High gain antenna (HGA)
- Low noise amplifier/diplexer
- RF combiners, splitters, and relays

The AES establishes a logon with a preferred GES by listening on the GES P channel. The selection of GES preference is based on programmed airline preferences, or stored or received comprehensive frequency tables. The AES establishes communications by data packets transmitted on the R and T channels. Data rates are a function of INMARSAT frequency assignment, and GES and AES equipage. Data rates in wide use today are effectively 300 bits per second, but growth to 600 or even 5250 bits per second is likely.

The use of SATCOM for voice, circuit mode data, and high speed packet data requires an HGA. The HGA is a phased array electrically steerable with a typical gain of 12 dBi. However, when the antenna steering required to maintain contact through a particular satellite requires the use of non-optimum beams, the effective gain is reduced. If the antenna reports less than 7 dBi gain, the AES must cease transmissions and search for another satellite, or wait until conditions improve with respect to the current satellite.

It is possible that the AES may be programmed to switch to the LGA, if installed, while the HGA is not available, to maintain contact. It is likely that the LGA is capable of maintaining data contact in conditions where the HGA is not. It is possible to program the AES to switch to the LGA if contact is not established through the HGA when the conditions for the HGA are expected to be acceptable. All current SATCOMs switch to the LGA only if the HGA reports a failure.

Each GES maintains a high gain link with the satellite in use. Each GES monitors the transmissions from all other GESs using the satellite in use, providing some limited inter-GES internetworking. The satellite acts as a transponder, translating the AES to satellite L-band communications into satellite to GES C-band communications. Each GES is connected to a single ACARS data link service provider. The data link service provider may have a separate SATCOM processor to collect both data and logon status, prior to passing data to the service provider's main ACARS system processor.

7.1.6 PRINTER

This optional printer is controlled by ARINC 740/744 and is installed in the center aisle stand. ARINC 740 describes the characteristics of a multiple input printer with a narrow carriage (40 characters). The ARINC 744 specification describes a wide carriage printer. This printer is interfaced with the ACARS, ACMS, FMCS [FANS 1] and CMC systems.

Appropriate status for printer states (ready, fail, busy, error) is available on the FMC CDU pages which provide printer interface capability.

7.1.7 ENGINE INDICATING AND CREW ALERTING SYSTEM (EICAS)

The Engine Indicating and Crew Alerting System is composed of two EICAS computers, Display Select Panel (DSP), Maintenance Control Panel, and two Display Units. This system provides the display of engine primary and secondary indications; display of warning, caution, advisory, communication, status and maintenance messages; and the display of maintenance information.

For the ATS function, additional processing and a new ARINC 429 interface to the FMC have been added to provide the "• ATC" communication level message. The EICAS also has an additional analog discrete output to drive the chime for the "• ATC" message.

The FANS-1 upgrade includes new EICAS crew alerting capability for ACARS and SATCOM in the form of advisory, comm, and status messages as described below:

Text	Type	Reason
DATALINK LOST	Advisory	ACARS NOCOMM
DATALINK SYS	Advisory	ACARS MU failed
SATCOM	Advisory	SATCOM function failed
SATVOICE LOST	Advisory (optional)	SATCOM voice system logged off
SATCOM VOICE	Advisory	SATCOM voice system failed
SATCOM DATALINK	Advisory	
•DATALINK AVAIL	Comm Low (Optional)	ACARS regained COMM
•VHF DATA OFF	Comm Low (Optional)	ACARS VHF voice mode
•ACARS	Comm Low and Medium	Flight crew should look at ACARS CDU menus
•ATC	Comm Medium	ATC uplink received
•FMC	Comm Medium	FMC company uplink received
•PRINTER	Comm Medium or Low	Uplink message (non-FMC) printed
•SATVOICE AVAIL	Comm Low (optional)	SATCOM voice system logged on after being unavailable
•SATCOM MESSAGE	Comm Medium (optional)	Flight crew should look at SATCOM CDU menus
DATA LINK SYS	Status	ACARS MU failed
SATCOM DATA	Status	ACARS/SATCOM interface failed
SATCOM SYSTEM	Status	SATCOM System failed
SATCOM HIGH GAIN	Status	SATCOM high gain antenna failed
SATCOM LOW GAIN	Status	SATCOM low gain antenna failed

7.2 SATELLITE ENVIRONMENT

INMARSAT operates a satellite constellation that provides world-wide coverage up to about 75 degrees of latitude. There are four geostationary positions. At each position, INMARSAT has placed a primary INMARSAT-II satellite, operating with global beams. In 1996, INMARSAT will add INMARSAT-III satellites, which provide spot beams. There are backup satellites at each orbital position.

Each GES uplinks satellite signal units on P channels. The AES downlinks satellite signal units on R and T channels. All circuit mode services are established with data link transmissions, followed by dedicated C channel assignment as needed.

System performance is affected by the level of traffic and the available RF link margin. In addition, the number of channels available, and the speed at which they operate, can significantly contribute to overall throughput. The use of special protocols may also enhance system operation in the future.

There may be other satellite operators that wish to process the FANS 1 data. The SATCOM avionics are specifically developed to be compatible with the INMARSAT system definition manual (SDM). Other satellite operators must ensure compatibility with existing avionics. It is not practical to develop regional satellite avionics.

7.3 GROUND ENVIRONMENT

This environment includes the remote VHF transceivers (RGS), satellite ground earth stations (GES), air/ground message processors, ground routers and the ground-ground links between ATC Facilities. The link between the RGS or GES and the ATC Facility is variable depending on the ATC Facility. This pathway can be either dedicated or leased lines to the datalink service provider, or the ATC Facility may be connected through its own datalink network (i.e., the ATC Facility be its own data link service provider).

7.3.1 NETWORK SERVICE PROVIDER

The network Service Providers operate networks of VHF transceivers and/or satellite ground stations which are the access points to the ACARS network system for the user aircraft. The ground stations are connected to an air-ground message processor which is the access point to the ACARS network service for all ground systems. The network Service Provider also provides automatic direction of uplink messages to the proper network and VHF/SATCOM selection. For the purposes of this document, downlink message routing after receipt by the ground station is assumed to be the responsibility of the network Service Provider.

7.3.2 AIR-GROUND INTERFACE

The Air-Ground communications are supported by three main elements: the avionics, the air-ground facilities (i.e.; RGSs and GESs) and the Datalink Service Processor (DSP).

The DSP provides a gateway/routing function which:

- Supports the ACARS protocol between itself and the Airborne Communications Management Function
- Provides an interface to the RGSs and GESs
- Provides aircraft tracking
- Converts messages from ACARS format to the ATA/IATA ground-ground format and
- Provides an interface to the ground network.

The Ground Network provides fixed point-to-point messaging.

7.3.2.1 DOWNLINK MESSAGE FLOW

On the ground, messages are received by either an RGS or a GES which forward the messages to the DSP. They also perform some minor processing. One important function being to facilitate 'tracking' by adding the identity of the receiving RGS or GES to the message.

Upon receiving a message, the DSP 'handshakes' with the aircraft Communications Management function according to the ACARS air-ground protocol. The DSP then performs a number of functions on the received message. It records the identity of the receiving GES or RGS against the aircraft registration for 'tracking' purposes. It converts the message from ACARS air-ground format to ATA/IATA ground-ground format. The aircraft registration is re-located within the message and the label/sub-label is converted to an equivalent identifier, called an SMI.

To properly deliver the message, the DSP does a number of things. First the DSP identifies the message as an ATS message; the DSP uses the MFI or label to do this. Once identified as an ATS message, the DSP looks to the 'supplementary address' field of the message to find the ground delivery address (inserted by the aircraft). [24] This address is then placed in the header of the converted ground/ground message. The message is then routed to this address.

7.3.2.2 UPLINK MESSAGE FLOW

The ATC Facility delivers messages to the DSP in ATA/IATA ground-ground format. To assure proper delivery to and within the aircraft, the message also contains ACARS and 622 information, such as the aircraft registration, an SMI and an MFI, if needed. This information is used to identify the aircraft, the aircraft device and the application being addressed, respectively.

The DSP converts the message to ACARS air-ground format. Part of this involves relocating the aircraft registration and converting the SMI to the equivalent label/sub-label combination. To deliver the message to the aircraft the DSP selects the appropriate air-ground facility.

Aircraft 'tracking' provides a list of the most recently used air-ground facilities. The DSP first attempts delivery via the last facility used. Should that attempt fail it makes a determination as to which facility to use based on the remaining 'tracking' information.

Once an air-ground facility has been chosen by the DSP, it transmits the message to the aircraft via that facility. Communications between the DSP and the aircraft take place using the ACARS air-ground protocol.

RGSs act as little more than remote VHF transceivers connected to the DSP whereas the GESs use a "link-layer" protocol for communication between themselves and the aircraft.

7.3.2.3 ACARS AIR-GROUND PROTOCOL

Regardless of the media used, all FANS-1 communication uses the ACARS air-ground protocol. This protocol operates between the airborne Communications Management function and the Service Provider's DSP.

Messages greater than 220 characters are termed 'multi-block' messages. That is, they are divided into 'blocks' no greater than 220 characters in size. Each 'block' then becomes an individual transmission on the air-ground subnetwork.

The ACARS air-ground protocol is a CSMA protocol with a window size of 1, which uses a simplex channel. In simple terms this means that if the VHF channel is in use then access is denied but when clear then all users may access it. An ACARS block must be acknowledged before another ACARS block can be transmitted. Transmission cannot occur if a block is being received.

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[24] Most ACARS messages today only require delivery to the airline host computer, to do this the DSP usually uses the aircraft registration. Copies of these messages are delivered to supplementary addresses if they are included in the message. ATS messages will (normally) only require delivery to the supplementary address (i.e.; the CAA). To accommodate this the DSP will be configured to recognize ATS messages and to limit delivery to the supplementary address.

For the remainder of this section the word "message' refers to an 'ACARS air-ground message' i.e.: application data within an ACARS air-ground envelope.

All ACARS message headers contain the aircraft registration, a technical acknowledgment field and an up/downlink block identifier (UBI/DBI). Messages are acknowledged by other messages with a Technical Acknowledgment set to the Block Identifier value used in the message being acknowledged. A negative acknowledgment is indicated by a special character. If either the DSP or the airborne Communications Management function has no data to send but must acknowledge a received message, it sends a 'general service message' with the appropriate Technical Ack.

All ACARS messages have a Block Check Sequence (BCS) appended to them for error checking purposes.

The following descriptions apply to the "clear sky" case, where the selected communications path is available. The means of selecting appropriate paths for communication are described in another section.

7.3.2.3.1 UPLINK TRANSMISSION

Uplink transmission from the ATC Facility to the Airborne ATS application system is depicted in Figure 5.

For each message transmitted, the DSP sets a NO ACK timer. One of three things may then happen:

- A message is received with a technical acknowledgment corresponding to the UBI used in the uplink message. The transmission is considered successful and the UBI is incremented for the next message.
- The DSP receives a message with a negative acknowledgment (NACK). The transmission is considered to have failed and a re-try is attempted. There may be three re-tries.
- The NO ACK timer expires and no acknowledgment has been received. The transmission is considered to have failed and a re-try is attempted. There may be three re-tries.

Once the NO ACK timer expires and none of the retries have been acknowledged, the DSP should route the message via an alternate media (such as SATCOM) or to another service provider using internetworking. If all attempts via all means are unsuccessful, the service provider originally receiving the uplink notifies the originator of the message that the message was not delivered. The service provider then purges the message.

This block diagram depicts an end-to-end uplink procedure, specifically for the ATS Application System residing in an ACARS peripheral and the Communication Management Function in an ACARS MU. A different aircraft architecture (e.g., with the ATS Application System and Communication Management Function residing in the same unit) would be effectively the same from the ground station’s perspective.

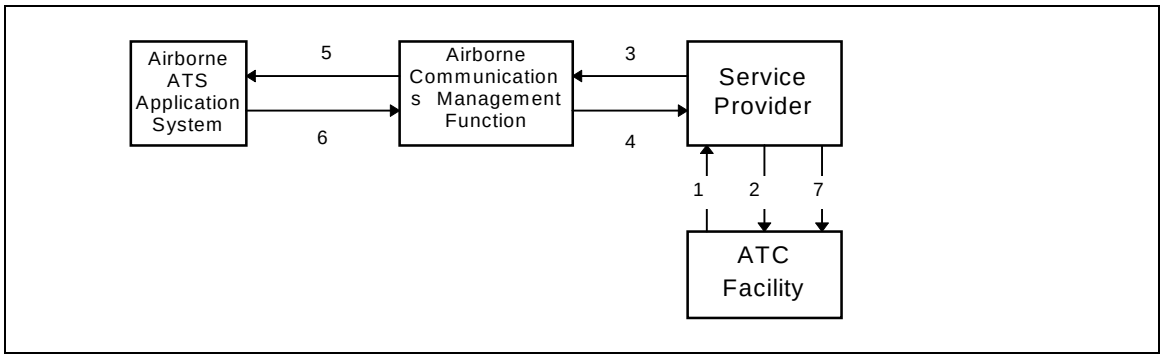

Figure 5 - Uplinks

Step	Description
1	ATC sends message to SP
2	SP sends message ACK to ATC [SP returns msg with reason if uplink cannot be formatted]
3	SP breaks message into blocks if necessary, then sends block to Airborne Communications Management function
4	Airborne Communications Management function sends block ACKs to SP [Airborne Communications Management function sends NAK if BCS fails]
5	Airborne Communications Management function re-assembles blocks if message is a multi-block message, then sends LDU[25] to Airborne ATS application system [Airborne Communications Management function sends reject to SP if uplink is undeliverable]
6	Airborne ATS application system sends link layer ACK to Airborne Communications Management function [Airborne ATS application system sends NAK if CRC fails or if the msg is larger than 2 LDUs]
7	SP sends MAS to ATC after all blocks are ACK'd by the Airborne Communications Management Function. [SP returns msg with reason if uplink was undeliverable]

7.3.2.3.2 DOWNLINK TRANSMISSION

The procedures for downlink transmissions from an airborne ATS application to an ATC Facility are depicted in Figure 6, and are similar to those for uplinks with the following exceptions:

- The Airborne Communications Management function may retry a message if the NO ACK timer expires. The timer is programmed differently depending upon whether the Airborne Communications Management function is using VHF or SATCOM, and depending upon the service provider. For example, in ARINC VHF, typically retries are between 10 - 25 seconds, whereas with SITA VHF, the retries are

25 Link Data Unit (LDU) is the packet used between an ACARS MU and an ACARS peripheral.

between 6 - 15 seconds. SATCOM retries are 180 seconds apart for the first two attempts, then the Airborne Communications Management function artificially declares the SATCOM to be NO COMM for 600 seconds before attempting a downlink again. The NO ACK timer is reset if an uplink is received.

- There are no less than two and no more than seven re-tries.

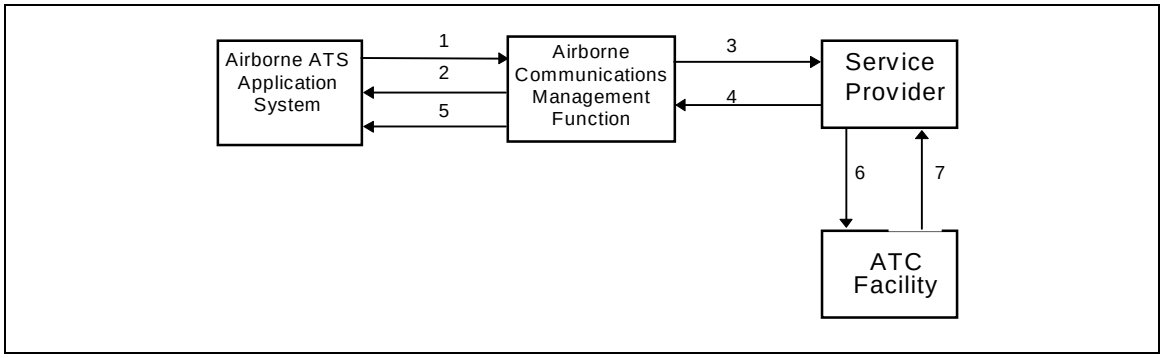

Figure 6 - Downlinks

Step	Description
1	Airborne ATS application system breaks message into LDUs if necessary, then sends LDU to Airborne Communications Management function
2	Airborne Communications Management function sends link layer ACK to Airborne ATS application system [Airborne Communications Management function sends NAK to Airborne ATS application system if CRC fails]
3	Airborne Communications Management function combines LDUs if necessary, divides message into blocks, then sends block to SP (Note: The Airborne Communications Management function continues to send the message until the SP responds.)
4	SP sends block ACK to Airborne Communications Management function [SP sends NAK or no response if BCS fails]
5	Airborne Communications Management function sends network ACK to Airborne ATS application system when ACK for last block received
6	SP sends message to ATC
7	ATC sends ACK to SP

7.3.2.3.3 ERROR CHECKING

The receiver of an ACARS message (i.e.; MU or DSP) always verifies the integrity of the received message by checking each character for parity errors and then checking the entire message using the BCS appended to each message. If a message fails the BCS check, the message will be discarded.

Messages in which errors are detected are discarded by the DSP (awaiting re transmission by the sender once the No ACK timer expires) however errors detected by an Airborne Communications Management function are responded to with a NACK. Downlink messages which cannot be formatted are responded to with an ACK but are not passed on. Messages with any of the following cannot be formatted:

- Unknown label
- Unknown sublabel
- Unknown agency
- Unknown format
- No address

7.3.2.3.4 CATEGORIES OF OPERATION

There are two categories of operation for VHF ACARS: Category A, used by ARINC and Category B used by SITA. Satellite communications is treated as a special case of Category A. Switch-over between the VHF and satellite media is discussed in sections 7.3.2.6 and 7.3.3.

The main differences between the categories are in their handling of downlink messages.

With Category A, all RGSs within range of an aircraft receive the transmitted message and on-forward it to the DSP. Received signal quality derived from the downlink is then used in selecting the RGS for any uplinks including Acknowledgments.

With Category B, downlink messages are addressed to a particular RGS. The Airborne Communications Management function obtains RGS addresses from regular transmissions known as a "squitters", which are provided by each RGS for acquisition and identification purposes.

For satellite communications, the task of acquiring a suitable GES for communication is handled by the SDU. As no special addressing is required by the MU, satellite communications appear (to the MU) as Category A.

Most ACARS MU can operate with both Category A and Category B networks.

7.3.2.4 THE DSP - RGS INTERFACE - SITA

Early SITA RGSs were connected to the DSP using the proprietary character-oriented network known as the DTN. The connection between the RGS and the network used a proprietary (character-oriented) protocol, known as P1024C. This is one of a family of Synchronous Link Control (SLC) protocols, in which the remote device, the RGS, is polled for data by the network node.

The network itself is hierarchical in nature, to deliver messages:

- Network nodes pass data to concentrators,
- Concentrators pass data to switches,
- Switches pass data to other switches ,
- Switches then pass data to concentrators and
- Concentrators pass data to nodes for final delivery.

Communication between each set of devices uses a slightly different protocol. Each protocol is one of the SLC family and provides message protection through the use of a 16-bit CRC. Note that overall protection is provided by the overlaid ACARS protocol.

New SITA RGSs come equipped with an X.25 interface. Connections between them and the DSP are made using SITA's OSI compliant network known as the Mega Transport Network (MTN). With X.25, data transmission does not depend on polling by the network.

7.3.2.5 THE GES - DSP INTERFACE

7.3.2.5A THE GES - DSP INTERFACE - SITA

For connection to terrestrial networks, GESs provide an X.75 interface.

The connection to the DSP is made using SITA's X.25 network (MTN), providing highly redundant connectivity to the DSP.

Different X.25 networks are linked using the X.75 standard. In this case the Aeronautical Mobile Satellite System (AMSS) system represents one network and the terrestrial system(s) represent another.

7.3.2.5B THE GES - DSP INTERFACE - ARINC

ARINC RGSs are connected to the DSP via a proprietary character-oriented network known as ADNS. The connection uses an Synchronous Link Control Protocol (SLC) protocol. The protocol uses a 16-bit CRC to ensure message integrity. Overall transmission is in accordance with the ACARS protocol.

Next generation ARINC RGSs will be equipped with an X.25 interface and connected to the DSP via an Open System Interconnect (OSI) compliant network known as the ARINC Packet Network (APN).

The GESs provide an X.75 interface to ARINC's Air/Ground Intermediate System (AGIS). AGIS is connected to the DSP using an SLC protocol. Overall transmission is in accordance with the ACARS protocol.

7.3.2.6 VHF/SATCOM SELECTION

Each service provider uses different methods of selecting the data link medium for unsolicited uplinks. Typically, all uplinks are routed to VHF, if VHF is available. However, it is possible for a message to be routed to SATCOM, if the last downlink were heard over SATCOM.

7.3.3 INTERNETWORKING

Internetworking refers to the agreements between service providers to forward each other's ATS messages. Internetworking allows seamless access between aircraft and ATC Facilities for ATS datalink applications.

7.3.3.1 DOWNLINK INTERNETWORKING

The aircraft shall downlink ATC messages over VHF if available, or else over SATCOM if available. The DSP receiving the ATC downlink shall deliver the downlink message to the ATC address contained in the message. If the DSP receiving the downlink is not connected to the ATC system addressed in the downlink, the DSP shall forward (internetwork) the ATC downlink to the DSP which has a connection to the addressed ATC system.

7.3.3.2 UPLINK INTERNETWORKING

The ATC Center shall send aircraft uplinks to the DSP with which it is contracted. That DSP shall determine if the addressed aircraft is active on its network. The DSP shall attempt ATC uplink delivery on an active medium until successfully delivered, via VHF, then SATCOM if necessary. If the addressed aircraft is not active in the DSP table or uplink delivery attempts on each approved active media are unsuccessful, the ATC uplink shall be forwarded (internetworked) to another DSP for delivery.

7.3.4 ATC FACILITY APPLICATIONS

The ATS Facility applications are the peers of the airborne ATS application systems. The airborne ATS application systems (such as AFN) communicate through the datalink with their ground based ATS application system partners.

The ATC Facility performs the following functions:

- Provides automatic or manual means of initiating communication, as appropriate for application, with individual aircraft;
- Provides automatic or manual means of terminating communication, as appropriate for application, with individual aircraft;
- Monitors communication link status and transactions for multiple aircraft;
- Decodes downlink messages and extracts received data for controller display or internal processing;
- Provides a means for ATS to compose messages and encode uplinks;
- Provides a means of displaying ADS position reports, waypoint reports and flight plan tracks to facilitate the provision of Air Traffic Management services; and
- Detects and annunciates uplink failures and/or downlink messages received in error, as necessary.

The ATC Facility supports operations appropriate to the air traffic environment. Air traffic environments can be divided into surface, terminal, en route (domestic) and oceanic. Oceanic ATC activities include: pre-departure review and approval, FIR entry/exit coordination, providing ATC-initiated clearances and advisories, processing and responding to pilot requested clearances and advisories, handling pop-up aircraft, and processing compulsory aircraft position reports.

7.3.5 ATS GROUND TO GROUND COMMUNICATION

ATC Facilities communicate today in their handling of traffic which transits their service areas. The procedures which govern this communication will have to change to accommodate the implementation of a FANS environment. Currently, communication can be controller to controller, but with increasing automation, the communication will become ATC Facility to ATC Facility through a digital network.

8.0 ALLOCATION OF REQUIREMENTS TO ENVIRONMENTS

The purpose of this section is to define requirements for the ATS functions. It is not the intent of this document to repeat existing industry documentation. These requirements are intended to be discussed in sufficient detail to:

- Complete the description of all assumptions to a requirement;
- Allocate requirements to an environment or environments; and
- Allocate requirements to individual systems within the airplane environment.

It should be noted that the end-to-end requirements are independent of the data pathways to be used by the functions. For example, the requirements for the AFN function are independent of whether the communication occurs over the satellite network or the VHF radio network.

The following sections list the requirements for each of the functions as they have been allocated to the specific environments: airplane, satellite or ground. In the case of the airplane environment, the requirements are allocated to the specific airplane subsystems. Any end-to-end performance requirements for the function are described along with the rationale for that performance requirement.

8.1 ATS FACILITIES NOTIFICATION FUNCTION (AFN)

8.1.1 ALLOCATION TO AIRPLANE ENVIRONMENT

a) The FANS 1 AFN application shall provide the functionality defined by sections 5.1 and shall meet the requirements listed below.

b) This functionality shall be developed to DO-178B Level C or per an equivalent or agreed to certification level.

c) The flight identifier and aircraft registration which the AFN application uses shall be exactly the same as the filed flight identifier and aircraft registration.

d) The AFN application shall include a time stamp in each AFN downlink message, using the format and rules defined in section 5.1, whenever time is available.

e) The AFN application shall not accept an AFN uplink message which contains a flight identifier or tail number which does not match the current flight identifier or tail number, respectively.

f) The AFN application shall accept alpha characters and numerics in ground addresses within AFN messages.

g) The AFN application shall implement the T_1 timer defined in section 5.1.

h) The AFN application shall process an uplink AFN Contact Advisory message, formulate the appropriate responses (AFN Response and AFN Contact) and attempt to send the responses within 5 minutes.[26] If the corresponding uplink AFN Acknowledgment message is received within the T_1 time, the AFN application shall formulate the appropriate response (AFN Complete with reason code as defined in ARINC 622) and attempt to send the response within 5 seconds; alternatively, if the AFN Acknowledgment is not received, the AFN application shall formulate and attempt to send the AFN Complete message (with reason code 1) within 5 seconds of the T_1 timer expiration.

i) The AFN application shall use the version number “01” for the ARINC 745-2 ADS application.

8.1.2 ALLOCATION TO SATELLITE ENVIRONMENT

a) There are no AFN function requirements allocated to the Satellite Environment.

8.1.3 ALLOCATION TO GROUND ENVIRONMENT

8.1.3.1 ALLOCATION TO SERVICE PROVIDER COMPONENT

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[26] The value of the ground timer is not in accordance with ARINC 622-1. The original T_1 value of 5 minutes was expanded due to unaccounted delays. The unaccounted delays are due to the fact that the AFN Response is sent before the AFN Contact, and the fact that AFN messages are lower in priority than ADS and ATC DL messages.

a) The datalink service provider shall perform a lookup of the 4-character ICAO (ATC Facility) code found in the user address field of a downlink AFN message to determine the 7-character network address to be used for routing purposes to a ground AFN application.

8.1.3.2 ALLOCATION TO ATC FACILITY COMPONENT

a) An AFN application, compatible to that defined by section 5.1, shall be implemented in the ATC Facility.

b) The ground AFN application shall be developed and modified using standards which provide equivalent safety to DO-178B Level C.

c) The ATC Facility shall coordinate with its service provider to establish its 4-character ICAO code identifier for use with the AFN Function (and the ATC DL Function).

d) The end-to-end Cyclic Redundancy Check (CRC) shall be calculated and verified by the ATC Facility to assure required integrity of the downlink AFN transmission. If the CRC check fails, the downlink shall be ignored. Similarly, the end-to-end CRC shall be calculated and inserted into the uplink AFN transmission.

e) The ATC Facility shall have an automated means to unambiguously identify an aircraft from the flight identifier and tail number (aircraft registration) as contained within the end system (CRC'd) portion of the AFN logon message[27].

f) The ATC Facility shall have the responsibility to assure that the ground application versions are compatible with the airplane application versions, as indicated by the airplane AFN logon.

g) The ATC Facility shall recognize the ADS application version number ‘01’ as representing the FANS 1 ADS application. The ATC Facility shall recognize the ATC application version number ‘01’ as representing the FANS 1 ATC DL application.

h) Routing of a logon message within an ATC Facility (e.g., local control, ground control, etc.) shall be the responsibility of that facility.

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[27] The intent of this requirement is to mitigate the hazard associated with delivery of a clearance to an aircraft other than the one for which it was intended. As such, it is incumbant upon the ATS facility to assure that the flight identifier by which an aircraft is tracked correlates with the tail number to which uplinked messages are addressed. Two options for satisfying this requirement have been suggested. Both options are acceptable.

1. Procedures in the South Pacific currently require aircrews to transmit a position report after crossing an FIR boundary or transmitting a new AFN logon. The ATC Facility may use this position report to identify an aircraft, as it provides sufficient route information to verify that the filed flight plan matches the flight identifier received for each aircraft. Since this method does not correlate tail number and flight identifier, the ATC Facility must also have a means to prevent establishment of a CPDLC connection with an aircraft if that aircraft's tail number is the same as the tail number associated with an existing CPDLC connection.
2. The ATC Facility may opt to compare the end system flight identifier and tail number as received in the AFN logon message against those identified in the filed flight plan.

i) The ATC Facility shall process the logon message and formulate an appropriate response within 3 minutes to assure that the uplink response to a downlink AFN Contact message will be received prior to expiration of the aircraft AFN application's T_1 timer.

j) The ATC Facility shall send a positive response to the aircraft, if ATS will be using ADS and/or ATC DL to communicate with the airplane, using the AFN Acknowledgment message (FAK MTI followed by reason code set equal to 0). The ATC Facility shall send a negative response using the AFN Acknowledgment message (FAK MTI followed by a non-zero reason code) if not.

k) If the ATC Facility uses the AFN Contact Advisory uplink, the facility shall implement the T_2 and T_3 timers, defined in section 5.1.

8.2 DATALINK

The detailed requirements for the datalink function are specified below.

8.2.1 ALLOCATION TO AIRPLANE ENVIRONMENT

8.2.1.1 FMCS

a) The following downlink message prioritization scheme shall be implemented in descending order of priority:

- ATC Datalink Messages
- ADS Messages
- AFN Messages
- AOC Messages, per ARINC 618[28]

b) The FMC shall abort all pending ATC DL downlinks, cancel all ADS contracts and terminate all connections after 16 consecutive minutes of NOCOMM, VOICE only, or FAIL.

c) The FMC shall send the DISCONNECT message defined in ARINC 622-1 in case of an ADS request from a 6th ATC Facility and other cases listed in ARINC 622-1.

d) The FMC shall include the tail number (aircraft registration) in each ATC DL and ADS downlink message as described in section 5.2.1. The FMC shall discard an uplink ATC DL and ADS message which contains a tail number which does not exactly match the ATS FMC's tail number.

e) The FMC shall perform the CRC calculation as modified by section 5.2.1.

8.2.1.2 ACARS MU

8.2.1.2.1 ACARS MU REQUIREMENTS

a) The ACARS MU shall conform to ARINC 724B and ARINC 618 with the additional requirements specified below.

b) The ACARS MU shall determine and maintain status alerting during all modes of operation whether each sub-network is considered available or not.

c) The ACARS MU shall respond to the FMC supplied-destination code (G) as defined in ARINC 724B.

d) For VHF, the ACARS MU shall consider frequency acquisition (frequency search) to be a VHF not available (ARINC 618, section 5.3). ACARS shall downlink an ATS message via SATCOM if the primary category B site fails to respond to all downlinks, and shall do so prior to searching the alternate sites to establish a new primary category B site.

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28 The prioritization of ATC DL messages over ADS messages is not in agreement with the relative Transport Layer priority requirements cumulatively set forth in DO-219, DO-212 and ARINC 745. ATC DL is higher priority because its messages may include corrective action resulting from analysis of ADS data. Periodic ADS reports from previous transmissions allow delays in subsequent ADS reports in the event a corrective action (via ATC DL) is necessary the same time an ADS report is required.

e) Receipt of any valid uplink block shall stimulate the ACARS MU to downlink a message to both verify the integrity of the data link as well as providing a stimulus for the DSP to recognize the path to that airplane. The ACARS MU shall not consider itself "IN COMM" until it receives an acknowledgment to it's downlink (ARINC 618, section 5.6.2.2). The ACARS MU shall declare VHF NOCOMM if a downlink is not acknowledged, and all retries are unsuccessful.

f) The ACARS MU shall consider VHF Voice mode to be a VHF not available state; the ACARS MU shall downlink an ATS message via SATCOM, if available.

g) For SATCOM, the ACARS MU shall first ensure that the SATCOM has declared a data link available. If the ACARS MU does not receive an acknowledgment within 180 seconds after first sending a message, the ACARS MU shall retransmit the message (ARINC 618, section 7.7.2, AT7 NO ACK timer). Failure to receive an uplink acknowledgment within 180 seconds of transmission of the second downlink attempt shall cause the ACARS MU to declare the SATCOM link to be NOCOMM (ARINC 618, section 7.7.2, AT6 NOCOMM timer). A SATCOM NOCOMM shall also be declared if SATCOM declares data link not available for any period of time. the ACARS MU shall presume the link is "IN COMM" once again if one of the following events occur (ARINC 618, section 7.7.5):

- A valid uplink is received;
- SATCOM transitions from data link not available to available; or
- 10 minutes have passed since declaring NOCOMM while the SATCOM declares data link available.

h) The ACARS MU shall send Q0 upon detecting that the SATCOM has logged on.[29]

i) The ACARS MU shall be capable of receiving and acknowledging uplink messages concurrently on SATCOM and VHF. The correct order of multi-block uplink messages shall be retained (including during a VHF/SATCOM change-over or concurrent use).

j) The ACARS MU shall complete message transmission over a given subnetwork if possible. If the subnetwork connection which The ACARS MU is currently transmitting a message upon is lost, the ACARS MU shall re-queue the downlink message when a link is acquired. If the subnetwork connection which the ACARS MU is currently receiving a message upon is lost, any multi-block uplink in progress shall be treated as an incomplete multi-block uplink.

k) The ACARS MU shall provide the capability to receive a downlink from the FMC while a message from another peripheral is being transmitted.

l) The ACARS MU shall transmit messages from the FMC, and those created from direct interface with the ACARS MU, prior to those from other peripherals.

m) When an appropriate channel is available, the ACARS MU shall transmit the next highest priority message (based on source as defined above) stored in its queue at the time. When the FMC has a downlink message which it is attempting to deliver to the ACARS MU, the MU should not send any other non-ATS downlink prior to receiving and sending the ATS message.

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[29] Any application level message initiated over SATCOM would fulfill this requirement.

n) The ACARS MU shall not operate such that a downlink message, with a destination code of "V", from one peripheral is able to prevent downlink messages, with a destination code of "S" or "G", from other peripherals from being sent.

o) The ACARS MU shall provide a positive technical acknowledgment to each valid uplink (ARINC 618, section 3.2.1).

p) The ACARS MU shall divide a downlink ATS message into ACARS blocks as necessary, add air-ground headers and its own checksum to the ATS message but shall not modify any part of the ATS message, beginning with the first byte immediately following the five byte Control/Accountability header, through and including, the last byte of the end system application CRC.

q) For an ATS uplink to the FMC, the ACARS MU shall translate the ACARS blocks into a file beginning with the first character immediately following the sublabel field. A five byte Control/Accountability header shall be added by the ACARS MU to the front of the file and the entire file is then transferred to the FMC.

8.2.1.2.2 ACARS PERFORMANCE ISSUES

It should be noted, that ACARS protocols as well as specific vendor implementations could introduce delays into the ATS end-to-end functions and could restrict the operational benefits.

The ACARS MU should be capable of interrupting a downlink multi-block message with a higher priority, downlink single block message (based on source as defined above). If MU has this capability, MU should use true message sequence numbers (instead of the time stamps) to ensure detection of incomplete multi-block messages.

The ACARS MU may alternatively (to nesting) downlink ATS messages via SATCOM if the VHF media is busy with lower priority traffic.

Downlink VHF re-transmission success depends on the DSP in use and ACARS vendor. Typically an MU will make a maximum of 6 downlink attempts per block at random intervals of 10-25 seconds for Category A operation. The number of attempts per block and the length of the intervals between attempts varies for Category B operation and is dependent upon the number of Category B sites being tracked at the time of the downlink.

Long multi-block uplink and downlink messages should generally be discouraged. If any given message source were to launch a 10 block exceedance message, all other traffic (other than single blocks if the ACARS MU is able to interleave these) would be held off the channel for several minutes during this transaction.

If the ACARS MU receives an uplink over SATCOM that does not acknowledge a downlink over SATCOM (criss-cross situation), the MU should immediately downlink a general response acknowledgment of the uplink and not reset the NO ACK timer for the original downlink.

8.2.1.3 SATCOM

a) The SATCOM System shall comply with ARINC 741 parts one and two. The SATCOM System is considered a pass-through system and it shall not modify any ATS message.

b) The SATCOM system shall support the alerting messages, described in section 7.1, as appropriate to the airplane. If the SATCOM system utilizes a high gain antenna, the SATCOM system shall provide for continued data transmission capability if the high gain antenna reports less than 7 dBi of gain. The SATCOM may either utilize a separate low gain antenna or utilize the high gain antenna as a low gain antenna in this circumstance.

8.2.1.4 VHF RADIO

a) There are no additional requirements beyond compliance to ARINC 716.

8.2.2 SATELLITE ENVIRONMENT

a) The current configuration and capability of the Inmarsat II satellites satisfy the requirements for ATS Messages. The satellite component is considered a pass-through system and shall not modify any ATS message.

b) Other satellite systems may be used to support the FANS 1 system, but the interfaces with the airplane SATCOM system and the ground system must be shown to be interoperable.

8.2.3 GROUND ENVIRONMENT

8.2.3.1 VHF SUB-NETWORK COMPONENT

a) This ground sub-network component is defined by ARINC 618 and no changes are necessary to support the implementation of FANS 1.

8.2.3.2 SERVICE PROVIDER COMPONENT

a) The ground service provider component is described by ARINC 620 and section 7.3.1 of this document.

b) The service provider shall recognize messages formatted per ARINC 622-1 and section 5.2.1 of this document as being ATS messages.

c) The service provider shall use the ACARS tail number in uplink ATS messages to address the aircraft.

d) Service providers shall not modify any ATS message parts, including insertion or addition of CR-LF characters, encapsulated by the end system CRC.

e) Service providers shall provide a positive technical acknowledgment to each valid ATS downlink (ARINC 618 section 3.2.2).

f) Service providers shall forward all ATS messages which have been acknowledged to the addressed (as specified in the user address field) ATC Facility.

g) Service providers shall pass on the User Address Field text, i.e., the MFI and/or destination address[30].

8.2.3.2.1 INTERNETWORKING

a) Uplinks shall contain the original source address unless they are passed on, in which case they shall contain the source router address. Downlinks shall all have the address of the router which originally received the downlink.[31]

Given the requirement that ARINC 622 functionality exists in the airplane and in the ATS end systems:[32]

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30 This was stated at Interoperability Team meeting #4 held on 6/16/94. Note that ARINC 622-2 section 2.2.1.2 states that SP's should not pass on the MFI.

31 This was stated at Interoperability meeting #5 held on 10/17/94.

b) ATC Facilities shall only need to contract with one Datalink Service Provider (DSP) for communications access to any FANS 1 aircraft. The contract shall be established with the DSP known as the "primary DSP" which will be responsible for internetworking of uplink messages to the aircraft. The primary DSP will also play a role in internetworking of downlink messages from the aircraft if required. [Note: Downlink messages should be routed to the ATC Facility in the most efficient manner. In some cases, downlink messages will not need to pass through the primary DSP's network].

c) ATC Facilities shall not be required to track communication/media usage (not station nor SATCOM/VHF nor DSP).

d) ATC Facilities shall only need to send data link messages to a single address per airplane.

e) Message assurance shall be provided for uplinks generated by ATC Facilities.

f) Internetworking transit times shall conform to data link performance parameters in section 8.2.4.

g) For uplink messages generated by ATC Facilities:

- The DSP providing service to the ATC Facility shall first determine if the aircraft is active in its own VHF and/or SATCOM activity table. If the addressed aircraft is not active in the DSP's activity table, the uplink should be forwarded (internetworked) to another DSP for uplink delivery. If the addressed aircraft is active in the DSP's activity table, the DSP shall attempt to deliver the uplink to the aircraft within the uplink message delivery performance objective as described in Section 8.2.4 Datalink Performance. In order meet the uplink message delivery performance objective, it may be necessary for the DSP to internetwork to another DSP instead of attempting the uplink on all media listed as active. ;
- If the DSP is unable to deliver the uplink, the DSP shall forward the uplink message to another DSP for delivery;
- If the message is delivered, the delivering DSP shall send the message assurance delivery confirmation message to the originating address;
- If the message is not delivered, the last DSP to handle the message shall send the message assurance intercept message to the originating address.

8.2.3.2.2 RECORDING OF ATS MESSAGES

a) All records shall be time stamped with time, to the nearest second. The service provider time source shall be within 2 seconds of UTC time.

b) All records shall allow proper decoding to determine conclusively the data that were expected to be transmitted, or actually received.

c) The data link service provider shall retain the records for at least 30 days. These records shall be made available for air safety investigative purposes on demand.

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[32] This assumption and the requirements which follow are based on the Internetworking Requirements for ATS SR&O, in Att. G to App. D, in the Final Report of the Seventh meeting of the Informal South Pacific ATS Coordinating Group, Nov. 14-18, 1994.

d) Each element shall be recorded in order to determine the exact data link operation.

8.2.3.3 ALLOCATION TO ATC FACILITY COMPONENT

a) All ATC Facility requirements herein shall apply to an airline facility which implements the ADS Function.

b) The end-to-end Cyclic Redundancy Check (CRC) shall be calculated, as defined in section 5.2.1, and verified by the ATC Facility to assure required integrity of the downlink ADS and ATC DL transmission. Similarly, the end-to-end CRC shall be calculated, as defined in section 5.2.1, and inserted into each uplink ADS and ATC DL transmission.

c) The ATC Facility shall compare the aircraft registration (tail number) in the CRC'd portion of each ATC DL and ADS downlink message against the information received in the CRC'd portion of the AFN logon message. Neither the ACARS header tail number nor the ACARS header flight number shall be used for verification purposes. Error handling procedures shall be conducted for an ATC DL and ADS message which is received with an aircraft registration which does not correspond with the AFN information.

d) The ATC Facility shall include the aircraft registration (tail number) in each uplink ADS and ATC DL message as described in section 5.2.1.

e) The ATC Facility shall place only a single ground address in the User Address Field of each uplink ADS message.

f) The ATC Facility shall not modify any ATS messages for avionic display purposes, including insertion or addition of CR-LF characters.

g) The ATC Facility shall include a unique identifier with each uplink message in order that the service provider may provide the tracing necessary for Message Assurance (defined in ARINC 620).

h) The ATC Facility shall be connected to a single service provider for uplink message service.[33] The ATC Facility may be connected to multiple service providers for downlink message service.

i) The ATC Facility shall include only the AN TEI for uplink aircraft addressing.

8.2.4 DATALINK PERFORMANCE

The datalink function can contribute a varying amount of transport delay to the ATS message. The contributing factors to that transport delay of a downlink message are as follows:

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[33] An ATC Facility connected to more than one service provider would require additional functionality from the service providers to support internetworking.

- Time to accept message from ATS application
- Time message spends in the communication management function's queue while other messages are sent or received
- Time to establish a valid air-ground connection (VHF or SATCOM)
- Time to route message to selected data pathway (radio or satellite)
- Time for the selected transmitter to transmit the message
- Time to transmit message from ground station to service provider's processor
- Time to route message from service provider to a ground end system router
- Time to route message from ground end system router to application

There are similar factors contributing to the transport delay of an uplink message.

The requirements in the following table have been established for FANS-1/A operations in the South Pacific[34]. These requirements address message transit delay, system availability, system reliability, and system integrity. It is assumed that similar requirements will be established in other operating regions.

[34] System performance requirements were set using best estimates during implementation of FANS-1/A operations in the SOPAC. By September 1998, it was evident that, despite the fact that performance requirements were being met, the system was not performing well enough to meet operational expectations. As the result of extended discussions during the Fourth FIT Meeting in Nadi, Fiji in September, 1998, revised requirements were proposed by the FIT. At the subsequent ISPACG meeting in Auckland, New Zealand, in December 1998, these recommendations were adopted.

Criteria	Definition	Values
Performance	End to end round trip time for uplinks. (sending and reception of MAS)	Round trip time of 2 minutes, 95% of the messages. Round trip time of 6 minutes, 99% of the messages.
	End to end one way time for downlinks. (comparison of message time stamp and receipt time)	One way time of 1 minute, 95% of the messages. One way time of 3 minutes, 99% of the messages
	Uplink messages only: Undelivered messages will be determined by: • Message assurance failure is received. After trying both VHF and SATCOM. Depending on reason code received, the message might, in fact, have made it to the aircraft. • No message assurance or flight crew response is received by ATSU after 900 seconds	Less than 1% of all attempted messages undelivered
Availability	The ability of the network data link service to perform a required function under given conditions at a given time: The maximum allowed time of continuous unavailability or downtime should be declared (MTTR)∗:	99.9% TBD
Reliability	The ability of a data link application/system to perform a required function under given conditions for a given time interval: it can be expressed in MTBF (Mean Time Between failure) ∗	TBD
Integrity	The probability of an undetected failure, event or occurrence within a given time interval.	10^{-6}

∗ Availability = MTBF/(MTBF+MTTR)

Datalink Performance Certification vs. Operational Approval

Datalink performance can affect both the Part 25 Type Certification approval and the Part 121 operational approval process or other means of obtaining operational authorization. Part 25 intended function supports Part 121 operational requirements. The operational performance, integrity, and availability criteria define the intended function and these criteria will be demonstrated during the Part 25 Type Certification airworthiness approval. The Part 25 "intended function" for data link with regards to the ATS functions is that the message arrives at the peer end system, can be accepted by a peer end system and satisfies the performance criteria above. The transport delay of the messages is very important for the operational approval of the functions.

The end-to-end transport delay of ATS communications is extremely dependent on aircraft configuration, satellite configuration, ground network configuration, and ATC Facilities. The Part 25 certification of the 757/767 (Pegasus '00) FANS 1 system will include a demonstration of the datalink system performance satisfying the performance criteria above. This demonstration will be conducted with only one service provider and one ATC Facility, but will satisfy the Part 25 certification requirements regardless of service provider or ATC Facility. The performance data that are collected during the certification will be available to support operational approval with other service providers or ATC Facilities.

8.2.5 DATALINK OPERATIONAL REQUIREMENTS

a) HF voice shall be maintained as an alternative means of communication.

b) Procedures to detect the loss of datalink or expected aircraft responses shall be established.

8.3 AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

8.3.1 ALLOCATION TO AIRPLANE ENVIRONMENT

a) The FMC shall provide the ADS Application functionality as defined in section 5.3 and shall meet the requirements listed below, to transmit and receive ADS messages over the ACARS datalink network.

b) This function shall be developed to DO-178B Level C or per an equivalent or agreed to certification level.

c) The FMC shall use the ADS Report data content definition contained in Appendix B to this document. The accuracy of the ADS Report data content shall match the accuracy of the source of the data as specified in Appendix B, limited in some instances by the reduced resolution of the ADS formats.

d) The FMC shall formulate and attempt to send the appropriate ADS response within 5 seconds of receipt of an ADS request. The FMC shall formulate and attempt to send the required periodic report within 5 seconds of the periodic trigger. The FMC shall formulate and attempt to send the appropriate event report within 5 seconds of detecting the event trigger.

e) When GPS is unavailable, the FMCS shall revert to using the flight deck clock as the time source for all FMCS functions, including the ADS application. The Position Determination Accuracy portion of the FOM shall be calculated as defined in section 5.3.

8.3.2 ALLOCATION TO SATELLITE ENVIRONMENT

a) There are no ADS function requirements allocated to the Satellite Environment.

8.3.3 ALLOCATION TO GROUND ENVIRONMENT

a) All ATC Facility requirements herein, except where related to the usage of five connections, shall apply to an airline facility which implements the ADS Function.

b) An ADS application, compatible to that defined in section 5.3, shall be implemented.

c) The ground ADS application shall be developed and modified using standards which provide equivalent safety to DO-178B Level C.

d) The ATC Facility shall insert the tail number (aircraft registration) from the CRC'd portion of the AFN logon message into the header of all ADS uplinks.

e) ATC Facilities shall arbitrate amongst themselves the establishment and cancellation of ADS connections with the airplanes. This means ATC Facilities use the forwarded flight plan, explained in section 6.2.1, to determine when to initiate and terminate ADS contracts for airplanes operating within their service volume. For example, the ground application should automatically cancel ADS connections or procedures shall be instituted to require ATS to manually cancel the connection, when the ADS reports are no longer required for ATS purposes.

f) ATC Facilities shall not request increased rates on aircraft operating in Emergency Mode unless they are controlling the aircraft. ATC Facilities shall request a return to normal reporting rates as soon as possible after an emergency situation has been declared as a high reporting frequency does induce response time delays in the airborne applications

g) ATC Facilities shall be able to handle non-compulsory reporting points and pilot entered waypoints as ADS waypoints (for event reports and for Predicted Route data).

h) If the aircraft is on an offset and is expected to return to the original flight plan, the ATC Facility should exercise discretion in use of the aircraft intent and predicted route group data. When an offset is active, the data in these groups will be predicated on continuation of the offset.

i) ATC Facilities shall have a means to assure that requests for periodic reports and demand reports are responded to within an adequate time (e.g., timers, procedures, etc.).

j) ATC Facilities shall not rely solely on ADS event reports to detect violation of separation minima.

8.4 ATC DATALINK (ATC DL)

8.4.1 ALLOCATION TO AIRPLANE ENVIRONMENT

a) The FMC shall provide the ATC DL functionality as defined by section 5.4 and shall meet the requirements listed below, to transmit and receive ATC DL messages over the ACARS datalink network.

b) This function shall be designed to DO-178B Level C per an equivalent or agreed to certification level.

c) All ATC DL data which could contribute to a major failure effect shall be displayable on a flight deck Display Unit.

d) The FMC shall include the time stamp, defined in section 5.4, in all ATC DL downlink messages whenever time is available. The time stamp shall be set to a value which is within 5 seconds of the time at which the message was initiated.

e) A route report or route request shall contain a truncated flight plan (not truncated Route Clearance Message variable), if necessary to send an ATC DL message due to message size limitations defined in section 5.4.

f) The ATC DL application shall automatically append message element DEVIATING [direction] [distance offset] OF ROUTE (#80) to route related reports if an active lateral offset exists at the time the report is generated.[35] (See Appendix A.)

g) The response to receipt of uplink message element 148, 151 or 152, shall be encoded in free text message element (#67), as there are no pre-defined downlink elements which are appropriate. (See Appendix A for text of free text messages.)

h) When a downlink report containing present altitude is sent, the downlink message element CLIMBING TO [altitude] (#29) or the downlink message element DESCENDING TO [altitude] (#30) shall be automatically attached if appropriate.

i) The flight crew shall modify data contained in position reports and other route related reports such that position reports only contain data relative to the mandatory reporting points.

j) The FANS 1 ATC DL application shall treat an uplink message which contains the message element [track detail msg] (#178) per the DO-219 requirements for handling received messages which contain undefined message elements (i.e., the message shall be discarded and a downlink error message shall be transmitted).

8.4.2 ALLOCATION TO SATELLITE ENVIRONMENT

a) There are no ATC DL function requirements allocated to the Satellite Environment.

8.4.3 ALLOCATION TO GROUND ENVIRONMENT

a) An ATC DL application, compatible to that defined in section 5.4, shall be implemented.

b) The ground ATC DL application shall be developed and modified using standards which provide equivalent safety to DO-178B Level C.

c) The ATC Facility shall insert the tail number (aircraft registration) from the CRC'd portion of the AFN logon message into the header of all ATC DL uplinks.

d) The [icao facility designation] used in the ATC DL uplink Connect Request message shall only contain alpha characters.[36]

e) The ATC Facility shall send uplinks to close downlinks for which the airborne ATC DL application is waiting for a response. Note that failure to do so may, depending on the aircraft model, eventually cause the airborne ATC DL application to exhaust all message identification numbers and to terminate the ATC DL connection.

f) The ATC Facility shall only send characters from within the set as defined in section 5.4.

g) The ATC Facility shall send uplink message element 143, CONFIRM REQUEST, with the reference number of the downlink in question.

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35 This is in lieu of sending the route data as modified by the offset (as ADS does).

36 To facilitate aircraft-initiated logon in case of loss of communications, it is recommended that the [icao facility designation] used by an ATC Facility be the same as the 4-character ICAO code that the flight crew would use to initiate a logon.

h) The ATC Facility shall have the capability to resolve "duplicate waypoint" names which will be sent in downlink [route clearance] variables.

i) The ATC Facility shall include the optional [latitudelongitude] with any [publishedidentifier] for which duplicates exist.

j) The ATC Facility shall be aware that there will be instances of duplicate identifiers within the same FMC NDB file. If such a duplicate is uplinked as a [position] in a loadable message element, the FMC will select one and load it into the flight plan. When duplicates lie geographically close to each other, the selected duplicate may not be the one which was intended.[37]

k) The ATC Facility shall not send an uplink message containing the message element [track detail message] (#178).

l) When using the [airwayidentifier] variable, the position at which the airplane is to join the airway shall be included, encoded as a [publishedidentifier], immediately preceding the [airwayidentifier] in the [routeinformation]. In addition, the position at which the airplane is to depart the airway shall be included, encoded as a [publishedidentifier], immediately following the [airwayidentifier] in the [routeinformation].

m) In order to assure that the data are loaded correctly into the flight plan, the following constituent variables of the [routeclearance] variable shall not be used with elements 79 or 83: airportdeparture, proceduredeparture, procedureapproach, procedurearrival, airwayintercept. In addition, the airportdestination variable shall not be used with element 79.

n) ATC Facilities shall not rely solely on ATC DL "armable[38]" reports to detect violation of separation minima.

9.0 POST-CERTIFICATION ACTIVITY

9.1 OPERATIONAL AUTHORIZATION

The culmination of FANS 1 development activity is an operational authorization for each airline to realize the benefits of the FANS 1 features. The milestones required for each operational authorization include a) a Type Certificate for a FANS 1 equipped airplane, b) commissioned ATS ground facilities, then c) the operational authorization.

The first purpose of this section is to suggest the process for commissioning of new ATS facilities and for obtaining operational authorizations. Second, this section suggests how changes to the ATS function in all environments might be handled. Also, provisions for reporting problems in service is discussed.

Initially, close monitoring of all operational authorizations, commissioning of ATS facilities, new procedures, and change activity is necessary to ensure continued safety and interoperability of FANS 1 ATS applications and to ensure that the requirements specified in this document are correct and complete.

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37 This is an unavoidable limitation of the DO-219 message set. There is no optional [latitudelongitude] for the [position] variable.

38 The “armable” reports are elements 28 (LEAVING [altitude]), 31 (PASSING [position]), 37 (LEVEL [altitude]), and 72 (REACHING [altitude]).

This document states (in section 8 and appendix D) the requirements placed upon the ATC facility to ensure safety and interoperability which should be satisfied prior to commissioning of a new ATS facility. Each new facility should be examined on a case by case basis for conformity to these requirements. In cases where the proposed use or implementation is not addressed by this document or the facility does not meet these requirements, the differences must be resolved or the operational authorization may be limited.

9.2 CHANGES TO THE ENVIRONMENTS

The airworthiness approval of the FANS 1 aircraft systems is based on a representative "end-to-end" configuration of the ATS functions that is consistent with the requirements defined in this document. These requirements are specified in terms of performance, integrity, and availability requirements allocated to each part of the system or environment and avoid the specification of requirements in terms of operational uses or specific implementations of ground/space systems. This approach provides flexibility in the design of ground ATS facilities and in authorizing the use of the ATS applications and data link for different purposes without the need to revise this document or the airworthiness approval. Instead, safety and interoperability requirements provide information to determine the level necessary to substantiate different uses of ATS applications and the data link within the defined operational environment as part of the operational authorization.

In general, any portion of the FANS 1 environments may be changed as long as the new environment continues to meet the requirements of this document. Each change should be preceded by a safety and interoperability assessment of the change to show that the modification (e.g., a new ATS workstation) will continue to meet the requirements of this document. Likewise, a safety and interoperability assessment should be conducted prior to implementing a new procedure (e.g., reduction in separation minima).

It is expected that the industry will continue to update standards documents for ADS, ATC DL, and AFN functions, and the supporting ARINC 622 ACARS Convergence Process. (The CAAs may choose to implement these new capabilities to support future FANS 1 equipped aircraft, however future equipage is outside of the scope of this document.) Since the FANS 1 avionics implementation is based on specific versions of industry documents (and provisions in this document), it is essential to ensure interoperability that the ground software implementation of FANS 1 continue to support the functionality defined herein.

Continued monitoring of changes to both airborne and ground systems is necessary to ensure interoperability of FANS 1 applications for a sufficient period to maintain economic viability of both. Future changes should take account of moves towards the recommendations of the ICAO ADSP. Where possible, updated systems should exhibit enhanced capability without detriment to existing support and operational benefit.

After FANS 1 Part 25 approval any changes in functionality which cause differences from the set of industry documents should be specified in the affected document and in the application or function message set by an increment in version number. This way, the version number serves as an indicator for the functionality being described for future implementations.

9.2.1 CHANGES TO THE AIRCRAFT ENVIRONMENT

Changes to the aircraft environment may impact the Safety/Failure Analysis conducted for the FANS 1 equipment particularly if the changes affect the system architecture. Changes must be approved accordingly.

The 757/767 (Pegasus '00) FANS 1 implementation isolates the hazards to the ATS applications, which are resident in the FMCS. The FMCS protects against anomalous behavior that is considered to have major effects on the aircraft.

The ACARS and other data link components have been shown not to contribute to major failure conditions because of system architecture.

Modifications to the FMCS ATS applications must be approved by the FAA or its delegate.

Modifications to the airborne datalink components (ACARS, VHF, SATCOM) must be approved by a certification authority. The approval must show that the datalink continues to meet the requirements of this document and satisfies the Aircraft Equipment Interoperability Test (AEIT) contained in Boeing Document D6-36412 or equivalent certification interoperability tests.

9.2.2 CHANGES TO OTHER ENVIRONMENTS

Changes to the satellite environment will be validated using the satellite service provider's commissioning test. This test will address the airborne and ground interfaces.

Changes to the datalink portion of the ground environment will be validated by the datalink service provider.

Changes to the ATS application portion of the ground environment will be validated by the aviation authority responsible for that workstation.

9.3 PROVISIONS FOR IN-SERVICE PROBLEM REPORTING

To assure that significant problems associated with the airborne equipment can be identified and corrected in future avionics updates it is required that in-service problems associated with the delivery of ATS messages to/from any FANS 1 airplanes be reported promptly. It is recommended that the procedures and forms as specified in Part C of the South Pacific Operations Manual be used when reporting problems.

The airlines should report any in-service problems associated with ATS Data Link via the established means for reporting problems directly to their local Boeing Field Service Representative.

APPENDIX A - FANS 1 FMC ATC DL MESSAGE IMPLEMENTATION

A.1 UPLINK MESSAGE ELEMENT TABLE

The Uplink Message table is divided by message type. The columns in the tables are defined below.

Uplink Message Element # (UL#): The FMC uses the uplink message element number to determine the proper decoding for the variable data contained in the uplink message. The FMC also uses the uplink message element number to determine the rule for displaying the uplink message element text and variable data, as appropriate, on the CDU.

Message Element Text: The second column shows the text, with the selected data inserted appropriately, which is displayed on the XXXXz ATC UPLINK page on the CDU.

Associated Downlink Message Element # (DL#): This column is for commentary only. For clearances and expect clearances, the downlink message element(s) identified is the request for which a flight crew would operationally be expecting the uplink message element. For requests and confirms, the downlink message element(s) identified is the report the flight crew would operationally be expected to send. 'Mult' indicates that multiple downlink message elements could be related to the indicated uplink message element. N/A indicates that there is neither a defined data link request for the uplink element nor is there a defined report which the crew should send in response to the uplink.

Display and Loading Provisions (D,P,L): Full text and variable data display is provided for those message elements marked 'D'. Capability is provided for the flight crew to load some or all of the variable data contained in those message elements marked 'L'. Limited display capability, and full text and variable data print capability are provided, for those message elements marked 'P'.

Additional Information: This column provides additional information regarding message usage, display format, and data defaults.

UL#	Responses/Acknowledgments	DL#	D,P,L	Additional Information
0	UNABLE	N/A	D	
1	STANDBY	N/A	D	
2	REQUEST DEFERRED	N/A	D	
3	ROGER	N/A	D	
4	AFFIRM	N/A	D	
5	NEGATIVE	N/A	D	

UL#	Vertical Clearances	DL#	D,P,L	Additional Information
6	EXPECT [altitude]	N/A	D	
7	EXPECT CLIMB AT [time]	52	D	
8	EXPECT CLIMB AT [position]	52	D	
9	EXPECT DESCENT AT [time]	53	D	
10	EXPECT DESCENT AT [position]	53	D	
11	EXPECT CRUISE CLIMB AT [time]	N/A	D	
12	EXPECT CRUISE CLIMB AT [position]	N/A	D	
13	AT [time] EXPECT CLIMB TO [altitude]	52, 67h	D	
14	AT [position] EXPECT CLIMB TO [altitude]	52, 67h	D	
15	AT [time] EXPECT DESCENT TO [altitude]	53, 67i	D	
16	AT [position] EXPECT DESCENT TO [altitude]	53, 67i	D	
17	AT [time] EXPECT CRUISE CLIMB TO [altitude]	54	D	
18	AT [position] EXPECT CRUISE CLIMB TO [altitude]	54	D	
19	MAINTAIN [altitude]	N/A	D	
20	CLIMB TO AND MAINTAIN [altitude]	9	D	
21	AT [time] CLIMB TO AND MAINTAIN [altitude]	13	D	
22	AT [position] CLIMB TO AND MAINTAIN [altitude]	11	D	
23	DESCEND TO AND MAINTAIN [altitude]	10	D	
24	AT [time] DESCEND TO AND MAINTAIN [altitude]	14	D	
25	AT [position] DESCEND TO AND MAINTAIN [altitude]	12	D	
26	CLIMB TO REACH [altitude] BY [time]	9	D	
27	CLIMB TO REACH [altitude] BY [position]	9	D	
28	DESCEND TO REACH [altitude] BY [time]	10	D	
29	DESCEND TO REACH [altitude] BY [position]	10	D	
30	MAINTAIN BLOCK [altitude] TO [altitude]	7	D	
31	CLIMB TO AND MAINTAIN BLOCK [altitude] TO [altitude]	7	D	
32	DESCEND TO AND MAINTAIN BLOCK [altitude] TO [altitude]	7	D	
33	CRUISE [altitude]	N/A	D	
34	CRUISE CLIMB TO [altitude]	8	D	
35	CRUISE CLIMB ABOVE [altitude]	N/A	D	
36	EXPEDITE CLIMB TO [altitude]	N/A	D	
37	EXPEDITE DESCENT TO [altitude]	N/A	D	
38	IMMEDIATELY CLIMB TO [altitude]	N/A	D	
39	IMMEDIATELY DESCEND TO [altitude]	N/A	D	
40	IMMEDIATELY STOP CLIMB AT [altitude]	N/A	D	
41	IMMEDIATELY STOP DESCENT AT [altitude]	N/A	D	
171	CLIMB AT [verticalRate] MINIMUM	N/A	D	
172	CLIMB AT [verticalRate] MAXIMUM	N/A	D	
173	DESCEND AT [verticalRate] MINIMUM	N/A	D	
174	DESCEND AT [verticalRate] MAXIMUM	N/A	D	

UL#	Crossing Constraints	DL#	D,P,L	Additional Information
42	EXPECT TO CROSS [position] AT [altitude]	N/A	D	
43	EXPECT TO CROSS [position] AT OR ABOVE [altitude]	N/A	D	
44	EXPECT TO CROSS [position] AT OR BELOW [altitude]	N/A	D	
45	EXPECT TO CROSS [position] AT AND MAINTAIN [altitude]	N/A	D	
46	CROSS [position] AT [altitude]	N/A	D,L	
47	CROSS [position] AT OR ABOVE [altitude]	N/A	D,L	
48	CROSS [position] AT OR BELOW [altitude]	N/A	D,L	
49	CROSS [position] AT AND MAINTAIN [altitude]	N/A	D	
50	CROSS [position] BETWEEN [altitude] AND [altitude]	N/A	D	
51	CROSS [position] AT [time]	N/A	D, L	
52	CROSS [position] AT OR BEFORE [time]	N/A	D, L	
53	CROSS [position] AT OR AFTER [time]	N/A	D, L	
54	CROSS [position] BETWEEN [time] AND [time]	N/A	D	
55	CROSS [position] AT [speed]	N/A	D	
56	CROSS [position] AT OR LESS THAN [speed]	N/A	D	
57	CROSS [position] AT OR GREATER THAN [speed]	N/A	D	
58	CROSS [position] AT [time] AT [altitude]	N/A	D	
59	CROSS [position] AT OR BEFORE [time] AT [altitude]	N/A	D	
60	CROSS [position] AT OR AFTER [time] AT [altitude]	N/A	D	
61	CROSS [position] AT AND MAINTAIN [altitude] AT [speed]	N/A	D	
62	AT [time] CROSS [position] AT AND MAINTAIN [altitude]	N/A	D	
63	AT [time] CROSS [position] AT AND MAINTAIN [altitude] AT [speed]	N/A	D	

UL#	Lateral Offsets	DL#	D,P,L	Additional Information
64	OFFSET [direction] [distanceOffset]	15	D,L	
65	AT [position] OFFSET [direction] [distanceOffset]	16	D	
66	AT [time] OFFSET [direction] [distanceOffset]	17	D	
67	PROCEED BACK ON ROUTE	N/A	D	
68	REJOIN ROUTE BY [position]	N/A	D	
69	REJOIN ROUTE BY [time]	N/A	D	
70	EXPECT BACK ON ROUTE BY [position]	51	D	
71	EXPECT BACK ON ROUTE BY [time]	51	D	
72	RESUME OWN NAVIGATION	N/A	D	

UL#	Route Modifications	DL#	D,P,L	Additional Information
73	PREDEPARTURE CLEARANCE	25	P,L	Print to see full text of [predepartureClearance].
74	PROCEED DIRECT TO [position]	22	D,L	
75	WHEN ABLE PROCEED DIRECT TO [position]	N/A	D,L	
76	AT [time] PROCEED DIRECT TO [position]	N/A	D	
77	AT [position] PROCEED DIRECT TO [position]	N/A	D,L	
78	AT [altitude] PROCEED DIRECT TO [position]	N/A	D	
79	CLEARED TO [position] VIA ROUTE CLEARANCE	26	P,L	Print to see full text of [routeclearance].
80	CLEARED ROUTE CLEARANCE	24, 25	P,L	Print to see full text of [routeclearance].
81	CLEARED [procedureName]	23	D,L	
82	CLEARED TO DEVIATE UP TO [direction] [distanceOffset]	27	D	
83	AT [position] CLEARED ROUTE CLEARANCE	N/A	P,L	Print to see full text of [routeclearance].
84	AT [position] CLEARED [procedureName]	N/A	D	
85	EXPECT ROUTE CLEARANCE	N/A	P	Print to see full text of [routeclearance].
86	AT [position] EXPECT ROUTE CLEARANCE	N/A	P	Print to see full text of [routeclearance].
87	EXPECT DIRECT TO [position]	N/A	D	
88	AT [position] EXPECT DIRECT TO [position]	N/A	D	
89	AT [time] EXPECT DIRECT TO [position]	N/A	D	
90	AT [altitude] EXPECT DIRECT TO [position]	N/A	D	
91	HOLD AT [position] MAINTAIN [altitude] INBOUND TRACK [degrees]/[direction] TURN LEGTIME [legType]	N/A	D	"LEGTIME" or "LEGDIST" displayed depending on [legType].
92	HOLD AT [position] AS PUBLISHED MAINTAIN [altitude]	N/A	D	
93	EXPECT FURTHER CLEARANCE AT [time]	N/A	D	
94	TURN [direction] HEADING [degrees]	70	D	
95	TURN [direction] GROUND TRACK [degrees]	71	D	
96	FLY PRESENT HEADING	N/A	D	
97	AT [position] FLY HEADING [degrees]	N/A	D	
98	IMMEDIATELY TURN [direction] HEADING [degrees]	N/A	D	
99	EXPECT [procedureName]	N/A	D	
178	Message not supported, no display on XXXX ATC UPLINK page	N/A		

UL#	Speed Changes	DL#	D,P,L	Additional Information
100	AT [time] EXPECT [speed]	49	D	
101	AT [position] EXPECT [speed]	49	D	
102	AT [altitude] EXPECT [speed]	49	D	
103	AT [time] EXPECT [speed] TO [speed]	50	D	Note: DL#50 is not supported in this software version
104	AT [position] EXPECT [speed] TO [speed]	50	D	Note: DL#50 is not supported in this software version
105	AT [altitude] EXPECT [speed] TO [speed]	50	D	Note: DL#50 is not supported in this software version
106	MAINTAIN [speed]	18	D	
107	MAINTAIN PRESENT SPEED	N/A	D	
108	MAINTAIN [speed] OR GREATER	N/A	D	
109	MAINTAIN [speed] OR LESS	N/A	D	
110	MAINTAIN [speed] TO [speed]	19	D	Note: DL#19 is not supported in this software version
111	INCREASE SPEED TO [speed]	18	D	
112	INCREASE SPEED TO [speed] OR GREATER	18	D	
113	REDUCE SPEED TO [speed]	18	D	
114	REDUCE SPEED TO [speed] OR LESS	18	D	
115	DO NOT EXCEED [speed]	N/A	D	
116	RESUME NORMAL SPEED	N/A	D	

UL#	Contact/Monitor/Surveillance Requests	DL#	D,P,L	Additonal Information
117	CONTACT [icaoUnitName] ON [frequency]	20, 21	D	
118	AT [position] CONTACT [icaoUnitName] ON [frequency]	N/A	D	
119	AT [time] CONTACT [icaoUnitName] ON [frequency]	N/A	D	
120	MONITOR [icaoUnitName] ON [frequency]	N/A	D	
121	AT [position] MONITOR [icaoUnitName] ON [frequency]	N/A	D	
122	AT [time] MONITOR [icaoUnitName] ON [frequency]	N/A	D	
123	SQUAWK [beaconCode]	N/A	D	
124	STOP SQUAWK	N/A	D	
125	SQUAWK ALTITUDE	N/A	D	
126	STOP ALTITUDE SQUAWK	N/A	D	
179	SQUAWK IDENT	N/A	D	

UL#	Report/Confirmation Requests	DL#	D,P,L	Additional Information
127	REPORT BACK ON ROUTE	41	D	
128	REPORT LEAVING [altitude]	28	D	
129	REPORT LEVEL [altitude]	37	D	
130	REPORT PASSING [position]	31	D	
131	REPORT REMAINING FUEL AND SOULS ON BOARD	57	D	
132	CONFIRM POSITION	33	D	
133	CONFIRM ALTITUDE	32	D	DL #'s 29 or 30 may also be sent as specified in table 4
134	CONFIRM SPEED	34	D	
135	CONFIRM ASSIGNED ALTITUDE	38, 77	D	
136	CONFIRM ASSIGNED SPEED	39	D	
137	CONFIRM ASSIGNED ROUTE	40	D	DL # 80 may also be sent as specified in table 4
138	CONFIRM TIME OVER REPORTED WAYPOINT	46	D	
139	CONFIRM REPORTED WAYPOINT	45	D	
140	CONFIRM NEXT WAYPOINT	42	D	DL # 80 may also be sent as specified in table 4
141	CONFIRM NEXT WAYPOINT ETA	43	D	
142	CONFIRM ENSUING WAYPOINT	44	D	DL # 80 may also be sent as specified in table 4
143	CONFIRM REQUEST	mult	D	
144	CONFIRM SQUAWK	47	D	
145	CONFIRM HEADING	35	D	
146	CONFIRM GROUND TRACK	36	D	
147	REQUEST POSITION REPORT	48	D	DL #'s 29, 30or 80 may also be sent as specified in table 4
175	REPORT REACHING [altitude]	72	D	
180	REPORT REACHING BLOCK [altitude] TO [altitude]	76	D	
181	REPORT DISTANCE [tofrom][position]	78	D	"TO" or "FROM" displayed depending on [toFrom] value.
182	CONFIRM ATIS CODE	79	D	

UL#	Negotiation Requests	DL#	D,P,L	Additional Information
148	WHEN CAN YOU ACCEPT [altitude]	67b, 67e	D	
149	CAN YOU ACCEPT [altitude] AT [position]	N/A	D	
150	CAN YOU ACCEPT [altitude] AT [time]	N/A	D	
151	WHEN CAN YOU ACCEPT [speed]	67c, 67f	D	
152	WHEN CAN YOU ACCEPT [direction] [distanceOffset] OFFSET	67d,67 g	D	

UL#	Air Traffic Advisories	DL#	D,P,L	Additional Information
153	ALTIMETER [altimeter]	N/A	D	
154	RADAR SERVICES TERMINATED	N/A	D	
155	RADAR CONTACT [position]	N/A	D	
156	RADAR CONTACT LOST	N/A	D	
157	CHECK STUCK MICROPHONE [frequency]	N/A	D	
158	ATIS [atisCode]	N/A	D	

UL#	System Management Messages	DL#	D,P,L	Additional Information
159	DOWNLINK ERROR	mult	D	
160	system message (NEXT DATA AUTHORITY), no display on XXXXz ATC UPLINK page	N/A		[icaoUnitName] displayed on ATC LOGON/STATUS page as 'NEXT CTR'.
161	system message (END SERVICE), no display on XXXXz ATC UPLINK page	N/A		Upon receipt, FMC will discontinue communication with ACT CTR and NEXT CTR becomes new ACT CTR.
162	SERVICE UNAVAILABLE	N/A	D	
163	system message ([icaoUnitName] [tp4Table]), no display on XXXXz ATC UPLINK page	73		[icaoUnitName] displayed on ATC LOGON/STATUS page as 'ACT CTR'.

UL#	Additional Messages	DL#	D,P,L	Additional Information
164	WHEN READY	mult	D	
165	THEN	mult	D	
166	DUE TO TRAFFIC	mult	D	
167	DUE TO AIRSPACE RESTRICTION	mult	D	
168	DISREGARD	mult	D	
169	[freetext]	mult	D	
170	[freetext]	mult	D	
176	MAINTAIN OWN SEPARATION AND VMC	mult	D	
177	AT PILOTS DISCRETION	mult	D	

A.2 [POSITION] AND [ROUTECLEARANCE] VARIABLE LOADING

a. [position] LOADING

The following rules for [position] loading apply to standalone [position] variables, as in message element 77, and to those embedded in the [routeclearance] variable.

In the message structure defined in DO-219, the [position] variable is defined as a choice of ‘fixname’, ‘navaid’, ‘airport’, ‘latitudeLongitude’, or ‘placebearingdistance’. The first three choices have "overlapping" definitions. [Fixname] is an IA5String (Size(1..5)); [navaid] is an IA5String (Size(1..4)); and [airport] is an IA5String (Size(4)). Consequently, a 1, 2, or 3 character identifier could be encoded as a [fixname] or [navaid], and a four character identifier could be encoded as any of the first three [position] choices.

The FMC NDB is configured to the ARINC 424 specification, which defines the record structure and naming conventions for NDB data. When the FMC receives an uplink with a loadable message element containing the [position] variable, it uses the [position] choice to determine which of its NDB records to search for a matching identifier. This is required in order for the FMC to be able to load the uplinked [position] into the flight plan.

For example, if an uplink with a [position] choice of 'navaid' is received, the FMC will search only the NDB Navaid record for a matching identifier. Similarly, the ‘airport’ choice leads to a search of the NDB airport record and the ‘fixname’ choice leads to a search of the NDB waypoint record and the NDB non-directional beacon record (explained further below).

If a match is not found, then the FMC will not load the specified [position] into the flight plan. Limiting the search in this manner (i.e., as opposed to searching all NDB records, irrespective of the [position] choice) decreases, but does not eliminate, the likelihood of the FMC finding duplicate matching identifiers.

There are also many non-directional beacons which have the same names as the VHF navaids to which they lie close. ARINC 424 allows an implementor the option of modifying the names of the non-directional beacons (by adding an NB) suffix and adding the entries to the waypoint record; or creating a separate non-directional beacon record. The FMC NDB has a separate record for non-directional beacons. Since there is no DO-219 [position] choice for non-directional beacons, a Non-directional Beacon included in a loadable [position] variable has to be defined with a choice of ‘fixname’, in order for the FMC to look for a match in its Non-directional Beacon record for a matching identifier.

The FMC will create a waypoint at the specified [position] when the ‘latitudeLongitude’ choice is selected.

If the ‘placebearingdistance’ choice is selected, the [fixname] must match an identifier in the FMC Navigation Database (waypoint, navaid, airport, or non-directional beacon), otherwise, the [fixname] and the corresponding [placebearingdistance] are not loadable.

Any [placebearingdistance] with a [distance] choice of 1 (distancekm) is not loadable.

Any [distancenm] greater than 700nm is not loadable.

b. [routeclearance] LOADING

The FMC has the capability to store 2 routes, designated as route 1 and route 2. The route which defines the flight plan along which the airplane is to be flown is the active route. For elements 73 and 80, the "selected route" is the active route, if one exists, else the empty route, if one route is empty, else, route 1. For elements 79 and 83, the selected route is the active route.

When loaded, elements 73 and 80 replace the entire existing route, unless the uplinked route does not include an [airportdeparture] and/or an [airportdestination]. If either of these is absent in the uplink, then the FMC will retain the departure or destination airport, as appropriate, from the existing route.

When loaded, elements 79 and 83 modify, but do not replace, the existing route.

Variable Name	**Loaded into the selected flight plan as:**	**Additional information**
[airportdeparture]	origin airport for the selected route	The [airportdeparture] variable is not loadable if the [airport] identifier does not match an identifier in the FMC Navigation Database. Otherwise, the [airportdeparture] is loadable.
[airportdestination]	destination airport for the selected route	The [airportdestination] variable is not loadable if the [airport] identifier does not match an identifier in the FMC Navigation Database. Otherwise, the [airportdestination] is loadable.
[runwaydeparture] [runway] [runwaydirection] [runwayconfiguration]	departure runway direction and configuration for the selected route	The [runwaydeparture] variable is not loadable if the [runway] [runwaydirection] and [runwayconfiguration] do not match a runway identifier for the applicable origin airport in the FMC Navigation Database. Otherwise, the [runwaydeparture] is loadable.
[proceduredeparture] [procedurename] [procedure] [proceduretransition]	departure procedure and departure transition for the selected route	The [proceduredeparture] variable is not loadable if the [proceduretype] choice is 0 (arrival) or 1 (approach). The [proceduredeparture] is not loadable if the [procedure], or [procedure] and [proceduretransition], do not match a departure procedure identifier, or departure procedure and transition identifiers, for the applicable origin airport in the FMC Navigation Database. Otherwise, the [proceduredeparture] is loadable.
[runwayarrival] [runway] [runwaydirection] [runwayconfiguration]	arrival runway direction and configuration for the selected route	The [runwayarrival] variable is not loadable if the [runway] [runwaydirection] and [runwayconfiguration] do not match a runway identifier for the applicable destination airport in the FMC Navigation Database. Otherwise, the [runwayarrival] is loadable

Variable Name	Loaded into the selected flight plan as:	Additional information
[procedureapproach] [procedurename] [procedure] [proceduretransition]	approach procedure and approach transition for the selected route	The [procedureapproach] variable is not loadable if the [proceduretype] choice is 0 (arrival) or 2 (departure). The [procedureapproach] is not loadable if the [procedure], or [procedure] and [proceduretransition], do not match an approach procedure identifier, or approach procedure and transition identifiers, for the applicable destination airport in the FMC Navigation Database. Approach procedures with eight-character identifiers (e.g., ILS2 24L) are loadable provided that the approach type and multiple approach character code (e.g., ILS2) are encoded as the [procedureapproach] variable and the runway number and direction (e.g., 24L) are encoded into the [runwayarrival] variable. Note that breaking the procedure identifier in this manner is necessary, as the DO-219 [procedurename] variable has a maximum size of 6 characters. Otherwise, the [procedureapproach] is loadable
[procedurearrival] [procedurename] [procedure] [proceduretransition]	arrival procedure and arrival transition for the selected route	The [procedurearrival] variable is not loadable if the [proceduretype] choice is 1 (approach) or 2 (departure). The [procedurearrival] is not loadable if the [procedure], or [procedure] and [proceduretransition], do not match an arrival procedure identifier, or arrival procedure and transition identifiers, for the applicable destination airport in the FMC Navigation Database. Otherwise, the [procedurearrival] is loadable
[airwayintercept]	the first airway in the en route portion of the selected route; the FMC automatically selects the point at which the airplane should join the airway.	Any [airwayintercept] variable which does not match an airway identifier in the FMC Navigation Database is not loadable. Any [airwayintercept] for which the point at which the airplane is to leave the airway is not defined by a [publishedidentifier] encoded as the first item in the [routeinformation] is not loadable. Otherwise, the [airwayintercept] is loadable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformation] [publishedidentifier] [latitudelongitude] [placebearingplacebearing] [placebearingdistance] [airwayidentifier] [trackdetail]	en route data for the selected route	The FMC ignores (and does not attempt to load) any [trackdetail] encoded in the [routeinformation] portion of a [routeclearance] variable. Any [publishedidentifier] [fixname], [placebearingdistance] [fixname] or [placebearingplacebearing] [fixname], for which the [fixname] does not match an identifier in the FMC Navigation Database (waypoint, navaid, airport, or non-directional beacon), is not loadable. In addition, the [publishedidentifier][fixname] can be a runway identifier and is loadable if the runway identifier is appropriate for the arrival airport. Any [airwayidentifier] which does not match an airway identifier in the FMC Navigation Database is not loadable. Any [airwayidentifier] for which the point at which the airplane is to join the airway is not defined by a [publishedidentifier] or by another [airwayidentifier] immediately preceding the [airwayidentifier] in the [routeinformation] is not loadable. Any [airwayidentifier] for which the point at which the airplane is to leave the airway is not defined by a [publishedidentifier] or by another [airwayidentifier] immediately following the [airwayidentifier] in the [routeinformation] is not loadable. Any [placebearingdistance] with a [distance] choice of 1 (distancekm) is not loadable. Any [distancenm] greater than 700nm is not loadable. The FMC attempts to load all other [routeinformation] variables into the selected route in the order in which they occur in the [routeinformation] variable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional]		
[routeinformationadditional] [atwalongtrackwaypoint-sequence] [atwalongtrackwaypoint]	place-bearing-distance (PBD) waypoint	When the [aTWalongtrackwaypoint] [position], [aTWdistance], and [aTWdistancetolerance] are all loadable (see below), the FMC converts these to a PBD and then inserts the resulting PBD into the correct location in the selected route
[routeinformationadditional] [atwalongtrackwaypoint] [position]		If the [position] does not match any of the following: a) a loadable [publishedidentifier] or [placebearingdistance] in the uplinked [routeinformation], b) a waypoint on an airway defined by an [airwayidentifier] in the uplinked [routeinformation], c) a fix in a [proceduredeparture], [procedurearrival], or [procedureapproach] included in the uplinked [routeclearance] d) the [position] portion of element 79 or 83, then the [position] (and the [aTWalongtrackwaypoint]) is not loadable. Otherwise, the [position] is loadable and is used to convert the along track waypoint to a PBD, as stated above.
[routeinformationadditional] [atwalongtrackwaypoint] [aTWdistance] [aTWdistancetolerance] [distance]		If the [aTWdistance] [distance] choice is 1 (distancekm), then the [aTWdistance] (and the [aTWalongtrackwaypoint]) is not loadable. If the resulting ATW would not fall between the [position] and the preceding or following waypoint or if the [distancenm] is greater than 700nm, then the [aTWdistance] (and the [aTWalongtrackwaypoint]) is not loadable. Otherwise the [distance] is loadable, and the [distance] and [aTWdistancetolerance] are used to covert the along track waypoint to a PBD, as stated above.
[routeinformationadditional] [atwalongtrackwaypoint] [speed]	speed constraint for the corresponding along track waypoint (PBD)	If the speed choice is anything other than choice 0 (speedindicated) or if the [speedindicated] value is less than 10 (100kts), then the [speed] is not loadable. If there is no [aTWaltitude] defined for the corresponding [aTWalongtrackwaypoint] or the [aTWaltitude][altitude] is not loadable (see below), then the [speed] is not loadable. Otherwise, the [speed] is loadable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional] [aTWalongtrackwaypoint-sequence] [aTWaltitudesequence] [aTWaltitude] [aTWaltitudetolerance] [altitude]	AT, AT OR ABOVE or AT OR BELOW altitude constraint or window altitude constraint for the corresponding along track waypoint (PBD)	If the [altitude] choice for either altitude in the [aTWaltitudesequence] is anything other than choice 0 (altitudeqnh), 1 (altitudeqnhmeters), or 6 (altitudeflightlevel), then the [aTWaltitude] [altitude] is not loadable. If the value for a single [aTWaltitude] or the first [altitude] in the [aTWaltitudeseqence] is at or above the current cruise altitude, then that [aTWaltitude] [altitude] is not loadable. Otherwise the [aTWaltitude] [altitude] and [altitudetolerance] are loadable.
[routeinformationadditional] [reportingpoints] [latlonreportingpoints] [latitudereportingpoints] [latitudedirection] [latitudedegrees] [longitudereportingpoints] [longitudedirection] [longitudedegrees] [degreeincrement]	latitude/longitude waypoint or series of latitude/longitude waypoints	If a latitude defined by a [latitudedirection] and [latitudedegrees], or a longitude defined by a [longitudedirection] and [longitudedegrees], does not intersect the selected route, then the [latlonreportingpoints] is not loadable. If a latitude defined by a [latitudedirection] and [latitudedegrees], or a longitude defined by a [longitudedirection] and [longitudedegrees], does intersect the selected route, then the FMC will insert a latitude/longitude waypoint at the intersection point. If the [degreeincrement] is included, then the FMC will insert reporting points at intervals along the selected route, as defined by the [degreesincrement] along the direction of flight starting at the intersection point.
[routeinformationadditional] [interceptcoursefromsequence] [interceptcoursefrom]	intercept course from waypoint	When the [interceptcoursefrom] [interceptcoursefromselection] and [degrees] are both loadable (see below), the FMC inserts the intercept course from waypoint into the correct location in the selected route If, after loading, the pilot does not terminate the intercept course from leg, then it remains an intercept course from leg in the flight plan. If, after loading, the pilot does terminate the intercept course from leg, then the FMC creates a latitude longitude waypoint at the termination point and the intercept course from leg no longer exists.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional] [interceptcoursefromsequence] [interceptcoursefrom] [interceptcoursefromselect-ion]		If the [interceptcoursefromselection] does not match any of the following: a) a loadable [publishedidentifier], [latitudelongitude], [placebearingplacebearing], or [placebearingdistance] in the uplinked [routeinformation], b) a waypoint on an airway defined by an [airwayidentifier] in the uplinked [routeinformation], c) a fix in a [proceduredeparture], [procedurearrival], or [procedureapproach] included in the uplinked [routeclearance] d) the [position] portion of element 79 or 83, then the [interceptcoursefromselection] (and the [interceptcoursefrom]) is not loadable. Otherwise, the [interceptcoursefromselection] is loadable.
[routeinformationadditional] [interceptcoursefromsequence] [interceptcoursefrom] [degrees]		[degrees] is loadable, irrespective of the [degrees] choice

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional] [holdatwaypointsequence] [holdatwaypoint]	Hold position and associated data for a given holding pattern in the selected route	If the [position] is loadable (see below), the [holdatwaypoint] is loadable regardless of whether any of the associated data exist or are not loadable. The FMC has pre-defined defaults for the associated data.
[routeinformationadditional] [holdatwaypoint] [position]	position for a given hold in the selected route	If the [position] does not match any of the following: a) a loadable [publishedidentifier], [latitudelongitude], or [placebearingdistance] in the uplinked [routeinformation], b) a waypoint on an airway defined by an [airwayidentifier] in the uplinked [routeinformation], c) a fix in a [proceduredeparture], [procedurearrival], or [procedureapproach] included in the uplinked [routeclearance] d) the [position] portion of element 79 or 83, then the [position] (and the [holdatwaypoint]) is not loadable. Otherwise, the [position] is loadable.
[routeinformationadditional] [holdatwaypoint] [holdatwaypointspeedlow]	speed constraint associated with a given hold in the selected route	If both the [holdatwaypointspeedlow] and [holdatwaypointspeedhigh] variables are specified, then the FMC ignores (and does not attempt to load) either speed. If the [holdatwaypointspeedlow] [speed] choice is anything other than choice 0 (speedindicated) or if the [speed] value is less than 10 (100kts), then the [holdatwaypointspeedlow] is not loadable. If there is no [aTWaltitude] defined for the corresponding [holdatwaypoint] [position] or the [aTWaltitude][altitude] is not loadable (see below), then the [holdatwaypointspeedlow] is not loadable. Otherwise, the [holdatwaypointspeedlow] is loadable.
[routeinformationadditional] [holdatwaypoint] [aTWaltitude] [aTWaltitudetolerance] [altitude]	AT, AT OR ABOVE or AT OR BELOW altitude constraint associated with a given hold in the selected route	If the [altitude] choice is anything other than choice 0 (altitudeqnh), 1 (altitudeqnhmeters), or 6 (altitudeflightlevel), then the [aTWaltitude] [altitude] is not loadable. If the value for the [aTWaltitude] is above the current cruise altitude, then that [aTWaltitude] [altitude] is not loadable. Otherwise the [aTWaltitude] [altitude] and [altitudetolerance] are loadable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional] [holdatwaypoint] [holdatwaypointspeedhigh]	speed constraint associated with a given hold in the selected route	If both the [holdatwaypointspeedlow] and [holdatwaypointspeedhigh] variables are specified, then the FMC ignores (and does not attempt to load) either speed. If the [holdatwaypointspeedhigh] [speed] choice is anything other than choice 0 (speedindicated), or if the [speed] value is less than 10 (100 kts), then the [holdatwaypointspeedhigh] is not loadable. If there is no [aTWaltitude] defined for the corresponding [holdatwaypoint] [position] or the [aTWaltitude][altitude] is not loadable (see above), then the [holdatwaypointspeedhigh] is not loadable. Otherwise, the [holdatwaypointspeedhigh] is loadable.
[routeinformationadditional] [holdatwaypoint] [direction]	Turn direction associated with a given hold in the selected route	If the [direction] choice is anything other than choice 0 (left) or 1 (right), then the [direction] is not loadable. Otherwise, the [direction] is loadable.
[routeinformationadditional] [holdatwaypoint] [degrees]	Inbound course associated with a given hold in the selected route	
[routeinformationadditional] [holdatwaypoint] [EFCtime]	Expect Further Clearance Time associated with a given hold in the selected route	
[routeinformationadditional] [holdatwaypoint] [legtype]	Leg Distance, if specified for a given hold in the selected route. Otherwise, Leg Time associated with a given hold in the selected route	When the [legtype] is [legdistance] and the [legdistance] choice is 1 (legdistancemetric) then the [legdistance] is not loadable. Otherwise, the [legtype] is loadable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[routeinformationadditional] [waypointspeedaltitude]	speed, altitude, and associated position for a given waypoint speed and altitude or altitude-only constraint in the selected route	
[routeinformationadditional] [waypointspeedaltitude] [position]	position of a waypoint in the selected route which has a corresponding speed and altitude or altitude-only constraint	If the [position] does not match any of the following: a) a loadable [publishedidentifier], [latitudelongitude], or [placebearingdistance] in the uplinked [routeinformation], b) a waypoint on an airway defined by an [airwayidentifier] in the uplinked [routeinformation], c) a fix in a [proceduredeparture], [procedurearrival], or [procedureapproach] included in the uplinked [routeclearance] d) the [position] portion of element 79 or 83, then the [position] (and the [waypointspeedaltitude]) is not loadable. Otherwise, the [position] is loadable..
[routeinformationadditional] [waypointspeedaltitude] [speed]	speed portion of speed and altitude constraint for a waypoint in the selected route	If the [speed] choice is anything other than choice 0 (speedindicated)) or if the [speed] value is less than 10 (100kts), then the [speed] is not loadable. If there is no [aTWaltitude] defined for the corresponding [waypointspeedaltitude] [position] or the [aTWaltitude][altitude] is not loadable (see below), then the [speed] is not loadable. Otherwise, the [speed] is loadable.
[routeinformationadditional] [waypointspeedaltitude] [ATWaltitudesequence]	AT, AT OR ABOVE, or AT OR BELOW altitude constraint or window altitude constraint for the corresponding [waypointspeedaltitude] [position]	If the [altitude] choice for either altitude in the [aTWaltitudesequence] is anything other than choice 0 (altitudeqnh), 1 (altitudeqnhmeters), or 6 (altitudeflightlevel), then the [aTWaltitude] [altitude] is not loadable. If the value for a single [aTWaltitude] or the first [altitude] in the [aTWaltitudseqence] is at or above the current cruise altitude, then that [aTWaltitude] [altitude] is not loadable. Otherwise the [aTWaltitude] [altitude] and [altitudetolerance] are loadable.

Variable Name	Loaded into the selected flight plan as:	Additional information
[RTArequiredtimeofarrival]	RTA on the specified position in the selected route	When the [RTArequiredtimeofarrival] [position] is loadable (see below), the FMC applies the RTA to the specified position in the selected route.
[RTArequiredtimeofarrival] [position]	position of a waypoint in the selected route which has an RTA applied to it	If the [position] does not match: a) a loadable [publishedidentifier], [latitudelongitude], or [placebearingdistance] in the uplinked [routeinformation], b) a waypoint on an airway defined by an [airwayidentifier] in the uplinked [routeinformation], c) a fix in a [proceduredeparture], [procedurearrival], or [procedureapproach] included in the uplinked [routeclearance] d) the [position] portion of element 79 or 83, then the [position] (and the [RTArequiredtimeofarrival]) is not loadable. Otherwise, the [RTArequiredtimeofarrival] is loadable.
[RTArequiredtimeofarrival] [RTAtime]]	[RTAtime] and [timetolerance] for the specified [position]	
[RTArequiredtimeofarrival] [RTAtolerance]	NOT USED	

A.3 DOWNLINK MESSAGE ELEMENT TABLE

The downlink message element table is divided by message type. The columns in the tables are defined below.

Downlink Message Element # (DL#): The FMC selects the appropriate downlink message element number based on the response, request or report messages created by the flight crew. The FMC sends the downlink message element number and variable data in the downlink.

Message Element Text: The second column shows the text, with the selected data inserted appropriately, which is displayed to the flight crew as verification of the downlink message.

Associated Uplink Message Element # (UL#): This column is for commentary only. For requests, the uplink message element(s) identified is the clearance the crew would operationally expect to receive. For reports, the uplink message element(s) identified is the request for which the crew would operationally be expected to generate the downlink. 'Mult' indicates that multiple uplink message elements could be related to the downlink message element. 'N/A' indicates that there is no related clearance or request for report.

FMC Provisions (P, E, N): Text and default data or selection prompts to solicit data entry or message selection are provided for those message elements marked 'P'. Text and box or dash prompts to solicit data entry are provided for those message elements marked 'E'. No selection or entry provisions are provided for those message elements marked 'N'.

Additional Information: This column provides additional information regarding message usage, display format, and data defaults.

DL#	Responses	UL#	P,E,N	Additional Information
0	WILCO	mult	P	ACCEPT prompt provided. WILCO is sent if appropriate for uplink message.
1	UNABLE	mult	P	REJECT prompt provided. UNABLE is sent if appropriate for uplink message.
2	STANDBY	mult	P	STANDBY prompt provided if appropriate for uplink message.
3	ROGER	mult	P	ACCEPT prompt provided. ROGER is sent if appropriate for uplink message.
4	AFFIRM	mult	P	ACCEPT prompt. AFFIRM is sent if appropriate for uplink message.
5	NEGATIVE	mult	P	REJECT prompt provided. NEGATIVE is sent if appropriate for uplink message.

DL#	Vertical Requests	UL#	P,E,N	Additional Information
6	REQUEST [altitude]	19	E	Selected when alt. entry within +/-150' of current alt.
7	REQUEST BLOCK [altitude] TO [altitude]	30, 31, 32	E	Selected when xxxxx/xxxxx entered in ALTITUDE request field.
8	REQUEST CRUISE CLIMB TO [altitude]	34	P,E	Selected when alt. entry > 150' above current alt. and CRZ CLB prompt selected.
9	REQUEST CLIMB TO [altitude]	20, 26, 27	E	Select when alt. entry > 150' above current alt.
10	REQUEST DESCENT TO [altitude]	23, 28, 29	E	Selected when alt. entry > 150' below current alt.
11	AT [position] REQUEST CLIMB TO [altitude]	22	E	Selected when alt. entry > 150' above current alt. and pos. entered. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
12	AT [position] REQUEST DESCENT TO [altitude]	25	E	Selected when alt. entry > 150' below current alt. and pos. entered. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
13	AT [time] REQUEST CLIMB TO [altitude]	21	E	Selected when alt. entry > 150' above current alt. and time entered.
14	AT [time] REQUEST DESCENT TO [altitude]	24	E	Selected when alt. entry > 150' below current alt. and time entered.
69	(message not supported)	N/A		

DL#	Lateral Off-Set Requests	UL#	P,E,N	Additional Information
15	REQUEST OFFSET [direction] [distanceOffset]	64	E	Selected when offset entered.
16	AT [position] REQUEST OFFSET [direction] [distanceOffset]	65	E	Selected when offset and pos. entered. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
17	AT [time] REQUEST OFFSET [direction] [distanceOffset]	66	E	Selected when offset and time entered.

DL#	Speed Requests	UL#	P,E,N	Additional Information
18	REQUEST [speed]	106, 111-114	E	Selected when speed entered.
19	(message not supported)	110		

DL#	Voice Contact Requests	UL#	P,E,N	Additional Information
20	REQUEST VOICE CONTACT	117	P	
21	(message not supported)	117		

DL#	Route Modification Requests	UL#	P,E,N	Additional Information
22	REQUEST DIRECT TO [position]	74	E	Selected when position entered. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
23	REQUEST [procedureName]	81	P	On ground, defaults to departure procedure selected on DEPARTURES page; in air, defaults to arrival or approach procedure selected on ARRIVALS pages.
24	REQUEST ROUTE CLEARANCE RTE[x] or REQUEST ROUTE CLEARANCE MODIFIED RTE[x]	80	P	Select RTE1 or RTE2. Provisional route will be sent if pending modification to selected route exists. Print to see full text of [routeclearance].
25	REQUEST CLEARANCE	73,80	P	
26	(message not supported)	79		
27	REQUEST WEATHER DEVIATION UP TO [direction] [distanceOffset]	82	P, E	Selected when offset entered and DUE TO WEATHER selected.
70	REQUEST HEADING [degrees]	94	E	Selected when heading entered.
71	REQUEST GROUND TRACK [degrees]	95	E	Selected when ground track entered.

DL#	Reports	UL#	P,E,N	Additional Information
28	LEAVING [altitude]	128	N	[altitude] default based on uplink.
29	CLIMBING TO [altitude]	133	P	[altitude] defaults to MCP alt.; transmitted with DL#s 32 and 48 when MCP alt > 150 ft above baro-corrected altitude
30	DESCENDING TO [altitude]	133	P	[altitude] defaults to MCP alt.; transmitted with DL#s 32 and 48 when MCP alt > 150 ft below baro-corrected altitude
31	PASSING [position]	130	N	[position] default based on uplink.
32	PRESENT ALTITUDE [altitude]	133	P	[altitude] defaults to baro-corrected alt
33	PRESENT POSITION [position]	132	P	[position] defaults to Master FMC lat./lon. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
34	PRESENT SPEED [speed]	134	P	[speed] defaults to speed in Mach when above 29000; in CAS, otherwise.
35	PRESENT HEADING [degrees]	145	P	[degrees] defaults to Master FMC magnetic or true heading.
36	PRESENT GROUND TRACK [degrees]	146	P	[degrees] defaults to Master FMC magnetic or true ground track.
37	LEVEL [altitude]	129	N	[altitude] default based on uplink.
38	ASSIGNED ALTITUDE [altitude]	135	P	[altitude] defaults to MCP alt.
39	ASSIGNED SPEED [speed]	136	E	[speed] defaults to speed in Mach when above 29000; in CAS, otherwise.
40	ASSIGNED ROUTE RTE[x]	137	N	[routeClearance] set to active route; RTE1 or RTE2 displayed on VERIFY REPORT page.
41	BACK ON ROUTE	127	N	
42	NEXT WAYPOINT [position]	140	P	[position] defaults to Master FMC active route active waypoint. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
43	NEXT WAYPOINT ETA [time]	141	P	[time] defaults to Master FMC active route active waypoint ETA.
44	ENSUING WAYPOINT [position]	142	P	[position] defaults to Master FMC active route next waypoint. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
45	REPORTED WAYPOINT [position]	139	P	[position] defaults to Master FMC active route last waypoint. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
46	REPORTED WAYPOINT [time]]	138	P	[time] defaults to Master FMC active route last waypoint ATA.
47	SQUAWKING [beaconCode]	144	E	Box prompts displayed.
48	POSITION REPORT	147	P	[positioncurrent] = Master FMC lat./lon. at time message created; [timeatpositioncurrent] = time at which message created; [altitude] = left ADC baro-corrected alt at time message is created; [fixnext] = Master FMC active route active waypoint; [timeetaatfixnext] = Master FMC active route active waypoint ETA; [fixnextplusone] = Master FMC active route next waypoint; [timeetadestination] = master FMC destination ETA; [temperature] = SAT in deg C; [winds] = Master FMC wind speed in English and direction; [speed] = Master FMC Mach target; [reportedwaypointposition] = Master FMC active route last waypoint, [reportedwaypointtime] = Master FMC active route last waypoint ATA; [reportedwaypointaltitude] = altitude at the last (sequenced) waypoint. When the [fixnext], [fixnextplusone], or [reportedwaypointposition] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude] will be included in the downlink. An abbreviated position report is transmitted with DL#56 (see table 4)
72	REACHING [altitude]	175	N	[altitude] default based on uplink.
76	REACHING BLOCK [altitude] TO [altitude]	180	N	[altitudes] default based on uplink.
77	ASSIGNED BLOCK [altitude] TO [altitude]	135	P	Selection when xxxxx to xxxxx entered.

78	AT [time] [distance] [toFrom] [position]	181	P	[time] defaults to current time; [Distance] default based on Master FMC prediction; [toFrom] and [position] defaults based on uplink.
79	ATIS [atisCode]	182	E	Box prompt displayed.
80	DEVIATING [direction][distanceoffset] OF ROUTE	137, 140, 142, 147	P	Defaults to offset displayed on active RTE page. Automatically transmitted with DL#'s 40, 42, 44, and 48 when offset active.

DL#	Negotiation Requests	**UL#**	P,E,N	Additional Information
49	WHEN CAN WE EXPECT [speed]	100-102	E	Selected when [speed] entered.
50	(message not supported)	103-105		
51	WHEN CAN WE EXPECT BACK ON ROUTE	70, 71	P	
52	WHEN CAN WE EXPECT LOWER ALTITUDE	9, 10,15, 16	P	
53	WHEN CAN WE EXPECT HIGHER ALTITUDE	7, 8,13, 14	P	
54	WHEN CAN WE EXPECT CRUISE CLIMB TO [altitude]	17, 18	E	Selected when altitude entered.

DL#	**Emergency Messages**	**UL#**	**P,E,N**	**Additional Information**
55	PAN PAN PAN	N/A	P	Message is intended to be sent alone, not in combination with 56-61.
56	MAYDAY MAYDAY MAYDAY	N/A	P	
57	[remainingFuel] OF FUEL REMAINING AND [remainingSouls] SOULS ON BOARD	131	P, E	Fuel defaults to minimum of Master FMC or totalizer values, in time remaining (hh+mm); box prompts for SOB. Can also send data in an Emergency Report.
58	CANCEL EMERGENCY	N/A	P	
59	DIVERTING TO [position] or DIVERTING TO [position] VIA ROUTE[x]	N/A	P	Position defaults to active destination; [routeClearance] set to active route if [position] in active or modified route. When the [position] choice is [placebearingdistance] and the FMC determines that the associated [fixname] identifier has duplicates in the NDB, then the optional [latitudelongitude will be included in the downlink.
60	OFFSETTING [direction] [distanceOffset]	N/A	E	Selected when offset entered.
61	DESCENDING TO [altitude]	N/A	P	[altitude] defaults to MCP altitude. - automatically selected when MCP alt >150 ft below current alt when MAYDAY selected.

DL#	**System Management Messages**	**UL#**	**P,E,N**	**Additional Information**
62	System Message (ERROR [errorInformation]), no display on CDU	mult	N	Message is automatically sent when uplink which cannot be decoded is received. This is a system message which is not dipslayed to the crew.
63	System Message (NOT CURRENT DATA AUTHORITY), no display on CDU	mult	N	Message is automatically sent when appropriate. This is a system message which is not displayed to the crew.
64	System Message ([icaoUnitName]), no display on CDU	163	N	Message is automatically sent when appropriate. This is a system message which is not displayed to the crew.
73	System Message ([versionNumber]), no display on CDU	163	N	Message is automatically sent when appropriate. This is a system message which is not dipslayed to the crew.

DL#	Additional Messages	UL#	P,E,N	Additional Information
65	DUE TO WEATHER	mult	P	May be added to 'UNABLE' or 'NEGATIVE' response or an altitude or speed request.
66	DUE TO AIRCRAFT PERFORMANCE	mult	P	May be added to 'UNABLE' or 'NEGATIVE' response or an altitude, speed, or offset request.
67	[freetext]	mult	E	May be sent with reports, requests & 'UNABLE' or 'NEGATIVE' response or alone.
67b	WE CAN ACCEPT [altitude] AT [time]	148	P,E	[altitude] defaults based on uplink. [time] defaults to box prompts. FMC formats free text downlink since no message element defined.
67c	WE CAN ACCEPT [speed] AT [time]	151	P,E	[speed] defaults based on uplink. [time] defaults to box prompts. FMC formats free text downlink since no message element defined.
67d	WE CAN ACCEPT [direction][distanceoffset] AT [time]	152	P,E	[direction] and [distanceoffset] default based on uplink. [time] defaults to box prompts. FMC formats free text downlink since no message element defined.
67e	WE CANNOT ACCEPT [altitude]	148	P	[altitude] defaults based on uplink. FMC formats free text downlink since no message element defined.
67f	WE CANNOT ACCEPT [speed]	151	P	[speed] defaults based on uplink. FMC formats free text downlink since no message element defined.
67g	WE CANNOT ACCEPT [direction][distanceoffset]	152	P	[direction] and [distanceoffset] default based on uplink. FMC formats free text downlink since no message element defined.
67h	WHEN CAN WE EXPECT CLIMB TO [altitude]	13,14	E	[altitude] defaults to dash prompts. FMC formats free text downlink since no message element defined. Note that there will be no automatic correlation between this downlink and the corresponding uplink.
67i	WHEN CAN WE EXPECT DESCENT TO [altitude]	15,16	E	[altitude] defaults to dash prompts. FMC formats free text downlink since no message element defined. . Note that there will be no automatic correlation between this downlink and the corresponding uplink.
67j	NOT CONSISTENT. RESEND	0,5	P	May be added to UNABLE or NEGATIVE response
67k	UNLOADABLE CLEARANCE	0,5	P	May be added to UNABLE or NEGATIVE response
68	[freetext]	mult	P	May be sent with emergency report or alone for an emergency message. Ground should treat DL #68 with higher priority than DL #67.
74	MAINTAIN OWN SEPARATION AND VMC		P	May be added to an altitude request.
75	AT PILOTS DISCRETION		P	May be added to an altitude request.

A.4 [ROUTECLEARANCE] VARIABLE ENCODING TABLE

The constituent variables of the [routeclearance] variable are all optional. If the data associated with a particular variable do not exist in the selected route, then no data are encoded for that variable when an element containing the [routeclearance] variable is sent in a downlink. The "selected route" is as described in the DOWNLINK MESSAGE ELEMENTS table A.3 above, elements 24, 40, and 59.

When encoding a [placebearingdistance] or [publishedidentifier] for which duplicates exist in the NDB for the associated [fixname], the optional [latitudelongitude] will be included with the [placebearingdistance] or [publishedidentifier] in the downlink.

[routeclearance] VARIABLE ENCODING TABLE

Variable Name	Data Source
[airportdeparture]	Origin airport for the selected route.
[airportdestination]	Destination airport for the selected route.
[runwaydeparture]	Departure runway ([runwaydirection] and [runwayconfiguration]) for the selected route.
[proceduredeparture]	Departure procedure and departure transition for the selected route.
[runwayarrival]	Arrival runway ([runwaydirection] and [runwayconfiguration]) for the selected route.
[procedureapproach]	Approach procedure and approach transition for the selected route. Approach procedures with eight-character identifiers (e.g., ILS2 24L) are encoded as follows: The approach type and multiple approach character code (e.g., ILS2) are encoded as the [procedureapproach] variable. The runway number and direction (e.g., 24L) are encoded into the [runwayarrival] variable. Note that breaking the procedure identifier in this manner is necessary, as the DO-219 [procedurename] variable has a maximum size of 6 characters.
[procedurearrival]	Arrival procedure and arrival transition for the selected route.
[airwayintercept]	NOT USED - FMC converts to publishedidentifier followed by an airway after entry/loading.
[routeinformation]	En route data for the selected route. All [routeinformation] variables are encoded in the order in which they occur in the selected route. The position of any intercept course from leg will be encoded in the routeinformation, inserted at the correct position within the selected route. (See also [interceptcoursefrom], below)
[routeinformationadditional]	
[routeinformationadditional] [atwalongtrackwaypoint-sequence]	NOT USED - ATWs (Along Track Waypoints) are stored in the FMC and sent in downlinks as [placebearingdistance]s.

Variable Name	Data Source
[routeinformationadditional] [reportingpoints]	NOT USED - Reporting Points are stored in the FMC and sent in downlinks as [latitudelongitude]s.
[routeinformationadditional] [interceptcoursefrom]	Position and outbound course for each intercept course from leg in the route
[routeinformationadditional] [interceptcoursefrom] [interceptcourse-fromselection]	The position of the intercept course from leg will be encoded as a [publishedidentifier], [placebearingdistance], or [latitudelongitude].
[routeinformationadditional] [interceptcoursefrom] [degrees]	Outbound course associated with a given intercept course from leg in the selected route. If the Outbound Course is in degrees magnetic, then [degrees] are encoded as choice value 0 (degreesmagnetic). If the Outbound Course is in degrees true, then [degrees] are encoded as choice value 1 (degreestrue).
[routeinformationadditional] [holdatwaypoint]	Hold data and associated position for each holding pattern in the selected route.
[routeinformationadditional] [holdatwaypoint] [position]	Position for a given hold in the selected route. If the [position] variable does not match an identifier in the FMC's Navigation Database or is not a Place Bearing Distance, then the [position] is encoded as choice value 3 (latitudelongitude). Otherwise, the [position] is encoded as choice value 0 (fixname), 1 (navaid), 2 (airport), or 4 (placebearingdistance), as appropriate.
[routeinformationadditional] [holdatwaypoint] [holdatwaypointspeedlow]	Speed constraint associated with a given hold in the selected route. The [speed] is encoded as choice value 0 (speedindicated).
[routeinformationadditional] [holdatwaypoint] [atwaltitude]	Altitude constraint associated with a given hold in the selected route. The [altitude] is encoded as choice value 0 (altitudeqnh) or as choice value 6 (altitudeflightlevel). If a window constraint exists on a hold, then the [atwaltitude] is treated as follows: If the flight phase is climb, the higher altitude (XXXB) is considered the [altitude] and the [atwaltitudetolerance] is encoded as choice value 2 (atorbelow); and If the flight phase is cruise or descent, the lower altitude (XXXA) is considered the [altitude] and the [altitudetolerance] is encoded as choice value 1 (atorabove).

Variable Name	Data Source
[routeinformationadditional] [holdatwaypoint] [holdatwaypointspeedhigh]	NOT USED
[routeinformationadditional] [holdatwaypoint] [direction]	Turn direction (left or right) associated with a given hold in the selected route.
[routeinformationadditional] [holdatwaypoint] [degrees]	Inbound course associated with a given hold in the selected route. If the Inbound Course for the hold is in degrees magnetic, then [degrees] are encoded as choice value 0 (degreesmagnetic). If the Inbound Course for the hold is in degrees true, then [degrees] are encoded as choice value 1 (degreestrue).
[routeinformationadditional] [holdatwaypoint] [EFCtime]	Expect Further Clearance Time associated with a given hold in the selected route.
[routeinformationadditional] [holdatwaypoint] [legtype]	Leg Distance, if specified for a given hold in the selected route. Otherwise, Leg Time associated with a given hold in the selected route. If a Leg Distance is specified, then [legdistance] is encoded as choice value 0 (legdistanceenglish).
[routeinformationadditional] [waypointspeedaltitude]	Speed and altitude constraint and associated position for each waypoint speed and altitude constraint in the selected route.
[routeinformationadditional] [waypointspeedaltitude] [position]	Position of a waypoint which has a corresponding altitude or speed and altitude constraint. If the [position] variable does NOT match an identifier in the FMC's Navigation Database or is not a Place Bearing Distance, then the [position] is encoded as choice value 3 (latitudelongitude). Otherwise, the [position] is encoded as choice value 0 (fixname), 1 (navaid), 2 (airport), or 4 (placebearingdistance), as appropriate.
[routeinformationadditional] [waypointspeedaltitude] [speed]	Speed portion of speed/altitude constraint for a waypoint in the selected route. The [speed] is encoded as choice value 0 (speedindicated).

Variable Name	Data Source
[routeinformationadditional] [waypointspeedaltitude] [ATWaltitudesequence]	Altitude portion of an altitude or speed/altitude or window altitude constraint associated with a waypoint in the selected route. The [altitude] is encoded as choice value 0 (altitudeqnh) or as choice value 6 (altitudeflightlevel). If a window constraint exists for a given waypoint, then the [ATWaltitudetolerance] for the lower of the two altitudes is encoded as choice value 1 (at or above) and the [ATWaltitudetolerance] for the higher of the two altitudes is encoded as choice value 2 (at or below).
[RTArequiredtimeofarrival]	RTA data for a position in the selected route. FMC can only have one at a time.
[RTArequiredtimeofarrival] [position]	Position of a waypoint which has a defined RTA. If the [position] variable does NOT match an identifier in the FMC's Navigation Database or is not a Place Bearing Distance, then the [position] is encoded as choice value 3 (latitudelongitude). Otherwise, the [position] is encoded as choice value 0 (fixname), 1 (navaid), 2 (airport), or 4 (placebearingdistance), as appropriate.
[RTArequiredtimeofarrival] [RTAtime]	RTA time and time tolerance for a position in the selected route.
[RTArequiredtimeofarrival] [RTAtolerance]	NOT USED

A.5 PERMITTED GROUPINGS OF DOWNLINK MESSAGE ELEMENTS

Response Message Elements:

All Models:

Elements 0, 2, 3, and 4 cannot be combined with any other message element in a downlink message.

Elements 1 and 5 can be combined with elements 65, 66, and 67 in a downlink message.

Request Message Elements:

Vertical, Lateral Off-Set, Speed, and Route Modification Requests can be combined in a downlink message with the following restrictions. These request elements can also be combined with elements 65, 66, 67, 74, and 75.

- elements 6,7,8,9,10,11,12,13,14, and 69 (all of the altitude requests) are mutually exclusive. (A request downlink message may contain only one altitude request).
- elements 15, 16, 17, and 27 (all lateral offset requests and the weather deviation via offset request) are mutually exclusive. (A request downlink message may contain only one lateral offset request).

Elements 20 and 25 can be combined with element 67 in a downlink message, but cannot be combined with any other message elements.

Report Message Elements:

With the exception of element 48, the flight crew is unable to formulate a report/confirmation downlink unless that report has been requested from the controller by means of the corresponding uplink report request. (Reference table 4 in section 5.4).

All report message elements except element 48 can be combined with message element 67. All report message elements are mutually exclusive, with the following exceptions.

- element 32 can be combined with message elements 29 or 30, as defined in Downlink Message Element Table.
- elements 40, 42, and 44 can be combined with message 80 as defined in Downlink Message Element Table.
- element 48 can be combined with message elements 29, 30, or 80 as defined in Downlink Message Element Table.

Negotiation Request Message Elements:

Negotiation Requests can be combined in a downlink message with the following restriction. These elements can also be combined with 67.

- elements 52, 53, and 54 are mutually exclusive.

Emergency Message Elements:

Emergency message elements can be combined in a downlink message with the following restriction. These elements can also be combined with 68.

- elements 55 and 56 are mutually exclusive.
- Element 58 cannot be combined with any other emergency message element

Additional Message Elements:

Elements 65, 66, 68, 74, and 75 cannot be transmitted as standalone messages. These elements must be combined with another message element as described above.

Element 67 can be transmitted as a standalone message.

A.6 LIMITATIONS ON DOWNLINK VARIABLE CHOICES AND RANGES

The following table describes the limitations on the choices and Data Entry ranges for each listed downlinkable variable. If a particular variable is not included in the following list, its absence indicates that there are no choice or range limits.

Downlink Variable	Choice Limit	Entry Range Limit
[altitude]	1. If the message element is 28, 37, 72, or 76, then there is no limitation on the [altitude] choice. 2. If the [altitude] is contained in the [routeinformationadditional] portion of [routeclearance] message elements 24, 40, or 59, then the [altitude] choices are restricted to choices 0 (altitudeqnh) or 6 (altitudeflightlevel) 3. If the message element is any of elements 6 - 14, 29, 30, 32, 38, 77, 54, or 61, then the [altitude] choices are restricted to choices 0 (altitudeqnh), 1 (altitudeqnhmeters), or 6 (altitudeflightlevel)	[altitudeqnh] - per DO-219 [altitudeqnhmeters] - per DO-219 [altitudeflightlevel] - (FL030..FL431)

Downlink Variable	Choice Limit	Entry Range Limit
[degrees]	1. the [degrees] choice is limited to [degreesmagnetic] when the aircraft's heading is referenced to magnetic north and to [degreestrue] when the aircraft's heading is referenced to true north for the following message elements and variables. (Note that the aircraft's heading is referenced to true north only in the polar regions). a) If the message element is 35, 36, 70, 71 b) If the [degrees] is contained in a [placebearingdistance] which is the [position] portion of message elements 11, 12, 16, 22, 33, 42, 44, 45, or 59 c) If the [degrees] is contained in a [placebearingdistance] which is the [fixnext], [fixnextplusone], or [reportedwaypointposition] of element 48 2. the [degrees] choice is limited to [degreestrue] for the following message elements and variables: a) If the [degrees] is contained in a [placebearingdistance] which is defined as a [routeinformation] [publishedidentifier] in elements 24, 40, or 59 b) If the [degrees] is contained in a [placebearingdistance]] which is the [position] portion of any [routeinformationadditional] variable of elements 24, 40, or 59 3. If the [degrees] is contained in a [placebearingdistance] which is the [position] portion of message elements 31 or 78, then there is no limitation on the [degrees] choice	
[distance]	1. the [distance] choice is limited to [distancenm] for the following message elements and variables: a) If the [distance] is contained in a [placebearingdistance] which is the [position] portion of message elements 11, 12, 16, 22, 33, 42, 44, 45, or 59 b) If the [distance] is contained in a [placebearingdistance]] which is the [position] portion of any [routeinformationadditional] variable of elements 24, 40, or 59 c) If the [distance] is contained in a [placebearingdistance] which is the [fixnext], [fixnextplusone], or [reportedwaypointposition] of element 48 d) If the [distance] is contained in a [placebearingdistance] which is defined as a [routeinformation] [publishedidentifier] in elements 24, 40, or 59 2. If the [distance] is contained in a [placebearingdistance] which is the [position] portion of message elements 31 or 78, then there is no limitation on the [distance] choice	[distancenm] - (0..700)
[distanceoffset]	The [distanceoffset] choice is limited to [distanceoffsetnm] for all downlink message elements containing the [distanceoffset] variable.	[distanceoffsetnm] - (0..99)

Downlink Variable	Choice Limit	Entry Range Limit
[direction]	The [direction] choice is limited to [left] or [right] for all downlink message elements containing the [direction] variable.	
[legdistance]	The [legdistance] choice is limited to [legdistanceenglish] for all downlink message elements containing the [routeclearance] [routeinformationadditional] [holdatwaypoint] variable.	
[remainingsouls]		[remainingsouls] - (1..999)
[speed]	1. If the message element is 18, 34, 39, or 49, then the [speed] choice is limited to [speedindicated] or [speedmach] 2. If the message element is 48, then the [speed] choice is limited to [speedmach] 3 If the [speed] is contained in the [ATWalongtrackwaypoint], [waypointspeedaltitude], or [holdatwaypoint] [holdatwaypointspeedlow] portion of the [routeinformationadditional] variable of elements 24, 40, or 59, then the [speed] choice is limited to [speedindicated].	[speedindicated] - (100..380) [speedmach] - (.61...91)
[windspeed]	The [windspeed] choice is limited to [windspeedenglish] for downlink message element 48. (Element 48 is the only downlink element which contains this variable).	

APPENDIX B - ADS REPORT DATA

Information contained in ADS reports have been categorized into groups. The information groups and the individual pieces of data which make up the group shall be as described in the table below.

ADS Data	Data Source
Basic ADS Group	
latitude	flight management function calculated latitude
longitude	flight managment function calculated longitude
altitude	uncorrected altitude (referenced to standard day pressure of 29.92 in. of Hg)
time	GPS UTC time, if available, or flight deck clock time when GPS unavailable.
figure-of-merit	
navigation redundancy discrete	If GPS is installed: 1, if there are two flight management functions and two GNSSUs providing valid input to the flight management functions; 0, otherwise If GPS is not installed: 1, if there are two or more inertial reference units providing valid position data to the flight management function; 0, otherwise
position determination accuracy	Level 0-7, which reflects the accuracy of the FMC position and time being reported.
TCAS state discrete	1, if TCAS is providing valid data to the ADS application; 0, otherwise
Flight Identification Group	
flight ID	flight ID flight-crew entered
Earth Reference Group	
true track	flight management function calculated true track
ground speed	flight management function calculated ground speed
vertical rate	inertial vertical rate
Air Reference Group	
true heading	inertial true heading
mach speed	air data mach
vertical rate	inertial vertical rate
Airframe Identification Group	
24-bit ICAO Identifier	not provided

ADS Data	Data Source
Meteorological Group	
wind speed	flight management function calculated wind speed
true wind direction	flight management function calculated true wind direction
temperature	air data static air temperature
Predicted Route Group	
latitude at next waypoint	flight management function active waypoint latitude
longitude at next waypoint	flight management function active waypoint longitude
altitude at next waypoint	flight management function predicted active waypoint altitude
estimated time at next waypoint	flight management function predicted active waypoint ETA
latitude at next+1 waypoint	flight management function next waypoint latitude
longitude at next+1 waypoint	flight management function next waypoint longitude
altitude at next+1 waypoint	flight management function predicted next waypoint altitude

Aircraft Intent Groups	
Intermediate Projected Intent Group	The flight management function locates up to 10 points in the active flight plan, between the current position and the requested time, where a change to the flight management function target altitude, target speed or course is predicted. For each of these points, an Intermediate Projected Intent Group is formed.
distance	flight management function calculated distance from current position for the first point; flight management function calculated distance from the previous point for the remaining points.
true track	flight management function calculated track from current position for the first point, FMC track from the previous point for the remaining points.
altitude	flight management function calculated projected altitude at the point
projected time	flight management function calculated projected travel time to the point
Fixed Intent Group	The flight management function locates the point at which the aircraft is projected to be along the active flight plan at the requested time. If the requested time falls past the end of the route, the last waypoint will be reported.
latitude	flight management function projected latitude at the point
longitude	flight management function projected longitude at the point
altitude	flight management function projected altitude at the point
projected time[39]	Travel time or flight management function projected travel time for the last waypoint along the active route

[39] This refers to a period of time (e.g. 2 hours) rather than a distinct time (e.g. 2:00pm).

APPENDIX C - TRACEABILITY OF SAFETY ASSUMPTIONS TO SR&O REQUIREMENTS

The following table lists the safety requirements on systems and procedures which were considered as assumptions in developing the FHA. The reference section numbers in brackets provide traceability to the assumptions in the ATS SR&O where applicable.

1. All voice communication capability will be retained (HF, VHF, SATCOM) and would be considered as a backup to the data link functionality. There will be no proposed change to the Master Minimum Equipment List (MMEL) for HF or VHF communication equipment based on the initial FANS 1 certification. [6.10]
2. There will be established procedures for each communication failure condition. The procedures must account for possible loss of messages and indicate how long a pilot or controller should wait before deciding a message has been lost. The time-out value must be small enough to assure adequate reaction time based on the separation minima. [6.10]
3. The AFN, ATC DL, and ADS FANS 1 software will be developed per level C of DO-178B or per an equivalent or agreed to certification level. [8.1.1, 8.3.1, 8.4.1]
4. ATC Workstations will be developed and modified to equivalent guidelines of DO-178B Level C. [8.1.3.2, 8.3.3, 8.4.3]
5. All LRUs that supply data to the AFN, ATC DL, and ADS applications for logon information and reports will be developed per level C of DO-178B or per an equivalent or agreed to certification level. [8.1.1, 8.3.1, 8.4.1]
6. Air Traffic Control procedures will use ADS periodic reporting or manual ATC DL position reports in addition to ARMed reports (if such functionality is provided on a particular airplane model) and/or ADS Event reports. [6.10]
7. Include the tail number of the airplane in each message encapsulated by the CRC. [8.2.1.1]
8. Generate and validate a 16 bit or better CRC for the tail number and data of each ATC DL, ADS, and AFN message. [8.2.1.1]
9. ATC procedures will be established which will not allow the controller to issue clearances to an airplane which is not in his area of control. [6.10]
10. ATC procedures, systems and personnel will not use AOC DL. [6.10]
11. If the printer is certified to level D of DO-178B or is non-essential, confirm print-only data using some other means, or do not use print-only data for those data which could contribute to a MAJOR failure effect. [6.10]
12. If the printer is certified to level D of DO-178B or is non-essential, ATC clearance data received through the ATC DL Application which can only be viewed on the cockpit printer must be independently verified per approved operational procedures. [6.10]
13. All ATC DL data which could contribute to a major failure effect must be displayable on a flight deck Display Unit. [8.4.1]
14. The crew shall reject clearances that they cannot comply with and current air traffic procedures will be used to resolve any resultant conflicts. [6.10]
15. The ATC Facility shall have the means to detect an erroneous flight identifier or tail number (aircraft registration) received in the end system (CRC'd) portion of the AFN logon message. [6.10]

APPENDIX D - VALIDATION REQUIREMENTS FOR ASSURANCE OF CONTINUED INTEROPERABILITY

The following table details the traceability between the requirements in this document, which test step validates that requirement, and which equipment modification would force rerun of the test.

8.1	**ATS Facilities Notification Function (AFN)**	**TEST DRIVER**	**Test Step**
8.1.1	**Allocation to Airplane Environment**		
	paragraphs a & b	AFN APPLICATION SYSTEM	Cert
	paragraph c	Procedure	
	paragraphs d through i	AFN APPLICATION SYSTEM	Cert
8.1.2	**Allocation to Satellite Environment**		
	all paragraphs	Never	Not Req.
8.1.3	**Allocation to Ground Environment**		
8.1.3.1	**Allocation to Service Provider Component**		
	all paragraphs	DSP	
8.1.3.2	**Allocation to ATC Facility Component**		
	all paragraphs	ATC	
8.2	**Datalink**		
8.2.1	**Allocation to Airplane Environment**		
8.2.1.1	**ATS application system**		

	all paragraphs	ATS Application System	Cert
8.2.1.2	**ACARS function**		
8.2.1.2.1	**ACARS Requirements**		
	all paragraphs	ACARS	AEIT or Cert
8.2.1.3	**SATCOM**		
	all paragraphs	SATCOM	AEIT
8.2.1.4	**VHF Radio**		
	all paragraphs	VHF	
8.2.2	**Satellite Environment**		
	all paragraphs	Satellite	

8.2.3	**Ground Environment**	**TEST DRIVER**	**Test Step**
8.2.3.1	**VHF Sub-Network Component**		
	all paragraphs	DSP	
8.2.3.2	**Service Provider Component**		
	all paragraphs	DSP	
8.2.3.2.1	**Internetworking**		
	all paragraphs	DSP	
8.2.3.2.2	**Recording of ATS Messages**		
	all paragraphs	DSP	
8.2.3.3	**Allocation to ATC Facility Component**		

	paragraph a	Airline	
	paragraphs b through i	ATC	
8.2.4	**Datalink Performance**		
	all paragraphs	Any	
8.2.5	**Datalink Operational Requirements**		
	all paragraphs	Never	Not Req.
8.3	**Automatic Dependent Surveillance (ADS)**		
8.3.1	**Allocation to Airplane Environment**		
	all paragraphs	ADS APPLICATIO N	Cert
8.3.2	**Allocation to Satellite Environment**		
	all paragraphs	Never	Not Req.
8.3.3	**Allocation to Ground Environment**		
	paragraph a	Airline	
	paragraphs b through j	ATC	
8.4	**ATC Datalink (ATC DL)**		
8.4.1	**Allocation to Airplane Environment**		
	all paragraphs	ATC DL APPLICATIO N	Cert
8.4.2	**Allocation to Satellite Environment**		
	all paragraphs	Never	Not Req.
8.4.3	**Allocation to Ground Environment**		
	all paragraphs	ATC	

APPENDIX E - DIFFERENCES BETWEEN ARINC 745-2, RTCA DO-212 AND ADSP ATC/ADS GUIDELINES

ADS Requirement	ARINC 745-2 (section)	RTCA DO-212 (section)	ICAO ADSP Guidelines as of 11-94
Periodic Report Rate Upon Emergency Mode Termination (per connection)	No effect (3.2.5)	Same as ARINC 745-2 (2.2.1.3.1.2)	Rate that existed before emergency was initiated is reinstated upon cancellation of emergency mode by either pilot or ATC
Airborne End System Priority of ADS Messages	Emergency reports replace other periodic reports. Event Reports continue.	Same as ARINC 745-2 (2.2.1.3.1.1)	1. Emergency reports 2. Reports containing Projected Profile Group 3. Remaining reports
Event Report Triggers	Event report triggers, except for waypoint events, remain armed only until the event occurs or the contract is canceled. (3.2.2.2)	Same as ARINC 745-2 (2.2.1.2.2)	Event report triggers remained armed (and trigger once per minute) until the event contract is canceled. (Note: This only works for the newly defined events.)
Extended Projected Profile Block On-Request Group	Not defined	Not defined	Defined as tag 25 and can containuses repetitive next waypoint groups for 1-12820 waypoints or next 15 - 96 minutes.. (Note: The definition is inconsistent as to whether or not an uplink modulus is defined for this on-request group.)
Weather On-Request Group	Not defined, although Air Reference Group uses the same tag (16) and contains same data except for Turbulence. (3.2.2.1 and 3.2.3)	Same as ARINC 745-2 (2.2.1.2.1 and 2.2.1.4)	Replaces Air Reference Group. Contains same data, plus Turbulence
Periodic Report Rate upon Emergency Mode Initiation (per connection).	64 second period or the existing rate, whichever is less	Same as ARINC 745-2 (2.2.1.3.1.1)	60 second period or 1/2 of existing rate, whichever is less
Periodic Contract Request Acknowledgement	Always sent with first periodic report	Same as ARINC 745-2 (2.2.1.4)	Sent alone if report cannot be sent within 5 seconds. Otherwise, sent with first periodic report.

ADS Requirement	ARINC 745-2 (section)	RTCA DO-212 (section)	ICAO ADSP Guidelines as of 11-94
Event Contract Requests	1. Waypoint Change (20) 2. Lateral Deviation Change (10) 3. Altitude Range (Ceiling/Floor - 19) 4. Vertical Rate Change (18) (3.2.2.2)	Same as ARINC 745-2 (2.2.1.2.2)	Same as ARINC 745-2, plus: 1. Air Speed Change (22) 2. Ground Speed Change (23) 3. Heading Change (24) 4. Extended Projected Profile Change (25) 5. FOM Change (26) 6. Track Angle Change (27) 7. Altitude Change (28)
Time Stamp Accuracy	Not specified	Within $\pm$ 2 sec of UTC (1.7[40])	Within $\pm$ 1 sec of UTC
Response Time	ADS response received within 2 seconds of receiving request from Transport Layer; Within 1 second of period expiration or event trigger (3.2.3)	Within 5 seconds of receiving request from Transport Layer; Within 2.5 seconds of period expiration or event trigger (2.2.1.4)	Within 5 seconds of receiving request from Transport Layer; Within .5 seconds of period expiration or event trigger.Not specified
Emergency Contract Report Modification	Can be modified just like normal mode contract	Same as ARINC 745-2 (2.2.1.2.2)	Only report rate (not report content) can be modified.

40 This is an assumption, not a requirement.

APPENDIX F1 - DIFFERENCES BETWEEN THE DESIRED FANS 1 REQUIREMENTS AND THE ACTUAL IMPLEMENTATION

The following are differences between the desired FANS 1 requirements and the actual implementation. It should be assumed that each of these items will be considered for change, if and when, the FANS 1 software is upgraded. For some items there is a requirement placed on another system to work around the problem; the remaining items are for information only.

I. AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

CHARACTERISTICS OF FMC-GENERATED DOWNLINKS

1. Correlation of ADS Intent Data with timestamp in the Basic Report

The FMC computes ADS Intent data on a periodic basis so that intent data will always be available when required for an ADS report. As such, the intent data may be "stale" with respect to the timestamp contained within the Basic group with which the intent data are transmitted. Lab analysis indicates the difference between the time the intent data are computed and the timestamp in the Basic group may be as long as 30 seconds.

REQUIREMENT ON ATC FACILITY: If ADS intent data are used for conflict probe or conformance monitoring, then the ground automation shall account for the position uncertainty introduced by the time difference described above.

II. ATC DATA LINK (ATC DL)

A. CHARACTERISTICS OF UPLINK ELEMENT ENCODING

1. Restriction on the use of runway waypoints in the [position] and [publishedidentifier] variables when using uplink elements 73, 74, 77, 79, 80 and 83.

   The FMC does not currently search its NDB runway file for a match to an uplink [position] or [publishedidentifier] variable. The FMC is supposed to allow the uplink of an arrival runway as a [position] or [publishedidentifier]. The [runwayarrival] variable in message elements 73 and 80 can be used.

   REQUIREMENT ON THE ATC FACILITY: To ensure the loadability of elements 73, 74, 77, 79, 80, and 83, a runway waypoint shall not be encoded as a [position] or [publishedidentifier] variable when any of these elements is included in an uplink.

2. Restriction on the number of [routeclearance] [routeinformation] variables

   The FMC is unable to load a [routeclearance] which contains 120 'latitudelongitude' [routeinformation] items. Attempting to load such a route clearance causes the FMC to reset, resulting in a loss of all existing flight plan data. The FMC is able to load a [routeclearance] which contains 80 'latitudelongitude' [routeinformation] items.

   REQUIREMENT ON THE ATC FACILITY: ATC shall not transmit a [routeclearance] containing more than 80 items in the [routeinformation] variable.

2. Second of two airways will not load if the airways do not intersect at a named fix

   When two airways intersect but not at a named fix, the FMC is able to Load the first airway but cannot load the second.

   REQUIREMENT ON ATC FACILITY: Do not uplink a [routeclearance] message which includes consecutive airways that do not intersect at a named fix.

B. CHARACTERISTICS OF FMC-GENERATED DOWNLINKS

1. Departure transition not included in downlink elements 24 or 40

   When the FMC transmits a [routeclearance] variable as part of downlink elements 24 or 40, and the airplane is still in a departure transition (has sequenced all the departure procedure waypoints, and has not sequenced all the departure transition waypoints), then the FMC may omit the departure transition and departure procedure from the encoded [routeclearance].

   REQUIREMENTS ON THE ATC FACILITY: None

2. Sequenced departure procedure included in downlink element 24

   When the FMC transmits a [routeclearance] variable as part of downlink element 24, and the airplane has not already sequenced the second en-route waypoint at the time the route is constructed for downlink, a sequenced departure procedure may be included in the downlinked [routeclearance].

   REQUIREMENTS ON THE ATC FACILITY: None

3. Place-bearing-distances in Position Reports may be encoded incorrectly

   When a Place-bearing-distance (PBD) is encoded as the [fixnext] or [fixnextplusone] and the PBD “parent” fix is a navaid or an airport, the PBD is incorrectly encoded as either a navaid or an airport. For example the PBD ABC120/10 would be encoded as ‘navaid’ ABC0.

   REQUIREMENT ON THE ATC FACILITY: None

APPENDIX F2 - PEGASUS '98 SOFTWARE CHANGES

The following 757/767 FMC ATS function characteristics have been corrected in the Pegasus '98 software version.

I. AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

CHARACTERISTICS OF FMC-GENERATED DOWNLINKS

1. Invalid altitude and ETA in waypoint change event report

When the FMC's active or next waypoint was changed by means of a flight plan modification, the FMC was unable to compute the predicted altitude and ETA before transmission of the resulting Waypoint Change Event report. The default altitude and time to go values were reported, as specified in ARINC 745-2.

The FMC software has been changed such that the Waypoint Change Event report is delayed up to 5 seconds following a change to the active or next waypoint to allow the FMC to complete computation of the altitude and ETA predictions.

2. Altitude in Basic Group vs. Predicted Altitudes

The altitude in the Basic Group is an uncorrected standard altitude, while the altitude in the Predicted Route Group was a baro-corrected altitude. The desired implementation is that all altitudes be uncorrected standard altitudes.

The FMC software has been changed such that all altitudes are reported as uncorrected standard altitudes.

3. Waypoint Change Event Reports and Holding Fixes

Insertion of a holding pattern as the active flight plan fix did not trigger a Waypoint Change event report.

The ETA included in a Waypoint Change event report when the aircraft entered a holding pattern was always reported as zero.

The FMC software has been changed as follows:

- Insertion of a holding pattern as the active flight plan fix triggers a Waypoint Change event report.
- The ETA included in a Waypoint Change event report when the aircraft enters a holding pattern is now reported as the correct value.

II. ATC DATA LINK (ATC DL)

A. CHARACTERISTICS OF UPLINK ELEMENT ENCODING

Restriction on the use of the [proceduredeparture] variable

If a SID and a runway-SID transition at a given airport had the same identifier, then when the FMC loaded a [routeclearance] variable containing a [proceduredeparture] with such a duplicate identifier, the runway-SID transition was loaded instead of the SID.

The FMC software has been changed such thatif a SID and a runway-SID transition at a given airport have the same identifier, the FMC will load the full SID.

B. CHARACTERISTICS OF FMC-GENERATED DOWNLINKS

1. Airway intersection point for consecutive airways not included in route clearance downlink

   When the FMC's flight plan included consecutive airways and the airways crossed at a named waypoint, the airway intersection point was not included in a [routeclearance] downlink. The route data were encoded into the [routeinformation] as follows: the point at which the aircraft was to join the first airway was encoded as a [publishedidentifier], the first airway was encoded as an [airwayidentifier], the second airway was encoded as an [airwayidentifier], and the point at which the aircraft was to depart the second airway was encoded as a [publishedidentifier].

   The FMC software has been changed such that the airway intersection point is included in a [routeclearance] downlink.

2. FMC sends blank [icaofacilitydesignation] in response to unexpected connect request

   When the FMC received a connect request from a source other than the Current Data Authority or the specified Next Data Authority (if one existed), the FMC responded with a Disconnect Request and element 64 ([icaofacilitydesignation]). The [icaofacilitydesignation] was encoded as four space characters. The [icaofacilitydesignation] variable should have been encoded as the identifier for the Current Data Authority.

   The FMC software has been changed such that the [icaofacilitydesignation] of the Current Data Authority is correctly encoded into element 64 under the described condition.

3. FMC does not include the optional [latitudelongitude] with [placebearingdistance] or [publishedidentifier]

   Table 4 in Section 5.4, Appendix 3, and Appendix A.4 state the following: "When encoding a [placebearingdistance] or [publishedidentifier] for which duplicates exist in the NDB for the associated [fixname], the optional [latitudelongitude] will be included with the [placebearingdistance] or [publishedidentifier] in the downlink".

   The FMC did not include the optional [latitudelongitude] in the downlink.

   The FMC software has been changed such that the optional [latitudelongitude] is included with the [placebearingdistance] or [publishedidentifier] when the associated [fixname] is a duplicate.

4. FMC encodes invalid characters in free text response to UL# 148 (WHEN CAN YOU ACCEPT [altitude])

   When the FMC receives UL# 148 (WHEN CAN YOU ACCEPT [altitude]), it automatically formats a free text response for the flight crew to transmit. If the [altitude] variable in the uplink is specified in terms of 'qnhmeters' then the FMC displays the altitude to the flight crew with the feet equivalent in parentheses next to the meters value. When the FMC encoded the free text report, the feet equivalent and parentheses were included in the downlink (e.g., WE<sp>CAN<sp>ACCEPT<sp>5000M<sp>(16404FT)<sp>AT<sp>1255).

   The FMC software has been changed such that parentheses and feet equivalent of the metric altitude are not included in the downlink message.

5. FMC may reject uplinked response to downlink which requires a response

When the FMC transmits a downlink message to the ACARS MU, the FMC holds that message in its downlink queue until it receives a network acknowledgment message back from the MU. If the FMC has not received the network acknowledgment after 5 minutes, then it automatically attempts to resend the message to the ACARS MU. An anomaly existed in the FMC which caused the FMC to reject an uplinked response to such a re-transmitted downlink. Specifically, it did not recognize the MRN in the uplink message as corresponding to an open downlink message.

The FMC software has been changed such that the FMC will recognize an uplinked response to a re-transmitted downlink.

APPENDIX F3 - PEGASUS ‘00 SOFTWARE CHANGES

The following 757/767 FMC ATS function characteristics have been corrected in the Pegasus ‘00 software version.

AUTOMATIC DEPENDENT SURVEILLANCE (ADS)

CHARACTERISTICS OF FMC-GENERATED DOWNLINKS

Intermediate Intent point with EFC time in hold

An anomaly existed such that when the flight plan contained a holding pattern with an EFC time in the climb flight phase, the Aircraft Intend Group contained an Intermediate Intent point with an erroneous distance.

The FMC software has been changed to correct this anomaly.

APPENDIX G - ATC DL ERROR PROCESSING

The following lists the conditions under which the FMC will transmit an error message. These conditions are listed by the error code that will be transmitted in the downlink message.

0) applicationError

The FMC receives an uplink message (IMI=AT1) containing an invalid IA5String (e.g. element 169 [freetext]). (Downlink IMI=AT1).

1) duplicateMsgIdentificationNumber

The FMC receives an uplink message (IMI=AT1) with an MIN equal the MIN of a previous uplink which is still OPEN.

2) unrecognizedMsgReferenceNumber

The FMC receives an uplink message (IMI=AT1) with an MRN and there is no OPEN downlink message in the FMC log with a matching MIN. (Downlink IMI=AT1).

The FMC receives an uplink with IMI=CR1 and the uplink includes an MRN. (Downlink IMI=DR1).

3) endServiceWithPendingMsgs

The FMC receives an uplink message (IMI=AT1) containing element 161 and no other element and there are OPEN downlink messages, (downlink IMI=DR1), or

The FMC receives an uplink message (IMI=AT1) containing element 161 plus another element requiring WILCO/UNABLE response and there are OPEN downlink messages and the pilot sends WILCO. (Downlink IMI=DR1).

4) endServiceWithNoValidResponse

The FMC receives an uplink message (IMI=AT1) containing element 161 and another element requiring no response or a response other than WILCO/UNABLE. (Downlink IMI=DR1).

5) insufficientMsgStorageCapacity

The FMC receives an uplink message (IMI=AT1) when the FMC log is full (see section 5.4 for the capacity of the FMC log). (Downlink IMI=AT1).

The FMC receives an uplink message (IMI=AT1) containing a [routeclearance] variable larger than 918 bytes. (Downlink IMI=AT1).

6) noAvailableMsgIdentificationNumber

The FMC has only one MIN available that is not being used for a pending downlink message. (Downlink IMI=DR1).

7) commandedTermination

The pilot turns ATC DL OFF, changes the entered flight number, or changes the entered aircraft registration (tail number) or the FMC goes through "flight completion". (Downlink IMI=DR1).

8) insufficientData

The FMC receives an uplink message (IMI=CR1 or AT1) without enough bits to define the header and one valid element, (If the uplink IMI=CR1, the downlink IMI=DR1. If the uplink IMI=AT1, the downlink IMI=AT1). or

The FMC receives an uplink message (IMI=AT1) without enough bits to define all variables required for each element, (downlink IMI=AT1), or

The FMC receives an uplink message (IMI=AT1) containing an IA5String and the string contains fewer characters than specified, (downlink IMI=AT1), or

The FMC receives an uplink message (IMI=AT1) containing a [routeclearance] variable and a [waypointspeedaltitude] variable without a [speed] variable and without an [aTWaltitude] variable. (Downlink IMI=AT1).

9) unexpectedData

The FMC receives an uplink (IMI=AT1) with more than 5 message elements. (Downlink IMI=AT1).

The FMC receives an uplink message (IMI=AT1) with more pad bits than required to make a full octet, (downlink IMI=AT1), or

The FMC receives an uplink message (IMI=AT1) containing an IA5String and the string contains more characters than specified, (downlink IMI=AT1), or

The FMC receives an uplink message with IMI=CR1 and an element other than 163, (downlink IMI=DR1), or

The FMC receives an uplink message with IMI=CR1 and element 163 plus any other element. (Downlink IMI=DR1).

10) invalidData

The FMC receives an uplink with IMI=CR1 and either datum in element 163 is invalid. (Downlink IMI=DR1).

The FMC receives an uplink message (IMI=AT1) with element 178 or 183-255, (downlink IMI=AT1), or

The FMC receives an uplink message (IMI=AT1) with a variable outside its valid range. (Downlink IMI=AT1).

16) reservedErrorMsg

Not Used