CAGE Code 81205

# 777-9
# Airplane Characteristics for Airport Planning

| DOCUMENT NUMBER: | REVISION: | REVISION DATE: |
|---|---|---|
| **D6-86073** | **REV NEW** | **March 2017** |

CONTENT OWNER:

**Boeing Commercial Airplanes**

All revisions to this document must be approved by the content owner before release.

# Revision Record

| | |
|---|---|
| **Revision Letter** | **NEW** |
| **Revision Date** | **March 2017** |
| **Changes in This Revision** | Initial release of 777-9 data |

# Table of Contents

## 1.0 SCOPE AND INTRODUCTION

### 1.1 SCOPE

This document provides, in a standardized format, airplane characteristics data for general airport planning. Since operational practices vary among airlines, specific data should be coordinated with the using airlines prior to facility design. Boeing Commercial Airplanes should be contacted for any additional information required.

Content of the document reflects the results of a coordinated effort by representatives from the following organizations:

- Aerospace Industries Association
- Airports Council International - North America
- Air Transport Association of America
- International Air Transport Association

The airport planner may also want to consider the information presented in the "Commercial Aircraft Design Characteristics - Trends and Growth Projections," for long range planning needs and can be accessed via the following website:

http://www.boeing.com/airports

The document is updated periodically and represents the coordinated efforts of the following organizations regarding future aircraft growth trends.

- International Coordinating Council of Aerospace Industries Associations
- Airports Council International - North American and World Organizations
- Air Transport Association of America
- International Air Transport Association

## 1.2 INTRODUCTION

This document conforms to NAS 3601. It provides characteristics of the Boeing 777X family of airplanes for airport planners and operators, airlines, architectural and engineering consultant organizations, and other interested industry agencies. Airplane changes and available options may alter model characteristics. The data presented herein reflects the 777X family. Data used is generic in scope and not customer-specific.

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## 1.3 A BRIEF DESCRIPTION OF THE 777X FAMILY OF AIRPLANES

**777X Family**

The 777X is the latest series of derivative airplanes in the 777 family of airplanes. The 777X family includes the 777-8 and 777-9. The 777-9 will be the first airplane model in the 777X series to enter into service. The remaining models will be added to this document in the future.

Proven technologies from the 777 and 787, combined with new technologies, bring a balanced design focused on efficiency. New composite wings and new engines reduce fuel burn and community noise. The new interior has a wider cabin to improve airline customer and passenger appeal.

**Main Gear Aft Axle Steering**

The main gear axle steering is automatically engaged based on the nose gear steering angle. This allows for less tire scrubbing and easier maneuvering into gates with limited parking clearances.

**Engines**

The 777X features new engines from General Electric for improved fuel burn and noise. The new GE9X-105B1A has a 134-inch fan diameter and 105,000 lb Boeing equivalent thrust (BET).

**Wings**

A folding wing tip design on the 777X results in substantial aerodynamic benefits in flight with the wing tip extended, while maintaining Code E wing span on the ground for taxiway and gate compatibility.

**Cargo Handling**

The lower lobe cargo compartments can accommodate a variety of containers and pallets now in use.

## 2.0 AIRPLANE DESCRIPTION

### 2.1 GENERAL CHARACTERISTICS

Maximum Design Taxi Weight (MTW). Maximum weight for ground maneuver as limited by aircraft strength and airworthiness requirements. (It includes weight of taxi and run-up fuel.)

Maximum Design Takeoff Weight (MTOW). Maximum weight for takeoff as limited by aircraft strength and airworthiness requirements. (This is the maximum weight at start of the takeoff run.)

Maximum Design Landing Weight (MLW). Maximum weight for landing as limited by aircraft strength and airworthiness requirements.

Maximum Design Zero Fuel Weight (MZFW). Maximum weight allowed before usable fuel and other specified usable agents must be loaded in defined sections of the aircraft as limited by strength and airworthiness requirements.

Operating Empty Weight (OEW). Weight of structure, powerplant, furnishing systems, unusable fuel and other unusable propulsion agents, and other items of equipment that are considered an integral part of a particular airplane configuration. Also included are certain standard items, personnel, equipment, and supplies necessary for full operations, excluding usable fuel and payload.

Maximum Structural Payload. Maximum design zero fuel weight minus operational empty weight.

Seating Capacity. The number of passengers in a typical seating arrangement.

Maximum Cargo Volume. The maximum space available for cargo.

Usable Fuel. Fuel available for aircraft propulsion.

### 2.1.1 General Characteristics: Model 777-9

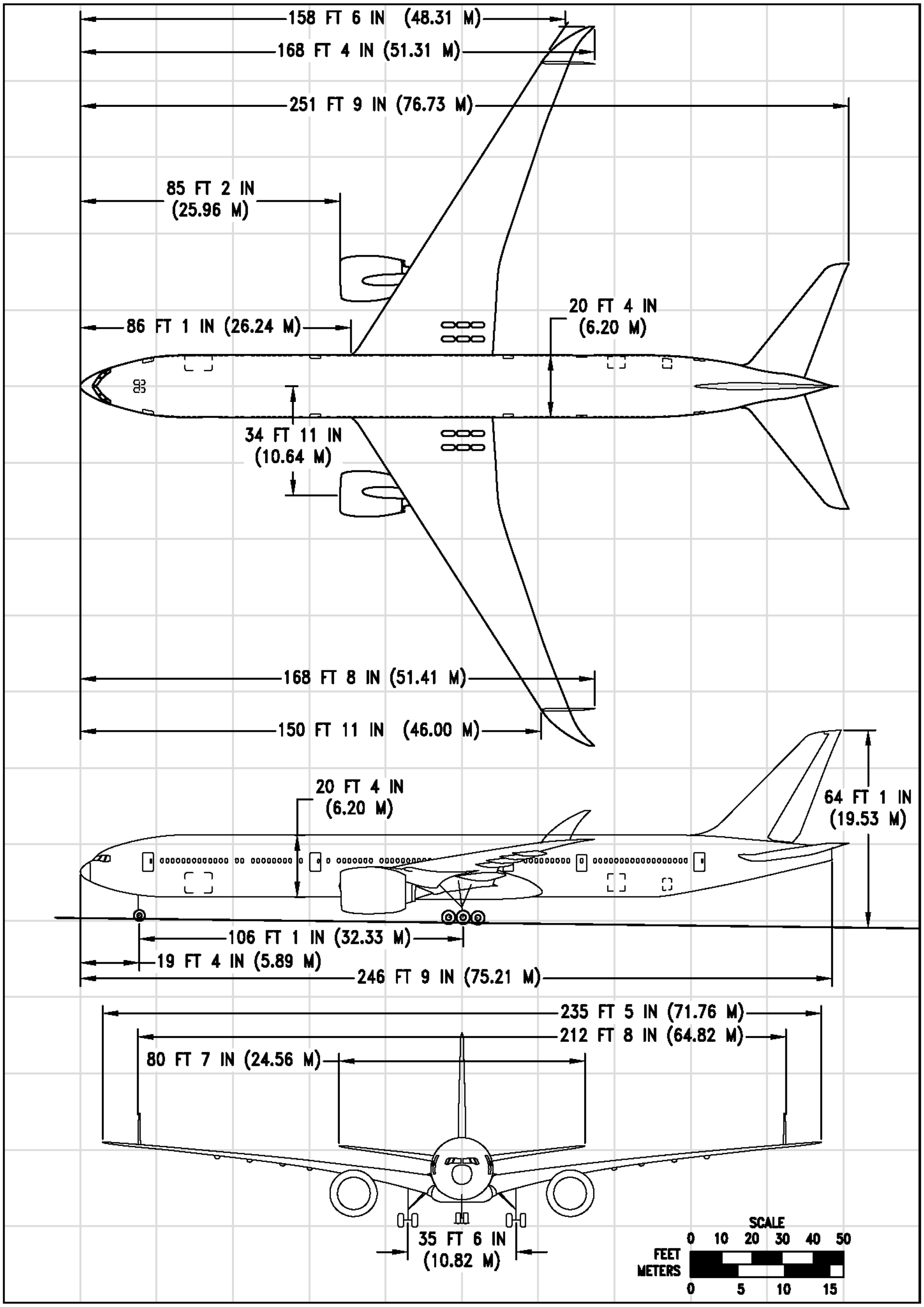
| CHARACTERISTICS | UNITS | 777-9 |
|---|---|---|
| MAX DESIGN TAXI WEIGHT | POUNDS | 777,000 |
| | KILOGRAMS | 352,442 |
| MAX DESIGN TAKEOFF WEIGHT | POUNDS | 775,000 |
| | KILOGRAMS | 351,534 |
| MAX DESIGN LANDING WEIGHT | POUNDS | 587,000 |
| | KILOGRAMS | 266,258 |
| MAX DESIGN ZERO FUEL WEIGHT | POUNDS | 562,000 |
| | KILOGRAMS | 254,918 |
| OPERATING EMPTY WEIGHT [1] | POUNDS | TBD |
| | KILOGRAMS | TBD |
| MAX STRUCTURAL PAYLOAD | POUNDS | TBD |
| | KILOGRAMS | TBD |
| TYPICAL SEATING CAPACITY | TWO CLASS | 414 [2] |
| | THREE CLASS | 349 [3] |
| MAX CARGO --LOWER DECK | CUBIC FEET | 7,815 [5] |
| | CUBIC METERS | 221.3 [5] |
| MAX CARGO --LOWER DECK [4] | CUBIC FEET | 8,131 [6] |
| | CUBIC METERS | 230.2 [6] |
| USABLE FUEL [7] | U.S. GALLONS | 52,300 |
| | LITERS | 197,977 |
| | POUNDS | 350,410 |
| | KILOGRAMS | 158,976 |

**NOTES:**

1. ESTIMATED WEIGHT FOR TYPICAL ENGINE / WEIGHT CONFIGURATION SHOWN IN TWO CLASS, ACTUAL WEIGHT WILL VARY FOR EACH AIRPLANE SERIAL NUMBER AND SPECIFIC AIRLINE CONFIGURATION.
2. 42 BUSINESS CLASS AND 372 ECONOMY CLASS
3. 8 FIRST CLASS, 49 BUSINESS CLASS AND 292 ECONOMY CLASS
4. OPTIONAL AFT LARGE CARGO DOOR
5. FWD CARGO = (26) LD-3 CONTAINERS AT 158 CU FT EACH
   AFT CARGO = (20) LD-3 CONTAINERS AT 158 CU FT EACH
   BULK CARGO = 547 CU FT
   SEE SEC 2.6 FOR OTHER LOADING COMBINATIONS.
6. FWD CARGO = (26) LD-3 CONTAINERS AT 158 CU FT EACH
   AFT CARGO = (22) LD-3 CONTAINERS AT 158 CU FT EACH
   BULK CARGO = 547 CU FT
   SEE SEC 2.6 FOR OTHER LOADING COMBINATIONS.
7. FUEL DENSITY = 6.7 LBS/US GAL

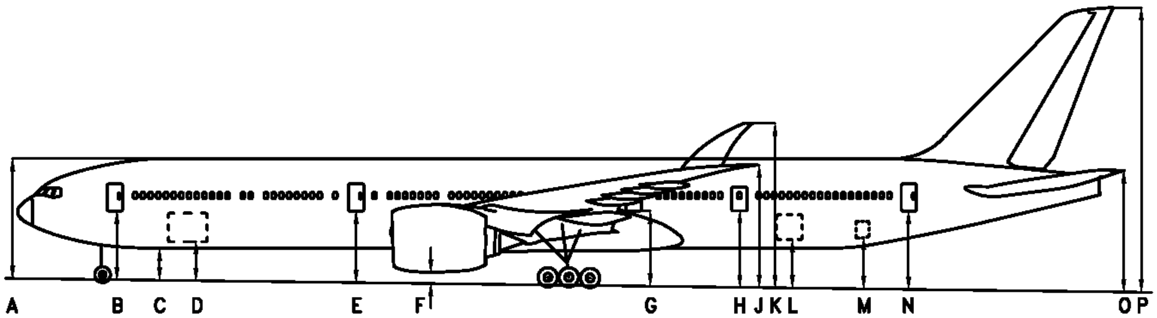
## 2.2 GENERAL DIMENSIONS

### 2.2.1 General Dimensions: Model 777-9



## 2.3 GROUND CLEARANCES

### 2.3.1 Ground Clearances: Model 777-9




| Dimension | MINIMUM* | | MAXIMUM* | |
|---|---|---|---|---|
| | FT - IN | M | FT - IN | M |
| A | 27-9 | 8.46 | 28-10 | 8.79 |
| B | 15-8 | 4.78 | 16-10 | 5.13 |
| C | 7-0 | 2.13 | 8-6 | 2.59 |
| D | 9-5 | 2.87 | 10-5 | 3.18 |
| E | 16-4 | 4.98 | 17-2 | 5.23 |
| F | TBD | TBD | TBD | TBD |
| G | 16-11 | 5.16 | 17-8 | 5.38 |
| H (OPTIONAL EXIT DOOR) | 16-11 | 5.16 | 17-11 | 5.46 |
| J (EXTENDED WING TIP) | TBD | TBD | TBD | TBD |
| K (FOLDED WING TIP) | TBD | TBD | TBD | TBD |
| L | 10-5 | 3.18 | 11-6 | 3.51 |
| M | 10-10 | 3.3 | 11-7 | 3.53 |
| N | 17-0 | 5.18 | 18-2 | 5.54 |
| O | 26-4 | 8.03 | 27-10 | 8.48 |
| P | 63-3 | 19.28 | 64-9 | 19.74 |

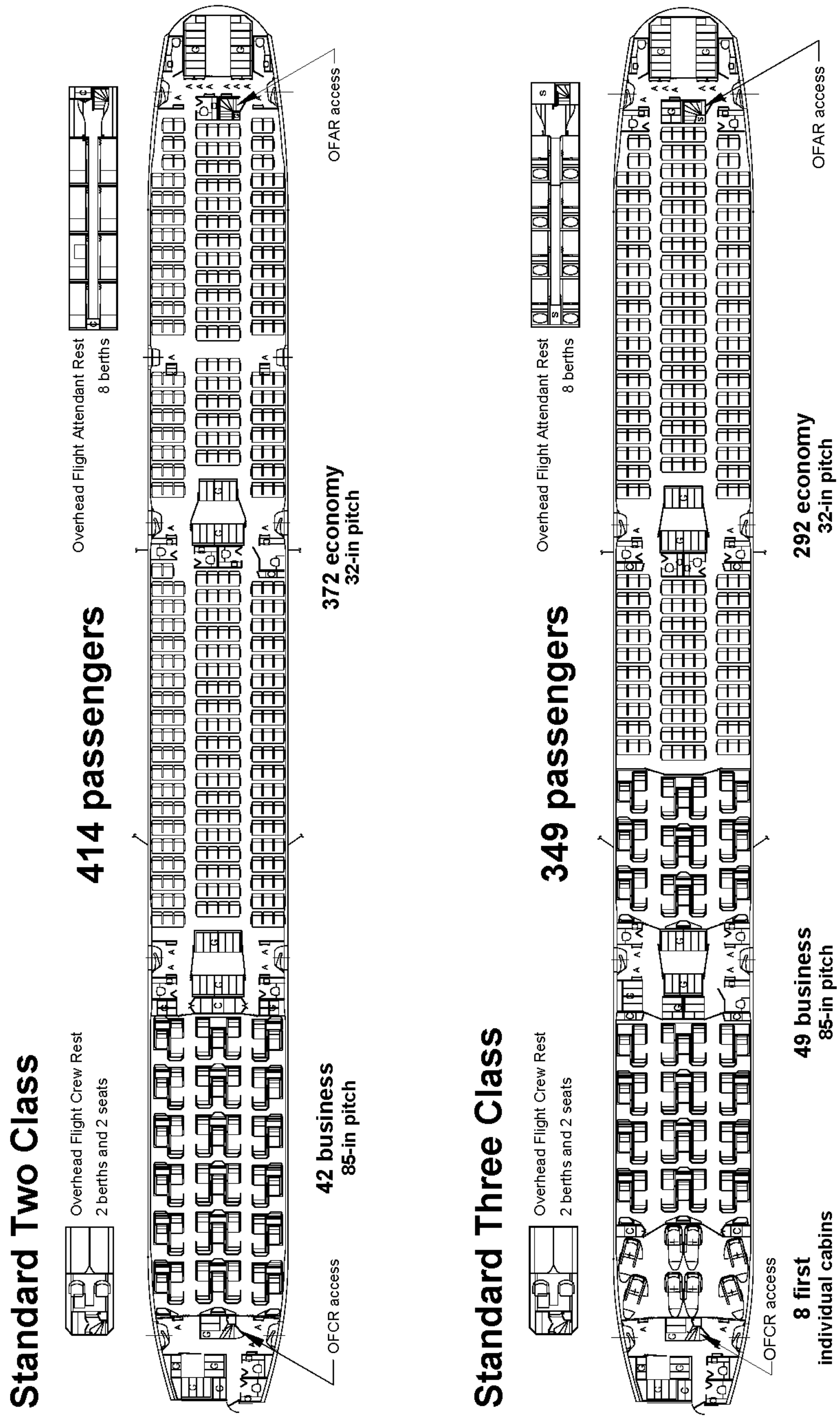
**NOTES:**

1. VERTICAL CLEARANCES SHOWN OCCUR DURING MAXIMUM VARIATIONS OF AIRPLANE ATTITUDE. COMBINATIONS OF AIRPLANE LOADING AND UNLOADING ACTIVITIES THAT PRODUCE THE GREATEST POSSIBLE VARIATION IN ATTITUDE WERE USED TO ESTABLISH THE VARIATIONS SHOWN.
2. DURING ROUTINE SERVICING, THE AIRPLANE REMAINS RELATIVELY STABLE, PITCH AND ELEVATION CHANGES OCCURRING SLOWLY.

* NOMINAL DIMENSIONS ROUNDED TO NEAREST INCH AND NEAREST CENTIMETER

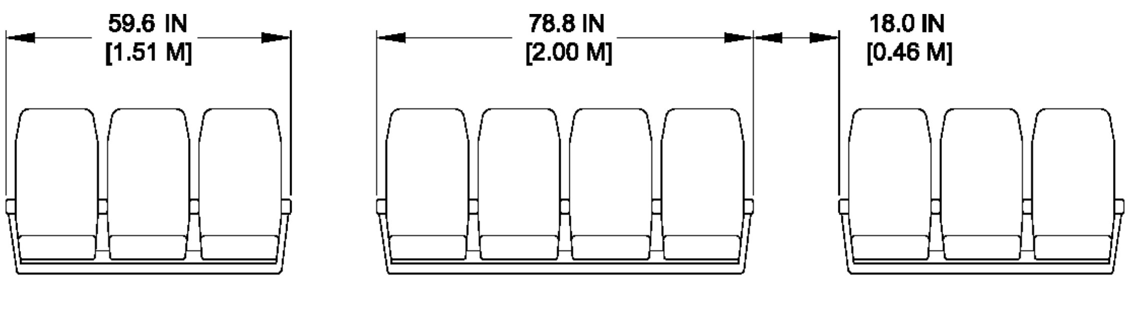
## 2.4 INTERIOR ARRANGEMENTS

### 2.4.1 Interior Arrangements - Typical: Model 777-9



## 2.5 CABIN CROSS SECTIONS

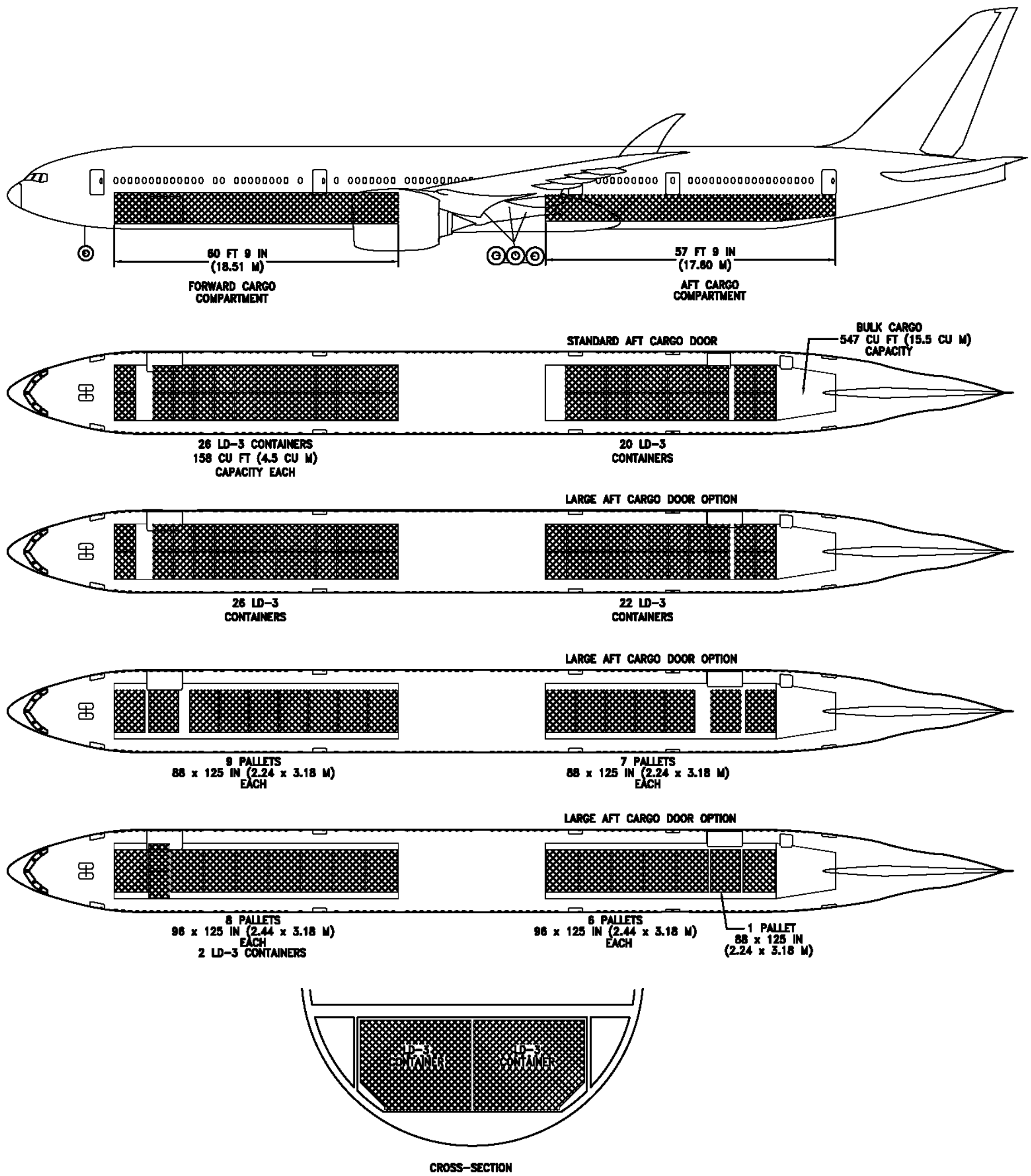
### 2.5.1 Cabin Cross-Sections: Model 777-9 Seats




ECONOMY CLASS SEATING
10 - ABREAST

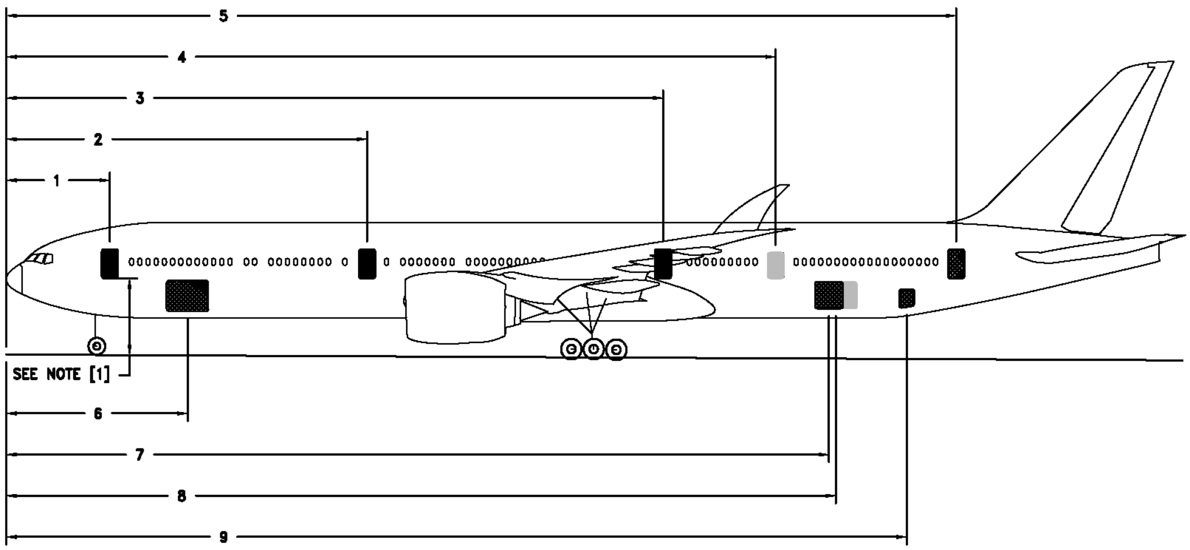
## 2.6 LOWER CARGO COMPARTMENTS

### 2.6.1 Lower Cargo Compartments: Model 777-9, Containers and Bulk Cargo



## 2.7 DOOR CLEARANCES

### 2.7.1 Door Clearances: Model 777-9, Door Locations

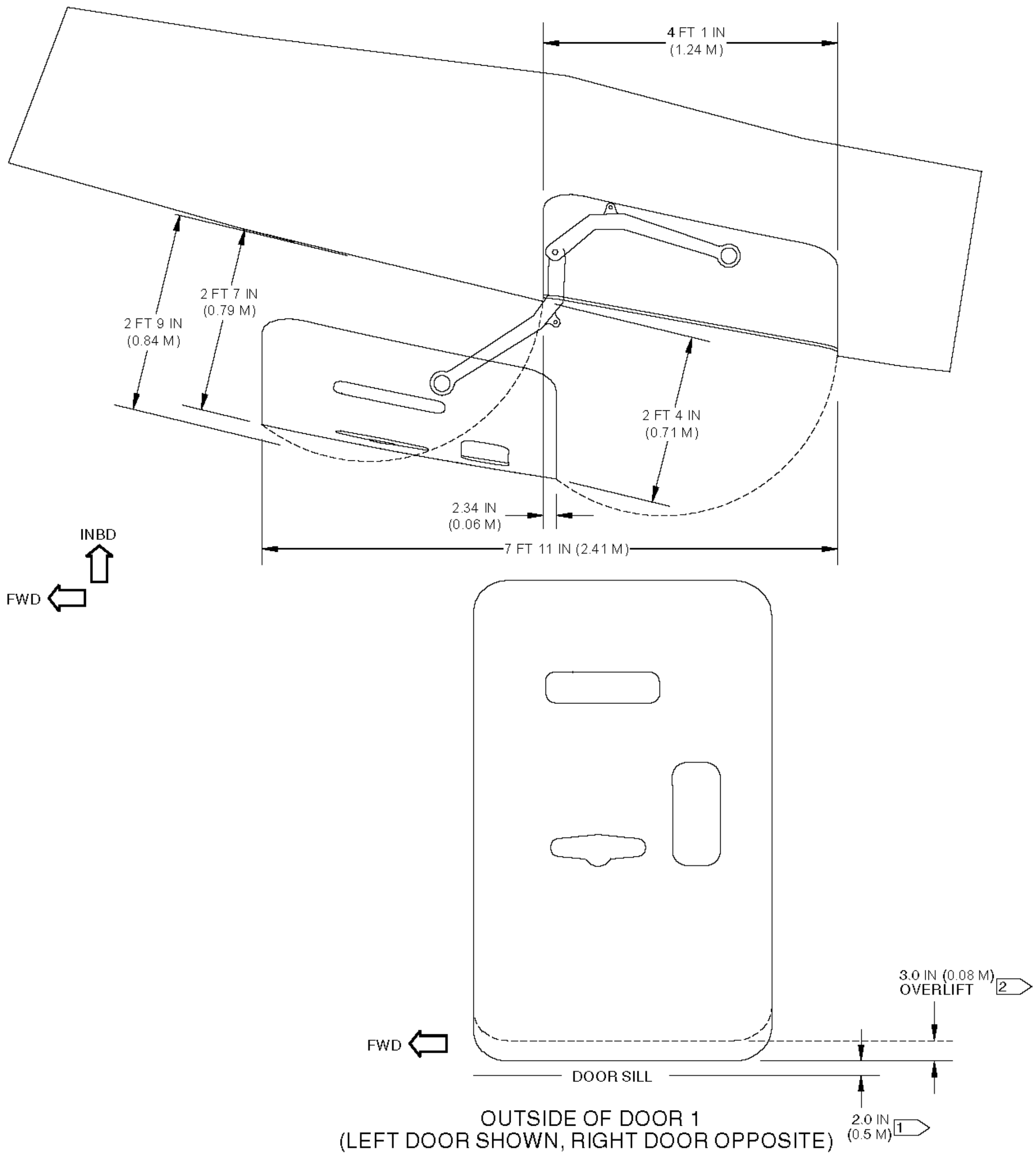



| | Door Name | Door Location | Location FT-IN (M) | Clear Opening IN (M) |
|---|---|---|---|---|
| 1 | MAIN ENTRY/SERVICE DOOR NO 1 [2] | LEFT AND RIGHT | 22-2 (6.76) | 42 X 74 (1.07 X 1.88) |
| 2 | MAIN ENTRY/SERVICE DOOR NO 2 [2] | LEFT AND RIGHT | 77-0 (23.47) | 42 X 74 (1.07 X 1.88) |
| 3 | MAIN ENTRY/SERVICE DOOR NO 3 [2] | LEFT AND RIGHT | 140-2 (42.72) | 42 X 74 (1.07 X 1.88) |
| 4 | OPTIONAL EMERGENCY EXIT/SERVICE DOOR | LEFT AND RIGHT | 164-3 (50.06) | 34 X 72 (0.86 X 1.83) |
| 5 | MAIN ENTRY/SERVICE DOOR NO 4 [2] | LEFT AND RIGHT | 202-9 (61.80) | 42 X 74 (1.07 X 1.88) |
| 6 | FORWARD CARGO DOOR | RIGHT | 38-9 (11.81) | 106 X 67 (2.69 X 1.7) |
| 7 | STANDARD AFT CARGO DOOR | RIGHT | 175-7 (53.52) | 70 X 67 (1.78 X 1.7) |
| 8 | OPTIONAL AFT LARGE CARGO DOOR | RIGHT | 177-1 (53.98) | 106 X 67 (2.69 X 1.7) |
| 9 | BULK CARGO DOOR | RIGHT | 192-3 (58.60) | 36 X 45 (0.91 X 1.14) |

**NOTES:**

1. SEE SEC 2.3 FOR DOOR SILL HEIGHTS
2. ENTRY DOORS LEFT SIDE, SERVICE DOORS RIGHT SIDE

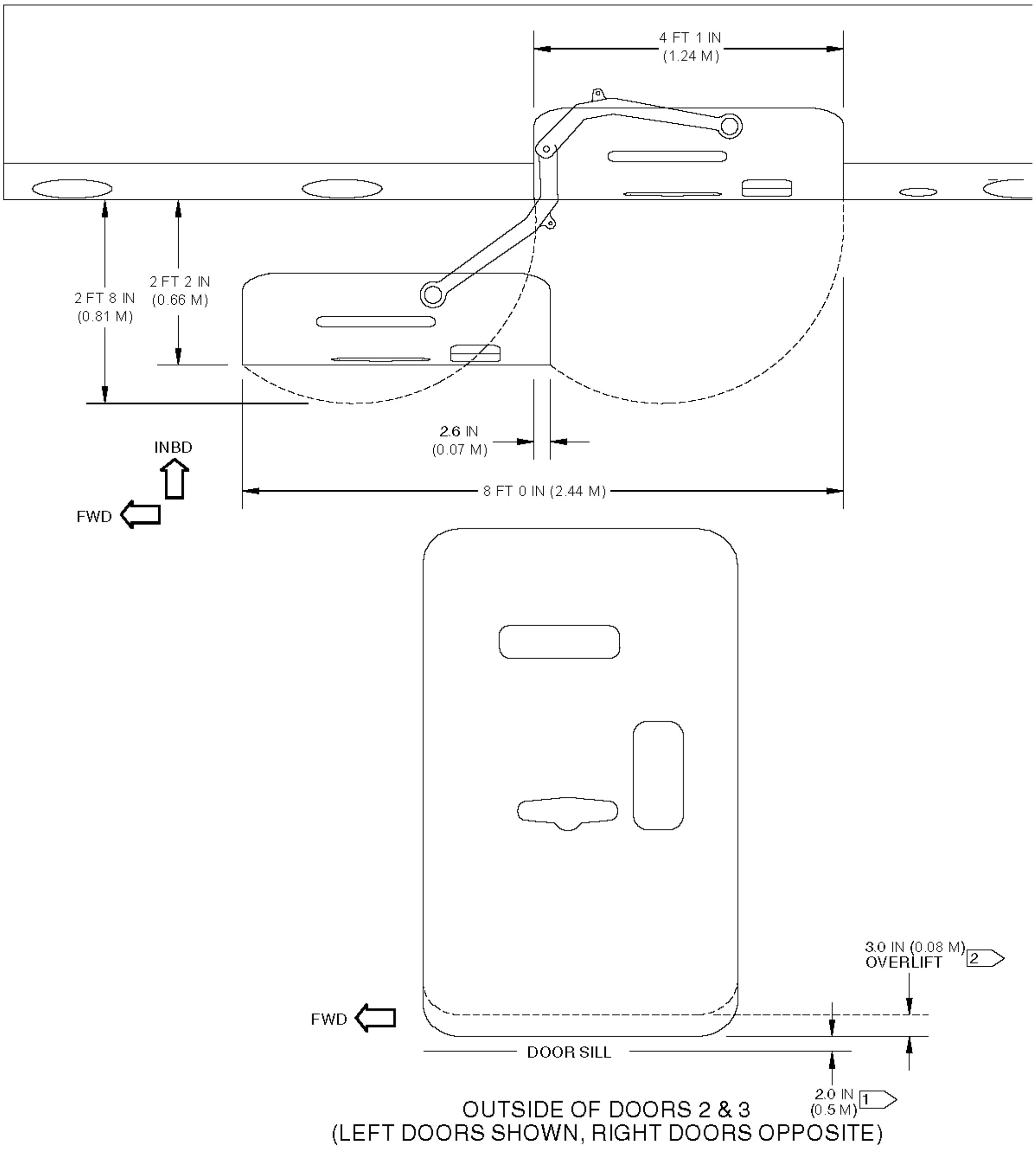
## 2.7.2 Door Clearances: Model 777-9, Main Entry Door No 1




1 DOOR MOVES UPWARD 2.0 IN. AND INWARD 0.4 IN. TO CLEAR STOPS BEFORE OPENING OUTWARD

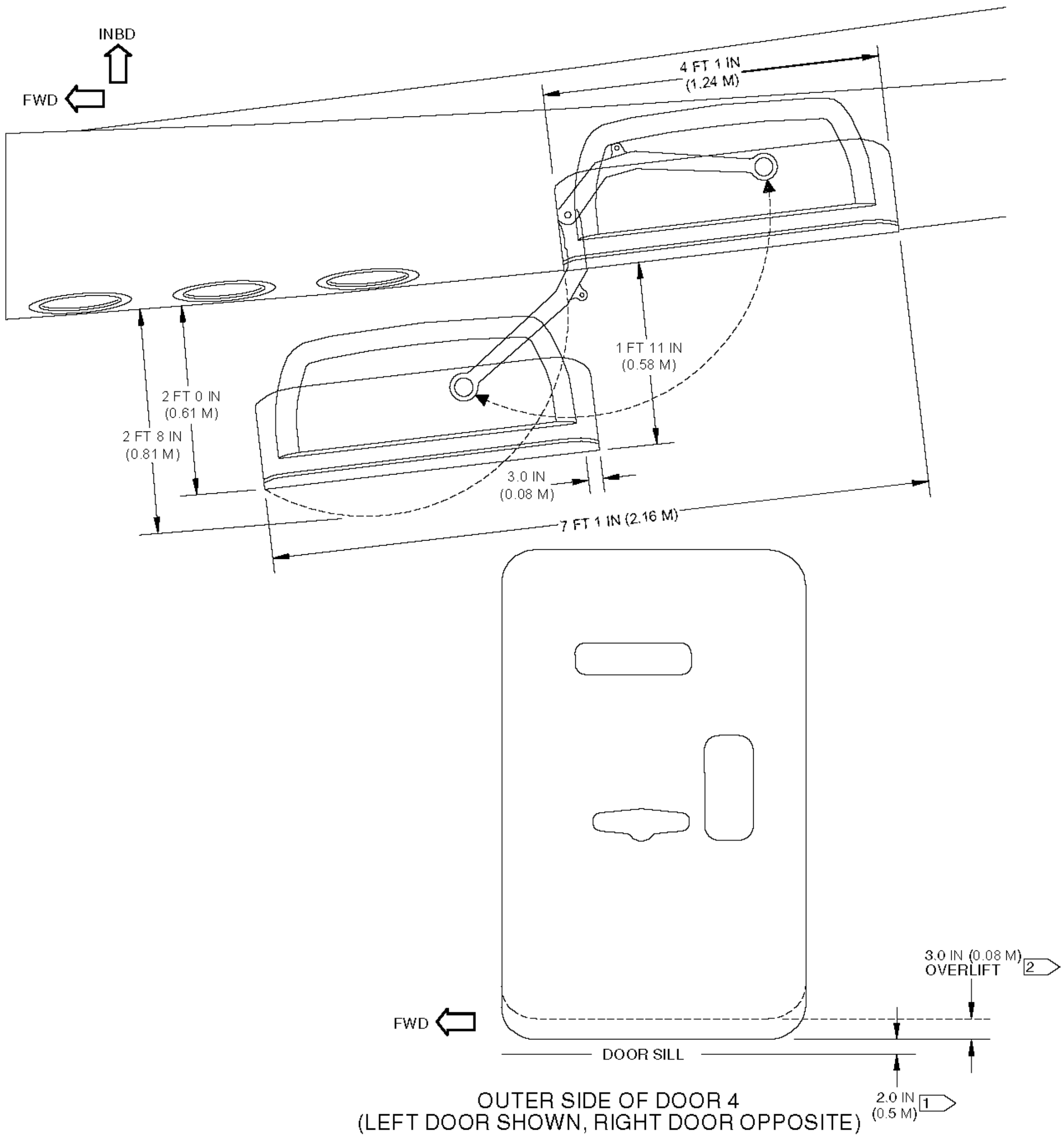
2 DOOR CAPABLE OF MOVING AN ADDITIONAL 3.0 IN. VERTICALLY (OVERLIFT) TO PRECLUDE DAMAGE FROM CONTACT WITH LOADING BRIDGE

### 2.7.3 Door Clearances: Model 777-9, Main Entry Door No 2, and No 3




1. DOOR MOVES UPWARD 2.0 IN. AND INWARD 0.4 IN. TO CLEAR STOPS BEFORE OPENING OUTWARD
2. DOOR CAPABLE OF MOVING AN ADDITIONAL 3.0 IN. VERTICALLY (OVERLIFT) TO PRECLUDE DAMAGE FROM CONTACT WITH LOADING BRIDGE

### 2.7.4 Door Clearances: Model 777-9, Main Entry Door No 4




1 DOOR MOVES UPWARD 2.0 IN. AND INWARD 0.4 IN. TO CLEAR STOPS BEFORE OPENING OUTWARD

2 DOOR CAPABLE OF MOVING AN ADDITIONAL 3.0 IN. VERTICALLY (OVERLIFT) TO PRECLUDE DAMAGE FROM CONTACT WITH LOADING BRIDGE

### 2.7.5 Door Clearances: Model 777-9, Optional Service Door

DATA TO BE PROVIDED
AT A LATER DATE

### 2.7.6 Door Clearances: Model 777-9, Forward Cargo Door

DATA TO BE PROVIDED
AT A LATER DATE

### 2.7.7 Door Clearances: Model 777-9, Small Aft Cargo Door

DATA TO BE PROVIDED
AT A LATER DATE

### 2.7.8 Door Clearances: Model 777-9, Bulk Cargo Door

DATA TO BE PROVIDED
AT A LATER DATE

# 3.0 AIRPLANE PERFORMANCE

## 3.1 GENERAL INFORMATION

The graphs in Section 3.2 provide information on payload-range capability of the 777 airplane. To use these graphs, if the trip range and zero fuel weight (OEW + payload) are known, the approximate takeoff weight can be found, limited by maximum zero fuel weight, maximum design takeoff weight, or fuel capacity.

The graphs in Section 3.3 provide information on FAA/EASA takeoff runway length requirements with typical engines at different pressure altitudes. Maximum takeoff weights shown on the graphs are the heaviest for the particular airplane models with the corresponding engines. Standard day temperatures for pressure altitudes shown on the FAA/EASA takeoff graphs are given below:

| PRESSURE ALTITUDE | | STANDARD DAY TEMP | |
|---|---|---|---|
| FEET | METERS | °F | °C |
| 0 | 0 | 59.0 | 15.0 |
| 2,000 | 610 | 51.9 | 11.0 |
| 4,000 | 1,219 | 44.7 | 7.1 |
| 6,000 | 1,829 | 37.6 | 3.1 |
| 8,000 | 2,438 | 30.5 | -0.8 |
| 10,000 | 3,048 | 23.3 | -4.8 |
| 12,000 | 3,658 | 16.2 | -8.8 |
| 14,000 | 4,267 | 9.1 | -12.7 |

The graphs in Section 3.4 provide information on landing runway length requirements for different airplane weights and airport altitudes. The maximum landing weights shown are the heaviest for the particular airplane model.

## 3.2 PAYLOAD/RANGE FOR LONG RANGE CRUISE

### 3.2.1 Payload/Range for Long Range Cruise: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 3.3 FAA/EASA TAKEOFF RUNWAY LENGTH REQUIREMENTS

### 3.3.1 FAA/EASA Takeoff Runway Length Requirements: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 3.4 FAA/EASA LANDING RUNWAY LENGTH REQUIREMENTS

### 3.4.1 FAA/EASA Landing Runway Length Requirements: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 4.0 GROUND MANEUVERING

### 4.1 GENERAL INFORMATION

The 777 main landing gear consists of two main struts, each strut with six wheels. The steering system incorporates aft axle steering of the main landing gear in addition to the nose gear steering. The aft axle steering system is hydraulically actuated and programmed to provide steering ratios proportionate to the nose gear steering angles. During takeoff and landing, the aft axle steering system is centered, mechanically locked, and depressurized.

The turning radii and turning curves shown in this section are derived from airplane geometry. Other factors that could influence the geometry of the turn include:

1. Engine power settings
2. Center of gravity location
3. Airplane weight
4. Pavement surface conditions
5. Amount of differential braking
6. Ground speed

This section provides airplane turning capability and maneuvering characteristics.

For ease of presentation, these data have been determined from the theoretical limits imposed by the geometry of the aircraft, and where noted, provide for a normal allowance for tire slippage. As such, they reflect the turning capability of the aircraft in favorable operating circumstances. These data should be used only as guidelines for the method of determination of such parameters and for the maneuvering characteristics of this aircraft.

In the ground operating mode, varying airline practices may demand that more conservative turning procedures be adopted to avoid excessive tire wear and reduce possible maintenance problems. Airline operating procedures will vary in the level of performance over a wide range of operating circumstances throughout the world. Variations from standard aircraft operating patterns may be necessary to satisfy physical constraints within the maneuvering area, such as adverse grades, limited area, or high risk of jet blast damage. For these reasons, ground maneuvering requirements should be coordinated with the using airlines prior to layout planning.

Section 4.2 presents turning radii for various nose gear steering angles. Radii for the main and nose gears are measured from the turn center to the outside of the tire.

Section 4.3 shows data on minimum width of pavement required for 180° turn.

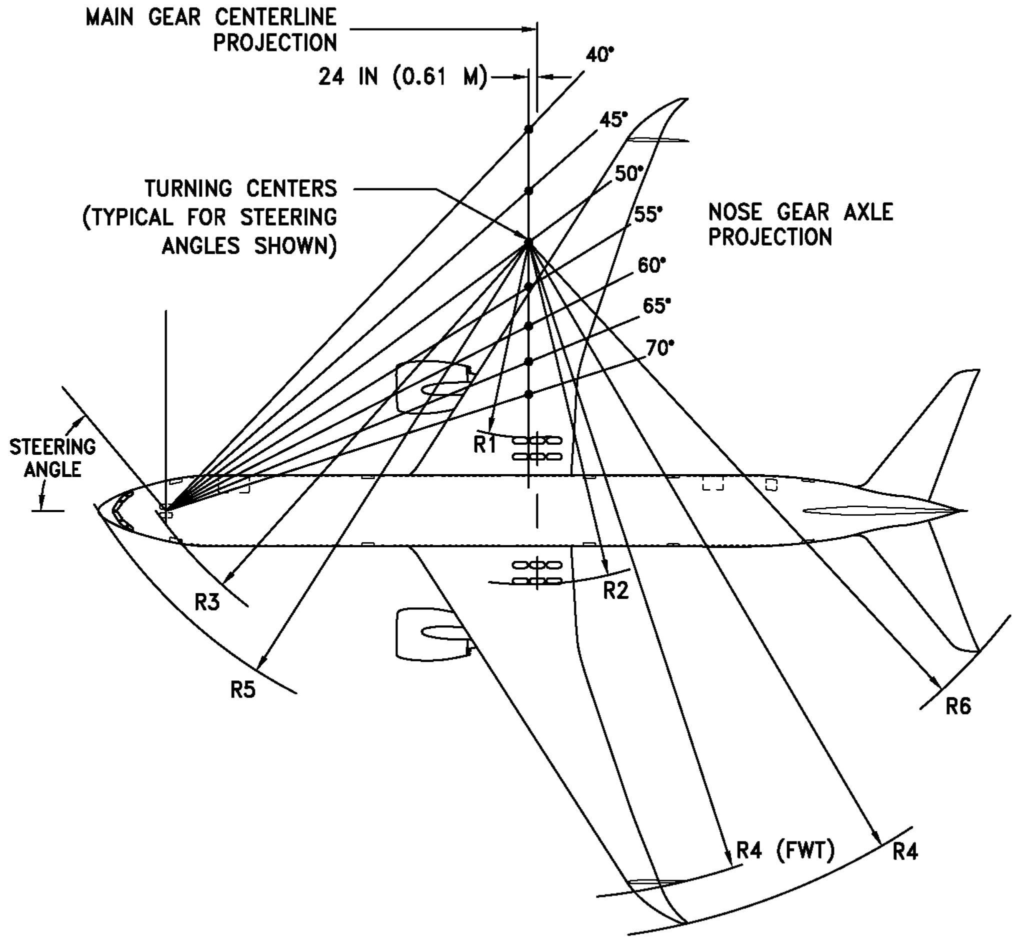
Section 4.4 provides pilot visibility data from the cockpit and the limits of ambinocular vision through the windows. Ambinocular vision is defined as the total field of vision seen simultaneously by both eyes.

Section 4.5 shows approximate wheel paths for various runway and taxiway turn scenarios. The pavement fillet geometries are based on the FAA's Advisory Circular (AC) 150/5300-13 (thru change 16). They represent typical fillet geometries built at many airports worldwide. ICAO and other civil aviation authorities publish many different fillet design methods. Prior to determining the size of fillets, airports are advised to check with the airlines regarding the operating procedures and aircraft types they expect to use at the airport. Further, given the cost of modifying fillets and the operational impact to ground movement and air traffic during construction, airports may want to design critical fillets for larger aircraft types to minimize future operational impacts.

Section 4.6 illustrates a typical runway holding bay configuration.

## 4.2 TURNING RADII

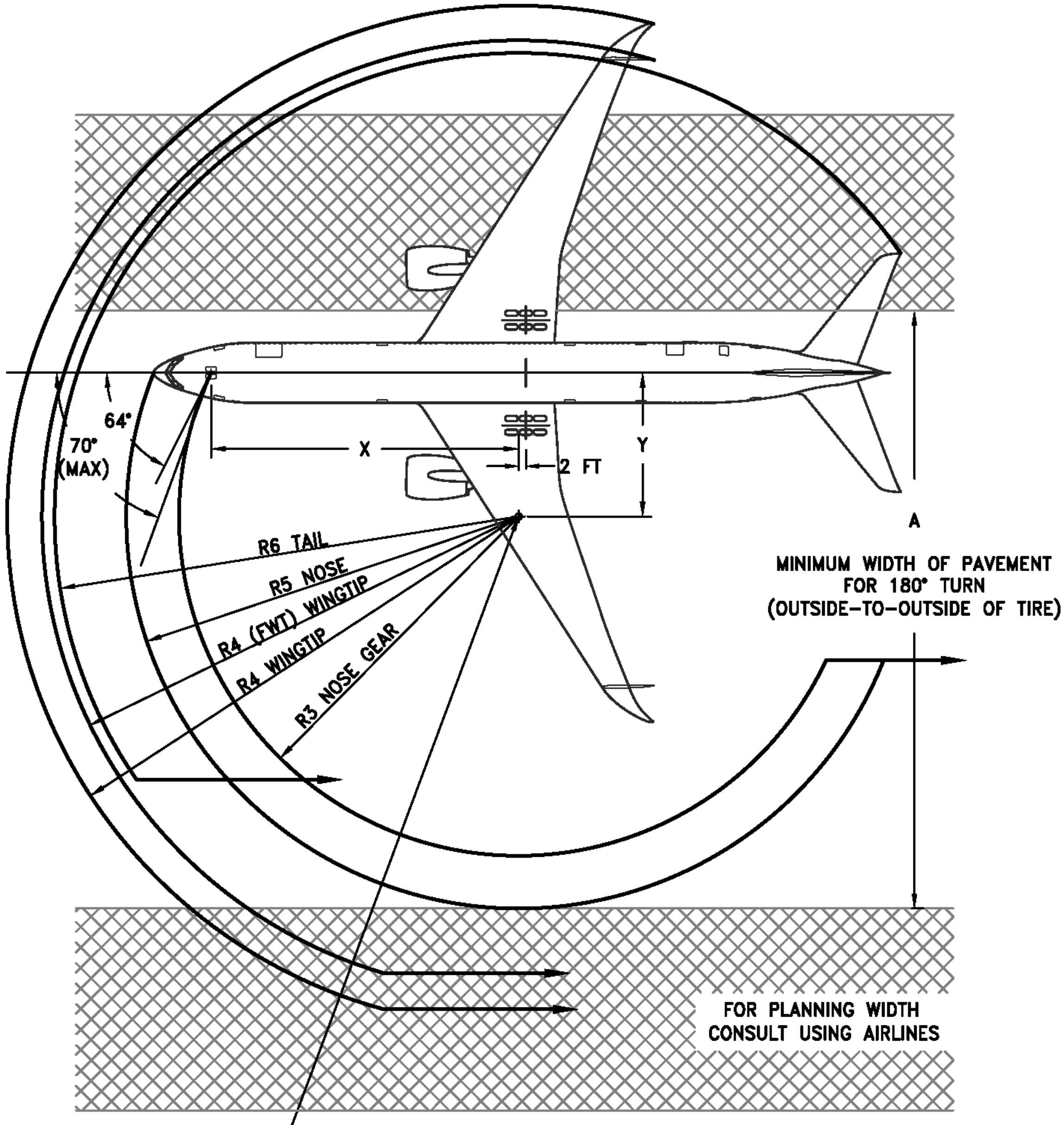
### 4.2.1 Turning Radii – No Slip Angle: Model 777-9




**NOTES**: DATA SHOWN FOR AIRPLANE WITH AFT AXLE STEERING
ACTUAL OPERATING TURNING RADII MAY BE GREATER THAN SHOWN
CONSULT WITH AIRLINE FOR SPECIFIC OPERATING PROCEDURE
DIMENSIONS ROUNDED TO NEAREST WHOLE FOOT AND 0.1 METER
FWT: FOLDED WING TIP

| STEERING ANGLE | R1 INNER GEAR | | R2 OUTER GEAR | | R3 NOSE GEAR | | R4 WING TIP | | R4 (FWT) WING TIP | | R5 NOSE | | R6 TAIL | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (DEG) | FT | M | FT | M | FT | M | FT | M | FT | M | FT | M | FT | M |
| 30 | 159 | 48.5 | 201 | 61.3 | 210 | 64.0 | 301 | 91.7 | 290 | 88.4 | 218 | 66.4 | 255 | 77.7 |
| 35 | 128 | 39.0 | 170 | 51.8 | 183 | 55.8 | 270 | 82.3 | 259 | 78.9 | 193 | 58.8 | 228 | 69.5 |
| 40 | 103 | 31.4 | 145 | 44.2 | 164 | 50.0 | 246 | 75.0 | 234 | 71.3 | 175 | 53.3 | 208 | 63.4 |
| 45 | 83 | 25.3 | 125 | 38.1 | 149 | 45.4 | 226 | 68.9 | 215 | 65.5 | 161 | 49.1 | 193 | 58.8 |
| 50 | 66 | 20.1 | 108 | 32.9 | 138 | 42.1 | 210 | 64.0 | 198 | 60.4 | 151 | 46.0 | 181 | 55.2 |
| 55 | 52 | 15.8 | 94 | 28.7 | 129 | 39.3 | 195 | 59.4 | 184 | 56.1 | 143 | 43.6 | 171 | 52.1 |
| 60 | 39 | 11.9 | 81 | 24.7 | 122 | 37.2 | 183 | 55.8 | 172 | 52.4 | 137 | 41.8 | 163 | 49.7 |
| 65 | 28 | 8.5 | 69 | 21.0 | 117 | 35.7 | 172 | 52.4 | 161 | 49.1 | 133 | 40.5 | 156 | 47.5 |
| 70 (MAX) | 17 | 5.2 | 59 | 18.0 | 113 | 34.4 | 161 | 49.1 | 151 | 46.0 | 129 | 39.3 | 150 | 45.7 |

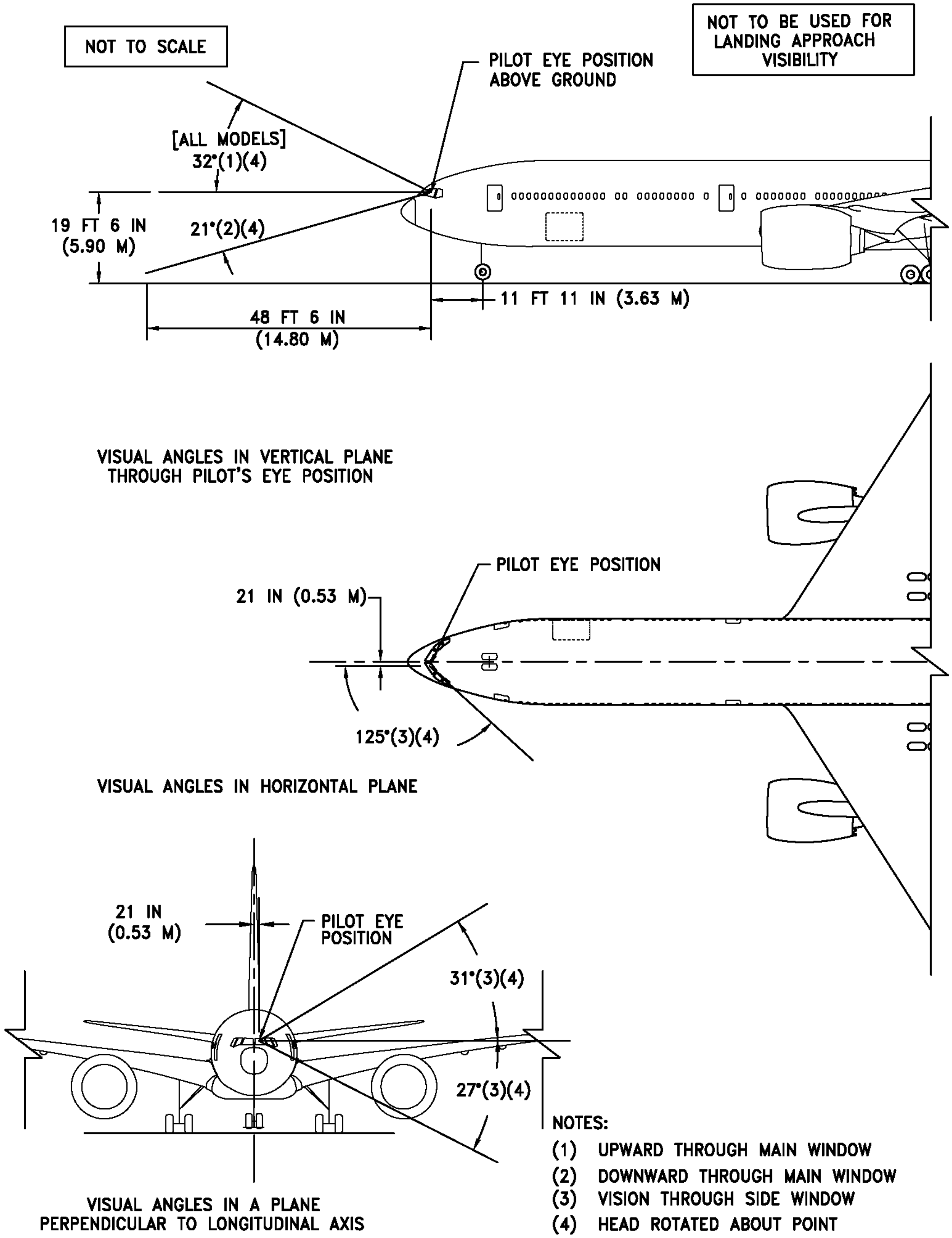
## 4.3 CLEARANCE RADII: MODEL 777-9




| AIRPLANE MODEL | EFFECTIVE TURNING ANGLE (DEG) | X | | Y | | A | | R3 | | R4 | | R4 (FWT) | | R5 | | R6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FT | M | FT | M | FT | M | FT | M | FT | M | FT | M | FT | M | FT | M |
| 777-9 | 64 | 104 | 31.7 | 51 | 15.5 | 189 | 57.6 | 118 | 36.0 | 174 | 53.0 | 163 | 49.7 | 133 | 40.5 | 157 | 47.9 |

**NOTE**: DIMENSIONS ARE ROUNDED TO THE NEAREST WHOLE FOOT AND 0.1 METER.
FWT: FOLDED WING TIP

## 4.4 VISIBILITY FROM COCKPIT IN STATIC POSITION: MODEL 777-9




NOTES:

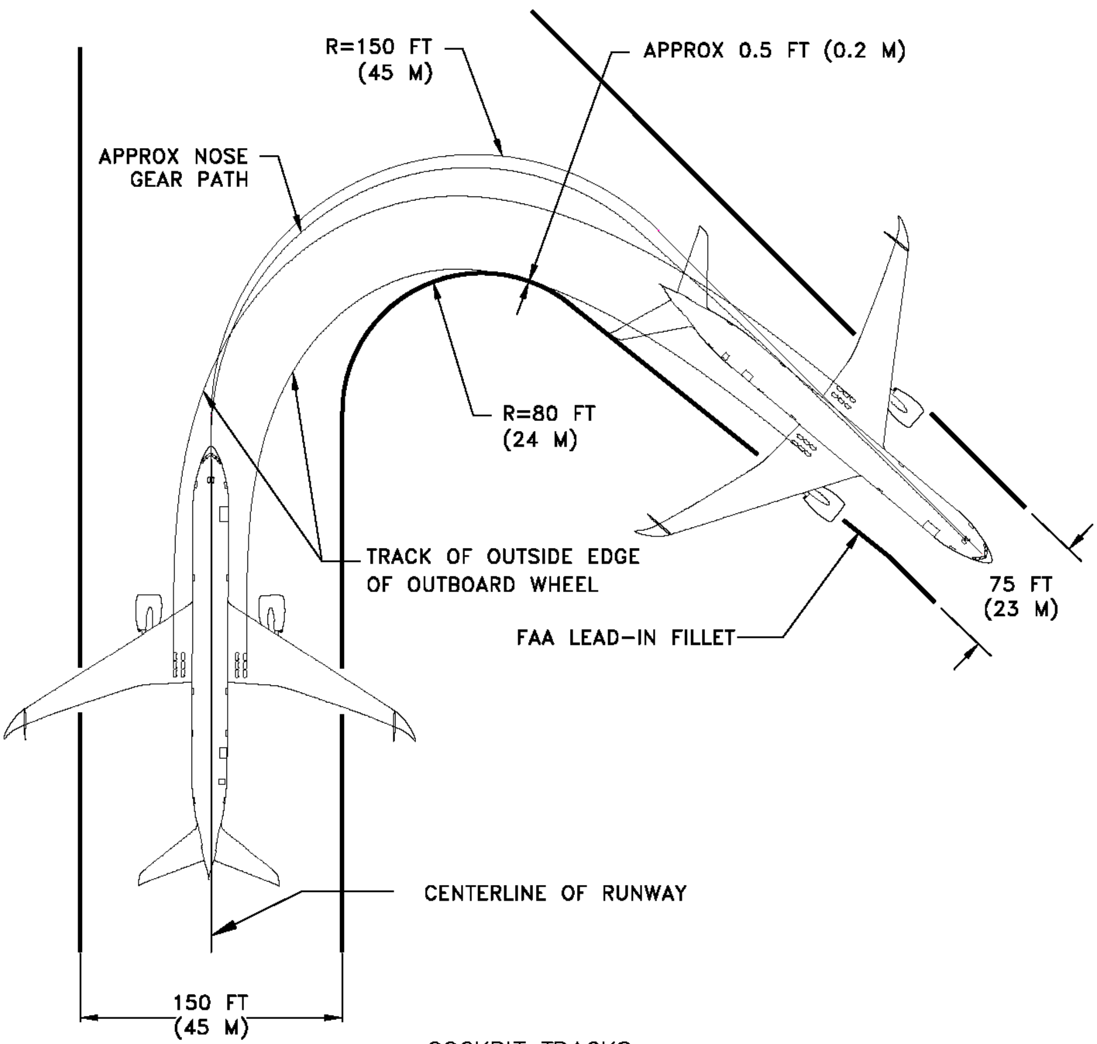
(1) UPWARD THROUGH MAIN WINDOW
(2) DOWNWARD THROUGH MAIN WINDOW
(3) VISION THROUGH SIDE WINDOW
(4) HEAD ROTATED ABOUT POINT 3.3 IN (0.08 M) AFT OF PILOT'S REFERENCE EYE POSITION.

## 4.5 RUNWAY AND TAXIWAY TURN PATHS

### 4.5.1 Runway and Taxiway Turn Paths - Runway-to-Taxiway, More Than 90 Degree Turn: Model 777-9

**NOTES:**

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT

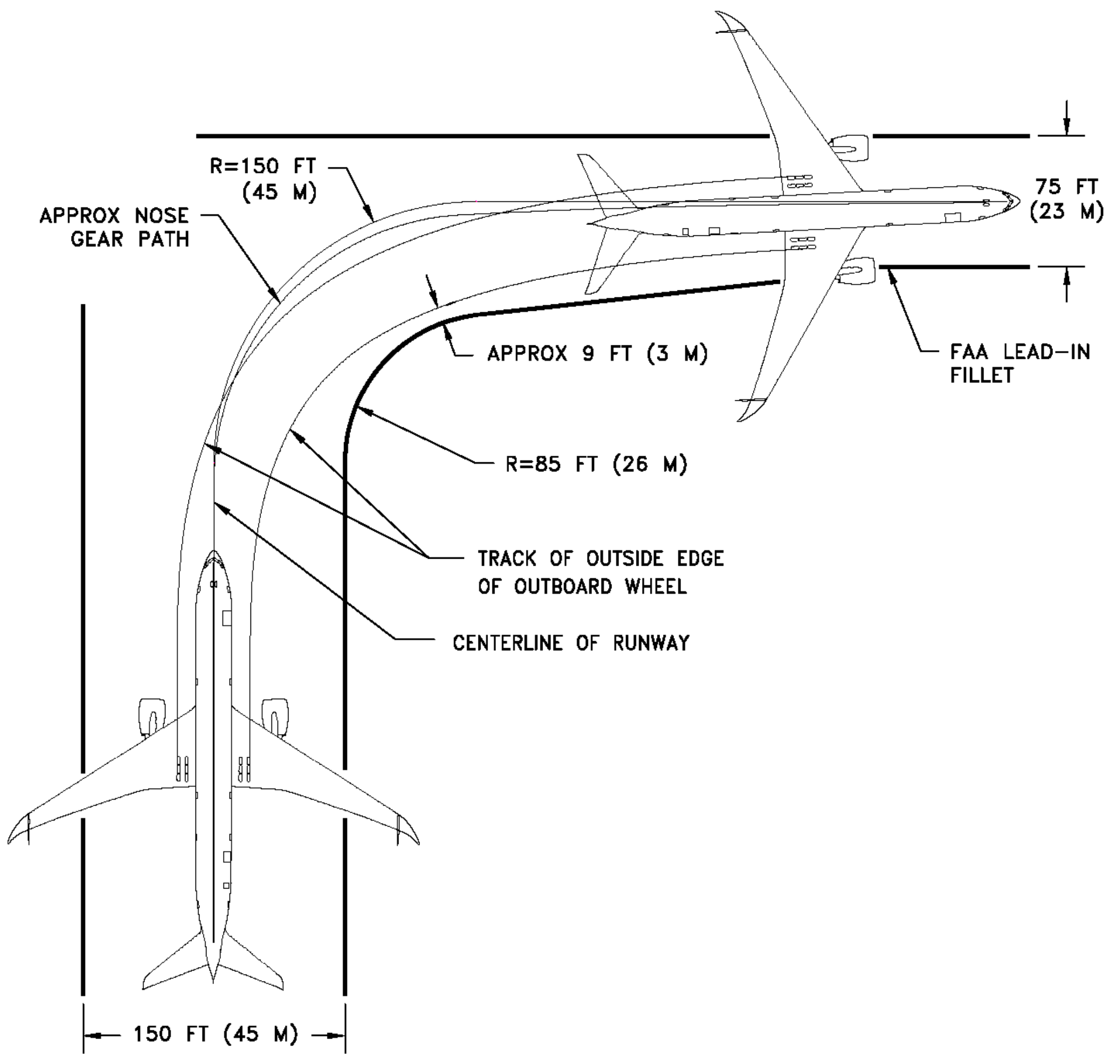



COCKPIT TRACKS
CENTERLINE OF TURNS

## 4.5.2 Runway and Taxiway Turn Paths - Runway-to-Taxiway, 90 Degree Turn: Model 777-9

**NOTES:**

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT

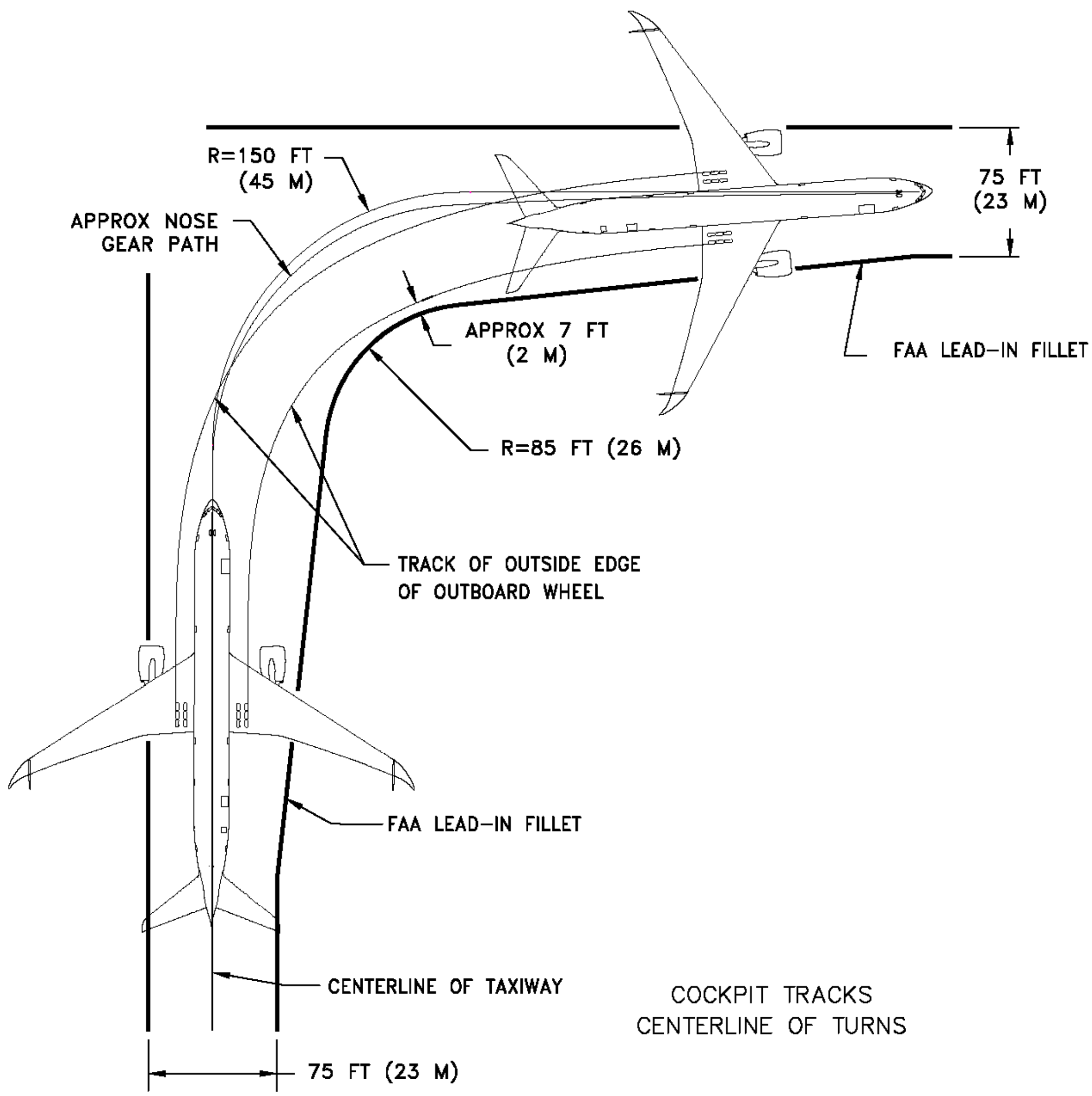



COCKPIT TRACKS
CENTERLINE OF TURNS

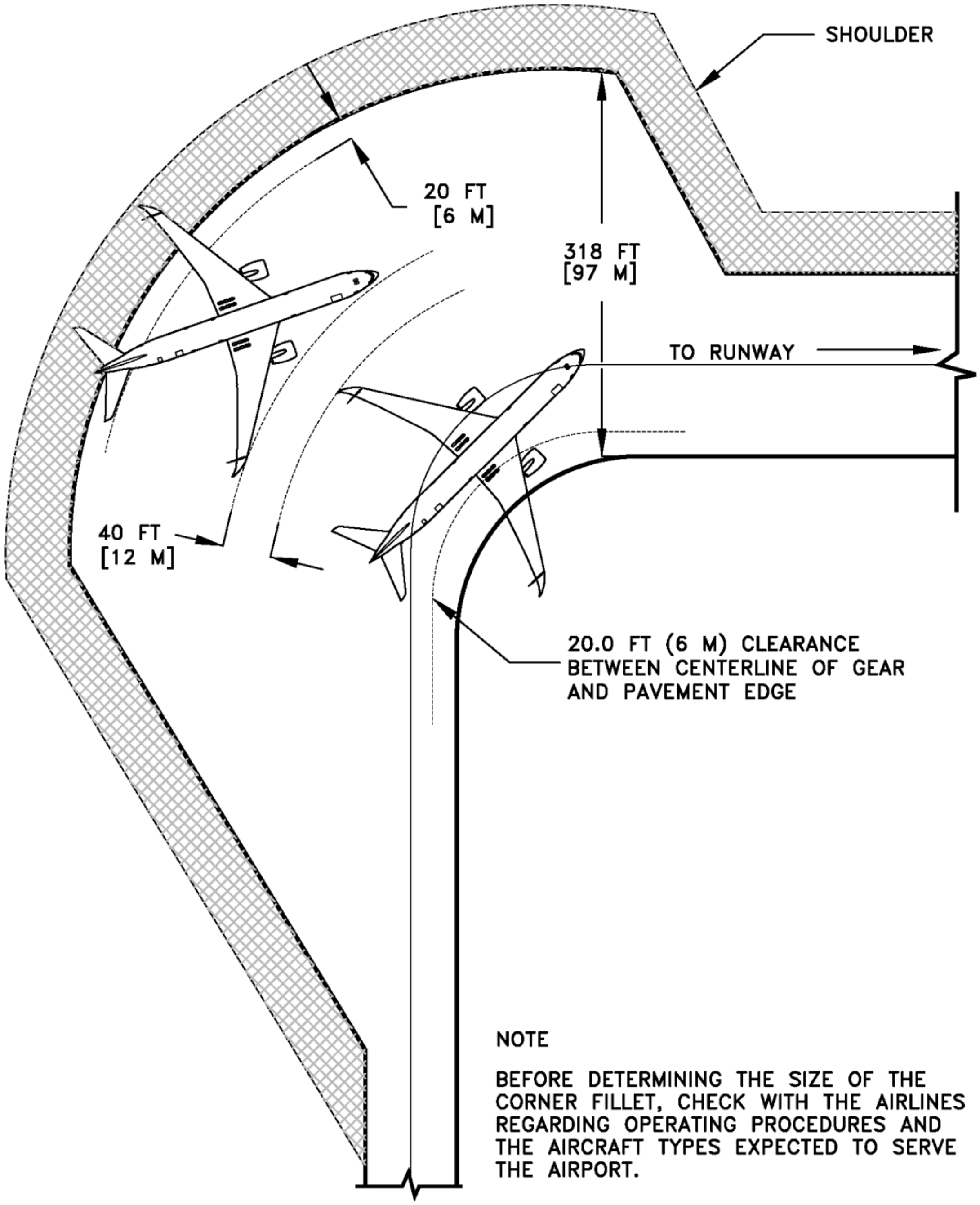
### 4.5.3 Runway and Taxiway Turn Paths - Taxiway-to-Taxiway, 90 Degree Turn: Model 777-9

**NOTES:**

BEFORE DETERMINING THE SIZE OF THE INTERSECTION FILLET, CHECK WITH THE AIRLINES REGARDING THE OPERATING PROCEDURES THAT THEY USE AND THE AIRCRAFT TYPES THEY ARE EXPECTED TO USE AT THE AIRPORT



## 4.6 RUNWAY HOLDING BAY: MODEL 777-9



## 5.0 TERMINAL SERVICING

During turnaround at the terminal, certain services must be performed on the aircraft, usually within a given time, to meet flight schedules. This section shows service vehicle arrangements, schedules, locations of service points, and typical service requirements. The data presented in this section reflect ideal conditions for a single airplane. Service requirements may vary according to airplane condition and airline procedure.

Section 5.1 shows typical arrangements of ground support equipment during turnaround. As noted, if the auxiliary power unit (APU) is used, the electrical, air start, and air-conditioning service vehicles would not be required. Passenger loading bridges or portable passenger stairs could be used to load or unload passengers.

Sections 5.2 and 5.3 show typical service times at the terminal. These charts give typical schedules for performing service on the airplane within a given time. Service times could be rearranged to suit availability of personnel, airplane configuration, and degree of service required.

Section 5.4 shows the locations of ground service connections in graphic and in tabular forms. Typical capacities and service requirements are shown in the tables. Services with requirements that vary with conditions are described in subsequent sections.

Section 5.5 shows typical sea level air pressure and flow requirements for starting the engines. The curves are based on an engine start time of 90 seconds.

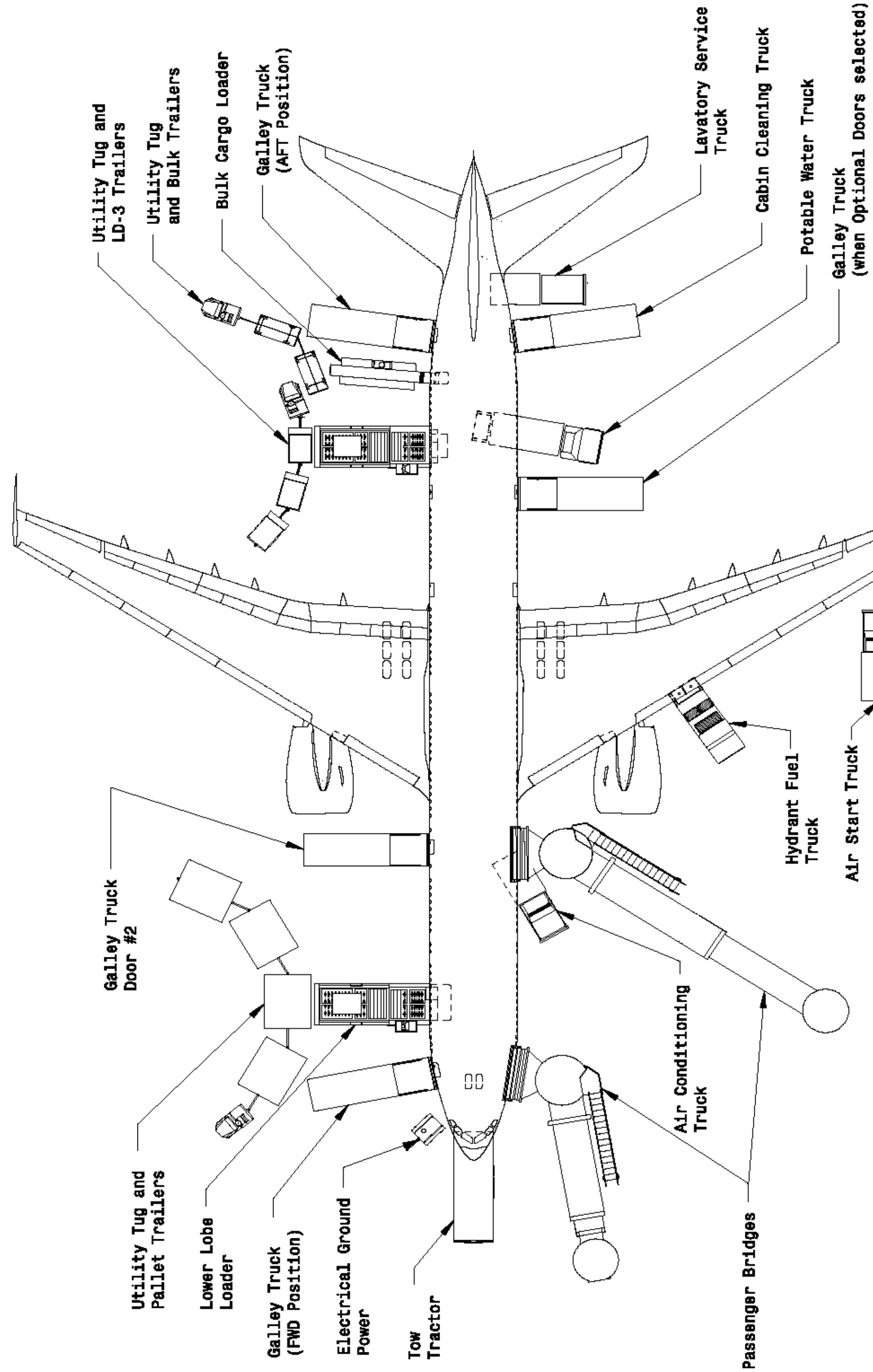
Section 5.6 shows air conditioning requirements for heating and cooling (pull-down and pull-up) using ground conditioned air. The curves show airflow requirements to heat or cool the airplane within a given time at ambient conditions.

Section 5.7 shows air conditioning requirements for heating and cooling to maintain a constant cabin air temperature using low pressure conditioned air. This conditioned air is supplied through an 8-in ground air connection (GAC) directly to the passenger cabin, bypassing the air cycle machines.

Section 5.8 shows ground towing requirements for various ground surface conditions.

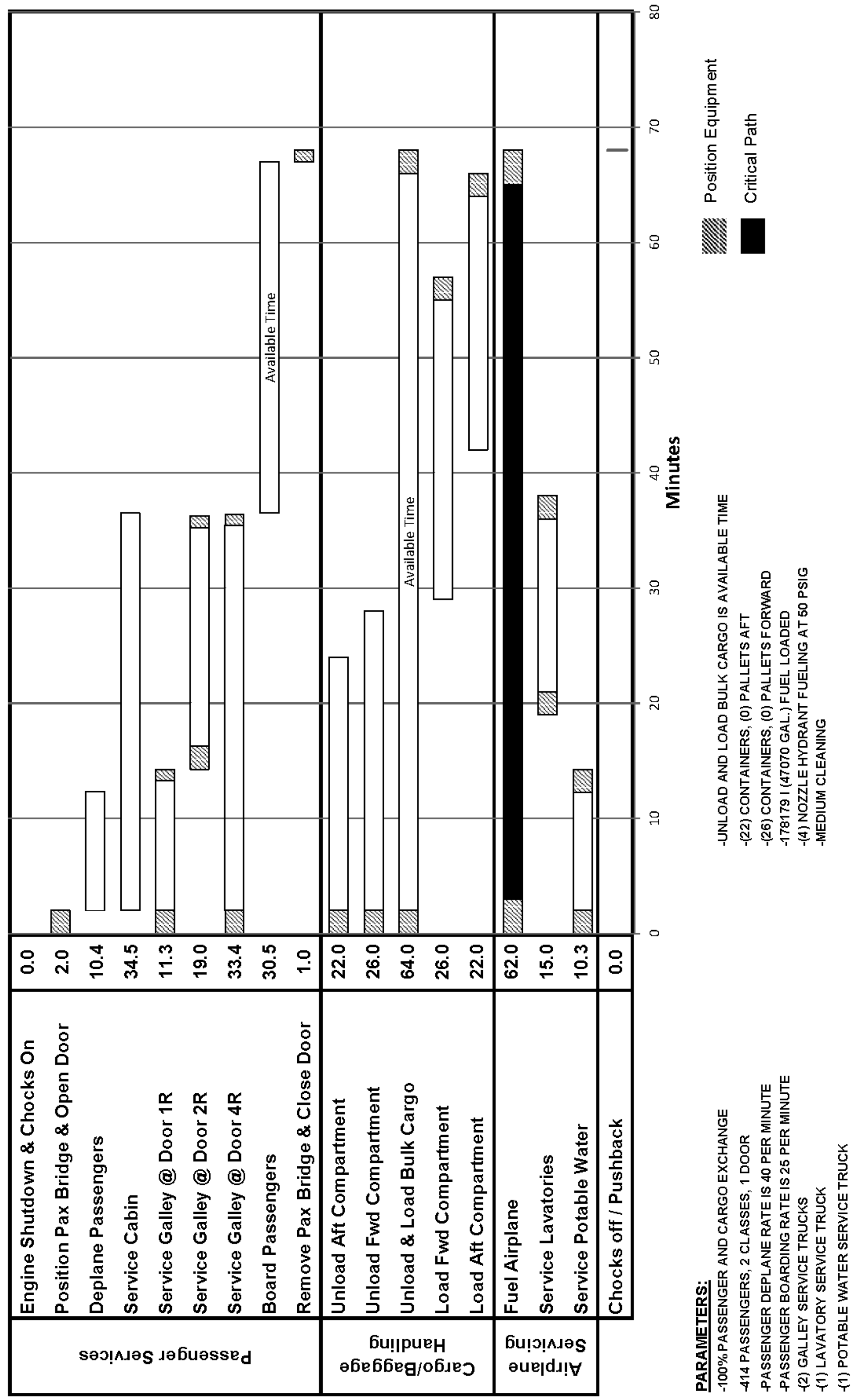
## 5.1 AIRPLANE SERVICING ARRANGEMENT - TYPICAL TURNAROUND

### 5.1.1 Airplane Servicing Arrangement - Typical Turnaround: Model 777-9



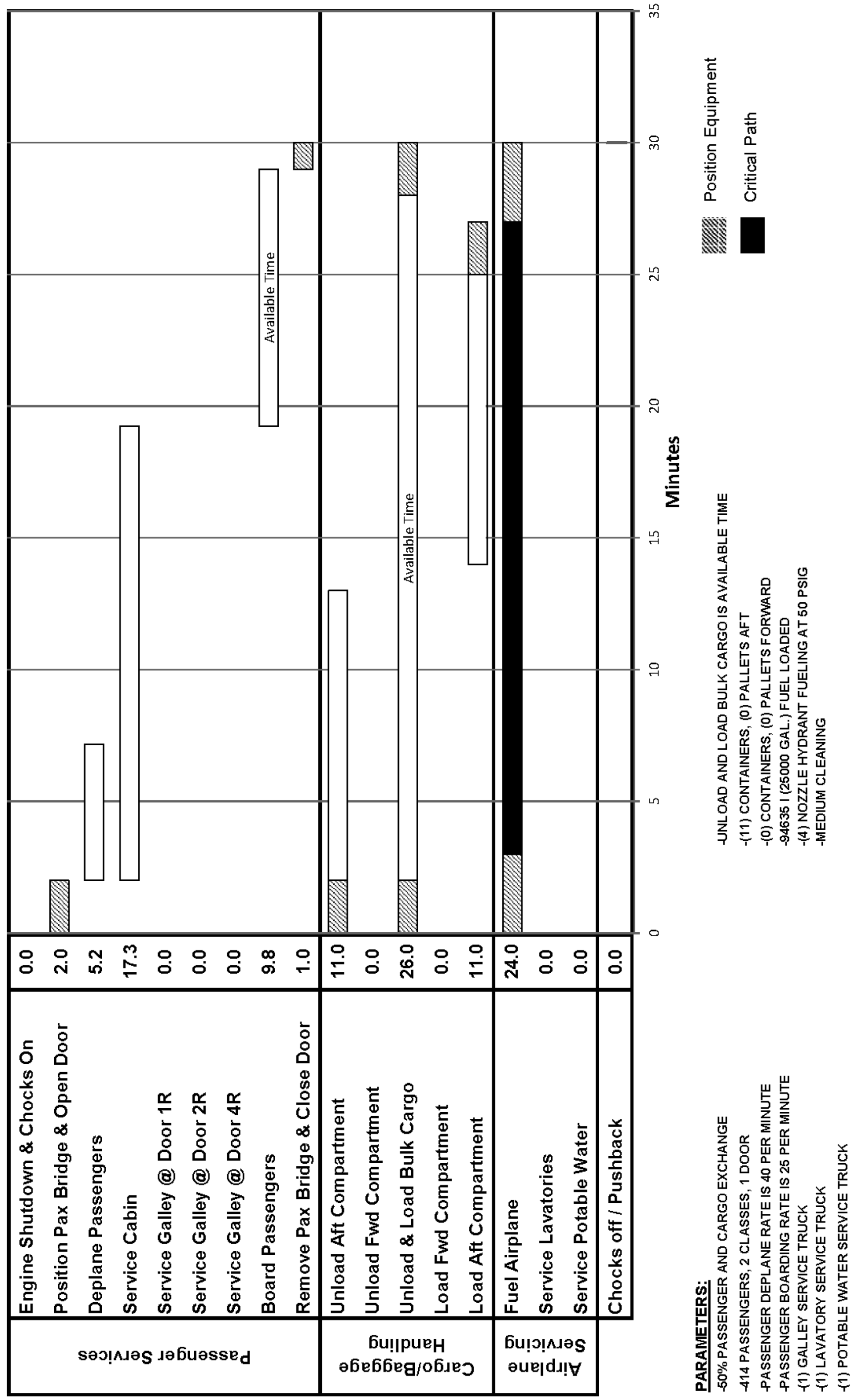
## 5.2 TERMINAL OPERATIONS - TURNAROUND STATION

### 5.2.1 Terminal Operations - Turnaround Station: Model 777-9



## 5.3 TERMINAL OPERATIONS - EN ROUTE STATION

### 5.3.1 Terminal Operations - En Route Station: Model 777-9



## 5.4 GROUND SERVICING CONNECTIONS

### 5.4.1 Ground Service Connections: Model 777-9

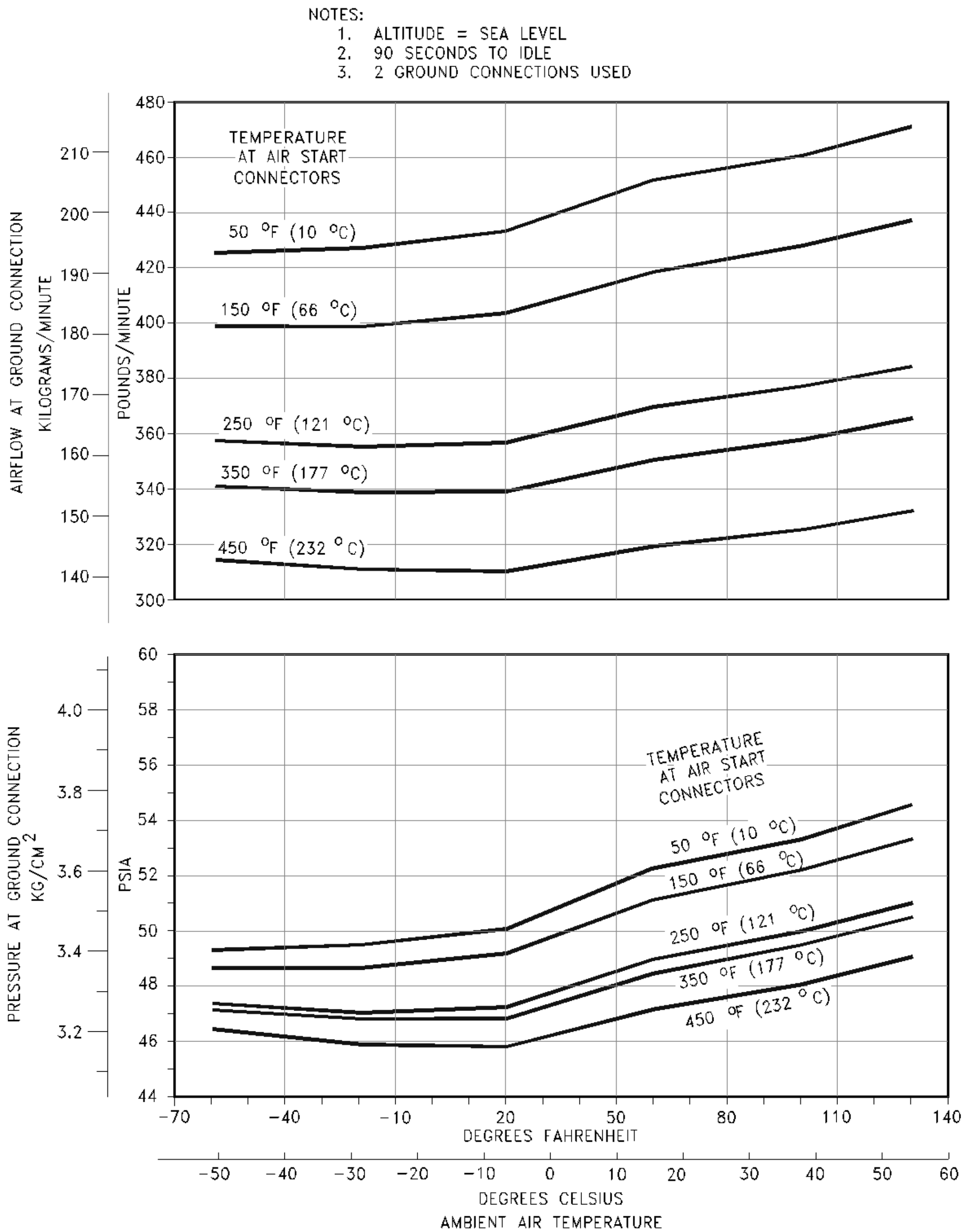
DATA TO BE PROVIDED
AT A LATER DATE

### 5.4.2 Ground Service Connections and Capacities: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 5.5 ENGINE STARTING PNEUMATIC REQUIREMENTS

### 5.5.1 Engine Start Pneumatic Requirements - Sea Level: Model 777-9



## 5.6 GROUND PNEUMATIC POWER REQUIREMENTS

### 5.6.1 Ground Conditioned Air Requirements – Heating, Pull-Up: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

### 5.6.2 Ground Conditioned Air Requirements – Cooling, Pull-Down: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 5.7 CONDITIONED AIR REQUIREMENTS

### 5.7.1 Conditioned Air Flow Requirements - Steady State Airflow: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

### 5.7.2 Air Conditioning Gauge Pressure Requirements - Steady State Airflow: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

### 5.7.3 Conditioned Air Flow Requirements - Steady State BTU's: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 5.8 GROUND TOWING REQUIREMENTS

### 5.8.1 Ground Towing Requirements - English and Metric Units: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

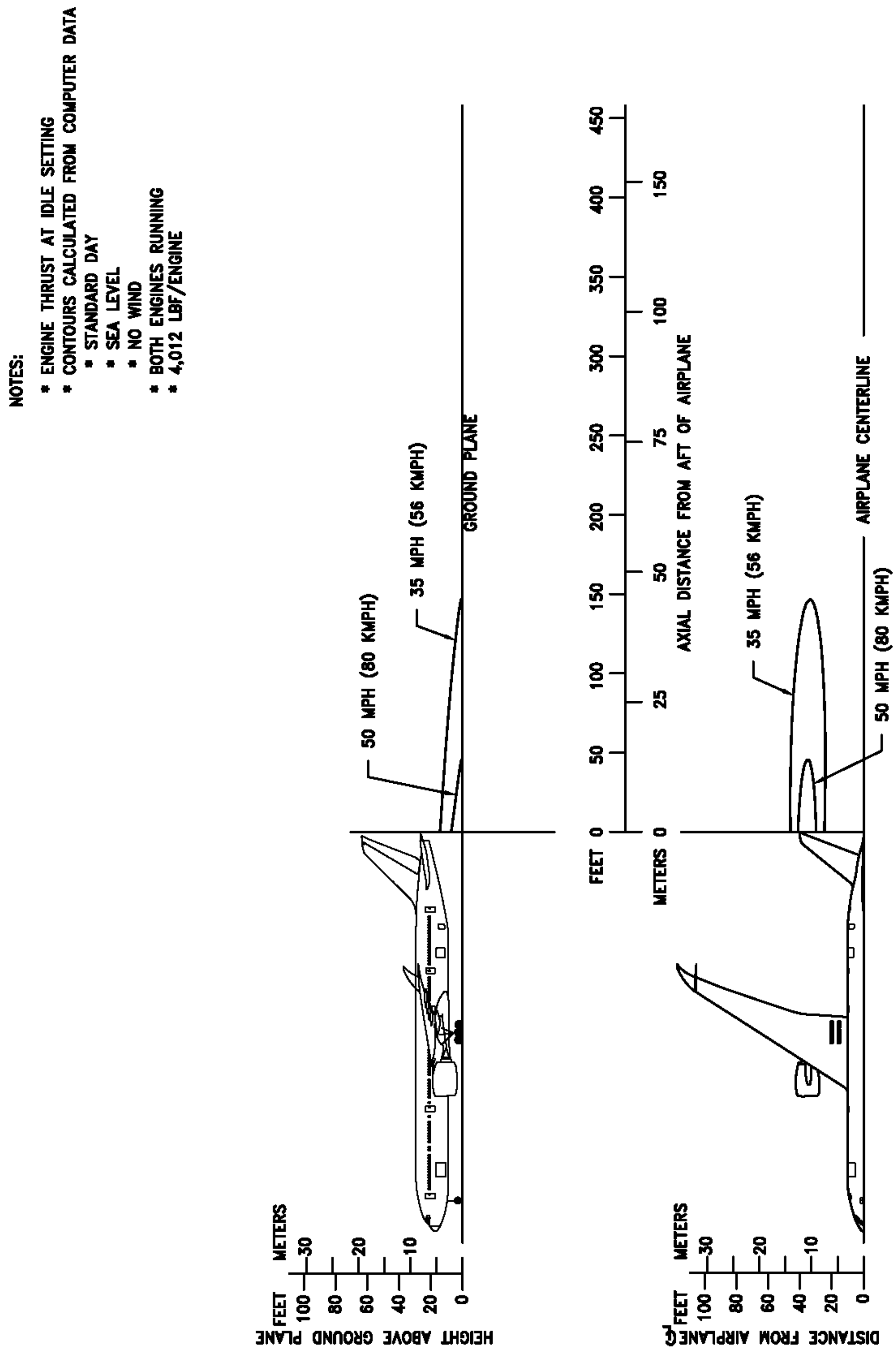
# 6.0 JET ENGINE WAKE AND NOISE DATA

## 6.1 JET ENGINE EXHAUST VELOCITIES AND TEMPERATURES

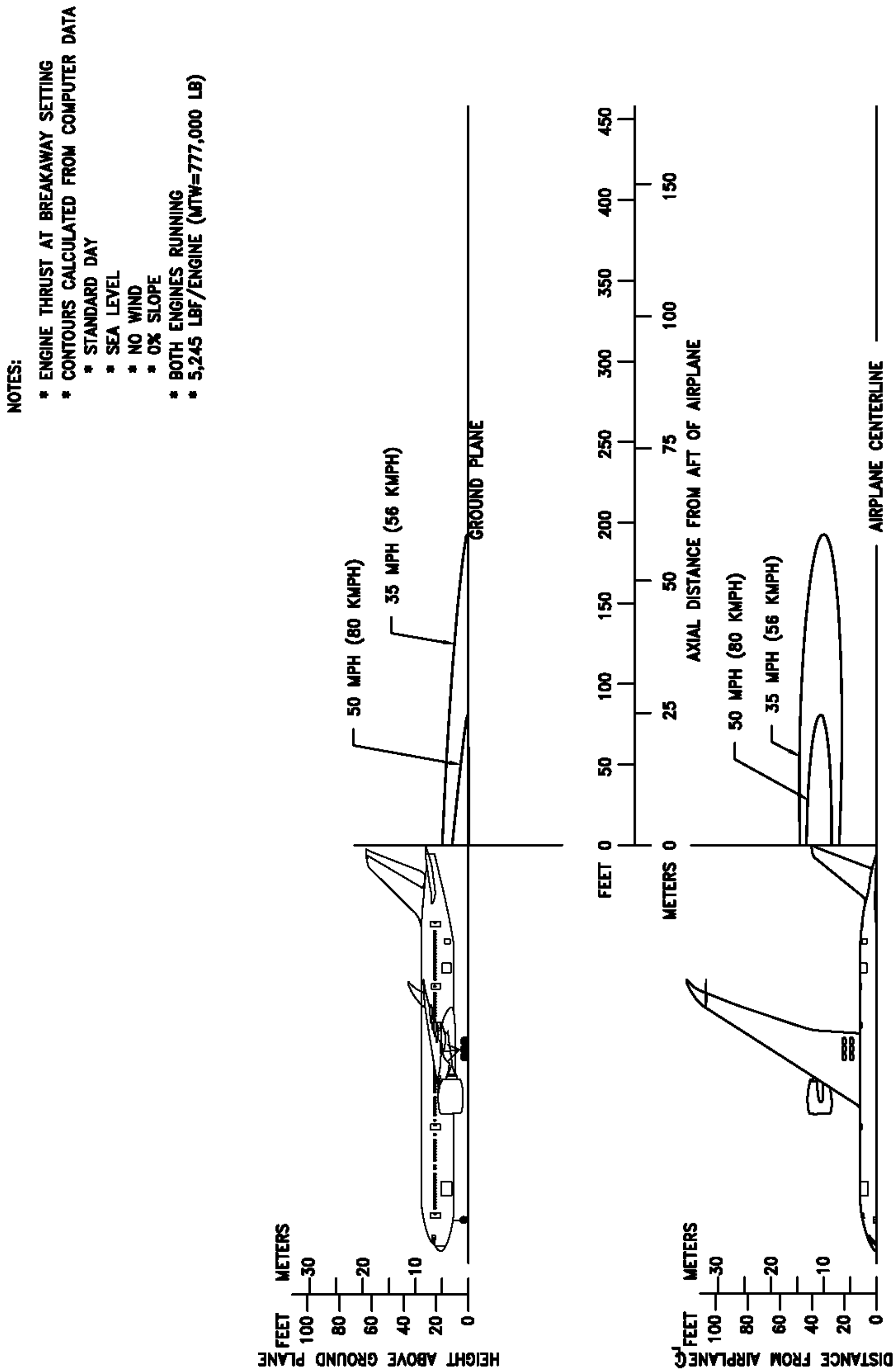
This section shows exhaust velocity and temperature contours aft of the 777-9 airplane. The contours were calculated from a standard computer analysis using three-dimensional viscous flow equations with mixing of primary, fan, and free-stream flow. The presence of the ground plane is included in the calculations as well as engine tilt and toe-in. Mixing of flows from the engines is also calculated. The analysis does not include thermal buoyancy effects which tend to elevate the jet wake above the ground plane. The buoyancy effects are considered to be small relative to the exhaust velocity and therefore are not included.

The graphs show jet wake velocity and temperature contours for a representative engine. The results are valid for sea level, static, standard day conditions. The effect of wind on jet wakes was not included. There is evidence to show that a downwind or an upwind component does not simply add or subtract from the jet wake velocity, but rather carries the whole envelope in the direction of the wind. Crosswinds may carry the jet wake contour far to the side at large distances behind the airplane.

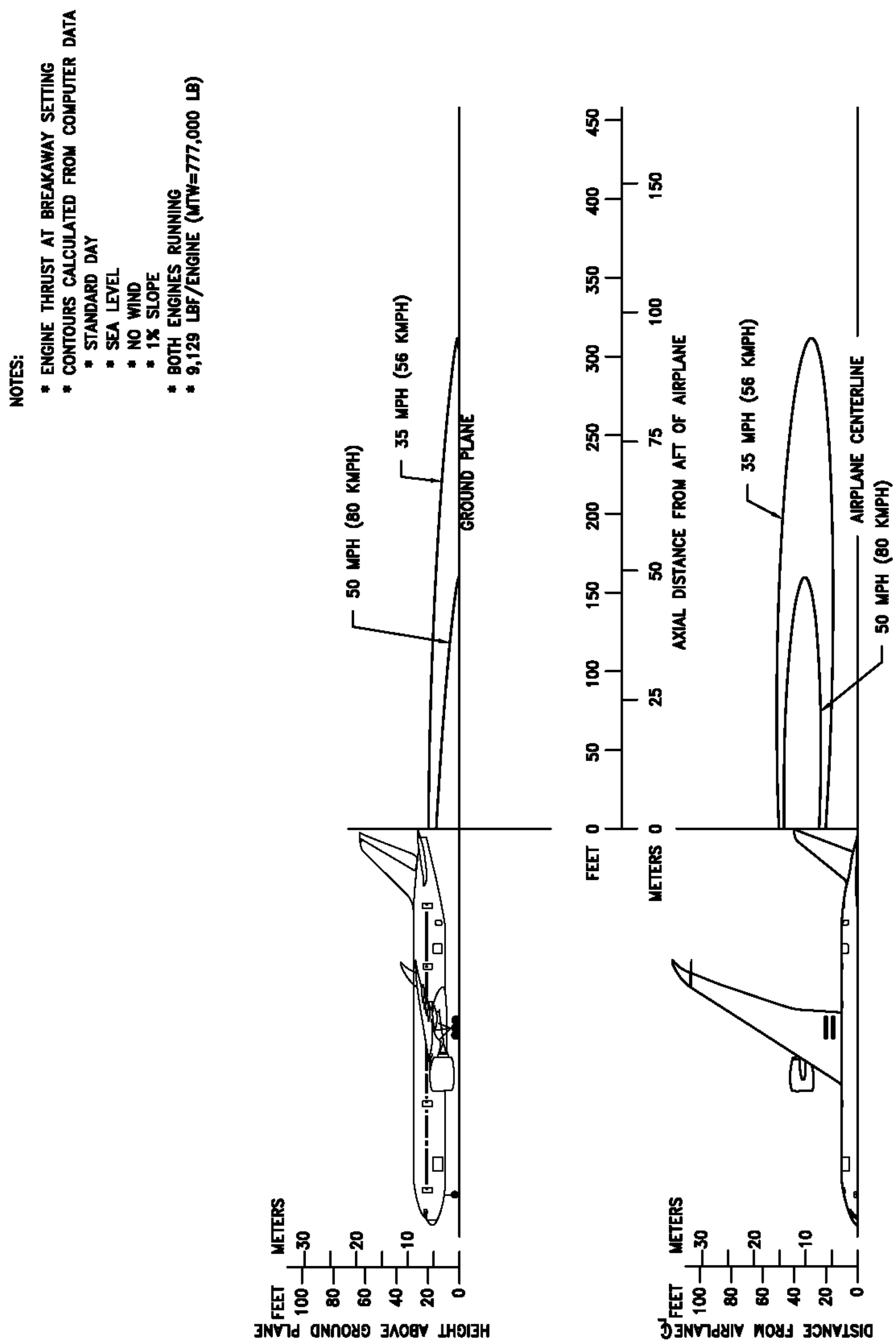
### 6.1.1 Jet Engine Exhaust Velocity Contours - Idle Thrust: Model 777-9



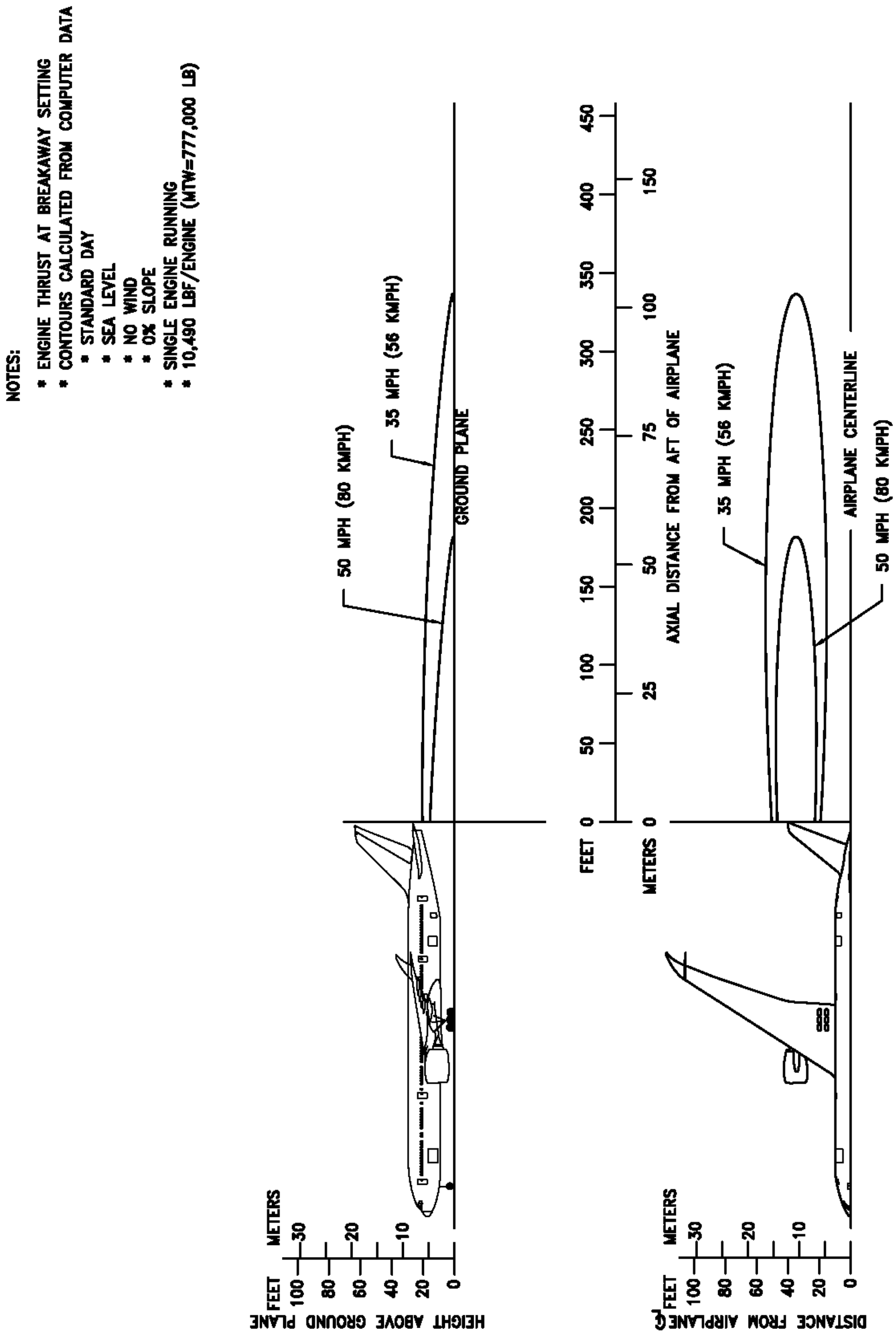
### 6.1.2 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Both Engines / MTW: Model 777-9



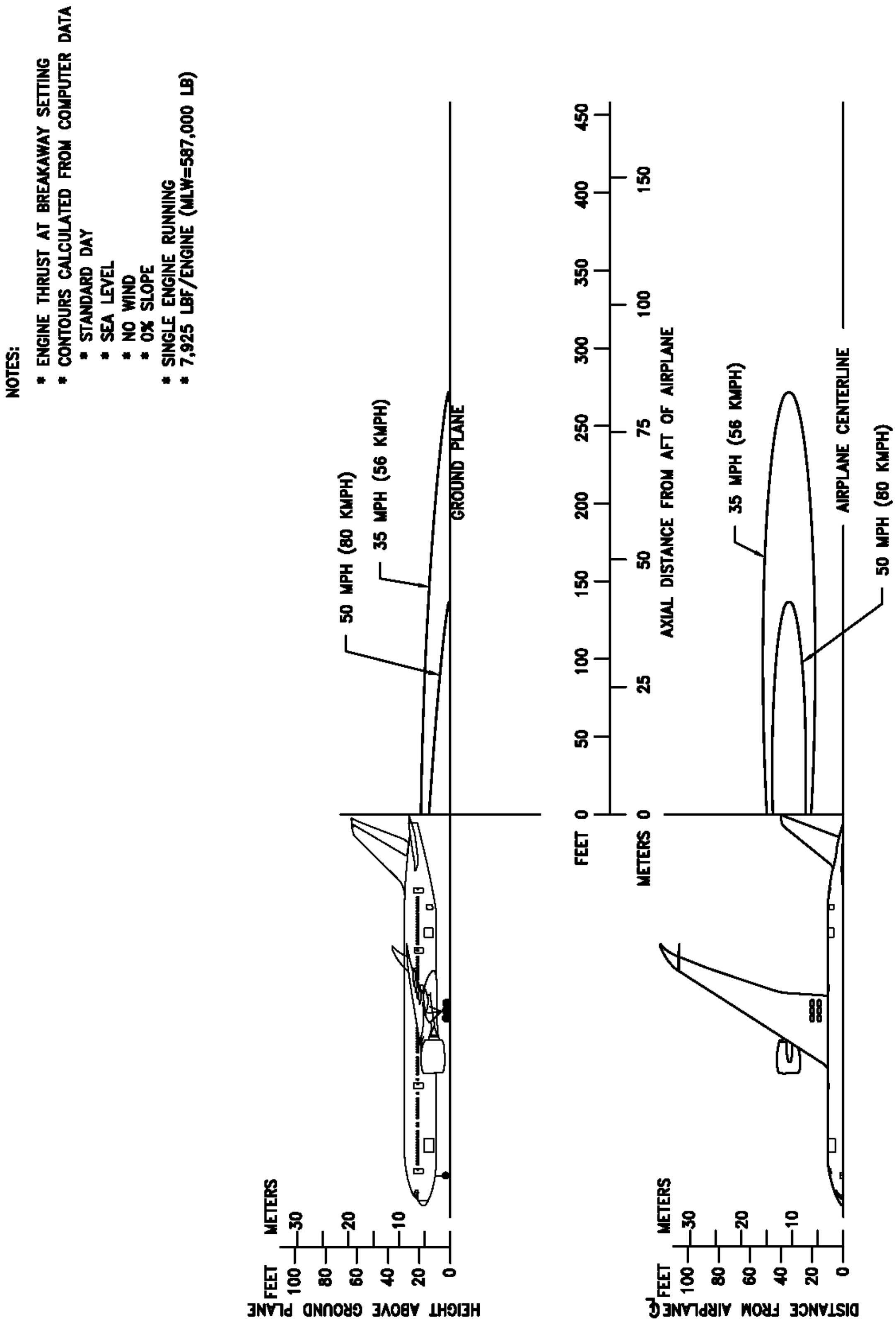
### 6.1.3 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 1% Slope / Both Engines / MTW: Model 777-9



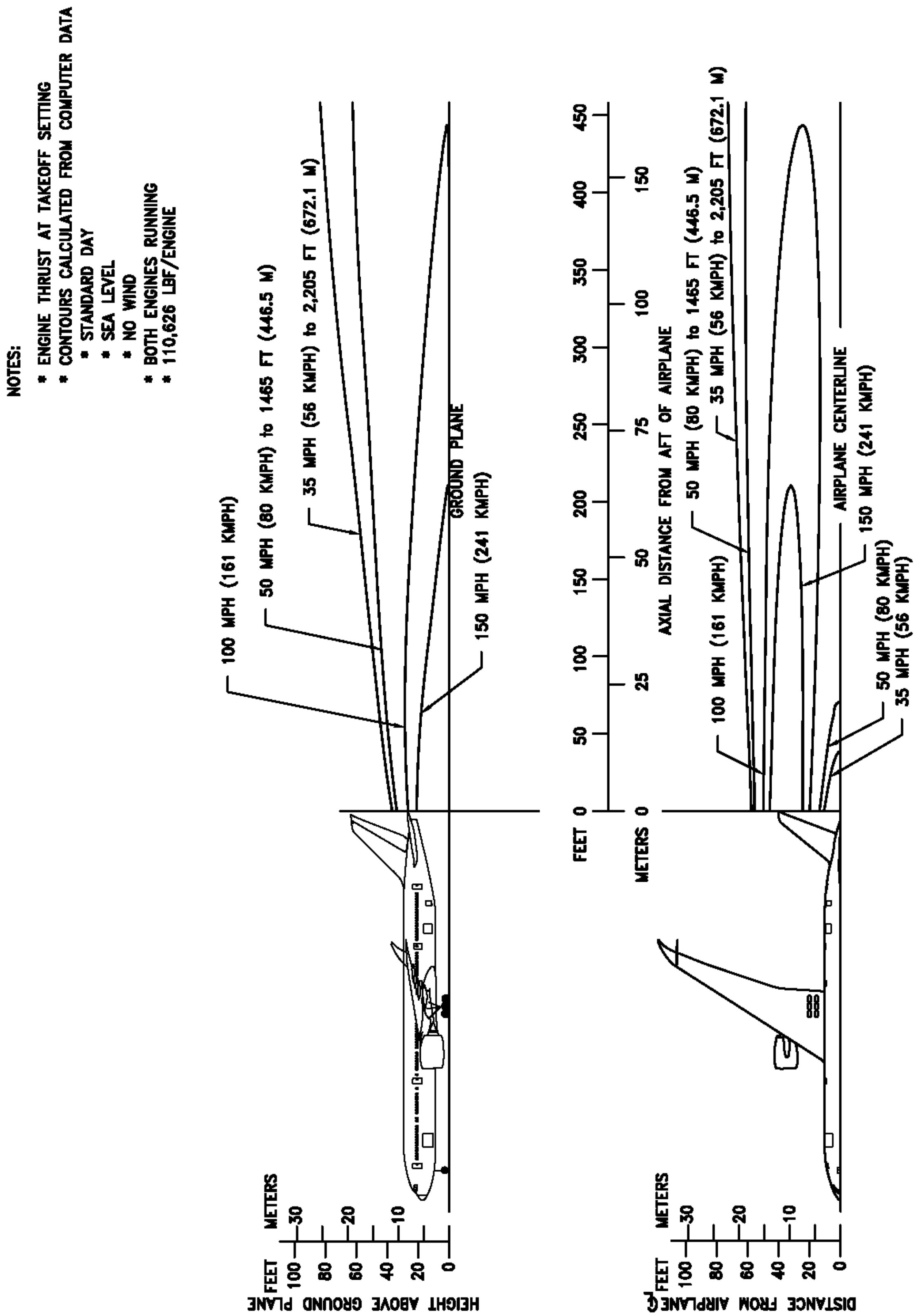
### 6.1.4 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MTW: Model 777-9



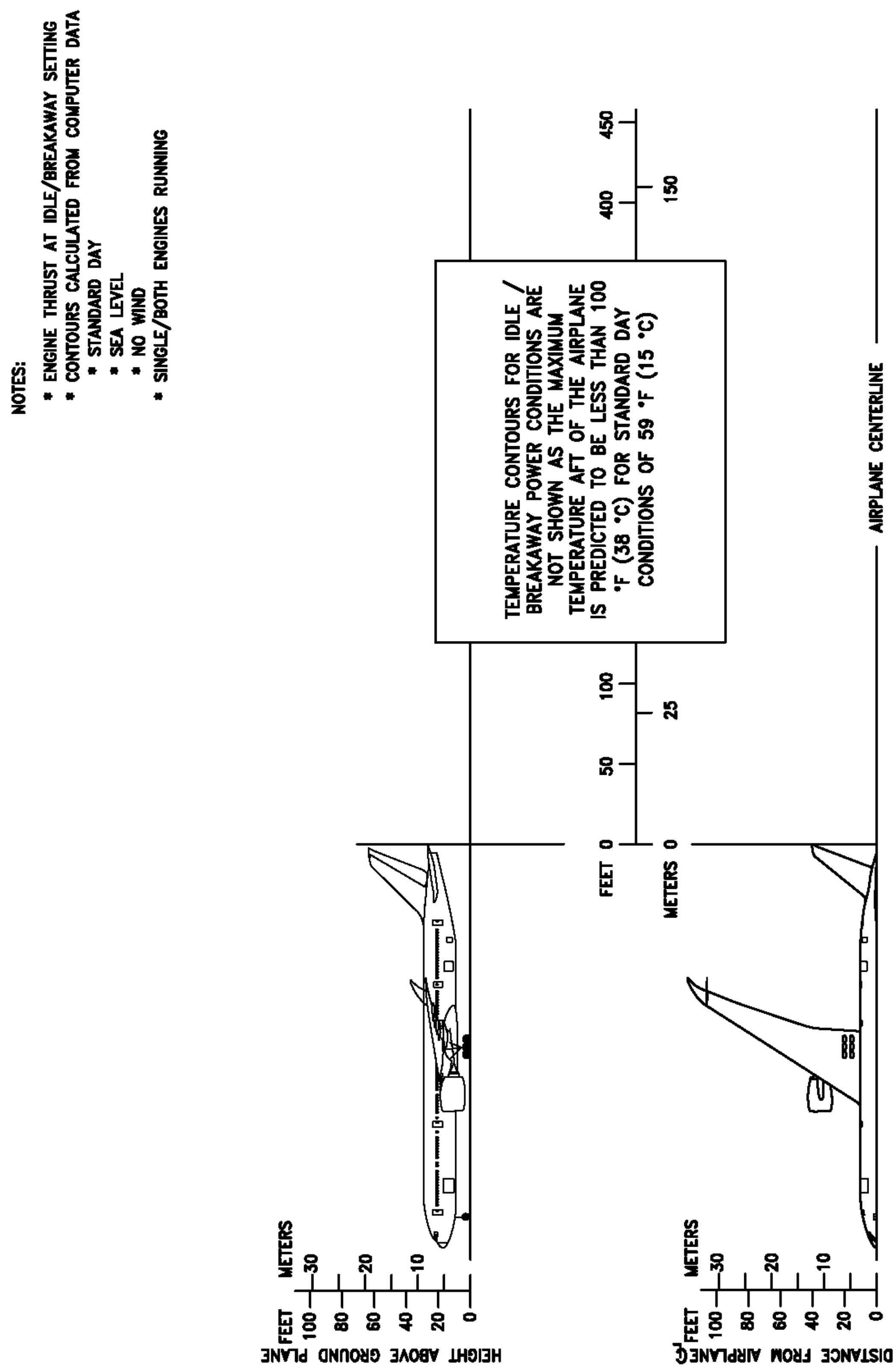
### 6.1.5 Jet Engine Exhaust Velocity Contours - Breakaway Thrust / 0% Slope / Single Engine / MLW: Model 777-9



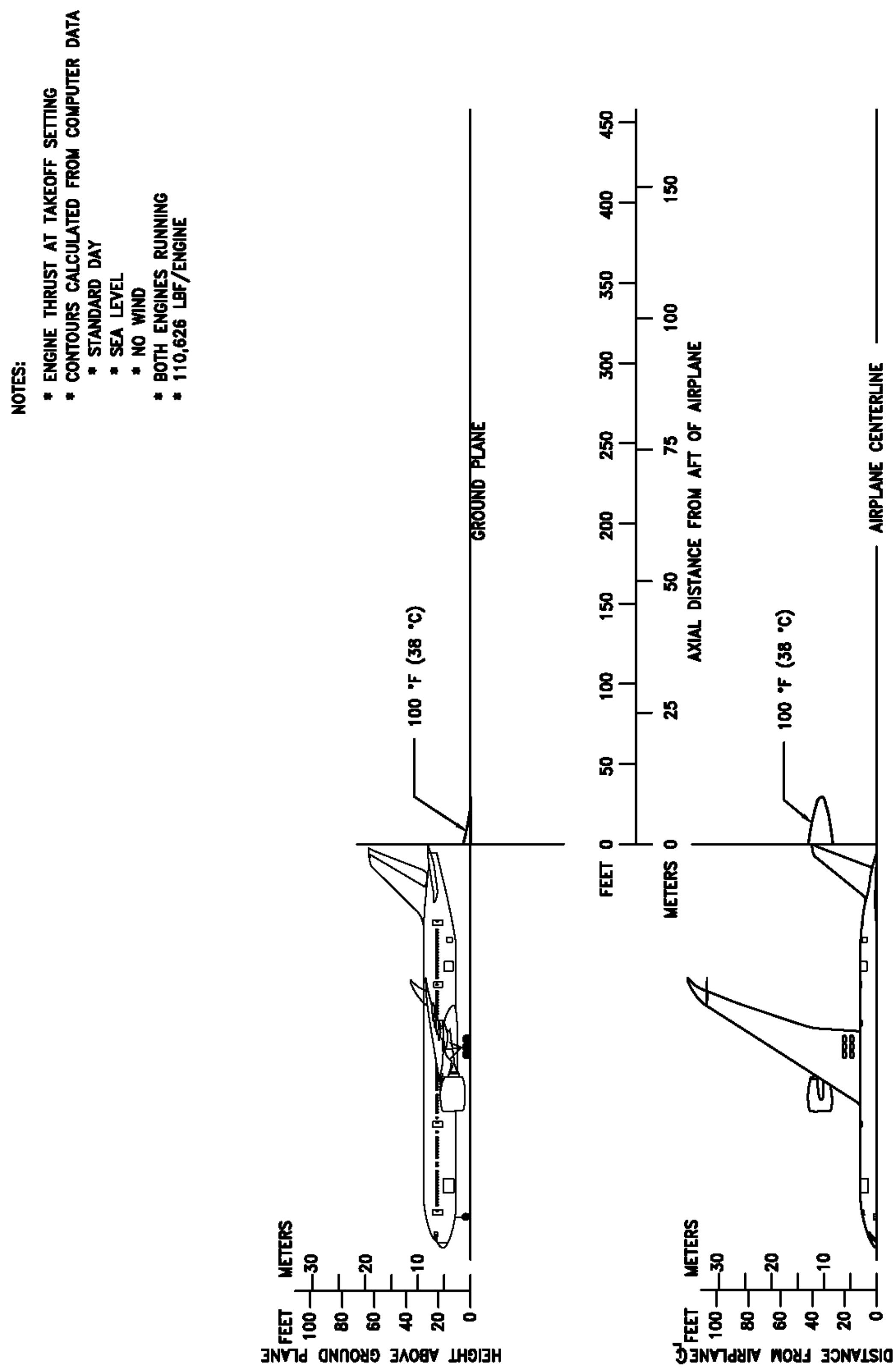
### 6.1.6 Jet Engine Exhaust Velocity Contours - Takeoff Thrust: Model 777-9



## 6.1.7 Jet Engine Exhaust Temperature Contours - Idle/Breakaway Thrust: Model 777-9



## 6.1.8 Jet Engine Exhaust Temperature Contours - Takeoff Thrust: Model 777-9



## 6.2 AIRPORT AND COMMUNITY NOISE

Airport noise is of major concern to the airport and community planner. The airport is a major element in the community's transportation system and, as such, is vital to its growth. However, the airport must also be a good neighbor, and this can be accomplished only with proper planning. Since aircraft noise extends beyond the boundaries of the airport, it is vital to consider the impact on surrounding communities. Many means have been devised to provide the planner with a tool to estimate the impact of airport operations. Too often they oversimplify noise to the point where the results become erroneous. Noise is not a simple subject; therefore, there are no simple answers.

The cumulative noise contour is an effective tool. However, care must be exercised to ensure that the contours, used correctly, estimate the noise resulting from aircraft operations conducted at an airport.

The size and shape of the single-event contours, which are inputs into the cumulative noise contours, are dependent upon numerous factors. They include the following:

7. Operational Factors

    a. Aircraft Weight - Aircraft weight is dependent on distance to be traveled, en route winds, payload, and anticipated aircraft delay upon reaching the destination.

    b. Engine Power Settings - The rates of ascent and descent and the noise levels emitted at the source are influenced by the power setting used.

    c. Airport Altitude - Higher airport altitude will affect engine performance and thus can influence noise.

8. Atmospheric Conditions-Sound Propagation

    a. Wind - With stronger headwinds, the aircraft can take off and climb more rapidly relative to the ground. Also, winds can influence the distribution of noise in surrounding communities.

    b. Temperature and Relative Humidity - The absorption of noise in the atmosphere along the transmission path between the aircraft and the ground observer varies with both temperature and relative humidity.

9. Surface Condition-Shielding, Extra Ground Attenuation (EGA)

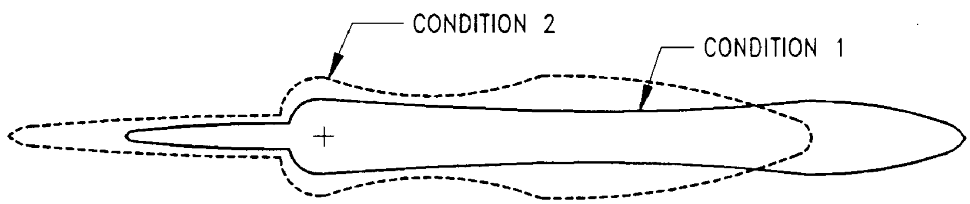
    a. Terrain - If the ground slopes down after takeoff or up before landing, noise will be reduced since the aircraft will be at a higher altitude above ground. Additionally, hills, shrubs, trees, and large buildings can act as sound buffers.

All these factors can alter the shape and size of the contours appreciably. To demonstrate the effect of some of these factors, estimated noise level contours for two different operating conditions are shown below. These contours reflect a given noise level upon a ground level plane at runway elevation.

<u>Condition 1</u>

Landing
- Maximum Structural Landing Weight
- 10-knot Headwind
- 3° Approach
- 84 °F
- Humidity 15%

Takeoff
- Maximum Gross Takeoff Weight
- Zero Wind
- 84 °F
- Humidity 15%




<u>Condition 2</u>

Landing
- 85% of Maximum Structural Landing Weight
- 10-knot Headwind
- 3° Approach
- 59 °F
- Humidity 70%

Takeoff
- 80% of Maximum Gross Takeoff Weight
- 10-knot Headwind
- 59 °F
- Humidity 70%

As indicated from these data, the contour size varies substantially with operating and atmospheric conditions. Most aircraft operations are, of course, conducted at less than maximum design weights because average flight distances are much shorter than maximum aircraft range capability and average load factors are less than 100%. Therefore, in developing cumulative contours for planning purposes, it is recommended that the airlines serving a particular city be contacted to provide operational information.

In addition, there are no universally accepted methods for developing aircraft noise contours or for relating the acceptability of specific zones to specific land uses. It is therefore expected that noise contour data for particular aircraft and the impact assessment methodology will be changing. To ensure that the best currently available information of this type is used in any planning study, it is recommended that it be obtained directly from the Office of Environmental Quality in the Federal Aviation Administration in Washington, D.C.

It should be noted that the contours shown herein are only for illustrating the impact of operating and atmospheric conditions and do not represent the single-event contour of the family of aircraft described in this document. It is expected that the cumulative contours will be developed as required by planners using the data and methodology applicable to their specific study.

# 7.0 PAVEMENT DATA

## 7.1 GENERAL INFORMATION

A brief description of the pavement charts that follow will help in their use for airport planning. Each airplane configuration is depicted with a minimum range of six loads imposed on the main landing gear to aid in interpolation between the discrete values shown. All curves for any single chart represent data based on rated loads and tire pressures considered normal and acceptable by current aircraft tire manufacturer's standards. Tire pressures, where specifically designated on tables and charts, are at values obtained under loaded conditions as certificated for commercial use.

Section 7.2 presents basic data on the landing gear footprint configuration, maximum design taxi loads, and tire sizes and pressures.

Maximum pavement loads for certain critical conditions at the tire-to-ground interface are shown in Section 7.3, with the tires having equal loads on the struts.

Pavement requirements for commercial airplanes are customarily derived from the static analysis of loads imposed on the main landing gear struts. The charts in Section 7.4 are provided in order to determine these loads throughout the stability limits of the airplane at rest on the pavement. These main landing gear loads are used as the point of entry to the pavement design charts, interpolating load values where necessary.

The flexible pavement design curves (Section 7.5) are based on procedures set forth in Instruction Report No. S-77-1, "Procedures for Development of CBR Design Curves," dated June 1977, and as modified according to the methods described in ICAO Aerodrome Design Manual, Part 3, Pavements, 2nd Edition, 1983, Section 1.1 (The ACN-PCN Method), and utilizing the alpha factors approved by ICAO in October 2007. Instruction Report No. S-77-1 was prepared by the U.S. Army Corps of Engineers Waterways Experiment Station, Soils and Pavements Laboratory, Vicksburg, Mississippi. The line showing 10,000 coverages is used to calculate Aircraft Classification Number (ACN).

The following procedure is used to develop the curves, such as shown in Section 7.5:

1. Having established the scale for pavement depth at the bottom and the scale for CBR at the top, an arbitrary line is drawn representing 6,000 annual departures.

2. Values of the aircraft gross weight are then plotted.

3. Additional annual departure lines are drawn based on the load lines of the aircraft gross weights already established.

4. An additional line representing 10,000 coverages (used to calculate the flexible pavement Aircraft Classification Number) is also placed.

The Load Classification Number (LCN) curves are no longer provided in Section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete and replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Compatibility Engineering:

AirportCompatibility@boeing.com

Rigid pavement design curves (Section 7.7) have been prepared with the Westergaard equation in general accordance with the procedures outlined in the Design of Concrete Airport Pavement (1995 edition) by Robert G. Packard, published by the Portland Cement Association, 5420 Old Orchard Road, Skokie, Illinois 60077-1059. These curves are modified to the format described in the Portland Cement Association (PCA) publication XP6705-2, Computer Program for Airport Pavement Design (Program PDILB), 1968, by Robert G. Packard.

The following procedure is used to develop the rigid pavement design curves shown in Section 7.7:

1. Having established the scale for pavement thickness to the left and the scale for allowable working stress to the right, an arbitrary load line is drawn representing the main landing gear maximum weight to be shown.

2. Values of the subgrade modulus (k) are then plotted.

3. Additional load lines for the incremental values of weight on the main landing gear are drawn on the basis of the curve for k = 300, already established.

For Section 7.9, the rigid pavement requirements based on the FAA design method refers to the FAA website (https://www.faa.gov/airports/) for Advisory Circular 150/5320-6F (date issued Nov 10, 2016), Airport Pavement Design and Evaluation, and the FAA standard airfield pavement design software FAARFIELD:

http://www.faa.gov/airports/engineering/design_software/

The ACN/PCN system (Section 7.10) as referenced in ICAO Annex 14, "Aerodromes," Seventh Edition, July 2016, provides a standardized international airplane/pavement rating system replacing the various., rating systems used throughout the world (e.g, S, T, TT, LCN, AUW, ISWL, etc). ACN is the Aircraft Classification Number and PCN is the Pavement Classification Number. An aircraft having an ACN equal to or less than the PCN can operate without restriction on the pavement subject to any limitation on the tire pressure. Numerically, the ACN is two times the derived single-wheel load expressed in thousands of kilograms, where the derived single wheel load is defined as the load on a single tire inflated to 181 psi (1.25 MPa) that would have the same pavement requirements as the aircraft. Computationally, the ACN/PCN system uses the PCA program PDILB for rigid pavements and S-77-1 for flexible pavements to calculate ACN values. The method of pavement evaluation is left up to the airport with the results of their evaluation presented as follows:

| PCN | PAVEMENT TYPE | SUBGRADE CATEGORY | TIRE PRESSURE CATEGORY | EVALUATION METHOD |
|---|---|---|---|---|
| | R = Rigid | A = High | W = No Limit | T = Technical |
| | F = Flexible | B = Medium | X = To 254 psi (1.75 MPa) | U = Using Aircraft |
| | | C = Low | Y = To 181 psi (1.25 MPa) | |
| | | D = Ultra Low | Z = To 73 psi (0.5 MPa) | |

ACN values for flexible pavements are calculated for the following four subgrade strength categories:

Code A - High Strength - CBR 15

Code B - Medium Strength - CBR 10

Code C - Low Strength - CBR 6

Code D - Ultra Low Strength - CBR 3

ACN values for rigid pavements are calculated for the following four subgrade strength categories:

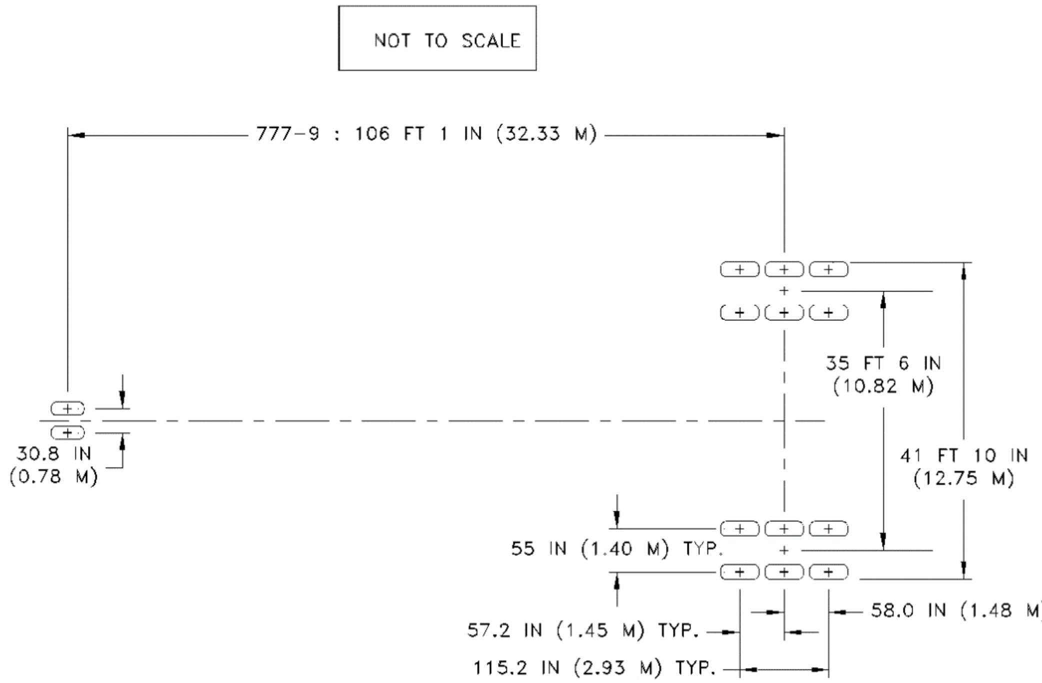
Code A - High Strength, k = 550 pci (150 $MN/m^3$)

Code B - Medium Strength, k = 300 pci (80 $MN/m^3$)

Code C - Low Strength, k = 150 pci (40 $MN/m^3$)

Code D - Ultra Low Strength, k = 75 pci (20 $MN/m^3$)

## 7.2 LANDING GEAR FOOTPRINT: MODEL 777-9




| | UNITS | MODEL 777-9 |
|---|---|---|
| MAXIMUM DESIGN TAXI WEIGHT | LB | 777,000 |
| | KG | 352,442 |
| PERCENT OF WEIGHT ON MAIN GEAR | % | SEE SECTION 7.4 |
| NOSE GEAR TIRE SIZE | IN. | 43 x 17.5 R17 / 32PR |
| NOSE GEAR TIRE PRESSURE | PSI | 218 |
| | $KG/CM^2$ | 15.3 |
| MAIN GEAR TIRE SIZE | IN. | 52 x 21.0 R22 / 38 PR |
| MAIN GEAR TIRE PRESSURE | PSI | 229 |
| | $KG/CM^2$ | 16.1 |

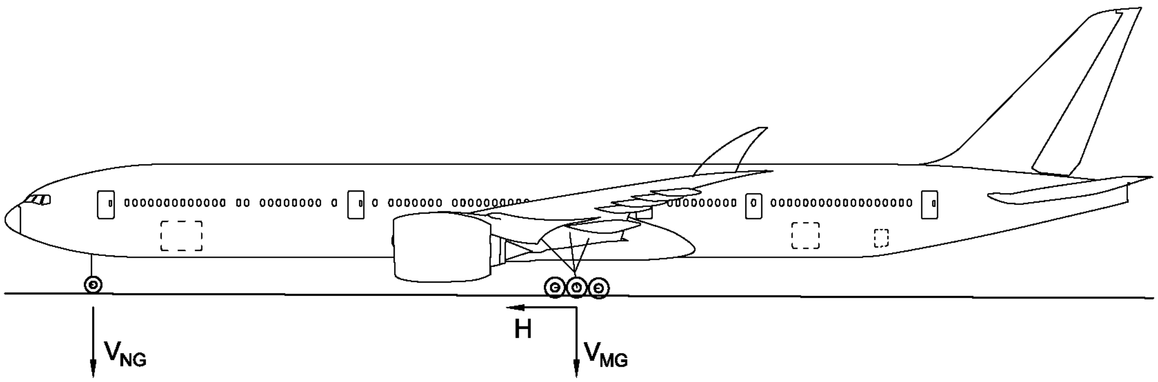
## 7.3 MAXIMUM PAVEMENT LOADS: MODEL 777-9

$V_{NG}$ = MAXIMUM VERTICAL NOSE GEAR GROUND LOAD AT MOST FORWARD CENTER OF GRAVITY

$V_{MG}$ = MAXIMUM VERTICAL MAIN GEAR GROUND LOAD AT MOST AFT CENTER OF GRAVITY

H = MAXIMUM HORIZONTAL GROUND LOAD FROM BRAKING

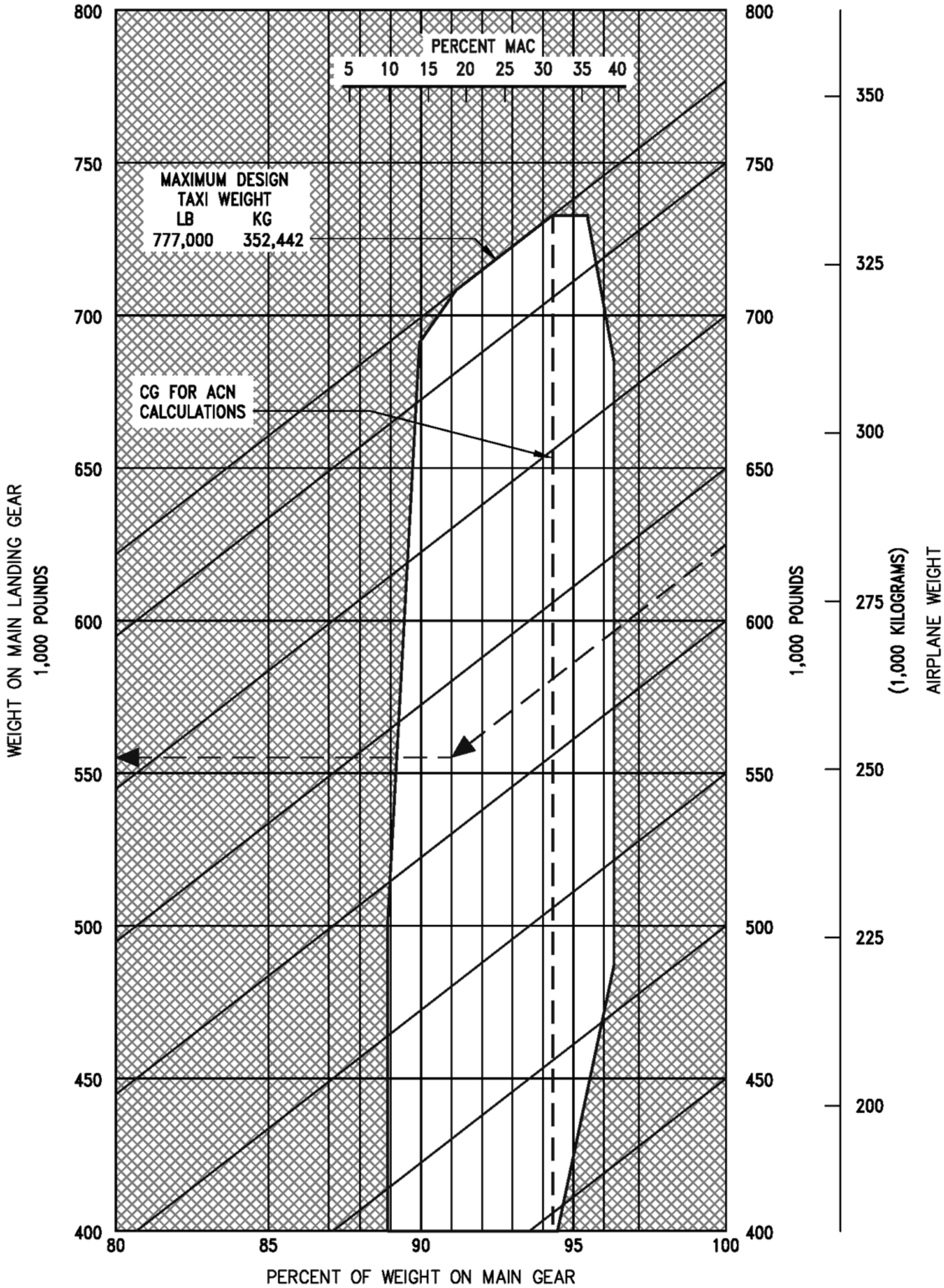
**NOTE:** ALL LOADS CALCULATED USING AIRPLANE MAXIMUM DESIGN TAXI WEIGHT




| AIRPLANE MODEL | UNITS | MAX DESIGN TAXI WEIGHT | $V_{NG}$ | | $V_{MG}$ PER STRUT AT MAX LOAD AT STATIC AFT C.G. | H PER STRUT | |
|---|---|---|---|---|---|---|---|
| | | | STATIC AT MOST FWD C.G. | STATIC + BRAKING 10 FT/SEC$^2$ DECEL | | STEADY BRAKING 10 FT/SEC$^2$ DECEL | AT INSTANTANEOUS BRAKING ($\mu$ = 0.8) |
| 777-9 | LB | 777,000 | 68,796 | 105,543 | 366,337 | 120,668 | 293,070 |
| | KG | 352,442 | 31,205 | 47,873 | 166,168 | 54,734 | 132,934 |

## 7.4 LANDING GEAR LOADING ON PAVEMENT

### 7.4.1 Landing Gear Loading on Pavement: Model 777-9



## 7.5 FLEXIBLE PAVEMENT REQUIREMENTS - U.S. ARMY CORPS OF ENGINEERS METHOD S-77-1

The following flexible-pavement design chart presents the data of six incremental main-gear loads at the minimum tire pressure required at the maximum design taxi weight.

The traditional FAA design method used a similar procedure using total airplane weight instead of weight on the main landing gears. The equivalent main gear loads for a given airplane weight could be calculated from Section 7.4.

### 7.5.1 Flexible Pavement Requirements - U.S. Army Corps of Engineers Design Method (S-77-1): Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 7.6 FLEXIBLE PAVEMENT REQUIREMENTS - LCN CONVERSION

The Load Classification Number (LCN) curves are no longer provided in section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete, being replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Compatibility Engineering:

AirportCompatibility@boeing.com

## 7.7 RIGID PAVEMENT REQUIREMENTS - PORTLAND CEMENT ASSOCIATION DESIGN METHOD

The Portland Cement Association method of calculating rigid pavement requirements is based on the computerized version of "Design of Concrete Airport Pavement" (Portland Cement Association, 1973) as described in XP6705-2, "Computer Program for Airport Pavement Design" by Robert G. Packard, Portland Cement Association, 1968.

The following rigid pavement design chart presents the data for five incremental main gear loads at the minimum tire pressure required at the maximum design taxi weight.

### 7.7.1 Rigid Pavement Requirements - Portland Cement Association Design Method: Model 777-9

DATA TO BE PROVIDED
AT A LATER DATE

## 7.8 RIGID PAVEMENT REQUIREMENTS - LCN CONVERSION

The Load Classification Number (LCN) curves are no longer provided in section 7.6 and 7.8 since the LCN system for reporting pavement strength is obsolete, being replaced by the ICAO recommended ACN/PCN system in 1983. For questions regarding the LCN system contact Boeing Airport Compatibility Engineering:

AirportCompatibility@boeing.com

## 7.9 RIGID PAVEMENT REQUIREMENTS - FAA DESIGN METHOD

FAA rigid pavement design refers to the FAA website (https://www.faa.gov/airports/) for Advisory Circular 150/5320-6F (date issued Nov 10, 2016), Airport Pavement Design and Evaluation, and the FAA standard airfield pavement design software FAARFIELD.

http://www.faa.gov/airports/engineering/design_software/

## 7.10 ACN/PCN REPORTING SYSTEM - FLEXIBLE AND RIGID PAVEMENTS

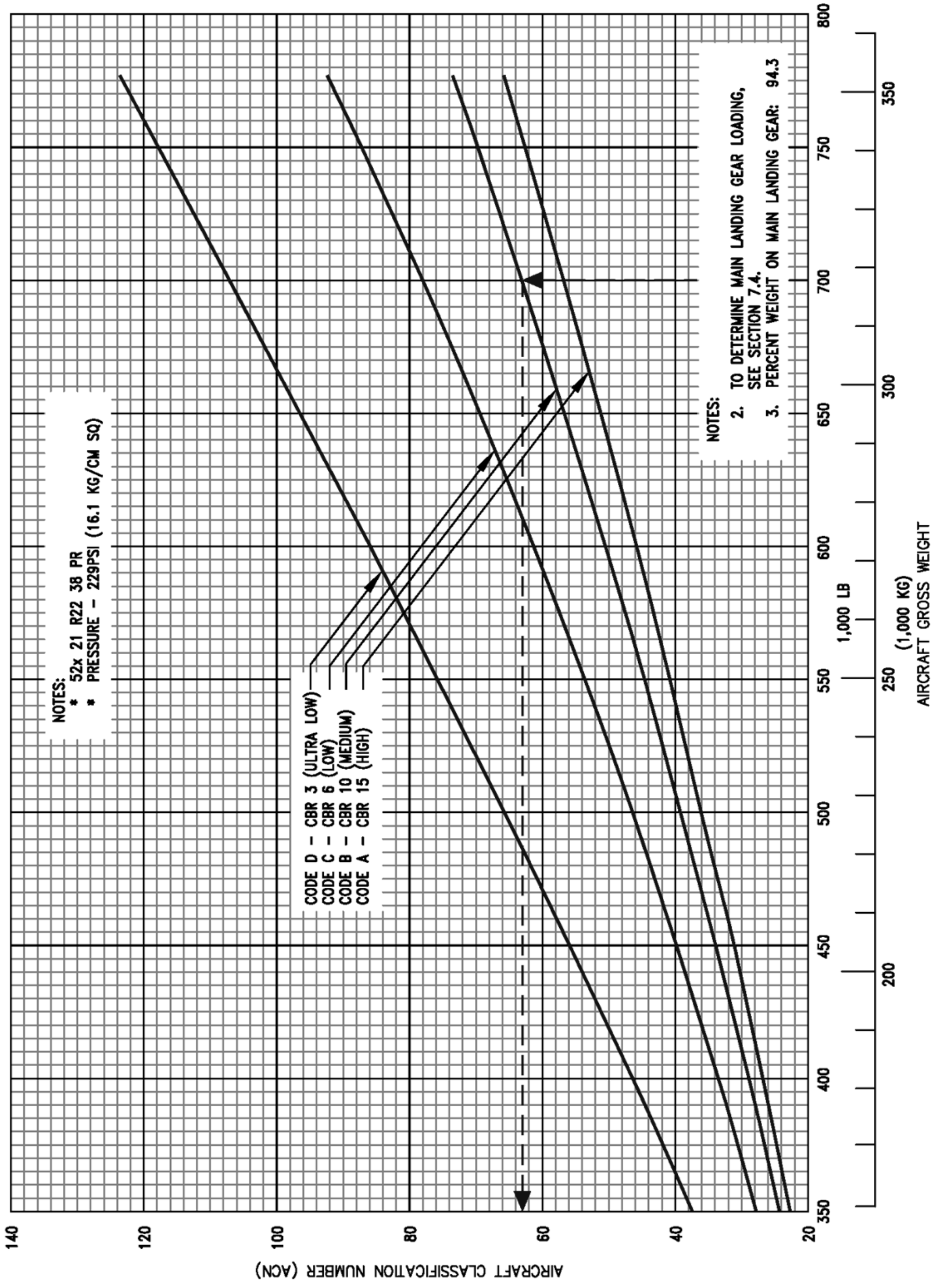
To determine the ACN of an aircraft on flexible or rigid pavement, both the aircraft gross weight and the subgrade strength category must be known. In the chart in 7.10.1, for an aircraft with gross weight of 700,000 lb on a (Code B), the flexible pavement ACN is 63. Referring to 7.10.2, the same aircraft on a high strength subgrade rigid pavement has an ACN of 75.

The following table provides ACN data in tabular format similar to the one used by ICAO in the "Aerodrome Design Manual Part 3, Pavements." If the ACN for an intermediate weight between maximum taxi weight and minimum weight of the aircraft is required, Figures 7.10.1 through 7.10.2 should be consulted. Linear interpolation of the ACN values between two weight points will provide an approximate ACN value.

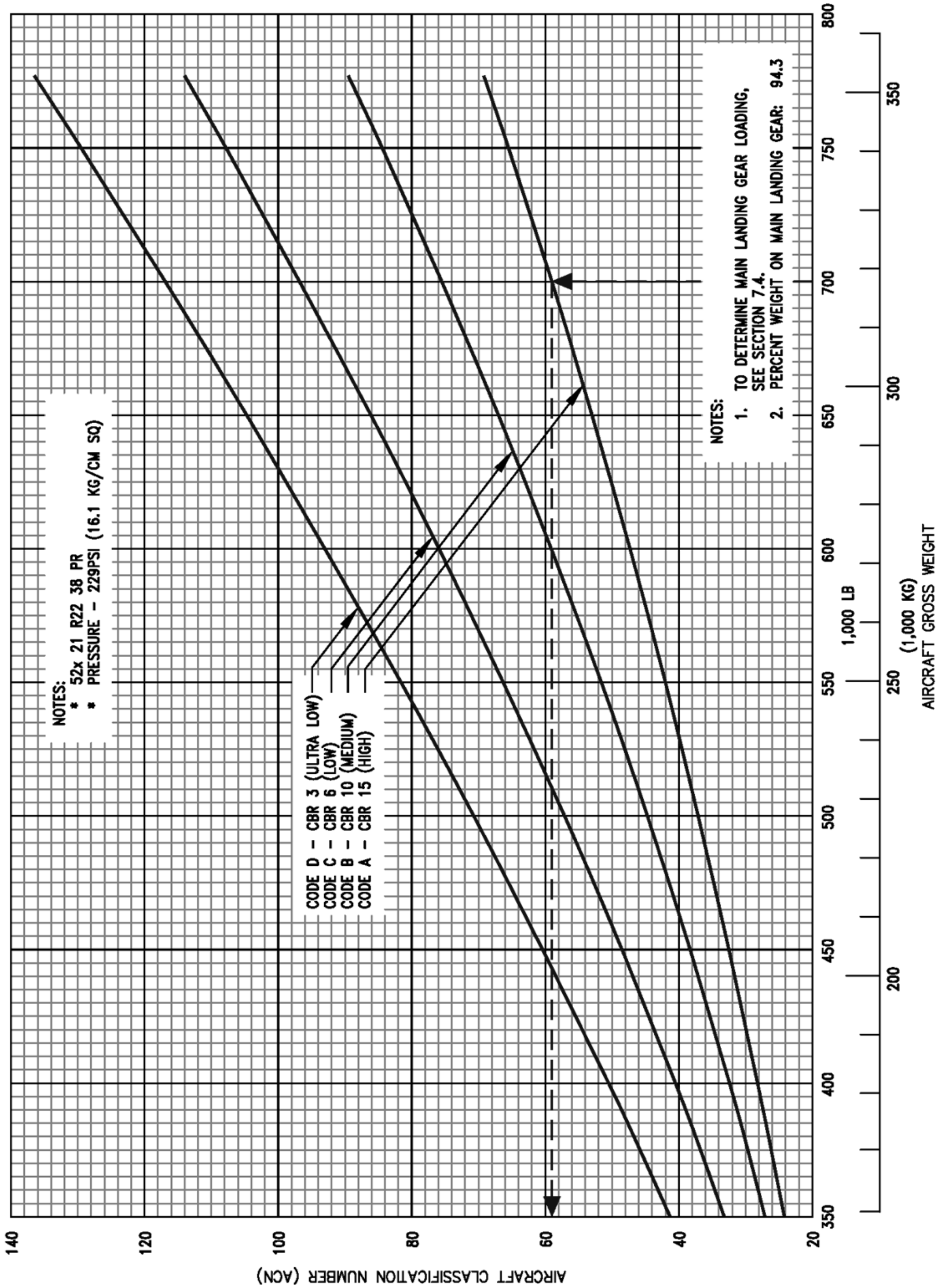
| | | | | ACN FOR RIGID PAVEMENT SUBGRADES – $MN/m^3$ | | | | ACN FOR FLEXIBLE PAVEMENT SUBGRADES – CBR | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AIRCRAFT TYPE | MAXIMUM TAXI WEIGHT<br>MINIMUM WEIGHT [1]<br>LB (KG) | LOAD ON ONE MAIN GEAR LEG (%) | TIRE PRESSURE<br>PSI (MPa) | HIGH 150 | MEDIUM 80 | LOW 40 | ULTRA LOW 20 | HIGH 15 | MEDIUM 10 | LOW 6 | ULTRA LOW 3 |
| 777-9 | 777,000 (352,442) | 47.15 | 229 (1.58) | 69 | 90 | 114 | 137 | 66 | 74 | 92 | 124 |
| | 350,000 (158,757) | | | 24 | 27 | 33 | 41 | 23 | 24 | 28 | 37 |

[1] Minimum weight used solely as a baseline for ACN curve generation.

### 7.10.1 Aircraft Classification Number - Flexible Pavement: Model 777-9



### 7.10.2 Aircraft Classification Number - Rigid Pavement: Model 777-9



## 8.0 FUTURE 777 DERIVATIVE AIRPLANES

Boeing's philosophy is to evaluate the derivative potential of its airplanes to provide capabilities that maximize value to our customers.

Decisions to design and manufacture future derivatives of an airplane depend on many considerations, including customer requirements. Along with many other parameters, airport facilities are considered during the development of any future airplane.

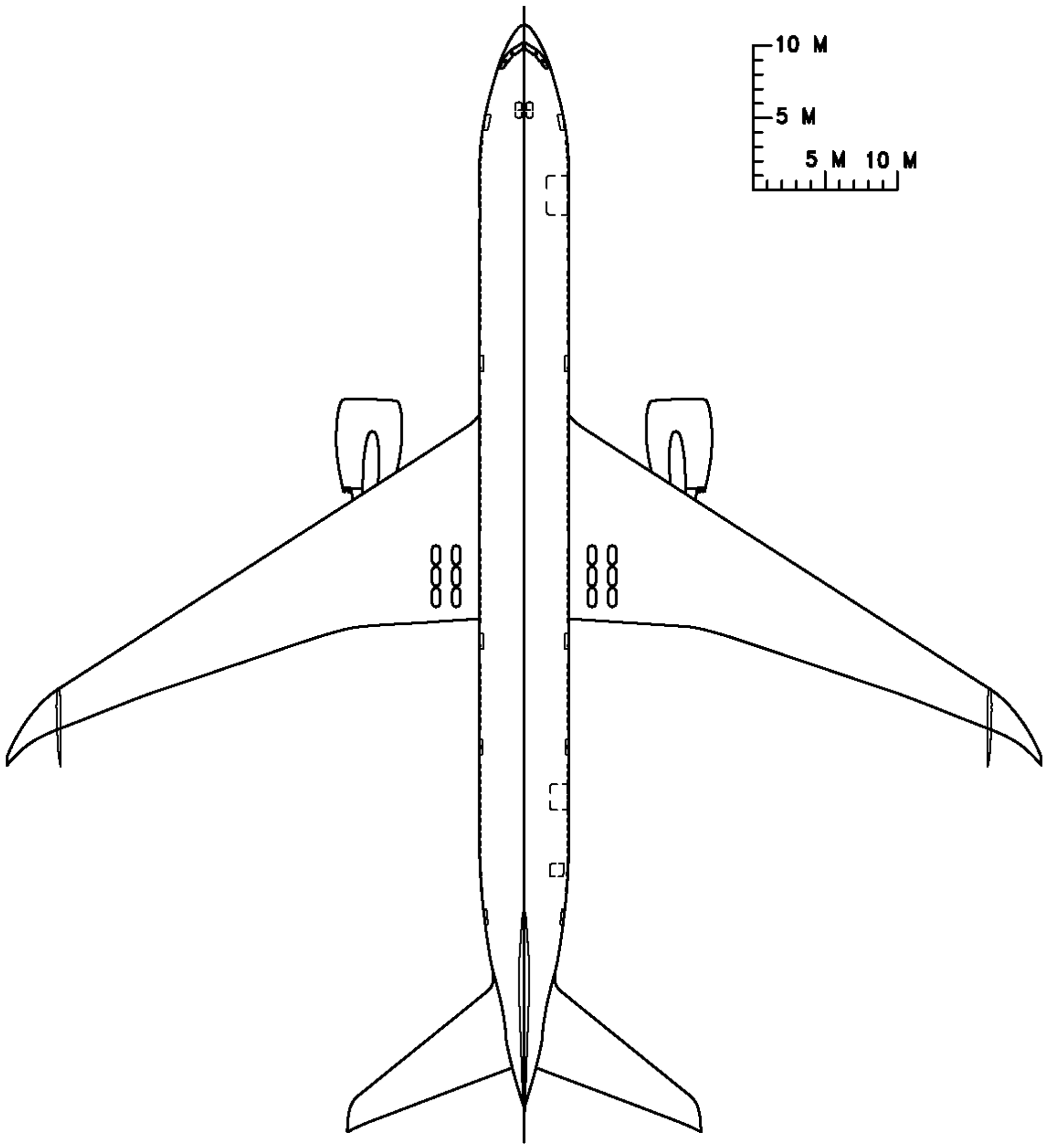
## 9.0 SCALED 777 DRAWINGS

The drawings in the following pages show airplane plan view drawings, drawn to approximate scale as noted. The drawings may not come out to exact scale when printed or copied from this document. Printing scale should be adjusted when attempting to reproduce these drawings. Three-view drawing files of the 777X, along with other Boeing airplane models, can be downloaded from the following website:

http://www.boeing.com/airports

## 9.1 MODEL 777-9

### 9.1.1 Scaled Drawings – 1:500: Model 777-9




**NOTE: ADJUST SCALE WHEN PRINTING THIS PAGE**