Primus Epic® 2

Honeywell

PILOT'S GUIDE

Integrated Avionics System (IAS) for the Embraer E-Jet E2 E190/E195-E2

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Primus Epic® 2 Integrated Avionics System (IAS)

for the Embraer E-Jet E2 E190/E195-E2

Pilot’s Guide

(Load 9)

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1. Introduction

This pilot's guide describes the operation, components, typical flight applications, and operating procedures for the Honeywell Primus Epic Integrated Avionics System installed in the Embraer E-Jet E-2 E190/E195-E2 series aircraft. This pilot's guide covers equipment and functions installed in the aircraft. Figure 1-1 shows an Embraer E190-E2 cockpit.

This revision of this pilot's guide is based on software Load 9.

STRUCTURE OF THIS GUIDE

This guide is divided into the following sections:

- **Section 1 - Introduction** – This section describes the structure of this guide and gives the product support and publications ordering information.
- **Section 2 - System Description** – This section describes the components, systems, and equipment associated with the Primus Epic system.
- **Section 3 - Controllers** – This section gives a consolidated description of the cockpit controls associated with the Primus Epic system.
- **Section 4 - Electronic Display System (EDS)** – This section describes the components and functions of the EDS.
- **Section 5 - Primary Flight Display (PFD)** – This section describes the operation and displays associated with the PFD.
- **Section 6 - Multifunction Display – Navigation** – This section describes the operation and displays associated with the navigation functions on the MFD.
- **Section 7 - Multifunction Display – Electronic Charts (Option)** – This section describes the operation and displays associated with the electronic charts function on the MFD.
- **Section 8 - Multifunction Display – Synoptics** – This section describes the operation and displays associated with the synoptics function on the MFD.

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- **Section 9 - Engine Indication and Crew Alerting System (EICAS)** – This section describes the EICAS window and each pertinent section in detail.
- **Section 10 - Modes of Operation** – This section describes the flight director and autopilot modes of operation.
- **Section 11 - Autothrottle System** – This section describes the function and operation of the autothrottle system.
- **Section 12 - Stall Warning Protection System (SWPS)** – This section describes the components and operation of the SWPS.
- **Section 13 - Radio System** – This section describes the operation and components of the radio system.
- **Section 14 - Audio System** – This section describes the operation and components of the audio system.
- **Section 15 - Micro Inertial Reference System (IRS)** – This section describes the operation and components of the micro IRS.
- **Section 16 - Global Positioning System (GPS)** – This section describes the operation and components of the GPS.
- **Section 17 - Radar Altimeter System** – This section describes the operation, components, and displays of the radar altimeter system.
- **Section 18 - Weather Radar Systems** – This section describes the operation, components, and displays of the weather radar systems.
- **Section 19 - Traffic Alert and Collision Avoidance System (TCAS)** – This section describes the systems, components, and operating procedures for the TCAS.
- **Section 20 - Enhanced Ground Proximity Warning System (EGPWS)** – This section describes the operation and components associated with the EGPWS and the SmartRunway/SmartLanding (SR/SL) system.
- **Section 21 - Digital Voice Data Recorder (DVDR)** – This section describes the operation and components of the DVDR.

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- **Section 22 - Satellite Communications (SATCOM) (Option)** – This section describes the operation and components associated with SATCOM.
- **Section 23 - Other Systems** – This section describes non-Honeywell equipment and systems that supply information to or receive information from the Primus Epic system.
- **Section 24 - Multifunction Control and Display Unit (MCDU) Menu Pages** – This section describes the various options, backup radios, setup, and maintenance information pages.

This publication is intended to be used as a guide and is written for system familiarization only. This guide does not supersede any Federal Aviation Administration (FAA) or original equipment manufacturer (OEM)-approved procedures.

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EQUIPMENT – STANDARD AND OPTIONAL

Honeywell avionics models and systems included in this guide are listed in the standard and optional installed tables, shown in Table 1-1 and Table 1-2. Table 1-1 lists the standard equipment.

Table 1-1
Standard Equipment

Model	Equipment	Qty
Automatic Flight Control System (AFCS) Components		
GP-750	Guidance Panel	1
Radio Altimeter Components		
KRA-405B	Radar Altimeter	1
AT-300	Radar Altimeter Antenna (Receive)	2
AT-300	Radar Altimeter Antenna (Transmit)	2
Weather Radar Components		
Primus-880	Weather Radar (Receiver, Transmitter, Antenna)	1
Electronic Flight Instrument System (EFIS) Components		
DU-1310	Flat Panel Display Unit (with LED backlight)	4
CC-800	Cursor Control Device (CCD)	2
Automatic Direction Finder (ADF) System Components		
AT-860	Automatic Direction Finder (ADF) Antenna	1
DF-855	ADF Module (MRC)	1
Airborne Audio System Components		
AV-900	Audio Panel	3
Micro Inertial Reference System (IRS) System Components		
MICRO-IRU	Laseref VI Micro IRU	2
Multifunction Control Display and Unit (MCDU)		
MC-860	Multifunction Control and Display Unit (MCDU)	2

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Table 1-1 (cont)
Standard Equipment

Model	Equipment	Qty
Traffic Collision Avoidance System (TCAS) Components		
TPA100C	Traffic Alert and Collision Avoidance System (TCAS) Computer	1
ANT-81A	TCAS Directional Antenna	1
HF Components		
KRX-1053	HF Comm Receiver/Exciter (Dual Installation)	2
Modular Avionics Unit Components #1		
MAU-16U	Modular Avionics Unit (MAU) – 16-slot chassis	1
PWR-210	Power Supply Module	2
AGM	AGM1 – Advanced Graphics Module 300 AGM3 – Advanced Graphics Module 300	2
PSEM-1	Proximity Sensor Evaluation Module	1
BCM-1	Brakes Input/Output (I/O) Module	1
CONTROL-IO	Control I/O Module	1
Generic-IO	Dual-Channel Generic I/O Module	1
Custom-IO	NG-Custom I/O Module	1
CMC-901	PROC9 CMC Module	1
Modular Avionics Unit Components #2		
MAU-16U	Modular Avionics Unit (MAU) – 16-slot chassis	1
PWR-210	PWR-210 Power Supply Module	2
AGM	AGM2–Advanced Graphics Module 300 AGM4–Advanced Graphics Module 300	2
Control IO	Control I/O Module	1
Generic-IO	Dual Channel Generic I/O Module	1
NIC/PROC	NG Network Interface Card/Proc With Database Module	2
AGM-300	PROC7 FMS/TOLD1	1

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Table 1-1 (cont)
Standard Equipment

Model	Equipment	Qty
Modular Avionics Unit Components #3		
MAU-10U	Modular Avionics Unit (MAU) – 10-slot chassis	1
PWR-210	Power Supply Module	2
BCM-2	Brakes Control Module (Inboard)	1
PSEM-2	Proximity Sensor Electronic Module	1
GIO-400	Dual Channel Generic I/O Module	1
NIC-221	NG NIC/PROC w/ DB Module (E-ASCB)	2
CUSTOM-IO	NG Custom Dual Channel I/O Module	1
AGM-300	PROC8 FMS/TOLD2	1
Modular Radio Cabinets (MRC) Components		
MRC-855	Modular Radio Cabinets	2
Distance Measuring Equipment (DME) System Components		
DM-855	DME Module	2
DME-855	DME Antenna	2
VHF Communications System Components		
TR-865B	Very High Frequency (VHF) Digital Radio (VDR) Module (VHF COM with Mode A & 2)	2
NV-879A	VIDL-G Navigation Module (VOR-ILS, WAAS, CAT II/CATIII, SBAS/LVP, GPS)	2
Additional Equipment		
IM-950	APM Module	2
IM-950	APM Micro IRS	2
S65-5366-720	WSU External (Fuselage) Antenna	1
S65-5366-720	WSU Alternate (E-Bay) Antenna	1
CVFDR-145	Digital Voice/Data Recorder (DVDR)	2
CVFDR-145	WSU Alternate Antenna (E-Bay) Cable	2
	DVDR Control Panel	1

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Table 1-1 (cont)
Standard Equipment

Model	Equipment	Qty
	Emergency Locator/Transmitter (ELT)	1
	ELT Antenna	1
S41422	Glideslope Antenna	1
S35-1000-2	Marker Beacon Antenna	1
S65-5366-895L	ADS-B/L-Band Antenna	1
S65-5366-7L	Transponder Antenna (bottom)	2
S65-5366-7L	Transponder Antenna (top)	2
16-21B	VHF COM 1 & 2 Antenna (top and bottom)	2
S65-247-33	VOR/LOC Antenna (dual, top of vertical stabilizer)	1
S65-5366-7L	Distance Measuring Equipment (DME) 1 Antenna	1
S67-1575-146	Global Positioning System (GPS) Antenna	2
	Integrated Electronic Standby Instrument	1
	Cockpit Voice Recorder (CVR) Impact Switch	2
SSPD-113-39	Marker Beacon Antenna Coupler	1
CM-2000	Radar Altimeter Configuration Module	1
AH-1000	Attitude and Heading Reference System (AHRS)	1
KCM-200	AHRS KCM-200 Configuration Module	1

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Table 1-2 lists the optional equipment available.

Table 1-2
Optional Equipment

Model	Equipment	Qty
Radar Altimeter Components		
KRX-1053	HF COM Receiver/Exciter	2
ADF System Components		
AT-860	ADF Antenna	1
DF-855	ADF Module	1
Weather Radar Components		
RDR-4000	Weather Radar (Receiver, Transmitter)	1
Other Equipment		
WSU	Wireless Server Unit 3G/4G and Wi-Fi	1
MC-7810	Satellite Communications (SATCOM) Satellite Data Unit	1
HP-700	SATCOM High Power Amplifier	1
	SATCOM Diplexer/Low Noise Amplifier	1
	SATCOM Intermediate Gain Antenna	1
MT-860	Mini-Cabinet	1
KPA-1052	HF Common Power Amplifier	1
	Remote Terminal	1
TP-4840	Printer	1
	VHF COM3 Antenna (Option)	1
	ELT/Navigation Interface Unit	1
	HF COM Antenna	1

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Figure 1-1
Embraer E-Jet E2 E190-E2 Aircraft Cockpit

HONEYWELL PRODUCT SUPPORT

The Honeywell spares exchange (SPEX) program for corporate operators supplies an extensive exchange and rental service that complements a worldwide network of support centers. An inventory of more than 30,000 spare components assures that the Honeywell equipped aircraft will be returned to service promptly and economically. This service is available both during and after warranty.

The aircraft owner/operator is required to ensure that units supplied through this program have been approved in accordance with their specific maintenance requirements.

All articles are returned to Reconditioned Specifications parameters when they are processed through a Honeywell repair facility. All articles are inspected by quality control personnel to verify proper workmanship and conformity to Type Design and to certify that the article meets all controlling documentation. Reconditioned Specification criteria are on file at Honeywell facilities and are available for review. All exchange units are updated with the latest performance reliability MODs on an attrition basis while in the repair cycle.

For information regarding the SPEX program, (Exchange/Rental Program for Corporate Operators), including maintenance, pricing, warranty, and support, log into the Honeywell website at:

https://aerospace.honeywell.com/en/secure/downloads/terms-and-conditions

After logging in, scroll down and select and download the latest *SPEX Catalog Terms and Conditions* document. For further information or support, contact Customer Support at the numbers listed in the Customer Support section.

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CUSTOMER SUPPORT

For support of products or to request the latest revision to a publication, contact the local Honeywell customer support.

For all aerospace inquiries including:

- After market spare quotes, exchanges, and engine rentals
- Services and maintenance programs
- Repair and overhaul
- Aircraft On Ground (AOG)
- Technical assistance
- Myaerospace.com web support
- All other inquiries.

Use the following contact numbers:

- Fax: 1-602-822-7272
- Phone: 1-800-601-3099 (U.S.A./Canada)
- Phone: 1-602-365-3099 (International).

Aerospace Technical Support (ATS)

For direct technical support, use the contact numbers listed above for Honeywell Customer Support.

Or log into the Honeywell website at:

- aerospace.honeywell.com

Flight Technical Services (FTS)

For direct technical pilot support, additional information, or operational questions, contact FTS by:

- Email: FTS@honeywell.com
- Website: https://pilots.honeywell.com/#/myac/.

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Honeywell Aerospace Technical Publications and Online Access

Honeywell has moved to an online access model for technical publications. This change was made to eliminate the cost of printing and shipping paper publications and to be a better environmental steward. The options are still available to download an electronic version, order hard copy prints, and report discrepancies through the Honeywell MyAerospace portal at https://hwll.co/myaerospace. Once the page opens, select the appropriate Technical Support Tools button for Technical Publications, Technical Support, etc. as applicable.

On the Technical Publications page, alerts can be set up so that if there is a change to a publication, customers can receive email notifications of changes. The user can add a manual to a Watch List using the Receive Email Updates link or use the My Email Notifications link on the Search Publications page. If there is a change, revision, or new release, request the publication at that time through the Honeywell MyAerospace portal at https://hwll.co/myaerospace.

For questions, concerns, or to report a discrepancy, contact the Technical Publications Order Management team via email at: pubs@honeywell.com.

If you do not have access to the Honeywell Online Technical Publications website and need technical publications information:

- Send an email message to: pubs@honeywell.com
- Send a fax or speak to a person, using the Customer Support contact numbers.

HONEYWELL FORGE

The demand for integrated services in avionics has never been greater. Operators want to improve safety, increase efficiency, and cut operating costs. Pilots want better tools that provide real-time information so they can focus on flying. Flight departments want to anticipate and fix problems to avoid grounding aircraft and passengers want a safe, comfortable flight with dependable, easy-to-use Wi-Fi like they get in their offices and homes.

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An Integrated Platform

Honeywell Forge is an integrated platform that gives pilots, operators, and flight departments direct access to the services they need most: cabin and cockpit connectivity, flight planning, software, maintenance services, navigation databases, and equipment protection plans, as well as a full suite of connected services.

With the Honeywell Forge Dashboard, users can quickly access Honeywell Aerospace services within a single consolidated view with one login https://bga.honeywellforge.com/. In addition to viewing current subscription services, users can access other offerings to help improve safety, performance, and cost-efficiency, including:

- Cabin connectivity and usage management
- Flight services and cockpit datalink
- Partnership integrations
- Maintenance and service plans.

Cabin Connectivity

Honeywell now offers a comprehensive suite of satellite communication services and solutions to deliver unparalleled connectivity and functionality in flight. Honeywell's Cabin Connectivity provides flexible, reliable cabin communications, including high-speed Ka, Ku, and Swift broadband Internet, which enables real-time and on demand TV, video conferencing and streaming, email, and Voice Over Internet Protocol (VoIP).

From routing software to subscribable value adds and everything in between, Honeywell's Cabin Connectivity provides a large suite of services to meet the needs of any operator allowing the passenger the best experience on board and the operator to manage their usage and costs in real time.

Honeywell Cabin Connectivity services include:

- **Value Added Services and Product** – Customize the experience on board and manage operating costs with remotely accessible tools such as Network Filter, Access, and Data control.

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- **Forge for Business Aviation Dashboard** – A single integrated website for accurate near real-time fleet tracking, usage reporting, and robust analytics, as well as integrated partners and Honeywell services.
- **Honeywell Forge Network App** – Makes it easy to quickly check the on board Wi-Fi network status and find ways to restore connectivity.

WORLDWIDE CONNECTIVITY SOLUTIONS

For General Aviation, BendixKing's Aerowave 100 is an affordable high-speed in-flight Internet solution that offers worldwide connectivity to twin, turboprop, and light jet aircraft.

JETWAVE HARDWARE

Honeywell's JetWave is an exclusive connectivity hardware that enables users to connect to Jet ConneX, Inmarsat's Global Xpress constellation of Ka-band satellites. JetWave satellite communication hardware includes antennas, routers, and other equipment to provide uninterrupted and consistent service to JetWave-equipped aircraft.

Flight Services

Honeywell Flight Services includes integrations with market leading global flight planners, on demand flight support, two-way data communications, and other services to keep pilots on the right route to avoid traffic, weather hazards, and delays.

FLIGHT SENTINEL

Honeywell Flight Sentinel is an industry leading, premier service offering, which enables an on-ground dispatch team to act as an extension of the flight crew. By monitoring airport volume, current air traffic control (ATC) initiatives, weather, and required routing, Flight Sentinel helps to minimize delays and reduce crew workload. The Flight Sentinel Team actively monitors all phases of flight, providing updates on hazardous weather and other conditions that could have an impact, providing proactive communications to keep the crew informed.

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PERFORMANCE-BASED COMMUNICATION SURVEILLANCE (PBCS) SERVICES

A new monitoring service for datalink subscribers helps operators almost immediately recognize when they have exceeded maximum allowed timing while using FANS datalink communications. It provides Performance-Based Communication and Surveillance (PBCS) monitoring data after each flight so the operator can deal proactively with any issues and retain the ability to fly the FANS reduced separated tracks. PBCS monitoring capabilities will become even more vital for operators going forward as air traffic, which has waned because of the coronavirus pandemic, recovers to more normal levels and air traffic authorities in the Pacific Region begin implementing FANS reduced separation strategies along heavily trafficked routes.

DATALINK

For more than 30 years, Honeywell's Flight Services has provided VHF and satellite datalink communications to datalink-equipped aircraft worldwide. Honeywell's robust two-way aircraft communications addressing and reporting system (ACARS) is compatible with all major VHF and satellite networks across the globe. With enterprise-level connections to communication networks worldwide, Honeywell Forge personnel can relay messages anywhere.

While airborne, flight crews are able to access a variety of critical weather, wind, and Digital Automatic Terminal Information Service (D-ATIS) products from virtually anywhere in the world for immediate flight deck display.

Maintenance and Service Plans

Honeywell's maintenance plans deliver a cost-efficient means to maintain assets optimally and ensure high dispatch availability. Services are available for many Honeywell products, including mechanical, avionics, and environmental control systems.

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EXTEND THE VALUE WITH REPAIR AND REPLACEMENT PROGRAMS

Repair and replacement programs protect customers from unexpected costs and unscheduled downtime. They include the Honeywell Avionics Protection Program, the Maintenance Service Plan for engines and auxiliary power units, and the Mechanical Protection Plan for environmental control and cabin pressurization systems.

Apps

Honeywell Forge Apps make each flight more efficient and help to reduce costs by providing flight crews with a variety of options so that aircraft spend less time on the ground and more time in the air.

COCKPIT APPS

Honeywell Pilot Gateway

The Honeywell Pilot Gateway provides free, instant access to dedicated resources for pilots of corporate aircraft outfitted with Honeywell products and services.

CABIN APPS

Honeywell Forge Toolkit

The Honeywell Forge Toolkit app makes it much easier for aircraft maintenance technicians to troubleshoot and service the Honeywell satellite communications and router hardware on their aircraft.

Honeywell Forge Network

The Honeywell Forge Network app allows flight crew and/or passengers on business aviation aircraft to diagnose and troubleshoot in-flight Wi-Fi connectivity.

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Honeywell Forge Voice

The Honeywell Forge Voice app is an easy-to-use application that enables voice calls for passengers who need to stay connected while in-flight.

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2. System Description

INTRODUCTION

This section describes the components, systems, and equipment associated with the Primus Epic system.

The Primus Epic system takes advantage of advancements in flat panel display technology and cursor control devices. Modular integration is coupled with many of the stand-alone utility functions into the avionics suite. Many control functions were previously individual line replacement units (LRU) in older systems and are integrated into the modular avionics unit (MAU) and the modular radio cabinets (MRC) of the Primus Epic system. The Primus Epic system is designed as an open architecture that integrates non-avionics functions and non-Honeywell equipment into the system. The following is a list of the main components of the Primus Epic system for the Embraer aircraft:

- **Modular Avionics Unit (MAU)** – The MAU is a cabinet containing line replaceable modules that integrate avionics, utilities, and selected flight control functions. There are three MAUs in a hardware cabinet. Two with 16-user slots and plug-in modules, and one with 10-user slots and plug-in modules. These modules are field replaceable and represent building blocks of the Embraer E-Jet E-2 E190/E195-E2 flight deck. The modules are linked to the eASCB-D data bus through the next generation network interface controller (NG-NIC) module.

- **Display Unit (DU)** – The display unit is a 14.1-inch diagonal liquid crystal display (LCD) (DU-1310). The display supports wide-viewing angles and adds more available viewing area to each display.

- **Modular Radio Cabinet (MRC)** – The MRC is a cabinet containing line replaceable radio modules. These modules provide traditional navigation and communication functions, including:

  – VHF NAV

  – VHF COM

  – ADF

  – DME

  – Diversity Mode S Transponder.

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- **Controllers** – The controllers consist of:
  - Integrated display and guidance panel
  - Cursor control device (CCD)
  - Multifunction control and display unit
  - Audio panel
  - Reversionary panel for display/sensor (ADC/IRS)
  - Dimming controller
  - Added software for automatic reversion functions.
- **Sensors** – The sensors consist of:
  - Global positioning system (GPS) module housed in the MAU
  - Air data module
  - Integrated multifunction probe
  - Inertial reference system (IRS).
- **Weather Radar**
- **Radar Altimeter**
- **DVDR**
- **TCAS TPA-100C Systems**
- **SATCOM System** (option)
- **VHF COM Unit** (option).

Figure 2-1 shows the baseline architecture for the Embraer aircraft in block diagram format.

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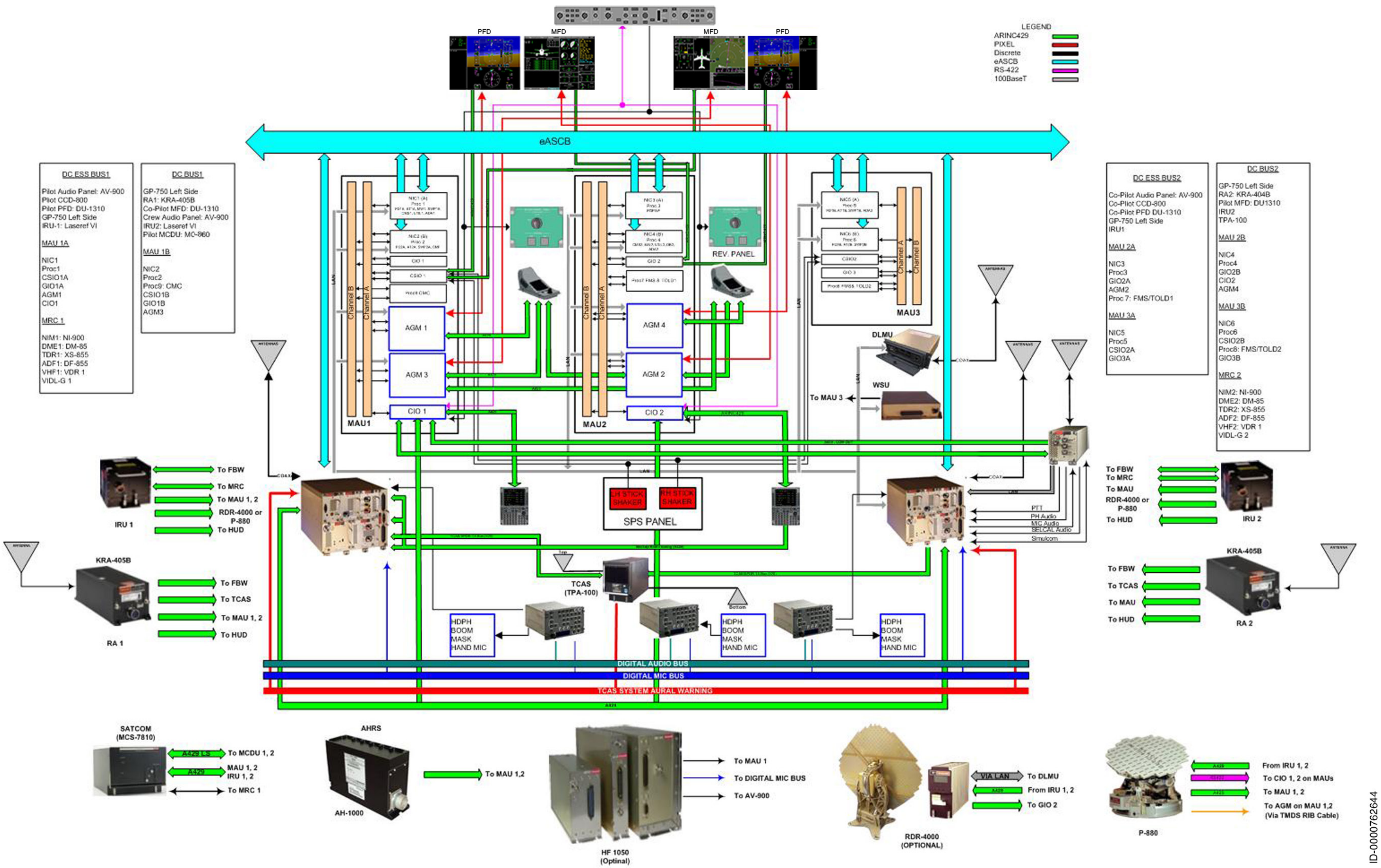

Figure 2-1
Primus Epic System Block Diagram for Embraer Aircraft

SYSTEM NETWORK BUSES

The system MAUs and the MRCs are attached directly to the system network buses. These buses consist of the Honeywell Enhanced Avionics Standard Communications Bus, Version D (eASCB-D), and a local area network (LAN). Data from these units is broadcast onto the network, then available to any unit connected to the ASCB.

eASCB-D Network

The enhanced ASCB-D (eASCB-D) network is the primary communication path between the major subsystems of the Primus Epic integrated avionics system, providing critical integrity and availability. The network consists of two primary buses and two backup buses. The network is fully synchronous and time division multiplexed. Each bus consists of tapped twisted-shielded differential pair wiring.

Local Area Network (LAN)

The major system components also connect to a single non-redundant LAN. The LAN is a commercial off-the-shelf (COTS) ethernet-protocol network using tapped coaxial wire. The LAN supplies the primary maintenance and software-loading interface for the system.

Essential System Configuration and Architecture for Primus Epic (ESCAPE)

The definition of all eASCB data from MAU channels, MRCs, and secondary power distribution assemblies (SPDAs) is performed using the ESCAPE tool. Prior to Primus Epic, eASCB transmission requirements were captured into documents that textually defined each software component eASCB bus transmission. The documents were constructed for each aircraft system and contained low-level details about the component. Such details included the location of each component and the parameters each component was expected to transmit.

At the simplest level, ESCAPE is a translator. ESCAPE translates eASCB-based inter-component communication details into the collection of registries. After ESCAPE generates the registries, they are verified.

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Modular Avionics Unit (MAU) System Architecture

The MAU cabinet is a single- or dual-channel unit (dual-channel units utilize independent power supplies and network interfaces). Two dual-channel, 16-slot MAUs and one dual-channel, 10-slot MAU are installed in the Embraer aircraft.

The modules within the MAU are designed to be building blocks using common designs. Input/output (I/O) and processing capability are upgraded in the MAU by adding more processing and/or I/O modules to slots in an MAU chassis. Each MAU channel incorporates one or two power supply modules and one NG-NIC module. The power supply and NG-NIC modules are an integral part of the MAU and are not counted as user modules.

MAU Backplane

The heart of the Primus Epic system is the virtual backplane. In general, the virtual backplane supplies:

- **Global Information Capability** – All elements tied to the network have access to all data generated by all processing, database, or I/O modules.
- **Seamless Communication** – Communication between modules is independent of physical location. Maximum flexibility enables efficient and scalable systems.
- **Wire Elimination** – Bidirectional buses eliminate many of the dedicated point-to-point wiring requirements found in other architectures.

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MAU Hardware

The MAU cabinet configuration, shown in Figure 2-2, contains the following types of circuit card assemblies (CCAs) (depending on the options selected for the aircraft):

- Power supply module
- Network interface controller plus processor module (NIC/Proc)
- Processor module (Proc)
- Advanced graphics module (AGM)
- Input/output modules:
  - Control I/O module
  - Generic I/O module
  - Custom I/O module.

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MAU 1
Forward E-Bay

#	BUS	CH	Power Supply 2 DC 1	CH	BUS
16			Spare		
15			Spare		
14	2		AGM 3		
13	2	B	(DU3)		
12	2	B	CSIO 1		
11				A	1
10	2		PROC 9		
9	2	B	CMC		
	2	B	NIC 2 (B)		
	2	B	PROC 2		
			PROC 1	A	1
			NIC 1 (A)	A	1
8	2	B	GENERIC I/O 1		
7				A	1
6			CIO 1	A	1
5			BRAKES (Out BD)	A	1
4			AGM 1	A	1
3			(DU1)		1
2			PSEM 1		
1				A	1
#	BUS	CH	Power Supply 1 ESS 1	CH	

MAU 2
Forward E-Bay

#	BUS	CH	Power Supply 2 ESS 2	CH	BUS
16			Spare		
15			Spare		
14			AGM 2	A	1
13			(DU2)		1
12			NOSEWHEEL	A	1
11			STEERING		
10			PROC 7	A	1
9			FMS/TOLD 1		1
	2	B	NIC 4 (B)		
	2	B	PROC 4		
			PROC 3	A	1
			NIC 3 (A)	A	1
8	2	B	GENERIC I/O 2		
7				A	1
6	2	B	CIO 2		
5			Spare		
4	2		AGM 4		
3	2	B	(DU4)		
2			Spare		
1			Spare		
#	BUS	CH	Power Supply 1 DC 2	CH	BUS

MAU 3
Mid E-Bay

#	BUS	CH	Power Supply 2 ESS 2	CH	BUS
10			Spare		
9	2		PROC 8		
8	2	B	FMS/TOLD 2		
7	2	B	CSIO 2		
6				A	1
	2	B	NIC 6 (B)		
	2	B	PROC 6		
			PROC 5	A	1
			NIC 5 (A)	A	1
5	2	B	GENERIC I/O 3		
4				A	1
3	2	B	PSEM 2		
2					
1	2	B	BRAKES (In BD)		
#	BUS	CH	Power Supply 1 DC 2	CH	BUS

BUS 1 = ASCB Left
BUS 2 = ASCB Right

Third Party Hardware
Brakes OB, IB
Nosewheel Steering
Nosewheel Steering

Proc1 - FD1A, AT1A, SWP1A, CMS1, CAL-RT1, CAL-MCDU1, CAL-TACTICAL1, MWS1, UTIL1, ADA1
Proc2 - FD2A, AT2A, SWP2A
Proc3 – EGPWF, GGF1-IO
Proc4 - FD2B, AT2B, SWP2B, CMS2, CAL-RT2, CAL-MCDU2, CAL-TACTICAL2, MWS2, UTIL2, ADA2
Proc5 - FD1B, AT1B, SWP1B, ECL1
Proc6 - CMF, ECL2, ADA3, GGF2-IO
Proc7 - FMS 1/TOLD 1/NavDB, BackupDB1
Proc8 - FMS 2/TOLD 2/NavDB, BackupDB2
Proc9 - CMC

AGM1,2,3,4 - GGF, CALF, CDTI, Charts, IPFD, INAV

ID-0000762645

Figure 2-2
MAU Configuration

AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS)

The automatic flight control system (AFCS) contains the following functions:

- Flight director (FD)
- Autopilot (AP) and autopilot trim
- Mach trim (MT)
- Thrust management system (TMS)
- Stall warning and protection system (SWPS).

Flight Director (FD) Guidance Overview

The FD cue and mode annunciators for the flight guidance control system (FGCS) are displayed on the primary flight display (PFD). Flight director modes are selected through the guidance panel. The vertical axis FD modes that follow are displayed:

- Altitude select/hold (ALT)
- Altitude select (ASEL)
- Flight level change (FLCH)
- Flight path angle (FPA)
- Glideslope (GS) approach
- Nose lowering (D-ROT)
- Overspeed protection (OVSP)
- Takeoff/go-around (TO/GA)
- Vertical navigation (PTH, FLCH)
- Vertical speed (VS)
- Windshear guidance (WSHR).

The lateral axis FD modes are displayed as follows:

- Basic roll modes (roll hold/heading hold/wings level) (ROLL)
- Heading select (HDG)

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- Lateral navigation (by the FMS lateral steering command) (LNAV)
- Localizer (LOC/ILS/GLS) approach and back course localizer (LOC/BC)
- Track hold (takeoff and go-around) (TRACK)
- Align (ALIGN)
- Rollout (RLOUT).

AUTOPILOT (AP) AND AUTOMATIC PITCH TRIM OVERVIEW

The AP performs the following functions:

- Pitch attitude control by elevator commands for:
  - AP stability computations
  - Coupling to the active vertical FD modes.
- AP pitch trim commands for:
  - Alleviation of column force.
- Roll attitude control by aileron commands for:
  - AP stability computations
  - Coupling to the active lateral flight director (FD) modes.

AP is engaged and disengaged by an **AUTOPILOT** button on the guidance panel. Applying sufficient force to the control column or using either AP quick disconnect switches on the control wheels also disengages the AP.

The AP servo clutches are disabled while either of the touch control steering (TCS) switches are pushed.

The AP trim function commands change to the horizontal stabilizer position. This is done through trim rate commands to the fly-by-wire (FBW) trim system to reduce steady-state offsets in column position.

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MACH TRIM (MT) SYSTEM OVERVIEW

The Mach trim function commands incremental changes in stabilizer position as a function of Mach number. This function eliminates the nose-down tendency of the aircraft in the transonic region. Mach trim is disabled while the AP is engaged.

THRUST MANAGEMENT SYSTEM (TMS)

The thrust management system (TMS) consists of three subfunctions:

- Thrust rating selection (TRS)
- Autothrottle (A/T)
- Electronic thrust trim system (ETTS).

When engaged, the A/T system automatically positions the thrust levers to control the aircraft thrust throughout the flight regime. The A/T system keeps the aircraft within the thrust and speed envelopes and controls the engine thrust modes in synchronization with the active FGCS modes.

Based on pilot-selection and flight phases, the ETTS automatically trims the aircraft thrust through the full authority digital engine control (FADEC) to supply:

- Tighter speed control (during A/T operation)
- Thrust match of the two engines (during takeoff)
- Electronic flats (during manual operation of the thrust levers)
- N_1 synchronization.

The baseline TMS configuration consists of a dual-channel TRS and A/T/ETTS. The MCDU permits the active TRS, A/T, and ETTS channels to be pilot-selected. The TRS is configured in an active/standby configuration, automatically going to standby if the selected TRS is inoperative. The A/T/ETTS is also configured with autopriority reversion. When the selected A/T/ETTS channel is inoperative, the A/T/ETTS automatically switches to the other channel.

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STALL WARNING PROTECTION SYSTEM (SWPS)

The SWPS supplies a two-stage system to warn and protect the aircraft from stalling. The stick shaker is the first level, warning the pilot the aircraft is approaching a stall condition by activating a motor mounted on each control column. A low-speed awareness indication on the airspeed tape and a pitch-limit indicator on the ADI of the PFD is a corresponding visual indication of an impending stall condition.

The second level is an angle-of-attack (AOA) limiter protection system supplied by the primary flight control system.

The SWPS compares the body AOA measurements with predefined threshold values. When the threshold is reached or exceeded, the SWPS activates the stick shakers on the control columns.

The SWPS consists of the following functions, components, and AOA computations:

- Local AOA
- Body AOA
- Complemented body AOA
- Redundancy management
- Sideslip (Beta) computation
- Aircraft mass computation.

Stall warning (shaker):

- Shaker motor actuation
- Shaker pattern generation
- On-ground shaker test function
- SPS panel cutout
- Display computations
- Computation of a low speed awareness (LSA) ratio
- Pitch limit indicator.

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Annunciators:

- Aural warnings
- PFD annunciators
- CAS messages.

COMMUNICATIONS EQUIPMENT

The VHF communication function (VHF COM), a VHF Data Radio (VDR) communication module, is hosted in each of the two MRCs. A digital audio system provides audio, interphone, and passenger address system. The system is controlled using the MCDUs and dual digital audio panels.

The option of a third VHF COM unit is a separate LRU interfaced by the ARINC 429 to the ASCB-D network. This is done through an I/O module in the MAU cabinet. A separate, single high frequency (HF) communication/datalink system is an option.

The Honeywell modular radio system consists of the following major components:

- **Cockpit Mounted Units** – There are three digital audio control panels, as shown in Figure 2-3.

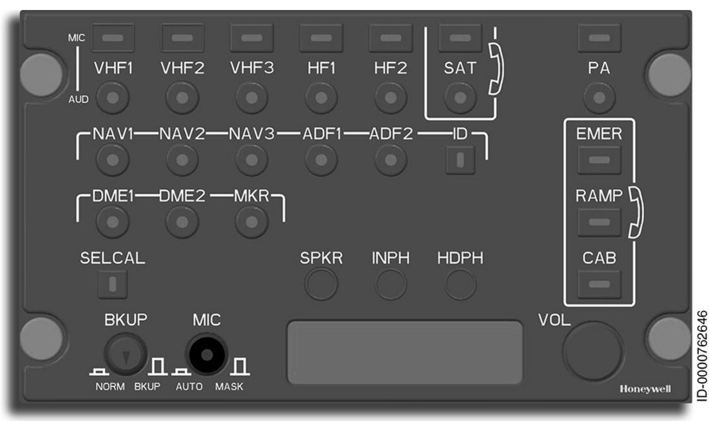

Figure 2-3
Audio Panel

- **Required Antennas** – Any properly approved antenna is compatible and certifiable with the Honeywell radio system modules.

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Digital Audio System

The digital audio system provides communication between the aircraft and ground and between the cockpit and the cabin. The system also outputs digitized audio warnings to the crew. Digitization of all audio signals is done in the MRC.

The digital audio system consists of:

- Audio control panels
- Radio modules within the MRCs
- Stand-alone communication LRUs
- Passenger address system
- Cockpit loudspeakers
- Headsets
- Microphones.

DIGITAL AUDIO CONTROL BUS

The digital audio bus is the primary audio communication path between major subsystems of the radio system and the audio panels. The digital audio bus consists of two primary buses. Each bus is electrically isolated from the other bus.

DIGITAL MICROPHONE CONTROL AND INTERPHONE BUS

Two bidirectional multiplexed buses with identical data are routed from each audio panel for system redundancy in case of a single bus failure. The audio panels transmit digital data samples of the selected microphone audio and control/status information from the audio panel.

Both buses are connected to each MRC next generation network interface module (NG-NIM). The NG-NIM converts the microphone data to an analog audio signal and applies the signal to the selected radio microphone input along with a decoded push-to-talk (PTT) signal. Each bus is connected to the corresponding bus side in all audio panels in the system to supply interphone communication. The audio data samples and control/status data from each audio panel are multiplexed at a high rate onto the bus by each audio panel. The digital audio system contains the following functions:

- Interphone link between crewmembers and flight attendants

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- Operation of communication and radio-navigation audio systems with individual volume control
- Input of audio warnings (TCAS and aural warning tones) through the MRCs
- Operation of ramp (maintenance) interphones
- Cockpit voice recorder output
- Public address (PA) selection and switched microphone.

SATCOM (OPTION)

The SATCOM system contains multi-channel voice and data functions. The SATCOM provides the crew with:

- Airline operational control services (AOC)
- Air traffic control (ATC) services (future development)
- Passenger services (voice, FAX, and PC).

The SATCOM system is used with the INMARSAT satellite network.

The multifunction control and display unit (MCDU) controls and selects predetermined telephone numbers, reviews maintenance information, and adjusts system parameters. The SATCOM communication is controlled using the selective calling (SELCAL) option.

The HPA supplies the gain required to transmit to the INMARSAT satellites. The HPA is nominally rated at 20 watts and maintains several channels of SATCOM at the same time.

The SATCOM system interfaces with an antenna subsystem consisting of two LRUs: the Aero-I (intermediate gain) antenna and the diplexer/low-noise amplifier (D/LNA).

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ELECTRONIC DISPLAY SYSTEM (EDS)

The EDS includes all of the display functions, normally referred to as the electronic flight instrument system (EFIS), as well as the engine instruments and crew alerting system (EICAS). The EDS contains primary flight instruments, navigation displays, synoptic displays, and system displays. It consists of four flat-panel, diagonal LCD display units (DU). The four displays are oriented horizontally (landscape). The display unit is the new 14.1-inch diagonal LCD (DU-1310). The display supports wide-viewing angles and adds more available real estate to each display area.

The EDS, shown in Figure 2-4, consists of four identical DUs having these main functions:

- Primary flight display (PFD)
- Interactive navigation (INAV)
- Synoptics
- Electronic charts
- Engine indication and crew alerting system (EICAS)
- Central maintenance computer (CMC).

Figure 2-4
Display Units

The PFDs display information for aircraft control and primary flight information. The two PFDs (DU1 and DU4) display the primary flight instruments, navigation information, flight mode annunciations, controller pilot datalink communications (CPDLC), and flight information window. The two MFDs (DU2 and DU3) display navigation, map, systems synoptics, electronic charts, EICAS, and CMC windows.

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The initial display format with the aircraft ON GROUND using DC power (batteries) only is as follows:

DU1 Out-board	DU1 In-board	DU2 Out-board	DU2 In-board	DU3 In-board	DU3 Out-board	DU4 In-board	DU4 Out-board
Status	EICAS	Blank	Blank	Blank	Blank	EICAS	Status

The initial display format with the aircraft ON GROUND using AC power is as follows:

DU1 Out-board	DU1 In-board	DU2 Out-board	DU2 In-board	DU3 In-board	DU3 Out-board	DU4 In-board	DU4 Out-board
PFD Auxiliary	PFD	Flight Control	EICAS	Status	Map	PFD	PFD Auxiliary

The display format with the aircraft IN AIR using AC power is as follows:

DU1 Out-board	DU1 In-board	DU2 Out-board	DU2 In-board	DU3 In-board	DU3 Out-board	DU4 In-board	DU4 Out-board
PFD Auxiliary	PFD	Flight Control	EICAS	Status	Map	PFD	PFD Auxiliary

The display format with the aircraft IN AIR and using only DC power is as follows:

DU1 Out-board	DU1 In-board	DU2 Out-board	DU2 In-board	DU3 In-board	DU3 Out-board	DU4 In-board	DU4 Out-board
PFD	EICAS	None	None	None	None	EICAS	PFD

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DISPLAYS

The three main displays featured in the cockpit are the primary flight display (PFD), multifunction display (MFD), and the engine indication and crew alerting system (EICAS).

For each DU displaying two windows, there is an inboard and outboard window, as shown in Figure 2-5. The inboard window is nearest to the centerline of the main instrument panel between DU2 and DU3. The outboard window is the window farthest from the centerline.

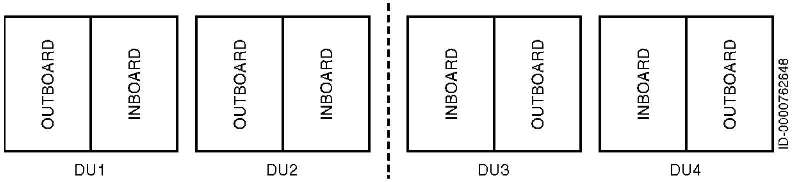

Figure 2-5
Display Units Showing Inboard/Outboard Formats

- For the full-screen INAV format, the image displayed is spread across both the outboard and inboard windows.
- The EICAS format can only be shown on an inboard window.
- The PFD half-screen format can only occur as an outboard format on any DU.
- The CPDLC + PFD window with flight information can only occur as an outboard format on DU1 and DU4 along with PFD 3/4 format.
- A format window can be changed by menu selection (half/full), manual/auto reversion, or reconfiguration by system monitors in order to maintain a minimum set of formats for the flight crew.

See the Window Management subsection described in Section 3, Controllers, for additional information.

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Primary Flight Display (PFD)

The PFD window, shown in Figure 2-6, displays primary flight information, CPDLC, and flight information. The PFD also displays annunciators to indicate which modes and settings have been initiated using the display controller.

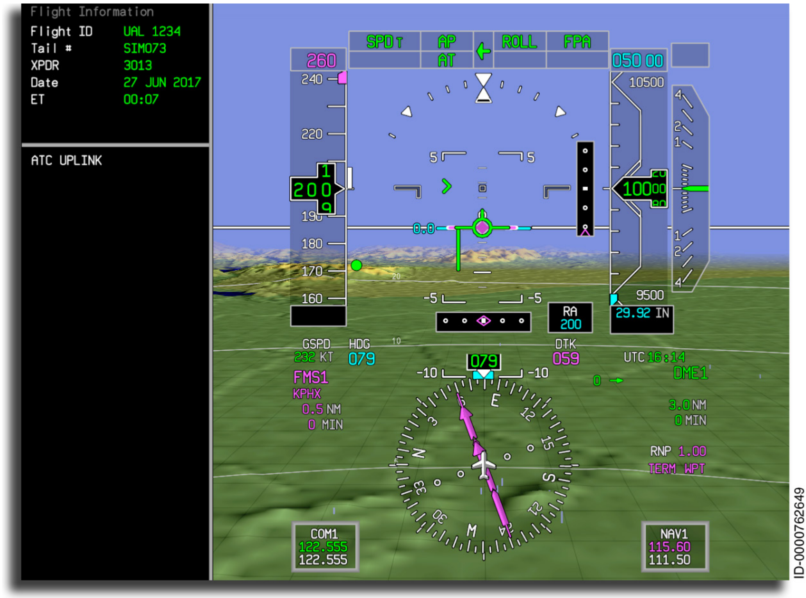

Figure 2-6
Pilot's PFD With CPDLC and Flight Information

The following information is displayed on the PFD window:

- Attitude director indicator (ADI)
- Flight director and autopilot modes and command cues
- Airspeed
- Altitude
- Vertical speed
- Horizontal situation indicator (HSI)
- Air data information
- Autothrottle modes

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- Weather radar (WX) images
- Traffic alert and collision avoidance system (TCAS) data
- Communications and navigation radio frequency information
- Terrain awareness and warning system (TAWS) data and windshear annunciators
- Time.

Attitude information is displayed on an electronic attitude director indicator (EADI). Heading and course information is displayed on an electronic horizontal situation indicator (EHSI).

The PFD annunciates the selected flight modes, alert altitude, and approach minimums. Pitch and roll steering commands are generated by the FGCS in conjunction with the guidance panel. The commands are displayed as command bars directing the pilot to maintain the desired flight path. Active and standby frequencies for the communications (COM) and navigation (NAV) radio are displayed at the bottom of the PFD.

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The synthetic vision system (SVS) option, shown in Figure 2-7, enhances flight crew awareness by providing a synthetic three-dimensional view of the surrounding environment, including sky, land, water, gridlines, obstacles, airports, and runways, in addition to standard flight and navigation data position, altitude, heading, and track.

NOTE: Placement of the primary flight instruments does not change when the SVS is turned on and off.

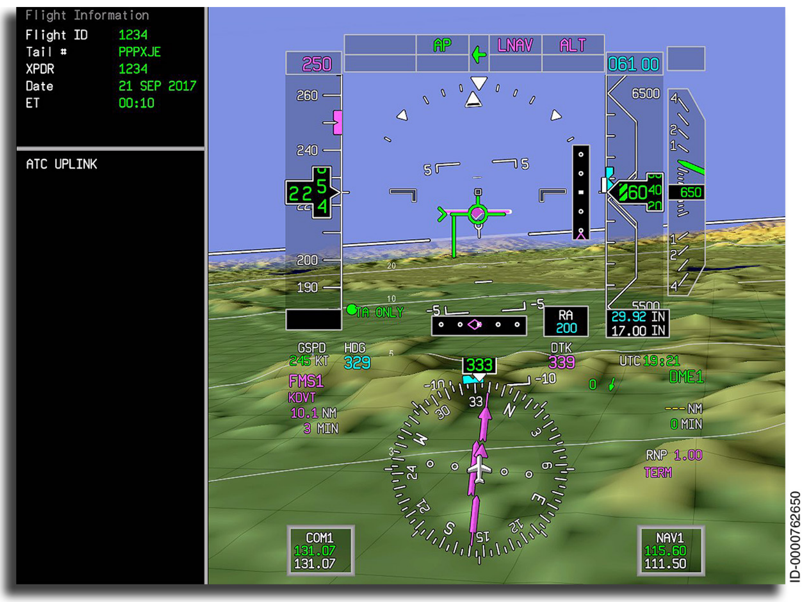

Figure 2-7
SVS on Pilot's PFD Window

The PFD is normally displayed in 3/4 format, with the CPDLC window displayed in the 1/4 format. The PFD can faildown to 50/50 (split MFD and PFD).

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Multifunction Display (MFD)

The MFD display, shown in Figure 2-8, has a set of menu buttons at the top and bottom of the display. The pilot selects these menu buttons to set formats, select overlays, and control subsystems.

Figure 2-8
MFD Map Display

A full-map format, similar to Figure 2-8, can be activated by selecting **Full** from the Map or Plan dropdown menu.

The MFD can be displayed in 1/2 or full-size formats. The full format allows the pilot to display the INAV map in heading-up or north-up modes.

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The default half-map format is shown in Figure 2-9.

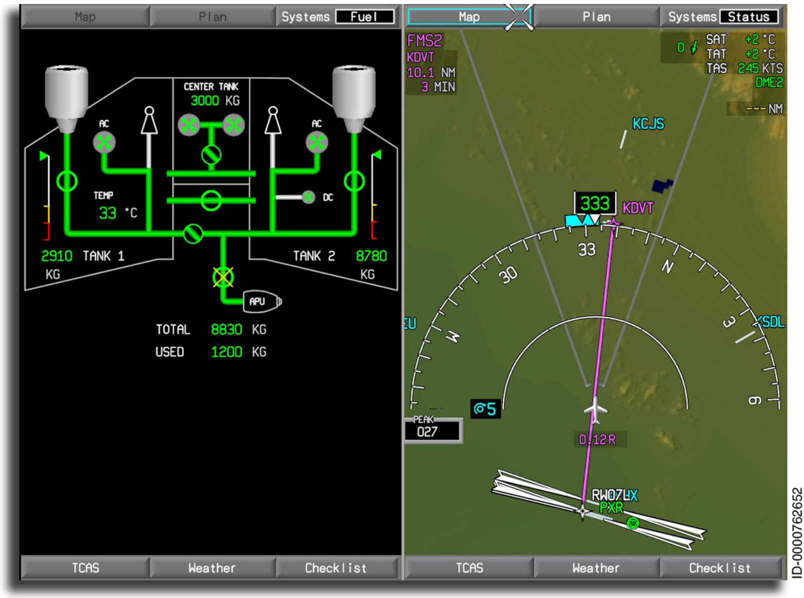

Figure 2-9
MFD Half-Map Format

The crew can manually power down displays and move formats to adjacent displays, depending on manual and automatic reversion requirements. In addition, the system monitors the formats displayed on adjacent displays and automatically reconfigures the formats on each DU to maintain the minimum set of formats for the pilot's field of view.

MENU TITLE BUTTONS

The MFD has two menu bars. One is on the top and another on the bottom of the screen. The upper menu bar has three menu title buttons.

The **Map** and **Plan** buttons are used to display Map and Plan navigation formats, respectively. The **Systems** button is used to display various synoptic formats, electronic charts, EICAS, or CMC pages.

The lower menu bar has three menu title buttons. **TCAS** zoom, the **Weather** radar virtual controller, and **Checklist** are selected for display in the lower area of the screen.

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NOTE: The ***Checklist*** *button is blank when the checklist function is not installed.*

The MFD acts as the redundancy backup to display the PFD and EICAS formats. The MFD menu bars are shown in Figure 2-10.

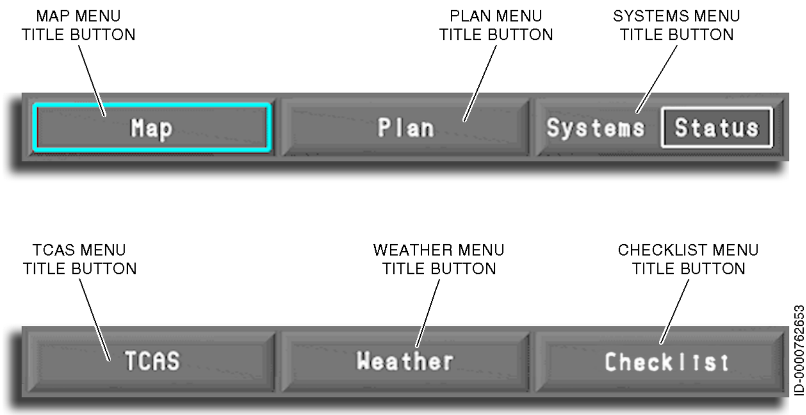

Figure 2-10
Upper and Lower Menu Bars

The six menu buttons are displayed in most instances and are located along the top and bottom of the MFD. The bottom menu buttons are removed when the EICAS is shown. The top and bottom menu buttons are removed when an eChart is displayed.

When a menu title button is selected, it will have the appearance of being **pushed in** on the display. The menu buttons not selected appear raised. The buttons are mutually exclusive. Selecting a menu title button automatically deselects all other menu buttons on that menu bar.

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Engine Indication and Crew Alerting System (EICAS)

The EICAS is displayed on the inboard of DU2 in a normal electrical power configuration. Each piece of information is displayed at a fixed location on the EICAS window, as shown in Figure 2-11. Items are removed or decluttered during specific flight conditions.

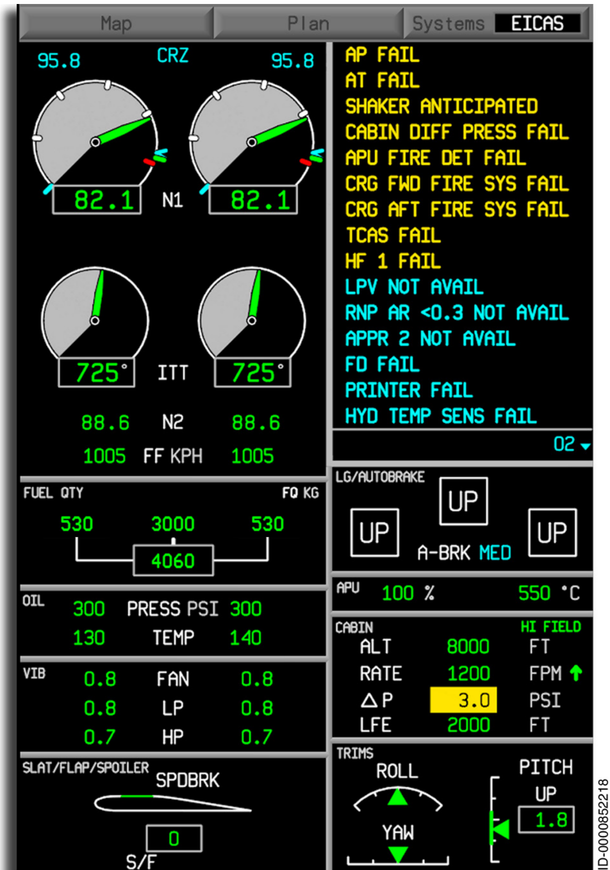

Figure 2-11
EICAS Window

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The information in the following list is displayed in the EICAS window on the MFD:

- CAS messages
- Primary/secondary engine data
- N_1
- Thrust reverser status
- Interturbine temperature (ITT)
- Ignition
- N_2
- Fuel flow
- Oil pressure/temperature
- Windmilling start icon
- Fan/low pressure (LP)/high pressure (HP) vibration
- Fuel information
- Flap/slat/spoiler configuration
- Roll, pitch, and yaw trim display
- Cabin pressurization information
- Auxiliary power unit (APU), exhaust gas temperature (EGT), and revolutions per minute (RPM) display
- Landing gear/autobrake status.

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CONTROLLERS

The main controllers installed are the guidance panel (GP), display controller (DC), multifunction control and display unit (MCDU), and the cursor control device (CCD).

Guidance Panel

The guidance panel, shown in Figure 2-12, engages the flight director, autopilot, and autothrottle systems. The GP is also used for selecting the operating modes, coupled-side source of navigation, heading data for the FGCS, FPA vertical speed control, and autothrottle speed control.

Figure 2-12
Guidance Panel

The FGCS functions controlled by the guidance panel include:

- Flight director modes
- Vertical speed and vertical references
- Engaging the autopilot and autothrottle functions
- Selecting left or right PFD HSI as the source of flight information for the FGCS.

The guidance panel is described in detail in Section 3, Controllers.

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PFD Control Panel

Each crewmember independently selects information for their respective PFD using their PFD controller located on the left and right sides of the guidance panel, shown in Figure 2-13.

Figure 2-13
PFD Control Panel on Guidance Panel

The left display controller is used to control information on the pilot's PFD. The right display controller is used to control information on the copilot's PFD.

The PFD Control Panel is described in Section 3, Controllers.

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Multifunction Control and Display Unit (MCDU)

The MCDU is an active-matrix liquid crystal display (AMLCD) showing pertinent aircraft subsystem information. The MCDU also displays flight, navigation, and aircraft-related information to the flight crew. The MCDU is also a source for the crew to control a host of aircraft functions.

The MCDU is the input source for alphanumeric data to various aircraft subsystems through the keyboard. The MCDU also gives numeric inputs to aircraft subsystems (such as radio tuning) with the entry knob. Each aircraft subsystem connected to the MCDU has its own functional page, which is described in the corresponding subsystem sections of this guide.

Figure 2-14 shows the MCDU front panel.

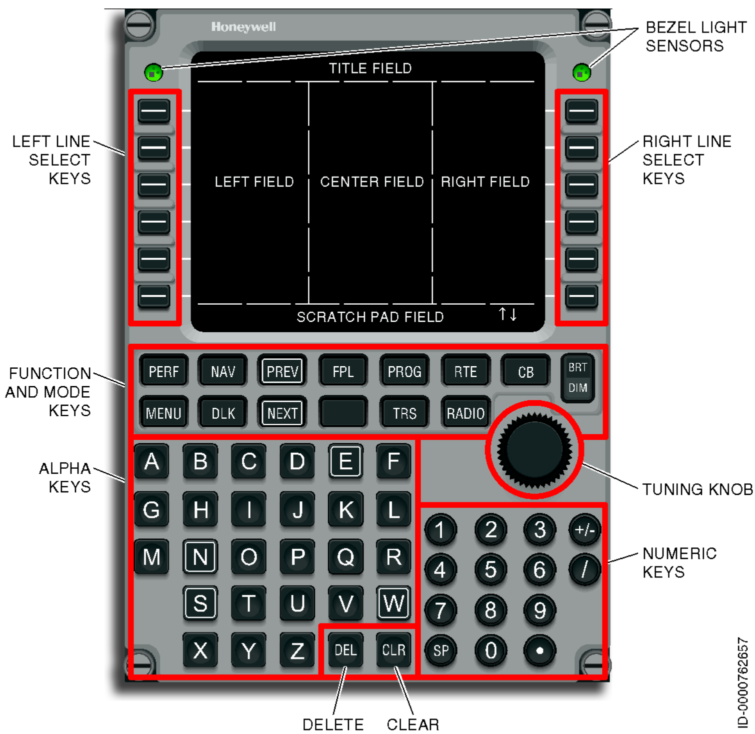

Figure 2-14
MCDU Front Panel

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The MCDU contains:

- Color display
- Keyboard
- Line select keys (LSK)
- Special function keys
- Alphanumeric keys
- BRT/DIM (bright/dim) rocker switch
- Bezel light sensors
- Panel illumination
- Data entry knob.

The MCDU display has 14 lines of display with 24 characters per line. The top line (line 1) of the display is the title line. The bottom line (line 14) of the display is the scratchpad for entering data using the keyboard. The remaining lines show data.

The keyboard is the primary user interface to the MCDU and contains the data entry keys and knobs for the pilot to:

- Select an aircraft subsystem
- Display aircraft subsystem data
- Enter data
- Control the selected aircraft subsystem.

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Up to 13 function keys are installed on the MCDU keyboard to accommodate special functions for different avionics subsystems (e.g., flight management system). Some of the function keys are designated special function keys (e.g., MENU, PREV, NEXT). The remaining function keys choose specific avionics functions (e.g., NAV, RADIO, FPL, RTE). Pushing these function keys shows the avionics functional page. Figure 2-15 shows the function key layout for the MCDU installed on the Embraer E-Jet E-2 E190/E195-E2 series aircraft.

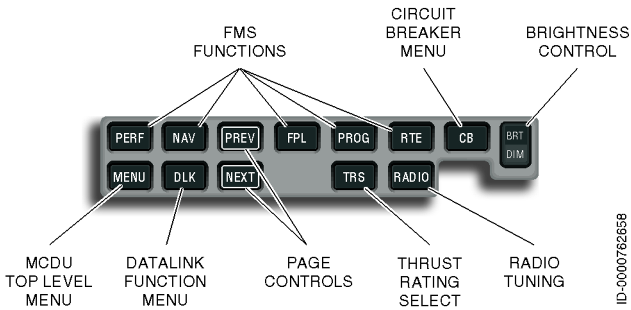

Figure 2-15
MCDU Function Keys

The MCDU has 12 LSKs, six on each side of the display. When the MCDU main menu is displayed, the LSKs are used for selecting aircraft subsystems that are interfaced with the MCDU. Specific avionics subsystem modes are selected by the LSKs when an avionics subsystem is active and being displayed. The LSKs are also used to enter scratchpad data into specific data fields.

The MCDU panel illumination is integrated with and powered by the panel light dimmer bus. The MCDU uses automatic brightness control to maintain display readability in various ambient light conditions. The manual brightness is controlled by the keyboard BRT/DIM rocker switch that sets the display brightness to 1 of 21 predetermined brightness levels. Two bezel light sensors detect changes in the ambient light. These bezel light sensors automatically control brightness in conjunction with the manual setting to ensure the display is readable in dim light.

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MCDU PAGE DISPLAYS

The top line (line 1) of the display is the title and page number. The bottom line (line 14) of the display is the scratchpad. The remaining lines show data. In general, the display is divided into areas, as shown in Figure 2-16. MCDU subsystem pages, the use, and control are described in the subsystem sections of this guide.

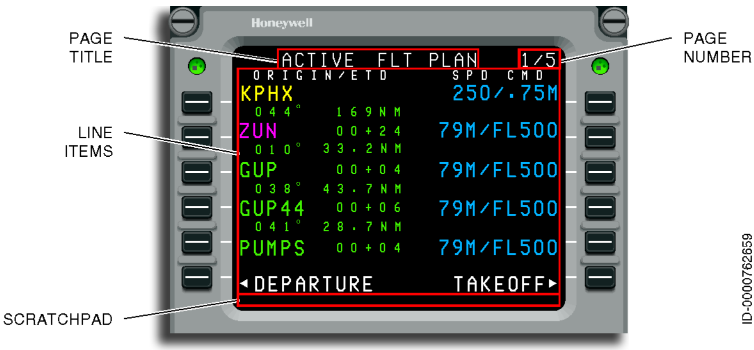

Figure 2-16
MCDU Page Layout

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Cursor Control Device (CCD)

Screen prompts, in the Primus Epic system, indicate when CCD action is required. The CCD, shown in Figure 2-17, is used to make menu selections and controls displayed items. There are two CCDs, one for each pilot, located on the center pedestal. Three buttons along the front edge are used for selecting the display to be controlled. The touchpad moves the screen cursor. The pilot can move to a specific location on the DU by quickly double-tapping the corresponding area on the touchpad. There are six double-tapping locations on the touchpad: the four corners, top-middle, and bottom-middle.

Two **ENTER** buttons, one on each side of the unit, are used to initiate action. Stacked concentric dual knobs, located in front of the screen selection buttons, are used to scroll through lists, make selections, or change items such as radio frequencies.

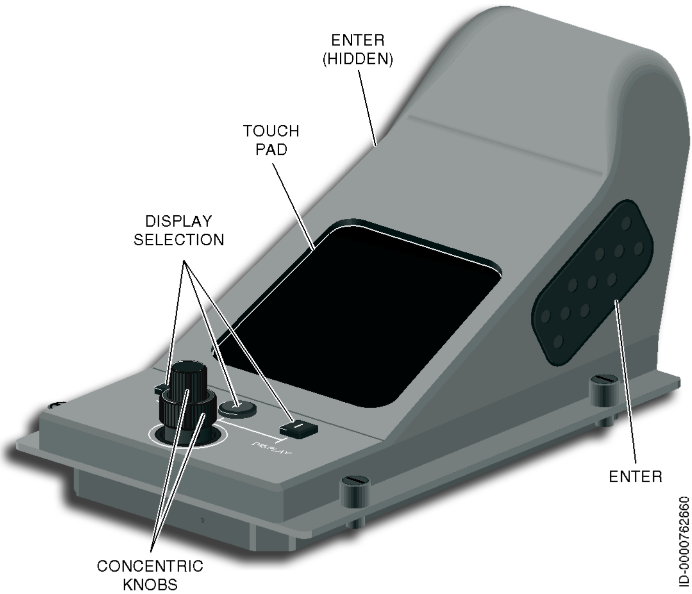

Figure 2-17
Cursor Control Device

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NAVIGATION FUNCTIONS AND FEATURES

The following navigation features are incorporated into the flight deck.

Flight Management System (FMS)

The FMS is an integrated system providing data for the cockpit displays and flight control system (FCS). The FMS serves as an aid to performance, flight planning, navigation, database, and redundancy management.

The FMS is a baseline system in the Embraer aircraft. The standard baseline configuration is a dual FMS system.

The FMS is used to complete flight planning activities, including predictions of fuel and time. Once programmed, the FMS gives control outputs to the autopilot system to fly the aircraft along the planned route, both laterally and vertically. The FMS also provides the electronic displays system (EDS) with the flight plan and status information for display.

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A block diagram of the FMS is shown in Figure 2-18.

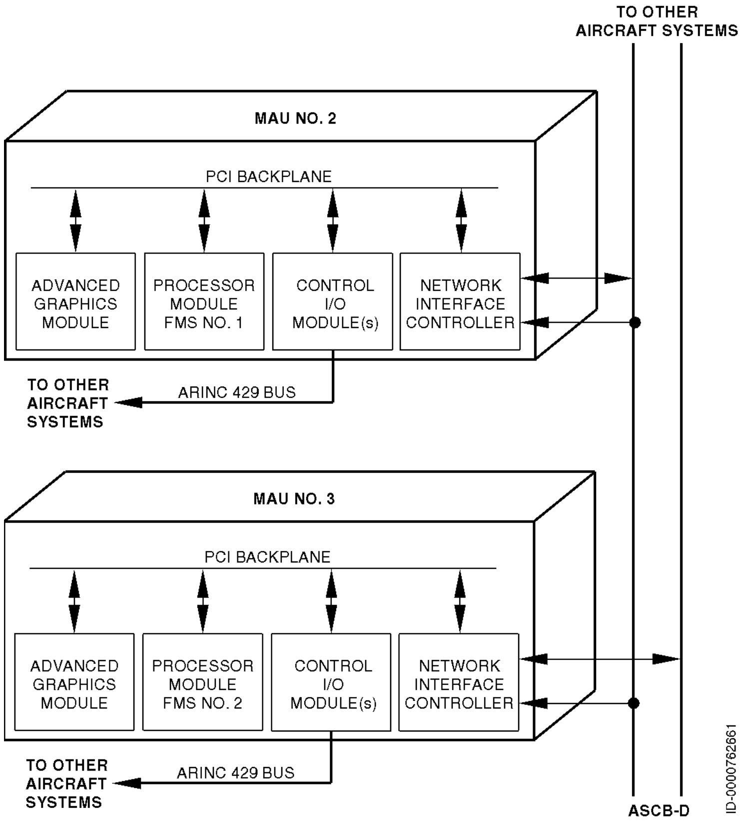

Figure 2-18
FMS Block Diagram

The FMS software is hosted on a processor module running the digital engine operating system (DEOS) within an MAU and interfaces with the following hardware components:

- Two independent MAU-based FMS applications running on separate processor cards in different MAUs. The FMS operates through the NG-NIC in MAU 2 and MAU 3.
- Copies of the FMS application software, navigation database, custom database, company route database, and learned performance information are stored separately in the DB area.
- An MAU-based I/O module interfaces to external systems, including the MCDU.

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- An MAU-based NG-NIC gives the FMS software application access to and from the ASCB and subsequently to the external I/O system.
- Two cockpit-installed MCDUs give pilots access to the FMS software application. (FMS page displays are described in the FMS pilot's guide, Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide, Pub. No. D202012001536).
- A dataloader updates associated FMS application software, as well as FMS databases. The loader is supported by the OMS.
- An aircraft personality module (APM) is used to configure the FMS options given to the user. The components of the FMS receive power from the following sources:
  - The FMS 1 function resides on the processor module in MAU 2 and receives power from DC bus 1.
  - The FMS 2 function resides on the processor module in MAU 3 and receives power from ESS bus 2.

Radio Navigation

Radio navigation functions, including VOR, ADF, DME, ILS, GLS, and Mode S transponder, are located in the MRCs with line replaceable modules. The system is controlled with the MCDUs and audio panels.

The baseline configuration of the modular radio cabinets is as follows:

- Modular radio cabinet number 1 contains the modules that follow:
  - NIM
  - VOR/ILS datalink (VIDL) navigation module
  - DME module
  - VDR communication module
  - Mode S diversity transponder module
  - ADF module.

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- Modular radio cabinet number 2 contains the modules that follow:
  - NIM
  - VIDL navigation module
  - DME module
  - VDR communication module
  - Mode S diversity transponder module
  - ADF Module.

Global Positioning System (GPS)

The GPS sensor module resides in the MRC on the VIDL-G and connects with an active antenna system. The GPS sensor module calculates and outputs navigation data, satellite measurement data, receiver autonomous integrity monitoring (RAIM), and predictive RAIM (PRAIM). The GPS module also manages sign status matrix (SSM) and satellite status. The module performs all built-in test equipment (BITE) functions.

The GPS module computes a pseudo-range to the satellites by timing the arrival of the GPS signal. The GPS module uses the pseudo-range to compute the internal clock offset and a three-dimensional position fix. From this data, the module creates position, velocity, time, and integrity parameters. This group of data, collectively known as the navigation block, is transmitted onto the ARINC 429 output bus. The GPS navigation data is transmitted over ARINC 429 to the FMS and IRS.

The GPS module also receives data from satellite-based augmentation system (SBAS) satellites that can be used to improve the accuracy of the basic pseudo-range measurement. SBAS corrections are used to provide improved performance during RNAV operations as well as to enable localizer performance with vertical guidance (LPV) approach capability. In addition, the GPS module can also receive data from VHF data broadcast (VDB) for ground-based augmentation systems (GBAS) to provide improved position accuracy and guidance for GBAS landing system (GLS) approaches.

The GPS module provides a time mark timing output. The GPS module uses 24 channels, each capable of tracking NAVSTAR GPS satellite signals or SBAS satellite signals.

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The GPS module uses seven operating modes and one non-operational mode. The module switches modes automatically. The operational modes are as follows:

- Self-test
- Initialization
- Acquisition
- Navigation
- SBAS navigation
- GBAS navigation
- Altitude aiding
- Aided
- Fault.

The non-operational mode is dataload.

The GPS module receiver uses the commercial access (C/A) code of the NAVSTAR GPS satellite constellation. The GPS module receiver operates when the system is either selectively available (SA) or when deactivated.

The GPS module executes a RAIM test in order to ensure the integrity of the data transmitted by the device. RAIM is a software function. RAIM gives a timely alert to the system and to the pilot for when the GPS module outputs are adequate or not adequate for navigation.

PRAIM calculates the estimated value of the high integrity limit at some future place and time. The GPS module supplies the following types of RAIM predictions:

- Destination
- Alternate waypoint.

The destination and alternate waypoint predictions are predictions at a specific location and estimated time of arrival (ETA). The FMS requests the predictions for flight planning purposes. Satellites are manually deselected or enabled for these destination and alternate waypoint predictions.

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Radar Altimeter

The radar altimeter system is a baseline system onboard the Embraer aircraft. A second radar altimeter system is an option.

The radar altimeter system supplies the pilots with dependable, accurate altitude, -20 to +2,500 feet above ground level (AGL). The system supplies this information during the approach and landing phases of aircraft operation. The radar altitude is displayed on the pilot and copilot PFDs. Each radar altimeter system consists of a receiver/transmitter mounted in a tray, a configuration module, a receive antenna, and a transmit antenna.

Micro Inertial Reference System (IRS)

Two IRSs are baseline systems onboard the aircraft. The main component of the IRS is the micro inertial reference unit (IRU).

The IRS gives dependable, accurate attitude, heading, and position information to aid in navigation. The inertial reference (IR) component of the micro IRU contains three force rebalance accelerometers and three-ring laser gyros. The accelerometers measure linear motion along the longitudinal, lateral, and vertical axes. The ring laser gyros measure angular motion along the longitudinal, lateral, and vertical axes. These sensors, coupled with high-speed microprocessors, let the IRUs maintain a stable platform mathematically rather than mechanically.

Air Data System (ADS)

The traditional air data computer (ADC) installed in most aircraft today is primarily a sensor unit. The traditional ADC supplies other systems on the aircraft with specific information derived from sensor inputs. The traditional ADC contains internal air pressure sensors measuring static and total pressure outside the aircraft. The ADC external sensor interfaces include the total air temperature (TAT) probe, barometric (BARO) correction setting, and discrete information.

The Primus Epic system has the pressure-sensing elements of the traditional ADC remotely mounted and is self-contained in the air data smart probes (ADSP). The ADSPs sense and transmit static and total pressure to the air data application (ADA) hosted on a DEOS platform. The ADA also receives the other traditional external sensor interfaces. The ADS for the Primus Epic consists of the ADSPs, TAT probe, and BARO settings, in conjunction with the ADA.

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Weather Radar

The Primus 880 weather radar system is a baseline system onboard the aircraft. The RDR-4000 weather radar system is offered as an option. The Primus 880 weather radar (WX) is a lightweight, X-Band, color digital radar displaying weather location and intensity, as well as ground mapping. The RDR-4000 IntuVue (option) is a 3-D automatic weather radar system with forward-looking windshear detection. The RDR-4000 is an airborne, solid state, X-Band weather radar system.

The function of the RDR-4000 is to increase situational awareness of weather by detecting and annunciating hazardous weather conditions, such as heavy precipitation, turbulence, and windshear. The MFDs show radar data and have dropdown menus that control the WX. WX data can be displayed on both of the MFDs and PFDs.

Traffic Alert and Collision Avoidance System (TCAS)

The TCAS is an independent airborne warning system. TCAS consists of the following:

- Two aircraft-mounted antennas
- TCAS computer unit
- Mode S diversity transponder
- Cockpit displays and controls.

The TCAS displays range, altitude, and bearing of other aircraft (using ICAO standard transponders) with respect to the location of the equipped aircraft. TCAS monitors the trajectory of these aircraft for the purpose of collision avoidance.

Enhanced Ground Proximity Warning System (EGPWS)

The EGPWS software is hosted on a processor module running the digital engine operating system (DEOS) within the MAU. The enhanced ground proximity warning system (EGPWS) is used to prevent controlled flight into terrain (CFIT) or severe windshear. This includes implementation of Modes 1 through 5 functions and optional Bank Angle and Runway Awareness and Advisory System (RAAS) or SmartRunway/SmartLanding functions.

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DIGITAL VOICE DATA RECORDER (DVDR)

The DVDR system combines a flight data recorder (FDR), a cockpit voice recorder (CVR), and a datalink recorder (DLR) into a single DVDR unit. Two DVDR units are installed in the aircraft. DVDR1 is located in the forward avionics bay, and DVDR2 is located in the aft avionics bay. DVDR1 includes the recorder independent power supply (RIPS), which provides 10 minutes of operation after loss of aircraft power. Each DVDR unit is a solid-state recording device that receives, records, and preserves all required data parameters and voice recordings from the crew and area microphones.

MAINTENANCE SYSTEM

The central maintenance system termed onboard maintenance system (OMS) is hosted on the central maintenance computer (CMC) module and is installed in an MAU, which provides access through the backplane to all data produced by modules in the system. The backplane includes all I/O and all data produced by units connected to the ASCB.

The aircraft diagnostic and maintenance system (ADMS) is part of the central maintenance computer (CMC) system.

The OMS is the central resource for collecting fault and parametric data as it occurs during flight. The CMC provides the analysis and recording functions for all member systems, allowing for complete, nose-to-tail aircraft coverage. The CMC supports the maintenance process for aircraft as well, reducing the amount of ground support equipment required to build the aircraft.

The OMS has operating modes to:

- View fault histories
- Download fault data
- Run line replaceable unit (LRU) tests
- Display real-time data.

A modifiable database is used for updating or changing the maintenance information for any member system.

The OMS is powered and functional in flight, but LRU tests and full OMS functionality are only available when the aircraft is on the ground.

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3. Controllers

INTRODUCTION

This section describes the system components and primary controllers associated with the Primus Epic 2 system.

Several components are used to control and interface with the Primus Epic system. The following list gives a brief description of the primary controllers for the Primus Epic system and in what sections the detailed description is found.

- **Cursor Control Device (CCD)** – The CCD controls the cursor position and selects the display configuration. The CCD is described in detail, starting on page 3-2.
- **Multifunction Control and Display Unit (MCDU)** – The MCDU is the primary interface for entering alphanumerical data into various systems using the MCDU as an input device. The radio tuning functions of the MCDU are described in Section 13, Radio System. The flight management system (FMS) functions are described in the NG FMS pilot's guide, Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide, Pub. No. D202012001536.
- **Guidance Panel** – The guidance panel controls flight director and autopilot functions, as described in detail starting on page 3-9.
- **Display Controllers** – The display controllers are used to show various functions on the primary flight display (PFD) and multifunction display (MFD), as described in this section.
- **Digital Audio Panel** – The digital audio panel is used to select radio transmitters and control the radio system audio, as described in Section 13, Radio System.
- **Weather Radar (WX) Controller** – The WX controller is a virtual controller window on the MFD. It controls the weather radar and its functions, such as range and mode, as described in Section 18. Weather Radar Systems.
- **Reversionary Panels** – The reversionary panels are used to control air data system (ADS) and inertial reference system (IRS) reversions, as described in detail starting on page 3-29.

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- **Dimming Control Panels** – The dimming control panels are located on the left and right glareshields and are described starting on page 3-34.
- **Inhibit Panel** – The inhibit panel is used to inhibit various annunciations under specific circumstances, as described starting on page 3-32.
- **T/O Configuration Button** – This button is located on the center pedestal and is described starting on page 3-35.
- **EICAS Declutter Button** – The engine indication and crew alerting system (EICAS) declutter button is located on the pedestal and is described starting on page 3-36.

CURSOR CONTROL DEVICE (CCD)

Each pilot has a CCD, shown in Figure 3-1, that is used for the following:

- Display selection
- Primary flight display (PFD) range, radio tuning, and attribute selection
- Crew alerting system (CAS) message scrolling
- MAP graphical radio tuning, range control, panning, virtual control, and displayed menu controls
- Graphical flight planning
- Button selection and scrolling on various 1/4, 1/2, 3/4, and full window formats.

Prompts are shown on the display screen in the selected area to indicate the action available to the pilot. For instance, when a curled-arrow prompt is displayed, the cursor-selected content can be changed using the concentric knobs on the CCD. In this guide, prompts are explained where used.

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CCD controls are described in the following paragraphs. Figure 3-1 shows the location and identity of the functions described.

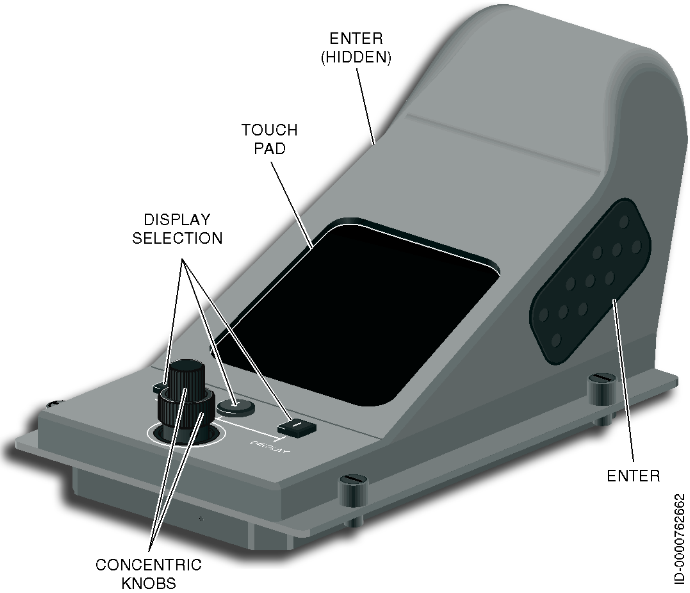

Figure 3-1
Cursor Control Device (CCD)

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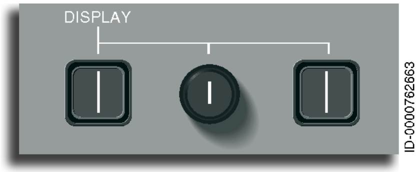

Display Selection Buttons – The three display selection buttons located on the CCD are used to select the corresponding display unit. Display screen selection is different for the left (pilot's) and right (copilot's) CCDs. The buttons correspond to the physical position of the displays in front of the pilot or copilot, as shown in Figure 3-2.

The CCD on the pilot's side is used to select displays DU1, DU2, and DU3. The CCD on the copilot's side is used to select displays DU2, DU3, and DU4. The selection reference does not change when in display reversion mode.

The buttons are selected by the physical position of the display screen, not the function. The DU2 and DU3 displays can be selected with either CCD. However, both CCDs cannot be used to control one DU at the same time. When a display is selected, the CCD cursor appears on the selected display window format.

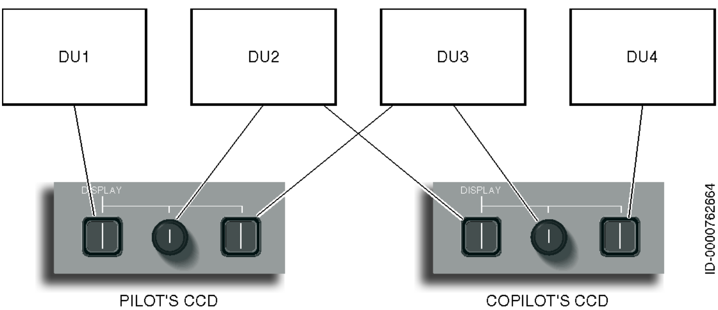

Figure 3-2
CCD Display Control

Touchpad – The touchpad moves the cursor on the selected display. The cursor on the screen moves with the finger movement on the pad.

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Concentric Rotary Knobs – The two stacked concentric knobs, shown in Figure 3-3, are used to scroll through lists or make selections, such as radio frequencies. Prompts on the display indicate which knob to use.

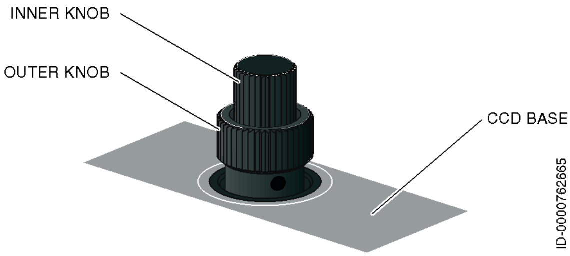

Figure 3-3
Concentric Knobs

ENTER Buttons – The two **ENTER** buttons, located on either side of the CCD, are used to initiate an action. The buttons function the same way as the **ENTER** button on any computer.

CURSOR MOVEMENT

CCD cursor movement is restricted depending on the format being used. Non-floating formats restrict the cursor movement to specific areas where the crew can make selections by pushing the CCD **ENTER** buttons. Floating formats allow the cursor to move freely over the selected format.

Cursor movements are constrained to the buttons, menus, and boxes for:

- Classic map format
- Synoptic formats
- EICAS format
- PFD format.

A floating cursor is allowed on the INAV Map/Plan, Chart, VSD, ECL, TCAS, Weather Controller, Maintenance Tool Page (and related Maint subpages), and SCMS.

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CURSOR MOVEMENT WITHIN MULTIPLE FORMATS

A maximum of two formats can be used at a time on a single DU. There is a vertical separator line to define windows for the CCD boundary on a single display unit with multiple formats. Cursor focus between multiple formats changes based on pushing CCD buttons, touchpad, reversion, and inactivity on a window over a period of time.

Pushing the CCD buttons selects a format on a display and transitions the cursor box to a default position.

For two-window formats, pushing the same CCD button twice toggles between inboard and outboard windows.

In addition, when a display fails, pushing the CCD button does not transition to a failed display. Instead, the focus remains on the last display.

The CCD touchpad is used to move the cursor within formats and between formats.

A double swipe is the base movement to move the cursor from one half-screen format to the other half-screen format within a display. The movement requires two-directional drags on the touchpad to transition from one window to the other. The first drag that touches the vertical separator line stops the cursor movement on the vertical line. The second drag in the direction of the vertical separator line transitions the cursor to the next window (if the window does not have an active cursor).

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CURSOR MOVEMENT WITHIN SAME FORMAT

Sliding a finger on the CCD touchpad moves the cursor within the same format/window.

The pilot can move to a specific location on the DU by quickly double-tapping the corresponding area on the touchpad. There are six double-tapping locations on the touchpad: the four corners, top-middle, and bottom-middle. Table 3-1 lists how the CCD hot spots are mapped to the MFD menus. Table 3-2 lists how the CCD hot spots are mapped to the PFD controls.

Table 3-1
CCD Hot Spots Mapping to MFD Menus

Hot Spot	MFD (Non-Chart)/ Non-EICAS/ Non-PFD)	EICAS	CHART
Top Left	Map	Map	Arpt
Top Middle	Plan	Plan	Appr
Top Right	System	System	Menu
Bottom Left	TCAS	N/A	N/A
Bottom Center	Weather	N/A	N/A
Bottom Right	Checklist	N/A	N/A

Table 3-2
CCD Hot Corner Mapping to PFD Controls

Hot Corner	PFD
Left	Radio1
Middle	Range and Tilt control if available
Right	Radio2

Panning – The pilot can use the CCD to enable panning in Map/Plan/Charts lateral displays by placing the cursor focus on the lateral display, pushing the **ENTER** button, and selecting the PAN option from the Task menu.

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CCD Knob Movements – The CCD knob is specific to the control item selected within a specific format. For example, some control items may use the knob to fine-tune numeric values on the radio or scroll through CAS messages.

CCD CURSOR FOCUS AND DISPLAY

There are two different cursors—the pilot-side cursor and the copilot-side cursor. The pilot-side cursor is a white **+** symbol, while the copilot-side cursor is a white **X** symbol, as shown in Figure 3-4.

Figure 3-4
On-Side Pilot and Copilot Cursors

These cursors have a semi-transparent circular background when both cursors are on the same display, as shown in Figure 3-5.

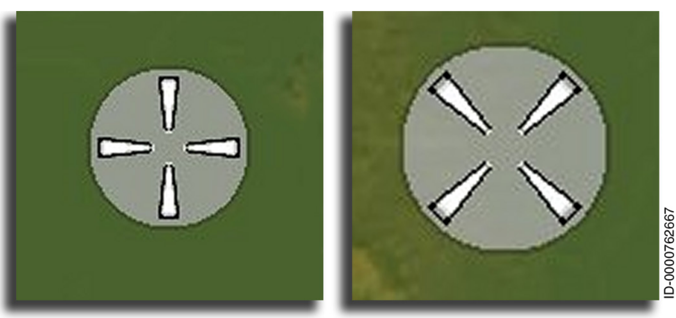

Figure 3-5
Off-Side Pilot and Copilot Cursors

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CURSOR-FOCUS RULES WHEN IN A DISPLAY WINDOW

Only one cursor can occupy a window at a time. The rules defining cursor operation are as follows:

- **Active Cursor** – A cursor that is currently in use in a window.
- **Inactive Cursor** – A cursor that has been idle inside a window for a period of time.
- **Invading Cursor** – A cursor that is attempting to enter a window. An invading cursor can kick out an inactive cursor but cannot kick out an active cursor.

Guidance Panel (GP)

The guidance panel, shown in Figure 3-6, is mounted in the center of the aircraft glareshield. The guidance panel contains two PFD controllers, one on each side.

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Figure 3-6
Guidance Panel

The individual parts of the guidance panel are described in the following paragraphs.

ID-762669

Flight Director (FD) Button – Flight director command cues are displayed automatically on the PFD when any lateral or vertical FD mode is selected. The **FD** button is used to turn the flight directors off. The various conditions in which the flight directors can be turned off are described in the following paragraphs.

The flight director on the coupled side cannot be removed while the autopilot is engaged. Pushing the **FD** button when the PFD is uncoupled removes the flight director, but the active mode FD modes are retained.

When either **FD** button is pushed when the autopilot is not engaged, the FD modes are canceled, and the FD modes and command cues are removed from both PFDs.

Flight director command cues are always displayed on both PFDs, and cannot be removed when go-around (GA), takeoff (T/O), windshear (WSHR), or dual-coupled approach modes (APPR2 and AUTOLAND1) are active.

ID-0000762670

Course (CRS) Knob – The CRS knob is used to select the desired course when in VOR/ILS/GLS navigation (the FMS navigation source automatically selects the proper course).

Turning the CRS knob clockwise increases the value of the associated course target in increments of 1-degree per click.

Turning the CRS knob counterclockwise decreases the value of the associated course target by 1-degree per click.

Pushing the **CRS** button (**PUSH DIR**) while navigating with a VOR/ILS/GLS source synchronizes the course pointer to point directly to the active VOR station.

ID-762671

Autothrottle (A/T) Button – The **A/T** button is used to arm, engage, or disengage the autothrottle system. When the system is engaged, AT is displayed in the flight mode annunciators (FMA) field.

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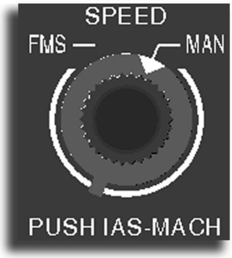
Pushing either of the **A/T** buttons on the engine thrust control levers disconnects the autothrottle system.



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Airspeed (SPEED) Knob – The FMS/MAN knob toggles between FMS or manual speed references.

To manually set the speed reference, the switch must be rotated to the MAN position. Rotating the SPEED knob sets the manual airspeed reference on the airspeed tape of each PFD.

Pushing the SPEED knob activates the PUSH IAS-MACH function. The speed bug setting is changed from calibrated airspeed to Mach or from Mach to calibrated airspeed.

ID-762673

Lateral Navigation (LNAV) Button – Pushing the **LNAV** button arms, captures, or tracks the lateral NAV mode associated with the displayed NAV source.

ID-762674

BANK Button – The high/low bank feature automatically or manually changes the bank angle limits used by the heading select mode. When the **BANK** button is pushed, the guidance system reduces bank angle from high to low when in the HDG mode. During a climb, the bank angle limit switches from 27 to 17 degrees automatically above 25,000 feet mean sea level (MSL). During descent, low bank limit switches to 27 degrees automatically below 25,000 MSL.

During low bank, a bank limit arc (eyebrow) is displayed on the ADI.

ID-762675

Heading (HDG) Button – The **HDG** button commands the flight guidance system to capture the heading indicated by the heading bug on the HSI. While in the heading mode, a lower bank limit is selected with the **BANK** button on the guidance panel. HDG is annunciated on the PFD mode field.

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Heading Select (HDG SEL) Knob – The HDG SEL knob controls the position of the heading bug on the horizontal situation indicator (HSI) on the PFDs and sets the heading bugs on both PFDs and both MFDs to the same value.

Turning the HDG SEL knob clockwise increases the value of the associated heading target in increments of 1-degree/click.

Turning the HDG SEL knob counterclockwise decreases the value of the associated heading target in increments of 1-degree/click.

Pushing the **HDG SEL** button (**PUSH SYNC**) sets the heading bugs to the current aircraft heading.

AUTOPILOT Button – The **AUTOPILOT** button engages and disengages the autopilot. For normal operations, the autopilot cannot be engaged on the ground or below shaker speed.

The active PFD source for the FD guidance is annunciated by the green arrow on the PFD.

The autopilot cannot remain engaged without any flight director guidance modes active. When no vertical or lateral modes are active and the autopilot is requested to engage, the FPA and ROLL basic FD modes are engaged.

The normal method to disengage the autopilot is to momentarily push the **AP DISC** (disconnect) button located on each control yoke. The autopilot can also be disengaged by any of the following actions:

- Pushing the **AUTOPILOT** button on the guidance panel
- Operating the pilot or copilot stabilizer manual trim switches
- Manually overpowering the control column.

NOTE: The autopilot is automatically disengaged when the stick shaker activates.

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The autopilot is temporarily disengaged by pushing and holding the touch control steering (**TCS**) button on either control wheel. Releasing the **TCS** button re-engages the autopilot servos.

Source (SRC) Button – At power-up, the guidance data for the FDs comes from the pilot's PFD, and the green arrow displayed on the FMA (←) points to the left. Pushing the **SRC** button toggles between the copilot's (right) PFD and the pilot's (left) PFD. Each push of the **SRC** button cancels all selected FD modes dropping to FD basic modes (ROLL/FPA) and toggles the coupled PFD arrow between the left and right sides.

Approach (APPR) Button – Pushing the **APPR** button arms the lateral and vertical approach modes based on the NAV source displayed on the selected PFD. LOC/GS or BC is displayed for the instrument landing system (ILS) and GLS approach. Glideslope capture is inhibited until the localizer is captured.

Glide path (GP) mode can also be armed. When glide path mode is armed, GP is annunciated in the PFD mode field.

NOTE: For GP mode to arm, FMS must be the NAV source, and LNAV must be engaged.

In APPR mode, the flight guidance control system (FGCS) tracks the lateral and vertical flight profiles supplied by the GLS, ILS, localizer, or vertical glide path (GP). The correct approach mode is annunciated on the PFD mode field.

Vertical Navigation (VNAV) Button – Pushing the **VNAV** button arms the VNAV modes of the flight director. In VNAV mode, the flight director responds to mode requests and altitude targets supplied by the FMS. The VNAV modes are:

- Vertical navigation flight level change (VFLCH)
- Vertical navigation flight path (PTH)
- Vertical altitude select (VASEL)
- Vertical navigation altitude hold (VALT).

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In VNAV mode, the FGCS tracks the vertical flight profile supplied by the FMS. The proper mode is shown on the PFD mode field.

ID-762681

Flight Level Change (FLCH) Button – Pushing the **FLCH** button selects the flight level change vertical mode. The FLCH mode controls pitch to achieve the active altitude target displayed on the PFD. That altitude target is manually set or supplied by the FMS and is displayed in feet or meters. FLCH (or VFLCH when in VNAV) is annunciated on the PFD mode field.

ID-762682

Altitude (ALT) Button – When the **ALT** button is pushed, the system is commanded to hold the altitude at the time the button was pushed. ALT is annunciated on the PFD mode field.

ID-0000762683

Altitude Select (ALT SEL) Knob – The ALT SEL knob is used to set the preselected altitude reference for the flight director or the FMS for automatic altitude capture.

The ALT SEL knob sets the barometric altitude reference on each PFD altitude tape. The selected altitude is used for the altitude preselect and altitude alert functions. Rotating the outer knob clockwise (CW) increases the preselect value in 1,000-foot increments. Rotating the outer knob counterclockwise (CCW) decreases the value in 1,000-foot increments.

Rotating the inner knob clockwise increases the preselect value in 100-foot increments. Rotating the inner knob counterclockwise decreases the preselect value in 100-foot increments.

Pushing the ALT SEL knob (**PUSH FT-M**) turns on/off the digital meters indication. Rotating the outer knob increases/decreases the value in 500-meter increments. Rotating the inner knob increases/decreases the value in 50-meter increments.

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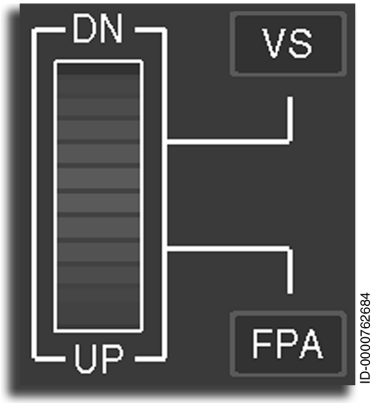

Vertical Speed (VS) and Flight Path Angle (FPA) Button and Thumbwheel – Pushing the **FPA** button activates the FPA vertical mode and deactivates the VS bug on the PFD. When FPA is the active vertical mode, rotating the thumbwheel adjusts the FPA reference line.

Rotating the thumbwheel downward increases the FPA target in 0.1-degree increments. Rotating the thumbwheel upward decreases the FPA target in 0.1-degree increments.

Pushing the **VS** button activates the VS vertical mode, activates the VS target, and deactivates the FPA line on the PFD.

Rotating the thumbwheel downward increases the VS target. Rotating the thumbwheel upward decreases the VS target.

When VS vertical mode is active and the absolute VS target is below 1,000 feet per minute, rotating the thumbwheel adjusts the VS target bug in increments of 50-feet per minute.

When VS vertical mode is active and the absolute VS target is at or above 1,000 feet per minute, rotating the thumbwheel adjusts the VS target bug in increments of 100-feet per minute.

VS is annunciated on the PFD mode field of the ADI.

OTHER COCKPIT CONTROLS

- **Autopilot Disconnect (AP DISC)** – The **AP DISC** buttons are located on the control yokes. Pushing the **AP DISC** button disconnects the autopilot. An audio alarm sounds, and the AP annunciator on the PFD flashes. Pushing the button again silences the audio alarm and removes the flashing AP annunciator.

NOTE: Operating the manual trim switches also disengages the autopilot but leaves the yaw damper engaged.

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- **Back Course (BC) Mode** – Pushing the **LNAV** or **APPR** button when the aircraft heading is more than 100 degrees off the localizer front course heading automatically arms the BC mode. BC is annunciated on the PFD mode field.

  In BC mode, the FD automatically reverses the polarity of the course error and localizer signals. Back course gain programming is also used because the aircraft is closer to the localizer antenna by the length of the runway plus 1,000 feet.

- **Go-Around (GA) Mode** – Pushing the **TOGA** button on either throttle engages the go-around mode of the FD when the aircraft is airborne. GA is annunciated on the PFD mode field.

- **Takeoff (TO) Mode** – Pushing the **TOGA** button on either throttle arms the takeoff mode of the FD when the aircraft is on the ground. TO is annunciated on the PFD mode field.

- **Touch Control Steering (TCS) Button** – The **TCS** button is located on the control yoke. Pushing and holding the **TCS** button temporarily disengages the servo clutches, permitting the pilot to maneuver the aircraft with the control yoke. Releasing the **TCS** button re-engages the servo clutches, and autopilot resumes control of the aircraft. The command bar synchronizes to the current vertical mode value selected and resumes guidance to the lateral mode previously selected. While the **TCS** button is pushed, TCS is annunciated on the PFD mode field.

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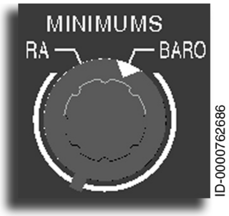
PFD Control Panel

There are two PFD control panels, one on each side of the guidance panel. The PFD control panels are used by the pilot and copilot to independently select information on their respective PFDs. Figure 3-7 shows one of the PFD control panels.

Figure 3-7
PFD Control Panel



MINIMUMS Knob – The RA/BARO outer ring switch is used to select radio altitude (RA) or barometric altitude (BARO) as the minimums altitude source. The radio altitude comes from the radio altitude system, and the barometric altitude comes from the air data system. This value is displayed in a small window in the lower right of the ADI.

Rotating the inner knob clockwise increases the value. Rotating the inner knob counterclockwise decreases the value. Slow rotation of the inner knob gives precise setting of the data (one-click = 10 feet), while rapid rotation changes the data at a faster rate (one-click = 100 feet).

Table 3-3 lists the DH and MDA set range of the inner control knob.

Table 3-3
DH and MDA Set Range

Parameter Outer Knob	Range Inner Knob
RA Set Range	0 to 990 feet AGL
Baro Set Range	0 to 16,000 feet MSL

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> *NOTE: When the pilot rotates the value past the maximum setting, **OFF** is displayed for 5 seconds. The display is then removed from the PFD.*

When RA MIN is not in view, and the RA/BARO switch is in the RA position, the following items are active:

- Cutout box
- Format
- Range
- Resolution.

When the MINIMUMS knob is rotated one-click in either direction, the initialization value is displayed.

Horizontal Situation Indicator (HSI) Button – The **HSI** button lets the pilot select a full compass display (360 degrees), an arc compass display (±45 degrees, centered on the nose of the aircraft), or arc with map. The map display places the next one to four FMS waypoints and course lines on the HSI display.

The **HSI** button sequence is:

Full compass → Arc compass → Arc with map → (repeat)

Bearing (BRG) Buttons – The PFD can show two independent bearing pointers on the HSI located on the lower portion of the PFD display. The pointers are connected to a navigation source by toggling the respective ○ or ◊ BRG button to the desired selection. The HSI bearing pointers also use the ○ or ◊ symbols for identification.

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Table 3-4 lists the selectable bearing sources for each pointer. The source is displayed on the on-side PFD on the left edge of the HSI.

Table 3-4
Bearing Pointer Designations

BRG ◯ Button Sequence	BRG ◊ Button Sequence
OFF	OFF
VOR1	VOR2
ADF1	ADF2 (see Note 1)
FMS1	FMS2

NOTES 1. ADF 2 is selectable only when the section ADF system option is installed.
2. When FMS is not the selected on-side navigation source on the PFD, the toggling sequence does not permit FMS as a bearing pointer source.

Weather Radar (WX) Button – Pushing the **WX** button displays weather radar data on the on-side HSI (PFD) in the arc mode.

When the **WX** button is pushed, the sequence is:

Radar Data (on) → Radar Data (off) → (repeat)

Radar modes of operation are controlled by the radar menu virtual controllers on the on-side MFD.

Preview (PREV) Button – When FMS is displayed as the primary navigation source, pushing the **PREV** button gives a preview display of the VOR/LOC/GLS lateral deviation and vertical deviation. The **PREV** button also gives a preview display of the distance on the HSI for the on-side short-range navigation source. The selection sequence of the **PREV** button is as follows:

OFF → On-side VOR/LOC/GLS → Cross-side VOR/LOC/GLS → (repeat)

If FMS is not the selected navigation source, pushing the **PREV** button has no effect on the display.

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Flight Path Reference (FPR) Button – Pushing the **FPR** button toggles the on-side ADI flight path reference line and digital readout on and off when VS or FPA is not the active FD vertical mode. When VS is the active FD vertical mode, pushing the **FPR** button has no function. When FPA is the active FD vertical mode, the FPR line and digital readout are automatically displayed, so pushing the **FPR** button has no additional function. The FPR line and digital readout can be adjusted using the VS/FPA thumbwheel (previously described in this section). The flight path reference line and readout are described in detail in Section 5, Primary Flight Display (PFD).

Flight Management System (FMS) Button – Pushing the **FMS** button toggles between the on-side and off-side FMS source. The selection sequence is as follows:

On-side FMS → Cross-side FMS → (repeat)

Navigation (NAV) Button – Pushing the **NAV** button manually changes the primary navigation source to short-range navigation source.

On-side VOR/LOC/GLS → Cross-side VOR/LOC/GLS → (repeat)

NOTES:

1. *The selected NAV radio frequency selects VOR or LOC/GLS.*
2. *NAV source buttons, **NAV** and **FMS**, permit the flight crew to select VOR/LOC/GLS (short-range) navigation sources on the on-side display. Pushing either button toggles between the on-side and cross-side sources.*

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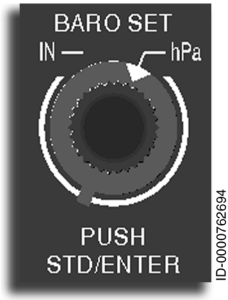

Barometric Set (BARO SET) Knob – The BARO SET knob is used to set barometric pressure information for the altitude tape. The BARO SET knob has an outer rotating knob, an inner button, and a rotary switch.

The outer rotating knob is used to preset the next altimeter value to be used. When the outer knob is rotated, a digital value is displayed in white below the altitude tape on the on-side PFD.

When the inner button is pushed, the preset altimeter value becomes the active altimeter value. When there is no preset altimeter value and the inner button is pushed, the standard barometric (29.92 inHg or 1013 hPa) is set.

The IN/hPa rotary switch beneath the BARO SET knob selects the format in inches of mercury or hectopascals.

WINDOW MANAGEMENT

The PFD is normally displayed in 3/4 format, with the CPDLC window displayed in the 1/4 format. The PFD can faildown to 50/50 (split MFD and PFD). The MFD can be displayed in 1/2 or full-size formats.

The avionics system monitors the formats displayed and automatically reverts the formats on each DU to maintain the PFD and EICAS formats for the pilot flying field of view.

The pilot monitoring may use the menu options, as described in the following paragraphs, to change the EICAS format as needed.

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MENU SELECTION

Menu button selections either change formats, drop down a menu list, retract a menu list, or act as toggles for the selectable items. Selection of a menu list item either changes format or selects a format option.

The menu buttons and menu dropdown list support the following display control format rules:

- The inboard and outboard half-screen formats cannot be the same format
- Map and plan cannot be inboard and outboard half-screen formats at the same time
- EICAS format can only be on the inboard side
- EICAS format cannot be hidden
- Primary Flight Indicators format cannot be hidden
- Map format cannot be hidden if a TAWS alert occurs
- CAS window cannot be hidden if RED or AMBER CAS messages are displayed
- Traffic overlay cannot be hidden if a traffic alert occurs.

Auto Reversion Formats – Auto-reversion of display format is enabled anytime when the system is on the ground (off battery) or when in the air. The auto-reversion configuration is shown in Figure 3-8.

Auto reversion is disabled when on the ground (on battery).

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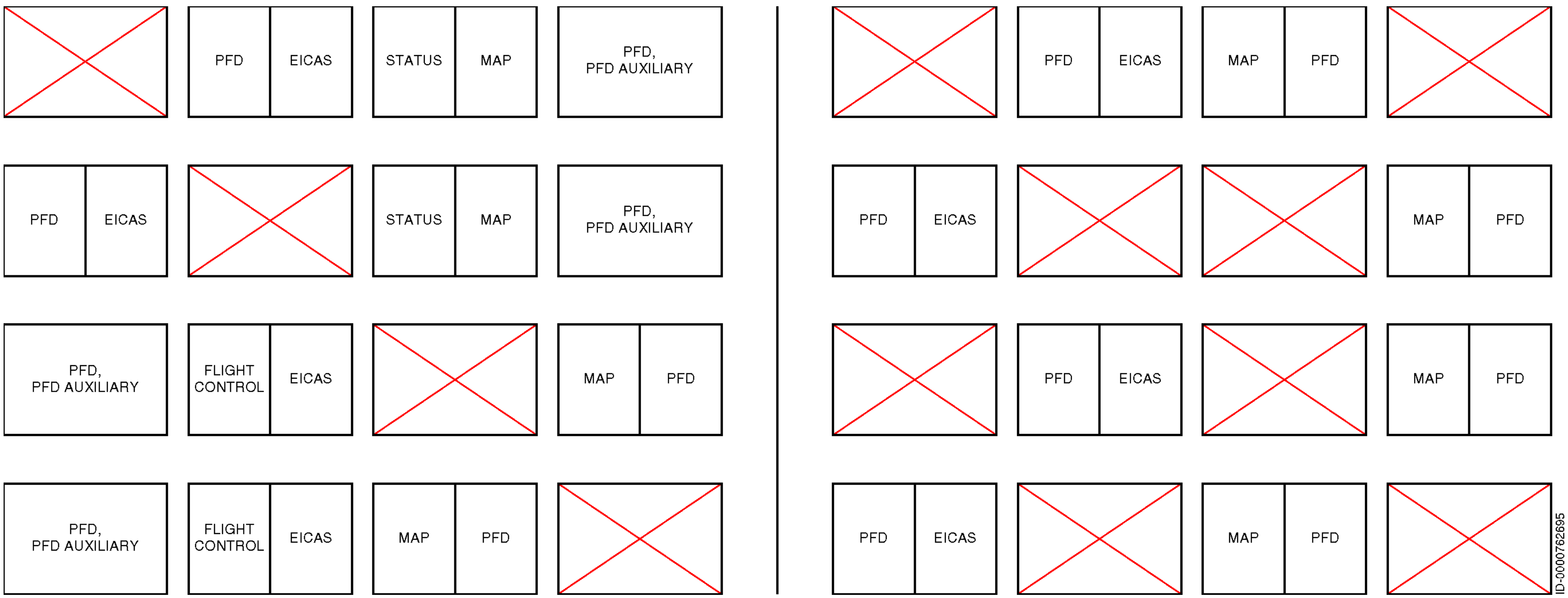


Figure 3-8
Auto Reversion Configuration

Reversionary Panel

Each pilot has a reversionary panel. The reversionary panel, shown in Figure 3-9, is used to automatically control the display reversion. It is also used to switch ADS and IRS sources.

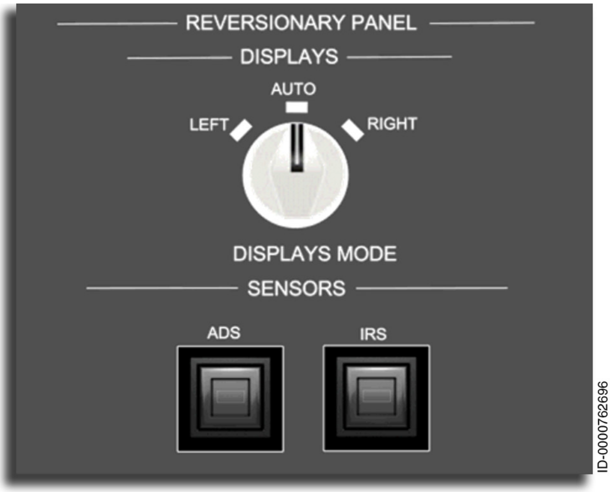
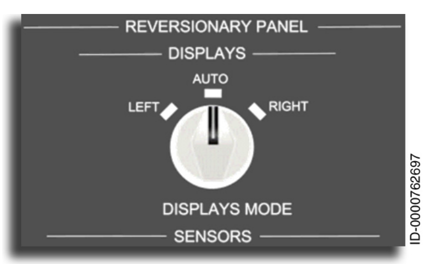


Figure 3-9
Reversionary Panel



Reversionary Switch – The reversionary switch is used to apply or remove power to DUs as follows:

- **AUTO** – Both DUs on one side (pilot or copilot) remain on. For the pilot's side, DU1 and DU2 remain on. For the copilot's side, DU3 and DU4 remain on. In this position, no manual reversion rules apply. However, the system will automatically revert certain displays or windows as required.
- **LEFT** – The left DU remains on, and the right DU is off for each side. For the pilot's side, DU1 remains on, and DU2 is off. For the copilot's side, DU4 is off, and DU3 changes to two half-screen formats.

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- **RIGHT** – The right DU remains on, and the left DU is off for each side. For the pilot's side, DU1 is off, and DU2 is on. For the copilot's side, DU3 is off, and DU4 changes to two half-screen formats.

Display format change conventions:

- The EICAS format can only display as an inboard format on any DU
- The PFD half-screen format can only display as an outboard format on any DU
- CPDLC + PFD Auxiliary window with Flight Information will only be shown as an outboard format on DU1 or DU4 along with PFD 3/4 format.

When manually reverting the PFD (normally on DU1 or DU4), the respective PFD reverts to half-screen outboard and an MFD format inboard where the MFD format is the adjacent MFD outboard format, as long as the auto-reversion does not apply.

NOTE: Once a PFD is reverted (whether manual or auto), it remains reverted and requires the flight crew to turn the Reversion switch from the LEFT or RIGHT position back to the AUTO position.

If an EICAS format is present on the MFDs, then the PFD unreverts to a CPDLC+PFI format. Otherwise, the PFD stays reverted.

NOTE: Once an MFD is reverted (whether manual or auto), it remains reverted (with the PFD format outboard) and requires the flight crew to turn the Reversion switch from the LEFT or RIGHT position back to the AUTO position.

If a PFD format is present on the adjacent PFD, then the MFD unreverts. When an MFD unreverts, if the inboard display is EICAS, only the outboard format unreverts. Otherwise, the format transitions back to the original formats (whether full-screen format or two half-screen formats).

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Display software will maintain at least one EICAS and one PFD half-screen format window displayed at all times unless all DUs are non-operational.

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Air Data System (ADS) Reversionary Button – The **ADS** reversionary button is used to select the backup or cross-side ADS. Pushing the button in selects the cross-side. Pushing the button again deselects the cross-side.

The default selection (on-side) is not annunciated. However, when both pilots select the same source or when the cross-side is selected, an *ADS2* annunciator is displayed on the PFD.

Table 3-5 lists the status of the annunciator when the pilot and copilot's selections are made.

Table 3-5
Three ADS Annunciators on PFD

Pilot's Selection	Pilot's PFD Annunciator	Copilot's Selection	Copilot's Annunciator
ADS1	None	ADS2	None
ADS2	**ADS2**	ADS2	**ADS2**
ADS1	**ADS1**	ADS1	**ADS1**
ADS2	**ADS2**	ADS1	**ADS1**
ADS3	**ADS3**	ADS3	**ADS3**

ID-000762699

Inertial Reference System (IRS) Button – The **IRS** reversionary buttons are used to select the cross-side IRS.

The **IRS** button selection sequence is:

On-Side IRS → Cross-Side IRS → (repeat)

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The default selection (on-side) is not annunciated. However, when both pilots select the same source or when the cross-side is selected, an IRS2 annunciator is displayed on the PFD.

Table 3-6 lists the status of the annunciator when the pilot's and copilot's selections are made.

Table 3-6
Two IRS Annunciators on PFD

Pilot's Selection	Pilot's PFD Annunciator	Copilot's Selection	Copilot's Annunciator
IRS1	None	IRS2	None
IRS2	IRS2	IRS2	IRS2
IRS1	IRS1	IRS1	IRS1
IRS2	IRS2	IRS1	IRS1

Inhibit Panel

The inhibit buttons have been combined onto one panel, shown in Figure 3-10. The Inhibit panel includes the following buttons and guarded switches:

- LG WRN INHIB
- GND PROX TERR INHIB
- GND PROX G/S INHIB
- GND PROX FLAP OVRD.

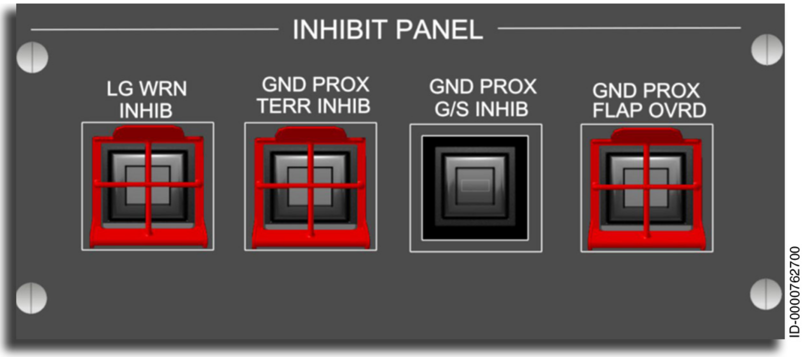

Figure 3-10
Inhibit Panel

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Landing Gear Warning Inhibit (LG WRN INHIB) Button – Pushing the **LG WRN INHIB** button inhibits the landing gear warning annunciator.

ID-0000762702

Ground Proximity Terrain Inhibit (GND PROX TERR INHIB) Button – Pushing the **GND PROX TERR INHIB** button inhibits the EGPWS terrain/obstacles awareness (referred to as TAD) and terrain clearance floor (TCF).

ID-0000762703

Ground Proximity Glideslope Inhibit (GND PROX G/S INHIB) Button – Pushing the **GND PROX G/S INHIB** button inhibits the ground proximity glideslope annunciator.

ID-0000762704

Ground Proximity Flap Override (GND PROX FLAP OVRD) Button – Pushing the **GND PROX FLAP OVRD** button inhibits the ground proximity flap annunciator.

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Pilot's and Copilot's Dimming Control Panels

The dimming controls for the pilot's PFD and MFD, shown in Figure 3-11, are located on the left glareshield. The dimming controls for the copilot's MFD and PFD are located on the right glareshield. Turning the dimming knobs clockwise increases the brightness of the display. When the dimming knobs are fully counterclockwise, the displays are at minimum brightness but cannot be completely dark.

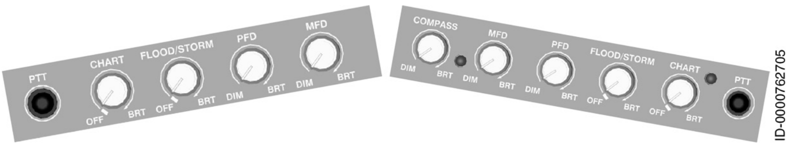

Figure 3-11
Dimming Control Panels

The controls are all the same, but the pilot has exclusive control of the EICAS dimming. The copilot has exclusive control of the COMPASS dimming. The other controls include:

- PTT (push to talk) button – audio panel control
- CHART
- FLOOD/STORM
- PFD
- MFD.

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Takeoff (T/O) Configuration Button

Pushing the **T/O CONFIG** button activates the takeoff configuration monitor. The configuration monitor is a function used on the ground to check that the aircraft is configured for takeoff. This function is activated by pushing and momentarily holding the button, shown in Figure 3-12, before takeoff. It is located on the center pedestal.

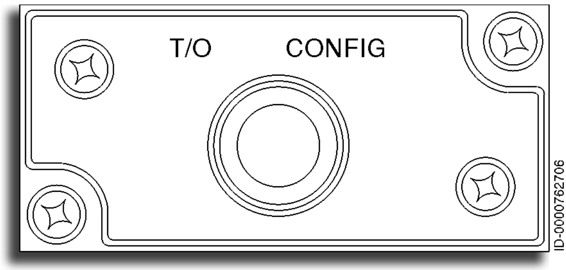

Figure 3-12
T/O CONFIG Button

When activated, the takeoff configuration monitor provides visual and aural warning messages such as **“NO TAKEOFF BRAKE,” “NO TAKEOFF SPOILER,” “NO TAKEOFF TRIM,”** and **“NO TAKEOFF FLAP”** to the crew as a result of an improper configuration. A CAS message is then displayed.

The crew manually activates a takeoff configuration check by pushing and holding the **T/O CONFIG** button in the cockpit. When the check is completed, the aural message, **“TAKEOFF OKAY,”** is provided if the aircraft is in proper takeoff configuration.

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Runway Awareness and Advisory System (RAAS) Inhibit Button (Option)

Pushing the **RAAS INHIBIT** button, shown in Figure 3-13, inhibits all of the SmartRunway/SmartLanding (SR/SL) EGPWS enhancements. The **RAAS INHIBIT** button is located below the copilot's CCD. When the RAAS option is not installed, the button is not installed in the cockpit. SR/SL is described in detail, starting on page 20-46.

Figure 3-13
RAAS INHIBIT Button

EICAS Full Button

One **EICAS FULL** button, shown in Figure 3-14, is located on the center pedestal below the MCDUs.

Figure 3-14
EICAS FULL Button

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The **EICAS FULL** button is a declutter override switch. When pushed, the display goes from a partially decluttered EICAS window, shown in Figure 3-15, to a full EICAS window, shown in Figure 3-16. The purpose is to give the pilot the ability to put data back onto the window that has been automatically decluttered after takeoff.

Figure 3-15
EICAS in Declutter Mode

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Figure 3-16 shows a full EICAS window.

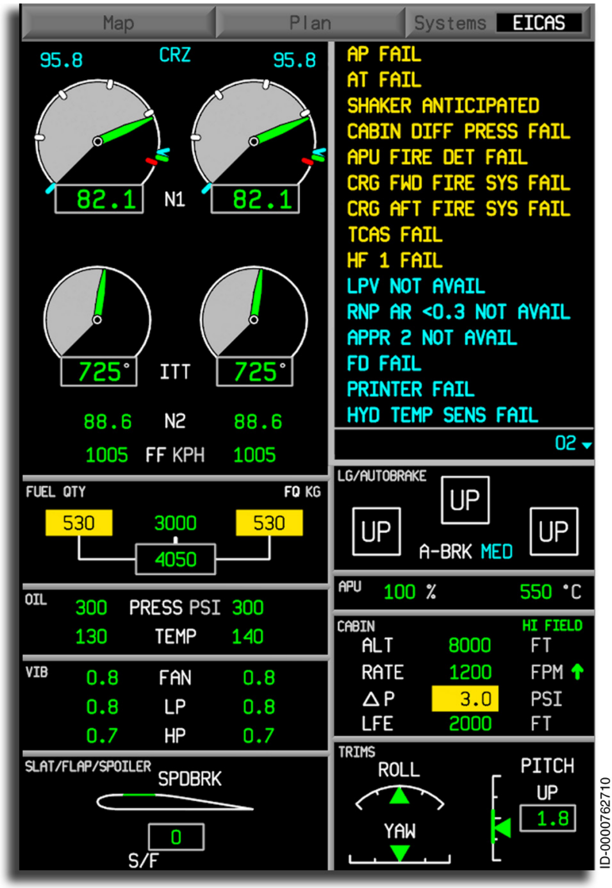

Figure 3-16
Full EICAS Window

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Control Yoke Switches

The control yoke switches are shown in Figure 3-17.

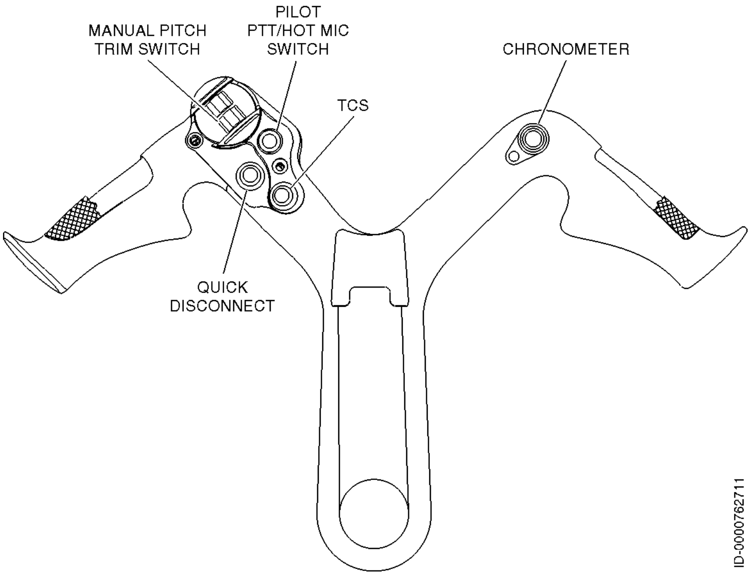

Figure 3-17
Control Yoke Switch Locations

The following switches are located on the control yoke:

- **AP Quick Disconnect Switch** – Pushing the AP quick disconnect switch disengages the AP, the aileron, the elevator, and the rudder servo clutch drives, and while pushed and held, directly stops the trim system from trimming.
- **Touch Control Steering (TCS) Button**– When the pilot pushes and holds the **TCS** button, the flight director is synchronized with the current airplane attitude. When the **TCS** button is released, the flight director returns to the lateral and vertical selection when the TCS was pushed. With Roll/VS/FPA modes, the flight director maintains the airplane attitude when the **TCS** button is released. When the AP is engaged, pushing and holding the **TCS** button momentarily overrides the AP. When the TCS is released, the AP resumes airplane control.

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- **Manual Pitch/Trim Switch** – When the pilot pushes the trim switch, the aircraft is trimmed in the direction pushed. The pilot pushes the upper half of both switches to trim up and the lower half of both switches to trim down.

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4. Electronic Display System (EDS)

INTRODUCTION

This section describes the components and functions of the electronic display system (EDS), as shown in Figure 4-1.

The system consists of four 1310 LCD display units (DU), which have formats as follows:

- Two Primary Flight Displays (PFDs)
  - Primary Flight Display with optional SmartView® Synthetic Vision System (SVS)
  - PFD Auxiliary window
  - Flight Info window
  - CPDLC Inbox.
- Two Multifunction Flight Displays (MFDs)
  - Menus
  - Interactive Navigation (INAV) (option)
  - Electronic Charts (eCharts) (option)
  - Electronic Checklist (ECL) (option)
  - Graphical Flight Planning (option)
  - Weather Radar Overlay Display
  - Uplink Graphical Weather (option)
  - Traffic Overlay Display (TCAS/CDTI) (option)
  - Engine Instrument and Crew Alerting System Display (EICAS)
  - Topography Terrain
  - Situational Awareness (SA) Terrain
  - Status
  - Flight Controls

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- Hydraulics
- Fuel
- Doors
- Electrical
- Environmental Control System (ECS)
- Anti-Ice
- Engine Maintenance
- External Video/Camera Display (option)
- Maintenance (OMS)
- System Configuration.

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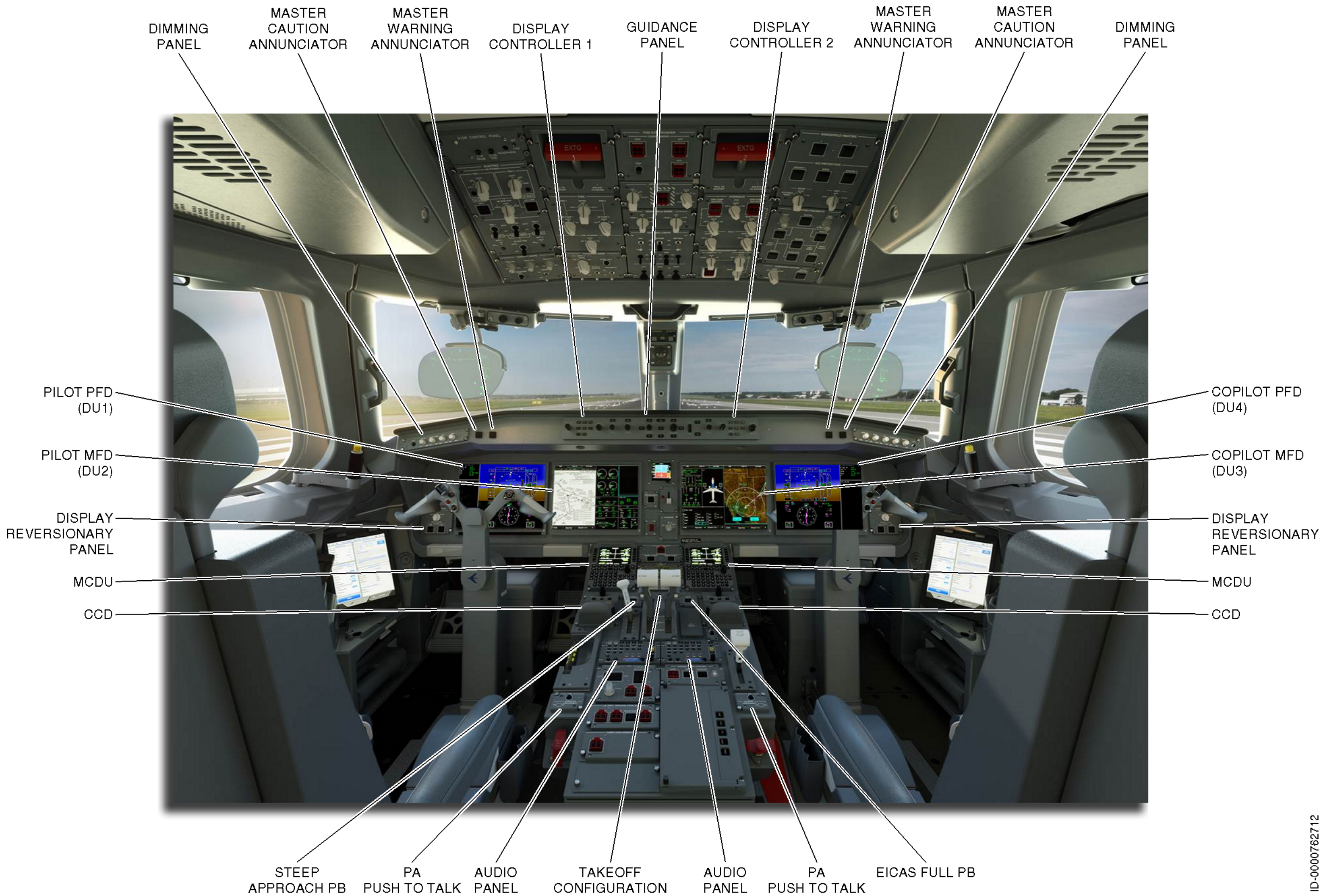

Figure 4-1
Embraer Primus Epic Cockpit Layout of EDS

Besides the displays, the EDS also includes:

- Guidance panel (1)
- PFD display controllers (2)
- Reversionary panels (2)
- Dimming control panels (2)
- EICAS declutter button (1)
- Steep approach button (1)
- Multifunction control and display unit (MCDU) (2)
- Cursor control devices (2).

The EDS is an integrated system that displays information to the crew. The following are displayed on DUs 1 and 4 (PFD windows):

- Flight attitude (pitch, roll, and yaw)
- Airspeed
- Vertical speed
- Flap retraction bug
- Ideal flap selection bug (green dot)
- Flight path angle (FPA)
- Horizontal situation indicator (HSI)
- Course
- Flight director modes
- Radio altitude
- SmartView Synthetic Vision System (SVS) including:
  - 3D terrain
  - Runway/airports
  - Obstacles
  - Range Rings
  - Gridlines

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- Weather overlay on HSI
- Source annunciators
- Navigation (NAV) preview
- Enhanced ground proximity warning system (EGPWS)
- SmartRunway and SmartLanding (SR/SL) alerts and annunciations (option)
- COM/NAV frequencies
- NAV data blocks
- Miscompare annunciation.

The following windows and overlays can be displayed on DU2 and DU3:

- INAV moving map with Map/Plan display including display in half or full display modes
- Vertical situational display (VSD)
- Weather overlay and weather controller
- TRAFFIC controller, TRAFFIC window, and TRAFFIC display overlay
- Electronic charts (option)
- System synoptics
- EICAS window
- Static air temperature (SAT)/Total air temperature (TAT)
- NAV data block
- Active flight plan and secondary flight plan overlays
- Video
- Central maintenance computer (CMC).

NOTE: Symbols and values are explained in the respective sections of this guide. Refer to the Aircraft Flight Manual for specific values, ranges, and limitations.

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EDS OPERATION

All four displays are connected to the avionics system. These include controllers, control panels, sensors, and other units required for a fully functional flight system. A block diagram of the EDS is shown in Figure 4-2.

Each unit displays essential information from sensor systems as follows:

- Automatic flight control
- Navigation
- Performance
- Caution-warning systems.

Navigation sources, bearing pointers, and course and heading inputs are selected with the PFD display controller. Navigation displays, weather, aircraft performance displays, and checklists are selected through menus operated with the cursor control devices (CCD). Radar and TCAS controllers are also selected and controlled using menus and the CCD.

Automatic and manual reversion are available during certain display failures, as described in Section 3, Controllers.

Each of the two types of displays in the EDS is described in the next sections of this guide.

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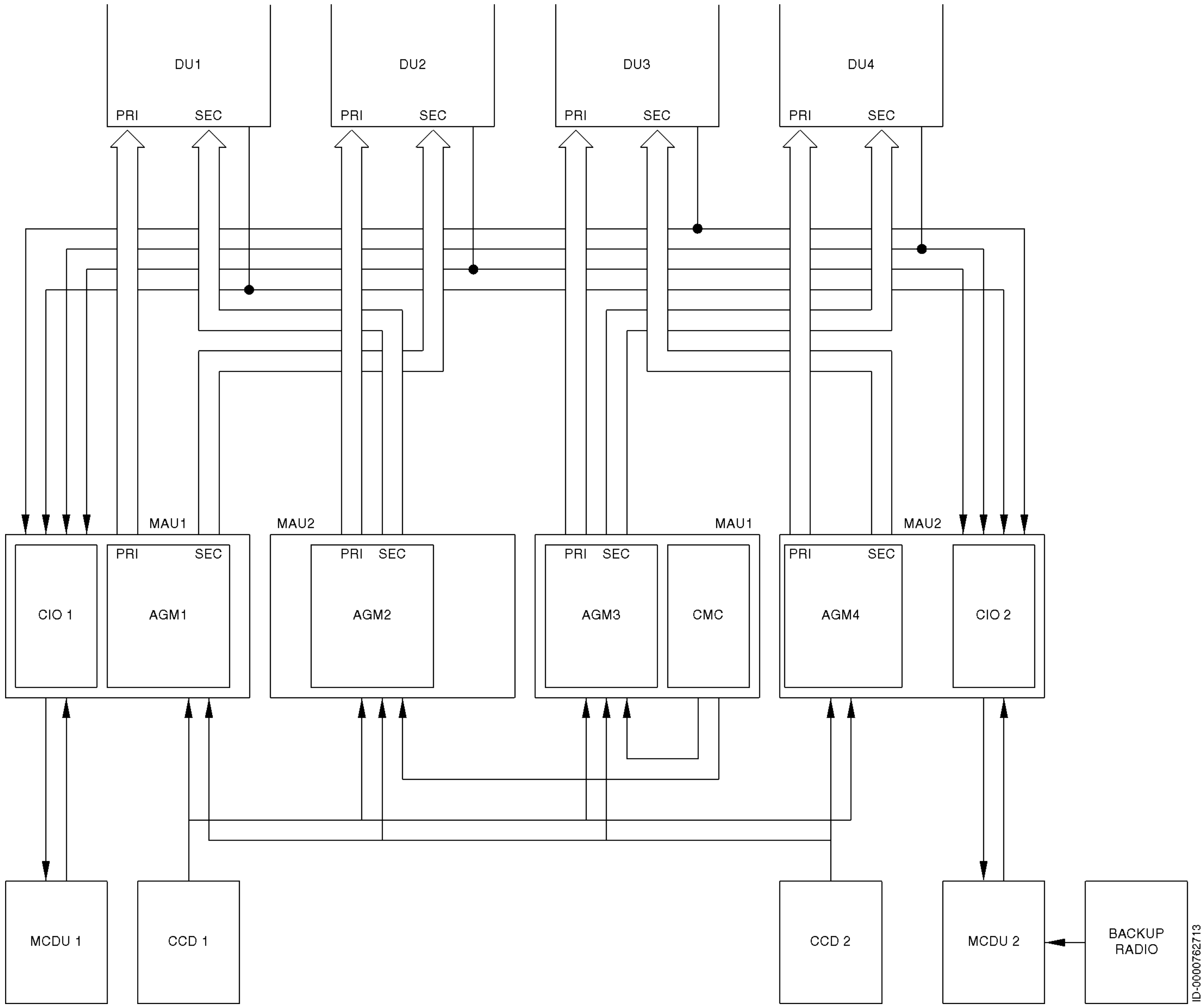

Figure 4-2
Embraer Primus Epic EDS Block Diagram

5. Primary Flight Display (PFD)

INTRODUCTION

This section describes the operation and displays associated with the primary flight display (PFD). The PFD can be displayed in the classic format or SmartView® Synthetic Vision System (SVS). The classic format is displayed in Figure 5-1. The SVS format is described later in this section.

NOTE: The CPDLC inbox is described in Section 23, Other Systems.

Figure 5-1
Classic PFD

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The PFD displays the following types of information:

- Attitude direction indicator
- Flight director and autopilot modes
- Airspeed, altitude, and vertical speed
- Heading, bearing, and track data
- Air data information
- Autothrottle modes
- Weather radar
- Traffic alert and collision avoidance system (TCAS)
- Horizontal situation indicator (HSI)
- Radio tuning
- Approach modes
- Flight path vector and symbology
- Flap retraction bug (green dot)
- Source annunciators
- Navigation preview.

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The PFD is divided into functional areas or windows, as shown in Figure 5-2. The following descriptions are segmented into the categories shown in the figure.

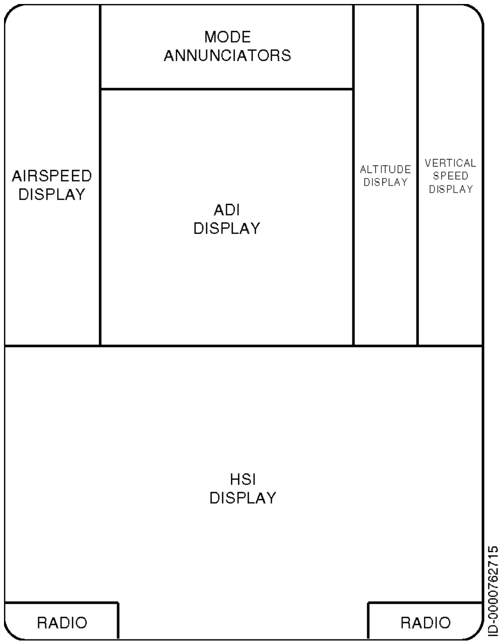

Figure 5-2
PFD Functional Display Area Layout

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FLIGHT MODE ANNUNCIATORS (FMA)

Control, autopilot/autothrottle status, and flight director mode annunciators are displayed at the top of the PFD above the attitude director indicator (ADI). Figure 5-3 shows the flight mode annunciator fields. Refer to the figure for the location of the FMAs described in the following paragraphs.

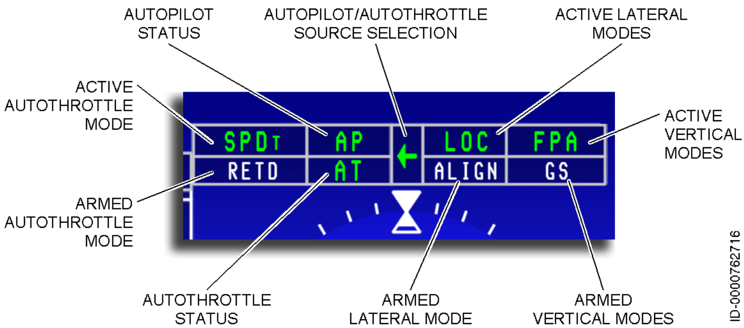
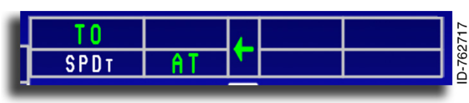


Figure 5-3
Flight Mode Annunciator Fields

The FMA flight guidance control system (FGCS) modes are controlled with the lateral and vertical mode select FGCS buttons. The buttons are located on the guidance panel (GP). The FMA autothrottle (A/T) modes are controlled automatically by the A/T.



Armed and Active Autothrottle (AT) Modes – A/T modes are displayed on the left corner of the mode field. The lower box contains armed modes displayed in white (AT). The upper box contains active modes displayed in green (AT). The lower-left center box displays the A/T status (A/T engaged, disengaged, or override). The autothrottle status annunciator and the autothrottle modes are displayed only when the autothrottles are engaged.

The A/T is engaged/disengaged through the flight GP **AT** button and can also be disconnected using the A/T disconnect buttons on the throttles. The autothrottle is engaged when the AT annunciator (displayed in green text) is displayed in the lower box to the left of the source selection arrow. When the field is blank, the autothrottle is disengaged. The A/T modes are shown in the two boxes to the left of the AT annunciator.

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When a new active mode is declared by the TMS, that active mode (shown in the top line) toggles between normal and reverse video for 5 seconds, then remains steady. When a new valid active mode is declared during the 5-second toggling period, the new mode is displayed immediately. The 5-second timer is then re-initialized so that the new mode toggles for the entire 5 seconds.

NOTE: The TMS does not retain the invalid mode as active. The pilot must manually reselect the desired mode.

The PFD source that currently supplies the references (primary NAV source and selected airspeed reference) for FGCS autothrottle or flight director operation is indicated by an arrow above the ADI. The arrow is displayed in the center box of the FMA. The arrow points to the left for the pilot's PFD and to the right for the copilot's PFD. The autopilot/autothrottle source annunciator is controlled by the **SRC** button on the GP.

NOTE: The autopilot/autothrottle mode annunciators and the source annunciator arrow are removed during an excessive attitude declutter condition.

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When the autothrottle is disengaged normally, the AT annunciator changes to AT and flashes reverse video (AT to AT) for 5 seconds. The flashing continues until the pilot acknowledges with the A/T disconnect on the throttle or the A/T is re-engaged.

ID-762719

In a normal/abnormal autothrottle disengagement, the AT annunciator changes to AT and flashes reverse video (AT to AT) for a minimum of 5 seconds. The flashing continues until the pilot acknowledges with the A/T disconnect or the A/T is re-engaged.

ID-762720

When the crew moves the throttles while the A/T is engaged, the A/T override function becomes active. The AT annunciator is then replaced by an OVRD annunciator.

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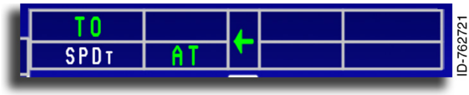

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Autothrottle Mode Annunciator – The A/T modes are coordinated with the FGCS modes (as selected by the crew) to distinguish when speed control is on the throttle (SPD_T) or on the elevators (SPD_E). A/T modes are displayed to the left of the source selection arrow. The armed A/T mode is shown below the active mode. When the mode annunciator LIM or GA is initiated, reverse video is toggled for 5 seconds and is then displayed steadily. Table 5-1 lists the A/T modes.

Table 5-1
A/T Mode Field Annunciators

Annunciator	Status	Mode Description
TO	Armed	A/T takeoff mode armed
TO	Active	A/T takeoff mode active
HOLD	Active	A/T hold active
SPD_T	Armed	A/T speed throttle mode
SPD_T	Active	A/T speed throttle mode
SPD_E	Active	A/T speed elevator mode
RETD	Armed	A/T retard mode
RETD	Active	A/T retard mode
GA	Active	A/T go-around mode
LIM	Active	A/T limit mode
AT	Engaged	A/T is engaged
AT	Disengaged	A/T has been normally disengaged (flashes in green reverse video)
AT	Disengaged	A/T has been abnormally disengaged (flashes in red reverse video)
OVRD	Active	A/T override is active
DD	Active	Driftdown

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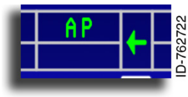
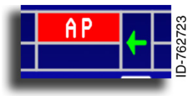
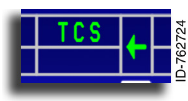


Autopilot Engage (AP/TCS) Annunciator – Autopilot engage and touch control steering (TCS) status are controlled by the GP **AP** button and the TCS and disconnect switches on the control columns. When the autopilot (AP) is engaged, AP is displayed at the top center of the PFD above the attitude sphere.



When the autopilot is disengaged (manually or due to failure), the AP annunciator flashes red reverse video (AP to AP). The annunciator continues to flash until one of the autopilot disconnect buttons is pushed.



The AP annunciator is replaced by a TCS annunciator while either pilot's **TCS** button is pushed, temporarily disengaging the AP. When the **TCS** button is released, the autopilot is re-engaged, TCS is removed, and AP returns.

Table 5-2 lists the AP mode field annunciators.

Table 5-2
AP Mode Field Annunciators

Annunciator	Status	Mode Description
AP	Engaged	AP is engaged
AP	Disengaged	AP has been normally/abnormally disengaged (flashes in red reverse video)
TCS	Active	Touch control steering is active

NOTE: The autopilot engage/TCS status annunciators are removed during an excessive attitude declutter condition.

Autopilot Source/Couple Arrow – A green arrow (← , →)is displayed in the center box of the mode field to indicate which PFD source is coupled to the FGCS. The arrow points to the left for the pilot's PFD and to the right for the copilot's PFD. The source selection button (**SRC**) on the GP is used to make the coupled-side selection.

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NOTES: 1. If the flight director function is invalid, the source/couple arrow is removed from the PFD.

2. The source/couple arrow is removed during an excessive attitude declutter condition.

Lateral and Vertical Modes

The lateral and vertical modes are controlled using the GP or the FMS.

- **Lateral and Vertical Flight Director Modes** – Lateral modes are displayed to the right of the autopilot select/couple arrow, and vertical modes are displayed to the far right. Only one lateral and one vertical mode are displayed.

Lateral and vertical armed windows are displayed, as shown in Figure 5-4.

Figure 5-4
Lateral and Vertical Flight Director Modes

The autopilot and flight director mode annunciators are displayed on both PFDs when active. Armed modes are displayed in the lower box in white, while active modes are displayed in green in the upper box. As modes transition from armed to active, reverse video flashes (e.g., ALT to ALT) for 5 seconds and then remains steady (ALT).

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Table 5-3 lists the lateral and vertical modes.

Table 5-3
Lateral and Vertical Mode Field Annunciators

Annunciator	Status	Mode Description
Armed Lateral Modes		
LOC	Armed	Localizer mode
BC	Armed	Back course mode
LNAV	Armed	Long-range NAV mode
ALIGN	Armed	Autoland align mode
RLOUT	Armed	Autoland rollout mode
TRACK	Armed	Track mode
Active Lateral Modes		
TRACK	Active	Takeoff or go-around mode or E2TS track mode is armed or active
ROLL	Active	Roll hold mode (roll hold, wings level, and heading hold) or E2TS roll mode is armed or active
LOC	Active	Localizer mode
BC	Active	Back course mode
LNAV	Active	Long-range NAV mode
HDG	Active	Heading hold mode
ALIGN	Active	Autoland align mode
RLOUT	Active	Autoland rollout mode
Armed Vertical Modes		
GP	Armed	Glide path mode
GS	Armed	Glideslope mode and ASEL armed vertical mode
VNAV	Armed	Vertical NAV mode
FLARE	Armed	Autoland FLARE mode
D-ROT	Armed	Autoland derotation (nose lowering) mode

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Table 5-3 (cont)
Lateral and Vertical Mode Field Annunciators

Annunciator	Status	Mode Description
Active Vertical Modes		
ALT	Active	Altitude hold mode
FLARE	Active	Autoland FLARE mode
D-ROT	Active	Autoland derotation (nose lowering) mode
FLCH	Active	Flight level change mode
GA	Active	Go-around mode
TO	Active	Takeoff mode or E2TS takeoff mode armed or active
FPA	Active	Flight path angle mode
ASEL	Active	Altitude select mode
GS	Active	Glideslope mode
VS	Active	Vertical speed hold mode
WSHR	Active	Windshear mode
FLCH	Active	Vertical flight level change (from FMS)
ASEL	Active	Altitude preselect and vertical altitude preselect (from FMS)
ALT	Active	FMS controlled altitude hold mode
PTH	Active	Path mode and vertical path (from FMS)
GP	Captured	Glide path mode and vertical glide path (from FMS)
OVSP	Active	Overspeed protection is active

Default Mode – Roll hold (ROLL) is the default lateral mode (roll hold, wings level, and heading hold). When the autopilot is engaged without any modes being selected, ROLL is automatically engaged. When a vertical mode is selected without a lateral mode, the default ROLL mode is activated. The mode is displayed above the attitude indicator on the PFD. Flight Path Angle (FPA) mode is the default vertical mode.

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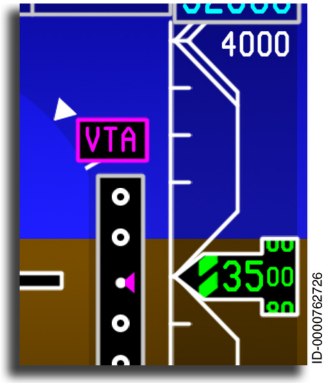

Vertical Track Alert Annunciator – A vertical track alert (VTA) alerts the flight crew of impending vertical profile transitions. Changes from climbing or descending to level flight have a VTA, and from level flight to climbing or descending. Vertical deviation is provided by the FMS for path type descents. A *VTA* annunciator is displayed above the vertical deviation indicator on the ADI. VTA is discussed in more detail in Section 10, Modes of Operation.

The VTA annunciator flashes reverse video for 5 seconds and then remains steady until removed from the display by the FMS (at the transition to the next leg). If the FMS data becomes invalid while the VTA annunciator is displayed, the annunciator is removed.

Approach Status Indication

The approach status indication is a single line directly above the two FMA lines. The approach status is shown in two columns without a divider line. The approach armed and engaged annunciators are shown in Figure 5-5.

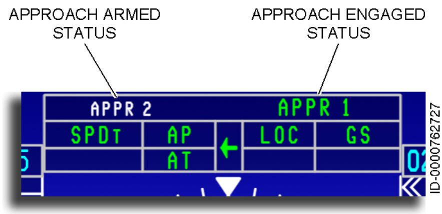

Figure 5-5
Approach Status Indicators

The approach status indication annunciates the highest approach mode available (armed and/or engaged) based on the current system settings/functionality available. When no approach mode is armed or engaged, the approach status indication line is blank.

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Table 5-4 lists the approach status annunciators. Approach modes are discussed in more detail in Section 10, Modes of Operation.

Table 5-4
Approach Status Indicators

Annunciator	Color	Mode Description
APPR 1	White	Approach 1 armed
APPR 2	White	Approach 2 armed
AUTOLAND 1	White	Autoland 1 armed
APPR 1 ONLY	White	Approach 1 armed AND is the only approach mode available
APPR 1 ONLY	Amber	Approach 1 engaged AND is the only approach mode available Flashes reverse video for 5 seconds, then remains steady
APPR 2 ONLY	White	Approach 2 armed AND is the only approach mode available
APPR 2 ONLY	Amber	Approach 2 engaged AND is the only approach mode available Flashes reverse video for 5 seconds, then remains steady
NO AUTOLAND	Red	AP engaged and previously engaged mode was AUTOLAND 1/AUTOLAND 2 Flashes reverse video for 5 seconds, then remains steady
APPR 1	Green	Approach 1 engaged Flashes reverse video for 5 seconds, then remains steady
APPR 2	Green	Approach 2 engaged Flashes reverse video for 5 seconds, then remains steady

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Table 5-4 (cont)
Approach Status Indicators

Annunciator	Color	Mode Description
AUTOLAND 1	Green	Autoland 1 engaged Flashes reverse video for 5 seconds, then remains steady
NO APPR	Amber	APPR 1 abnormally disengages Flashes reverse video for 5 seconds, then remains steady

Table 5-5 lists the armed FMS approach annunciators.

Table 5-5
Armed FMS Approach Annunciators

Annunciator	Color	Mode Description
L/VNAV	White	L/VNAV armed
RNP 0.XX	White	RNP 0.3 or RNP < 0.3 approach armed
LPV	White	LPV approach armed
G-APPR1	White	GLS approach armed

Table 5-6 lists the active FMS approach annunciators.

Table 5-6
Active FMS Approach Annunciators

Annunciator	Color	Mode Description
L/VNAV	Magenta	L/VNAV engaged Flashes reverse video for 5 seconds, then remains steady
NO L/VNAV	Amber	L/VNAV abnormal disengage Flashes reverse video for 5 seconds, then remains steady

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Table 5-6 (cont)
Active FMS Approach Annunciators

Annunciator	Color	Mode Description
RNP 0.XX	Magenta	RNP = 0.3 or RNP < 0.3 engaged Flashes reverse video for 5 seconds, then remains steady
NO RNP	Amber	RNP = 0.3 abnormal disengage or attempt to arm RNP = 0.3 approach is not capable Flashes reverse video for 5 seconds, then remains steady
NO RNP	Red	RNP < 0.3 abnormal disengage or attempt to arm RNP < 0.3 approach is not capable Flashes reverse video for 5 seconds, then remains steady
LPV	Magenta	LPV engaged Flashes reverse video for 5 seconds, then remains steady
NO LPV	Amber	LPV abnormal disengage or attempt to arm LPV approach is not capable Flashes reverse video for 5 seconds, then remains steady
G-APPR1	Green	GLS approach active
NO G-APPR	Amber	G-APPR1 abnormally disengages Flashes reverse video for 5 seconds, then remains steady
E2TS	White	E2TS is armed
E2TS	Green	E2TS is active
NO E2TS	Red	E2TS abnormal disengagement

Approaches are described in detail in Section 10, Modes of Operation.

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Engine Out Status Indication

The status indication for the engine out mode is displayed in the FMA. Table 5-7 lists the armed and active engine out annunciators.

Table 5-7
Engine Out Armed and Active Annunciators

Annunciator	Color	Mode Description
EO AUTO	White	FMS engine out automatic mode is armed
DRIFT DOWN	Magenta	Driftdown mode is engaged Flashes reverse video for 5 seconds, then remains steady
NO DRIFTDWN	Amber	Driftdown abnormal disengage Flashes reverse video for 5 seconds, then remains steady
EO AUTO	Magenta	Engine out auto mode is engaged Flashes reverse video for 5 seconds, then remains steady
NO AUTO EO	Amber	Engine out auto mode abnormal disengage Flashes reverse video for 5 seconds, then remains steady

Steep Approach Status Indication

The status indication for the steep approach mode is displayed in a single box directly to the left of the approach status indication. The STEEP approach armed, engaged, and disengaged annunciators are located in the STEEP indication window, as shown in Figure 5-6.

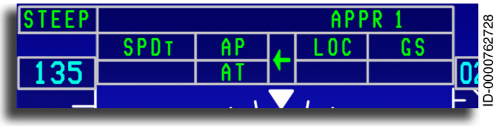

Figure 5-6
Steep Approach Status Annunciator

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Table 5-8 lists the steep approach status annunciators.

Table 5-8
Steep Approach Status Annunciators

Annunciator	Color	Mode Description
STEEP	White	Steep approach armed
STEEP	Green	Steep approach engaged
STEEP	Amber	Transition from engaged to disengaged

Steep approach is discussed in more detail in Section 10, Modes of Operation.

ATTITUDE DIRECTOR INDICATOR (ADI) DISPLAY AND ANNUNCIATORS

The basic ADI display and annunciators on the PFD are shown in Figure 5-7. The descriptions of the elements of the ADI are described in the following paragraphs.

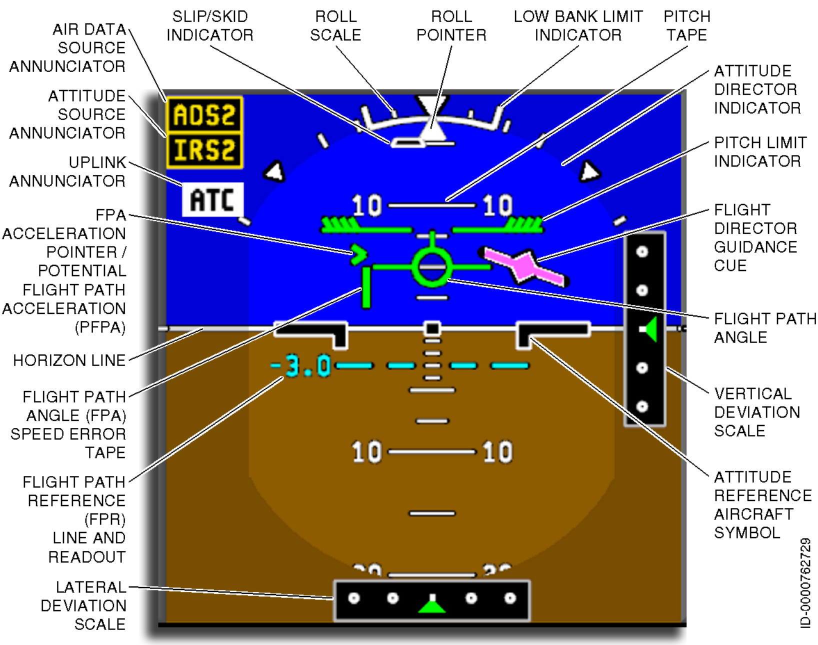

Figure 5-7
ADI Display

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Attitude Shading – The colors of the attitude display are blue for sky and brown for ground. The truncated ADI sphere is lighter in color than the attitude shading background. The displayed artificial horizon ranges between ±17 degrees and is removed from the display at pitch angles greater than 17 degrees. For pitch-up attitudes greater than 17 degrees, the attitude display is almost all sky (blue), as shown in Figure 5-8. A thin eyebrow of ground is retained for reference. For pitch-down attitudes greater than 17 degrees, the attitude display is almost all ground (brown) with an eyebrow of sky (blue).

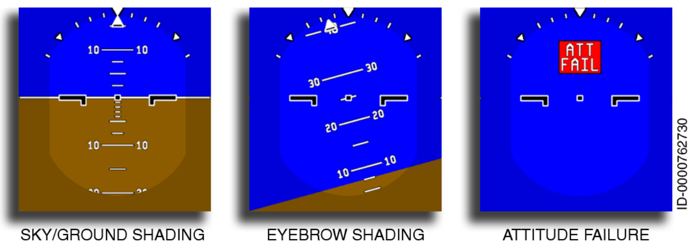

Figure 5-8
ADI Indications

When attitude data is invalid, the entire attitude sphere changes to sky blue, and ATT FAIL is annunciated.

Attitude Pitch Scale – Table 5-9 lists the white scale markings on the pitch scale tape.

Table 5-9
Pitch Scale Markings

Up	Down
90°	10°
60°	20°
40°	30°
30°	45°
20°	60°
10°	90°

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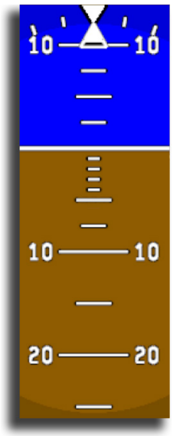

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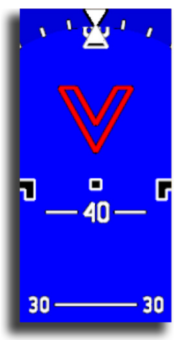
On the sky (blue) scale, pitch reference markings are every 2.5 degrees up to 10 degrees and every 5 degrees between 10 degrees and 30 degrees. On the ground (brown) scale, pitch reference markings are every 1 degree down to 5 degrees, at 7.5 degrees, 10 degrees, and every 5 degrees between 10 degrees and 30 degrees.



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Pitch attitude warning indicators (excessive pitch chevrons) come into view under excessive pitch conditions. Red fly down pitch warning chevrons are displayed at 45 degrees and 65 degrees pitch up. The red fly up pitch warning chevrons are displayed at 35 degrees, 50 degrees, and 65 degrees pitch down.

When aircraft pitch exceeds 30 degrees up or 20 degrees down, some of the symbols on the PFD are removed to declutter the display. The symbols are restored when the aircraft returns to a normal attitude.

Excessive Attitude Declutter – Under excessive attitude conditions, low priority display items are removed from the PFD. Unusual attitude is defined as one or more of the following conditions:

- Bank angle is greater than 65 degrees
- Pitch up angle is greater than 30 degrees
- Pitch down angle is greater than 20 degrees.

The following items are removed from the PFD in an excessive attitude condition, as shown in Figure 5-9:

- Autopilot (AP) engage and touch control steering (TCS) status
- Autothrottle (AT) engage status
- Flight mode annunciators (armed and active)

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- AP/AT source arrow
- Low bank limit arc
- Vertical deviation scale, pointer, and annunciator
- Marker beacon annunciator
- Selected airspeed reference bug and readout
- V_{SPEED} bugs
- Radio altitude readout
- Minimum altitude readout
- Selected altitude readout and bug
- VNAV altitude target readout
- Failure flags for all of the preceding items
- The comparison monitor annunciators:
  - HDG
  - RA
  - LOC
  - GS
  - GPS
- Flight path angle (FPA) and associated symbols (acceleration cue and speed error tape)
- Flight director command bug
- Flight path reference line and label readout.

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An example of excessive attitude declutter display is shown in Figure 5-9.

Figure 5-9
Excessive Attitude Declutter Display

NOTE: Attitude declutter is inactive in windshear mode.

The symbols listed previously are restored when both conditions that follow are met:

- Roll attitude is less than 63 degrees
- Pitch up attitude is less than 28 degrees, or pitch down attitude is less than 18 degrees.

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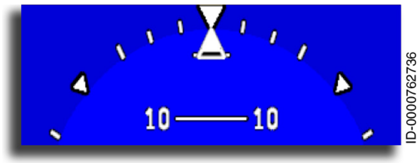
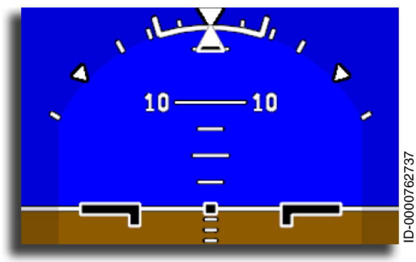
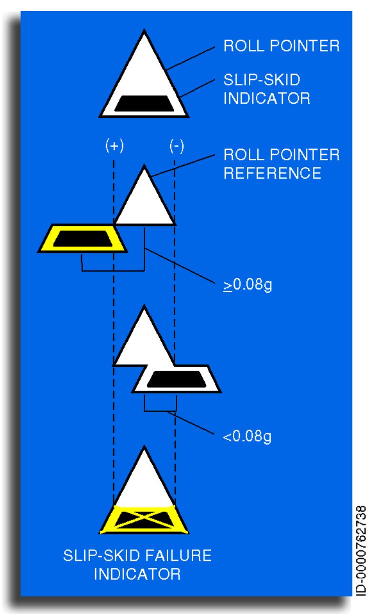


Roll Scale – The roll scale has tick marks at 10 degrees, 20 degrees, 30 degrees, and 60 degrees of roll. The 30-degree marks are highlighted with a longer tick mark. Inverted triangles are displayed at 0 degrees and 45 degrees of roll. The white triangle under the roll scale is the roll pointer. The triangle rotates around the roll scale on a degree-for-degree basis for the IRS roll input.



Low Bank Limit Arc – The low bank limit arc is a visual reference to help the pilot avoid banking the aircraft too steeply. The white low bank limit arc extends 17 degrees on either side of the 0-degree mark on the roll scale. Ticks are displayed at 17 degrees. The low bank limit arc is commanded on and off automatically by the automatic flight control system (AFCS) or manually by the pilots (through the AFCS) using the **BANK** button on the GP.



Slip/Skid Indication – The bottom half of the roll pointer is used as a slip/skid indicator. The lower portion of the triangle moves left or right to show the slip or skid condition. When a force greater than or equal to 0.08g is met, the slip/skid indicator changes from white to amber. The slip/skid indicator remains at the outer limit for forces of 0.08g and greater.

When the slip/skid function fails, an X is displayed inside the slip/skid portion of the triangle.

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Optimal Beta Indication – The beta target is a reference given to the flight crew to maintain a certain sideslip. This optimizes the aircraft climb performance during takeoff or go-around with a single engine. The bottom half of the roll pointer is used as an optimal beta indicator.

The lower portion of the triangle moves left or right to show the best beta condition. When a force greater than or equal to 0.08g is met, the optimal beta indicator changes from cyan to amber and remains at the outer limit.

Flight Path Display – Figure 5-10 shows the flight path display elements.

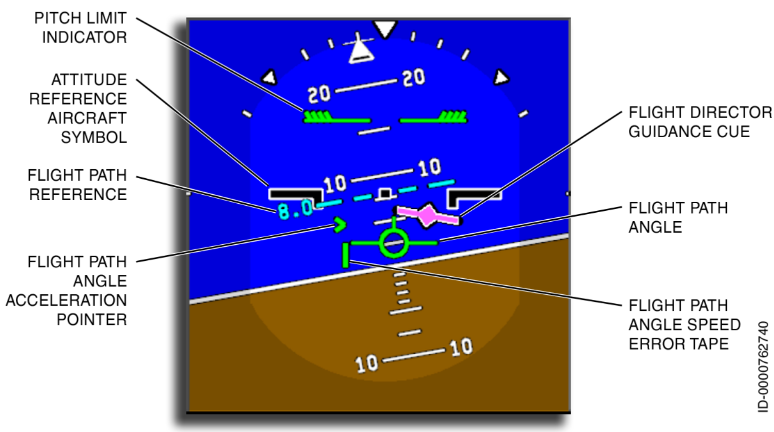
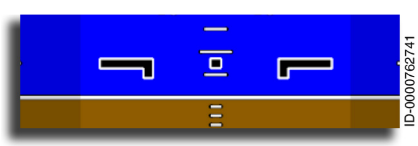


Figure 5-10
Flight Path Components



Attitude Reference Aircraft Symbol – The attitude reference aircraft symbol is fixed and does not move with aircraft movement. The aircraft symbol is centered and always points to the top of the display. The aircraft symbol is used with the pitch tape to reflect aircraft pitch and roll attitude in relation to the horizon line. The aircraft symbol is displayed at all times.

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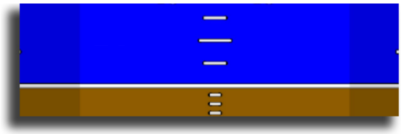
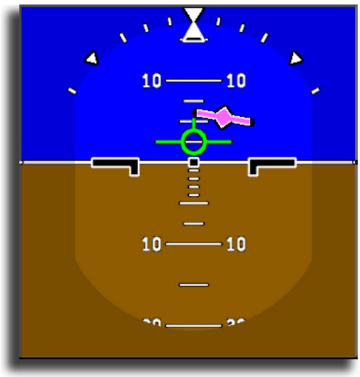


Horizon Line – The white horizon line position is based on the current airplane pitch and roll attitude. When the horizon line and the attitude reference aircraft symbol are overlaid, the airplane is in a level pitch attitude. The attitude shading and horizon line are displayed when valid data is received from the IRS.



Flight Director Guidance Cue – The flight director (FD) guidance cue (non-takeoff mode) is displayed as a diamond with short wings that moves within the center area of the ADI. The cue fits within the flight path angle symbol. The cue is magenta and is positioned based on the FD modes in use. The cue motion is as follows:

- The cue moves along the center of the pitch ladder to provide vertical guidance.
- The cue rotates about its own axis to provide lateral guidance.

Display conditions are as follows:

- The **FD** button on the guidance panel (GP) turns the cue on or off on both displays.
  - When GA, windshear, or approach modes are not engaged, pushing the **FD** button on the coupled PFD disengages the FD active modes, removing the cue on both displays. The **FD** button on the coupled PFD is inactive while the AP is engaged.
  - Pushing the **FD** button on the non-coupled side of the PFD turns the cue on or off in that display.
- When the GA or windshear flight director modes are active, the **FD** buttons are inactive, and the FD cue is displayed on both PFDs.

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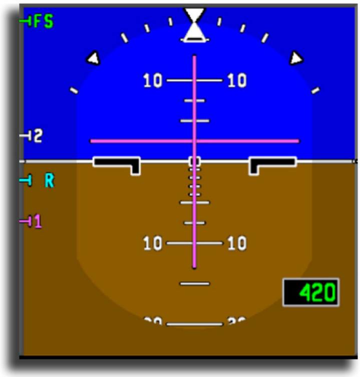
- When any APPR 1/APPR 2 (Category 1 or 2) or Autoland (Category 3) is active, the **FD** buttons are inactive, and the FD cue is displayed on both PFDs.

If the pitch or roll command data is invalid, the flight director guidance cue is removed.



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Flight Director Guidance Cue in Takeoff Mode – The TO mode FD guidance cue symbol is displayed as a horizontal guidance cue (or bar) and a vertical guidance cue (or bar). The horizontal cue moves vertically along the center of the aircraft reference symbol to provide vertical guidance. The vertical cue moves horizontally along the center of the aircraft reference symbol to provide lateral guidance.

When the TO flight director mode is active, the FD cue is displayed on both PFDs.

The takeoff mode FD guidance cue is displayed when the FGCS supplies the following valid parameters:

- Lateral and vertical FD modes
- Lateral and vertical FD guidance cue position data
- The vertical FD mode is TO.

If the valid parameters are not supplied, the takeoff mode FD guidance cue is removed.

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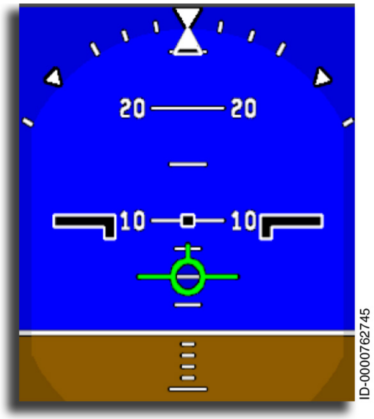

Flight Path Angle (FPA) – The flight path angle consists of a green aircraft symbol that indicates the current flight path angle in reference to the horizon line. The FPA moves up on the pitch tape for increasing flight path angles relative to the horizon. The FPA moves down for decreasing flight path angles.

The FPA symbol is displayed parallel to the attitude reference aircraft symbol. The FPA moves in the vertical scale only. Lateral deviation due to slip/skid, drift, or roll is not computed or displayed in this symbol.

FPA is displayed on the PFD when FPA is valid and any of the following conditions are satisfied:

- The aircraft is in the air longer than 20 seconds and TO FD mode is inactive
- There is an active FD mode other than TO mode
- TCAS guidance is displayed on the PFD.

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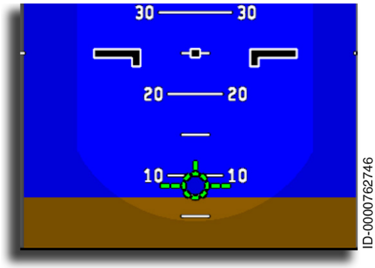
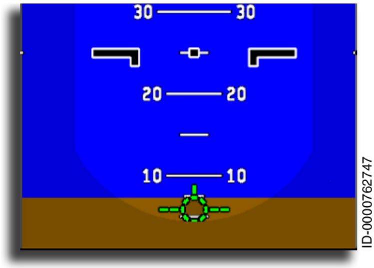
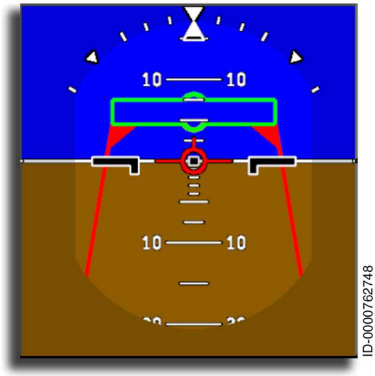




The FPA symbol has a movement range limited by the ADI racetrack. When the FPA becomes non-conformal (not placed on the value on the pitch tape), the FPA symbol changes to green dashed lines (- - - -). The FPA is always able to communicate the correct rate of climb. This is achieved by placing the non-conformal symbol above the horizon/ eyebrow for a positive rate of climb. The symbol is placed below for a negative rate.



The green FPA turns red when TCAS RA is active and the FPA is in the avoidance zone.

The FPA is removed from the display when excessive pitch is exceeded.

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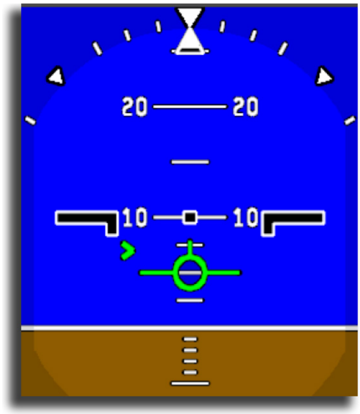

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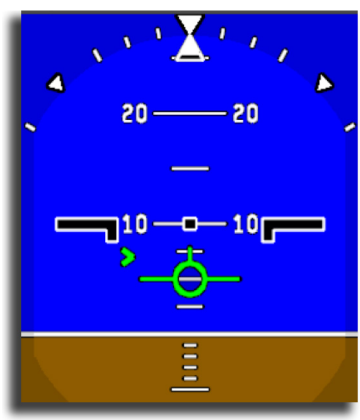
Flight Path Angle Speed Error Tape – The FPA speed error is a green tape that rises or descends from the left wing of the FPA symbol. The tape gives information to the crew regarding aircraft deviation from the airspeed target. The speed error tape represents the difference between the selected airspeed and the current airspeed. Down indicates current airspeed is less than the selected airspeed, and up indicates current airspeed is higher than selected.

The speed error tape is limited to ±15 knots, which is indicated as 5 degrees of pitch (that is, the scale factor is 3 knots per degree of pitch).



ID-0000762750

Flight Path Angle Acceleration Pointer – The FPA acceleration pointer, or potential flight path acceleration (PFPA), is displayed when FD is selected and gives an analog indication of acceleration and deceleration rate along the flight path.

The pointer consists of a green chevron (>) that points to the right. The pointer moves along a vertical line that goes from the top to the bottom of the ADI. The FPA acceleration pointer, or PFPA, moves up for increasing values of flight path acceleration. PFPA moves down for decreasing values of flight path acceleration. The pointer moves relative to the FPA symbol based on airspeed rate and compensated with acceleration along the FPA.

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ID-0000762751

Flight Path Reference (FPR) – The FPR represents the desired flight path angle. The flight path reference consists of an FPR line and digital readout.

The FPR line is displayed as a cyan dashed segment line (- - - -). The line is positioned parallel to the horizon line on the pitch tape. The FPR line moves up for increasing values and down for decreasing values.

The FPR digital readout is displayed in cyan to the left of the reference line. The FPR readout moves in conjunction with the FPR line. The FPR readout is displayed with two digits in the format X.X. The displayable range is -9.9 degrees to +9.9 degrees in reference to the horizon line with a resolution of 0.1 degrees.

ID-0000841392

FPR ghosting occurs in two conditions. In classic mode, the FPR changes from a four-dashed segmented line to a cyan horizontal dotted line (ghosted) and is displayed either at the upper limits (below the top of the ADI sphere) or lower limits (above the lower portion of the ADI sphere). In SVS mode, the FPR is ghosted when it reaches the upper limit (below the FMA) or lower limit (above the heading readout) of the displayable pitch scale.

The FPR line and digital readout are automatically displayed when FPA is the active vertical mode. The FPR line and digital readout are displayed manually by pushing the **FPR** button on the flight guidance as long as VS is not the active vertical FD mode. The FPR line and digital readout are set using the VS/FPA thumbwheel.

On initial selection of FPR for display, the FPR readout value is set to the current IRS FPA value. Rotating the VS/FPA thumbwheel up decreases the FPA value, and rotating the VS/FPA thumbwheel down increases the FPA value.

The FPR line and readout are inhibited when the FPA is invalid.

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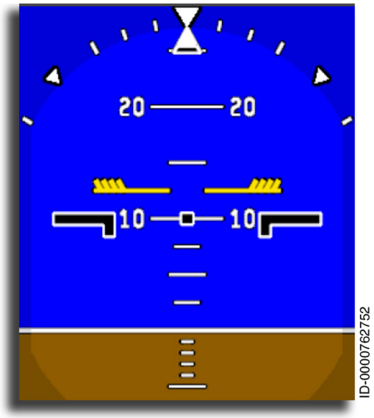

Pitch Limit Indicator (PLI) – The PLI (half-feathered lines) is a pitch-based indication of the margin (in degrees) between the stick shaker speed and the current airspeed. The PLI is displayed against the aircraft pitch attitude using the aircraft symbol as zero degrees. When the margin is zero, the PLI symbol is placed on the centerline of the wings of the aircraft symbol. This gives the pilot a reference of the remaining pitch attitude margin to the stick shaker. The PLI is displayed on the ADI, parallel to the airplane symbol. The PLI margin is calculated continuously and displayed when the value is less than or equal to 7 degrees. The PLI is removed from display when the current airspeed exceeds 1.2 times the stall speed (V_{STALL}). Table 5-10 lists PLI color schemes.

Table 5-10
Pitch Limit Indicator Color Scheme

PLI Color	Pitch Margin to Stall
PLI not displayed	$CAS > K_{Green*}V_{Shaker}$ where K_{Green} is 1.15
Green	$K_{Amber*}V_{Shaker} < CAS \leq K_{Green*}V_{Shaker}$ where K_{Green} is 1.15
Amber	$1.0*V_{Shaker} < CAS \leq K_{Amber*}V_{Shaker}$
Red	$CAS \leq 1.0*V_{Shaker}$

Where:

V_{SHAKER} = Shaker actuation speed (KCAS)

K_{Amber}=1.08, when Flap Continuous Configuration > 0.1

Else when aircraft Type = E-Jet E2 E190/E195-E2, K = Table 5-11

NOTE: The margin gain value, K, defaults to 1.08 when any of the following items are undetermined or invalid (group invalid or status invalid):

- Mach data
- Flap data
- Aircraft type.

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Table 5-11 lists the margin gain (K).

Table 5-11
K_{Amber}

Mach	E190/E195-E2
0.00	1.08
0.30	1.08
0.50	1.08
0.55	1.08
0.60	1.08
0.65	1.08
0.70	1.08
0.75	1.08
0.80	1.08
0.85	1.08
0.90	1.08
0.95	1.08

If the PLI data or pitch or roll command data is invalid, the pitch limit indicator is removed.

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Enhanced Ground Proximity Warning System (EGPWS) Annunciators

Terrain and windshear warnings are provided by the enhanced ground proximity warning system (EGPWS).

Terrain Annunciators – Visual messages are displayed on the PFD to accompany aural messages generated by the EGPWS for ground proximity conditions. Ground proximity is annunciated on the ADI and initially flashes for 10 seconds. Ground proximity then remains steady in a constant reverse video format until the condition is no longer detected, as shown in Figure 5-11.

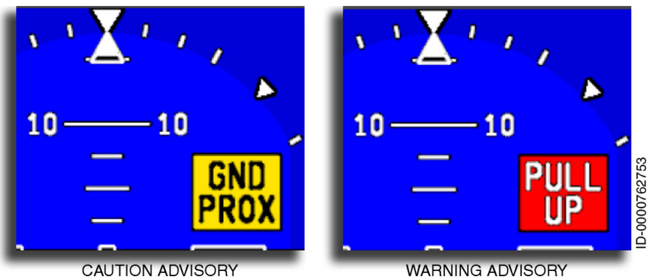

Figure 5-11
Terrain Annunciators

If EGPWS data is invalid, the annunciator is removed or is not displayed.

Windshear Annunciators – Windshear visual messages are displayed on the PFD to accompany aural messages generated by the EGPWS for windshear conditions. The annunciator initially flashes for 10 seconds then remains steady in a constant reverse video format until the condition is no longer detected, as shown in Figure 5-12.

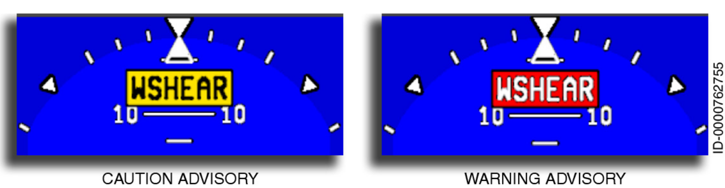

Figure 5-12
Windshear Annunciators

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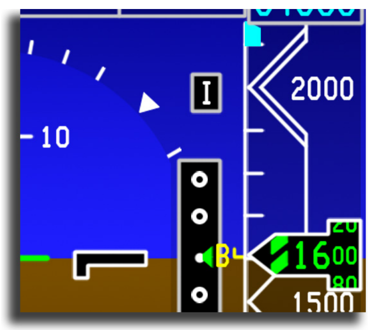
Windshear Declutter – When the flight director windshear guidance mode is active, the following items are not displayed on the PFD:

- MIN annunciator
- Speed error pointer
- Flight path reference line
- Flight path reference readout
- Overspeed FMA annunciator.

NOTE: The WSHEAR annunciator is only displayed when windshear capability is installed.

Marker Beacons



ID-0000762757

The boxed flashing (normal/reverse video) marker beacon annunciator is displayed inside the upper-right corner of the attitude sphere. Each marker beacon annunciator is displayed in the same location when active.

Table 5-12 lists the three marker beacons.

Table 5-12
Marker Beacons

Annunciator	Marker	Color
O	Outer	Cyan
M	Middle	Yellow
I	Inner	White

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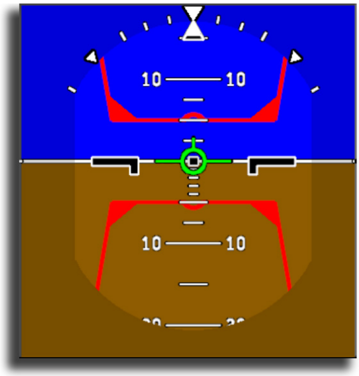
ADI Traffic Alert and Collision Avoidance System (TCAS) Displays

A TCAS RA is a command to the crew recommending a maneuver to increase vertical separation relative to an intruding aircraft. These commands are displayed on the ADI sphere. Two types of resolution advisories (RA) are used—a **preventive RA** and a **corrective RA**.



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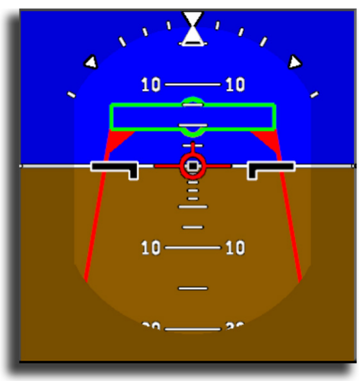
TCAS Avoidance Zones – The **preventive RA** consists of one or two red trapezoid avoidance zones. The crew must not fly in the red avoidance zone.



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Fly-to Zone – A **corrective RA** adds a corrective green fly-to zone. When the green fly-to zone is shown, the aircraft must be maneuvered in that direction to avoid the threat.

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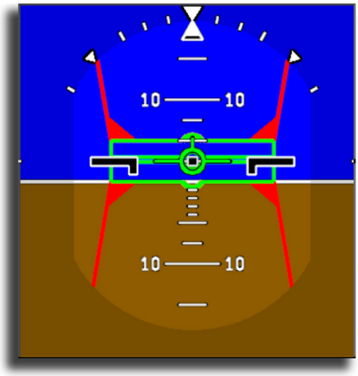
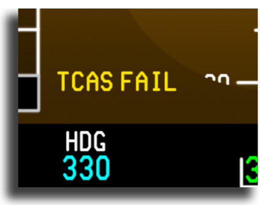


ID-0000762760

TCAS RA threats are above and below. Two avoidance zones and two fly-to zones can be displayed. In this case, position the aircraft symbol in the green fly-to zone to minimize the threats and avoid the red avoidance zone.

The zones are associated with resolution advisories generated by the TCAS system and are intended as commands to the crew. The TCAS system ADI display uses vertical separation to increase aircraft safety.



ID-0000762761

TCAS Annunciator – The TCAS display has an annunciator at the bottom left of the ADI sphere.

Table 5-13 lists the TCAS annunciators.

Table 5-13
TCAS Annunciators

Annunciator	Description
TCAS OFF	TCAS is OFF
TCAS FAIL	TCAS system failed
TCAS TEST	TCAS is in test mode
TA ONLY	TCAS is in TA only mode
RA FAIL	TCAS resolution advisory failure

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ADI Source Annunciators

Attitude Source Annunciator – The attitude reference source is not annunciated when the normal on-side source is valid for that PFD. When the reversionary panel is used to change the source so that both pilots are using the same attitude source, a respective IRS1 or IRS2 annunciator is displayed in the upper-left of both PFDs.

Air Data Source Annunciator – The air data source is not annunciated when the normal on-side source is valid for that PFD. When the reversionary panel changes the source, the air data source annunciator ADS1 , ADS2 , or ADS3 is displayed in amber on both PFDs. The annunciator is also displayed if the air data source is autoselected on failure of an ADC system. These conditions indicate a system other than the on-side system is providing the data, or both sides are using the same source. In the case of an electrical emergency or failure of all three air data systems, ADS4 is displayed in amber on both PFDs.

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Uplink Annunciator

Uplink Annunciator – The **ATC** annunciator is displayed in the upper left of the attitude sphere when an ATC uplink message or sidelink message is in the New or Open state. The ATC annunciator on the PFD is displayed in high rate flashing white reverse video (**ATC** – **ATC**) when any ATC uplink is in the New state indicating the message has not been read. The ATC annunciator is displayed in low rate flashing white reverse video (**ATC** – **ATC**) when any ATC uplink message remains in the Open state.

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AIRSPEED DISPLAY AND ANNUNCIATORS

The following paragraphs describe the airspeed displays and annunciators used at the upper left of the PFD. Figure 5-13 shows a basic airspeed display and includes:

- Selected airspeed readout
- Airspeed trend vector
- Selected airspeed bug
- Selected Mach display
- Airspeed rolling digits display
- Indicated airspeed tape
- Other annunciators.

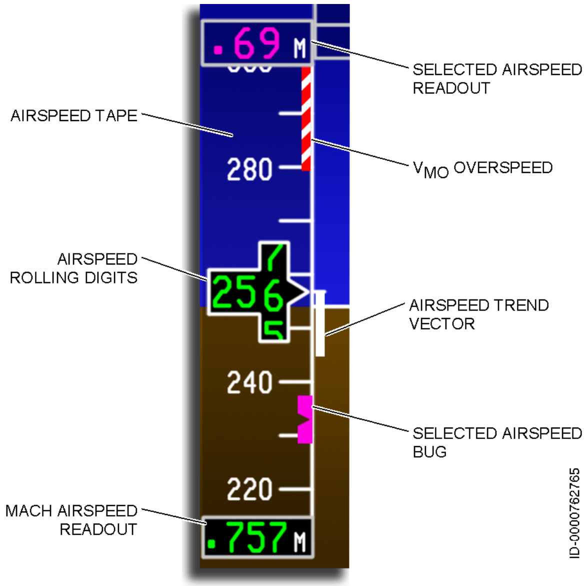

Figure 5-13
Airspeed Display

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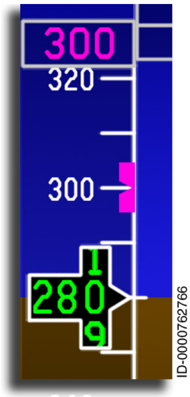
Airspeed Displays



Selected Indicated Airspeed (IAS) Digital Readout and Bug – The selected IAS digital readout is displayed above the airspeed tape. The corresponding airspeed bug is displayed along the right edge of the airspeed tape. The selected airspeed digital readout and bug are magenta for FMS mode or cyan for MAN (manual) mode.

The FMS/MAN switch of the speed knob control on the guidance panel selects manual or automatic modes. In AUTO mode, the FMS sets the selected speed readout and bug. In MAN mode, the selected airspeed is set using the guidance panel SPEED knob.

NOTES:

1. *When switching from FMS to MAN, the selected airspeed matches the previous FMS target (when valid).*
2. *When switching from MAN to FMS, the selected airspeed is displayed as magenta dashes (- - -). This occurs when a valid FMS speed is not available.*
3. *When the selected airspeed value is outside the current airspeed tape range, the selected airspeed bug stops at the limit on the applicable end of the airspeed tape.*
4. *On ground power-up, the selected airspeed readout is displayed as cyan dashes (- - -). On the first click of the SPEED knob in either direction, the display becomes 100 knots.*
5. *When the selected airspeed value is invalid or outside the maximum displayable range, the selected airspeed readout is replaced with amber dashes (- - -). The bug is then removed.*
6. *The selected airspeed is limited to V_{MO}/M_{MO} and the stick shaker speed. The speed bug remains parked when the airspeed is outside of these limits or the displayed range.*

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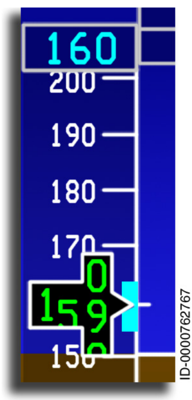
FMS Airspeed Bug – The magenta bug is displayed at the FMS airspeed target when an FMS mode is valid. The bug moves along the right side of the airspeed tape. The airspeed bug is displayed in the flight director vertical capture modes as follows:

- VFLCH (VNAV flight level change)
- VASEL (VNAV altitude select)
- VALT (VNAV altitude hold)
- PTH (VNAV path).

The VNAV airspeed bug stops at the applicable end of the airspeed tape when it is off-scale. At this position, one-half of the bug remains on the tape to indicate the direction of the bug.



This example shows a manual mode (cyan) selected airspeed.

When the selected airspeed value is outside the current airspeed tape range, the selected airspeed bug stops at the limit of the applicable end of the airspeed tape. Half of the bug is out of view. This indicates the bug is set and is above or below the current displayed speed tape.

When the selected airspeed value is invalid or has not yet been set after power-up, the selected airspeed readout is replaced with amber dashes (- - -). The bug is then removed.

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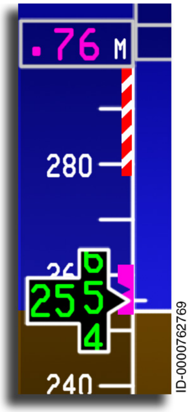

Selected Mach Airspeed Digital Display – The selected target Mach airspeed value replaces the selected International Standard Atmosphere (ISA) airspeed displayed above the airspeed tape, and the selected bug is displayed on the speed tape. The color coding for Mach is the same as for IAS.

The bug stops at the top or bottom end of the tape in the same way as the selected airspeed. This indicates the bug is set above or below the current speed display area.

The SPEED knob on the GP is used to set the selected Mach speed when the **PUSH CAS-MACH** button is set to MACH, and the FMS-MAN switch is set to MAN.

When the selected Mach is invalid or has not been set after power-up, the Mach readout is replaced with amber dashes (- - -). The bug is then removed.

Mach Airspeed Digital Display – A digital display of the current Mach speed is displayed below the airspeed tape, followed by an M label. The color of the Mach digits follows the color of the airspeed digits. The Mach airspeed readout is displayed to a resolution of 0.001 Mach.

The Mach readout is displayed when speed is greater than 0.450 Mach and remains displayed until the aircraft speed falls below 0.400 Mach.

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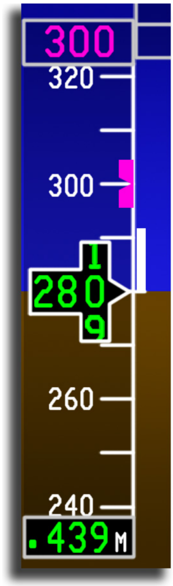
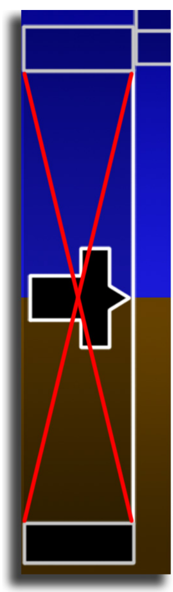


ID-0000762772

Indicated Airspeed (IAS) Analog Tape – The IAS tape is a moving scale display with an airspeed reference line and calibrated airspeed marks. The display has a range of 30 to 942 knots. The scale displays ±42 knots from the vertical center (airspeed reference line) of the tape. The scale moves down when airspeed is increasing and moves up when airspeed is decreasing. The airspeed reference line extends from the middle of the airspeed rolling digits window. The reference line acts as the zero-point for the white airspeed trend vector.

The white scale tick markings on the tape are in 10-knot increments beginning at 30 knots to the top of the tape. The tick marks are labeled every 10 knots from 30 to 200 knots. For airspeeds greater than 200 knots, the tick marks are labeled every 20 knots. Tick marks and labels are not shown below 30 knots. This area is reserved for previewing the takeoff and landing bug speeds.



ID-0000762774

When the air data computer (ADC) has failed or airspeed data is invalid, the airspeed tape is replaced by an X .

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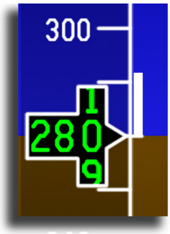

ID-0000762773

Airspeed Trend Vector – The white airspeed trend vector bar represents the airspeed in 10 seconds when the current acceleration/deceleration trend is maintained. The airspeed trend vector bar is positioned along the right side of the airspeed tape and extends up or down from the airspeed reference line. A trend vector above the reference line indicates acceleration, and a trend vector below the reference line indicates deceleration. Maximum vector length is the top or bottom edge of the airspeed tape. The minimum display is 2 knots. If the indicated airspeed or true airspeed (TAS) data is invalid, the airspeed trend vector bar is removed.

ID-0000762775

Airspeed Rolling Digits Display – A rolling digits display reflecting the current calibrated airspeed (CAS) is displayed in a window in the vertical middle of the airspeed tape. The digits are normally green. The digits roll down for increasing speeds and up for decreasing speeds.

ID-0000762776

The airspeed rolling digits turn amber under three conditions:

1. The airspeed trend vector is equal to or greater than the aircraft current overspeed value (current V_{MO} + 1 knot, or M_{MO} + 0.005 M).

2. The airspeed trend vector is equal to or smaller than the aircraft current low-speed trend value (1.0 V_{SHAKER} - 1.0 knot).

3. The airspeed is equal to or smaller than 1.15 V_{SHAKER} (stall speed) but greater than 1.0 V_{SHAKER}. There is a visual indication when the white trend vector overlaps the red and white barber pole, as shown. There is also a visual indication when the rolling digits display is in the amber region of the speed awareness bar.

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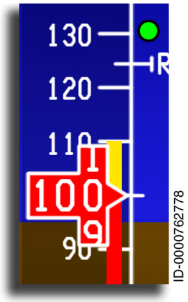
When the current airspeed is equal to or exceeds V_{MO} (the red and white barber pole), the rolling digits are red reverse video.



When the aircraft is in a low-speed condition (that is, equal to or smaller than 1.0 V_{SHAKER}). The rolling digits turn to red reverse video. This is indicated by the red low-speed awareness (LSA) bar extending from the bottom of the airspeed tape to the digital readout pointer.

At power-up, the airspeed rolling digits are not displayed until the airspeed is equal to or greater than 30 knots. If the ADS status is invalid, the rolling digits are removed.

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V_{MO}/M_{MO} Overspeed Barber Pole – The V_{MO}/M_{MO} overspeed barber pole is a red and white striped barber pole, shown in Figure 5-14. The barber pole is displayed along the right side of the airspeed tape when approaching or operating in overspeed conditions. The barber pole originates at the top-right side of the airspeed tape and extends down, indicating V_{MO}/M_{MO} overspeed range. The V_{MO}/M_{MO} barber pole is displayed to a resolution of 1 knot.

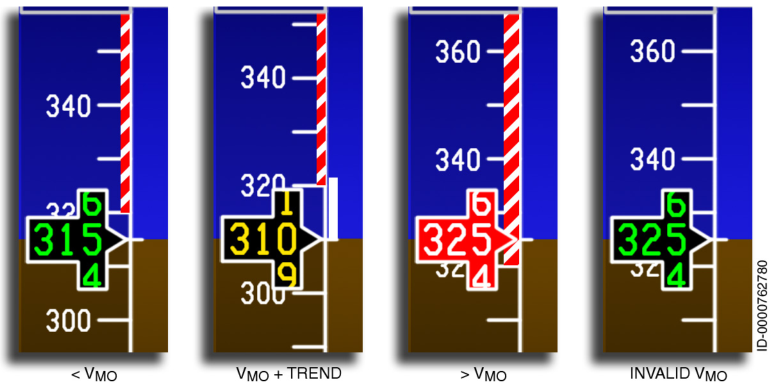

Figure 5-14
V_{MO} Overspeed Barber Pole

A narrow version of the pole is displayed at 40 knots above current airspeed. The vertical portion of the barber pole moves with the airspeed tape. The pole widens when it exceeds V_{MO}/M_{MO}. When the airspeed falls to the current barber pole value minus 1 knot/.0025 M, the normal display returns. If maximum operating airspeed status is invalid, the overspeed bar is removed or does not show.

V_{MO}/M_{MO} speed is a function of placard speeds that are configuration-dependent, maximum-limit airspeeds. Each flap/slat configuration and landing gear (LG) extension/retraction has a speed limit placard and is displayed through the V_{MO}/M_{MO} barber pole.

When the aircraft goes to direct mode, the barber pole indication is limited to 280 KCAS or 0.79 Mach.

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The bottom of the barber pole is positioned at the placard speed for the current aircraft configuration. When a new configuration is selected, the bottom of the V_{MO}/M_{MO} barber pole is repositioned to the new placard. The bottom of the barber pole is positioned on the airspeed tape at the lowest valid value that currently exists; V_{MO}/M_{MO}, flap/slat configuration speed, direct mode configuration speed, or the landing gear extension speed. All valid inputs (that is, V_{MO}/M_{MO} converted to airspeed and the currently active flap/slat/LG limits) are compared, and the lowest value is used to position the barber pole.

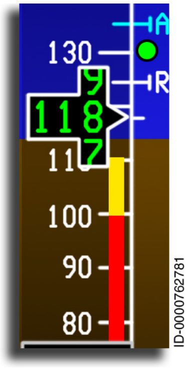
The V_{MO}/M_{MO} barber pole reverts to a speed equivalent to the placard speed of flap position 0 when the following conditions exist:

- Loss of valid V_{MO} or M_{MO}
- Loss of flap/slat position
- Position disagreement
- Landing gear is retracted.

When the conditions do not exist, the barber pole displays the landing gear placard speed.

In the manual speed select mode, the top portion of the speed select bug is located under the barber pole (not displayed). The lower portion of the speed select bug remains in view. The middle of the bug is set to the maximum speed (limit speed) when commanded manually or automatically.

In FMS mode, the speed select bug is located over the barber pole (displayed). The lower portion of the speed select bug remains in view.



Low Speed Awareness (LSA) Tape – A low-speed awareness tape is displayed along the lower-right inside of the airspeed tape. The tape position is based on airspeed, aircraft configuration, and angle-of-attack. The tape rises from the bottom of the airspeed tape to the calculated stall or stick shaker speed and has two colored ranges.

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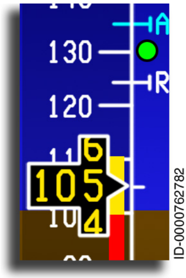
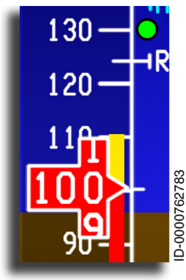


The amber tape range is from 1.0 V_{SHAKER} speed to 1.13 V_{STALL}. The top of the red range stall warning system shakes the control yokes to warn of a potential stall. An audible alarm is also given.

When the amber section of the tape reaches the rolling digits readout, the rolling digits become amber.

The stall occurs at the top of the red range. The red stall range is when airspeed is less than or equal to V_{SHAKER} to the bottom of the airspeed tape.



When the top of the red tape reaches or passes the pointer, the rolling digits become red reverse video.

When the indicated airspeed, angle-of-attack, or stall warning detection data is invalid, the tape is removed.

V_{SPEED} Bugs

The V_{SPEED} display consists of a digital V_{SPEED} readout, bugs, and corresponding labels. Four V_{SPEEDS} are displayed prior to takeoff, and four V_{SPEEDS} are displayed prior to landing. If V_{SPEED} is not entered or valid, or if it is deselected, no V_{SPEED} symbol or bug is displayed on the airspeed tape.

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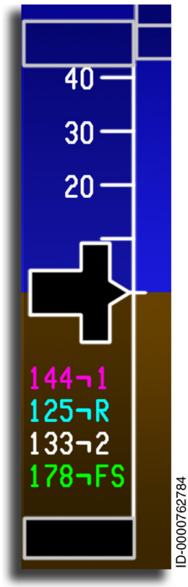

Preview Mode – The pilot enters V_{SPEEDS} through the multifunction control and display unit (MCDU). The pilot also deselects V_{SPEEDS} on the MCDU. When the aircraft is below 30 knots groundspeed, the display is in preview mode. The preview mode is displayed in the lower portion of the airspeed tape. The flight crew enters takeoff V_{SPEEDS} when the aircraft is on the ground. The readout for each V_{SPEED} is displayed at the bottom of the airspeed tape in the preview area.

Table 5-14 lists the various V_{SPEED} bugs.

Table 5-14
V_{SPEED} Bugs

Label	Color	V_{SPEED}	Definition
¬1	Magenta	V_1	Takeoff decision speed
¬R	Cyan	V_R	Takeoff rotation speed
¬2	White	V_2	Takeoff safety speed
¬FS	Green	V_{FS}	Final segment speed
¬AP	Cyan	V_{AP}	Approach speed
¬RF	White	V_{REF}	Reference speed
¬AC	Magenta	V_{AC}	Approach climb speed
NOTE: V_1 is set equal to or less than V_R. V_R is set equal to or less than V_2.			

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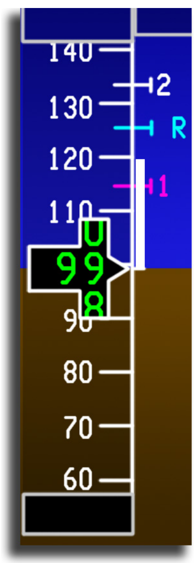
When no valid V_{SPEED} data is available and the aircraft is on the ground, cyan dashes (- - -) are displayed. The dashes are displayed next to the corresponding takeoff V_{SPEED} symbol/bug in the preview area of the airspeed tape.

When on the ground, the flight crew can enter the V_{SPEED} values. Also, the takeoff V_{SPEEDS} are displayed in the preview area of the airspeed tape, replacing the dashes.



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Takeoff V_{SPEED} Bugs – During the takeoff roll, above 30 knots groundspeed (normal operations), the preview mode digital readouts are removed. The bugs and labels are displayed at the applicable positions along the outside right edge of the airspeed tape.

If a V_{SPEED} value is more than the currently displayed range of the airspeed tape, the V_{SPEED} readout and bug are not shown. When that portion of the tape rolls into view, the readout and bug come into view again.

When each takeoff V_{SPEED} rolls completely out of view on the bottom of the airspeed tape, it becomes inactive (that is, it is not displayed again on the airspeed tape). It stays inactive for the duration of that in-air cycle.

Landing V_{SPEEDS} and takeoff V_{SPEEDS} are both exclusive. If conditions become valid that enable the display of landing V_{SPEEDS} while any takeoff V_{SPEEDS} are still displayed, the takeoff V_{SPEEDS} are removed from the airspeed tape for the duration of that in-air cycle.

NOTE: The V_{SPEEDS} and bugs are removed from the display during an excessive attitude declutter condition.

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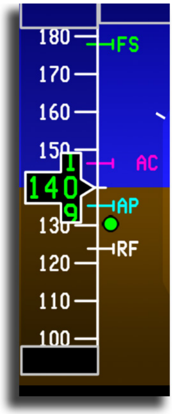

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Landing V_{SPEED} Bugs – Landing V_{SPEEDS} and bugs are displayed when the V_{SPEED} configuration is landing and the airspeed is ≤ 230 knots.

Approach bugs are shown along the right edge and are removed once on the ground.

The landing V_{SPEEDS} and bugs remain enabled and come into view when the applicable portion of the airspeed tape comes into view with the aircraft on-ground for 10 seconds or more. At that time, landing V_{SPEEDS} are disabled from display on the airspeed tape until the next in-air cycle. Also, takeoff V_{SPEEDS} and bugs are enabled.

The landing V_{SPEEDS} are also enabled when the flight crew commands the landing gear up. Any time after the landing gear is commanded down, it is interpreted as a positive intention to land. Ten seconds after touchdown, the takeoff V_{SPEEDS} are re-enabled.

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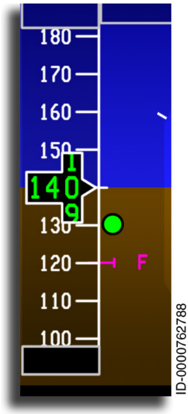

Ideal Flap Selection and Flap Retraction Speed Bugs – The ideal flap selection speed symbol consists of a green bug () located along the right edge of the airspeed tape. This indicates the ideal speed for selecting flaps.

The green bug also indicates the drift down speed when slat/flap is retracted and the flap maneuvering speeds for other slat/flap settings. The flap maneuvering speeds are computed based on airplane weight and slat/flap setting. The green bug does not change with bank angle or turbulence. The indication accounts for ice accumulation.

The green bug is removed when any of the following conditions exist:

- Loss of valid airspeed
- Loss of valid stall speed
- Invalid or loss of flap/slat position
- Flap/slat position disagreement or in an undetermined state
- When aircraft is on the ground.

The flap retraction (V_F) speed bug consists of a magenta bug () located along the right edge of the airspeed tape.

If calibrated airspeed data is invalid, the flap bugs are removed.

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ALTITUDE DISPLAY AND ANNUNCIATORS

The altitude display, shown in Figure 5-15, includes:

- Selected altitude readout and bug
- Metric selected altitude
- Altitude tape
- Altitude rolling digits
- Metric altitude
- Trend vector
- VNAV target altitudes and bug
- Barometric setting
- Radio altitude awareness.

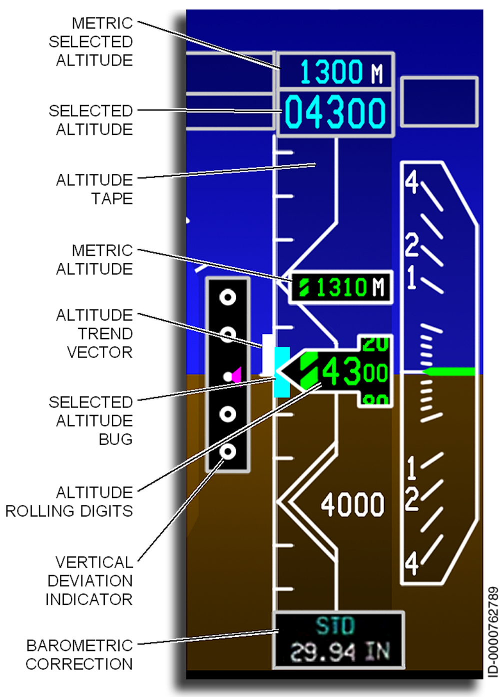

Figure 5-15
Altitude Display

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Selected Altitude Digital Readout and Bug – This readout is displayed in cyan at the top of the altitude scale in feet and metric units. The readout is up to five digits displayed in the format XXXxx with a minimum of three digits shown. Leading zeros are used when necessary.

Selected altitude is displayed as a flight level (FL) (e.g., FL2000) when STD has been selected as the BARO correction. The flight level is displayed in the format FLXXX, using leading zeros when necessary.

In manual mode, the selected altitude is set using the ALT SEL knob on the guidance panel. In auto mode, it is set by the FMS.

The selected altitude bug moves along the left side of the altitude tape. The bug position corresponds to the altitude value set in the altitude alert select digital display. The bug is always the same color (cyan bug or amber bug) and has the same flashing characteristics as the selected altitude digital readout. When the selected altitude is off the displayed range, half of the bug remains on the top or bottom of the scale to indicate the direction to the selected altitude. The selected altitude bug is removed from the display if a selected altitude value is not displayed.

The altitude alert operating region is between 1,000 and 200 feet from the preselected altitude. When approaching the preselected altitude, the digital readout (initially flashes reverse video for 5 seconds, then remains steady amber) and the bug turn amber, and a momentary audio alert sounds when the aircraft is within 1,000 feet of that altitude. Once the aircraft is within 180 feet of the preselected altitude, the digital readout and the bug turn back to cyan. After altitude capture, when the aircraft departs more than 200 feet from the selected altitude, the digital readout and the bug turn amber, and the audio alert is sounded.

On ground power-up, the selected altitude readout consists of cyan dashes (- - - - -). On the first knob click, the readout displays the value derived by rounding the current altitude rolling digits readout to the next higher 100-foot value. When no value for the digits is displayed, the selected altitude displays zero with the first knob click.

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Two rates of adjustment exist for the selected altitude value increments/decrements:

1. The slow rate increases or decreases the selected altitude by 100 feet for each knob click.
2. The fast rate increases or decreases the selected altitude by 1,000 feet for each knob click.

Clockwise rotation increases the selected altitude value, and counterclockwise rotation decreases the value. The selected altitude is displayable from 0 to 41,000 feet. The readout is rounded to a resolution of 100 feet. When the current selected altitude value reaches the maximum or minimum, the readout remains at the maximum or minimum with no indication that the limit is reached.

When the selected altitude data is invalid or outside the displayable range, the readout is replaced with five amber dashes (- - - - -).

NOTE: The selected altitude digital readout and bug are removed from the display during an excessive attitude declutter condition.

Metric Selected Altitude Readout – The metric selected altitude readout is shown in meters in a cutout box above the Imperial selected altitude readout.

The readout is followed by an M label located directly to the right of the digits.

The metric selected altitude readout cutout box is alternately displayed or removed from display on both PFDs as a function of the PUSH FTM switch that is integral to the ALT SEL knob on the guidance panel.

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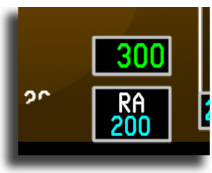
The metric selected altitude readout consists of five digits displayed in the format XXXXX without leading zeros. The metric selected altitude readout digits always have the same color and flashing characteristics as the selected altitude readout (cyan readout or amber readout). When the metric selected altitude readout cutout box is displayed, the metric selected altitude consists of the metric value corresponding to the current Imperial value of the selected altitude. The metric selected altitude has range of 0 to 12,500 meters and is rounded to a resolution of 50 meters.

The metric selected altitude is shown as dashes when the selected altitude is shown as dashes. The metric selected altitude value is not displayed when the selected altitude value is not displayed.



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Selected Minimum Radio Altitude (RA) Altitude Readout – The selected minimum radio altitude readout is located in the lower-right corner of the attitude sphere. The format is XXX in cyan. The range of the RA readout value is from 0 to 990 feet. Leading zeros are not displayed.

On power-up on the ground, the minimum altitude is not displayed:

- After initial system power-up, or after RA minimum has been turned OFF by the pilot, the RA minimum value initializes to 200.
- After initial system power-up, or after BARO minimum has been turned OFF by the pilot, the BARO minimum value initializes to 2,000.
- When BARO minimum is selected while an RA minimum value is displayed and RA minimum is reselected, the RA minimum value initializes to the last set RA minimum value.
- When RA minimum is selected while a BARO minimum value is displayed and BARO minimum is reselected, the BARO minimum value initializes to the last set BARO minimum value.

The altitude value is set using the MINIMUMS rotary knob on the PFD controller section of the guidance panel when RA is selected on the MINIMUMS RA/BARO select switch.

The resolution of the RA minimum altitude is 5 feet for 0 - 200 feet and 10 feet for greater than 200 to 990 feet.

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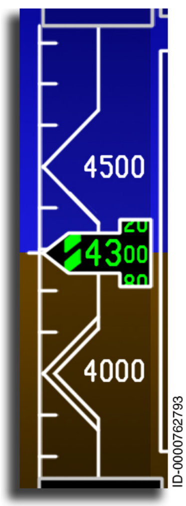
When the RA minimum is not in view, and the RA/BARO skirted switch is in the RA position, the RA minimum cutout box and range are active when the MINIMUMS knob is rotated one click in either direction with the initialization value in view.

Two rates of adjustment exist for the RA minimum value increments/decrements:

1. The slow rate increases or decreases the RA minimum value by one current minimum resolution increment for each knob click.
2. The fast rate increases or decreases the RA minimum value by ten current minimum resolution increments for each knob click.

When the metric selected altitude readout data is invalid or outside the displayable range, the readout is replaced with five amber dashes (- - - - -).



Barometric Altitude Tape – The barometric altitude tape is a moving scale displayed under a fixed pointer reference line. The background is blue with white markings and numbers. The scale moves behind the feet and metric rolling digits displays. The scale displays ±550 feet from the center of the tape. White tick marks are at 100-foot increments, except the white chevrons shown at the 500-foot increments. Double chevrons are displayed at 1,000-foot increments. The altitude is identified at each chevron in white digits.

The altitude reference line extends left from the altitude rolling digits window to the airspeed window. The reference line also acts as the zero-point for the altitude trend vector.

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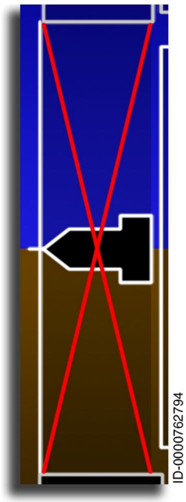
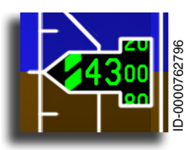


When barometric altitude status or BARO correction data is invalid, the altitude data is removed, and an X is placed over the entire altitude tape area.

Altitude Rolling Digits Display – The barometric altitude rolling digits display the actual altitude rolled to a resolution of 1 foot but labeled every 20 feet. The digits are green on a black background. For negative altitudes, a minus sign is displayed in the place of the thousands digit. A minimum of three digits is displayed with leading zeros when required. The ten-thousands, thousands, and hundreds digits are taller in the display to more easily distinguish hundreds of feet or flight levels. The rolling digits roll down for increasing values and roll up for decreasing values.



For altitudes above 0 but less than 10,000 feet, a green/black hashed box symbol replaces the ten-thousands digit to emphasize low-altitude awareness.

If barometric altitude status or BARO correction data is invalid, the rolling digits are removed. Also, if the altitude value is outside the displayable range (<-2,000 feet or >60,000 feet), the rolling digits are removed from the display.

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Metric Altitude Display – The metric altitude readout is alternately displayed or removed from display on both PFDs as a function of the PUSH FTM switch that is integral to the ALT SEL knob on the guidance panel. The current altitude in meters is displayed in a small gray-bordered box above the altitude rolling digit display. An M follows the digits to indicate meters. When the left-most digit is a zero, a green/black hashed box symbol place holder is displayed. The metric altitude readout is displayed to a resolution of 5 meters.

If barometric altitude status or BARO correction data is invalid, the metric display is removed.

Altitude Trend Vector – The altitude trend vector is a white thermometer starting at the altitude reference line and extends to the altitude the aircraft is at in 6 seconds, based on the current vertical speed.

The trend vector stops at the respective end of the altitude tape. There is no indication the limit is reached if the current value for the altitude trend vector goes outside the currently displayed range of altitude tape.

The altitude trend vector is removed from the display when the air data indicates a trend vector of less than 20 feet, when the altitude tape is not displayed, or when the trend vector data is invalid.

VNAV Altitude Waypoint Constraint Readout – The VNAV altitude waypoint constraint readout is displayed when the FMS is the primary NAV source. The readout is shown in a cutout box located in the upper-right region of the attitude window. The VNAV altitude waypoint constraint readout is displayed in feet or flight level, as reported by the FMS.

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The VNAV altitude indication is used to inform the pilot of an active waypoint constraint altitude automatically honored by the FMS prior to arrival at the preselected altitude. The VNAV altitude waypoint constraint readout displays the lower value constraint (Constraint 1), as reported by the FMS.

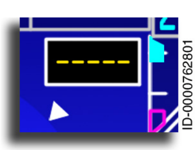
When the VNAV altitude waypoint constraint is reported as temperature compensated by the FMS, the constraint readout is displayed in reverse video.

The VNAV altitude waypoint constraint has up to five digits displayed in feet (in the format XXXXX) or up to three digits in flight level (as FLXXX) using leading zeros when necessary. The format type is determined by the FMS. The constraint readout is rounded to a resolution of 1 foot when displayed in feet. The constraint readout is rounded to a resolution of 100 feet when displayed in-flight level.

The display method for VNAV altitude waypoint constraint readout depends on the VNAV altitude constraint type and phase of flight. Table 5-15 lists the constraint type and phase of flight along with the display method.

Table 5-15
VNAV Altitude Waypoint Constraint Display Method

Constraint Type and Phase of Flight	Display Method	
AT	XXXXX	over-scored and under-scored
AT or ABOVE	XXXXX	under-scored
AT or BELOW	XXXXX	over-scored
WINDOW in Climb	XXXXX	over-scored
WINDOW in Descent	XXXXX	under-scored



When VNAV altitude waypoint constraint data is invalid or outside the displayable range, the readout digits are replaced with five amber dashes (- - - - -).

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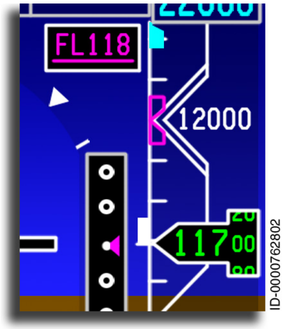

VNAV Target Altitude Bug – The VNAV target altitude bug, a magenta hollow rectangular bug, is displayed when a VNAV target altitude is valid and the FMS is the primary NAV source.

The target altitude bug is positioned at the VNAV target altitude value on the left side of the altitude tape and is the same shape as the selected altitude bug. The VNAV target altitude bug is displayed on top of the selected altitude bug when beginning to overlap or are located at the same position.

When the VNAV target altitude is beyond the displayable range of the altitude tape, the VNAV target altitude bug parks at the applicable end of the tape. Half of the bug remains in view.

If VNAV data is invalid, the bug is removed.

BARO (Barometric) Altimeter Setting – The BARO set window is located directly below the altitude tape. The pilot can set the BARO correction in English units of inches of mercury (inHg) IN or metric units of hectopascals (hPa) HPA . The value is adjusted with the PFD control BARO SET knob on the guidance panel.

When the **PUSH STD** button on the guidance panel controller is pushed, the altimeter setting window changes to STD and the barometric correction is set to 29.92 inHg or 1013 hPa.

When the BARO set correction status is invalid, the digits are replaced with amber dashes (----). If the barometric altitude data is invalid, the BARO set display is removed.

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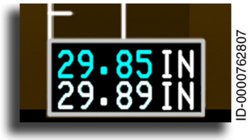

BARO Preset Digital Readout – The preset digital readout is displayed in white below the active BARO readout. When the preset value is set, pushing the BARO SET knob again swaps the preset barometric value with the active barometric setting. The BARO preset corrections are side-dependent.

Radio Altitude

The radio altitude displays, shown in Figure 5-16, include the following:

- Radio altitude readout
- Radio altitude low altitude awareness display
- Selected minimum RA/BARO altitude readout
- Minimum altitude annunciator
- BARO minimum altitude bug.

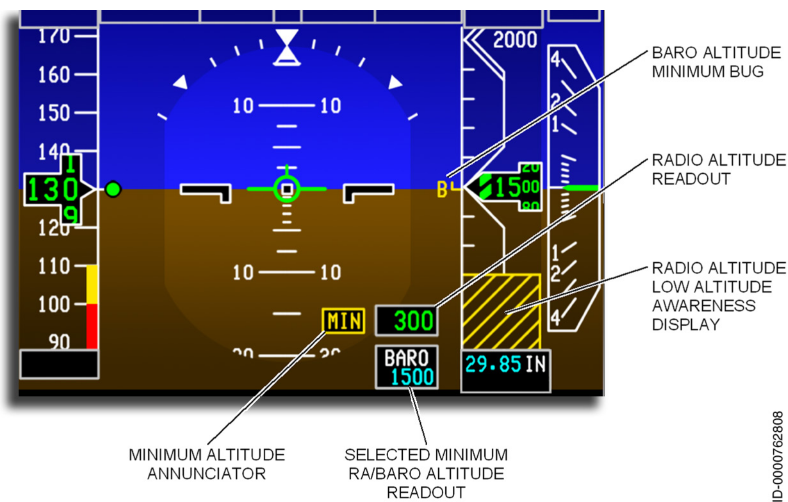

Figure 5-16
Radio Altitude Displays

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Radio Altitude Readout – Radio altitude readout is displayed in a black box with green digits in the lower right of the attitude sphere. The radio altitude consists of up to four digits in the format of XXXX with no leading zeros. Radio altitude is only displayed when the radio altitude is valid and less than 2,500 feet. When the aircraft climbs through 2,560 feet, the display is removed.

The range of the radio altimeter system is -20 to 2,500 feet with resolution of 5 feet below 200 feet, 10 feet for 200-1,500 feet, and 50 feet above 1,500 feet.

In **single radio altitude installations**, when a data miscompare (an RA difference between left and right PFD) or a non-computed data state occurs, the radio altitude and the box are removed from both PFDs. When the system fails, the radio altitude data is removed from the displays, and a corresponding CAS message is generated to identify the failed system.

In **dual radio altimeter installations** and the absence of failures, RALT 1 is displayed on the pilots PFD, and RALT 2 is displayed on the copilots PFD. When one radio altimeter is invalid, the system automatically selects the other radio altimeter. The radio altitude digital displays on both PFDs turn amber, and a corresponding CAS message is posted for the non-valid radio altitude system.

In **dual installations**, when a miscompare occurs between system 1 and 2, an RA source data miscompare annunciator (RA) is displayed above the digital readout box.

In **dual installations**, when the radio altitude is invalid in both RA systems, the radio altitude readout is removed and replaced with a boxed -RA- annunciator. A corresponding CAS message is posted, indicating both radio altitude systems have failed.

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Radio Altitude Low Altitude Awareness Display – The RA low altitude awareness indicates the ground proximity on the altitude tape. Low altitude awareness is displayed as cross-hatched brown and yellow. RA low altitude awareness is displayed when the altitude is below 550 feet AGL. The brown area increases linearly for altitudes from 550 to 0 feet until the shaded area covers the altitude tape to the horizon line where the RA altitude equals zero.

When the radio altitude data is invalid (both invalid in a dual installation), the brown and yellow background changes back to brown, and the amber line is removed.

When the current RA minimum value reaches zero, additional counterclockwise clicks result in the value to display OFF . While OFF is in view, a single clockwise click results in zero being shown regardless of the number of counterclockwise clicks that occurred while OFF was displayed. If OFF is left in view for 5 seconds (that is, an RA minimum of zero or more is not selected), the display RA minimum cutout box and readout are removed from view.

When the current RA minimum value reaches 990, additional clockwise clicks result in the value to display OFF . While OFF is in view, a single counterclockwise click results in 990 being shown, regardless of the number of clockwise clicks that occurred while OFF was displayed. If OFF is left in view for 5 seconds (that is, an RA minimum of 990 or less is not selected), the display RA minimum cutout box and readout are removed from view.

During Flight Modes:

- When APPROACH 1 ONLY (APPR 1 ONLY) is displayed in amber in the FMA armed status field, the RA minimums value on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.

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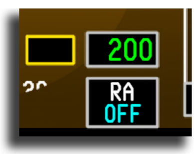
- When APPROACH 2 ONLY (APPR 2 ONLY) is displayed in amber in the FMA armed status field, the RA minimums value on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.
- When NO AUTOLAND (NO AUTOLAND) is displayed in the FMA armed status field, the RA minimums value on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.

If the minimum altitude readout data is invalid, the digital display is removed.

NOTE: The minimum altitude readout is removed from the display during an excessive attitude declutter condition.



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Minimum Altitude Annunciator – When the actual radio or BARO altitude decreases to within 50 feet of the set minimums value, an approach altitude alert annunciator is displayed in the form of an amber lined empty black box ( ) (armed mode) to the left of the radar altitude display.

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When the actual RA or BARO altitude is equal to or less than the approach minimum set value (captured mode), a flashing amber reverse video annunciator (MIN / MIN) is displayed in the box. The MIN annunciator flashes reverse video for 5 seconds and then remains steady.

The minimum altitude annunciator cutout box is removed from the display if the RA/BARO altitude is greater than the selected minimum altitude (+60 feet), if RA/BARO altitude is not displayed, if RA/BARO minimum is not displayed, if the aircraft is on the ground (WOW), or if RA or BARO minimum is selected as active.

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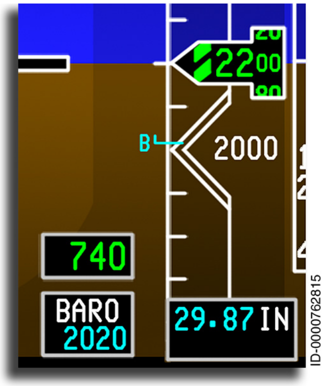


Selected Minimum BARO Altitude Readout and Bug – The selected minimum BARO altitude readout is located in the lower-right corner of the attitude sphere. The normally cyan bug, B (with a ⌙ that sticks out from the left edge of the altitude tape), marks the set altitude. The format of the BARO digital readout is XXXXX in cyan. The range of the BARO readout value is from 0 to 16,000 feet. Leading zeros are not displayed.

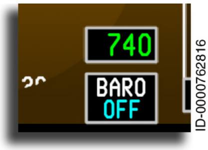
The altitude value is set using the MINIMUMS rotary knob on the PFD controller section of the guidance panel when BARO (barometric altitude) is selected on the MINIMUMS RA/BARO select switch.

When the BARO minimum is not in view, and the RA/BARO skirted switch is in the BARO position, the BARO select altitude cutout box and range are active when the MINIMUMS knob is rotated one click in either direction with the initialization value in view.

Two rates of adjustment exist for the BARO minimum value increments/decrements:

- The slow rate increases or decreases the BARO minimum value by 10 feet for each knob click
- The fast rate increases or decreases the BARO minimum value by 200 feet for each knob click.

Clockwise rotation increases the BARO minimum value, and counterclockwise rotation decreases the value.



When the current BARO minimum value reaches zero, additional counterclockwise clicks result in the value to display OFF. While OFF is in view, a single clockwise click results in zero to be displayed regardless of the number of counterclockwise clicks occurring while OFF was displayed. If OFF is left in view for 5 seconds (that is, a BARO minimum of zero or more is not selected), the display BARO minimum cutout box and readout are removed from view.

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When the current BARO minimum value reaches 16,000, additional clockwise clicks result in the value to display OFF . While OFF is in view, a single counterclockwise click results in 16,000 to be displayed, regardless of the number of clockwise clicks occurring while OFF was displayed. If OFF is left in view for 5 seconds (that is, a BARO minimum of 16,000 or less is not selected), the display BARO minimum cutout box and readout are removed from view.

The BARO minimum altitude bug is normally a cyan label B with a ⌙ sticking out from the left edge of the altitude tape. The minimum altitude bug is positioned by the minimum value controlled by the MINIMUMS knob on the guidance panel and marks the set altitude. It is not displayed if the aircraft is not within +550 feet of the current altitude.

When barometric altitude is equal to or less than the approach minimums set value, the bug (B) turns amber, and the MIN altitude annunciator is displayed in an amber box. The minimum altitude bug flashes with the minimum altitude annunciator when the MIN annunciator is in view.

The BARO minimum bug has priority over the altitude trend vector. The tail overwrites the selected altitude bug.

During Flight Modes:

- When APPROACH 1 ONLY (APPR 1 ONLY) is displayed in amber in the FMA armed status field, the minimum descent altitude on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.
- When APPROACH 2 ONLY (APPR 2 ONLY) is displayed in amber in the FMA armed status field, the minimum descent altitude on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.
- When NO AUTOLAND is displayed in the FMA armed status field, the minimum descent altitude on both PFDs flashes in amber reverse video for 5 seconds and then displays steady in amber.

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On takeoff, the minimums annunciator is inhibited. The display is removed when the value is set to less than 10 feet.

If the minimum altitude readout data is invalid, the digital display is removed, and the B bug is removed.

NOTE: The minimum altitude readout is removed from the display during an excessive attitude declutter condition.

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Vertical Speed (VS) Display

The vertical speed indicates altitude rate. Figure 5-17 shows the vertical speed display. The vertical speed scale is displayed to the right of the altitude tape and includes:

- Vertical speed scale (tape)
- Vertical speed readout
- Selected vertical speed and bug
- VSI/TCAS resolution advisory commands.

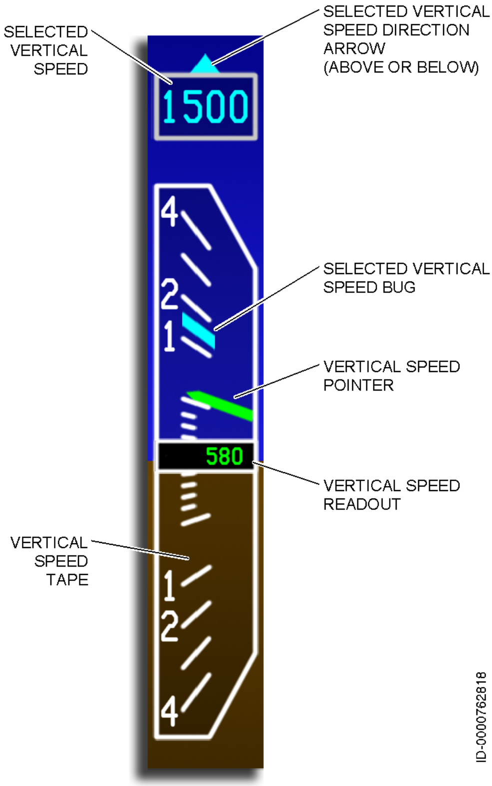

Figure 5-17
Vertical Speed Display

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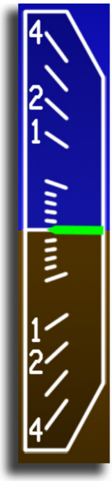


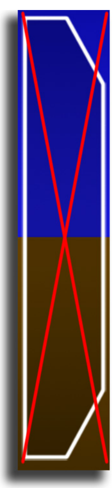
ID-0000762819

Vertical Speed Scale – The vertical speed scale is a fixed white scale with a moving green pointer. The scale ranges from +4,000 to -4,000 feet per minute (FPM). From 0 to ±500 FPM, one white tick mark is at every 100 FPM. From ±1,000 FPM to ±4,000 FPM, one white tick mark is at every 1,000 FPM. The scale is labeled at the thousand FPM tick marks in white as 1 , 2 , and 4 . The scale is expanded between +1,000 to -1,000 FPM.

The vertical speed reference line extends from the vertical center of the display. The reference acts as the zero-point for the vertical speeds.

A green pointer indicates the vertical speed on the scale. For vertical speeds in excess of ±4,000 FPM, the pointer stops at the end of the scale, and the digital display shows the actual vertical speed up to ±9,900 FPM.

When the vertical speed readout goes invalid, amber dashes are displayed (- - - -), and the pointer is removed.


ID-0000762820

When pressure altitude data is invalid, the scale markings and pointer are replaced with an X .

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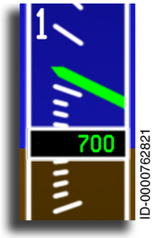
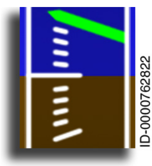


Vertical Speed Digital Readout – The green vertical speed readout is in the center of the vertical speed tape. The readout is only displayed when the vertical speed (up or down) is greater than 550 FPM.

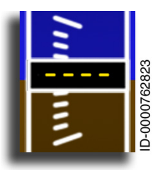
The digital display remains displayed until vertical speed readout value falls between ±500 FPM.

The vertical speed readout is four digits in the format XXXX . Leading zeros are not displayed. The vertical speed readout has a range of ±9,900 FPM. The resolution for the vertical speed readout is 50 FPM for vertical speeds less than 1,000 FPM and 100 FPM for vertical speeds equal to or greater than 1,000 FPM.



For vertical speeds less than ±550 FPM, the digital readout is not displayed.

At vertical speeds greater than ±9,900 FPM, the display changes to amber dashes (- - - -), and the pointer stops at the applicable scale limit.



When the pressure altitude data received is invalid, or when the altitude rate data is invalid, the vertical speed readout value is removed from display and replaced by amber dashes (- - - -).

NOTE: If a TCAS RA is active, the vertical speed readout is removed.

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Selected Vertical Speed Readout and Bug – When VS is the active vertical flight director mode in the FMA, and a valid and within range selected vertical speed value exists, the selected vertical speed readout and bug are displayed.

The cyan selected vertical speed readout is displayed above the vertical speed tape. The selected vertical speed is manually entered by the flight crew using the guidance panel VS wheel when the FGCS is in VS mode. The selected vertical speed readout is four digits in the format XXXX with a resolution of 100 FPM. Leading zeros are not displayed. The selected vertical speed readout is limited to ±9,900 FPM.

The cyan-filled bug is displayed on the vertical speed scale and is positioned at the selected vertical speed readout value. When the value is outside of the vertical speed scale displayable range, the bug stops at the applicable end of the vertical speed scale.

Cyan arrows (▲ / ▼) above or below the display indicate the aircraft must climb or descend to attain the target vertical speed.

The selected vertical speed readout is controlled by the pitch wheel on the guidance panel. Two rates of adjustment exist for the selected vertical speed value increments/decrements:

1. The slow rate increases or decreases the selected vertical speed by 100 FPM for each wheel click.

2. The fast rate increases or decreases the selected vertical speed by 1,000 FPM for each wheel click.

Rotation of the vertical speed knob gives the following results:

- Forward (towards the DN label on the guidance panel) rotation decreases the selected vertical speed value

- Backward (towards the UP label on the guidance panel) rotation increases the selected vertical speed value.

If pressure altitude status is invalid, the selected vertical digital display and bug are removed.

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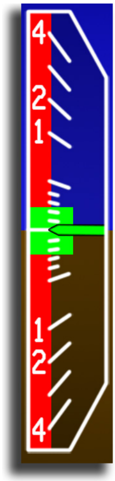
VSI TCAS Resolution Advisory Commands – The VSI is used to display TCAS resolution advisories. An RA is a display indication given to the pilot recommending or prohibiting a maneuver to prevent hazardously close encounters with intruding aircraft. The RA consists of one or two red bands and up to one green band located on the inside the vertical speed indicator. Resolution advisories are also displayed on the ADI.



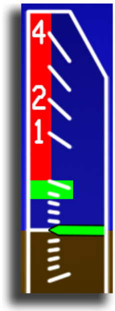
ID-0000762825

The **upper zone** is a fly down avoidance area when red and a fly up area when green.

The **center zone** is a maintain zone when green and an avoidance zone when red.

The **lower zone** is a fly up zone when red and a fly down zone when green.

The up avoidance zone, when displayed, extends from the bottom of the VSI up to the vertical speed corrective guidance provided from TCAS.



ID-0000762826

The up avoidance zone is displayed when a down advisory (descend corrective) is received, and RA on the VSI is activated by the aircraft personality module (APM) configuration file.

The down avoidance zone, when displayed, extends from the top of the VSI down to the vertical speed corrective guidance provided from TCAS.

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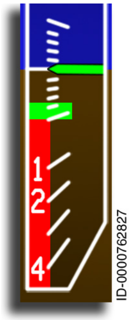

A down avoidance zone is displayed when an up advisory (climb corrective) is received.

When either single corrective is received, the fly-to zone is displayed on the end of the avoidance zone symbol unless a preventive command is indicated. If a preventive command is indicated, the fly-to zone symbols are not shown.

When both a corrective and a preventive command are received at the same time, the fly-to zone is displayed between the avoidance zones. The fly-to zone symbol is compressed as the preventive and corrective commands begin to merge. The fly-to zone is compressed until a minimum fly-to zone height (500 FPM) remains. The minimum fly-to zone height is no longer compressed to make sure a flyable command is displayed.

While a TCAS RA is active to aid in the pilot's compliance with the corrective and/or preventive command, the color of the vertical speed pointer changes when the displayed vertical speed is within an avoidance zone.

- The vertical speed pointer transitions from being displayed in green to being displayed in red when the vertical speed used to position the pointer is 50 FPM greater than the displayed down advisory zone or 50 FPM less than the displayed up advisory zone.
- The vertical speed pointer transitions from being displayed in red to being displayed in green when the vertical speed used to position the pointer is 50 FPM less than the displayed down advisory zone or 50 FPM greater than the displayed up advisory zone.

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Resolution advisory commands are not displayed for an indicated TCAS failure, stale data, invalid command data (or an invalid combination of valid command data), a PFD TCAS abnormal mode annunciator other than TCAS test (while in the air), or if vertical speed is invalid.

Vertical and Lateral Deviation

The ILS vertical and lateral deviation indicators are shown in Figure 5-18. The ILS and FMS deviation indicators are described in the following paragraphs.

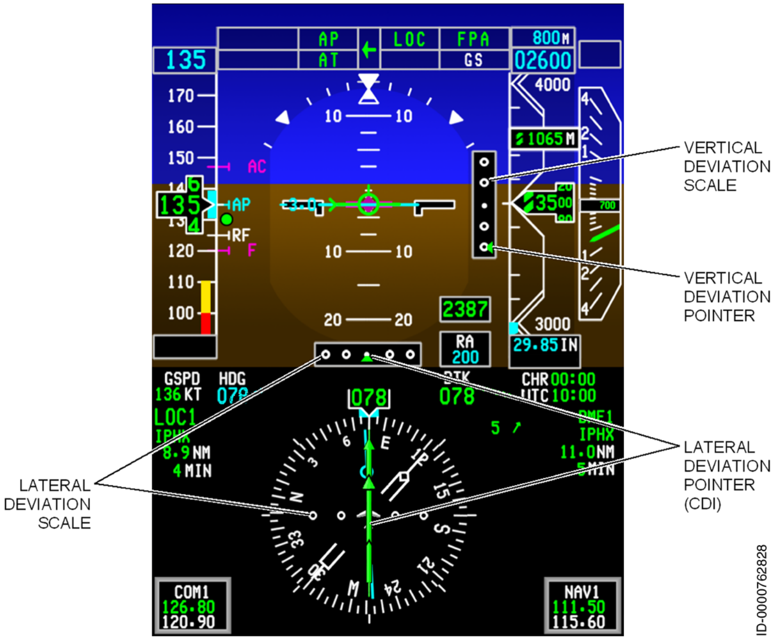

Figure 5-18
Vertical and Lateral Deviation Indicators

VERTICAL DEVIATION

Vertical Deviation Scale and Pointer – The vertical deviation scale is positioned vertically on the right side of the ADI. The vertical deviation display consists of a rectangular centerpoint with two dots above and below and a pointer indicating current vertical deviation. The pointer is controlled by the selected primary navigation source (PNS).

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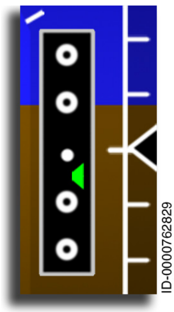
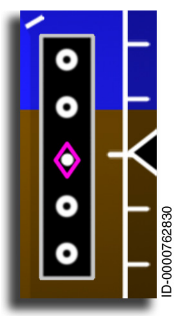
The vertical deviation scale is displayed when:

- Localizer (LOC) is selected as the PNS
- GLS (GBAS channel is tuned) is selected as the PNS
- FMS is selected as the PNS, and the FMS commands the VNAV vertical scale in view.



The vertical deviation display consists of a rectangular centerpoint reference with two circles (dots) above and two below the reference. The first dot above or below the rectangle reference is 50 percent, and the second dot above or below is 100 percent. The top and bottom of the scale represent 125 percent vertical deviation.

The color and shape of the arrow indicate the source of the vertical deviation data. The ILS LOC deviation pointer is a green trapezoid ( ). The VNAV FMS is a magenta hollow diamond ( ). The scale and markings are identical regardless of the source (ILS or FMS). The scale and markings are white.



When the deviation symbol is centered on the vertical deviation scale, there is zero deviation. The scale is divided into two linear portions with different scale factors. One linear portion consists of the area from the center rectangle to each of the outer dots. The second linear portion consists of the area past the outer dots on each end of the scale.

The first and second dots represent the deflection as follows (in one direction on the inner scale):

- The first dot represents 50% deflection
- The second dot represents 100% deflection.

Deviation smoothly transitions to the second scale factor, which extends from the outer edge of the outer dots to the outermost edge of the scale. This is maximum deflection.

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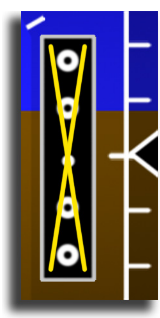
During a typical 3° approach with angular deviations (ILS, LPV, and GLS), a one-dot vertical deflection at 5 NM equals approximately 186 feet deviation from center. A one-dot deflection at the middle marker (MM) equals approximately 18 feet deviation from center.

During an approach with linear deviations (LNAV/VNAV), the deviation distance for a one-dot vertical deflection at 5 NM and a one-dot vertical deflection at the MM are the same. The vertical distance from center varies depending on the sensitivity of the selected approach.

Table 5-16 lists the resolution of the FMS vertical deviation scale.

Table 5-16
FMS Vertical Deviation Scale

Pointer Deflection	FMS
Centered	0
One dot	1/2 * FMS vertical deviation scale
Two dots	1 * FMS vertical deviation scale
Maximum deflection	2 * FMS vertical deviation scale


ID-0000762831

When glideslope data is invalid, the pointer and scale are removed, and an X is placed over the deviation scale.

When the vertical deviation scale is commanded into view by the FMS, and a valid deviation is not available, the failure is indicated by replacing the vertical deviation pointer with an X .

NOTE: The vertical deviation scale and pointer are removed from the display during an excessive attitude declutter condition.

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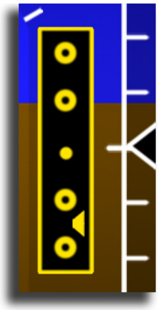
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Excessive Vertical Deviation – The excessive vertical deviation display provides the pilot with an indication that the aircraft has deviated excessively from the Approach 2 vertical approach path. When excessive deviation is detected, the scale markings and pointer change to amber, and the scale flashes (the glideslope pointer does not flash).

NOTE: The excessive vertical deviation value is defined as one dot.

Excessive vertical deviation is enabled when all of the following conditions are met for greater than 0.5 seconds and remains displayed for a minimum of 5 seconds to prevent transient flashing to the pilot:

For APPR2 or higher approaches (APPR2 or AUTOLAND1):

- APPR 2 or AUTOLAND 1 is engaged
- 700 feet > RAD Alt ≥ RA MIN and RAD Alt ≥ 100 feet or
- 700 feet > RAD Alt and Baro MIN = 0 ft/OFF.

For ILS/GLS Approaches:

- APPR1 or G-APPR1 is engaged
- 700 feet > Rad Alt ≥ RA MIN and RAD Alt ≥ 200 feet or
- 700 feet > RAD Alt and Baro Alt ≥ Baro MIN and Rad Alt ≥ 200 feet.

LPV Approach:

- LPV approach is engaged
- RAD ALT ≥ 200 feet and VGP or GS mode is active
- A/C is between FAF and MAP
- Valid GPS deviation or FMS vertical deviation has been less than the excessive vertical deviation value at least once since VGP or GS mode has been active.

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RNP Approach:

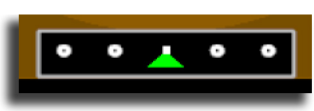
- RNP approach is engaged
- RAD ALT ≥ 200 feet and VGP mode is active
- A/C is between FAF and MAP
- Valid FMS vertical deviation has been less than the excessive vertical deviation value at least once since VGP has been active.

LNAV/VNAV Approach:

- LNAV/VNAV approach is engaged
- RAD ALT ≥ 200 feet and VGP mode is active
- A/C is between FAF and MAP
- Valid FMS vertical deviation has been less than the excessive vertical deviation value at least once since VGP has been active.

LATERAL DEVIATION

ADI Lateral Deviation – The ADI lateral deviation display is a scale that has a rectangular centerpoint and four dots. Two are to the left of the reference symbol, and two are to the right. Two different pointers are used to indicate current lateral deviation. A magenta open diamond-shaped pointer ( ) is used for FMS deviation, and a green triangular-shaped pointer ( ) is used for LOC. When both pointers are in view at the same time, such as during PREV operation, the FMS pointer overwrites the LOC pointer when both are at the same point on the scale. The ADI lateral deviation display is located near the bottom of the ADI. The pointer of the ADI lateral deviation display is controlled by the selected primary navigation source.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Localizer Lateral Deviation Display – Any time a localizer frequency is tuned, the lateral deviation indicator is displayed at the bottom of the ADI with a green triangular-shaped pointer ( ). This is a raw-data indicator that amplifies localizer lateral deviation data to center the aircraft on the localizer. The green pointer indicates 1 degree for each dot. When the aircraft has a heading of more than 92 degrees from the selected course, the deviation pointer sensing is reversed.

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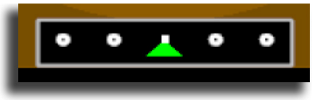

ID-762834

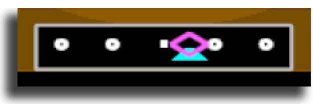
GLS Lateral Deviation Display – Any time a GBAS frequency is tuned, the lateral deviation indicator is displayed at the bottom of the ADI with a green triangular-shaped pointer ( ). The GPS-provided lateral deviation data provides aircraft lateral deflection from the approach path.


ID-762835

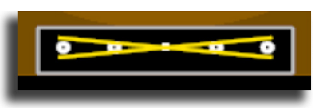
FMS Lateral Deviation Display – Any time FMS is selected as the primary, the lateral deviation indicator is displayed at the bottom of the ADI with a magenta open diamond-shaped pointer ( ).

If FMS is the PNS and desired track is not within ±95 degrees of the lubber line, the ADI lateral deviation scale is removed to prevent the HSI lateral deviation from moving in the opposite direction of the ADI lateral deviation.

For deviations in excess of maximum deflection, the ADI lateral deviation indicator stops at the limit of the ADI lateral deviation scale in the applicable direction.


ID-762836

When FMS is the PNS and preview mode is active, a cyan preview pointer ( ) is displayed with the FMS lateral deviation pointer. When both pointers are in view at the same time, and both are at the same point on the scale, the FMS pointer overwrites the preview pointer.


ID-762837

When a valid deviation is not available, the failure is indicated by replacing the ADI lateral deviation pointer with an X .

Expanded Lateral Deviation – The expanded lateral deviation display is a horizontally positioned rectangular scale. The expanded scale is displayed in place of the ADI scale for Category 2 operations.

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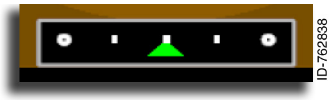

The expanded lateral deviation display has a rectangular centerpoint with one rectangle and one dot on each side of the centerpoint. The LOC pointer indicates current lateral deviation. The expanded lateral deviation display is located below the ADI sphere. The expanded lateral deviation scale and pointer are displayed when LOC is selected as the primary navigation source and the APPR 2 or higher landing is active.

For deviations in excess of maximum deflection, the expanded lateral deviation indicator moves to the limit of the expanded lateral deviation scale in the applicable direction and stops.

When a valid deviation is not available, the expanded lateral deviation pointer is removed, and an X is displayed.

When the deviation symbol is centered on the vertical deviation scale, there is zero deviation. The scale is divided into two linear portions with different scale factors. One linear portion consists of the area from the center square to each of the outer dots. The second linear portion consists of the area past the outer dots on each end of the scale.

The first and second dots represent the deflection as follows (in one direction on the inner scale):

- The first dot represents 50% deflection
- The second dot represents 100% deflection.

Deviation smoothly transitions to the second scale factor, which extends from the outer edge of the outer dots to the outermost edge of the scale. This is maximum deflection.

The dot on the expanded lateral deviation display is equal to the excessive LOC deviation value. Maximum deflection is equal to twice the value of the excessive LOC deviation value.

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Excessive Lateral Deviation – The excessive lateral deviation display supplies the pilot with an indication that the aircraft has deviated excessively from the Approach 2 lateral approach path. The display is in the same format and location as the expanded lateral deviation. When excessive deviation is detected, the scale markings and pointer change to amber, and the scale flashes (the LOC pointer does not flash).

Excessive lateral deviation is enabled when all of the following conditions are met for greater than 0.5 seconds and remains displayed for a minimum of 5 seconds to prevent transient flashing to the pilot:

For APPR2 or higher approaches (APPR2 or AUTOLAND1):

- APPR 2 or AUTOLAND 1 is engaged
- 700 feet > RAD Alt ≥ RA MIN and RAD Alt ≥ 50 feet or
- 700 feet > RAD Alt and Baro MIN = 0 ft/OFF.

For ILS/GLS Approaches:

- APPR1 or G-APPR1 is engaged
- 700 feet > RAD Alt ≥ RA MIN and RAD Alt ≥ 200 feet or
- 700 feet > RAD Alt and Baro Alt ≥ Baro MIN and RAD Alt ≥ 200 feet.

LPV Approach:

- LPV approach is engaged
- RAD ALT ≥ 200 feet
- A/C is between FAF and MAP
- Valid GPS lateral deviation has been less than the excessive lateral deviation value at least once since LPV approach is engaged.

RNP Approach:

- RNP approach is engaged
- RAD ALT ≥ 200 feet

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- A/C is between FAF and MAP
- Valid FMS lateral deviation has been less than the excessive lateral deviation value at least once since RNP approach is engaged.

LNAV/VNAV Approach:

- LNAV/VNAV approach is engaged
- RAD ALT ≥ 200 feet and VGP mode is active
- A/C is between FAF and MAP
- Valid FMS lateral deviation has been less than the excessive lateral deviation value at least once since LNAV/VNAV has been active.

HSI Lateral Deviation – Lateral deviation information from the currently selected PNS is displayed as the center bar inside the HSI in the Full Compass view (shown previously in Figure 5-18) and Arc view (shown here). In the Full Compass and Arc views, the lateral deviation bar is the center portion of the selected course pointer. A deviation scale is included and consists of an aircraft symbol and four dots. There are two to the left of the aircraft symbol and two to the right. Both the scale and the deviation bar rotate with the selected course/desired track.

The deviation symbol is centered on the aircraft symbol when there is zero deviation. The scale is divided into two linear portions with different scale factors:

- One linear portion goes from the aircraft symbol to the outer dots
- The second linear portion is the area past the outer dots on each end of the scale.

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The first and second dots represent the percent (%) deflection as follows (in one direction on the inner scale):

- One dot out from center represents 50% deflection
- Two dots out represents 100% deflection.

Deviation smoothly transitions to the second scale factor, which extends from the center of the second dot to the outermost edge of the scale. This is the maximum deflection. Resolution of each linear portion varies depending on the active PNS.

During a typical approach with angular deviations (ILS, LPV, or GLS), a one-dot lateral deflection at 5 NM equals approximately 730 feet deviation from center. A one-dot deflection at the MM equals approximately 228 feet deviation from center.

During an approach with linear deviations (RNP, LNAV/VNAV), the deviation distance for a one-dot lateral deflection at 5 NM and a one-dot lateral deflection at the MM are the same. The lateral distance from center varies depending on the sensitivity of the selected approach.

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Table 5-17 lists the PFD HSI lateral deviation range.

Table 5-17
PFD HSI Lateral Deviation Range

Pointer Deflection	VOR PNS	FMS
Centered	0	0
One dot	5 degrees	1/2 * FMS lateral deviation scale
Two dots	5 degrees	1 * FMS lateral deviation scale
Maximum deflection	5 degrees	2 * FMS lateral deviation scale

Table 5-18 lists lateral deviation with GPS (LPV) or GLS PNS.

Table 5-18
Lateral Deviation

Pointer Deflection	LOC PNS	FMS PNS With GPS (LPV) or GLS PNS
Centered	0	0
One dot	0.0775 DDM (175 feet)	0.0775 DDM (175 feet)
Two dots	0.1550 DDM (350 feet)	0.1550 DDM (350 feet)
Maximum deflection	0.3100 DDM (718 feet)	0.3100 DDM (718 feet)

For deviations in excess of the maximum deflection bar, the lateral deviation bar stops at the limit of the lateral deviation scale in the applicable direction.


ID-762842

When a valid deviation is not available from the currently selected PNS, the lateral deviation bar is replaced with an X.

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In the arc with map view, which is only available when FMS is the PNS, the lateral deviation is displayed in digital format under the aircraft symbol at the bottom of the display, as shown in Figure 5-19. The display consists of a digital readout and a label of L or R, indicating deviation to the right or left.

Figure 5-19
Lateral Deviation Display on PFD in Arc Mode With Map View

The lateral deviation digital readout consists of a digital readout followed by the letter L or R, as applicable when FMS is the PNS. The L or R direction indicates the aircraft is to the left or right of the flight plan ground track. R is also displayed when the deviation is zero (0.00 R), serving as a nomenclature substitute. The range of the digital readout is -99.9 NM to 99.9 NM, with the resolution rounded to 0.1 or 0.01 NM, depending on the numerical format.

When the deviation is greater than 99.9 or less than -99.9, the digital readout stops at 99.9 and adds a trailing plus sign (+) and the applicable letter (e.g., 99.9 R +).

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When a valid deviation is not available from the currently selected FMS PNS, the + and L or R annunciators are removed, and the lateral deviation readout is displayed as three amber dashes (- - -).

FMS SBAS APPROACHES

The satellite-based augmentation system (SBAS) is the implementation of a ground sensor-generated correction signal transmitted to an SBAS-equipped GPS receiver by way of a geosynchronous satellite. Several countries and/or groups of countries are developing their own SBAS system with their own respective names. The SBAS systems in development at this time are as follows:

- Wide Area Augmentation System (WAAS) for the United States and Canada
- European Geostationary Navigation Overlay System (EGNOS) for Europe
- Multifunction Transportation Satellite-Based Augmentation System (MSAS) for Japan
- GPS Aided Geo Augmented Navigation (GAGAN) for India.

The SBAS GNSSU is compatible with WAAS and EGNOS and is designed for future SBAS systems, as defined by RTCA/DO- 229D.

Localizer Performance With Vertical Guidance (LPV)

ADDITIONAL RESOURCES: LOCALIZER PERFORMANCE WITH VERTICAL GUIDANCE	
Video (ID-585316)	For an operational description of Honeywell FMS Localizer Perf with Vertical Guidance (LPV) for Embraer E-Jets, select the link or scan the QR code. http://y2u.be/RdJyNyLaW98

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RNAV (GPS) approaches with LPV minimums are typically lower than LNAV or LNAV/VNAV approaches. An approach with LPV minimums is designed specifically for SBAS environments. SBAS/ LPV procedures are RNAV approaches defined as one of four possible lines of approach minimums found on an RNAV approach chart. SBAS avionics equipment approved for RNAV approaches with LPV minimums is required for this type of approach.

The term LPV is used to generically describe SBAS approaches.

RNAV approaches with LPV minimums are normally conducted utilizing the LNAV and GP flight director modes. The FMS lateral navigation (LNAV) function is utilized to provide lateral guidance by way of roll steering commands to the AFCS to capture and maintain the lateral course by way of the LNAV flight director mode.

The FMS glide path (GP) function computes the approach geometry based on GPS altitude data (for LPV approach pointer). It provides vertical guidance to the AFCS to capture and maintain the GPS linear glide path until the final approach segment (FAS).

NOTE: When the displayed deviations are received directly from the GPS, the HSI navigation source indicators remain FMS.

FINAL APPROACH SEGMENT (FAS) DATA BLOCK

RNAV approaches with LPV minimums have an additional data construct stored in the navigation database called a FAS data block. The FAS data block describes the points of an approach that permit the lateral and vertical deviations to mimic the angular deviations found on an ILS. The data in the FAS data block describes where the localizer and glideslope antennas would be when installed. Selecting the LPV minimums on the RNAV MIN page of the FMS loads the GPS receiver with the proper FAS data block.

NOTE: When available, LPV minimums are automatically selected by default.

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APPROACH SELECTION

When an RNAV approach with LPV minimums is selected on the FMS ARRIVAL page, a prompt labeled **RNAV MIN** is displayed in line 4R. The **RNAV MIN** prompt is shown in Figure 5-20.

NOTE: This page can be used to verify the correct channel ID and approach ID that are loaded into the FMS and match the approach plate.

Figure 5-20
RNAV MIN Prompt (ARRIVAL Page)

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Selecting RNAV MIN at 4R on the ARRIVAL page shows the APPROACH MINIMA TYPE page, as shown in Figure 5-21. The APPROACH MINIMA TYPE page is used to select the type of minimums corresponding to the selected RNAV approach.

Figure 5-21
APPROACH MINIMA TYPE Page

The APPROACH MINIMA TYPE page displays the available RNAV minimums for the selected approach. LPV is displayed at 1L, and LNAV/VNAV is displayed at 3L. Pushing 1L selects LPV minimums for the approach (and loads the FAS data block into the GPS). Pushing 3L selects LNAV/VNAV minimums for the approach. (SEL) is displayed in white next to the selected RNAV minimums. The default RNAV minimums selection is LPV.

Approach Displays

The status of the RNAV approach to LPV minimums is displayed in the approach status line of the FMA. The following paragraphs describe the annunciations associated with an RNAV approach to LPV minimums.

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LPV ARMED

LPV is displayed in white on the PFD, as shown in Figure 5-22, when armed. LPV becomes armed when an LPV approach is selected, the **APPR** button is pushed, the coupled PFD NAV source is FMS, the LNAV and GP modes are armed or active, and the coupled NAV preview source is not selected. Lateral and vertical deviations on the PFD are still driven by the FMS. The navigation source is annunciated as FMS1 or FMS2 .

Figure 5-22
LPV Armed Indication

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LPV ACTIVE

LPV is displayed in magenta on the PFD, as shown in Figure 5-23, when active. LPV becomes active within 2 NM of the final approach fix (FAF). APPR is displayed on the PFD or GPS distance of 5 NM or less to the runway. When LPV transitions from armed to active, the lateral and vertical deviations displayed on the PFD are angular in nature and are sent directly from the SBAS capable GPS sensor. All systems are operational for the approach. The AFCS applies existing ILS control laws to the GPS deviations to provide flight director commands. The pilot can descend to LPV minimums.

NOTE: If LPV is active and the default GPS source displayed on the coupled PFD fails, the mode source automatically transitions to the other valid GPS source without disengaging LPV. The coupled PFD will display the other valid GPS source as the mode source on the coupled PFD.

Figure 5-23
LPV Active Indication

Lateral deviation is indicated by a magenta FMS lateral deviation indicator on the HSI. Vertical deviation is indicated by a magenta GP deviation indicator displayed on the vertical deviation scale located to the left of the altitude readout. The deviations are driven directly by the GPS receiver. However, the FMS still acts as the source of the database data and resumes as the source of NAV deviation data in the event a missed approach is initiated.

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The GP pointer is used to indicate vertical path deviations during an approach to LPV minimums. When GP is armed, the preview pointer is displayed. When the GP mode is armed, and the GP pointer moves toward the center, and the capture criteria are satisfied, the FMS captures the GP mode. The GP preview pointer is displayed until the GP mode is captured. The GP preview and active pointers are shown in Figure 5-24.

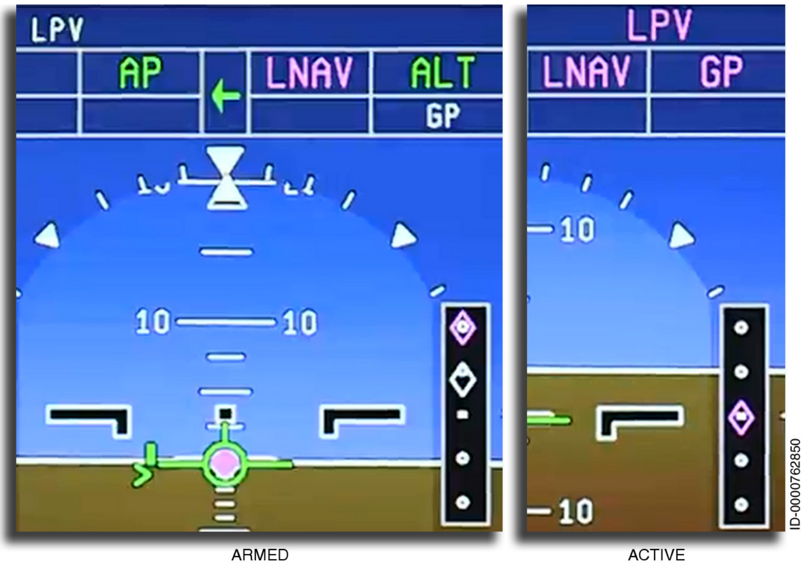

Figure 5-24
GP Pointers

NOTE: When the VPATH and GP vertical paths are non-coincidental, a split may be seen between the VPATH and GP pointers.

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LPV ERROR INDICATIONS

When LPV is armed (LPV) and the system is unable to perform an approach to LPV minimums, the LPV NOT AVAIL CAS message is displayed, and the LPV annunciation is removed from display.

When LPV is active (LPV) and a failure is detected, the NO LPV annunciator, shown in Figure 5-25, flashes reverse video, and an *X* is displayed on the vertical deviation scale. The *X* adds emphasis to the pilot that the guidance is no longer valid. Pilots can continue to LNAV minimums when the aircraft is above the minimums or the next step-down altitude for the LNAV approach. A missed approach must be performed when the aircraft is below a required altitude on the approach and cannot transition visually to land. Loading a different approach may also be considered.

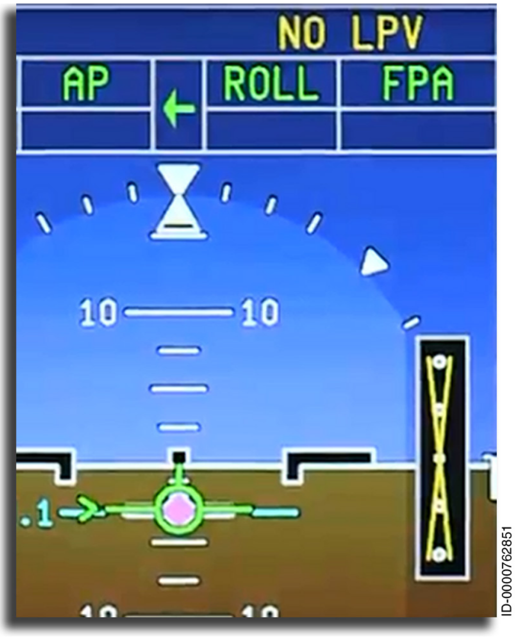

Figure 5-25
LPV Abnormal Disengage Indication

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IDENTIFICATION OF APPROACH

To ensure the proper approach is loaded into the GPS, the reference path identifier (sometimes called the Approach ID) replaces the DME source annunciator on the PFD, as shown in Figure 5-26. The reference path identifier field is displayed when LPV is active. The DME readout is also replaced by GPS distance when LPV is active.

ID-0000762852

Figure 5-26
Reference Path Identifier

The GPS-derived airport ICAO identifier is also displayed below the reference path identifier. The flight crew must visually match this data with the information on the approach chart to verify that the proper FAS data block is loaded into the GPS.

NOTE: The channel ID is only displayed on the ARRIVAL and APPROACH MINIMA TYPE page on the MCDU and is not displayed on the PFD.

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If LPV is active and a failure is detected (NO LPV annunciation), the airport identifier and reference path identifier flash amber reverse video for 5 seconds and then are displayed in steady amber.

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RNP DISPLAY

The numeric display of required navigation performance (RNP) is not displayed for an RNAV approach to LPV minimums. The displayed distance is the GPS distance and not a distance to a NAVAID or FMS distance.

Canceling an RNAV Approach to LPV Minimums

An RNAV approach to LPV minimums is canceled by any of the following:

- Direct-to the runway waypoint is selected
- Flight plan destination is changed
- Missed approach is activated by pushing a **TOGA** button or by selecting the MISSED APPR prompt on the FMS
- The alternate flight plan is activated
- The aircraft is on the ground
- An approach is activated with minima other than LPV selected
- The flight plan is cleared
- Selecting HDG or FLCH modes once LPV engaged
- Selecting the **APPR** button once LPV engaged.

The following takes place when an LPV approach is canceled:

- Lateral and vertical deviation indicators are driven by the FMS. At this point, the lateral and vertical deviation indications are no longer angular but linear
- The course width of the lateral deviation scale is the RNP value, and the numeric RNP value is once again displayed on the PFD
- The LPV status indication is removed from the PFD
- The FMS sends a signal to the GPS to clear the FAS data block out of memory
- The ICAO Airport ID and the reference path identifier display are removed from the PFD

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- When a missed approach is initiated by a **TOGA** button, the vertical mode changes to GA, and the missed approach is activated. When the MISSED APPR prompt on the MCDU is pushed, the vertical mode does not change. However, the missed approach procedure is activated.

LPV Scratchpad Messages

The scratchpad **PREDICT LPV UNAVAIL** is displayed when the GPS 5-minute look-ahead horizontal integrity limit (HIL) value is greater than the FAS data block horizontal alert limit (HAL) value when 5 minutes from the FAF.

The scratchpad message **FMS/LPV MISCOMPARE** is displayed when the FMS channel ID for the approach is different from the GPS channel ID loaded for the approach. The channel ID for a WAAS approach is displayed on the approach plate. Pilot-action is to reload the approach to sync the channel IDs.

The scratchpad message **LPV APPR LOAD FAIL** is displayed if the FAS data block fails to load successfully.

RNAV Approach to LPV Minimums Sequence

An RNAV approach with LPV minimums is initially selected in the MCDU. Figure 5-27 shows an ARRIVAL page with an RNAV approach (with LPV minimums) selected.

Figure 5-27
RNAV Approach With LPV Minimums Selected

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The **LPV** armed annunciator is displayed when an LPV approach is selected, the **APPR** button is pushed, the coupled PFD NAV source is FMS, and the LNAV and GP modes are armed or active. Figure 5-28 shows the **LPV** armed annunciator.

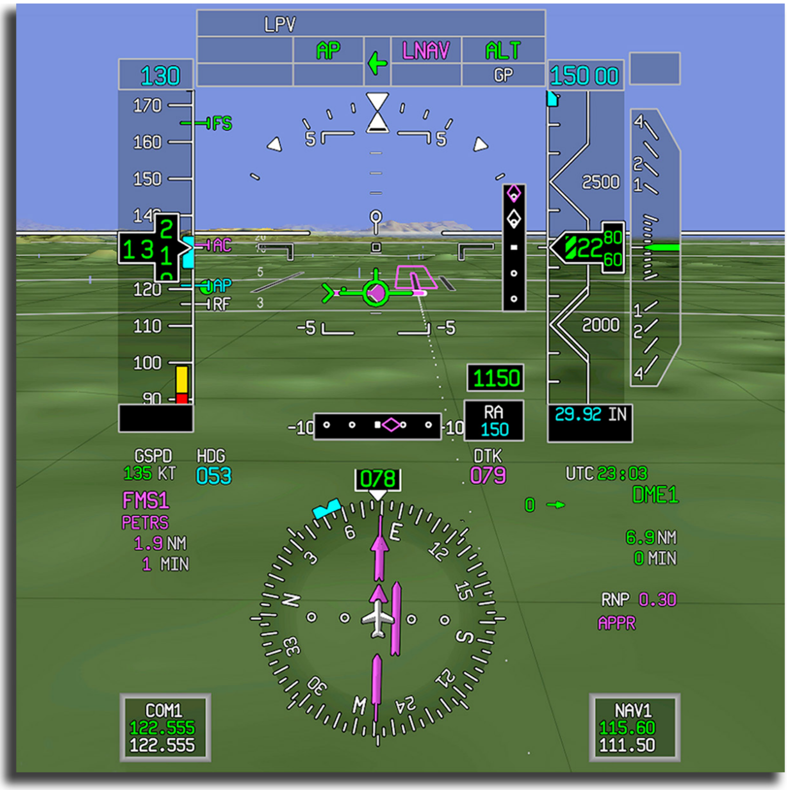

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Figure 5-28
LPV Armed

The **GP** mode is armed once the FMS determines the **GP** mode arm criteria have been met, and the **APPR** button on the guidance panel is pushed. The **APPR** button also arms the FMS LNAV.

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Once the GP mode is armed, LNAV is captured, and the GP pointer moves toward the center of the scale and enters the FMS capture criteria, the FMS captures the GP mode. Figure 5-29 shows the GP mode captured.

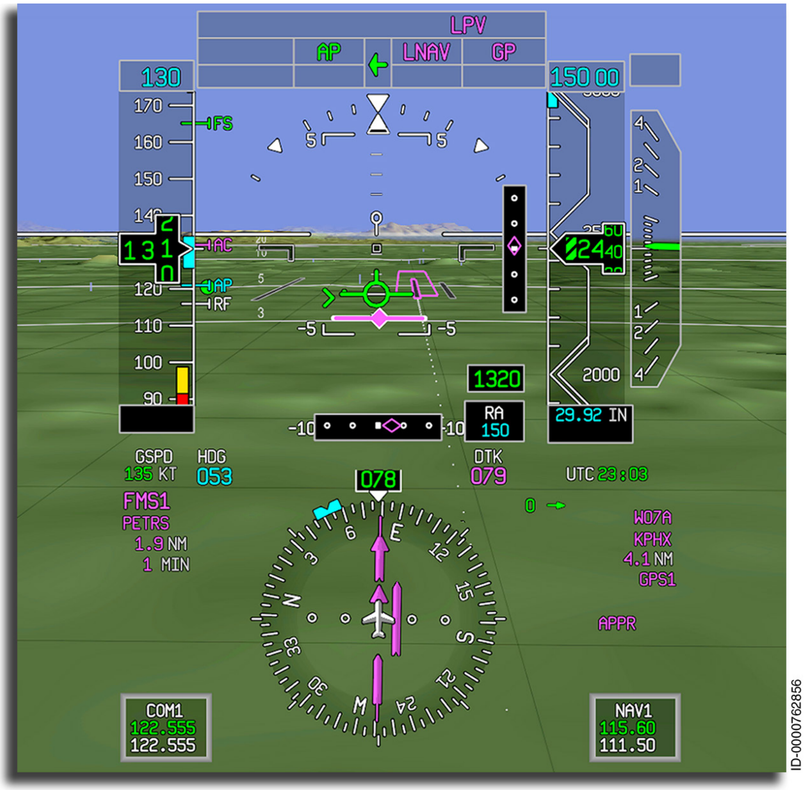

Figure 5-29
LPV Captured

Once the LPV capture criteria are met, the LPV captured annunciator is displayed. This indicates the system is now using angular deviations directly from the GPS.

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PFD COMPARISON MONITORS

The comparison monitor annunciators shown in Figure 5-30, are located in various places on the ADI. When displayed, the comparison monitor annunciators flash reverse video for the first 5 seconds, then remain steady. Active messages are cleared when the miscompare condition is resolved.

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Figure 5-30
Comparison Monitor Annunciator Locations

The comparison is made when the pilot and copilot have different sources selected for display. The comparisons are inactive when the pilot and copilot have the same source selected (amber source annunciator).

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Comparison Monitor Annunciator – A monitor warning annunciates when an unacceptable cross-compare of any of the following parameters is detected. Table 5-19 lists the following comparison monitors and limits:

- Pitch
- Roll
- Attitude
- Heading
- BARO altitude
- Airspeed
- Localizer
- Glideslope
- Radar altitude
- Flight path angle
- GPS lateral and vertical glide path
- PFD 1-2
- MFD 1-2
- Crew Alerting System (CAS).

Table 5-19
Monitor Annunciators

<table>
<tr><th>Annunciator</th><th>Parameter</th><th>Comparison Limits</th></tr>
<tr><td>PIT
ROL
ATT</td><td>Attitude</td><td>Pitch – >5°
Roll – >6°
ATT – both monitors tripped</td></tr>
<tr><td>HDG</td><td>Heading</td><td>>6°</td></tr>
<tr><td colspan="3">NOTE: When the pilot and copilot’s heading modes are different (true vs. magnetic), the output of the monitor is set false, inhibiting the monitor.</td></tr>
<tr><td>ALT</td><td>Altitude</td><td>> 200 feet</td></tr>
<tr><td>IAS</td><td>Airspeed</td><td>> 5 knots</td></tr>
<tr><td colspan="3">NOTE: When both the pilot and copilot’s displayed airspeed is below 100 knots, the output of the monitor is set false, inhibiting the monitor.</td></tr>
</table>

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Table 5-19 (cont)
Monitor Annunciators

Annunciator	Parameter	Comparison Limits
LOC	Localizer	> 1/2 dot (> 40 mv)
NOTE: When the pilot and copilot's primary navigation source is not LOC, the output of the monitor is set false, inhibiting the monitor.		
GS	Glideslope	> 2/3 dot (> 40 µA)
GPS	GPS Vertical and Lateral	> 50 µA
RA	Radio Altitude	> 10 ft (dual configuration only)
FPA	Flight Path Angle	> 2°
MFD 1-1/ PFD 1-2	CAS	Graphics Test data monitor fail annunciator for EICAS. Priority is given to DU (PFD vs. MFD), which has EICAS window.
CAS MSG	CAS	CAS miscompare monitor is performed continuously on all valid sources of CAS data and annunciates on each available PFD when a miscompare between these sources is detected.
NOTES 1. The CAS miscompare monitor verifies that both monitor warning functions (MWF) are producing the same active text messages. The monitor warning function calculates a checksum of the active message level and text to be compared by the PFD process. The monitor is debounced to make sure each MWF has time to generate a new message. When a difference is detected, an amber message is displayed on the PFD, indicating a miscompare. Miscompare occurs only when the CAS text checksums disagree for a continuous period of 7 seconds. Any agreement in checksum values resets the debounce logic. Agreement resets the miscompare immediately (that is, there is no off timer). 2. During eASCB fault, when one MWF source is not able to see the other MWF source, CAS MSG annunciation is posted.		

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NOTE: When GPS mode is active, the FMS uses the blended GPS position to update the FMS present position. The FMS uses a position comparison test to determine which GPS position inputs must be used to form the blended GPS position. The FMS uses a priority scheme (each FMS uses the on-side GPS) to choose a single GPS for position update when the two GPS sensors are providing positions that differ by an amount greater than the limits used in the position comparison test. When GPS mode is active, GPS is displayed as the position determination mode on the PROGRESS 1/3 page on the MCDU.

The aural warning "**PFD MISCOMPARE, PFD MISCOMPARE**" double chime) is sounded for the following miscompares on the PFD:

- Altitude
- Airspeed
- Pitch
- Attitude
- Roll
- Radar altimeter
- FPA.

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The E-Jet E2 E190/E195-E2 is equipped with the Head-Up Display (HUD) (option) (Non-Honeywell). It is able to provide flare guidance to aid the pilot in completing the visual segment of the landing. In case of failure in which the HUD cannot provide flare guidance, the annunciator **NO FLARE** is displayed on the PFD in amber, as shown in Figure 5-31.

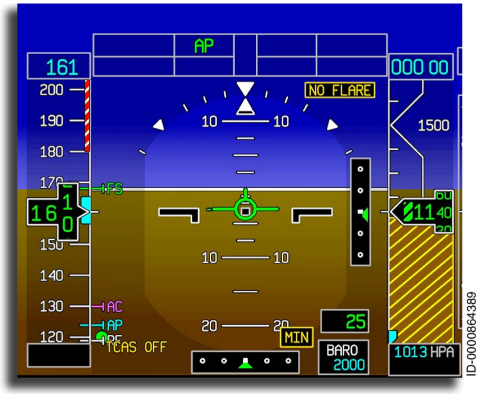

Figure 5-31
PFD with NO FLARE Annunciator

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HORIZONTAL SITUATION INDICATOR (HSI) DISPLAYS AND ANNUNCIATORS

The heading display on the HSI for the PFD has three selectable modes:

1. Full compass mode
2. Arc mode
3. Map mode.

The full compass, arc, or map mode is selected by pushing the **HSI** button on the guidance panel. The full compass mode is shown in Figure 5-32.

Figure 5-32
HSI Full Compass Mode

On initialization, the full compass mode is displayed. The full compass mode gives a 360-degree compass view with the aircraft centered in the compass scale. The full compass mode contains the following:

- A full compass heading scale with fixed 45-degree tick marks
- An aircraft symbol
- A fixed lubber line
- A digital heading readout
- A selected heading readout and bug
- A heading source annunciator
- A drift angle bug

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- A selected course (CRS)/desired track (DTK) readout and pointer
- A TO/FROM pointer
- FMS track target indicator.

The arc mode is shown in Figure 5-33.

Figure 5-33
HSI Arc Mode

The arc mode gives 90 degrees of compass view with the aircraft at the bottom of the compass scale. The arc mode contains the following:

- An arc heading scale
- An aircraft symbol
- A fixed lubber line
- A digital heading readout
- A selected heading readout, bug, and bug out-of-view arrow
- A heading source annunciator
- A drift angle bug
- A selected course (CRS)/desired track (DTK) readout and pointer
- A TO/FROM pointer
- FMS track target indicator.

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The arc mode with weather enabled is shown in Figure 5-34.

Figure 5-34
HSI Arc Mode With Weather Enabled

The map mode is shown in Figure 5-35.

Figure 5-35
HSI Map Mode With Weather Enabled

The map mode gives 90 degrees of compass view with the aircraft at the bottom of the compass scale. The map mode contains the following:

- An arc heading scale
- An aircraft symbol
- A fixed lubber line
- A digital heading readout

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- A selected heading readout and bug
- A heading source annunciator
- A selected course (CRS)/desired track (DTK) readout.

Full Compass Heading Scale

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Full Compass Display – The full compass display is a 360° compass rose. The cardinal headings are labeled N, S, E, and W. Headings at 30-degree increments are labeled with one-digit or two-digit degree markings (e.g., 060° is 6, 330° is 33).

The scale tick markings are in 5-degree increments. Long tick marks are at 10-degree increments, and short ones are in between.

Fixed 45-degree tick marks are displayed at 45-degree intervals along the circumference of the heading scale with respect to the lubber line (V) to give directional reference.

The compass is centered around the reference aircraft symbol with the scale rotated to align the current aircraft heading to the 12 o'clock position.

Present heading is indicated by a fixed lubber line (V) at the top of the heading scale with a digital heading readout directly above the lubber line. The layout for the heading readout is three digits in the format XXX, with leading zeros as necessary. Heading readout has a range from 1 degree to 360 degrees with a resolution of 1 degree. The current aircraft heading is provided by the selected IRS and is in reference to magnetic heading or true heading, as selected.

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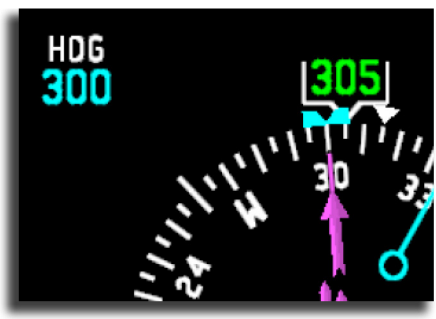
When heading data is invalid, the full compass heading scale is rotated to align with a major tick mark. The compass digits and cardinal labels are removed, and the course deviation indicator (CDI) and bearing pointers are removed. Also, HDG FAIL is displayed inside the compass rose. Selected HDG, digital heading readout, and CRS / DTK values are replaced with amber dashes (- - -).

Selected Heading Digital Readout and Bug



The cyan selected heading digital readout is displayed in the upper-left corner of the HSI below the selected heading (HDG) annunciator. The selected heading readout displays the digital value for the aircraft selected heading.

The cyan heading select bug is positioned around the compass by rotating the HDG SEL knob on the GP and is based on the aircraft selected heading. The cyan heading select bug is aligned to the applicable tick marks/labels.

Two rates of adjustment exist for the selected heading value increments/decrements:

1. The slow rate increases or decreases the selected heading by 1 degree for each knob click.

2. The fast rate increases or decreases the selected heading by 10 degrees for each knob click.

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The layout for the selected heading readout is three digits, in the format XXX, with leading zeros, as necessary. The selected heading readout has a range from 1 degree to 360 degrees with a resolution of 1 degree. The selected heading bug is positioned on the heading scale to a resolution of 1 degree.

On on-ground power-up, the selected heading readout and selected heading bug are set to 001 degrees. On an in-air power-up, the selected heading readout and selected heading bug revert to the last aircraft selected heading.

Pushing the **PUSH SYNC** button on the HDG SEL knob on the GP synchronizes the heading bug and readout to the current aircraft heading.

NOTE: The selected heading bug is displayed on the outside edge of the heading scale on both the full compass and arc modes. In the arc mode only, when the value of the selected heading results in the bug being placed outside of the viewable section of the arc, a selected heading bug out-of-view arrow is displayed. The bug out-of-view arrow is displayed on the side of the arc, which indicates the direction of the shortest distance to the bug. This is described and illustrated later in this section.

As the heading scale rotates to reflect changes in referenced aircraft heading, the selected heading bug rotates with the heading scale.

When the aircraft selected heading (or the referenced aircraft heading) is invalid, the bug is removed, and the digital readout is replaced with three amber dashes (- - -).

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Drift Angle Bug

The drift angle bug is represented by an inverted solid white triangle (▼) displayed on the outside edge of the heading scale in both arc and full compass modes. The drift angle bug is based on information supplied by the IRS. The difference between the aircraft heading and the aircraft ground track is the drift angle. The drift angle bug is placed on the edge of the heading scale and aligned to the drift angle with respect to the lubber line. The drift angle bug has a range of 1 to 360 degrees and is positioned on the heading scale to a resolution of 1 degree. As the heading scale rotates to reflect changes in referenced aircraft heading, the drift angle bug remains positioned as an angle from the lubber line.

The drift angle bug shows the actual direction of the aircraft track across the ground when wind correction is added. The drift angle bug represents the actual track relative to the compass display. The difference between the drift bug and the heading reference triangle is the wind drift angle. When the drift angle is 0 degrees, the drift bug fits inside the heading bracket notch.

When the partial compass drift angle bug is beyond the range of the displayed partial compass, the drift angle bug scrolls out of view.

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FMS Track Target Indicator

The FMS track target indicator displays the value of the FMS next track target for the selected FMS NAV source and is displayed in full compass and arc views. The FMS track target indicator is displayed as a magenta inverted triangle displayed on the outside edge of the heading scale, as shown in Figure 5-36.

NOTE: The display of the FMS track target indicator is compensated by the magnetic variance when the aircraft heading is referenced to magnetic north.

Figure 5-36
FMS Track Target Indicator

The FMS track target indicator is displayed when the FMS track target is not equal to the desired track readout. When the FMS track target is the same as the desired track readout, the FMS track target is removed from display.

NOTE: The FMS track target indicator has a higher display priority than the selected heading bug and drift angle bug.

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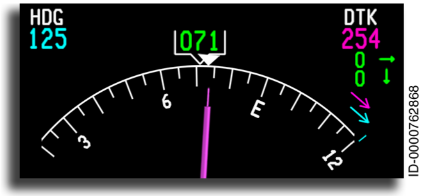

When the FMS track target indicator is beyond the range of display in arc mode, a magenta arrow is displayed to indicate the FMS track target is out of view. When both the FMS track target out-of-view arrow and selected heading out-of-view arrow are displayed at the same time, the FMS track target out-of-view arrow is displayed above the selected heading out-of-view arrow.

Primary Navigation Source Annunciators

The primary navigation (NAV) source identifies the source of navigation information currently being displayed. Also, the primary NAV distance identifier, primary NAV distance readout, and primary NAV estimated time en route are displayed below the primary NAV annunciator. The primary navigation source for short-range (VOR, LOC, or GLS) or long-range (FMS) is displayed on the upper-left edge of the HSI. The source is selected by the **NAV** and **FMS** buttons on the guidance panel.

The primary NAV source annunciators are displayed, as shown in Figure 5-37.

Figure 5-37
NAV and Heading Sources

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Primary NAV Source Annunciator – The primary NAV source is selected using the **NAV** or **FMS** buttons on the guidance panel. When the guidance panel data is invalid, the system defaults to the on-side primary NAV source. The pilot's default is VOR1/LOC1/GLS1, and the copilot's default is VOR2/LOC2/GLS2. The source is annunciated to the upper left of the HSI. The possible NAV source selections are:

- **SRN (Short-Range Navigation)** – The **NAV** (VOR/LOC/GLS) button selects the available SRN source, displayed in green. The NAV associated annunciators are VOR1 , VOR2 , LOC1 , *LOC2* , GLS 1 , or GLS 2 .
- **FMS** – The **FMS** button selects FMS as the source. The FMS annunciator is magenta. The FMS associated annunciators are FMS1 or FMS2 . If one of the FMS sources fail, the FMS source automatically reverts to the non-failed source.

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Primary Navigation Source Identifier, Distance, and ETE Readout – The NAV source station identifier is displayed directly below the NAV source annunciator. When FMS is selected on the guidance panel, the next magenta TO waypoint identifier is displayed. The waypoint identifier has as many as six characters.

The distance and estimated time en route to the selected FMS waypoint are displayed below the waypoint identifier. For distances of 100 NM or more, the digits are displayed with 1 NM resolution. For distances less than 100 NM, the digits are displayed with 0.1 NM resolution. Time is always in minutes.

ID-0000762871

When the pilot and copilot have the same NAV source selected, the digital readout is amber. The displayed distance is to the next waypoint for FMS long-range NAV.

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When SRN is selected on the guidance panel, the FMS waypoint identifier, distance, and estimated time en route (ETE) displays are removed. When distance or time information is invalid, the corresponding digital readout is replaced with three amber dashes (- - -). When the station identifier status is invalid, the identifier is removed.

Heading Source

The heading source combines the magnetic (MAG) or true (TRU) heading reference and the selected IRS number. The IRS number is selected using the **IRS** reversionary button on the on-side reversionary panel. The true or magnetic reference is selected by the FMS.

Heading Source Annunciator – The heading source annunciator is used to indicate when a non-normal heading source is selected and is displayed adjacent to the heading readout on the HSI. When the on-side IRS and magnetic heading reference are selected, the heading source annunciator is not displayed as this is a normal heading source. The heading source is displayed in white (i.e., TRU1) when the on-side IRS and true heading reference are selected. The heading source is annunciated in amber (i.e., MAG1 or TRU1) when a cross-side IRS is selected (by either pilot) in either magnetic or true heading reference.

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Course Select/Desired Track Readout and Pointer – The course/desired track pointer rotates around the center of the HSI heading arc. The course select pointer, deviation bar, and course digital readout are green for VOR, LOC, and GLS navigation, and the label is CRS (course). When a short-range NAV source (VOR, LOC, or GLS) is selected on the guidance panel, the track pointer is positioned by turning the CRS knob. Changes to the selected course are inhibited when autoland is engaged. When the **SYNCH** button in the center of the course select knob is pushed, the course select value is set to the course that minimizes the lateral deviation. When the NAV source is FMS1* or FMS2, the desired track pointer, deviation bar, and digital readout are magenta, and the label is DTK. The value of the desired track is supplied by the FMS.

ID-0000762875

The course deviation bar moves laterally and shows lateral deviation.

When the pilot and copilot have selected the same navigation source, the pointer, deviation bar, and digital readout become amber.

ID-0000762876

When the course/desired track data is invalid, the pointer is removed, and the digital readout is replaced with three amber dashes (- - -).

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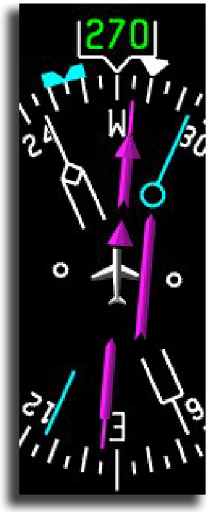

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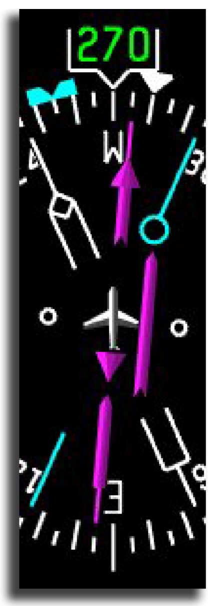
TO/FROM Indicator – The TO/FROM indicator is a colored triangle displayed near the center of the compass. The pointer indicates the aircraft is flying to (▲) or away (▼) from the selected navigation source. The TO/FROM pointer supplied by the selected FMS is magenta. When supplied by VOR, LOC, or GLS, the pointer is green. When the navigation source is the same source for the pilot and copilot, the TO/FROM pointer changes to amber.

For a TO indication, the triangle is located above the nose of the aircraft symbol. The TO pointer is displayed as long as the selected course pointer is within ±88 degrees of the bearing to the selected NAV source.



ID-0000762878

The FROM indication is a triangle pointer on the tail of the aircraft symbol. The FROM pointer is displayed as long as the selected bearing is greater than ±92 degrees of the bearing to the selected NAV source.

For values between 88 degrees and 92 degrees, the TO/FROM symbol is removed.

If heading status is invalid, the TO/FROM symbol is removed.

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ID-0000762879

Course Deviation Indicator (CDI) and Lateral Deviation Scale – The four-dot CDI scale and pointer are only displayed when a navigation source is active. The white CDI scale in the center of the HSI revolves around the aircraft symbol and remains perpendicular to the course arrow. The deviation bar moves to the left or right to show the deviation from the selected NAV source. Table 5-20 lists the deviations for the primary NAV sources.

CDI Slewing – The CDI remains centered during waypoint transitions.

Table 5-20
Deviations for Primary NAV Sources

Primary NAV Source	Centered	One Dot	Two Dots	Max Deflection
VOR	0	5°	10°	20°
LOC	0	0.0775 DDM (175 ft)	0.1550 DDM (350 ft)	0.3100 DDM (718 ft)
GLS	0	0.0775 DDM (175 ft)	0.1550 DDM (350 ft)	0.3100 DDM (718 ft)
FMS (LPV/GPS)	0	0.0775 DDM (175 ft)	0.1550 DDM (350 ft)	0.3100 DDM (718 ft)
FMS En Route	0	1.0 NM	2.0 NM	20 NM
FMS Terminal	0	0.5 NM	1.0 NM	4.0 NM
FMS Approach	0	0.15 NM	0.3 NM	1.2 NM

When the back course mode is selected, or when tuned to a localizer frequency and the selected course is more than 100 degrees from the aircraft heading, the course deviation automatically reverses to properly sense deviation with respect to the course centerline.

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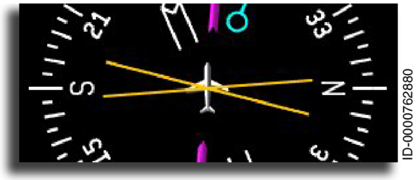

When lateral deviation data is invalid, the CDI is removed, and an X is placed in the CDI scale area.

Bearing Pointers – The bearing pointer source is either VOR, ADF, or FMS. Two bearing pointers are displayed, and when the pointers are over each other, both pointers with identifying symbols are seen. The pointers rotate around the compass center the same as the course pointer.

The bearing pointer source is selected using the **BRG○** or **BRG◊** buttons on the guidance panel. When the PFD controller fails, the default sources are VOR1 for the circle (○) pointer and VOR2 for the diamond (◊) pointer, as previously shown. Source identifiers to the left of the compass display are the same color as the pointer.

When the data for the bearing source selected is invalid, the corresponding bearing pointer is removed.

Groundspeed – Groundspeed is displayed in the upper-left corner of the HSI just below the airspeed tape. The digits are green, and the label is GSPD . Groundspeed is determined by the inertial reference system (IRS). When the IRS is invalid, the digits are replaced with three amber dashes (- - -). Groundspeed has a range of 0 to 999 knots, with a resolution of 1 knot.

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DME Distance Display

The distance measuring equipment (DME) source identifies the source of DME information currently being displayed. In addition, the DME station identifier, DME distance readout, and DME time-to-go (TTG) readout are displayed below the DME source annunciator. The PFD DME source annunciator is located to the right of the HSI on the PFD. Also, the distance DME hold annunciator is located here. The source is selected by the **NAV** button on the guidance panel.

The DME distance display annunciators are displayed, as shown in Figure 5-38.

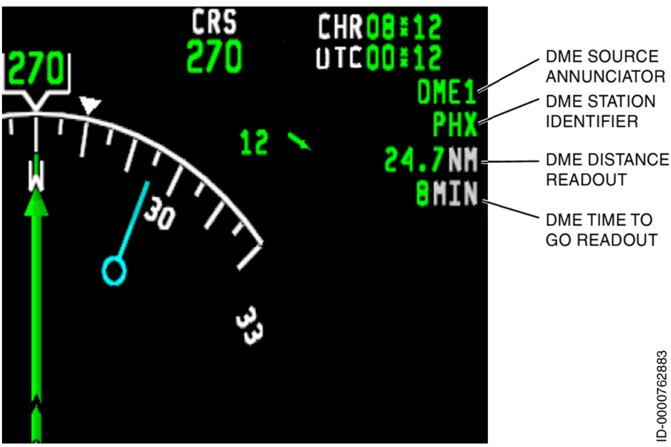

Figure 5-38
DME Distance Display

DME Source Annunciator – The DME source annunciator displays the DME source (DME1 or DME2 when dual DMEs are installed). The DME source is selected by pushing the **NAV** button on the PFD display controller. Regardless of the number of DMEs installed, the DME source annunciator reflects the short-range navigation source selection. For example, when VOR1/LOC1 is selected, DME1 is displayed. When VOR2/LOC2 is selected, DME2 is displayed.

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NOTE: When the primary NAV source is GLS, the DME information (source annunciation, station identifier, distance readout, HOLD, time-to-go, and DME distance) display is removed.

When the primary NAV source is FMS, the last selected VOR/LOC is used for the DME distance display.

The DME source annunciator is displayed in green when the same source is not selected. When the same source is selected, the DME data is displayed in amber (i.e., DME1).

ID-0000762885

When an RNAV approach to LPV minimums is active, the GPS reference path identifier (sometimes called the Approach ID) replaces the DME source annunciator on the PFD.

ID-0000762886

DME Station Identifier, Distance, and TTG Readout – The DME source station identifier is displayed directly below the DME source annunciator. The station identifier is the same color as the DME source annunciator, and up to four characters are displayed for VHF NAV stations.

The DME distance readout is displayed below the station identifier. The DME distance readout is the same color as the source annunciator. For distances of 100 NM or more, the digits are displayed with 1 NM resolution. For distances less than 100 NM, the digits are displayed with 0.1 NM resolution.

The DME TTG readout is displayed below the distance readout. TTG to the waypoint, identified by the DME station identifier, is shown in minutes.

ID-0000762887

The DME source station identifier is replaced by the WAAS identifier (W258) for an RNAV approach to LPV minimums when LPV is active. The DME distance readout is replaced by the GPS distance readout when LPV is active. The DME TTG readout is replaced by the GPS1 or GPS 2 identifier readout when LPV is active.

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ID-0000762888

When the station identifier, distance, or time information is invalid, the digits are replaced with amber dashes (---).

ID-0000762889

DME Hold Annunciator – When the DME is in DME hold mode, an H is displayed in front of the distance readout. If the DME distance data is invalid or the FMS is the primary navigation source, the DME hold annunciator is not displayed.

NOTE: The DME hold annunciator is removed from the display when LPV is enabled.

Wind Readout – The wind readout can be displayed in either Vector or Cartesian (XY) formats. The format of the wind readout is selected on the SETUP Page, described on page 24-3.

ID-0000762890

Vector Wind Display – The Vector wind display uses a digital readout for wind speed and an arrow vector for direction. The arrow points in the direction the wind is blowing. The readout and arrow are green.

ID-0000762891

Cartesian Wind Display – The Cartesian display indicates the magnitude and direction of the wind as X and Y components in relation to the aircraft symbol. Arrows indicate the direction of the wind, and the numbers show velocity (in knots). The readouts and arrows are green.

ID-762892

Elapsed Timer – The elapsed timer or chronometer is located at the top-right corner of the HSI display area. The elapsed timer is labeled CHR and displays time in hours and minutes (HH:MM) or minutes and seconds (MM:SS) in green.

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The chronometer is controlled by the chronometer button on the control yokes. When the chronometer is not displayed, the first push of the button displays the CHR and readout with the readout counting up from 00:00. The next push pauses the readout. The next push resets the readout back to 00:00 and pauses. The next push restarts the count, and the cycle begins again. The chronometer display is removed when displayed for 30 seconds, and no count has been displayed (that is, the display is in pause or reset). When timer status is invalid, the chronometer display digits become amber dashes (--:--).

FMS Mode Annunciators – The FMS mode annunciator region on the PFD displays the active and applicable FMS mode annunciators and is displayed to the right of the HSI compass below the DME distance display.

RNP is displayed when FMS is the primary navigation source. RNP ensures accurate, repeatable, and predictable navigation performance. RNP values are determined in the priority order as follows:

- Manual entry by the pilot
- Default based on the phase of flight:
  - Approach 0.3
  - Terminal 1.00
  - En route 2.00
  - Oceanic/Remote 2.00.

If the FMS data is invalid, the active and applicable annunciator is removed. When FMS data becomes invalid or times out while the RNP annunciator is displayed, the RNP value is displayed as three amber dashes (---).

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Table 5-21 lists the possible FMS mode annunciators.

Table 5-21
FMS Mode Annunciators

Annunciator	FMS Mode
APPR	Approach Sensitivity
TERM	Terminal Approach
WPT	Waypoint Alert
OFFSET	Lateral Offset
MSG (flashing)	MCDU Message
DR	Dead Reckoning
DGRAD	Degrade

Radio Displays – Two radio frequencies are controlled on each of the PFDs, as shown in Figure 5-39. The COM frequencies are either VHF COM, HF COM, or one of each. Radios are selected through the MCDU SETUP page for each PFD. The frequencies include a radio identifier above each of them. See Section 13, Radio System, for more details on radio controls and displays.

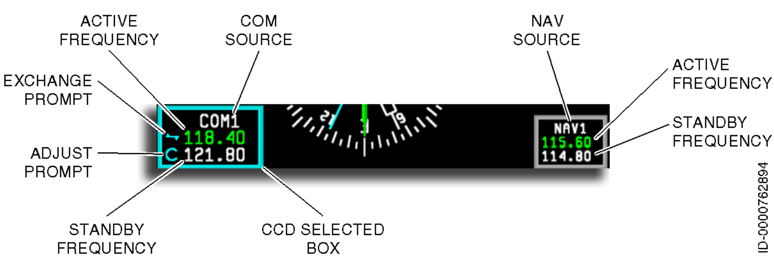

Figure 5-39
Radio Display

PFD Radio Cursor Box – When the PFD is selected using the CCD, a cyan box is placed around the last selected radio frequency. The font size of the frequency digits and the radio source identifier become larger.

The exchange prompt is displayed to the left of the cursor box in cyan for the selected active frequencies. The exchange prompt indicates the green active frequency data is exchanged with the white standby frequency when the CCD **ENTER** button is pushed.

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The adjust prompt is displayed to the left of the cursor box in cyan for any of the selected standby frequencies. The adjust prompt indicates the frequency is changed using the CCD rotary knobs. The outer concentric knob changes the whole numbers, and the inner concentric knob changes the decimal numbers. The frequency is also changed using the MCDU radio pages.

The radio cursor box defaults back to the original gray outline, and the font decreases in size when the frequency tuning has been completed and remains inactive for a specified amount of time.

COM Frequency and Identifier Display – The COM frequency display has a white COM source identifier annunciator (COM1 or COM2), a green COM active frequency, and a white COM standby frequency of up to six characters each. When radio status is invalid, the frequency changes to amber dashes (---.---).

NAV Frequency and Identifier Display – The NAV frequency display consists of a white NAV source identifier annunciator (NAV1 or NAV2) and a NAV active frequency of up to five characters. The active frequency is displayed in green when manually tuned and magenta when auto-tuned. When invalid, radio status changes to amber dashes (---.--). The NAV active and standby frequencies are changed, as discussed previously.

HSI Arc Mode

The arc mode display is shown in Figure 5-40. Most of the arc display symbols are the same as the full compass HSI display. The differences are described in the following paragraphs.

Figure 5-40
HSI Arc Mode With Weather

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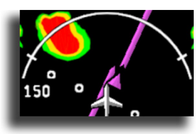
HSI Arc Display – The heading arc is displayed ±90 degrees from the current aircraft heading. The partial compass heading digital readout is displayed in green at the top of the compass arc. Headings from 1 degree to 360 degrees are displayed. When heading status is invalid, the digits are replaced by three amber dashes (- - -). The arc or partial compass mode is selected using the guidance panel **HSI** button.

Weather Display – Weather is displayed on the arc or map display, as shown in Figure 5-40 and Figure 5-41, when the **WX** button on the PFD display controller is pushed. Weather and the control functions are described in detail in Section 18. Weather Radar Systems. Each PFD displays independently selected weather information. The weather radar system is controlled by a selected pop-up menu on the on-side MFD.



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Weather Radar Sector – The weather radar display sector is indicated by tick marks on the half-range ring. The left and right position of the tick marks is at ±60, referenced to current heading. When the weather radar system is operating in the sector scan mode (SECT is selected through the virtual controller), the left and right tick mark positions are at ±30, referenced to current heading. In sector scan mode, the portion of the half-range ring between the tick marks is dashed to provide more indication of the display sector.

ID-0000762897

Weather Radar Annunciators – The weather radar annunciators are displayed on the PFD to the left of the NAV radio box in the lower right area below the HSI. The MFD also displays the specific weather mode. Refer to Section 18. Weather Radar Systems for a list of the weather radar annunciators.

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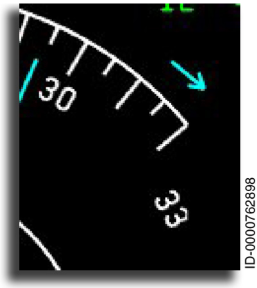

Selected Heading Out-of-View Arrow – When the HSI is in the arc mode and the heading select bug goes beyond the display range, a cyan arrow (→) is displayed. The arrow is outside the compass ring and shows the shortest direction (left or right) to the heading select bug.

Invalid heading data is indicated by removing the cardinal heading labels and displaying HDG FAIL inside the partial compass rose.

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HSI Map Mode Display

The HSI map mode is shown in Figure 5-41. Most of the map display symbols are the same as the full compass and arc displays. The differences are as follows:

- Flight plans are displayed
- Cannot be used for preview mode.

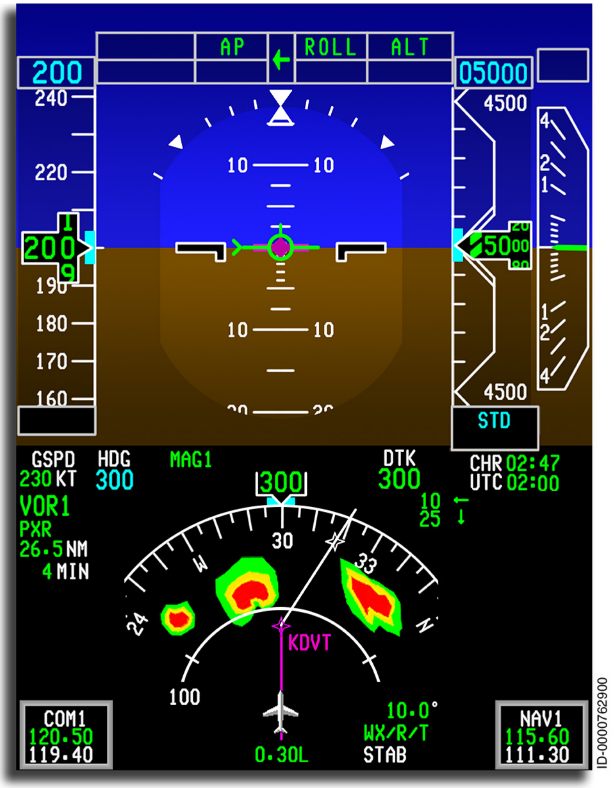

Figure 5-41
PFD HSI Map Mode With Weather Displayed

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Flight Plan Displays – The map mode can display FMS flight plan data, as shown in Figure 5-42. The aircraft symbol at the center of the display represents the present aircraft position. The FMS map data is oriented to the current aircraft heading (up). The heading can either be magnetic or true referenced. The display is updated continuously in relation to the present aircraft position and heading.

Figure 5-42
HSI Map Mode With Flight Plan Displayed

The FMS map data displayed includes waypoints and vectors. Waypoint symbols and waypoint identifiers show the relative location of a waypoint in the flight plan. The vectors are used to show continuity of the flight plan between waypoints.

The FMS flight plan data is displayed when:

- The HSI map mode has been selected
- The FMS indicates valid electronic flight instrument system (EFIS) data
- The selected heading reference (mag or true) is valid
- The aircraft present position data is valid.

The FMS map data is removed when any of the previously discussed conditions are lost.

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Up to five waypoints are displayed on the HSI display, depending on the range considerations. The HSI map displays compulsory, non-compulsory, and flyover waypoints. When additional waypoints are in the flight plan but are not displayed because of the five-waypoint display limitation, an undisplayed waypoint bearing pointer (Fixed Length Arrow) is displayed from the fifth waypoint. The pointer points to the position of the next waypoint to indicate additional flight plan elements.

If one or more waypoints are not displayed because of map range limitations, and the first out of range waypoint is the fifth or less waypoint in the current flight plan order, a normal leg vector is displayed from the last in range waypoint to the edge of the map display, pointing towards the first out-of-range waypoint.

The current leg and next waypoint (the TO waypoint) are displayed in magenta. All other legs and waypoints are displayed in white.

FMS map data is positioned on the display with respect to the current aircraft position and heading using aircraft latitude and longitude, aircraft heading, and the selected map range. Any text associated with a symbol (e.g., waypoint identifier) is presented horizontally to the right of the associated symbol. Symbols placed outside the compass arc or that interfere with other HSI display data areas are not displayed.

Lateral Deviation Display – In the HSI map mode, the lateral deviation is displayed below the aircraft symbol at the bottom of the display. The display consists of a digital readout and label of R or L in the color of the primary navigation source, indicating deviation to the right or left.

When the deviation is greater than 99.9 or less than -99.9, the digital readout stops at 99.9 and adds a trailing plus sign (+) to the applicable letter (e.g., 99.9 L +).

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Preview Mode

When FMS is the selected primary navigation source (PNS), course, lateral deviation, and vertical deviation are previewed when selected on the display controller portion of the guidance panel. Lateral deviation is displayed on the HSI and the ADI lateral deviation indicator. Vertical deviation is displayed in the vertical deviation indicator within the ADI. The previewed navigation source automatically transitions to the primary navigation source when captured by the flight director (FD)/automatic flight control system (AFCS).

If the heading or preview selected course data is invalid, the preview course pointer, digital readout, and course deviation pointer are removed.

The preview mode is shown in Figure 5-43.

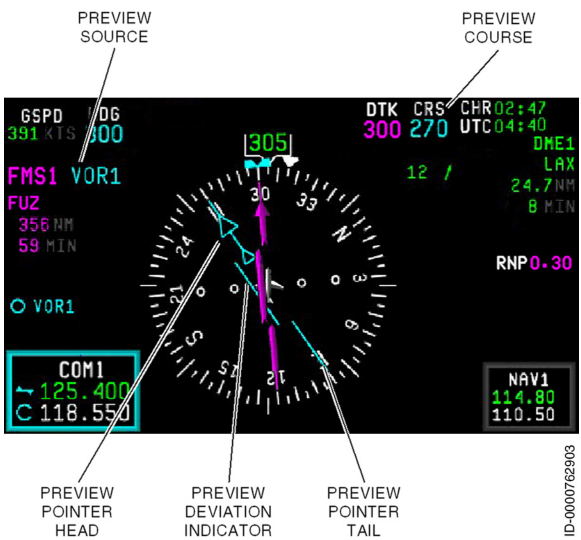

Figure 5-43
Preview Mode

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Preview Navigation Source – The preview NAV source (VOR1) is annunciated in cyan to the right of the primary NAV source. The possible NAV source annunciators for preview are:

- VOR1/2
- LOC1/2
- GLS 1/2.

The navigation preview mode is available when FMS is the selected primary navigation source, and HSI full compass or arc mode format is active. When map mode is the current format, pushing the **PREV** button has no effect. When PREV is active and the map mode is selected, PREV is automatically canceled.

NOTE: Navigation preview mode is not available when any approach is active.

Pushing the **PREV** button multiple times toggles the previewed source as follows:

On-side SRN radios → Off-side SRN radios → Remove PREV display → On-side SRN radios.

When PREV is selected and the frequency of the SRN is changed, the PREV legend (VOR, LOC, or GLS) is automatically changed to match the frequency. The source-side PFD primary navigation source automatically transitions to the previewed navigation source when the approach mode has been captured in the lateral channel. When the SRN transitions to the primary NAV source, the PREV course and lateral deviation bar/pointer change to the primary NAV source, and the FMS data is removed from the display.

NOTE: When an RNAV approach is armed and PREV is selected, the approach becomes disarmed (removed from FMA) and previews the VOR or ILS that is tuned in the radio.

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When the non-source side PFD displays the same or equivalent PREV source as the source PFD, the non-source PFD also transitions the preview source to the primary source when lateral FD/AFCS capture occurs.

Preview Course Pointer and Deviation Bar – The preview pointer is a cyan course arrow and deviation bar displayed on the HSI at the same time the primary NAV source DTK pointer and deviation bar are displayed. Both bearing pointers can also be in view.

When PREV is active, a preview cyan course digital readout with a **CRS** label is displayed to the right of the FMS **DTK** readout. When the PREV CRS is displayed, the on-side course select knob on the GP is turned to set the SRN previewed course and changes the position of the preview course pointer and deviation bar.

The PREV pointer and bar are visible when all pointers are aligned over each other. The VOR/LOC/GLS scale factor is not the same as the FMS scale factor. When valid, the preview deviation bar is displayed against the existing primary NAV source scale, but VOR/LOC/GLS uses the same scale factor as with primary NAV sources.

The TO/FROM pointer is the hollow smaller cyan arrowhead that is displayed at the top (TO) or bottom (FROM) of the deviation bar. The preview TO/FROM pointer is displayed when the PREV source is VOR. The TO/FROM logic is the same as when VOR is the primary NAV source.

If the preview lateral deviation is invalid, the lateral deviation bar is not displayed, and there is no failure indication. If the preview is VOR and TO/FROM is invalid, the TO/FROM pointer is not displayed, and there is no failure indication.

The primary NAV source lateral deviation failure indication is displayed, as required by the conditions defined, for the primary NAV source that is used. If the primary NAV source failure indication is shown, the primary NAV source and the preview deviation bars are removed.

For the VOR/ILS/GLS previewed course, turning the course select knob moves the arrow around the compass with the same selection gradient used for the VOR/LOC/GLS course arrow. The CRS push-to-synch (push DIR) button still works in the same manner as when the VOR is the PNS.

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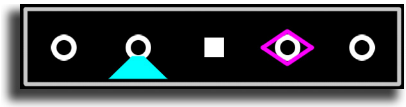

ID-762904

Preview Lateral Deviation – The ADI lateral deviation scale, under the ADI, is displayed when the FMS is the primary NAV source. The FMS deviation is displayed as a hollow magenta diamond (). When the preview navigation source is LOC, VOR, or GLS, the preview lateral deviation is displayed as a filled cyan trapezoid.

LOC or GLS deviation and FMS ADI lateral deviation are displayed while preview mode is selected. The FMS ADI lateral deviation is removed, and the LOC/GLS deviation remains in view when preview is automatically deselected.

When PREV lateral deviation is displayed and the PREV deviation goes invalid, the PREV pointer is removed from display, but no failure flag is displayed. The primary NAV source lateral deviation failure indication is displayed, as required, by the conditions defined for that source. If the primary NAV source fails, the primary NAV source and the preview deviation are removed.

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Preview Vertical Deviation – The vertical deviation scale, adjacent to the ADI, is displayed when the FMS is the primary NAV source and the FMS commands it into view when the GPS deviation is populated on the preview deviation signal, or in preview mode when LOC or GLS is the preview source. The primary navigation source and FMS deviation are displayed the same way as the lateral deviation. Preview vertical deviations are shown as a hollow magenta diamond, and the GLS/LOC preview pointers are displayed in cyan, as shown in Figure 5-44. The pointers are displayed so that both pointers are identifiable at all times. The same display and failure conditions that apply to lateral deviation apply to vertical deviation.

NOTE: When the transition to APP is made from VNAV, the active vertical mode is FPA unless VNAV mode was VALT, changing then to ALT. It does not matter whether GS is armed or not.

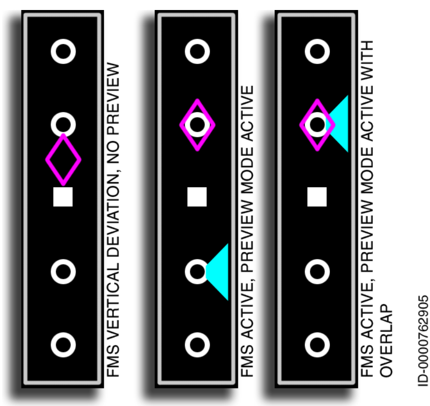

Figure 5-44
Preview Vertical Deviation

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PFD TEST

With the aircraft on the ground (WOW switch closed), selecting the PFD test on the MCDU TEST page displays the PFD, shown in Figure 5-45. The display cycles the test pattern of comparators for 4 seconds, then the failure flags for 4 seconds.

Figure 5-45
PFD Test Display

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SMARTVIEW – SYNTHETIC VISION SYSTEM (SVS)

The synthetic vision system (SVS) enhances flight crew awareness by providing a synthetic three-dimensional view of the surrounding environment, including sky, land, water, grid lines, obstacles, airports, and runways, in addition to standard flight and navigation data (position, altitude, heading, and track).

The SVS uses obstacle and terrain databases to integrate existing flight deck data, field of view, and advanced symbology elements to assist in the pilot's ability to identify potential terrain and obstacle conflicts, as well as to identify visual references.

Synthetic vision helps to reduce workload during certain tasks due to the increased information presented to the pilot on the PFD in a very intuitive way. It reduces the need to scan between the PFD and MFD for the purpose of ascertaining situation information relating to terrain, aircraft position, and other important information.

WARNING: Synthetic vision should not be used for primary navigation, nor should the flight crew rely solely on synthetic vision to avoid terrain or obstacles.

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Displaying Synthetic Vision on the Primary Flight Display (PFD)

Synthetic vision works by rendering terrain elevation data-oriented in real-time to aircraft attitude and altitude. When synthetic vision is on, all of the existing PFD symbology is overlaid on top of the SVS terrain. During power-up, the classic PFD is initially displayed.

The SVS is turned on or off by toggling line select key (LSK) 6L on the DISPLAY SETUP page, shown in Figure 5-46, between ON or OFF. The DISPLAY SETUP page is accessed by selecting the DISP SETUP prompt on the MENU page. The MENU page is described in Section 24, Multifunction Control and Display Unit (MCDU) Menu Pages.

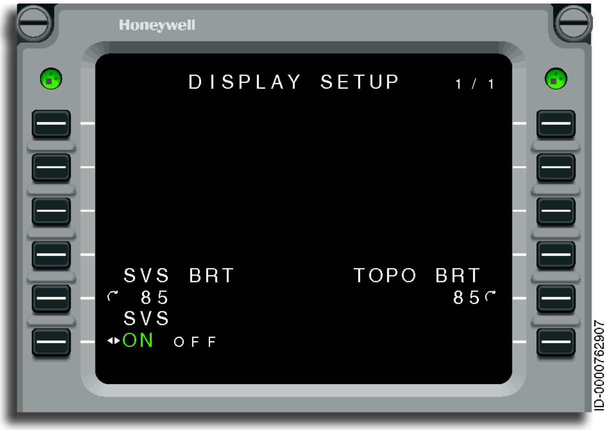

Figure 5-46
Display Setup Page

SVS and terrain/sky elements are dimmable by selecting LSK 5L.

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When SVS is selected **ON** , SVS is activated. When SVS **OFF** is selected, the PFD reverts to the classic display. Figure 5-47 shows the PFD with SVS off and on.

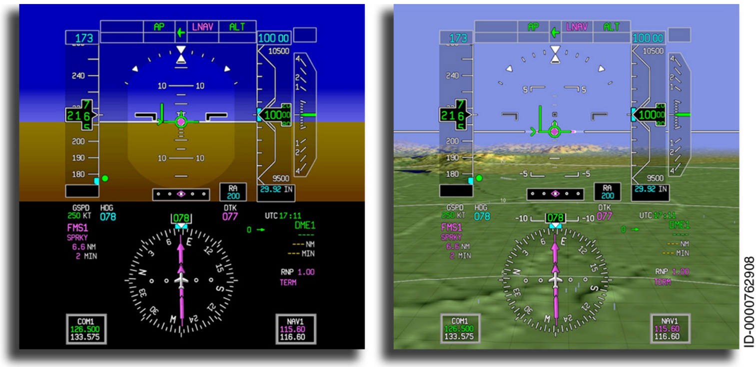

Figure 5-47
PFD With Synthetic Vision Off and On

NOTE: The PFD reverts to the classic display should a failure occur.

The SVS depicts a synthetic vision scene representing an out-the-window view of surrounding terrain for any combination of the following conditions:

- Roll angles between -60 and 60 degrees
- Pitch angles between -18 and 23 degrees.

Synthetic vision is available for altitudes up to 55,000 feet MSL but is removed (PFD reverts to legacy PFD format) for the following conditions:

- Beyond 70 degrees north and south latitude in all longitudes
- If the SVS is not available, **SVS FAIL** is displayed on the lower left side of the ADI.

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NOTE: The SVS terrain image may appear slightly different between PFD1 and PFD2 on-ground. The image discrepancy is more noticeable when the airplane is positioned close to a changing terrain feature (like a small hill). The discrepancy is not noticeable between the PFDs images when the airplane is airborne. The runways and obstacles are not affected by the terrain image since they are displayed based on the latitude and longitude reference.

SVS Symbols and Features

Figure 5-48 shows the symbols and features displayed on the PFD when synthetic vision is enabled. The symbology on the SVS display is similar to the legacy PFD display with the addition of three-dimensional terrain, obstacles, and other features associated with SVS. Features unique to the SVS display are described in the following paragraphs.

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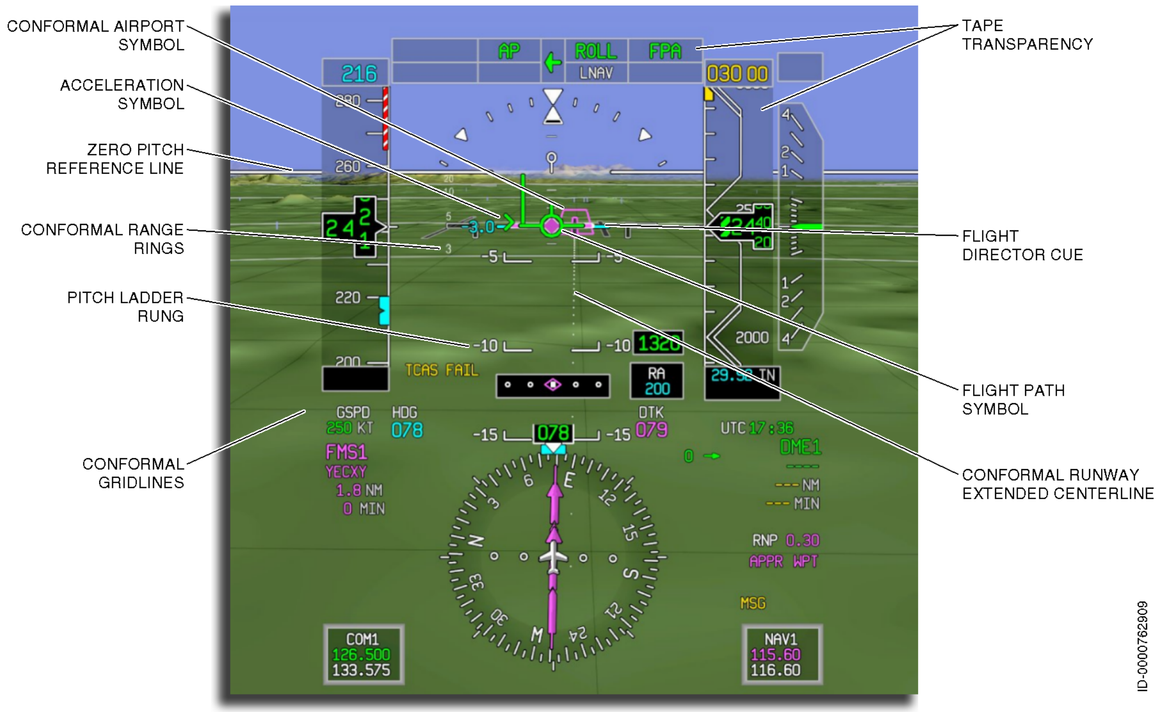

Figure 5-48
PFD With SVS Symbols and Features

SYNTHETIC SCENERY

The SVS uses the obstacle and terrain databases for rendering the SVS image on the PFD. Databases are updated periodically, and new updates are loaded by way of the dataloader. The SVS obstacle and terrain databases have a worldwide area of coverage for reported obstacles taller than 100 feet and airports with hard and soft runways. Terrain is displayed out to a range of 40 NM from the aircraft position.

FLIGHT PATH VECTOR (FPV)

The SVS displays a green flight path vector (FPV) that is conformal to the SV scene. The FPV provides a visual depiction of the actual path of the aircraft and has the ability to move vertically. The FPV is always displayed when SVS is enabled except during excessive attitudes. When SVS is turned off, the FPV is not shown. When the FPV position exceeds the display limits on the synthetic vision (SVS) PFD, the FPV becomes striped and is placed at the edge of the ADI area, as shown in Figure 5-49, indicating that the FPV is not currently showing the actual path of the aircraft.

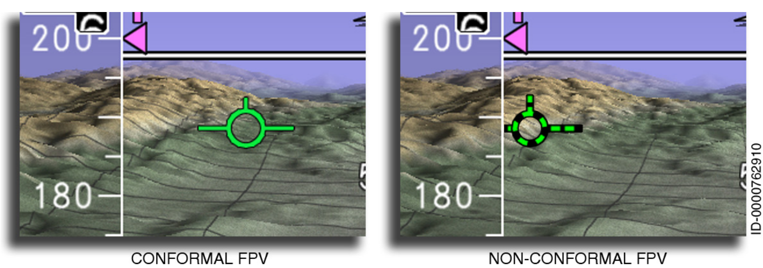

Figure 5-49
Flight Path Vector

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SVS GROUND AND SKY VEIL

Because the SVS terrain is drawn conformal to the outside scene, it is possible to orient the aircraft such that the entire rendered SVS terrain imagery is displayed outside the viewable region of the display. To address situations where there is a limited amount of SVS terrain visible on the display, a ground veil, shown in Figure 5-50, fills the area between the zero-pitch reference line and the top of the terrain horizon. The ground veil ensures that a clear and unambiguous presentation of ground direction is always provided to the pilot.

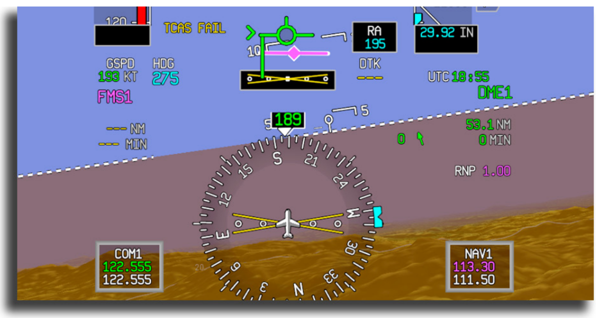

Figure 5-50
SVS With Ground Veil Overlay

There are three factors that are monitored to determine when the amount of SVS terrain is approaching the limit to enable the ground veil.

1. **Aircraft Pitch:** The amount of SVS terrain is decreased in the field of view as pitch is increased.

2. **Aircraft Roll:** The amount of SVS terrain in the field of view is decreased as the roll attitude becomes excessive.

3. **Altitude:** Due to the curvature of the earth, the distance between the SV terrain horizon and the zero-pitch reference line increases as altitude increases.

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To address situations where there is a limited amount of sky visible on the display, a sky veil fills the area between the zero-pitch reference line and the top of the horizon, as shown in Figure 5-51.

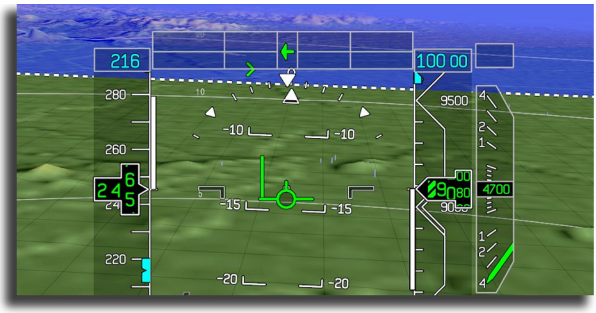

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Figure 5-51
SVS With Sky Veil Overlay

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HSI PUSHDOWN

Due to an expanded pitch tape, the FPS might drop down far enough on the display during takeoff that it interferes with the HSI. SmartView moves the HSI out of the way to permit an FPA representing a large angle-of-attack (AOA) during takeoff, as shown in Figure 5-52. SVS provides inputs for pushing the HSI down during large AOAs, such as during takeoff, go-around, and windshear conditions. The HSI push down permits a maximum of 4-degree push.

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Figure 5-52
HSI Pushdown

EXCESSIVE ATTITUDE DECLUTTER DISPLAY

The functionality of the excessive attitude declutter display symbology is the same as mentioned previously in this section except that the flight path symbol (FPS) is also removed.

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GRID LINES

Grid lines are regularly spaced semi-transparent black lines overlaying the synthetic terrain. The grid lines convey a sense of motion as the aircraft is flying over featureless terrain. Grid lines help the pilot visualize how high the aircraft is above the terrain since the grid pattern displays larger when the aircraft is close to the ground. The grid lines run approximately true north/south and east/west and are spaced at a distance of 0.4 NM from each other. They follow the contour of the terrain and are always present. Figure 5-53 shows an example of grid lines displayed on the SVS.

Figure 5-53
Grid Lines Overlying Synthetic Terrain

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RANGE RINGS

A range ring indicates what points on the terrain are at the same indicated distance (ground range) from the aircraft. Range rings consist of a range ring line and label, as shown in Figure 5-54. They are displayed at 3, 5, 10, and 20 NM from the aircraft position.

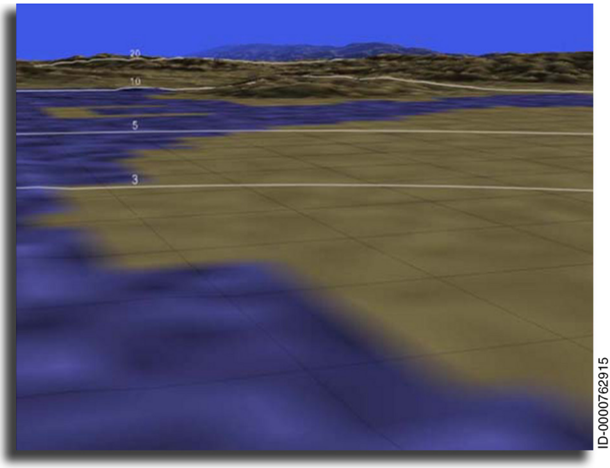

Figure 5-54
Range Rings

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RUNWAYS

Runways are displayed by the SVS when the length of the runway exceeds 3,500 feet. Runways fade in and out of view at 40 NM and display larger as the distance to the runway decreases or smaller as the distance increases. The FMS-selected destination runway is displayed with a magenta outline, as shown in Figure 5-55. Other runways not selected by the FMS are outlined in white.

NOTE: The destination runway is highlighted on the PFD display only when the destination runway is one of the ten remaining waypoints.

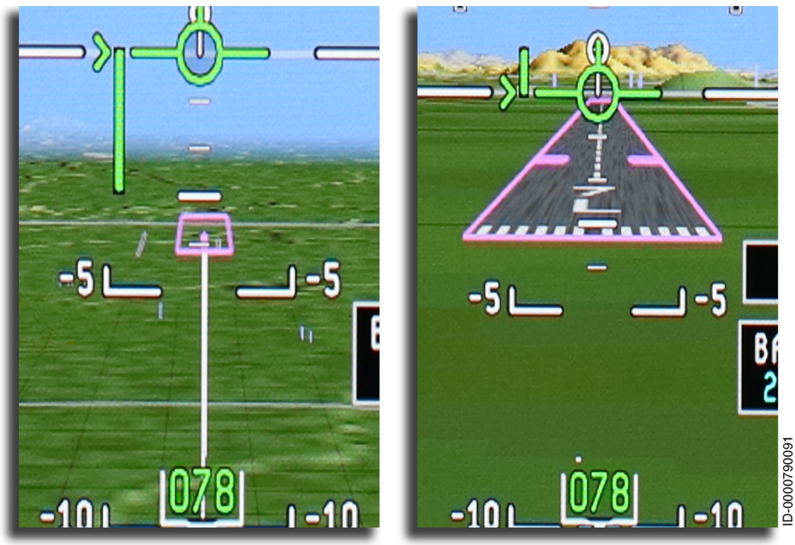

Figure 5-55
Runway Highlight Depictions

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Hard-surfaced runways are displayed with runway designation, threshold markings, sidestripe markings, aiming point markings, and a runway centerline. Runway pavement is displayed in dark gray. Runway designation and centerlines are displayed in light gray to approximate the appearance of actual runway markings. Runway designations that include letters are displayed with the letter below the number. Light gray threshold markings are displayed with a varying number of stripes, depending on the runway width:

- Four stripes for runways with widths up to 60 feet
- Six stripes for runways with widths greater than 60 feet and less than or equal to 100 feet
- Eight stripes for runways with widths greater than 100 feet and less than or equal to 150 feet
- Twelve stripes for runways with widths greater than 150 feet and less than or equal to 200 feet
- Sixteen stripes for runways with widths greater than 200 feet.

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Displaced threshold and stopway runway detailing are also displayed (when contained in the navigation database) for applicable hard-surfaced runways. Figure 5-56 and Figure 5-57 show examples of runway markings displayed with the SVS.

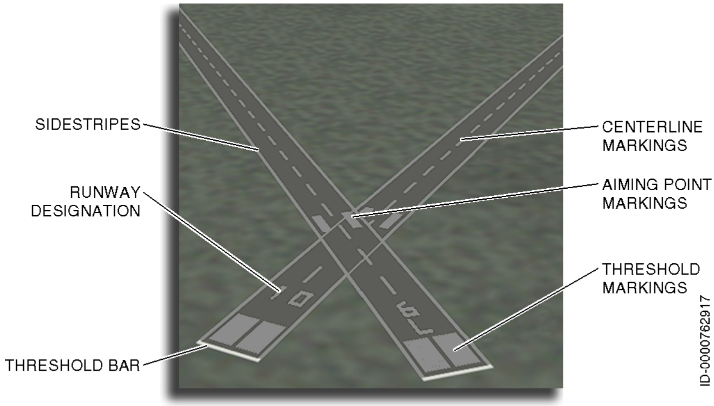

Figure 5-56
Runway Markings

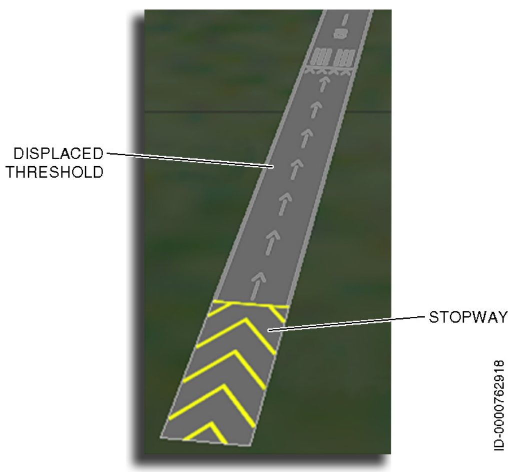

Figure 5-57
Runway Displaced Threshold and Stopway

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RUNWAY GLIDE PATH INTERCEPT POINT MARKERS

The glide path intercept point markers on the runway serve as a visual aiming point for landing the aircraft on the FMS-selected arrival runway. The runway glide path intercept point markers consist of magenta rectangular stripes located on each side of the runway approximately 1,000 feet from the runway threshold, as shown in Figure 5-58. The precise distance from the threshold is based on the threshold crossing height (TCH) and the published glideslope (GS) for the runway.

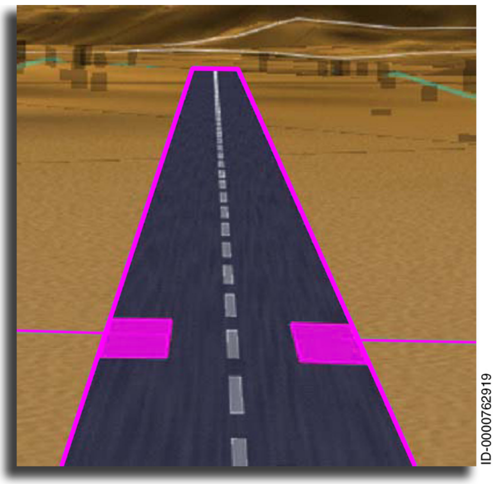

Figure 5-58
Glide Path Intercept Point Markers

The glide path intercept point markers represent the glide path intercept point on the runway and serve as a reference point for the flight path symbol (FPS). As the aircraft follows the defined glide path to the runway, the FPS lines up with the markers.

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AIRPORT SYMBOL

The airport symbol, shown in Figure 5-59 and Figure 5-60, marks the FMS-selected arrival runway. This symbol allows the pilot to easily identify the location of the selected arrival runway in the displayed terrain picture while the aircraft is still far from the runway.

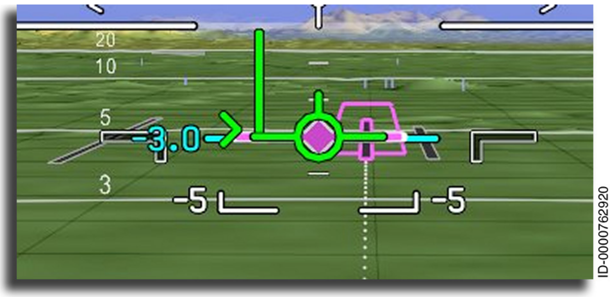

Figure 5-59
Airport Symbol

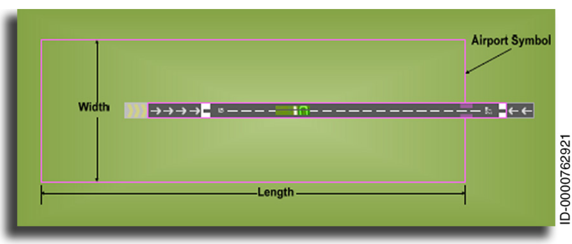

Figure 5-60
Airport Symbol Outline

The leading edge of the airport symbol is aligned with the arrival glide path intercept point marker to assist in positioning the flight path marker symbol. By aligning the flight path marker symbol with the leading edge of the airport symbol, the aircraft will be properly aimed at the glide path intercept point as opposed to the runway threshold.

The airport symbol is removed from the display when the aircraft approaches the runway, when the weight-on-wheels indicates **ground**, the aircraft has descended to less than 100 feet above the threshold, or when the aircraft transitions to go-around.

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The airport symbol is displayed again when all the following conditions have been met for more than 30 seconds:

- The aircraft height above the runway threshold is greater than 100 feet
- Weight-on-wheels indicates **airborne**
- Greater than 10 seconds have passed since the aircraft transitioned to go-around.

3D EXTENDED RUNWAY CENTERLINE

The 3D extended runway centerline displayed in white, shown in Figure 5-61, gives the pilot a visual reference of the FMS-selected arrival runways orientation while the aircraft is still far from the runway.

Figure 5-61
3D Extended Runway Centerline Classic

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OBSTACLES

All reported obstacles in the terrain view that are taller than 200 feet are shown. Obstacles are displayed centered at their respective latitude/longitude and drawn to their published height.

SVS obstacles begin to fade into view at 40 NM and are fully in view at 15 NM. Obstacles that are closer to the aircraft position display larger than obstacles that are further away. Figure 5-62 shows an example of obstacles displayed with the SVS.

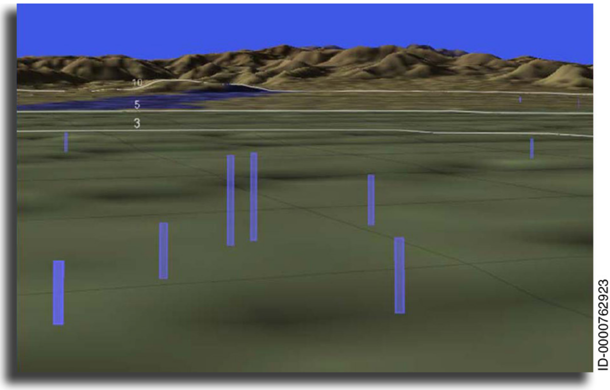

Figure 5-62
Obstacles on SVS

NOTE: Balloon festival events in the U.S. are depicted as very tall obstacles (in the range of 14,000 to 15,000 feet).

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ZERO PITCH REFERENCE LINE (ZPRL)

The heading bug is positioned on the ZPRL using true heading and drift from the selected IRS source. ZPRL is a white lollipop symbol, shown in Figure 5-63, which is displayed on top. The heading bug is conformal to the terrain. During an approach, the ZPRL heading bug helps the pilot to be aware of the aircraft drift angle and where to look for the runway outside of the front window compared to how the runway is displayed on the PFD.

Figure 5-63
ZPRL Heading Bug

The heading bug is ghosted when it is out of view, as shown in Figure 5-64.

Figure 5-64
ZPRL Heading Bug - Ghosted

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FIELD OF VIEW (FOV) LINES ON 2D MAP

Lateral FOV lines are displayed on a Map/Plan window, shown in Figure 5-65, which indicates the portion of 3D terrain that is being displayed on the PFD. These gray lines are for general reference only and will not always exactly represent the 3D terrain being displayed on the SVS. These lines give an approximation as to the closest 3D terrain that can be seen. The lines always show the furthest terrain that can be seen regardless if 3D terrain can or cannot be seen out to that distance due to closer terrain features. Roll is not taken into account when determining the placement of the lines.

Figure 5-65
Field of View Lines

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SVS ANNUNCIATORS

The SVS FAIL annunciator, shown in Figure 5-66, is displayed when terrain is removed due to lack of terrain data or a terrain rendering failure, any parameter needed to display terrain is invalid, or the aircraft has entered a polar region.

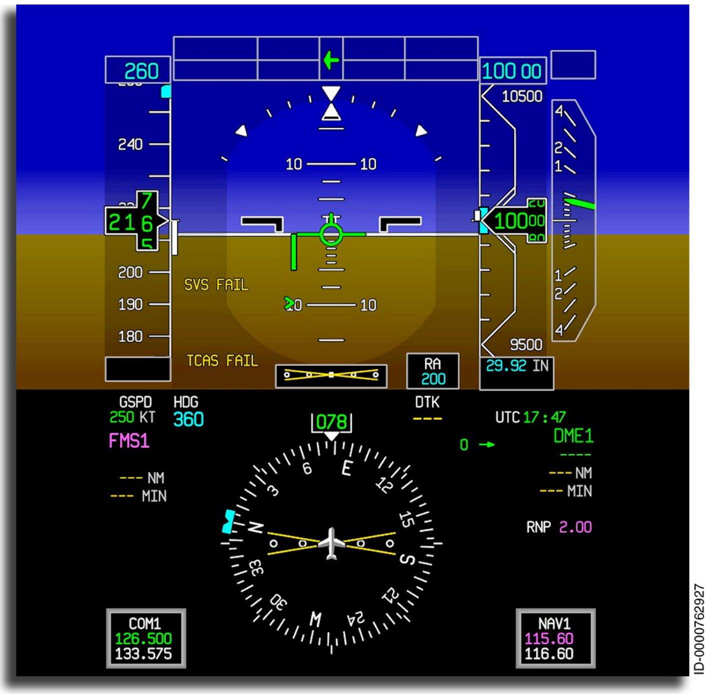

Figure 5-66
SVS FAIL Annunciator

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6. Multifunction Display – Navigation

INTRODUCTION

This section describes the operation and displays associated with the multifunction display (MFD). The MFD is the primary navigation display. The two MFD displays (pilot's side and copilot's side) function the same and are controlled by either cursor control device (CCD).

Two MFD formats are available by APM option: classic MFD and MFD with enhanced interactive navigation (INAV) enabled. This section primarily describes the MFD with enhanced INAV. Differences between the two APM options are described throughout this section when necessary.

The MFD has two formats: full window format and half window format. The formats can be selected from the Map or Plan dropdown menu, described later in this section. Only one MFD can be displayed in the full window format, as shown in Figure 6-1, at any time.

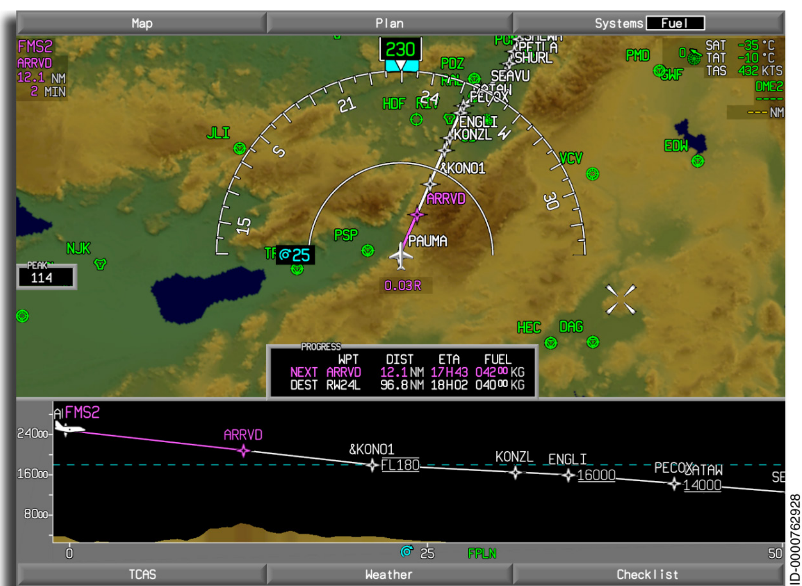

Figure 6-1
MFD in Full Window Format

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NOTE: Display reversion and screen brightness are described in Section 4, Electronic Display System (EDS).

When the MFD is displayed in the half window format, as shown in Figure 6-2, the other half of the MFD displays the window selected in the Systems dropdown menu. The systems synoptic pages are described in Section 8, Multifunction Display - Synoptics.

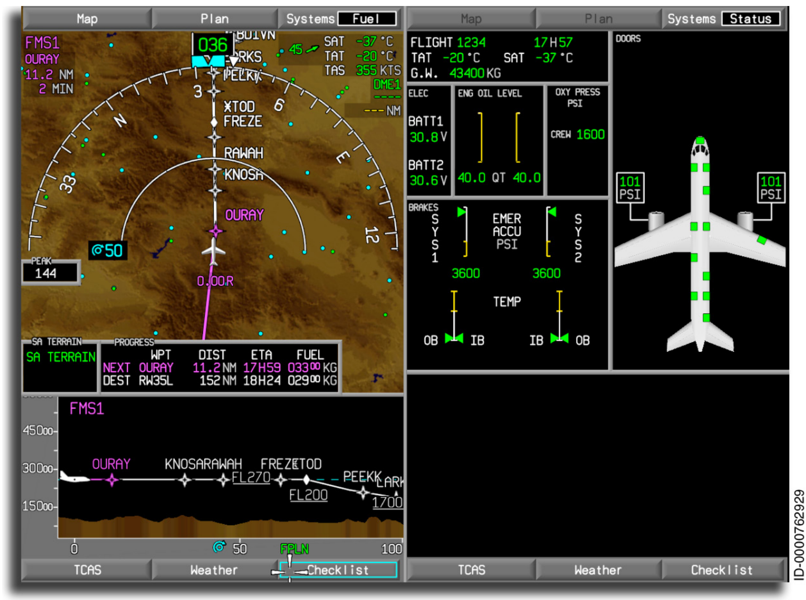

Figure 6-2
MFD in Half Window Format

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Access and Control

The CCD, shown in Figure 6-3, is primarily used to control the MFD. The CCD also provides radio tuning on the primary flight display (PFD) and crew alerting system (CAS) message scrolling on the engine indication and crew alerting system (EICAS).

Figure 6-3
Controlling the MFD With the CCD

The center select button on either CCD selects the on-side MFD. The touchpad moves the cursor creating a cyan rectangular cursor box around the menu title buttons on the MFD. Pushing the CCD **ENTER** button on either side of the CCD activates or deactivates the title button menu or selection.

When a menu is open, the touchpad moves the cyan rectangular cursor. The prompts in the menu indicate what functions are available. The **ENTER** button selects or deselects the function.

There are six hot spots on the CCD—the four corners, the top-middle, and the bottom-middle; this can be useful for quick access to all six menus (top and bottom) on the MFD.

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MFD MENUS

Each MFD has six title menu bars, three along the top of the screen and three along the bottom. These bars are used to access the information and controls available on the MFD. The three on top of the screen are:

1. Map
2. Plan
3. Systems.

The three on the bottom of the screen are:

1. TCAS
2. Weather
3. Checklist.

NOTE: When the checklist option is not installed, the Checklist bar is blank.

Each has dropdown menus to control and show the associated MFD display pages. MFD title menu buttons have the following characteristics:

- Only one title menu button is selected by the cyan cursor box at a time.
- Title menu buttons are selected by using the touchpad on the CCD to move the cursor or by simply touching any of the six hot spots of the CCD to quickly move the cursor to the associated corner of the MFD. When **ENTER** is pushed, the associated dropdown menu is displayed.

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- When a dropdown menu is open, the cursor is caged within the dropdown menu until the dropdown menu is closed. To collapse or close the dropdown menu, position the cursor over the menu exit button (X) and push **ENTER** or take the cursor to the top of the menu and push **ENTER**.

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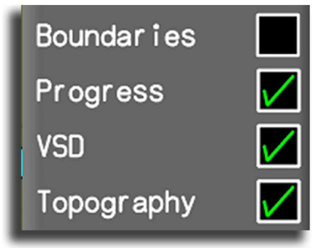
Menu Button Types

The buttons located on the menu control the functions on the MFD display. The selected menu button is highlighted in a cyan cursor box. Some buttons are used in combinations. Both CCD **ENTER** buttons are used to activate or deactivate the menus and make selections or deselections in the control menus.

The menu button types are:



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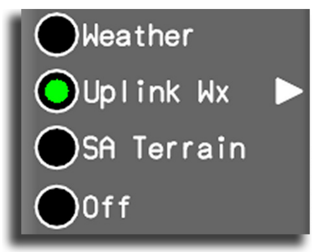
Checkbox Button – This is a non-exclusive menu selection. More than one checkbox can be checked (contains a green checkmark), and all checked boxes are considered active. A green check is placed in the white box when the **ENTER** button is pushed or removed if a checkmark was already present.



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Radio Button – This is a mutually exclusive menu selection. Pushing **ENTER** selects a button and deselects all other buttons on the menu. Radio buttons are white circles ( ). The active button has a green center.

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Toggle Button – This results in the transition between attributes listed in the text item. The active choice is white, and the inactive is gray. The **ENTER** button toggles between selections.

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Menu Exit Button – A selectable menu exit box with a white X is displayed to the right of the menu option where the cursor is when in the Map, Plan, or Systems dropdown menus. Moving the cursor to the button and pushing **ENTER** selects the button and exits the menu.

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Knob Prompts – The knob prompts indicate knob control is required for changing or scrolling the selected item. The knob button prompt is normally cyan. The following prompts are used in the displays.

The inner concentric knob button prompt is indicated by a round curled arrow around a small dot.

The outer concentric knob button prompt is indicated by a round curled arrow around a small circle.

Both the inner and outer concentric knob button prompts are indicated by a round curled arrow with no dot or circle symbol inside.

The knob prompt in the dropdown menu is a green circle with a white center surrounded by green dots.

Momentary Button – When a momentary button is pushed, the item remains active for a period of time and then reverts to the previous state. This type of button is normally used as a clear or reset button.

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Map Menu

The Map menu, shown in Figure 6-4, is used to select the types of navigation data to be shown on the MFD map display. The selections are layered on top of each other to build a composite display. If the display is too cluttered, overlays or selections can be removed by using the menu or zooming in/out of the display with the range knob selection.

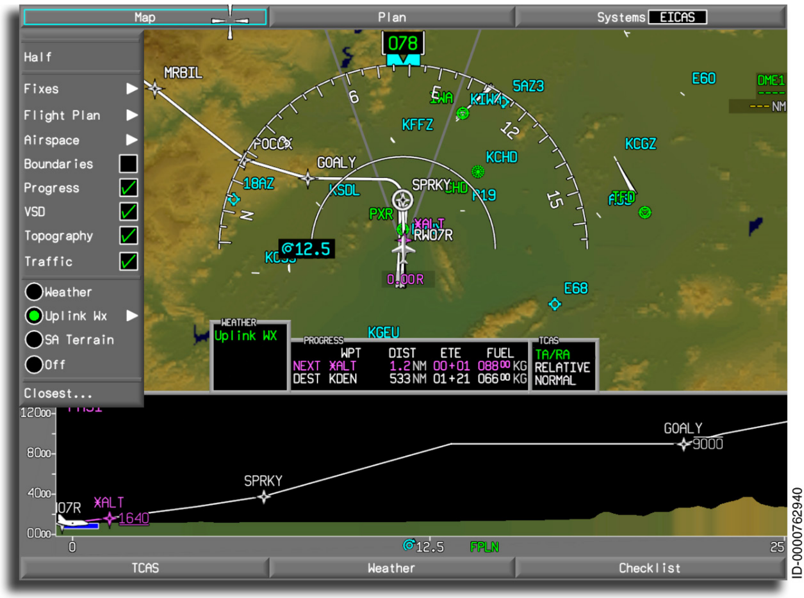

Figure 6-4
Map Title Button Dropdown Menu

The Map menu varies between the classic MFD and the MFD with enhanced INAV options and is described in detail later in this section.

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Plan Menu

The Plan mode is used to display flight plan and navigation database information as well as flight progress along the planned route, as shown in Figure 6-5. Display orientation is north-up.

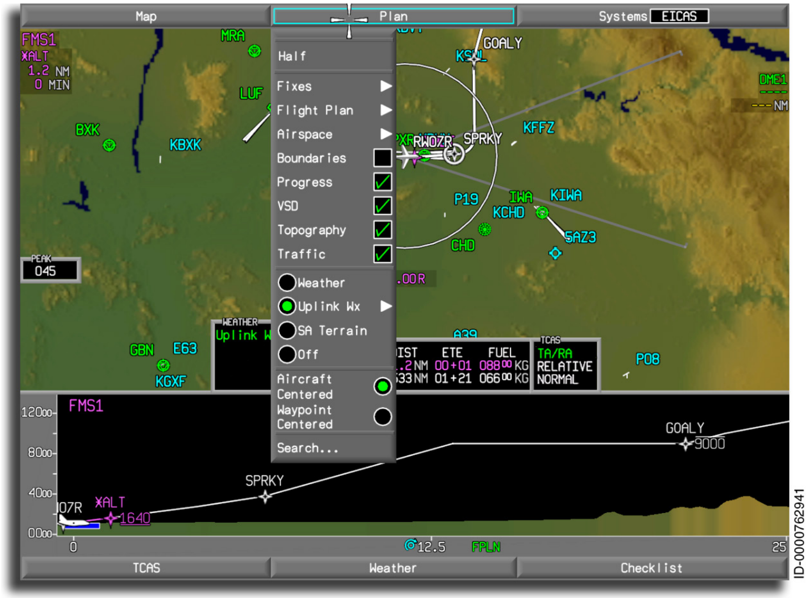

Figure 6-5
Plan Menu

The Plan menu varies between the classic MFD and the MFD with enhanced INAV options and is described in detail later in this section.

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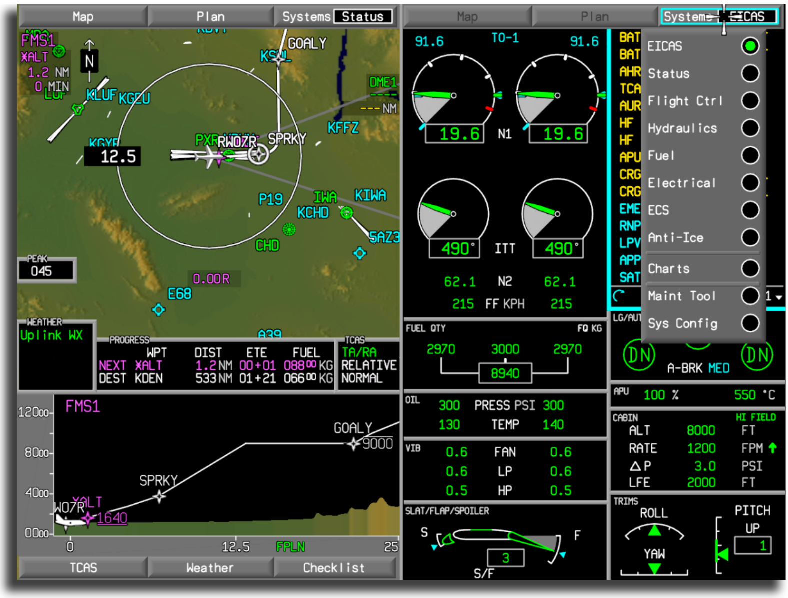
Systems Menu

The aircraft Systems menu, shown in Figure 6-6, is used to access information about aircraft systems.



ID-000762942

Figure 6-6
Systems Title Button Dropdown Menu

The Systems menu is described in detail in Section 8, Multifunction Display - Synoptics.

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TCAS Menu

The TCAS zoom format is controlled by the TCAS menu and is displayed on the lower 1/3 of the MFD display, as shown in Figure 6-7. The TCAS checkbox on the Map dropdown menu, as shown previously in Figure 6-4, overlays targets on the upper 2/3 of the MFD map display. A TCAS virtual controller is also displayed when the TCAS menu button is activated. The virtual controller controls the TCAS data shown in the upper and lower MFD windows.

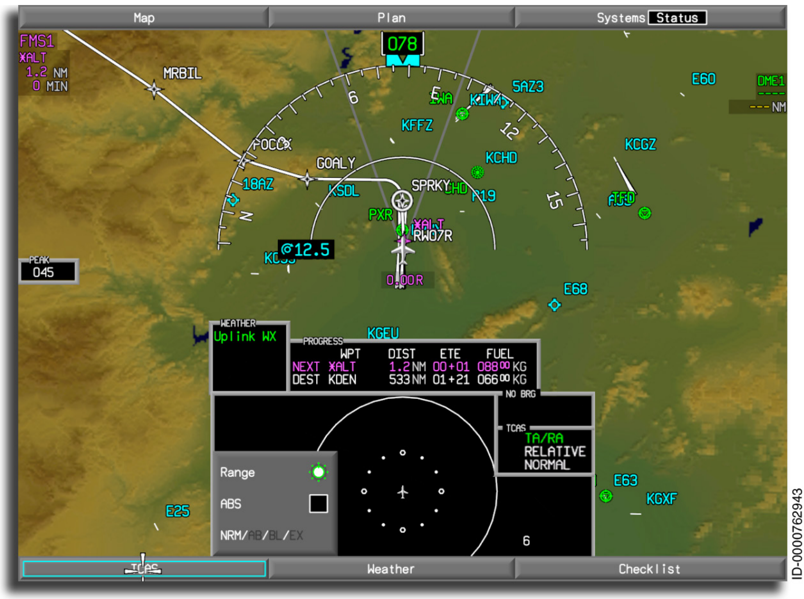

Figure 6-7
TCAS Title Button Pop-Up Menu

TCAS is described in detail in Section 19, Traffic Alert and Collision Avoidance System (TCAS).

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Weather Menu

Weather radar returns from either the Primus-880 or RDR-4000 (option) are available for display on the MFD. The weather radar display is selected in the Map menu by selecting the weather (WX) radio button, shown in Figure 6-8. Weather images are displayed on the MFD Map display, but the radar is controlled from the Weather controller at the bottom of the display. The radar images are also displayed on the PFD.

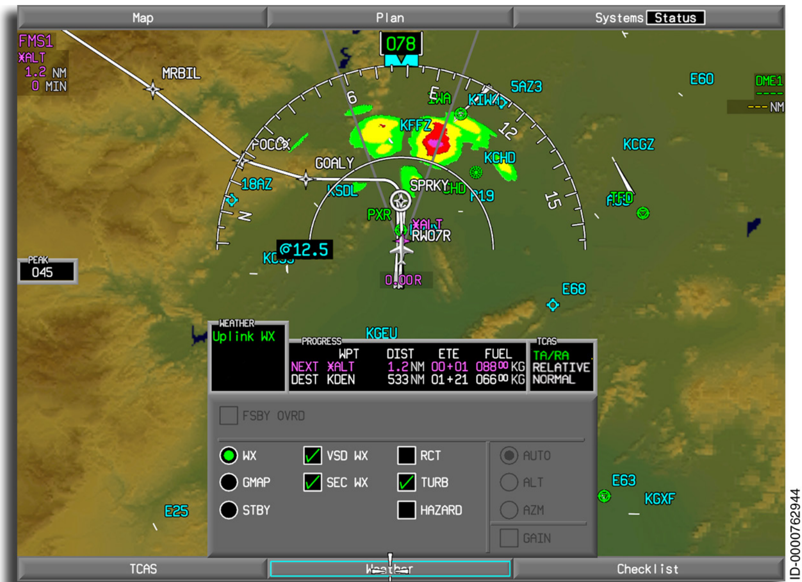

Figure 6-8
Radar Title Button Pop-Up Menu

Weather radar control options are different for the Primus-880 and RDR-4000 (option). The weather radar is described in detail in Section 18, Weather Radar Systems.

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Checklist Menu

Electronic checklists (option) are controlled and displayed using the Checklist menu button, shown in Figure 6-9.

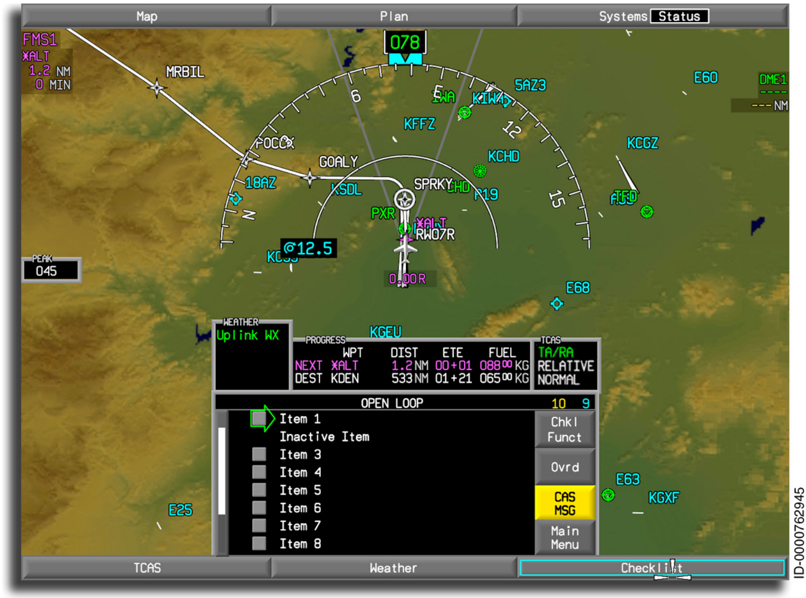

Figure 6-9
Checklist Title Button Pop-Up Menu

Electronic checklists are described starting on page 6-93.

INTERACTIVE NAVIGATION (INAV)

Interactive navigation (INAV) is the interactive graphical map of the Primus Epic flight deck. The interactive map displays various sets of databases such as terrain, airways, airspace, navigation aids (NAVAIDs), airports, communication, and geopolitical boundaries. The interactive map also has the ability to merge information received from various onboard sensors (FMS flight plan and aircraft position, weather, lightning, and TCAS) to provide an intuitive and synthetic display of the aircraft situational environment both in the horizontal and vertical planes.

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Map Display

The INAV window consists of the map display. The primary function of the map is to display lateral and vertical positioning information to the pilot and copilot. The map is capable of, but not limited to, displaying the following information:

- Magnetic or true heading
- Magnetic track
- Graphical representation of the flight plan
- North-up orientated
- Objects in navigation database (e.g., STARs and waypoints)
- Weather information
- TCAS information
- Topography
- Wind direction and speed
- Vertical flight profiles
- Absolute terrain
- Airways, airspaces, and geopolitical boundaries
- Closest airports
- VOR, NDB, airports
- Airborne weather radar
- Miscellaneous annunciators.

The INAV provides the pilot with a Show Info feature that displays information for any object on the lateral map. The pilot can also search for objects and zoom on the lateral map.

The INAV supports highlighting any object on the map and centering the map on that object. The INAV map can also be panned without changing the zoom level. Both functions are described later in this section.

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The MFD with the enhanced INAV option provides graphical flight planning (GFP). GFP is described in detail in Pub. No. D202012001536, Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide.

The map has two user-selectable display modes: north-up (Plan mode) and heading-up (Map mode). Figure 6-10 shows the map in north-up mode.

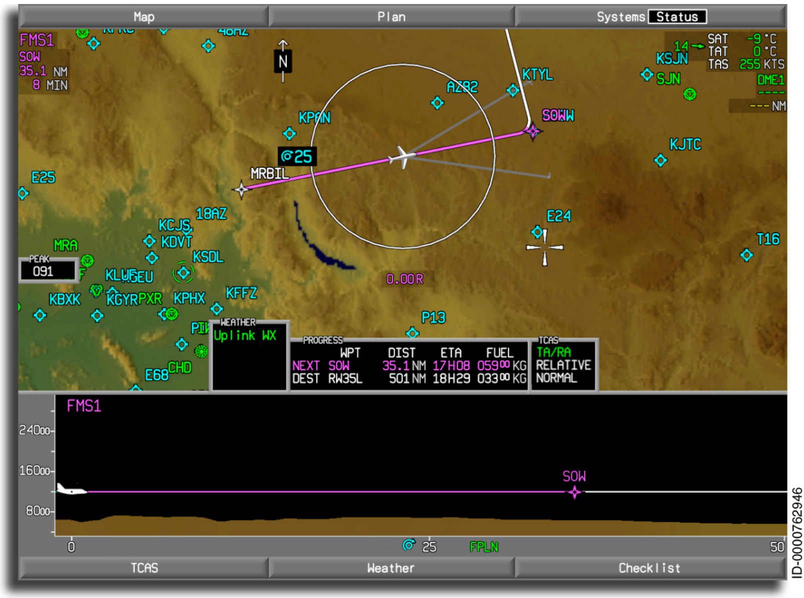

Figure 6-10
North-Up Mode

The Map display is toggled between north-up and heading-up by selecting the **Plan** menu button or **Map** menu button.

The INAV supports a fixed mode, which is map mode, but with the aircraft not centered. For example, when the map is panned while in map mode, the fixed map mode remains oriented to the heading at the time fixed mode was entered.

When the map is in the north-up mode, the top of the map is always oriented towards true north, and the lines of latitude and longitude are parallel with the edges of the display. Configuring the map to be oriented to magnetic north-up is not possible.

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Figure 6-11 shows the map in heading-up mode. In this mode, the top of the map is always oriented with the aircraft heading.

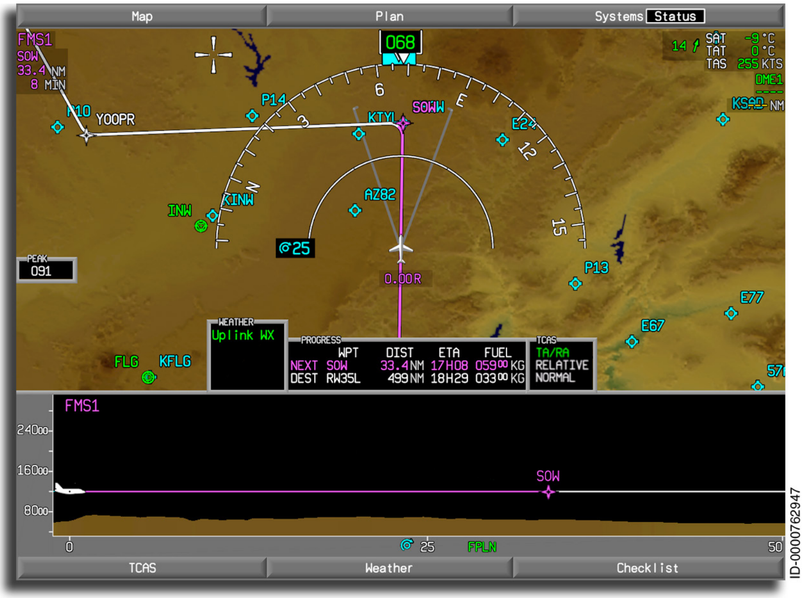

Figure 6-11
Heading-Up Mode

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Map Dropdown Menu

The dropdown menu for the map mode is displayed by pushing the **Map** button on the top of the display. The Map dropdown menu for the MFD with the enhanced INAV option is shown in Figure 6-12.

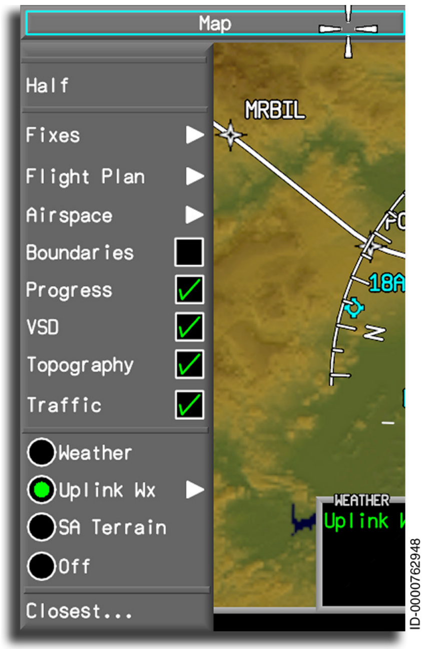

Figure 6-12
MFD With Enhanced INAV Option Map Dropdown Menu

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The Map dropdown menu for the classic MFD option is shown in Figure 6-13.

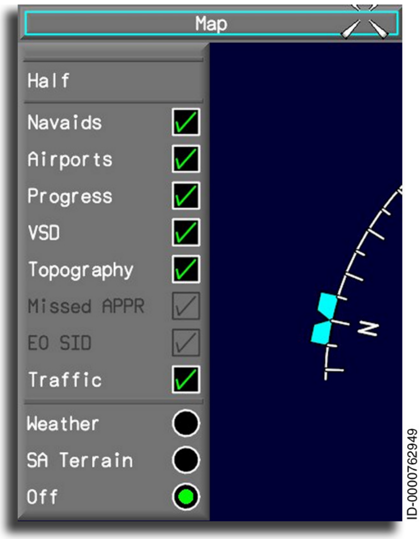

Figure 6-13
Classic MFD Option Map Dropdown Menu

The following paragraphs describe the prompts available in either MFD option Map dropdown menu.

Half – The INAV can be displayed in half display mode by selecting the Half prompt in the dropdown menu. The Half prompt is displayed when in full display mode. The INAV can be displayed on either side of the MFD in the half display mode.

Full – The INAV can be displayed in full display mode by selecting the Full prompt in the dropdown menu. The Full prompt is displayed when in half display mode. When in full mode, the INAV is stretched across both sides of the MFD.

Fixes – Selecting the Fixes submenu (MFD with enhanced INAV option only) displays the Navaids and Airports checkboxes. More than one checkbox can be checked (contains a), and all checked boxes are considered active. A green check is placed in the white box when the **ENTER** button is pushed or removed if a checkmark is already present.

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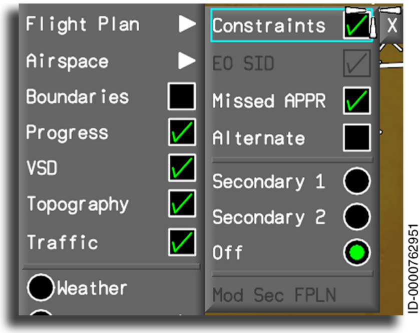
Navaids – Navaids displays navigation aids.

Airports – Airports displays airports on the map and also enables display of runways/localizers.



Flight Plan – Selecting the Flight Plan submenu (MFD with enhanced INAV option only) displays the Constraints , EO SID , Missed APPR , Alternate checkboxes and Secondary 1 , Secondary 2 , and OFF radio buttons. More than one checkbox can be checked (contains a ), and all checked boxes are considered active. A green check is placed in the white box when the **ENTER** button is pushed or removed if a checkmark is already present.

Radio buttons are mutually exclusive, and only one secondary flight plan can be selected at a time. A green dot is displayed in the radio button for the selected flight plan.

Constraints – Constraints (MFD with enhanced INAV option only) displays constraints imposed on waypoints (e.g., angle, speed, time).

NOTE: Constraints are displayed on the Vertical Situation Display (VSD), described later in this section.

EO SID – EO SID displays the engine out departure procedure when selected.

Missed APPR – Missed APPR displays the missed approach route at the destination when an approach has been selected.

Alternate – Alternate (MFD with enhanced INAV option only) displays the route from the destination to the alternate when an alternate and route to that alternate have been defined.

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When Secondary 1 or Secondary 2 (MFD with enhanced INAV option only) is selected, the secondary flight plan is displayed on the MFD. OFF removes the secondary flight plan from the MFD.

The Mod Act FPLN or Mod Sec FPLN (MFD with enhanced INAV option only) is displayed when the active or secondary flight plan is not interactive. When Mod Act FPLN or Mod Sec FPLN is selected, the active or secondary flight plan becomes interactive. Interactive flight planning allows the pilot to make flight plan changes on the INAV map and is described in Pub. No. D202012001536, Flight Management System (FMS) for the Embraer E-Jet E2 E190-E2 Pilot's Guide.

ID-0000762952

Airspace – Selecting the Airspace submenu (MFD with enhanced INAV option only) displays the HI Airways, LOW Airways, Terminal, and Special Use checkboxes. More than one checkbox can be checked (contains a ✓), and all checked boxes are considered active. A green check is placed in the white box when the **ENTER** button is pushed or removed if a checkmark is already present.

Hi Airways – HI Airways (MFD with enhanced INAV option only) displays high altitude jet routes on the map.

LOW Airways – LOW Airways (MFD with enhanced INAV option only) displays low altitude airways on the map.

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Terminal – Terminal (MFD with enhanced INAV option only) displays airspace in which approach control service or airport traffic control service is given.

Within North America, the terminal airspace layer consists of the following classes of airspace displayed in cyan:

- Control Area (CTA) or Special Rules Area (SRA)
- Class B
- Class C

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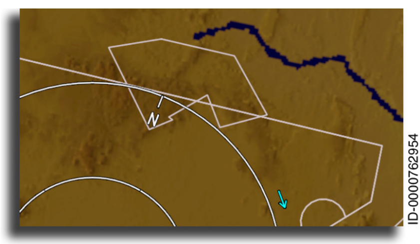
- Class D
- Class E
- Class F
- Control Zone (CTLZ), Military Air Traffic Zone (MATZ), or Special Rules Zone (SRZ)
- Radar Area
- Terminal Control Area (TCA) or Military Terminal Control Area (MTCA)
- Air Route Traffic Control Center (ARTCC)
- Terminal Maneuvering Area (TMA).

Outside North America, the classes of terminal airspace shown may not include all of those listed here.



Special Use – Special Use (MFD with enhanced INAV option only) displays areas designated for operations of a nature such that limitations can be imposed on aircraft not participating in those operations.

Within North America, the special use airspace (SUA) layer consists of the following classes of airspace displayed in gray:

- Advisory Area (ADA) or User Defined Area (UDA)
- Air Defense Identification Zone (ADIZ)
- Air Control Center (ACC)
- Buffer Zone (BZ)
- Flight Information Region (FIR)
- Ocean Control Area (OCA)
- Upper Flight Information Region (UIR)
- Alert
- Danger Area

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- Military Operations Area (MOA)
- Prohibited Area
- Restricted Area
- Temporary Reserved Airspace (TRA)
- Warning.

Outside North America, the classes of special use airspace shown may not include all of those listed here.

The checkbox buttons are used to select and overlay any or all of the following items:

- **Boundaries** (MFD with enhanced INAV option only) – Geopolitical boundaries are displayed, including lines of latitude and longitude. The political boundaries displayed consist of international country boundaries and province/state boundaries for Canada and the United States, as shown in Figure 6-14. Coastlines are also displayed.

Figure 6-14
Geopolitical Layer

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- **Progress** – Flight progress information is displayed below the map. The PROGRESS window is described later in this section.
- **Vertical Situation Display (VSD)** – Vertical flight profiles are displayed below the map on the same page. The VSD is described later in this section.
- **Topography** – Terrain features are displayed on the map in brown and green shading.
- **Traffic** – Traffic alert and collision avoidance system (TCAS) targets are displayed on the map, as shown in Figure 6-15. When cockpit display of traffic information (CDTI) is installed (option), the CDTI targets are also displayed. For a detailed description on TCAS, see Section 19, Traffic Alert and Collision Avoidance System (TCAS).

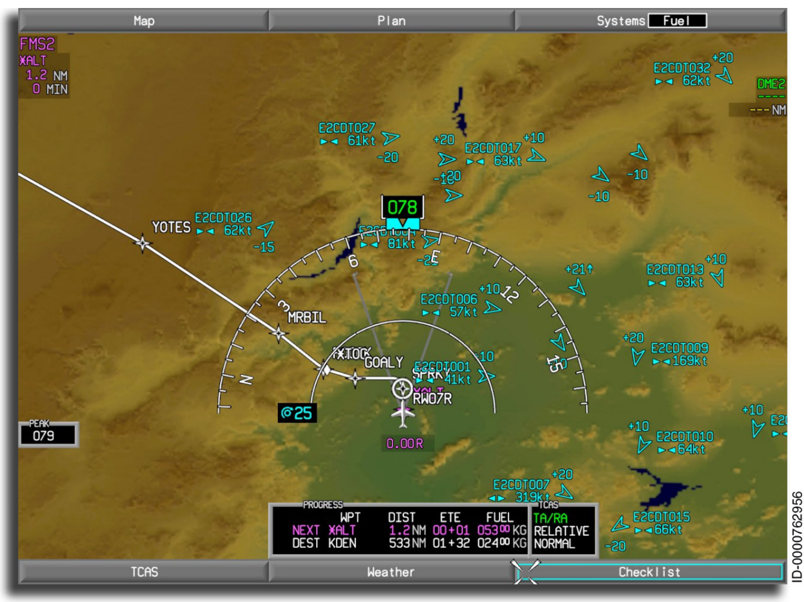

Figure 6-15
TCAS and CDTI Targets on INAV Display

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The Map menu also uses radio buttons to select one of the displays to be overlaid with the previously listed items:

- **Weather** -Weather is displayed on the map format when weather has been selected from the Map dropdown menu. Weather is controlled using the virtual weather menu on the bottom of the MFD. Weather cannot be shown at the same time with SA terrain as both are mutually exclusive. The weather system is described in detail in Section 18, Weather Radar Systems.

- **Uplink Weather** (MFD with enhanced INAV option only) – Selecting the **Uplink Wx** radio button displays checkboxes to select NEXRAD, Satellite, and Winds overlays on the MFD, as well as request additional weather uplinks. Selecting the uplink weather menu deselects the onboard weather radar or SA terrain selection. Uplink weather can display radar, satellite, and wind data provided by the way of an uplink. For a detailed description of uplink weather, see Section 23, Other Systems.

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- **SA Terrain** – Situational awareness terrain information is displayed on each MFD when selected for display. Terrain information consists of terrain images retrieved from the terrain database, mode annunciation, and peak information. The situational awareness terrain display is constructed by generating a bitmap with colors assigned based on the comparison between aircraft altitude and the five different altitude level data provided by the enhanced ground proximity warning function (EGPWF). The terrain image is displayed in the map area using varying colors to distinguish terrain altitude, as shown in Figure 6-16. SA terrain is described in detail in Section 20, Enhanced Ground Proximity Warning System (EGPWS).

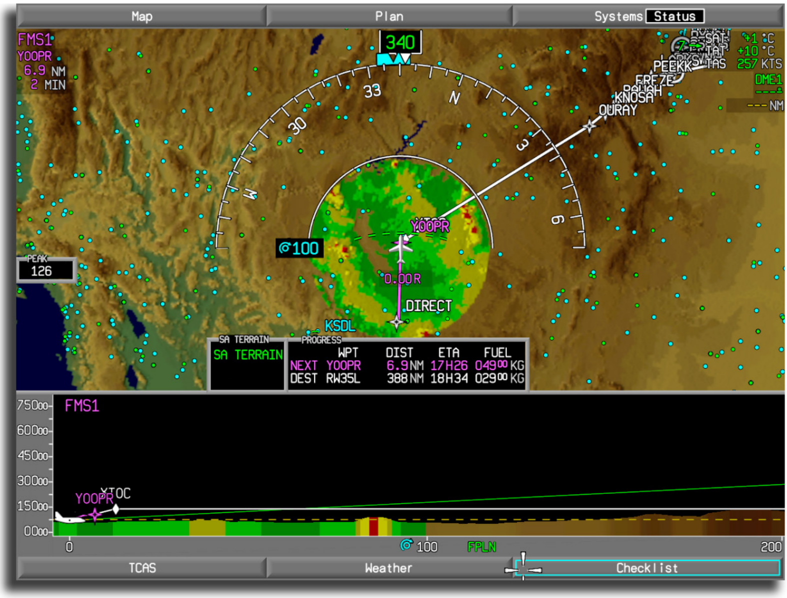

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Figure 6-16
SA Terrain Layer on INAV Display

- **Off** – No radar or terrain awareness and warning system (TAWS) images on the map are selected.

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NOTES: 1. Display range is controlled by the outer concentric knob on the CCD when the map page is displayed.

2. Weather and terrain cannot be displayed together. They are mutually exclusive.

3. The engine out standard instrument departure (EOSID) is displayed in solid cyan on the MFD when previewed. When activated, the normal FMS color display schemes apply. The EOSID display is discernible from the active flight plan.

Closest (MFD with enhanced INAV option only) – The Closest... button at the bottom of the Map dropdown menu automatically adjusts the map range such that at least five of the closest airports are visible on the INAV map area. Closest airports are airports near the present position of the aircraft but not in the flight plan. The pilot can use the CCD scroll knob to scroll through the ten closest airports to the present position of the aircraft in a dialog box on the lateral map, as shown in Figure 6-17.

Figure 6-17
Closest Airports Dialog Box

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When the Closest Airports window is open, a cyan dashed line connecting the aircraft to the displayed airport in the closest window is displayed, as shown in Figure 6-17.

Plan Dropdown Menu

The dropdown menu for the Plan mode is displayed by pushing the **Plan** button on the top of the display. The Plan dropdown menu for the MFD with Enhanced INAV option is shown in Figure 6-18.

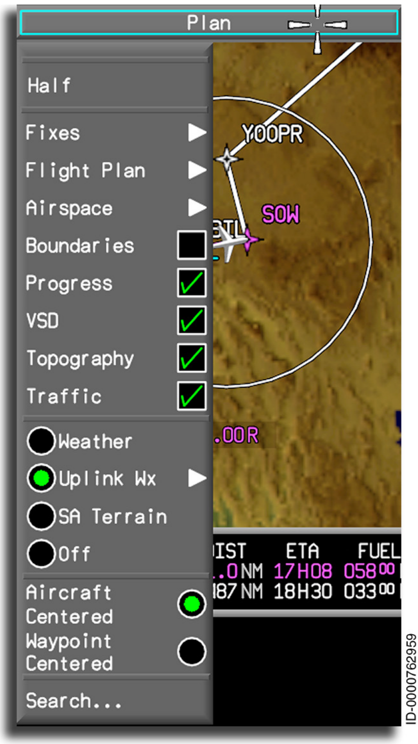

Figure 6-18
MFD With Enhanced INAV Option Plan Dropdown Menu

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The Plan dropdown menu for the Classic MFD option is shown in Figure 6-19.

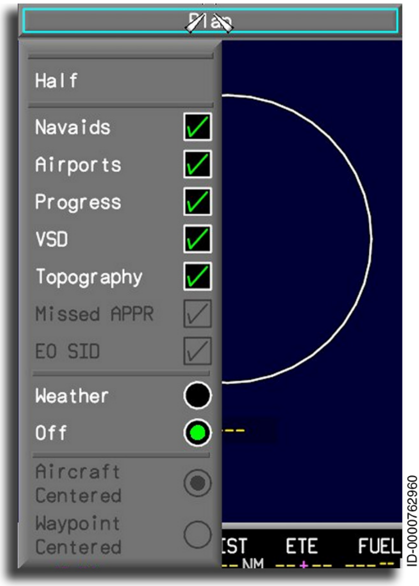

Figure 6-19
Classic MFD Option Plan Dropdown Menu

The submenu and checkbox buttons have the same function as those previously discussed for the Map dropdown menu. The additional options for Plan mode are described in the following paragraphs.

- **Aircraft Centered** – The aircraft-centered display of the MFD Plan mode is displayed when the Plan mode is selected, and the Aircraft Centered radio button is selected from the Plan menu. The center of the MFD Plan mode is fixed at the present position of the aircraft. After selection, the position and orientation of the aircraft are updated to reflect changes in aircraft position and heading.

  The aircraft symbol is positioned on the display with respect to the initial aircraft location using aircraft present position and current aircraft heading from the FMS.

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- **Waypoint Centered** – The waypoint-centered display of the MFD Plan mode is displayed when the Plan mode is selected and the Waypoint Centered radio button is selected from the Plan menu. The center of the MFD Plan mode is fixed at the selected waypoint at the time the waypoint-centered option was selected. After selection, the position and orientation of the aircraft are updated to reflect changes in aircraft position and heading. The waypoint in the center of the display can be changed using the inner concentric knob on the CCD. When the selection is made, Waypoint Center is displayed in the lower-right corner of the display, as shown in Figure 6-20.

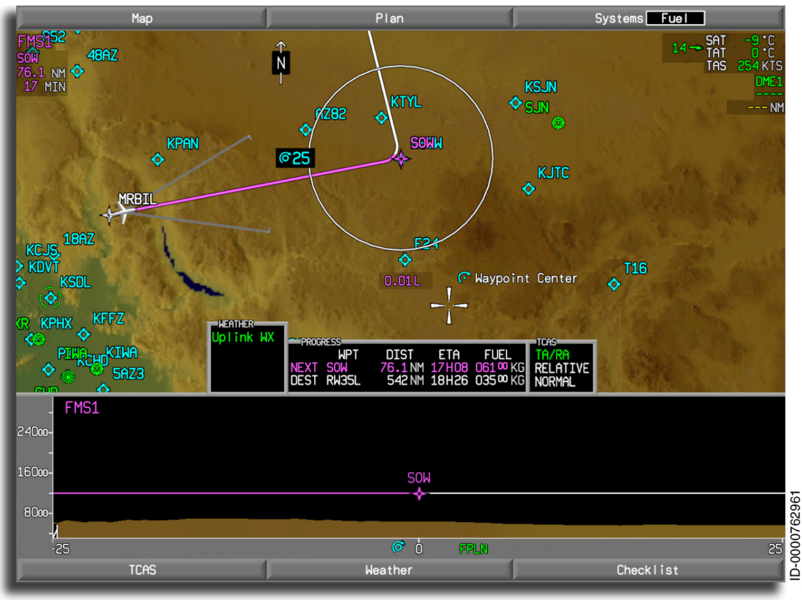

Figure 6-20
Waypoint Center

On initial selection of the waypoint-centered display, the current T/O waypoint is placed at the center of the MFD Plan mode with other waypoints, NAVAIDs, airports, and other symbols, including the aircraft symbol, placed at the correct distance and bearing based on position (latitude, longitude) and range selection.

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NOTE: *Display range is controlled by the outer concentric knob on the CCD when the Plan mode is selected.*

When the TCAS zoom range adjustment becomes active, the variable gain on the weather radar virtual control becomes active, or if the electronic checklist (ECL) is activated, the CCD inner concentric knob icon is removed from the Plan mode, and operation of the CCD does not affect the centering on the display.

SEARCH BUTTON

The Search... button (MFD with enhanced INAV option only) in the Plan dropdown menu permits the pilot to search for NAVAIDs, named waypoints, airports, ILS, and airways by entering the identifier or name of the object. If the object is found in the navigation database, INAV displays the object on the lateral map. When selected, the Search dialog box is displayed, as shown in Figure 6-21.

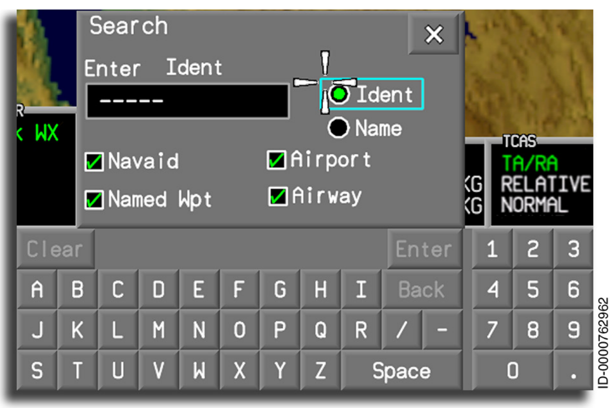

Figure 6-21
Search Function Dialog Box

The cursor is automatically placed on the Ident button. The Navaid , Airport , Named Wpt , and Airway checkboxes are all selected by default.

A virtual keyboard is used for text entry with the addition of INAV and electronic charts and maps.

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Selecting the Clear button clears the text field in the virtual keyboard and puts the focus on the A key. Selecting the Enter button has INAV search the navigation database for the entered identifier text. When it is found, the Search box is closed. If it is not found, the message No Matches Found is displayed. Invalid entries flash the text entry field in reverse video and reset it to dashes. Selection of the X button closes the dialog box.

After the search is complete and multiple objects with the same identifier name are found in the navigation database, INAV shows the Select Object dialog box, as shown in Figure 6-22.

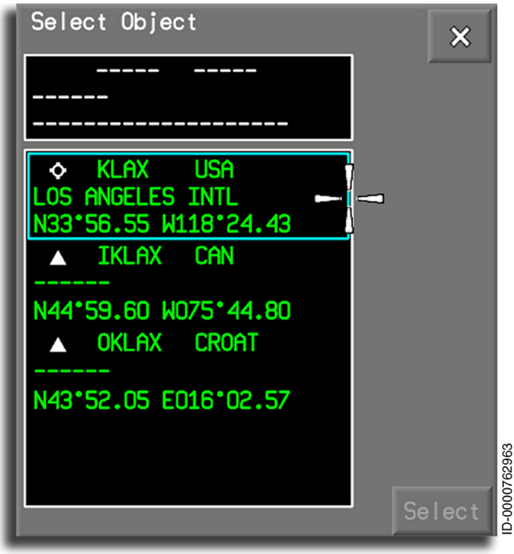

Figure 6-22
Select Object Dialog Box

When the cursor is positioned over an identifier in the select object dialog box, the object is highlighted with a cyan border. When more than four identifiers are found in the search, INAV provides a scroll bar on the Select Object dialog box.

Once an identifier is selected, the information for that Identifier is copied in the identifier box below the header of the Select Object dialog box, and the Insert button is active with the cursor placed on it. Once a selection is made, the Select Object dialog box is closed. The X button, when selected, also closes the box.

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Map and Plan Display Mode Differences

Table 6-1 lists the main differences between Map and Plan modes.

Table 6-1
Map and Plan Mode Differences

Function	Map Mode	Plan Mode
Display orientation	Heading-Up*	North-up
View	Looking at map from nose of aircraft	Looking at map relative to north-up
Non-moving reference at center of display	Aircraft symbol (Nose UP)	Next waypoint or aircraft symbol
Heading indication	Compass	Aircraft symbols nose (no compass displayed)
What moves (on display)	The map	Aircraft ref. = map ref. = aircraft
Range measured from	Aircraft symbol	Selected reference
Weather overlay (Radar)	YES	NO (Primus 880 radar) Yes (RDR 4000 radar)
NOTE: * – Fixed mode is displayed while in Map mode when panning is performed to any object other than the aircraft.		

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INAV Symbols

Figure 6-23 identifies some of the symbols shown on the INAV display.

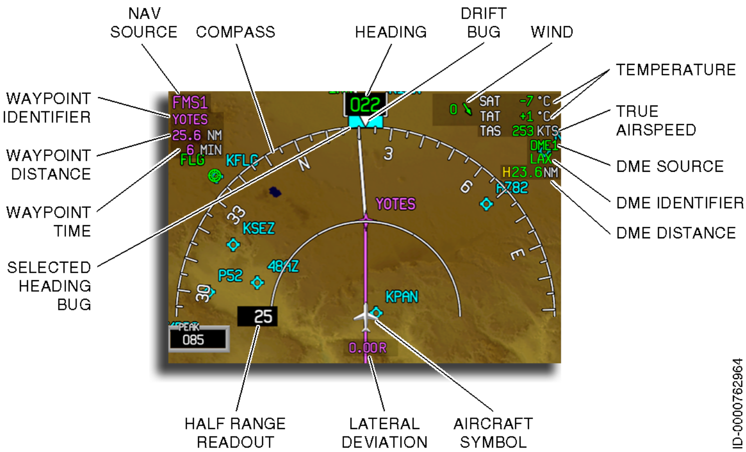

Figure 6-23
INAV Symbols

NAV Source – The NAV source annunciator is located in the upper-left corner of the MFD Map or Plan modes. The navigation source is selected on the on-side PFD controller and shown on the Map and Plan modes. Each MFD can use a different source, selected by the on-side PFD controller using the **FMS** button on the on-side PFD controller. Only one source is permitted on each side. When the pilot and copilot are using the same NAV source, the source annunciators on both MFDs become amber.

The FMS NAV source can be FMS1 or FMS2 . The source annunciator is magenta and is selected by stepping through the possible selections using the **FMS** button on the on-side PFD controller.

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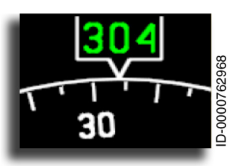
TO Waypoint Identifier, Time, and Distance Display – The FMS distance display is shown in magenta. The navigation distance information includes the TO waypoint identifier, distance readout, and time-to-go readout. When distance or time information is invalid, the corresponding digital readout is replaced with three amber dashes (---).

The navigation source distance readout has a display range of 0.0 NM to 9,999 NM. The navigation source distance readout is displayed to a resolution of one-tenth of a nautical mile for distances less than 100 NM. For distances equal to or over 100 NM, the primary navigation source distance readout is shown to a resolution of 1 NM.

Compass Rose – The map heading display is a 180° compass rose. The cardinal headings are labeled N , S , E , and W . Heading at 30° increments are labeled with one or two-digit degree markings (e.g., 060° is 6 , 330° is 33). The scale tick markings are in 5° increments. The compass turns as the aircraft heading changes.

Heading Source Annunciator – The source of heading data is displayed above the HSI just left of the lubber line. When the on-side source is used and a normal magnetic heading reference is selected, the source is not annunciated. When the pilot and copilot are using the same source or non-normal source, the annunciator is displayed in amber. The IRS source is selected on the on-side reversionary panel.



Heading Readout/Display – Aircraft heading is displayed at the top center above the compass by a pointer and digital heading readout. Aircraft heading is displayed the same way as the heading readout on the PFD HSI. The heading source is true or magnetic selected on the MCDU.

The heading readout is contained in the pointer window at the top center of the display. The readout is three green digits from 001 to 360 . When heading status is invalid, the digits are replaced with three amber dashes (---).

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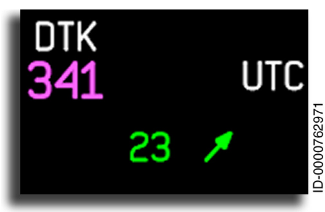
Selected Heading Bug – The cyan selected heading bug position is changed using the HDG knob on the guidance panel. Pushing the **SYNC** button on the guidance panel sets the bug to the current aircraft heading. The heading bug is only displayed when the map is in heading-up mode.

Drift Bug – The difference between the aircraft heading and aircraft ground track is the drift angle. The drift bug is represented by a white inverted triangle displayed on the outside edge of the heading scale in both arc and full compass modes, based on information supplied by the IRS.

If heading or drift angle status is invalid, the drift bug is removed.



Wind Display – The wind display can be displayed in Cartesian (X Y) or vector formats. Both formats use a green digital readout for wind speed and an arrow vector for direction. The arrow points in the direction the wind is blowing. The vector format is displayed in either heading-up or north-up mode. The format of the wind readout is selected on the SETUP Page, described on page 24-3.

The Cartesian format consists of a lateral and longitudinal digital wind speed and arrow.

The FMS is the source of the wind data, and the wind value displayed is the instantaneous wind acting on the aircraft at the moment. Wind data is only displayed when the aircraft is centered.

The wind display is removed when in TRACK mode and is replaced with the annunciation A/C Track when north-up is selected to indicate that the aircraft is track-oriented.

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ID-0000762973

Flight Information Display – The flight information display is located in the upper right-hand corner of the Map or Plan mode on the MFD. The display includes information on temperature and airspeed and is explained in the following paragraphs.

ID-0000762974

Static Air Temperature (SAT) – The SAT display consists of a white static air temperature label (SAT), a green temperature readout, and a gray unit label (°C). A plus (+) or minus (-) sign is displayed to the left of the temperature readout.

If the static air temperature is invalid, the temperature readout is replaced with amber dashes (- - - -), and the polarity sign is removed.

ID-0000762975

Total Air Temperature (TAT) – The TAT display consists of a white total air temperature label (TAT), a green temperature readout, and a gray unit label (°C). A plus (+) or minus (-) sign is displayed to the left of the temperature readout.

If the total air temperature is invalid, the temperature readout is replaced with amber dashes (- - - -), and the polarity sign is removed.

ID-0000762976

True Airspeed (TAS) – The TAS display consists of a white true airspeed label (TAS), a green airspeed readout, and a gray unit label (KTS). True airspeed is displayed in knots with 1-knot resolution.

When the TAS is invalid, the TAS readout is replaced with amber dashes (- - -).

ID-0000762977

DME Display – The DME display is located to the right of the navigation display. The DME information on the MFD is displayed in green under normal conditions. When the data is abnormal or same source, the DME display is amber.

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DME Source – The DME source annunciator reflects the SRN source selection. For example, when VOR1/LOC1 is selected on the PFD, DME1 is displayed on the corresponding MFD. When VOR2/LOC2 is selected on the PFD, DME2 is displayed on the corresponding MFD. When the primary navigation source is FMS, the last selected VOR/LOC is used. When the DME source is invalid, the DME source readout is replaced with three amber dashes (- - -).

DME Station Identifier – The DME source annunciator displays the DME ground station that is tuned by the source DME receiver. When the data is invalid, the DME station identifier is replaced with three amber dashes (- - -).

Distance Readout – The DME distance readout is displayed in nautical miles on the MFD. DME has a resolution of 0.1 NM for ranges between 0 and 99 NM and 1 NM for ranges over 100 NM. When the DME data is invalid, the DME distance readout is replaced with three amber dashes (- - -).

DME Hold – The DME hold annunciator (hold mode active) is represented with an H . The distance DME hold annunciator is displayed to the left of the DME distance readout. The crew selects DME hold using the MCDU radio control pages.

When an RNAV approach to LPV minimums is active, the GPS reference path identifier (W258) (sometimes called the Approach ID) replaces the DME source annunciator. In addition, the DME station identifier is replaced by the WAAS identifier, the DME distance readout is replaced by the GPS distance readout, and the DME TTG readout is replaced by the GPS1 or GPS 2 identifier readout.

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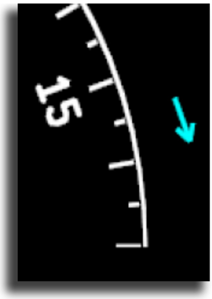

ID-0000762980

Heading Select Bug Off-Scale Arrow – In the Map mode, the selected heading bug can be rotated off the compass scale. When the heading select bug is off the visible scaled arc, a cyan heading bug off-scale arrow (→) is displayed on the left or right side of the arc to indicate the shortest direction to the bug. The arrow is removed when the bug is in view.

If heading status or the selected heading bug data is invalid, the heading bug and arrow are removed.


ID-0000762981

Aircraft Symbol – A white aircraft symbol, nose pointing up on the Map display, is displayed in the lower center of the map compass display area. The aircraft symbol is a visual cue to aircraft position relative to actual heading and selected heading.

ID-762982

Half-Range Readout – Map range (half-range arc) is represented by a ±180 arc halfway between the aircraft symbol and the heading arc. The range value shown is one-half of the full-range value (2.5, 5, 12.5, 50, 100, 150, 250, 500, and 1,000). The range value is controlled by the CCD range outer concentric control knob. The display range shows the range on the Map and Plan modes, including weather radar returns, ground proximity indications, and flight plan waypoints when shown. The half-range, when controllable, consists of cyan range digits representing one-half the selected range value and a cyan outer knob icon. When the range is not controllable, the range digits are displayed in white.

The minimum and maximum displayed range values correspond to the values listed in Table 6-2.

Table 6-2
HDG or North-Up Minimum and Maximum Range Values

	Heading-Up	North-Up
Minimum	2.5 NM	2.5 NM
Maximum	1,000 NM	1,000 NM

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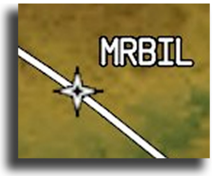


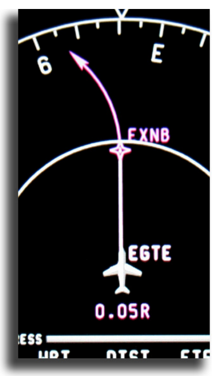
ID-0000762983

Waypoint Symbol – Waypoint symbols and identifiers display the relative location of up to 100 waypoints in the active flight plan and up to 35 waypoints in the alternate flight plan. **WPT Ident** is selected from the Map or Plan menu to show waypoint symbols and identifiers.

The current leg and T/O waypoints are displayed in magenta. All other legs and waypoints are displayed in white.

ID-0000762984

Flyover Waypoint Symbol – A white flyover waypoint symbol is displayed with the waypoint identifier located in the upper right quadrant. A flyover waypoint indicates to the pilot that a turn must be delayed until the waypoint is overflown.



ID-0000762985

Directional Turn Arrow – The FMS provides a directional turn arrow when changes to the aircraft speed and the geometry of a course results in a non-displayable lateral flight path vector. In this case, the FMS provides lateral guidance starting in the direction of the turn arrow and flies without a visible flight path vector to the TO waypoint. The turn arrow is only a directional turn reference symbol and does not imply a specific turn path.

NAVAIDs – Navigation aid (NAVAID) symbols and identifiers are displayed on the Map or Plan mode. NAVAID displays are enabled when the NAVAIDs checkbox is selected from the Map or Plan menus. The NAVAID symbol shown is according to the station type information received from the FMS. The NAVAID symbol and identifier are displayed in green.

The NAVAIDs are shown at a relative location that are not waypoints on the flight plan. When selected, the NAVAIDs are displayed as a unique symbol for a VORTAC, VOR/DME, VOR TACAN, DME, or NDB with an associated NAVAID identifier, as shown in the following examples.

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VORTAC symbol

VOR/DME symbol

VOR symbol

TACAN symbol

DME symbol

NDB symbol

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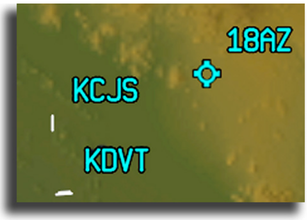

ID-0000762992

Airport Symbol – Airport symbols vary in display depending on the size of the airport and the half-range selected. Airport symbols are either a cyan dot, a cyan hollow circle with tick marks, or a white runway symbol. Airports with a localizer or ILS approaches are shown as white runway symbols with a localizer feather extending from each runway served by a localizer.

ID-0000762993

Equal Time Point (ETP) and Selected Airport – The ETP display provides the diversion airports (WPT1 and WPT2) entered on the EQUAL TIME POINT (ETP) page on the lateral map along with the ETP when selected for display. The ETP symbol is displayed as a double arrow. The diversion airport (WPT1 and WPT2) is displayed, outlined by a white diamond.

ID-0000762994

Localizer Symbol – A white feathered symbol is used to display a localizer approach when the half-range is 12.5 NM or less.

ID-0000762995

Airways – High and low altitude airways are displayed when the map half-range is 25 NM or less and selected in the map dropdown menu. The route numbers (i.e., V16) are displayed when map half-range is 12.5 NM or less.

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ID-0000762996

The airway number is displayed in a black box outlined in cyan when the cursor hovers over the desired airway when the map half-range is 25 NM or less.

ID-0000762997

Synthetic Vision Field of View (FOV) – FOV lines are always displayed on the MFD INAV window to indicate the lateral area of terrain being depicted on the PFD.

The FOV lines show lateral limits of synthetic terrain being displayed and approximately what the closest displayed terrain is. The field of view is approximately 41 degrees (same as the lateral field of view) with a range of 40 NM.

NOTE: The lateral FOV lines may not always line up symmetrically with the centerline of the aircraft displayed on the INAV because the terrain being viewed may not line up with the aircraft centerline due to the drift angle.

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An ETOPS (extended operations) indication, shown in Figure 6-24, is displayed to the pilots on the INAV display when the ETOPS selection is made through the MCDU. Extended operations permit air carriers to fly an extended range (over 60 minutes) over places where airports and landing areas are sparse.

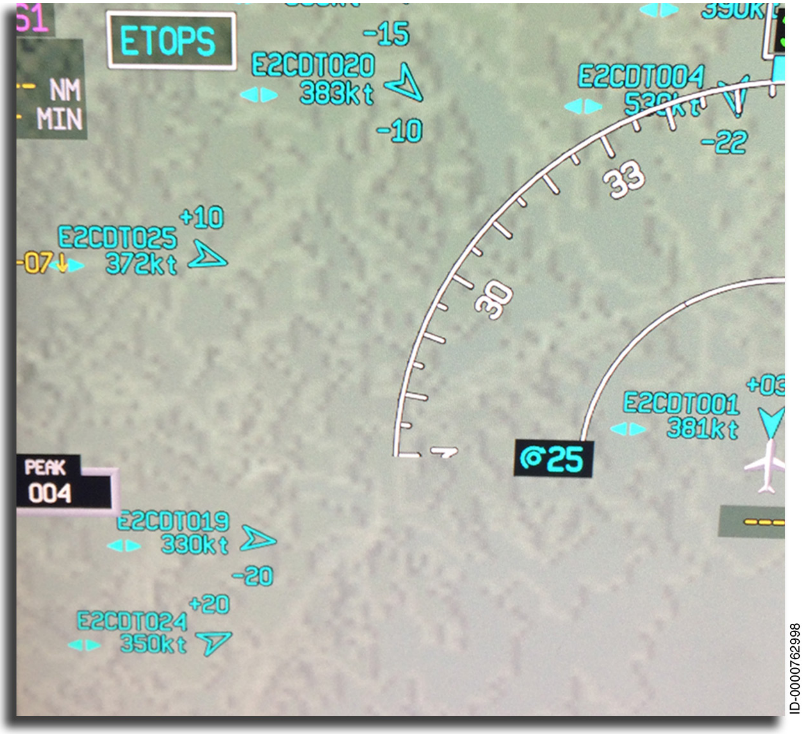

Figure 6-24
ETOPS Indication

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FMS Flight Plan Map Data

An example of FMS flight plan data displayed on the INAV map is shown in Figure 6-25.

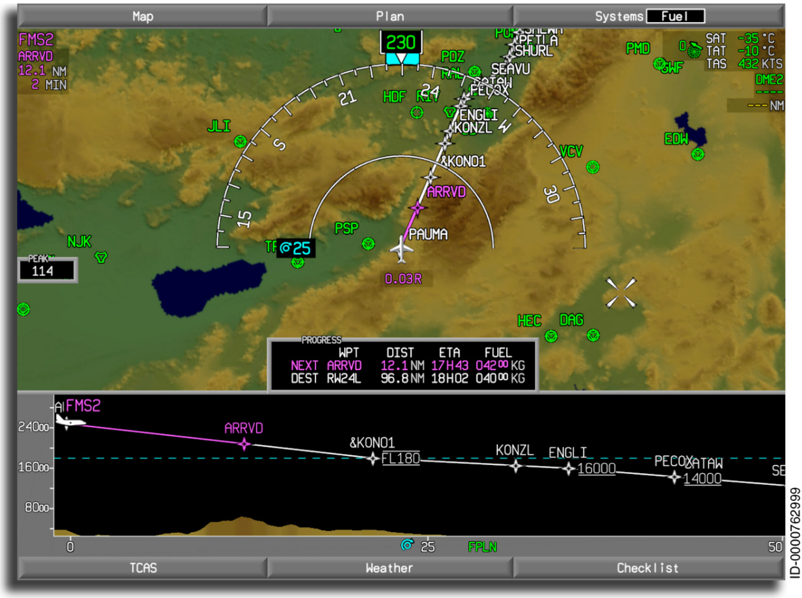
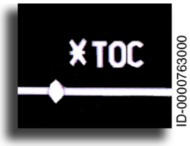


Figure 6-25
FMS Flight Plan



Altitude Profile Point – Altitude profile points consist of projected top-of-climb (TOC) and projected top-of-descent (TOD). TOC is the point the aircraft levels off after a climb. TOD is the point the aircraft begins a descent. An asterisk (*) is always placed in front of the TOC and TOD waypoints, indicating these waypoints are generated by the FMS, not the pilot.

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Altitude Intercept Point – The altitude intercept point is a green dashed arc positioned on the flight plan. The altitude intercept icon is used to indicate where the aircraft will reach the altitude preselect value. The altitude intercept point is displayed automatically when the altitude selector is not at present aircraft altitude and the vertical speed is greater than 300 feet per minute.

The arc is removed from the display when the aircraft climb/ descent rate is less than or equal to 300 feet per minute, or if any parameters used to calculate the position of the arc (barometric altitude, groundspeed, altitude rate, and so on) are invalid.

Holding Patterns – Holding patterns are represented by a symmetrical oval racetrack symbol. Holding pattern entries are displayed when the FMS recommends a teardrop or parallel hold entry. Holding patterns are displayed in white when the hold is not the active leg. The holding pattern entry and holding pattern are displayed in magenta when the hold is the active leg. After the aircraft completes the hold entry by flying over the holding fix, the holding pattern entry is removed, and only the holding pattern is displayed in magenta.

NOTE: Holding pattern entries are approximate.

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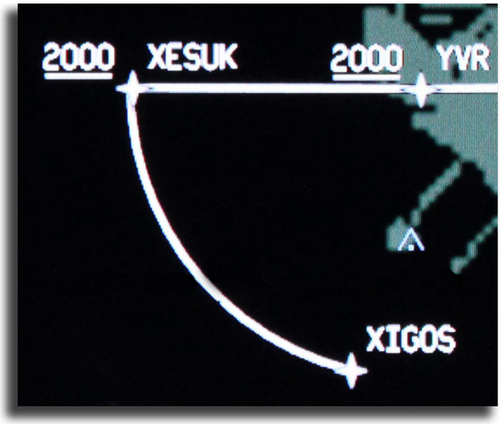
ID-0000763003

Procedure Turn – A procedure turn shows the location of a procedure turn in the flight plan. Procedure turns are positioned on the display with respect to the current aircraft location and heading. Procedure turns represent the active flight plan, solid white or magenta lines, or a modified route, dashed white lines (- - - -).



ID-0000763004

Arc Turns – Arc turns are represented by a curved line between the two waypoints that define the beginning and the end of the arc turn.

ID-0000763005

Lateral Deviation Display – When FMS is the selected NAV source, lateral deviation of the aircraft to the left or right of the desired track is indicated by a number with the letter L or R . The number and letter are displayed on the bottom of the aircraft symbol. The indication is only provided when the INAV map is in heading-up mode.

The digital readout resolution is 0.01 miles to 0.99 miles, 0.1 miles from 1.0 to 99.9 miles, and 1.0 mile for distances of 100 miles and higher. The display is removed for zero deviation or invalid FMS lateral deviation data.

When the pilot activates an offset from the route centerline, as described later in this section, the number displayed indicates deviation from the route centerline as defined by the pilot-entered offset.

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Flight Plan Segments

Lines and curves are drawn in the flight plan to connect successive waypoints, transition onto a waypoint, and draw holding patterns, holding pattern entries, and procedure turns on the map; they are as follows:

- The active flight plan segments are solid white lines (). The currently active segment (segment to the TO waypoint) is a solid magenta line ().
- The missed approach segments are solid cyan lines ().
- The alternate flight plan segments are cyan dashed lines ().
- Secondary flight plans are displayed as whited dotted lines ().
- Pending flight plan segments in the active flight plan are white dashed lines ().

Airspace Information

Additional airspace information is displayed when the cursor is placed over terminal or special use airspace (SUA) lines depicted on the INAV map.

Placing the cursor over an airspace line highlights the selected airspace to distinguish which line has been selected.

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When an airspace line is highlighted, the airspace identifier and upper and lower altitude limits of the airspace are displayed in the upper-left corner of the INAV map display. The airspace identifier displays the type of airspace selected (e.g., Class B). The airspace name for both terminal and special use airspace is displayed above the airspace identifier (e.g., PHOENIX). The upper altitude limit is displayed below the airspace identifier (e.g., 9000 MSL). The lower altitude limit is displayed below the upper altitude and is separated by a green line (e.g., 3000 MSL).

The altitude values can be displayed in AGL , MSL , FL , or NOTAM , depending on how the data is stored in the navigation database.

GND is displayed when the lower altitude limit is at ground level, and UNLTD is displayed when the upper altitude limit is unlimited.

The information is displayed until the cursor is moved.

WARNING: The display of airspace on the INAV map must not be used as the sole means of reference for determination of airspace boundaries.

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PROGRESS Display Window

The PROGRESS display window, shown in Figure 6-26, gives the flight crew information on the next waypoint and the destination, including:

- Waypoint name
- Distance-to-go
- Estimated time of arrival (ETA)/estimated time en route (ETE)
- Fuel remaining, based on calculations received from the FMS.

Figure 6-26
PROGRESS Display

When the VSD is shown, the FMS PROGRESS window is displayed in the center of the MFD Map and Plan modes. When the VSD is removed from the display, the FMS PROGRESS window is moved to the bottom of the display. The PROGRESS window is displayed when PROGRESS is selected from the respective menus.

Progress Waypoint Name – The waypoint name shows the name of the next waypoint and the name of the destination. The waypoint name is displayed below the **WPT** label with the magenta next waypoint name on the first line and the white destination name on the second. If the next waypoint or destination is invalid, the waypoint identifier is replaced with six amber dashes (------).

Progress Distance-To-Go Display – The distance to the next waypoint is displayed in magenta below the **DIST** label. The distance to the destination is displayed in white. When the distance is less than 100 NM (nautical miles), the resolution is 0.5 miles. From 100 NM to 10,000 NM, the resolution is 1 NM. When distance information is invalid, the waypoint distance is replaced with four amber dashes (----).

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Progress ETA or ETE Display – When ETA is displayed, the calculated universal time coordinated (UTC) is shown, in hours and minutes, of arrival at the next waypoint and at the destination. When ETE is displayed, the time is shown in hours and minutes to go to the next waypoint and to the destination.

- When ETA is valid, the label displayed is ETA. The value for ETA or ETE is displayed below the ETA / ETE label with the next waypoint time on the first line and the destination time on the second.
- The ETE represents the time-to-go to the next waypoint or to the destination. ETE is displayed when the ETA is invalid (that is, the aircraft departure time was not available).

When a valid waypoint ETA/ETE outside the current displayable range is received for the current format, or when the waypoint ETA/ETE data is invalid or missing, amber dashes (- - + - -) are displayed in the respective waypoint ETA/ETE location.

Progress Fuel Display – Fuel remaining shows predicted fuel remaining at the next waypoint and at the destination, as computed by the FMS. The fuel remaining is shown in pounds or kilograms, as determined by the option configuration settings of the aircraft personality module (APM). The fuel remaining is displayed up to five digits, with the rightmost (least significant) two digits always shown as zeros, in the format XXX^{00} with leading zeros suppressed.

The fuel remaining is displayed below the FUEL label. The next waypoint remaining fuel on the first line is magenta, and the destination remaining fuel on the second line is white. Fuel remaining is displayed with a resolution of 100 with the label LB* or KG, as applicable.

When a valid waypoint fuel remaining outside the displayable range is received, or when the waypoint fuel remaining data is invalid or missing for the next destination waypoint, amber dashes (- - - - -) are displayed in the respective waypoint fuel remaining location.

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Selected Reference Points

The selected reference point, shown in Figure 6-27, is used to designate and display a specific waypoint and is entered through the FMS. The designated waypoint is displayed with a distance from the designated waypoint (shown as a range ring) and a radial from the designated waypoint (shown as a radial line). The designated waypoint is displayed as a selected reference point fix and identifier. All reference point symbols are green.

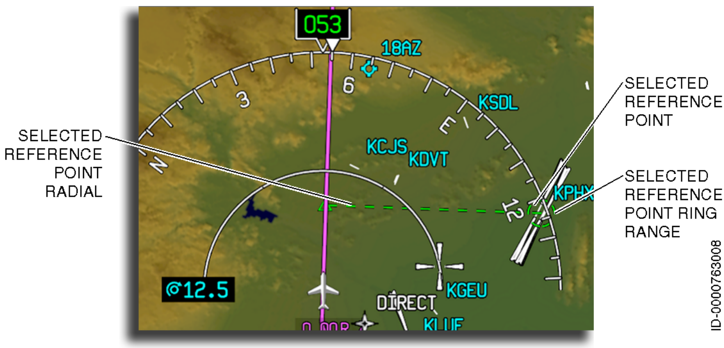

Figure 6-27
Selected Reference Point

The selected reference point and associated symbols are removed from the display, if invalid or if missing, from the FMS database.

The selected reference point radial bearing is displayed in the XXX format (i.e., 265 in Figure 6-27) with no leading zeros. The bearing digits are displayed near the radial line. A heading reference indication (T for true north or M for magnetic north) is displayed when the reference point radial bearing is entered referenced to true north with the map heading referenced to magnetic north, or when the reference point radial is entered referenced to magnetic north with the map heading referenced to true north. If the heading reference and radial reference are pointed toward the same source (true or magnetic), the T or M is not displayed.

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MFD Failure and Warning Displays

The following paragraphs describe the failure and warning indicators shown on the MFD, as shown in Figure 6-28.

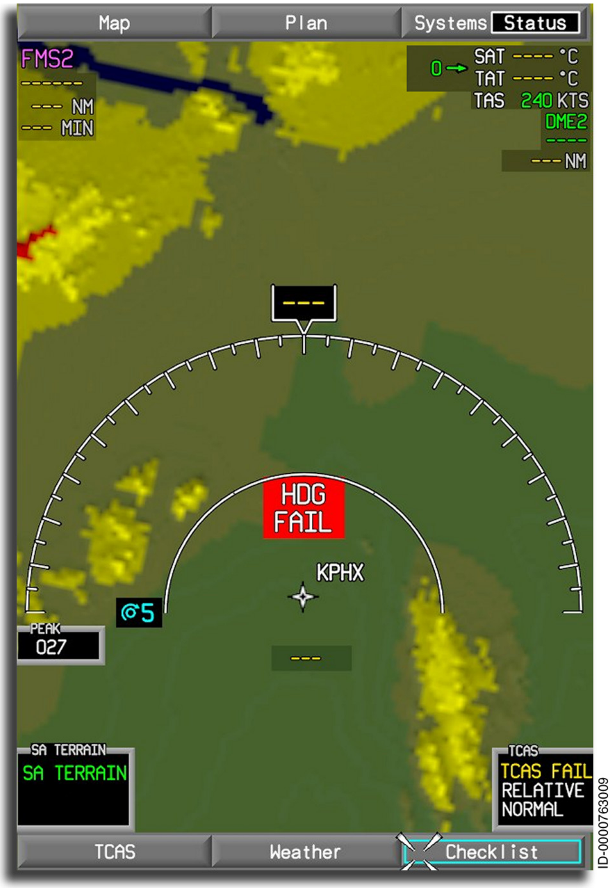

Figure 6-28
Map Failure and Warning Displays

Heading Select Invalid – If the heading select data is invalid, the heading bug is removed from the display.

Aircraft Heading Invalid – If the referenced aircraft heading received is invalid, the heading readout is replaced with three amber dashes (- - -), the compass numbers are removed, and HDG FAIL is displayed slightly below the half-range scale.

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Course Select Invalid – If the course select signals fail, the digital display is replaced with three amber dashes (- - -), and the course pointer is removed from the display. This indication is also given during an invalid heading display or FMS source.

Course Deviation Invalid – When the CDI data is invalid, the deviation data below the aircraft symbol is replaced with three amber dashes (- - -).

Distance Display Invalid – When the DME or FMS distance data is invalid, the digital display is replaced with three amber dashes (- - -).

ADS Invalid – ADS data invalid is indicated by replacing the SAT, TAT, and TAS digital displays with amber dashes (- - -).

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VERTICAL SITUATION DISPLAY (VSD)

The VSD depicts the associated lateral map from a vertical perspective and is displayed on the bottom 1/4 of the INAV map window, as shown in Figure 6-29. The VSD corresponds to the VNAV profile of the FMS flight plan. The waypoint symbols, altitude profile points, and vertical track lines are displayed bottom to top relative to the actual aircraft altitude. The waypoint symbols and altitude profile points are displayed left to right as a function of distance from the aircraft. Waypoints and associated data, altitude profile points, and vertical track lines move from right to left along the fixed display. Vertical data is displayed in both the Map and Plan modes.

> *NOTE: In descent, the VSD shows the frozen descent path until the descent path is reconstructed due to a flight plan change. A FLCH action does not cause the descent path to be reconstructed.*

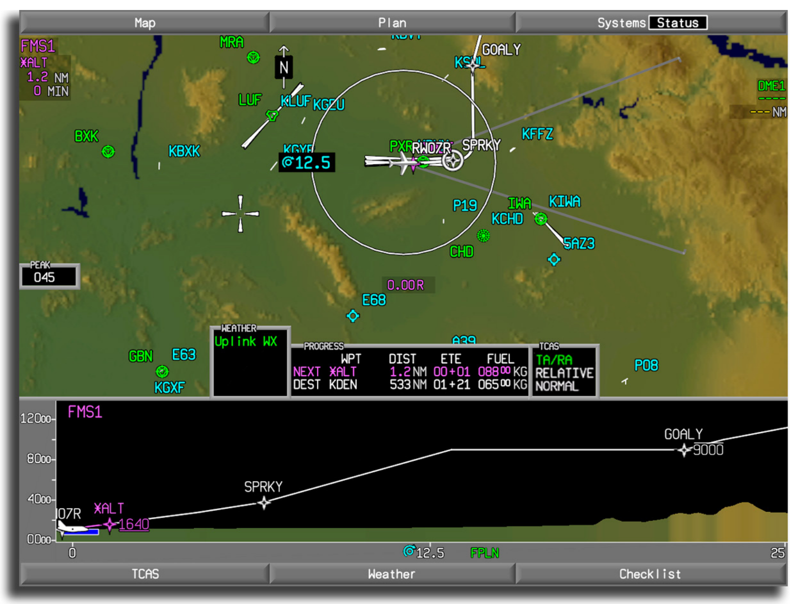

Figure 6-29
Vertical Situation Display

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The VSD is displayed by selecting the VSD checkbox on the dropdown menu.

VSD Symbols

VSD components are shown in Figure 6-30 and are described in the following paragraphs.

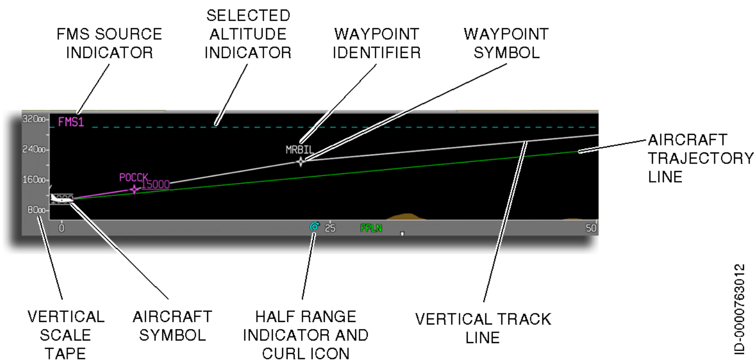
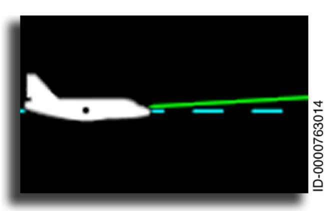


Figure 6-30
Vertical Profile Components

Aircraft Symbol – The white aircraft symbol gives a horizontal and vertical reference point for down path waypoints. During the climb phase of flight, the aircraft symbol is placed 80% from the top edge and 20% from the bottom edge of the display. During the cruise phase of flight, the aircraft symbol is placed 50% from the top and 50% from the bottom of the display. During the descent phase of flight, the aircraft symbol is placed 20% from the top and 80% from the bottom of the display.



Actual Flight Path Angle – The actual flight path is displayed as a solid green line (—) extending forward from the nose of the aircraft to the end of the VSD window. This line shows the flight path angle trend of the aircraft in the vertical axis.

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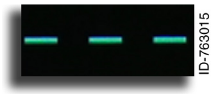


Selected Altitude Line – The selected altitude indicator is represented by a cyan dashed line ( ) extending across the vertical profile window. The indicator shows the selected altitude set by the altitude select (ALT SEL) knob on the guidance panel. When altitude alert is active, the dashed line is amber ( ). When not selected, the dashed line is cyan. When the altitude preselect line is set beyond the display range, the line goes out of view. The line returns to view when the setting is within the displayed range.

Half-Range and Full-Range Indicators – The half-range and full-range indicators consist of white digits corresponding to the arc half- and full-ranges displayed on the NAV map, as shown in Figure 6-31. The half-range and full-range indicators remain fixed at the bottom of the VSD. In heading-up mode, a fourth range indicator is displayed between 0 and the half-range mark, indicating quarter range. If the selected range value is invalid, the half-range and full-range indicators are removed and replaced with white dashes ( ).

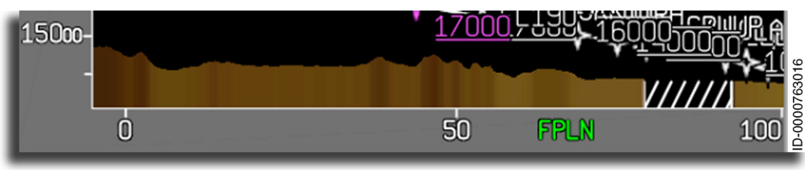
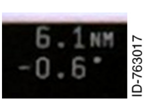


Figure 6-31
Half-Range and Full-Range Indicators



Cursor Angle and Distance – The angle and horizontal distance values from the aircraft symbol to the cursor position on the VSD are displayed at the top middle portion of the VSD. The cursor angle is displayed in degrees with a resolution of 0.1 degrees. Horizontal distances are displayed in nautical miles with a resolution of 0.1 NM. Moving the cursor in the VSD window changes the cursor angle and distance values.

NOTE: Due to the vertical profile using straight line distances and the waypoint list using curved path distances, some slight distance discrepancies are possible.

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FMS Source Indicator – The FMS source indicator is displayed in the upper-left corner of the vertical profile display in magenta. The FMS source indicator is the same as the FMS selected as the MFD map source.

Vertical Scale Tape – The vertical scale tape is a 0.6-inch wide white tape extending from the top to the bottom of the vertical profile display on a gray background. The vertical scale tape is located on the left side of the vertical display and is used as an altitude reference for the pilot. The vertical scale tape has up to 10 evenly spaced hash marks. Five of the hash marks include a digital readout for the associated BARO-corrected altitude in feet MSL.

The vertical scaling ranges are selected based on the horizontal half-range currently shown. Vertical scaling is based on a symmetrical range from the vertical center of the display. The vertical scale ranging is based on the phase of flight (climb, cruise, or descent).

The vertical scale for the vertical profile display when the aircraft phase of flight is climb is listed in Table 6-3.

Table 6-3
Vertical Scale – Climb

Selected Half-Range Value	Vertical Scale
2.5	+4,000 feet -1,000 feet
5	+8,000 feet -2,000 feet
12.5	+16,000 feet -4,000 feet
25	+24,000 feet -6,000 feet
50	+32,000 feet -8,000 feet
100-1000	+44,000 feet -11,000 feet

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The vertical scale for the vertical profile display when the aircraft phase of flight is cruise is listed in Table 6-4.

Table 6-4
Vertical Scale – Cruise

Selected Half-Range Value	Vertical Scale
2.5	+1,000 feet -1,000 feet
5	+2,000 feet -2,000 feet
12.5	+5,000 feet -5,000 feet
25	+5,000 feet -5,000 feet
50	+10,000 feet -10,000 feet
100-1000	+20,000 feet -20,000 feet

The vertical scale for the vertical profile display when the aircraft phase of flight is descent is listed in Table 6-5.

Table 6-5
Vertical Scale – Descent

Selected Half-Range Value	Vertical Scale
2.5	+1,000 feet -4,000 feet
5	+2,000 feet -8,000 feet
12.5	+4,000 feet -16,000 feet
25	+6,000 feet -24,000 feet
50	+8,000 feet -32,000 feet
100-1000	+11,000 feet -44,000 feet

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The vertical scale for Plan mode on the vertical profile display is listed in Table 6-6.

Table 6-6
Vertical Scale for Plan Mode

Selected Half-Range Value	Vertical Scale
2.5	+1,000 feet -1,000 feet
5	+2,000 feet -2,000 feet
12.5	+5,000 feet -5,000 feet
25	+5,000 feet -5,000 feet
50	+10,000 feet -10,000 feet
100-1000	+20,000 feet -20,000 feet

When the vertical position is invalid, the vertical scale tape is replaced with white dashes (- - - - -), and **Position Invalid** is displayed, as shown in Figure 6-32. The half-range and full-range indicators are also replaced with white dashes (- - -).

Figure 6-32
Vertical Position Invalid

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FMS Flight Plan Symbols

FMS flight plan symbols (waypoints, legs, TOC, TOD, missed approach, intermediate level-offs) are displayed when the VSD is selected for display. When displayed, flight plan items are positioned in the VSD according to the respective barometric predicted altitude. Items defined by flight level are positioned using the VSD barometric reference setting (for example, FL200 is displayed at the barometric altitude of 20,000 feet in the VSD).

ID-0000763019

Waypoint Displays – Waypoints are displayed on the vertical profile display and contain a waypoint symbol, waypoint identifier, waypoint altitude, and, when required, a waypoint hold annunciator. The waypoints shown on the vertical profile display represent the same waypoints shown on the Map or Plan mode on the MFD. Vertical track lines connect the flight plan waypoints.

The waypoint symbol on the vertical profile display is represented by a four-pointed star symbol (or a diamond for the altitude profile points). No other symbols are used. The waypoint identifier is displayed above the waypoint symbol. Waypoints having an associated hold have a HOLD annunciator below the waypoint altitude digital readout.

The active waypoint, associated information, and the vertical track line from the left side of the display (past the aircraft symbol) to the T/O (active) waypoint are displayed in magenta. Other waypoints, associated information, and associated vertical track lines are displayed in white.

Vertical Track Lines – These lines connect continuous waypoints in the flight plan. Track lines are displayed between waypoints and from the left side to the next waypoint in the flight plan.

Vertical track lines are displayed when flight plan information is available and valid and the selected range value is valid. If not, the vertical track lines are not displayed. When consecutive waypoints have an associated altitude, and the waypoints have a horizontal track between, the waypoints are connected by a vertical track line. Waypoints with no horizontal track between (that is, there is a discontinuity) do not have a connecting vertical track line.

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The descent path depicted in the VSD is consistent with the vertical deviation displayed in the attitude indicator.

Constraints (MFD with Enhanced INAV APM option only) – When selected on the Map or Plan dropdown menu, waypoints with crossing constraints are depicted as follows (constraint symbols replace default waypoint symbol):

ID-0000763020

AT or ABOVE waypoint constraints are under-scored.

ID-0000763021

AT or BELOW waypoint constraints are over-scored.

ID-0000763022

AT waypoint constraints are over-scored and under-scored.

Altitude Profile Points – An altitude profile point shows the relative location of specific altitude transition points on the vertical flight plan. These points include top-of-climb (TOC), top-of-descent (TOD), and bottom-of-step climb (BOSC). The altitude profile point identifier is displayed on the right side of the altitude profile point symbol. Each of these points is displayed on the vertical profile when available and valid. If not, the point is not displayed.

ID-0000763023

Top-of-climb.

ID-0000763024

Top-of-descent.

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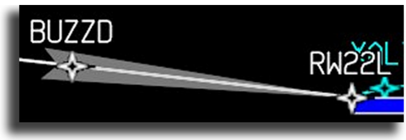
NOTE: Because the flight plan legs are positioned by the FMS flight path, the legs may or may not pass through the constraint symbols.

FPL waypoint colors are white. However, the color of the constraint symbols and text follow the color shown on the waypoint list.



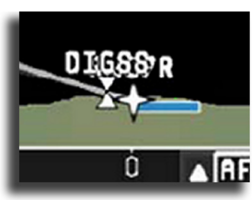
ID-0000763025

Instrument Landing System (ILS) Beam – The ILS beam is displayed as a light gray feather symbol. The symbol is positioned appropriately with respect to the glideslope from the navigation database for runways having an associated ILS or ILSDME facility.

ID-0000763026

GBAS Landing System (GLS) Beam – The GLS beam is displayed as a dark gray feather symbol. The symbol is positioned appropriately with respect to the glide path from the navigation database for runways having an associated GLS facility.

NOTE: ILS beams for LOC facilities are not displayed on the VSD. However, they are displayed on the lateral map.


ID-0000763027

Runway – Runways related to the NAV map FPL are displayed according to barometric altitude. These rectangular symbols are the same color as on the NAV map. The rectangle sizes displayed depend on the actual runway length.

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VSD Modes

The VSD displays data in two automatic modes; track mode (annunciated as TRACK), which displays terrain under track, and flight plan mode (annunciated as FPLN), which displays terrain under flight plan. Flight plan mode is entered when aircraft performance predictions are valid and any one of the following conditions are met:

- LNAV is armed while on the ground or takeoff mode is engaged
- LNAV is engaged
- VSD orientation is waypoint centered
- LPV is engaged
- Crosstrack is valid when all of the following conditions are met:
  - Present position of the aircraft is valid
  - RNP is valid
  - Track angle is valid
  - VSD flight plan data is valid
  - Aircraft lateral deviation is less than RNP value.

When the VSD is in flight plan mode, the VSD displays FPLN in green between the half- and full-range indicators, as shown in Figure 6-33.

Figure 6-33
Auto Mode FPLN Annunciator

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The VSD automatically transitions from flight plan mode to track mode when the conditions for the flight plan mode are not satisfied. When the VSD is in track mode, the VSD displays TRACK in green between the half- and full-range indicators, as shown in Figure 6-34.

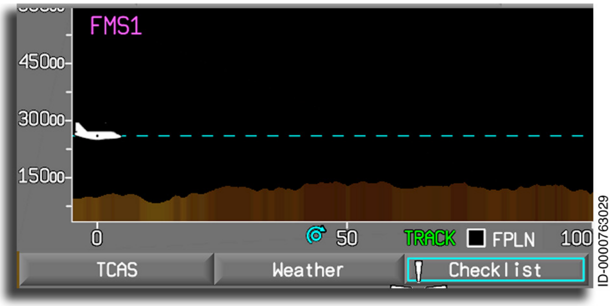

Figure 6-34
Auto Mode TRACK Annunciator

When the VSD transitions from flight plan mode to track mode, an unchecked checkbox and the text FPLN are displayed to the right of the TRACK annunciator in the VSD, as shown in Figure 6-34. When the FPLN checkbox is selected, as shown in Figure 6-35, the following occurs:

- The aircraft is removed from the display
- Terrain (topography) from the VSD is displayed
- The weather from the VSD is displayed (applicable to RDR-4000 weather radar only)
- Flight plan (and constraints if selected) are displayed in the VSD.

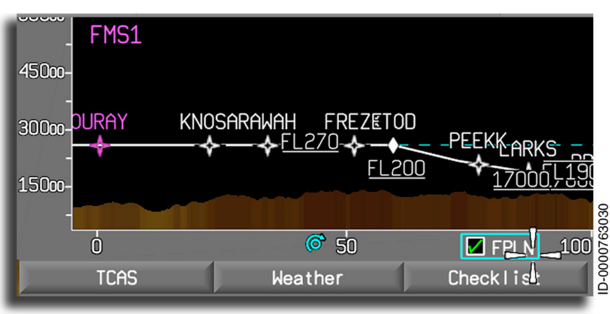

Figure 6-35
FPLN Checkbox

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When the FPLN checkbox is selected and an EGPWS terrain alert occurs, the VSD mode automatically transitions to track mode.

When the FPLN checkbox is deselected, track mode is entered, weather is re-displayed on the VSD when the WX layer was previously selected, and the TRACK annunciator is displayed in green.

When VSD azimuth mode is selected on the WX controller, the VSD mode changes to WXAZ mode. If manual azimuth or manual altitude RDR-4000 modes are initiated, the FPLN checkbox is removed from the VSD window.

The VSD is always oriented so that the remaining flight plan or track to be flown is to the right in the display. The VSD is either aircraft-centered or waypoint-centered. When aircraft-centered, terrain and the flight plan always move right to left in the display. When waypoint-centered, the aircraft symbol moves from left to right on the display. The horizontal axis is oriented with zero centered horizontally when waypoint-centered or with zero at the left edge when aircraft-centered. Points that are not part of a flight plan displayed in the INAV lateral map are referred to as remote locations. When the INAV map is centered to a remote location, then VSD is forced to aircraft-centered orientation.

NOTE: When flight plan data is being recalculated, the FPL is removed, and a **Computing Data...** *message is displayed in the center of the VSD.*

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VSD Weather

The INAV provides the capability to display weather information on the VSD received from the optional RDR-4000 airborne weather radar. VSD weather is displayed in Figure 6-36.

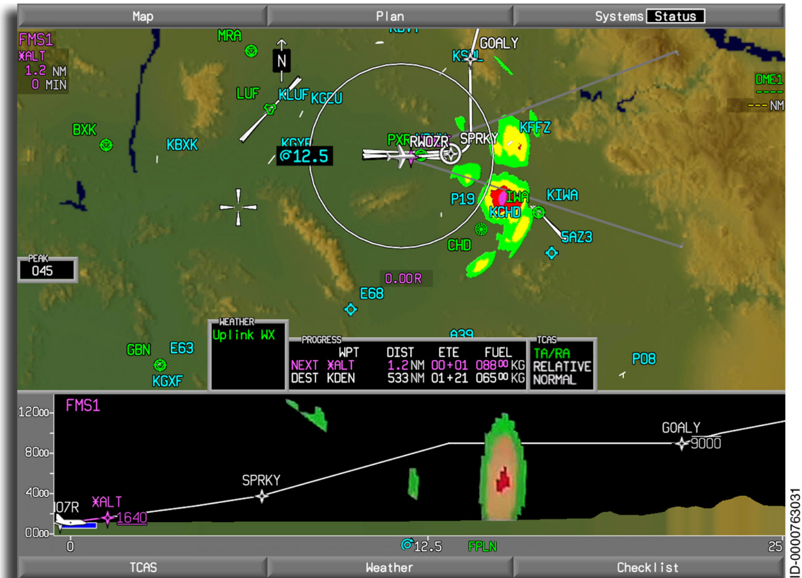

Figure 6-36
VSD Weather Display

VSD weather is described in detail in Section 18, Weather Radar Systems.

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VSD Terrain

The VSD terrain profile presents a side view of the topographical terrain below and in the forward flight path of the airplane, as shown in Figure 6-37. The topography is represented by profile texture connecting the highest points of the earth below and ahead of the airplane in the direction of the flight plan or the track. The profile textures are color-coded to provide awareness of the proximity of the terrain.

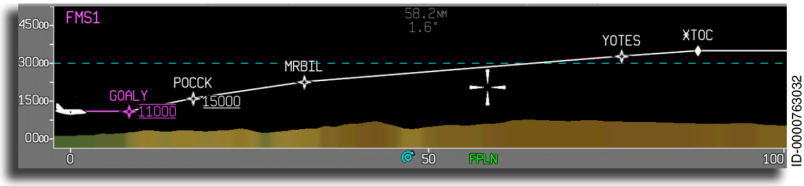

Figure 6-37
VSD Terrain

Availability of topographical terrain for display in the VSD is tied to the lateral map terrain requests and display. The VSD uses the lateral map terrain patch to extract either terrain under track or terrain under the flight plan. For this reason, there are various cases in which the terrain under the VSD cannot be shown. For example, terrain is removed from the VSD during manual transition legs or when the FMS indicates that certain transitions are to be flown manually. When the terrain data is not available, it is indicated as cross-hatches, as shown in Figure 6-38.

Figure 6-38
Terrain Unavailable – Cross-Hatch Symbology

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OBJECT TASK MENU

Placing the cursor on an object in the INAV display and pushing the CCD **ENTER** button displays a task menu corresponding to the selected object. The type and content of the task menu vary depending on the item selected.

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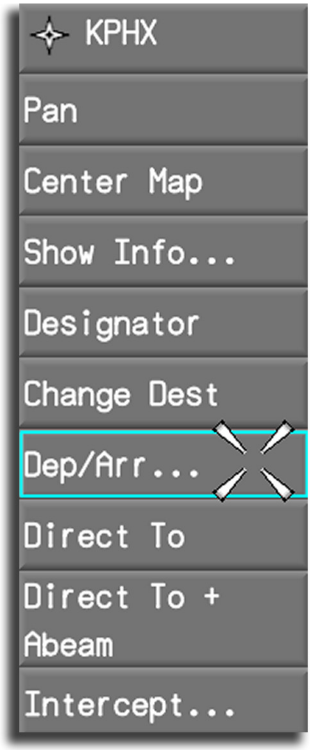
Select Object Menu – When multiple objects are colocated or located close to one another (such as a VOR located on an airport), clicking on one of the objects displays the Select Object menu. The Select Object menu is used to specify the object to be selected. Selecting an object in the Select Object menu displays the task menu corresponding to that object.



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Task Menu – When multiple objects are not colocated or located close to one another or when an object is selected on the Select Object menu, the symbol and name/identifier of the object the task menu pertains to is displayed in the Task menu header. The Task menu header is the first item in the task menu.

A cyan box outlines the desired task using the joystick. Pushing the **ENTER** button activates the desired task.

The task menu times out (is removed from display) if the cursor is moved away from the menu for 5 seconds or if the cursor is left on the menu for 20 seconds, and a selection is not made.

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Task Menu Commands

The following tasks menu commands are possible. Not all tasks are presented in every dropdown menu. For example, the Offset... task is only presented in the dropdown menu when the pilot selects the aircraft symbol or a waypoint in the flight plan.

- Pan – Moves the map to a location not in the view area of the map (described in the subsection Pan Mode on page 6-71).
- Center Map – Centers the map at the position of the selected object.
- Show Info... – Opens a dialog box showing all the information about the selected object (described in the subsection Show Info Dialog Box on page 6-75).
- Designator – The Designator function is used to add a waypoint into the flight plan through the MCDU (described in the subsection Designator Function on page 6-70).
- Tune Nav 1/2 – Selecting Tune Nav 1 or Tune Nav 2 automatically places the NAV frequency stored in the database into the active frequency field of the corresponding NAV radio. The previous active frequency is then placed into the standby field. When the selected NAVAID is an ILS, the ILS course contained in the database is automatically set.
- Direct To – Performs a Direct-To (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- Direct To + Abeam – Performs a Direct-To and keeps abeam waypoints (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- Hold... – Defines and activates a hold (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- Intercept... – Sets an intercept to a NAVAID or airway (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- Amend Route – Allows route modifications to be made (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).

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- **Offset...** – Defines and activates an offset (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Make FROM Wpt** – Makes the selected waypoint the From waypoint (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Cross...** – Creates and applies constraints to waypoints (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Delete Wpt** – Deletes waypoints in the flight plan (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Vectors** – Activates the vectors to final function (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Insert Awy** – Inserts an airway (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Create LL Wpt** – Creates a latitude/longitude waypoint (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Join Awy** – Inserts an airway into the flight plan (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Change Dest** – Changes the destination airport (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Dep/Arr** – Inserts or modifies the departure and arrival procedure (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).
- **Proc Turn** – Permits the pilot to delete an already defined procedure turn (described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide).

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Designator Function

The Designator function is used to add a waypoint into the flight plan through the MCDU. The pilot designates a point on the display, and the corresponding latitude/longitude is sent to the onside FMS scratchpad. The pilot can then enter that point into the flight plan. When INAV detects a waypoint in the flight plan that matches the designated point, it then exits the designate mode.

On selecting the Designator function from the task menu, and the object selected is not the destination or the aircraft symbol waypoint, then a cyan dashed line is drawn from the designator origin to the cursor position and from the cursor position to the waypoint next to the designator origin, as shown in Figure 6-39.

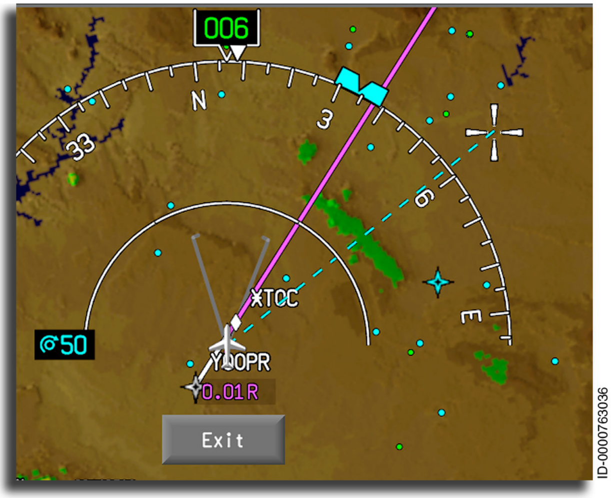

Figure 6-39
Designator Dashed Line From Intermediate Waypoint

The Designator function can be exited in three ways:

- Selecting the **Exit** button
- Selecting any of the six menu options (Map, Plan, Systems, TCAS, Weather, Checklist)
- Clicking on any waypoint in the flight plan after the designator origin has been selected.

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Pan Mode

Panning is an operation by which the pilot can move the map to a location that is currently not in the view area of the map. It is initiated through the INAV task menu shown in Figure 6-40.

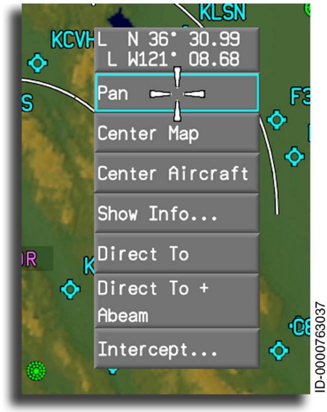

Figure 6-40
Pan Map Task Menu

During pan operation, the map (heading-up or north-up) changes to different display modes. The following definitions will help clarify these modes.

- **Map (heading-up)** – Standard heading-up while the aircraft is centered on the display. The map is continuously updated as the aircraft moves.
- **Plan (north-up)** – Standard Plan mode in either Aircraft-Centered or Waypoint-Centered modes. If aircraft-centered, the map is continuously updated as the aircraft moves. If waypoint-centered, the map is frozen on the selected waypoint.
- **Pan Mode** – The ability to pan the terrain around to different locations using the touchpad of the CCD.
- **Armed Pan Mode** – The pan selection on the task menu has been selected, but the touchpad has not been used. The free-floating cursor is removed, the Pan icon is displayed, and the map is still in heading-up (if in map mode).
- **Active Pan Mode** – The touchpad on the CCD is being used to pan the terrain.

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- **Inactive Pan Mode** – The touchpad on the CCD is not being used; however, it was previously used to pan to a different location. If previously in map mode, Fixed mode is now the new map display.
- **Fixed Mode** – Pilot has performed a pan operation while in map (heading-up) mode. Orientation of the map is the same as what the last aircraft heading was before panning. If Pan is exited, the Pan icon is removed, the cursor is re-displayed, and objects can be selected.
- **North-Up (Non AC/WC) Mode** – The pilot has performed a pan operation while in Plan (north-up) mode. The mode is no longer aircraft-centered (AC) or waypoint-centered (WC). Orientation of the map stays in north-up. If Pan is exited, the Pan icon is removed, the cursor is re-displayed, and objects can be selected.

Pan mode is indicated by a green cross with arrows along the middle-right side of the INAV, as shown in Figure 6-41. Pan mode is a useful way to move the map around the display.

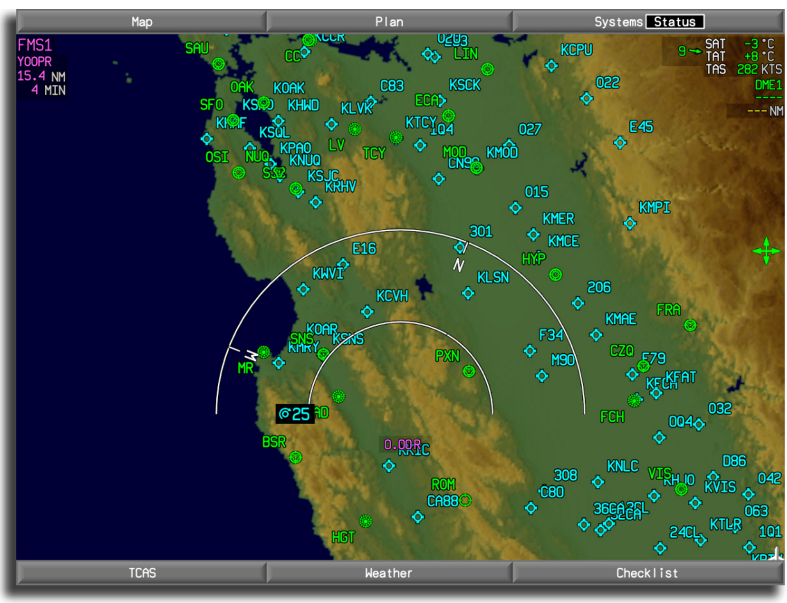

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Figure 6-41
Pan Operation

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While panning is active and the INAV lateral map range is greater than 25 NM, the following layers can be removed depending on the current map range:

- VOR/DME
- NDB
- Airports
- High altitude airways
- Low altitude airways
- PEAK readout.


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When the map has been panned outside the aircraft displayable area, the aircraft symbol is placed at the edge of the display area.

Panning is exited when the CCD **ENTER** button is pushed. Once panning is exited, the map center position remains unchanged.

NOTE: At this point, the cursor will be back to free-floating, permitting the pilot to select any viewable objects in that area.

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Lateral Offset Display

The lateral offset flight path is displayed on the INAV map, as shown in Figure 6-42. Lateral offset is defined by the flight crew for the active flight plan and continues until terminating at a specified point. Lateral offset functionality only applies to the active flight plan.

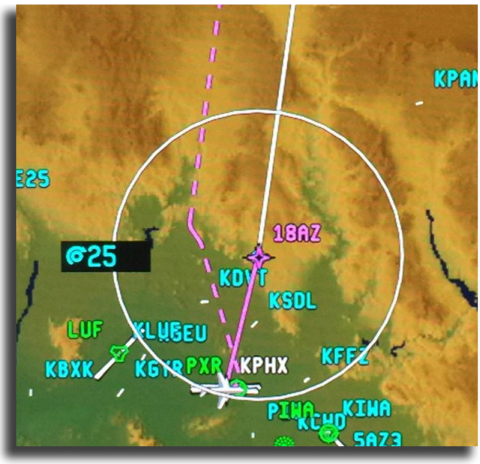

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Figure 6-42
Offset Flight Plan

The offset is displayed as a white dashed line for a modified flight plan. Once activated, it is displayed as a magenta dashed line.

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DIALOG BOXES

The following paragraphs describe the various dialog boxes.

Show Info Dialog Box

The Show Info dialog box provides additional information about a selected object. Selecting Show Info... from the task menu of a selected object displays the Show Info dialog box.

The Show Info dialog box can be displayed for the following type of objects:

- All NAVAIDS (VOR, NDB, GLS, etc.)
- Airports
- General database (Named waypoint)
- Pilot-entered waypoints
- Temporary waypoints (Latitude/Longitude, Place/Bearing/Distance, and Place/Bearing/Place/Bearing).

Database – The Database tab shows navigation database information for the selected waypoint.

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VHF NAVAIDS Show Info Dialog Box

The VHF NAVAID Show Info dialog box is shown in Figure 6-43.

Figure 6-43
Show Info for NAVAID

The Show Info dialog box displays the following NAVAID information:

- ICAO identifier (e.g., INW)
- Full identifier name (e.g., WINSLOW)
- Latitude and longitude (e.g., N35°03.70 W110°47.70)
- Type/class (e.g., VORTAC/HA)
- Frequency (e.g., 112.60)
- Country (e.g., USA)
- Elevation (e.g., 4910 ft)
- Magnetic declination (e.g., 14°E).

The NAVAID type is displayed as follows:

- DME – DME only
- N DME – Non-colocated DME
- TACAN – TACAN only
- N TACAN – Non-colocated TACAN

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- VORTAC – VORTAC
- VORDME – VOR and DME
- VOR – VOR only
- NVOR – Non-colocated VOR DME.

The NAVAID class is displayed as follows:

- T – Terminal
- LA – Low altitude
- HA – High altitude
- UR – Unrestricted.

Magnetic declination values are displayed for all VHF NAVAIDS (except for DME-only NAVAIDS). Magnetic variation is displayed for DME-only NAVAIDS.

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Non-Directional Beacon (NDB) Show Info Dialog Box

The NDB Show Info dialog box is shown in Figure 6-44.

Figure 6-44
Show Info for NDB

The NDB Show Info dialog box displays the following NAVAID information:

- Full identifier name (e.g., CHANDLER)
- Latitude and longitude (e.g., N33°15.99 W111°48.47)
- Type/class (e.g., NDB)
- Country (e.g., USA)
- Frequency (e.g., 407).

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ILS NAVAID Show Info Dialog Box

The ILS Show Info dialog box is shown in Figure 6-45.

Figure 6-45
ILS Show Info Dialog Box

The ILS Show Info dialog box displays the following information:

- ICAO identifier (e.g., IPRC)
- Latitude and longitude (e.g., N34°38.66 W112°25.81)
- Type (e.g., CAT I ILS/DME)
- Frequency (e.g., 108.50)
- Front course (e.g., 221°)
- Glideslope (e.g., 3.00°)
- Country (e.g., USA)
- Elevation (e.g., 4960 ft)
- Magnetic declination (e.g., 13°E).

The ILS category is displayed as follows:

- CAT I
- CAT II
- CAT III.

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The type is displayed with up to seven characters as follows:

- ILS – ILS only
- LOC – Localizer only
- LOCDME – Localizer only with DME
- ILSDME – ILS with an associated DME.

GLS NAVAID Show Info Dialog Box

The GLS Show Info dialog box is shown in Figure 6-46.

Figure 6-46
GLS Show Info Dialog Box

The GLS Show Info dialog box displays the following information:

- Latitude/longitude (e.g., N40°41.55 W074°10.12)
- Category and type (e.g., CAT I GLS)
- Frequency (e.g., 20672.00)
- Front course angle (e.g., 207°)
- Glideslope angle (e.g., 3.00°)
- Country (e.g., USA)
- Elevation (e.g., 20 ft)
- Magnetic declination (e.g., 13°W).

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Airport Information Services (AIS)

The Show Info dialog box for airport information provides a dropdown menu of different categories of information, as shown in Figure 6-47.

Figure 6-47
Airport Information Services (AIS)

The airport database stores the following information:

- General
- Runway
- VHF NAVAIDS
- Maintenance and fuel
- Airport notes
- Hotels
- Ground transportation.

Not all categories contain information at any given airport.

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GENERAL AIRPORT DATABASE (GENERAL)

The General airport information page is displayed by selecting **General** from the dropdown menu, as shown in Figure 6-48. General is the default selection.

Figure 6-48
Show Info for Airport

The General dropdown menu displays the following airport information:

- Airport name (e.g., KSEZ)
- Town name (e.g., Sedona)
- Province or State (North American only)/Country name (e.g., AZ USA)
- Airport type (e.g., Public Airport)
- Latitude and longitude (e.g., N34°50.92 W111°47.31)
- Longest runway (e.g., 03/21 (1564 M))
- Elevation above MSL (e.g., 4830 ft)
- Magnetic variation (e.g., 13°E)
- Transition level (e.g., FL180)
- Transition altitude (e.g., 18000 ft)

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- Attended (e.g., 0600-2100LT)
- Lighting schedule (e.g., 1900-0600LT)
- Beacon (e.g., Green/White).

RUNWAY DATABASE

The Runway dropdown menu is displayed on the Runway Info airport page, shown in Figure 6-49, and is used for selecting runways.

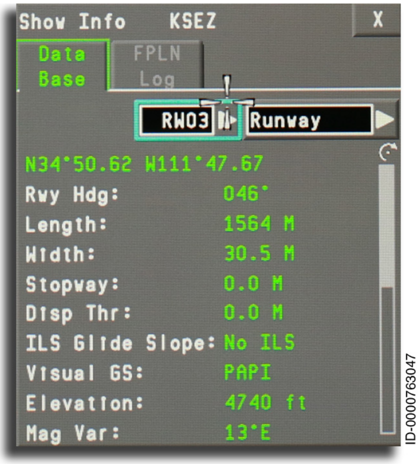

Figure 6-49
Runway Database

Selecting the **Runway** dropdown menu displays available runways at the selected airport in a second dropdown menu to the left.

The Runway dropdown menu shows the following information:

- Airport name (e.g., KSEZ)
- Latitude and longitude (e.g., N34°50.62 W111°47.67)
- Runway heading (magnetic and true) (e.g., 046°)
- Runway length (e.g., 1564 M)
- Runway width (e.g., 30.5 M)
- Stopway (e.g., 0.0 M)
- Displaced threshold (e.g., 0.0 M)

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- ILS glideslope (e.g., No ILS)
- Visual approach aids (e.g., PAPI)
- Elevation above sea level (e.g., 4740 ft)
- Magnetic variation (e.g., 13° E)
- RWY slope (e.g., .5%)
- Material runway surface (e.g., Asphalt)
- Surface treatment (e.g., Grooved)
- APP lights (e.g., ALSF)
- Edge lights (e.g., Yes)
- Runway end identification lights (REIL) (e.g., No)
- Runway centerline lighting system (RCLS) (e.g., No)
- TDZ RVR Equip (e.g., No)
- Midfield RVR Equip (e.g., No)
- Rollout RVR Equip (e.g., No)
- VFR Traffic Dir (e.g., Right)
- Notes (as required).

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VHF

The VHF page on the Show Info airport page is shown in Figure 6-50.

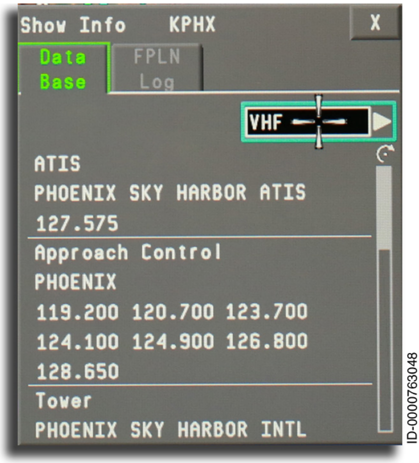

Figure 6-50
Show Info – VHF

The VHF page displays frequencies in the order the pilot likely uses. An example frequency order is as follows:

- ATIS
- Clearance Delivery
- Ground Control
- Tower.

A scroll bar is provided when the number of frequencies exceeds the space provided in the display.

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MAINTENANCE/FUEL (MAINT/FUEL) PAGE

The Maint/Fuel page is shown in Figure 6-51.

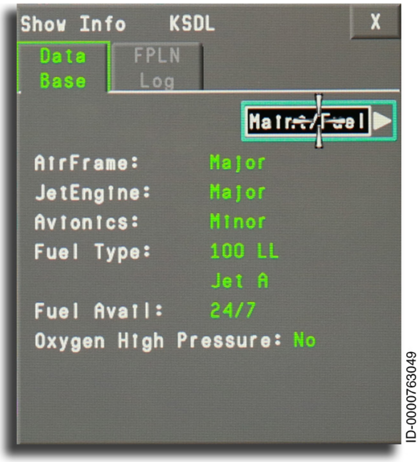

Figure 6-51
Show Info – Maint/Fuel

The Maint/Fuel page shows the following information:

- Airframe (e.g., Major)
- Jet engine (e.g., Major)
- Avionics (e.g., Minor)
- Fuel type (e.g., 100 LL)
- Fuel available (e.g., 24/7)
- Oxygen high pressure (e.g., No).

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AIRPORT NOTES (APRT NOTES) PAGE

The Aprt Notes page is shown in Figure 6-52.

Figure 6-52
Show Info – Aprt Notes

The information displayed on the Aprt Notes page provides similar information found in the Airport Facility Directory (AFD) for that particular airport.

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HOTELS PAGE

The Hotels page is shown in Figure 6-53.

Figure 6-53
Show Info – Hotels

The Hotels page shows local hotels, phone numbers, and whether free pickup is provided.

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GROUND TRANSPORTATION (GND TRNSP) PAGE

The ground transportation page is shown in Figure 6-54.

Figure 6-54
Show Info – Gnd Transp

The ground transportation page shows car rental, taxi, and other ground transportation services available at or nearby the airport.

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GENERAL DATABASE (NAMED WAYPOINT)

The Show Info dialog box shows the Database category for a named waypoint, as shown in Figure 6-55.

Figure 6-55
Named Waypoint Database Show Info Dialog Box

The Named Waypoint Database Show Info dialog box shows the following information:

- Identifier (e.g., OGETU)
- Latitude and longitude (e.g., N61°52.30 E008°42.32)
- Type (e.g., Named Wpt)
- Country (e.g., NORWY).

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L/L (Temporary Waypoint)

The Show Info dialog box shows details for a latitude/longitude waypoint and is displayed in the format shown in Figure 6-56.

Figure 6-56
Lat/Lon Show Info Dialog Box

Temporary Waypoint

The Show Info dialog box displays details for a temporary waypoint and is displayed in the format shown in Figure 6-57.

Figure 6-57
Show Info Dialog Box – Temporary Waypoint

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Similar information is displayed for the Place/Bearing/Place/Bearing (temporary waypoint) and Place/Distance dialog box.

FPLN (Flight Plan) Log Tab

The FPLN Log tab is accessible through the Show Info dialog box menu tab. The FPLN Log tab displays flight plan and performance-related data when the selected waypoint is part of the active flight plan. The format for the flight plan log is identical for any active flight plan waypoint, regardless of the type of waypoint. Figure 6-58 shows a flight plan log. Note that any pending flight plan data is displayed in cyan.

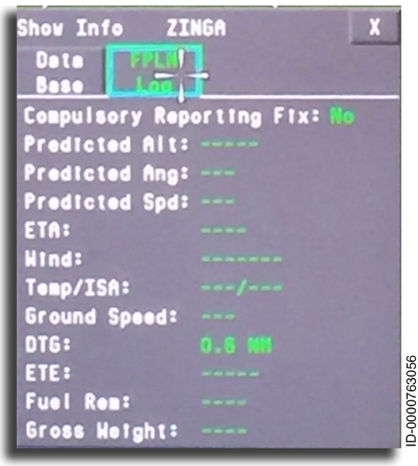

Figure 6-58
Flight Plan Log Data

Tune NAV1/NAV2/NAV3

The Tune NAV1/2/3 items are displayed in the task menu when a VOR is selected on the map and the radios are valid. NAV3 is only displayed if it is currently not in Com Data mode. When this menu item is chosen, the respective NAV1, NAV2, or NAV3 radio is tuned to the frequency required for the selected VOR. There is no Accept/Cancel for this operation, nor is there any feedback on the map following this action.

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ELECTRONIC CHECKLIST (ECL)

The ECL (option) function automates the operation of checklists to reduce crew workload. The electronic checklist and the associated menu are located on the lower half of the MFD, as shown in Figure 6-59. The ECL does not eliminate the requirement for paper checklists in the cockpit.

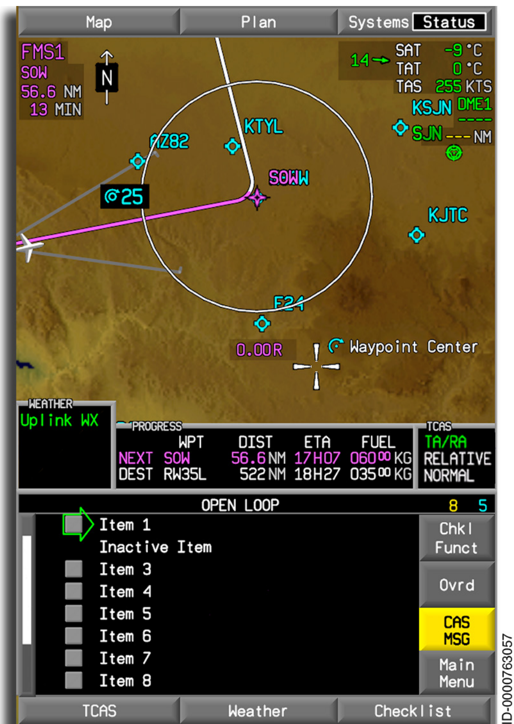

Figure 6-59
Electronic Checklist Display

The ECL combines automatic and manual response functions. Automatic responses receive information from the aircraft system and sensors. Manual responses are inputs made by the flight crew. The CCD controls the checklist using the Checklist menu and responds to the checklist items.

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Electronic Checklist Application

During standard flight operations, the crew follows a set of procedures to check aircraft operational status. These procedures are combined to form an aircraft-level checklist. A single checklist is a collection of line items defining the procedure to verify aircraft status and manage aircraft systems for safe operation.

Normal checklists are commonly organized to reflect the flow of events in preparing the aircraft for flight, flying, and shutdown. The Abnormal and Emergency checklists are considered non-normal checklists and are commonly grouped by aircraft subsystems.

The ECL groups the procedures in the checklist categories as follows:

- Normal
- Abnormal (cautions + advisories)
- Emergency (warnings)
- Non-annunciated (warnings and cautions)
- User-defined.

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CHECKLIST ORGANIZATION

Normally, each procedure index is organized to reflect some logical sequence or grouping. A graphical diagram of a typical checklist hierarchy is shown in Figure 6-60.

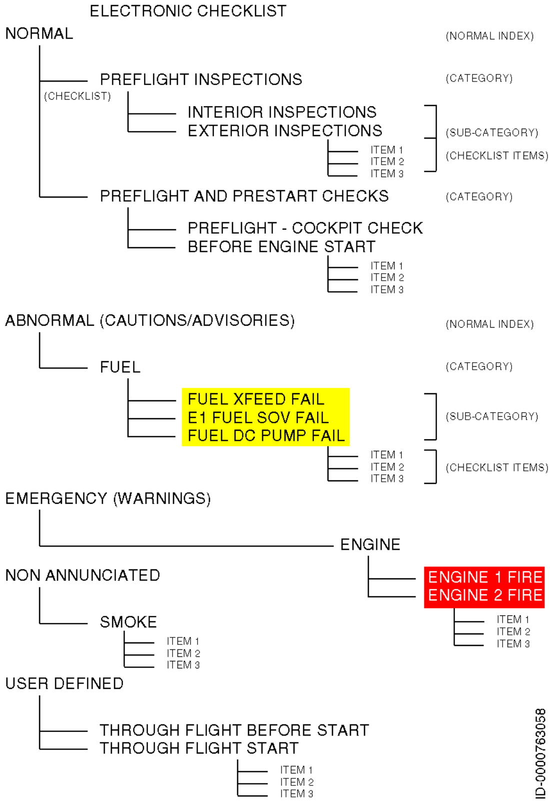

Figure 6-60
Checklist Hierarchy Example

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CHECKLIST WINDOW

The ECL is displayed on the bottom of the MFD. The ECL window layout shows nine lines, each having up to 36 characters. The checklist display consists of a title, checklist line item, a line item indicator, a cursor, and the function buttons. An example checklist window and checklist menu are shown in Figure 6-61.

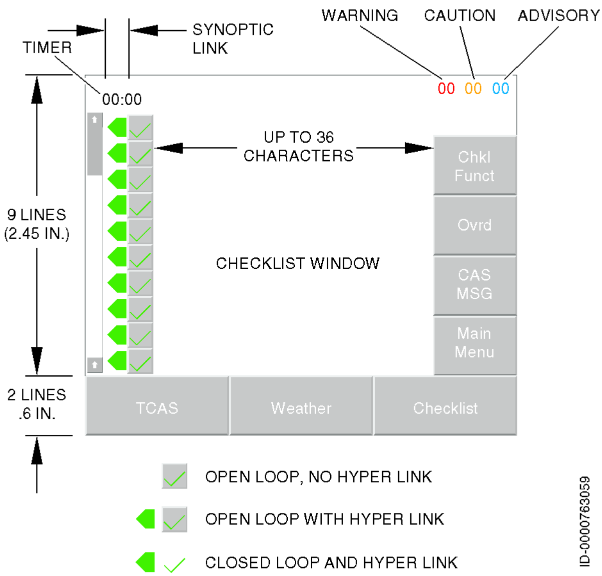

Figure 6-61
Checklist Window

CHECKLIST COLOR USAGE

Colors used in the checklist display:

- The **normal checklist** heading is white.
- The **warning checklist** heading is red normal video.
- The **caution checklist** heading is amber normal video.
- The **advisory checklist** heading color is cyan normal video.
- Checklist completed and line items completed text are green.
- Checklist incomplete and incomplete line item text are white.
- Overridden open-loop items are displayed in gray text with a filled gray box.

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- Overridden closed-loop items are displayed in gray text with a gray box with an X inside.
- Inactive items or procedural notes with the checklist are displayed in white.
- The current line item indicator is a hollow green arrow.
- The scroll bar is white when the CCD knob control is outside the ECL and cyan when inside the ECL.
- The **CAS MSG** button color is state-dependent:
  - Active emergency condition = **red reverse video**
  - Active abnormal caution condition = **amber reverse video**
  - Active abnormal advisory condition = **cyan reverse video**
  - No active emergencies or abnormals = gray text (inactive).

CHECKLIST DISPLAY

The checklist display is shown in Figure 6-62 with callouts. Refer to the callouts for the location of ECL functions described in the following paragraphs.

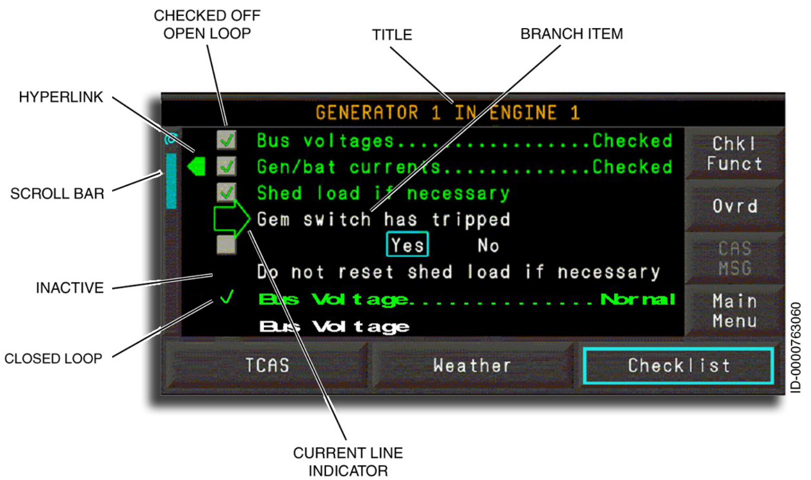

Figure 6-62
Checklist Display Layout

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- **Checked Off Open-Loop/Closed-Loop** – When the pilot indicates an item is completed, a green check () is placed in the gray tile to the left of the line item for open-loop items. Closed-loop items have the green check with no gray tile.
- **Checklist Title** – The checklist title is always on the top center of the checklist.
- **Branch Item** – Branch items are displayed in white and are sub-checklists of green checklist items.
- **Current Line Indicator** – The hollow green arrow points to the current checklist item. When an item is marked complete, the arrow moves down one item. When the last checklist item is completed, and incomplete items are in the checklist, the indicator jumps to the last unchecked item. The current line indicator is moved using the CCD touchpad or moves automatically to the next item when the current item is completed.
- **Scroll Bar** – A cyan scroll bar on the left side of the checklist display indicates the position of the visible checklist items relative to the entire checklist. The viewable portion of the checklist is scrolled forward or backward using one of the knobs on the CCD.

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FUNCTION BUTTONS

The electronic checklist uses a set of function buttons, shown in Figure 6-63, to perform various checklist operations.

Figure 6-63
Checklist Buttons

- Chkl Funct (Checklist Function) – This opens a pop-up menu containing added function buttons: Reset All , Chkl Reset , and Undo .
- Reset All – This button resets all checklists resulting in the system re-assessing the completion status of all closed-loop sensed items. A warning window opens, asking the pilot to verify the execution of that action.
- Chkl Reset – This button resets all items inside a checklist resulting in the system re-assessing the completion status of closed-loop sensed items. When this button is selected at the checklist menu level or the checklist item level, the entire checklist is reset.
- Undo – This button undoes the last crew action inside the checklist. Selecting the Undo button repeatedly results in all actions being undone one at a time until the last item within the checklist has been undone.

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- Ovrd – This button overrides a checklist when the cursor is in a menu and overrides a checklist item when the cursor is inside a checklist. Checklist Overridden is displayed in the ECL window when the entire checklist is overridden.
- CAS MSG (Abnormal/Emergency) – This button is used to access the active non-normal checklist (CAS messages with associated checklist items). This button is disabled (grayed-out) when a non-normal checklist is inactive. The active status is described in the following paragraphs.
- Main Menu – This button opens a pop-up menu, shown in Figure 6-64, that includes the function buttons giving access to these checklists: User Defined , Abnorm (abnormal), Emer (emergency), Non Annun (non-annunciated), and Normal . These keys are described in the following paragraphs.

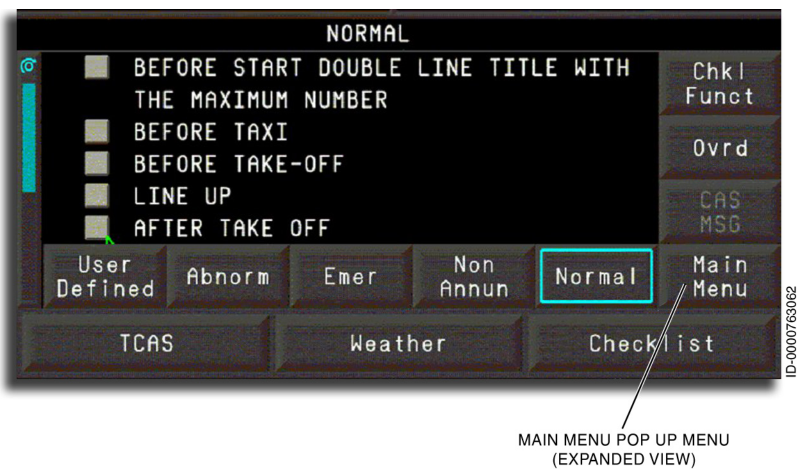

Figure 6-64
Pop-Up Menu and Buttons

NOTE: When any of these buttons are selected, and the associated menu is displayed, the cursor is placed on the first incomplete checklist item or after the last completed checklist when the pilot has worked the checklists out of sequence.

- User Defined – This button accesses the User-Defined checklist menu.

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- **Abnorm** – This button accesses the Abnormal checklist menu.
- **Emer** – This button accesses the Emergency checklist menu.
- **Non Annun** – This button accesses the Non-Annunciated checklist menu.
- **Normal** – This button accesses the Normal checklist menu.

MANUAL CONDITION BRANCHING

When during the execution of a checklist procedure, the pilot must answer a YES/NO question about the condition of the airplane while completing the checklist, the pilot's answer determines which branch of the checklist is followed to complete the checklist. The pilot responds by selecting a YES or NO prompt shown in the conditional line item. Once a selection is made, the path not taken is displayed in gray text and is not selectable with the CCD. The flight crew selects the **Undo** button to reset a branched item.

NOTE: The ECL permits one nested branch (one branch within another), and a branch cannot be overridden.

LINK TO SYNOPTIC PAGE

Some line items give a hyperlink to a related system synoptic page to aid in system monitoring. The system only uses pilot-prompted inputs for display of the corresponding display page. When a checklist is completed, the selected synoptic is closed, and the map is displayed. When the pilot leaves the checklist function from an incomplete checklist, the selected synoptic remains displayed.

The following synoptic pages are linked to any line item:

- Status
- Flight controls
- Electrical
- Hydraulic
- Fuel
- Anti-Ice
- ECS.

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AUTO CHECK-OFF OF SENSED ITEMS

The electronic checklist is a combination of automatic and manual checklist items. For automatic items, the proper condition of the item is computer verified and indicated as completed or failed (that is, crew attention is required). When verified as complete, the cursor moves to the next incomplete checklist item. The automatic items verified by the computer are as follows:

- Parking brake lever (released or NOT released)
- Engines 1 and 2 start/stop/run switch (start position, stop position, or run position)
- Throttle lever 1 and 2 lever positions (idle position or TOGA position or NOT at IDLE and NOT at TOGA position)
- Autobrake RTO knob (RTO position or NOT RTO position)
- Slat/flap lever (zero position, full position, or NOT zero and NOT full positions)
- Gear lever (UP position or DOWN position)
- Brakes Temp – Green zone temperature display indicates brake temperature is OK. When the brake temperature display is not green, it indicates the brake temperature is NOT OK.
- Hydraulics knobs (1B, 2B, 3B) (OFF position, AUTO position, or ON position)
- Hydraulics knobs (3A) (OFF position or ON position)
- Fuel knobs (AC 1, AC 2) (OFF position or AUTO position or ON position)
- Packs 1 and 2 buttons (OUT position or IN position).

NOTE: The flight crew can manually override any incomplete item.

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LINE ITEM TIMER FUNCTION

Some checklist line items require that the flight crew wait for a specified period before continuing to the next checklist line item. To assist the flight crew, ECL has a line item timer function. The timer is displayed in the top left-hand corner of the checklist display, as shown in Figure 6-65. The timer is automatically shown and automatically begins the prescribed countdown. The timer function locks out item check-off while the timer is running. The timer is overridden by selecting the Ovrd button. Overriding a timer removes the timer from the display.

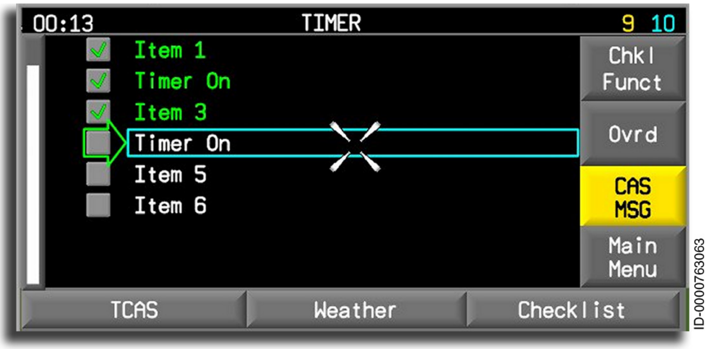

Figure 6-65
Checklist Timer

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Checklist Operation

Only one MFD has control of the checklist function. The display with control of the checklist is the active display, as shown in Figure 6-66. Any other display containing the checklist is a passive display and cannot control the checklist because no cursor is in the checklist.

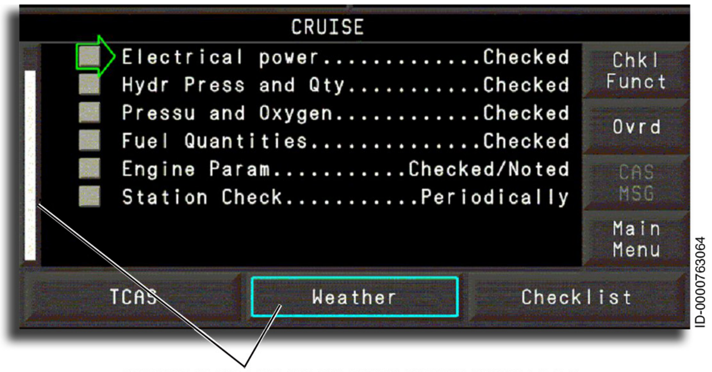

Figure 6-66
Passive Display

The passive MFD becomes the active MFD when the active side is not using the checklist (no active MFD cursor movement), and the cursor is moved into the passive MFD. When the active side transitions to the passive state, the cursor is moved to the MFD **Checklist** menu button. When the passive side is not displaying the checklist, pushing the CCD **ENTER** button when the cursor is on the MFD **Checklist** menu button opens the checklist into passive display.

The finger movement on the CCD touchpad moves the cursor inside the checklist window and is used to select function buttons. Once an item is checked, the current line item indicator and CCD cursor automatically moves to the next line item. The CCD rotary knob scrolls through a checklist. Rotating one of the two knobs on the CCD has the same effect as scrolling through the checklist one line at a time, up or down. The checklist function is activated as follows:

- **Normal Flight Conditions** – During normal flight conditions, the pilot positions the CCD cursor on the MFD **Checklist** menu button and pushes one of the CCD **ENTER** buttons. The button bar is displayed on the right side of the ECL display.

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- **Abnormal Flight Conditions** – During non-normal flight conditions (active CAS message with an associated checklist), the pilot positions the CCD cursor on the MFD **Checklist** menu button and pushes one of the CCD **ENTER** buttons to show the active checklist or a queue of the active checklists.

If the pilot had closed the ECL window without completing a normal or non-normal checklist, the ECL window re-opens to the previously selected checklist with the cursor positioned at the same point where the ECL was exited.

NORMAL CHECKLIST OPERATION

The five checklist indices are accessed by first selecting the **Main Menu** button that shows the pop-up menu and then selecting the desired checklist. Selecting any of the checklist index buttons in the pop-up menu closes the menu and shows the corresponding checklist menu. Selecting the **Main Menu** button closes the pop-up menu. The Chkl Funct pop-up menu operates the same way.

Under normal operations, the cursor is placed on the first normal checklist item not completed when a normal checklist is selected.

After all line items have been completed, the message *Checklist Complete is displayed, and the ECL returns to the normal checklist menu.

When the ECL is closed and opened again after *Checklist Complete* is displayed (under normal situation), the system returns the checklist window to the normal checklist menu.

NON-NORMAL CHECKLIST OPERATION

The non-normal checklist is accessed as follows:

- **ECL Window Closed** – When one CAS message with a related checklist is active, the cursor is placed on the first item not completed in the corresponding checklist when the MFD **Checklist** menu button is selected.

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- **ECL Window Opened** – When a menu is displayed, the CAS activated checklist is automatically displayed. When a checklist is displayed, the **CAS MSG** button becomes active, as shown in Figure 6-67. The active checklist count is displayed at the top-right corner of the checklist display. Pushing the **CAS MSG** button opens the corresponding checklist when only one message is active or opens the active abnormal checklist queue when more than one message is active.

Figure 6-67
CAS Message Active

- **Non-Normal Checklists Without CAS Messages** – When the ECL window is open, the pilot can access the non-normal checklists at any time, regardless of CAS messages, by selecting the Abnormal or Emergency checklist buttons located in the main menu pop-up menu.

- After all line items within the checklist have been completed, the message **Checklist Complete** is displayed. Pushing the CCD **ENTER** button closes the checklist and changes the window as follows:

  – When one CAS message is active, the window returns to the main menu.

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- When one checklist is complete and two CAS messages with associated checklists are active, the display shows the remaining checklist and then returns the window to the main menu when the last checklist is completed.
- When a non-normal checklist selected through the Abnormal or Emergency buttons is completed, the window returns to the Abnormal or Emergency checklist menu, respectively.

NOTE: A completed checklist is automatically removed from the active abnormal queue. A previously completed Abnormal or Emergency checklist is automatically reset when the associated CAS message is shown again.

- **Active Warning/Caution Displays** – The state of the active abnormal/emergency queue is displayed at the top-right corner of the checklist display. The numbers separately indicate the total number of warning, caution, or advisory checklists currently active and are only shown when more than one checklist is active.

CHECKLIST PRIORITIES

Active abnormal emergency and caution checklists are prioritized in two ways. The technique of first in, first out (FIFO) is applied, and all warnings are displayed above all cautions in the active abnormal queue. No prioritization is within emergency checklists, caution checklists, or advisory checklists. The pilot selects any checklist in any sequence.

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The **CAS MSG** button color prioritization for CAS messages with associated checklist items is as follows:

- Any active EMERGENCY displays a CAS MSG button, as shown in Figure 6-68, regardless of what checklist is currently being worked.
- Any active ABNORMAL caution shows a CAS MSG button, as long as there are no active EMERGENCY checklists, regardless of what checklist is currently being worked.
- Any active ABNORMAL advisory shows a CAS MSG button, as long as there are no active EMERGENCY checklists and no active ABNORMAL caution checklists, regardless of what checklist is currently being worked.

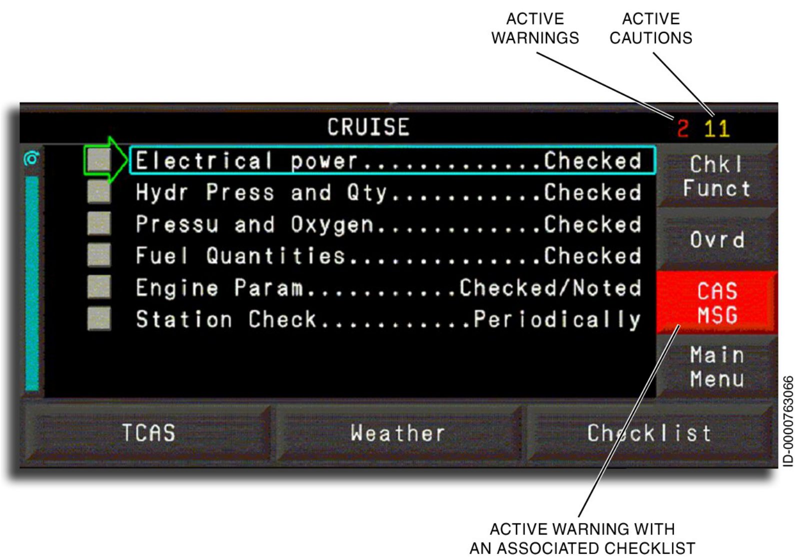

Figure 6-68
CAS Message Warnings and Cautions

Abnormal ECL Operation

The ECL system is not essential and does not require special provisions for operation under emergency power. The ECL is not required for dispatch. The ECL does not include any emergency or caution checklists and information not covered in the paper checklist. A Checklist Unavailable message is displayed in the MFD checklist window if the ECL has failed.

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7. Multifunction Display – Electronic Charts (Option)

INTRODUCTION

The electronic charts (eCharts) function provides the crew with the ability to view terminal charts on the multifunction display (MFD). The charts are provided to the aircraft operator in the form of a loadable eCharts database. The crew has the ability to select the desired chart for display as well as manipulate the chart for optimal viewing (e.g., zoom, scroll, rotate).

The eCharts function is capable of displaying the following types of charts from the charts database:

- Airport
- Standard Instrument Departure (SID)
- Standard Terminal Arrival Route (STAR)
- Approach
- Noise
- Notice To Airmen (NOTAM)
- Airspace.

The flight management system (FMS) provides airport and terminal procedure data required by the eCharts to automatically search and link charts matching the active flight plan. For geo-referenced charts, information about the current position and the orientation of the aircraft is required. The position information is provided by the FMS, and the orientation information is provided by the inertial reference system (IRS).

NOTE: Chart linking is disabled if a custom chart subscription is purchased.

A night mode capability is provided with eCharts to display charts with an opposite color palette that is optimized for night-time viewing.

There is also an optional print feature that interfaces with the cockpit printer to print hard copies of selected charts.

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CHARTS ACCESS

Selecting **Systems** on the upper-right side of the MFD displays an aircraft Systems dropdown menu. Selecting **Charts**, shown in Figure 7-1, displays the charts on the MFD.

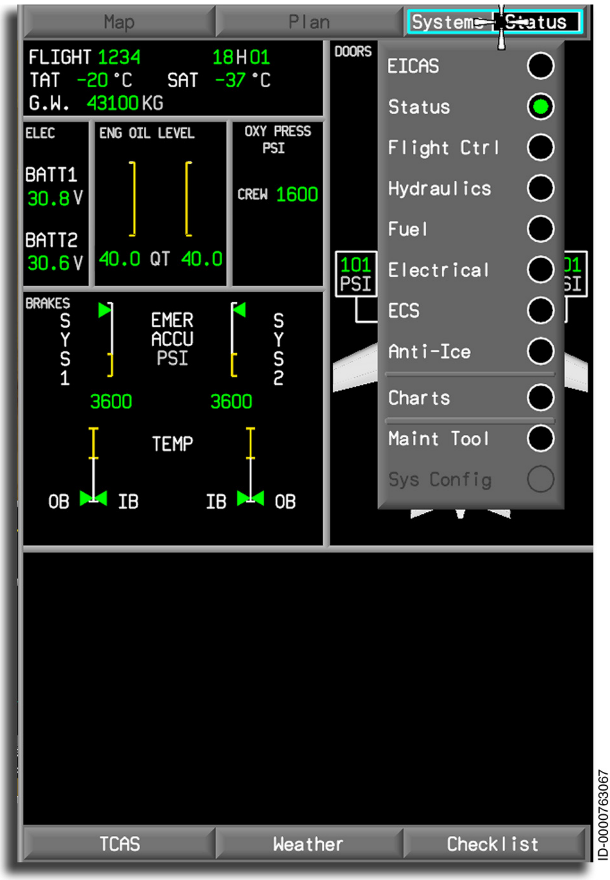

Figure 7-1
eCharts Display Selection

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Revision Info

The **Revision Info** page, shown in Figure 7-2, displays the dataset (charts) effectivity date, subscriber serial number, and dataset coverage map.

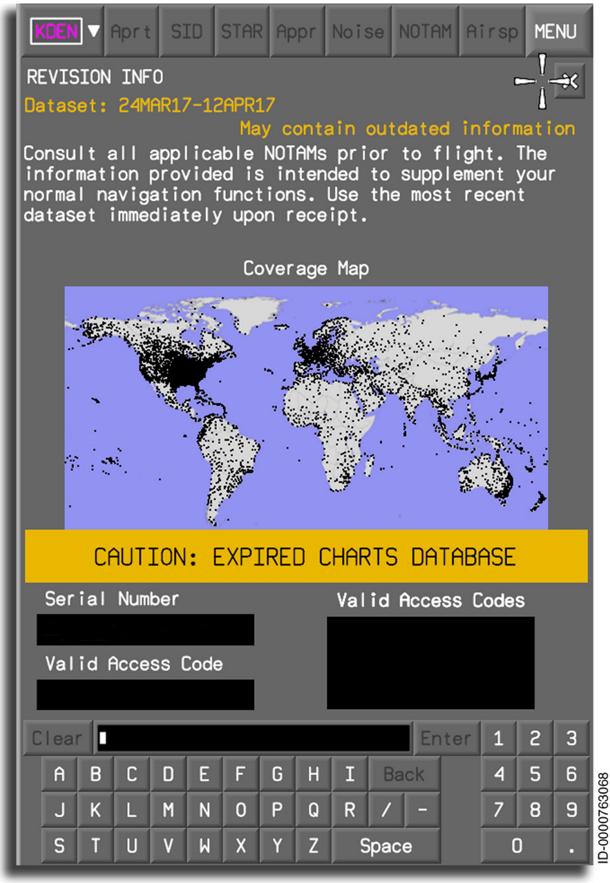

Figure 7-2
Revision Info Page

Selecting **Revision Info...** from the airport dropdown menu displays the **Revision Info** page. The airport dropdown menu is discussed in the subsection Airport Selection Window and Dropdown Menu on page 7-8.

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The **Revision Info** dialog box is displayed automatically when the chart window is accessed, and one or more of the following abnormal conditions exists:

- No valid serial number and no valid access code entries
- Charts database integrity check failure
- Product code check failure
- Database out-of-date/expired.

DATASET EFFECTIVE PERIOD

The chart database effective period is displayed in the top-left corner, beneath the title, as **Dataset: DDMMMYY - DDMMMYY** with **DD** representing the day, **MMM** representing the month, and **YY** representing the year.

If the database is outdated, the effective period is displayed as **Dataset DDMMMYY - DDMMMYY** , along with the warning **May contain outdated information** . Also, a **CAUTION: EXPIRED CHARTS DATABASE** banner is shown below the coverage map, as shown in Figure 7-2.

PRODUCT CODE WARNING

If the product code is not correct, the notice **Invalid Entry** is displayed on the entry field of the keyboard.

WORLD MAP

The world map picture is used to display the approximate locations of the airports in the coverage region when a valid serial number and/or access code are entered. The airports are represented by black dots, using the latitude/longitude coordinates listed in the Jeppesen database.

SERIAL NUMBER

The serial number is entered using the virtual keyboard with each character displayed in the scratchpad as it is selected using the cursor control device (CCD). Initiating validation of the entered serial number is done by pushing the **Enter** button to the right of the scratchpad.

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Once a valid serial number is inserted, it is displayed in the Serial Number window. If a serial number is entered after one has already been entered, the most recent valid serial number is stored in the memory and is displayed in the Serial Number window. If an invalid serial number is entered following the entry of a valid serial number, the valid serial number remains stored within the chart function.

If no valid serial number has been entered, the Serial Number window is displayed with amber dashed lines. If an invalid serial number is entered (initially or to change customer access), Invalid Entry is displayed in the scratchpad. This message is cleared either by entering another serial number or selecting the Clear button.

NOTE: The serial number is reset by entering zero for all 16 characters of the serial number. This permits the pilot to clear the charts database subscription granted by the serial number only (access code entries are unaffected). Serial number resets are disabled while in-flight to prevent losing chart access.

ACCESS CODE

The access code is entered using the virtual keyboard with each character displayed in the scratchpad as it is selected using the CCD. Initiating validation of the access code is done by pushing the Enter button to the right of the scratchpad. Once an access code is validated, it is displayed in the Valid Access Codes window, replacing any previous access code.

When the access code is validated, it is displayed in numerical order in the Valid Access Codes window. If the quantity of access codes exceeds the window, a scroll bar is displayed. The access codes are only shown while data is being entered, and the window is displayed.

If an access code is entered that cannot be validated, Invalid Entry is displayed in the scratchpad. This message is cleared either by entering another access code or selecting the Clear button on the keyboard.

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NOTE: Access codes are reset by entering zero for all 10 characters of the coverage code. When the access codes are cleared, the region coverage provided by those codes is revoked unless a serial number is entered that provides equivalent coverage for those regions. Access code resets are disabled while in-flight to prevent losing chart access.

Selecting **X** on the upper-right corner closes the **Revision Info** page and displays the charts main page with the **Aprt** tab selected.

NOTE: The access code is provided to customers that subscribe to a regional coverage rather than worldwide (excluding military) and have purchased a TRIP KIT to extend their coverage. This does not apply to users of IDM/JDM or tailored coverage customers who only load regional coverage they subscribe to.

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CHARTS DISPLAY COMPONENTS

The main components of the charts display are shown in Figure 7-3.

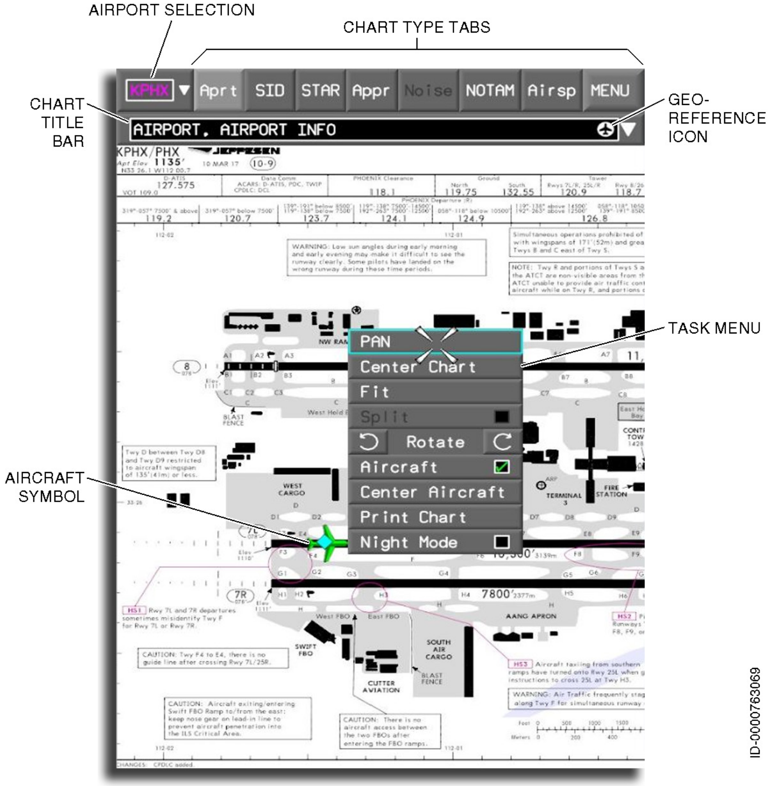

Figure 7-3
Charts Display

Details regarding available menus, tabs, and graphical operations for eCharts are described in the following sections.

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Airport Selection Window and Dropdown Menu

The airport dropdown menu, shown in Figure 7-4, is displayed by positioning the cursor on the airport selection dropdown menu button and pushing the CCD **ENTER** button.

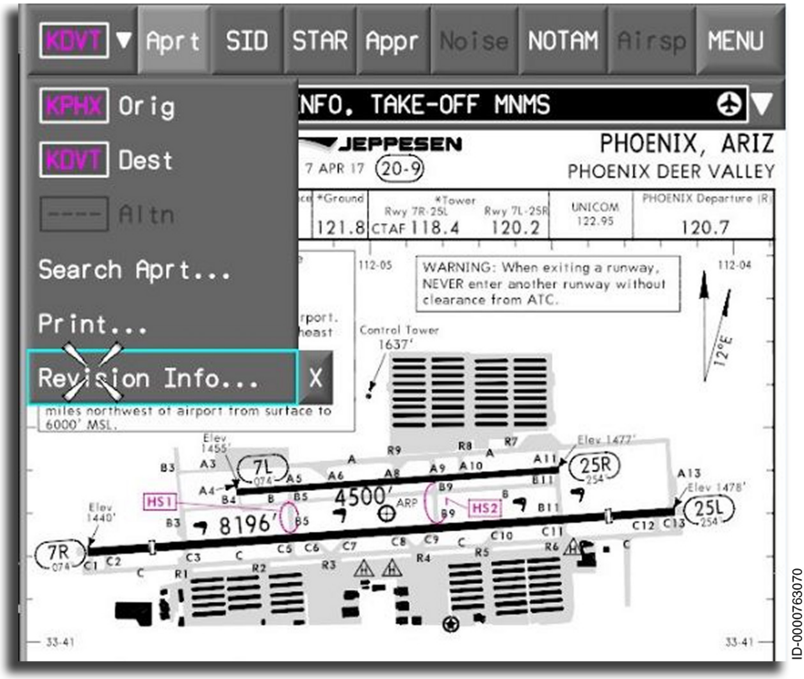

Figure 7-4
Airport Dropdown Menu

When the airport dropdown menu is activated, the cursor is positioned over the airport selection window.

Regardless of whether the airport identifier is part of the active flight plan or not, the Orig, Dest, and Altn labels are shown on the dropdown menu. If an airport identifier is dashed in the airport dropdown menu, it is not selectable.

ORIGIN, DESTINATION, ALTERNATE

The Orig, Dest, and Altn airport identifiers represent the origin, destination, and alternate (if applicable) airports entered into the FMS-linked flight plan. If an FMS-linked airport cannot be identified for the origin, destination, or alternate airport, four white dashes (- - - -) are shown.

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If a flight plan has not been entered and activated, the airport identifier is not available through the Jeppesen dataset, or is not part of the subscription coverage, the airport identifier is displayed as four amber dashes (- - - -).

When the dropdown menu is activated, and selection of the Orig , Dest , and Altn option is made, the identifier for the selected airport is shown in the airport selection window, and the dropdown menu is removed.

SEARCH AIRPORT

Selecting Search Aprt... from the airport selection dropdown menu displays the Airport Search Results page, as shown in Figure 7-5.

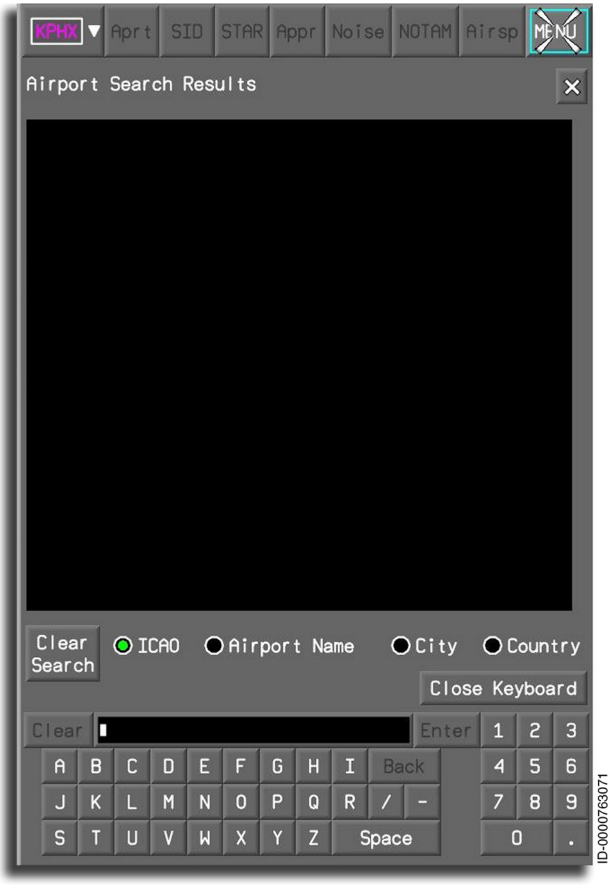

Figure 7-5
Airport Search Results Page

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The **Airport Search Results** page is used to search for and display charts for any airport in the chart database. The first time after power-up, the **Airport Search Results** page is blank.

An airport can be searched by the International Civil Aviation Organization (ICAO) identifier, the airport name, or by the city or country in which it is located. This is accomplished by selecting one of the four radio buttons above the scratchpad of the virtual keyboard using the CCD.

If no airports are found as a result of the search criteria, the message **No airports found for the search criterion.** is displayed in the center of the screen.

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If the number of airports returned based on the search criteria exceeds the Search Results window, a scroll bar is displayed on the right side border, as shown in Figure 7-6.

Figure 7-6
Airport Search Results Window With Scroll Bar

As the cursor is placed and moved in the Search Results window, the text row location of the cursor is highlighted with a cyan rectangle.

An airport chart is displayed by placing the CCD cursor on the desired airport row and pushing the **ENTER** button. The airport identifier is displayed in the airport dropdown menu window, and the airport title is displayed in the chart dropdown menu title window. The Aprt , SID , STAR , Appr , Noise , NOTAM , and Airsp tabs are displayed with the Aprt tab initially selected.

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Selecting the **Clear Search** button clears the scratchpad and Search Results window and defaults the radio button selection to **ICAO** .

Selecting **X** in the upper-right corner closes the **Airport Search Results** page.

NOTE: If the search results and scratchpad data are not cleared before exiting the page, the search results and scratchpad data from the previous search are displayed when the page is re-entered, regardless of the method used to exit.

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PRINT (OPTION)

A print feature is provided with eCharts that interfaces with the CMC cockpit printer to permit the crew to print hard copies of selected charts.

The Print page, shown in Figure 7-7, is displayed by placing the CCD cursor over the Print... option on the airport dropdown menu and pushing the **ENTER** button.

Figure 7-7
Print Page

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The print page is primarily designed to print multiple charts from the origin, destination, alternate, or search airport results. The print page contains four tabs across the top left with the labels: Orig , Dest , Altn , and Search . The ICAO airport identifier is listed underneath each of these labels.

When a tab is selected, all of the charts for that airport are listed in the Available Charts window and are separated by a header for each type of chart. The types of charts listed in order are airport, SID, STAR, approach, noise, and airspace. The crew can select individual charts, all charts of each type, or select all of the charts available for the airport.

When all the charts to be printed are selected for a particular tab, another tab can be selected, and the charts for that airport can be selected for printing. The selected charts will be stored in memory even when another tab is selected. The selected charts for each tab remain selected until they are sent to the print queue by selecting the Print button. Once the charts are sent to the print queue, all the charts for each tab display as unselected.

The Print Queue window, shown in Figure 7-8, displays up to three charts at a time. For each line, the chart name is listed along with the print job status of the chart.

Figure 7-8
Print Queue Window

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Chart Type Tabs

The charts shown for each airport are defined by seven chart types. The chart types are organized using tabs displayed in the upper portion of the chart display to the right of the airport selection dropdown menu. The chart type tabs are shown in Figure 7-9.

Figure 7-9
Tab Bar

The chart type tabs shown in the chart display are as follows:

- Aprt – Airport diagrams
- SID – Standard Instrument Departures
- STAR – Standard Terminal Arrival Routes
- Appr – Approach procedures
- Noise – Noise abatement procedures
- NOTAM – Chart Notices to Airmen
- Airsp – Terminal airspace
- MENU – Displays the aircraft Systems dropdown menu.

Selecting the desired chart tab shows the corresponding charts for the selected airport. When there are no charts available for a given chart type, the tab is grayed out and is not selectable.

NOTE: The initial chart displayed after power-up when selecting the SID *,* STAR *, or* Appr *tabs for the origin and destination airports is the chart associated with the active procedure entered in the coupled FMS flight plan.*

When a tab is selected, if there is no default chart defined in the FMS, the chart list is automatically selected with the cursor highlighting the first list entry. If a specific chart is not determined for a tab selection, the tabs are selectable, so the pilot can use the chart dropdown menu to select a chart.

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Chart Title Bar and Dropdown Menu

When the chart has been manually selected, the title of a displayed chart is displayed in white letters on black background above the chart below the chart type tabs. If the chart has been automatically selected as a result of the pilot loading the procedure or airport into the flight plan, the chart title is displayed in magenta, prefaced with the text FMSX: (where X is 1, 2, or 3). The chart title bar is shown in Figure 7-10.

Figure 7-10
Chart Title Bar

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The chart dropdown menu is used for selecting individual charts (within the selected chart type tab). Selecting the chart title bar shows the chart dropdown menu, as shown in Figure 7-11.

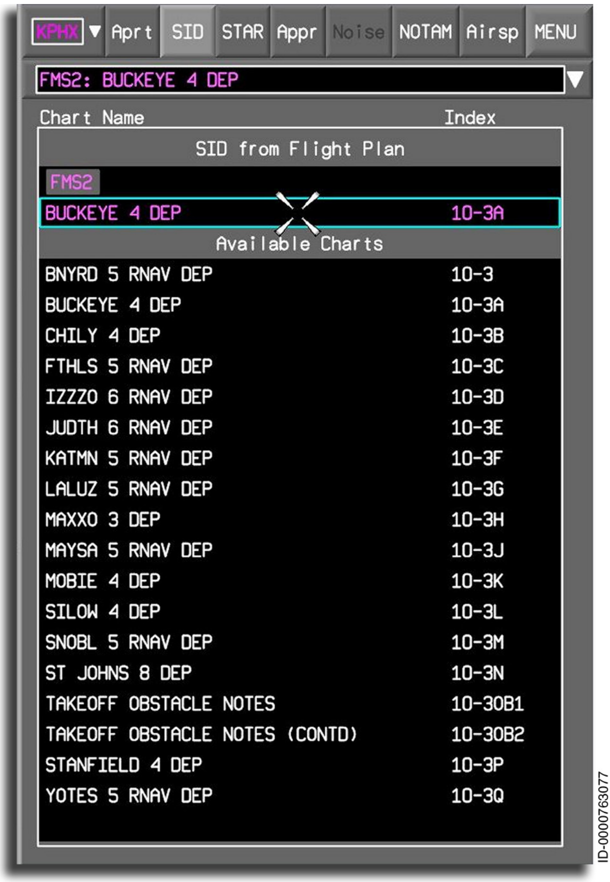

Figure 7-11
Chart Dropdown Menu

The charts displayed in the charts dropdown menu are based on the ICAO airport displayed in the airport dropdown menu window as well as the currently selected tab. If a chart is being displayed and the dropdown menu is selected, the cursor is positioned on the displayed chart name in the list.

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When the list of available charts is longer than the displayed chart dropdown menu, a cyan scroll bar is displayed to the right of the menu. The CCD knob is used to scroll through the available charts when the cyan scroll bar is displayed. The cursor is used to highlight the desired chart title. Selecting the chart title shows the chart in the chart display.

NOTE: Only the chart name, chart index number, and geo-referenced icon (white or magenta aircraft symbol) are displayed in the chart title dropdown menu. Other identifying characteristics of a chart (the revision date, action, effective date) are displayed on the chart.

The charts shown in the chart dropdown menu are separated into two sections. The first section, titled XXXX From Flight Plan (where XXXX is the selected chart type (SID, STAR, approach)), lists the chart selected by the flight management system (FMS) that matches the airport or procedure currently loaded in the flight plan. An FMSX (where X is 1, 2, or 3) label at the top left corner is displayed when an FMS is linked. An example of the FMS-linked charts window is shown in Figure 7-12.

Figure 7-12
FMS Linked Charts Window

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The second section is titled **Available Charts**, as shown in Figure 7-13, and lists all the available charts for the selected airport and tab. The charts are listed in alphabetical then numerical order.

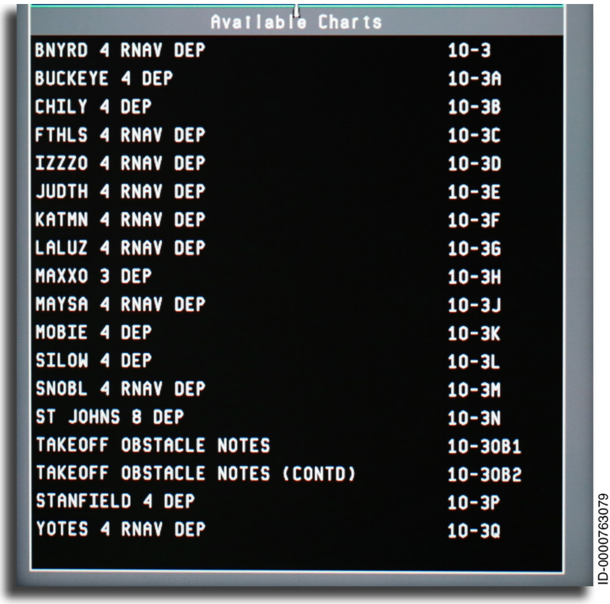

Figure 7-13
Available Charts Window

In some cases, a third section is displayed. This is because two versions of a chart may exist. Charts that are available to be viewed that may be outdated are listed in the chart dropdown menu and displayed in the ***** Charts may be outdated ***** window shown in Figure 7-14.

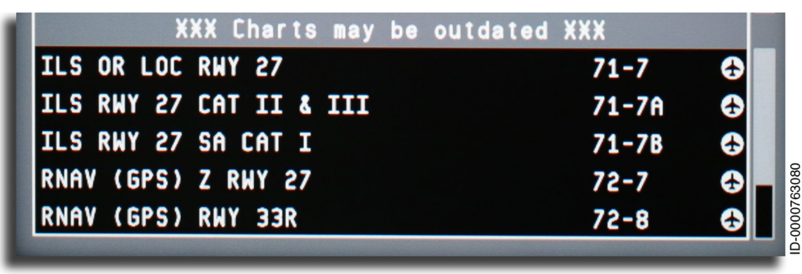

Figure 7-14
Charts Outdated Window

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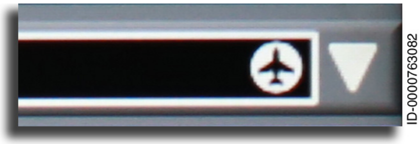
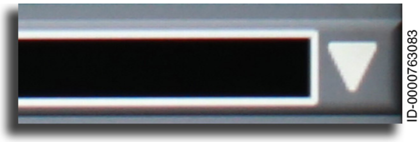
GEO-REFERENCED CHARTS

Jeppesen charts support the capability of displaying an aircraft symbol on airport diagrams, SIDs, STARs, and approach charts. These types of charts are referred to as geo-referenced charts. The positions of navigation symbols depicted on geo-referenced charts have been verified by Jeppesen to be highly accurate by cross-checking the symbol plots against independent navigation data. Not all charts are geo-referenced.

A magenta airplane icon, shown to the right of the chart title dropdown menu, indicates the chart is geo-referenced, and the procedure shown is in the active flight plan.



A white airplane icon, shown to the right of the chart title dropdown menu, indicates the chart is geo-referenced, and the procedure shown is not in the active flight plan.



No airplane icon, shown to the right of the chart title dropdown menu, indicates the chart is not geo-referenced.

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NO CHARTS SELECTED/AVAILABLE

A chart is normally displayed when a tab is selected. The chart shown is either automatically selected by the system or selected by the pilot. If no chart exists within a given tab, the tab is grayed out and not selectable. In certain cases, for a given tab, the system does not automatically select a chart. When a chart has not been selected for a particular chart type, the message NO CHART SELECTED is displayed in the chart title bar, as shown in Figure 7-15.

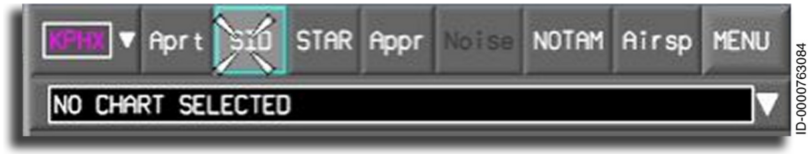

Figure 7-15
No Chart Selected

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The message No data available for XXXXXX Airport YYYY is displayed when the airport for the selected tab is in the airports database, but no current effective charts are available, as shown in Figure 7-16. XXXXXX is either Orig, Dest, Altn, or Search, and YYYY is the identifier of the corresponding airport.

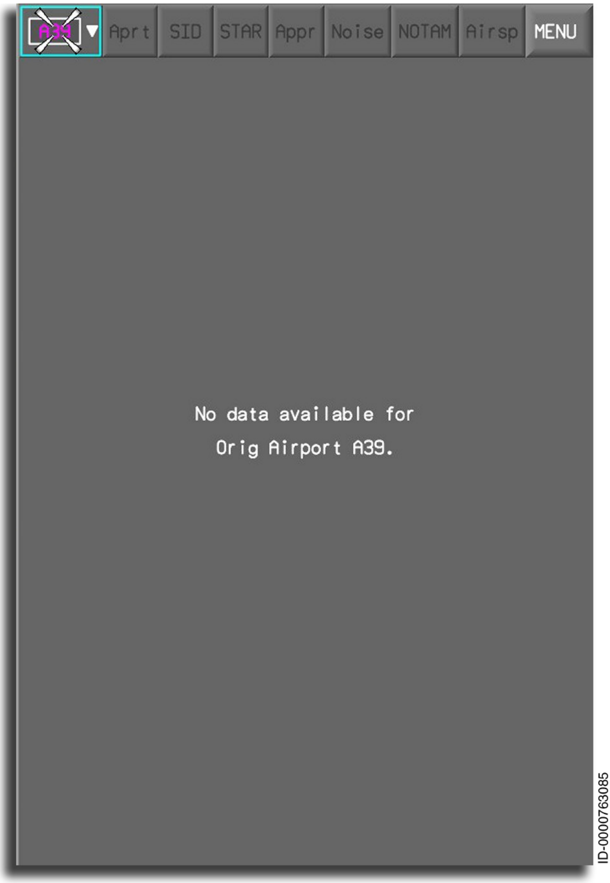

Figure 7-16
No Charts Available

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Chart NOTAMs

Selecting the NOTAM tab, as shown in Figure 7-17, displays the chart NOTAMs using the airport as a reference. When a NOTAM is assigned to a country, the chart NOTAM applies to all airports in that country.

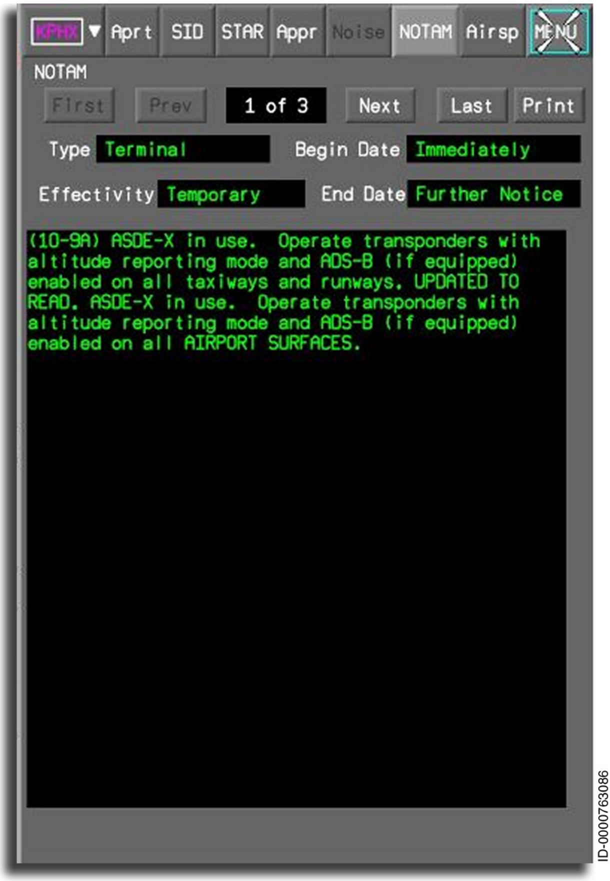

Figure 7-17
Chart NOTAM Page

The number of the NOTAMs being shown and the total number of chart NOTAMs for the selected airport is displayed near the top of the chart NOTAM page. The NOTAM tab is not selectable if there are no chart NOTAMs for the selected airport.

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CHART NOTAM FIELDS

Each chart NOTAM has four fields. The four chart NOTAM fields are displayed as follows:

- Type
- Effectivity
- Begin Date
- End Date .

The Type field shows the type of chart NOTAM. The types of chart NOTAMs shown are Terminal or General . Terminal indicates the chart NOTAM is associated with a specific airport. General* indicates the chart NOTAM is associated with a country.

The Effectivity field shows the duration of the chart NOTAM. The chart NOTAM effectivity is either Permanent or Temporary .

The Begin Date field contains two types of entries: Immediately* or an actual date shown in the format DDMMMYY . The End Date field contains three types of entries: an end date shown in the format DDMMMYY , Further Notice , or No End Date .

CHART NOTAM TEXT

Chart NOTAM text is displayed below the heading fields. A scroll bar is displayed on the right side of the display when a single chart NOTAM contains more text than can be contained on the screen. The CCD knob is used to scroll the chart NOTAM text when a scroll bar is displayed.

NOTAM PRINT BUTTON

The NOTAM Print button is used to send the displayed NOTAM to the cockpit printer if this option is enabled. The button is grayed out if another print request is active in the print queue.

When the Print button is selected, the printer status is displayed along the bottom of the display. The print queue displays all NOTAMs that are queued for printing. The print status remains displayed until another NOTAM is displayed or another chart is selected.

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OUTDATED NOTAM ANNUNCIATIONS

In some cases, a pilot may have to display recently outdated NOTAMs. The chart function does not limit the pilot from viewing these NOTAMs. However, an annunciator is used to identify an outdated NOTAM.

If a NOTAM is no longer effective, the NOTAM is displayed with the message *** This NOTAM may no longer be in effect. *** centered on the first line of the NOTAM and *** Check the End Date before using. *** centered on the second line of the NOTAM.

If the date information from the aircraft systems is determined to be invalid, the NOTAM is displayed with the message *** The effectivity of NOTAM is undetermined. *** centered on the first line of the NOTAM and *** Invalid aircraft date. *** centered on the second line of the NOTAM.

Automatically Selected Charts

The chart function automatically selects charts for airports and procedures that are part of the active flight plan. This removes the reason for the pilot to search for each chart required during a flight. Instead, when the appropriate chart tab button is pushed, the chart associated with the active flight plan airport or procedure is displayed.

For example, the BUCKEYE 4 RNAV SID, shown in Figure 7-18, is displayed when the BUCKEYE 4 departure is selected as the departure procedure in the active flight plan, and SID is selected on the chart tab.

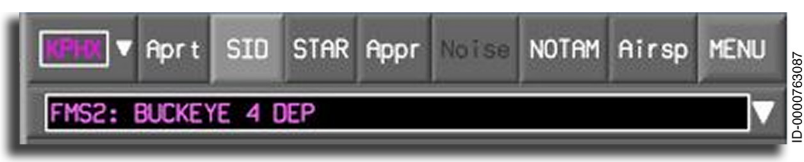

Figure 7-18
Automatically Selected Chart

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Each time the chart display is accessed, the chart function retrieves the current flight plan information from the FMS and loads the relevant charts associated with the flight plan. This is useful during flight when an approach is selected. Loading the approach in the flight plan first and then accessing the chart display loads the appropriate approach chart to be displayed.

When a chart is automatically loaded, the text FMSX (where X is 1, 2, or 3) is displayed in the chart title bar before the chart title.

The destination airport diagram is automatically displayed after landing (weight-on-wheels) if a chart was previously displayed on an MFD during landing.

Charts for some airports do not have automatic selection capability. This occurs when the chart does not exist in the FMS or the operator does not have subscription coverage for the chart. The message *FMSX: NO CHART SELECTED (where X is 1, 2, or 3) is displayed when automatically-selected charts are not available.

CHART MANIPULATION

The CCD is used to manipulate the chart display. Magnification, operation of menus and buttons, and selection of tabs are controlled with the CCD cursor, data set knob, and CCD **ENTER** button.

Zoom

The zoom function permits the pilot to increase or decrease the apparent viewing distance from the chart. The data set knob on the CCD is used to control zoom. The scaling of the chart is reduced or enlarged by 25% per click of the data set knob based on the initial chart size.

The chart is enlarged or reduced around the center point of the chart display. The maximum scale factor of the chart is three times the initial chart display, and the minimum displayable size (or minimum scale factor) of a chart is when the chart is viewable in its entirety in the display.

The zoom function continues to be active when the cursor is moved to the top menu bar.

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Scroll

The scroll frame is displayed when the cursor is placed along the edge of the chart display (in any direction). The scroll frame is shown in Figure 7-19.

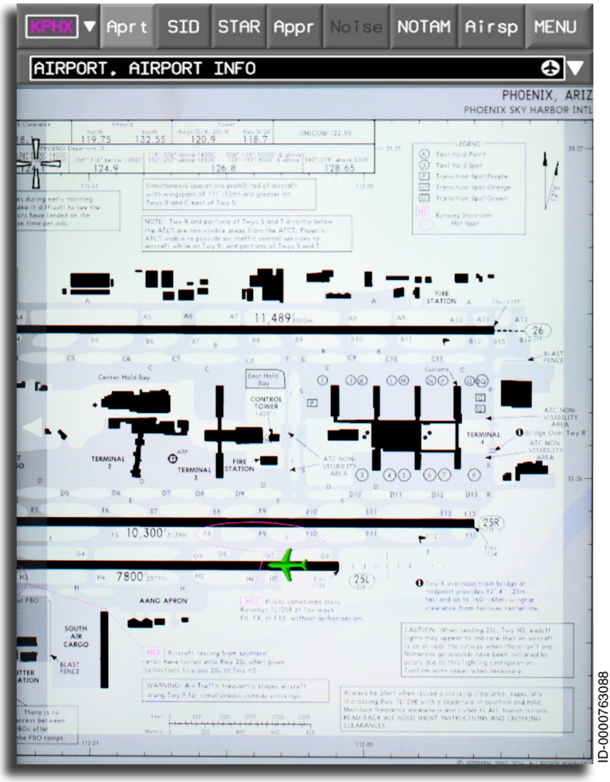

Figure 7-19
Scroll Frame

Scrolling is performed by placing the cursor within the scroll frame located in the desired scroll direction and pushing the CCD **ENTER** button. For each **ENTER** button push, the chart is scrolled in increments in the direction of the arrows. Pushing and holding the **ENTER** button for greater than 1 second is an alternate method for multiple button pushes.

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When the cursor is placed in the center of a scroll bar and the **ENTER** button is pushed, the chart scrolls in the direction indicated by the directional arrowhead. When the cursor is placed off-center in the scroll bar and the **ENTER** button is pushed, the chart scrolls diagonally in the direction of the cursor. Scrolling is limited to the point where the edge of the chart reaches the edge of the display.

Scrolling is disabled if the chart is completely displayed, and in the case of a split chart, scrolling is disabled if the section within the respective split window is displayed in its entirety.

Chart Task Menu

The chart task menu is used to manipulate the chart within the chart display. The chart task menu is accessed by placing the cursor on any location on the chart and pushing the CCD **ENTER** button. The chart task menu is shown in Figure 7-20.

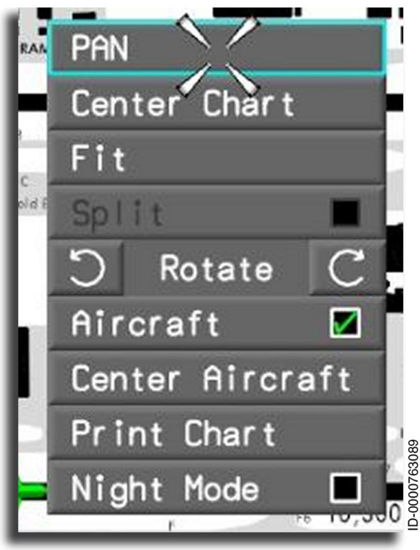

Figure 7-20
Chart Task Menu

PAN

Pan mode is similar to scroll mode in the sense that scroll and pan operations permit the pilot to move to an area of interest on the chart. Pan mode, however, is activated and deactivated using the chart task menu.

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Selecting PAN removes the cursor position from the display, and a pan indicator is positioned at the center of the chart display, as shown in Figure 7-21.

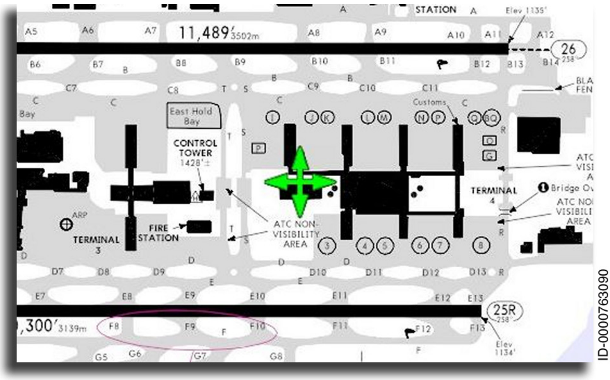

Figure 7-21
Pan Mode Indicator

Moving the CCD results in the chart to pan in the direction of CCD movement.

The pan mode indicator remains at the center of the chart display while pan is active. When pan is de-activated, the pan mode indicator at the center of the chart display is replaced by the cursor symbol positioned at the center of the chart display.

CENTER CHART

Selecting Center Chart centers the chart at the point of focus where the chart was selected. This selection is used in conjunction with magnification to increase the readability of the charts. The Center Chart selection is available for all charts.

FIT

Selecting Fit scales the chart horizontally or vertically so that the smallest dimension of the chart fills the display. For portrait displayed charts, the Fit selection horizontally sizes the chart to fill the display and align the top of the chart with the top of the display. For landscape displayed charts, the Fit task vertically sizes the chart to fill the display and align the right side (header side) of the chart with right side of the display.

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SPLIT

Selecting **Split** provides the pilot with the ability to split an approach chart into two windows (a larger window and a smaller window). The larger window shows the plan portion of the chart, and the smaller window shows the Header, Profile, or Minimums section of the chart, as shown in Figure 7-22.

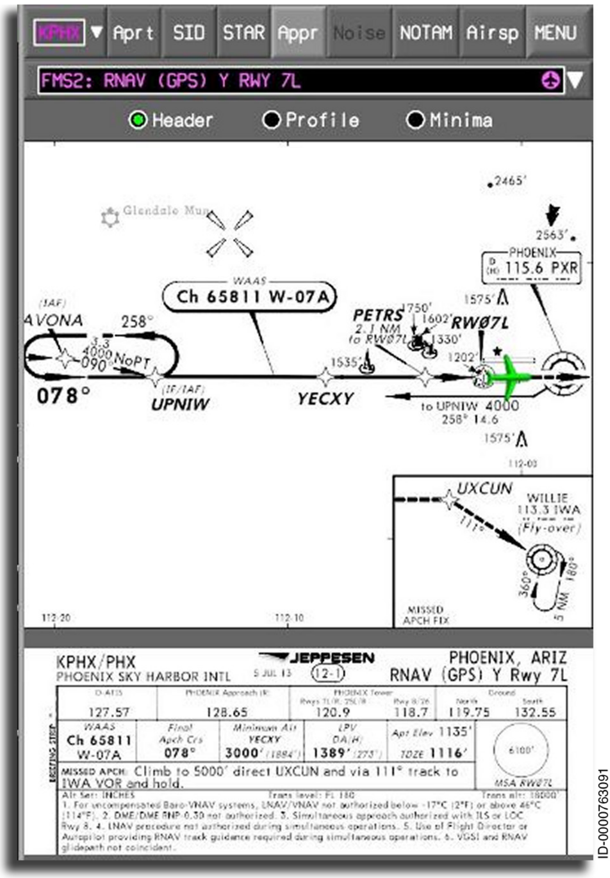

Figure 7-22
Split Chart Display (Header Section Shown)

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Figure 7-23 shows the split chart display with the Profile section shown.

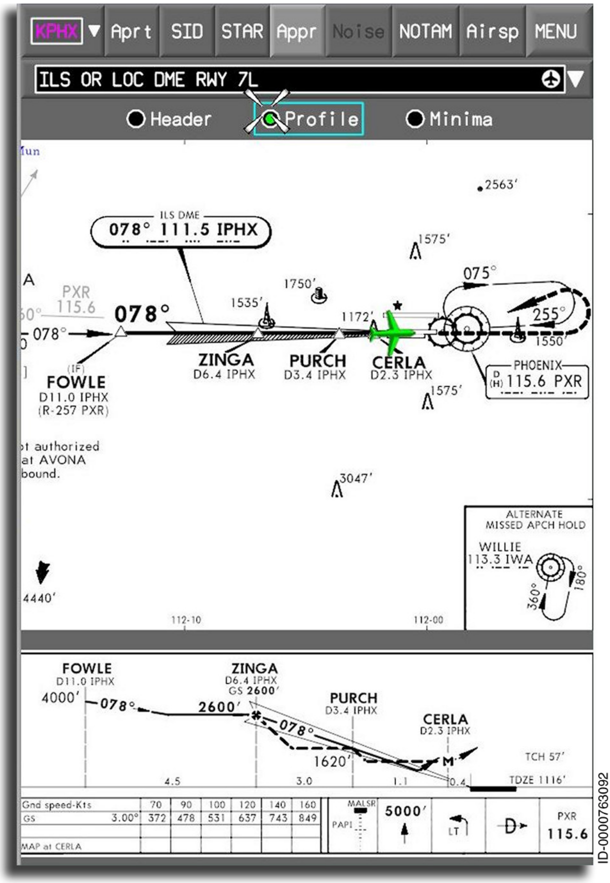

Figure 7-23
Split Chart Display (Profile Section Shown)

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Figure 7-24 shows the split chart display with the Minima section shown.

Figure 7-24
Split Chart Display (Minima Section Shown)

Once the chart has been split, the pilot has the ability to sequence the smaller or bottom portion of the display between the Profile, Header, and Minima sections of the chart. This is accomplished by selecting the desired radio button selection shown near the top of the display below the chart title. In Figure 7-24, the Header is selected. Zooming can be performed in both windows. The zoom level can be set individually for each window.

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NOTE: Pilots should not split any charts other than approach charts due to formatting issues.

ROTATE

Selecting **Rotate** rotates the chart 90 degrees clockwise or counterclockwise. To minimize the reason to rotate a chart, charts are initially shown in portrait or landscape according to the orientation most conducive to viewing.

Only charts containing a map element can be rotated. The **Rotate** selection is unavailable (not selectable) when the displayed chart cannot be rotated.

AIRCRAFT

Selecting **Aircraft** shows the aircraft position (as a green aircraft symbol) on a chart. The **Aircraft** selection is only available when the following conditions are satisfied:

- The selected chart is a geo-referenced chart (white geo-referenced icon is displayed to the right of the chart title)
- The selected airport chart is to scale
- The FMS is producing a valid bearing and position
- The aircraft position is visible on the display.

By default, the chart remains fixed, and the aircraft symbol moves across the chart.

The aircraft symbol is removed from the chart when supporting information from the aircraft systems (FMS, IRS) is unavailable or the aircraft location is outside of the displayed plan view of the chart.

CENTER AIRCRAFT

Selecting **Center Aircraft** centers the aircraft on the chart display. When **Center Aircraft** is selected, the chart moves relative to the aircraft up to the point when a chart edge reaches the edge of the display. When the chart edge is aligned with the edge of the display, the aircraft moves relative to the display. **Center Aircraft** is only available for selection when **Aircraft** is selected.

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PRINT CHART (OPTION)

Selecting **Print Chart** prints the current chart on the cockpit printer.

NIGHT MODE

Selecting **Night Mode** displays all charts (excluding NOTAMs) in a color palette that is optimized for viewing in dark cockpit environments. Once selected, night mode remains active until unselected or after a power cycle. After a power cycle, day or night mode is automatically selected based on day or night time at the ownship location. An example of night mode is shown in Figure 7-25.

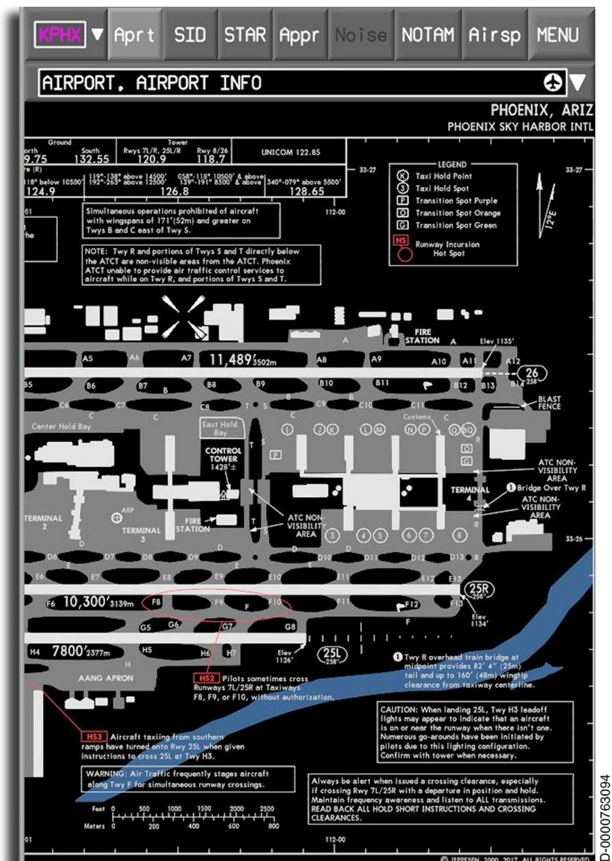

Figure 7-25
Night Mode

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8. Multifunction Display – Synoptics

INTRODUCTION

This section describes the functions and displays associated with the Systems dropdown menu.

SYSTEMS DROPDOWN MENU

The Systems dropdown menu is located on the top-right corner of the multifunction display (MFD). Placing the cursor on the systems bar and pushing the **ENTER** button on the cursor control device (CCD) displays the Systems dropdown menu, shown in Figure 8-1.

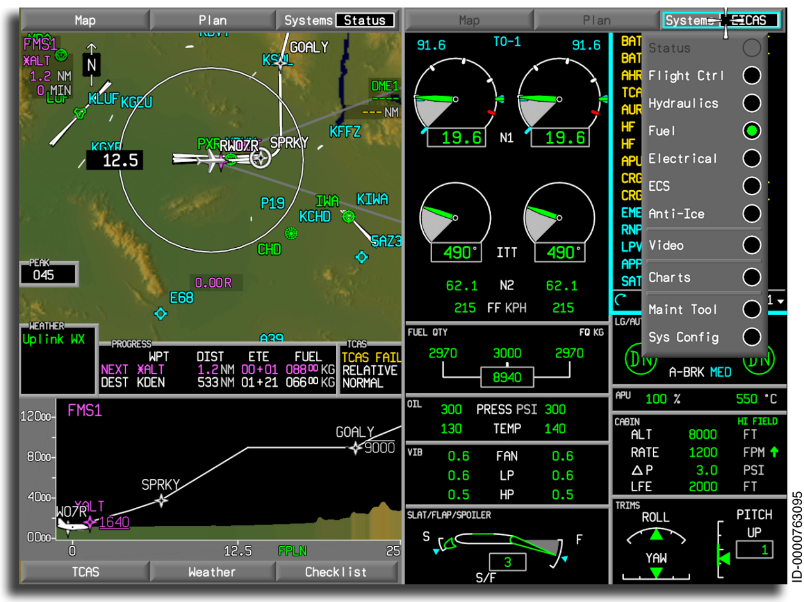

Figure 8-1
Systems Button Dropdown Menu

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NOTES: 1. Charts (option) are also selected using the Systems dropdown menu and are described in Section 7, Multifunction Display - Electronic Charts (Option).

2. The Engine Indication and Crew Alerting System (EICAS) window is selected using the Systems dropdown menu and selecting the EICAS *radio button. The EICAS window is described in detail in Section 9, Engine Indication and Crew Alerting System (EICAS).*

The Systems dropdown menu is used to select the following aircraft systems synoptic pages: Status, Flight Controls, Hydraulics, Fuel, Electrical, Environmental Control System (ECS), Anti-Ice, System Maintenance, and System Configuration. These synoptic pages show detailed information about aircraft systems and can help the crew identify aircraft system-related problems.

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Systems Menu Button Types

The abbreviated name of the aircraft system synoptic selected is shown in the systems title button. Table 8-1 lists the labeling structure. The title button page name remains displayed until another synoptic page is selected.

Table 8-1
Aircraft System Synoptic Pages

Name in Dropdown Menu	Description of Systems Synoptic Page	Name in Systems Title Button
EICAS	Engine indications and crew alerting system (CAS) messages	EICAS
Status	Status of systems, data, and doors	Status
Flight Ctrl	Flight control system	Flt Ctl
Hydraulics	Aircraft hydraulic system	Hyd
Fuel	Fuel system	Fuel
Electrical	Electrical system	Elec
ECS	Cabin environmental control system	ECS
Anti-Ice	Engine air bleed anti-ice system	A-Ice
Charts	Electronic charts	Charts
Video	External video/camera display page	Video
Maintenance Tool	Provides access to engine/APU maintenance and CMC pages	Maint Tool
Sys Config	Displays the configuration monitor systems page	SysCfg

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GENERAL CHARACTERISTICS OF SYNOPTIC PAGES

Synoptics-type pages are only available in the Systems dropdown menu. All key components are displayed using descriptive icons. Some examples are:

- Control actuators
- Valves
- Pumps
- Generators
- Engines
- Auxiliary power unit (APU)
- Interconnecting electrical, hydraulic, or plumbing
- Engine symbol outlines to represent engines
- A small engine outline to represent the APU
- A simple cart to represent a ground power unit.

Key icons are green when active and white when inactive. The key icons become amber-dashed icons when valid computer data is not available.

The synoptic displays use flow tubes to represent paths between icons or symbols. Flow tubes are used to represent the flow of electricity, hydraulic fluid, fuel, and bleed air. The flow tubes are green when flow or pressure is present. When flow is not present, the flow tubes are white. When there is no data or invalid data concerning the flow tubes, the flow tubes become amber-dashed lines (- - -).

GENERAL SYNOPTIC COLOR USAGE

General color-coding of information on the synoptic pages is arranged to be consistent with the CAS message color structure used on the EICAS window. A general color description is:

- Black for the screen background
- Green for normal active conditions, fuel flow, electrical flow, hydraulic flow, valve on, switch on, generator active, or pump active

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- White for normal inactive states, status conditions, and status messages
- Gray for structures not normally changing and for information text
- Cyan for advisory conditions and advisory messages
- Amber for invalid data conditions, failure conditions, caution conditions, and caution messages
- Red is for warning conditions and warning messages.

SELECTABLE MEASURE UNITS

Some temperature displays are in degrees Centigrade (°C) or degrees Fahrenheit (°F). This is selectable on the SETUP page in the MCDU. The following descriptions use Centigrade or Fahrenheit.

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STATUS SYNOPTIC PAGE

The System Status synoptic page, shown in Figure 8-2, describes the general condition of the aircraft. The System Status synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the Status radio button.

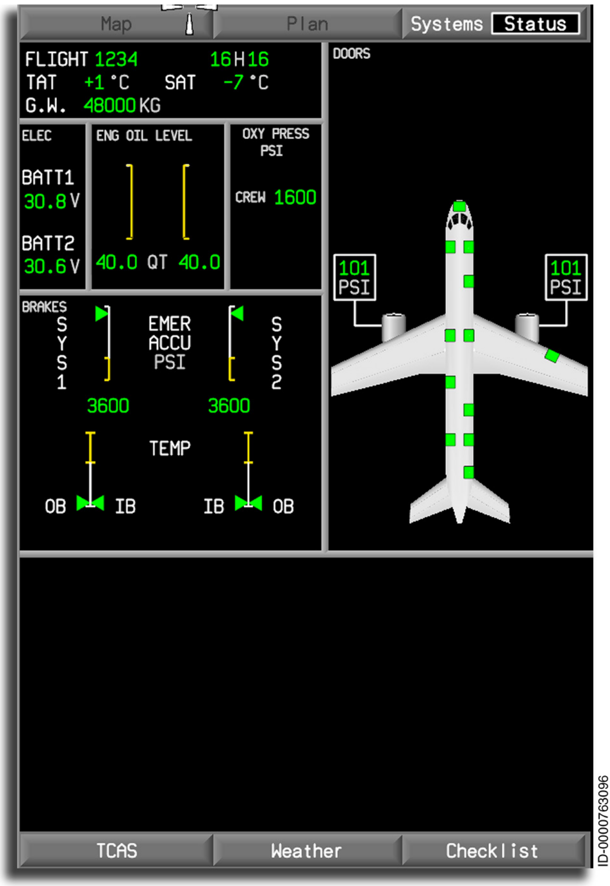

Figure 8-2
Systems/Status Synoptic Page

The Status display page displays the following:

- Cabin door and bay access display
- Flight data

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- Electrical batteries
- Engine oil quantities
- Crew oxygen
- Brake temperatures, system pressures, and emergency brake accumulators.

Cabin Door Display

The cabin and compartment access doors are displayed in green with black outlines on a gray aircraft fuselage when closed. The cabin doors are monitored and displayed as follows:

- Forward electronics bay access door
- Central electronics bay access door
- Hydraulic panel access door
- Refueling panel access door
- Forward service door
- Rear service door
- Forward passenger door
- Rear passenger door
- Forward baggage door
- Rear baggage door
- Emergency central door.

Closed doors are displayed in green. Open doors are displayed in amber or red. Undetermined or invalid data for a door is displayed with broken amber sides on a black background.

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Figure 8-3 identifies all doors and shows them open with red for passenger and baggage access and amber for equipment access.

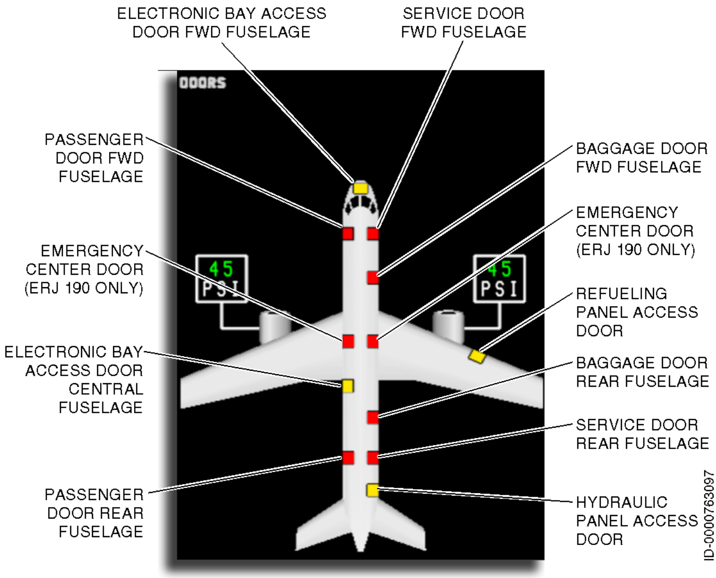

Figure 8-3
Door Identification

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Figure 8-4 shows all doors open. The passenger, service, cargo, and emergency warning annunciators and doors are displayed in red. The electronic, hydraulic, and fueling access bay doors are displayed in amber.

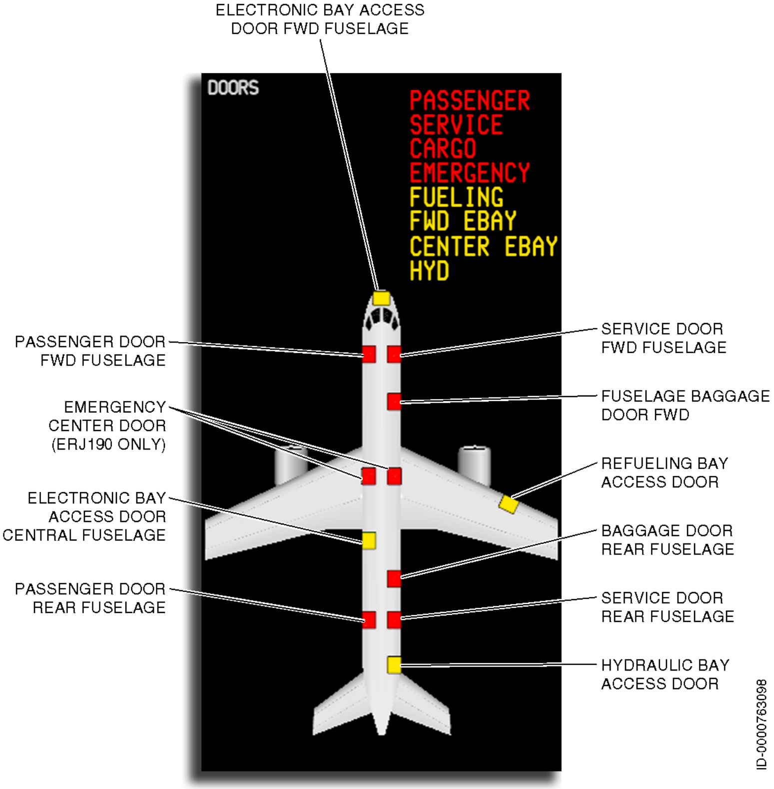
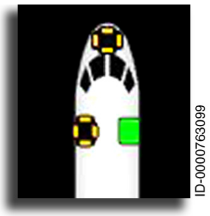


Figure 8-4
Doors Display



A door with broken amber sides with a black background is displayed when data is invalid.

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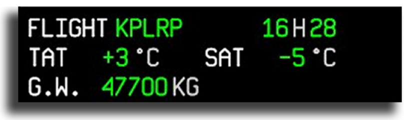
Flight Data

The flight data is displayed in the gray boxed outline in the upper-left corner of the MFD. The display includes:

- Flight number or identification and time
- Total air temperature (TAT)
- Static air temperature (SAT)
- Gross weight (G.W.).



ID-0000763100

Flight Number and Time – The flight number or identification is displayed in green after the FLIGHT label. The current time is displayed to the right of the flight number and is identified by an H between the hours and minutes.

TAT and SAT are displayed with a green readout preceded by a + or – , followed by °C . Both temperatures have a resolution of 1 °C.

G.W. for the aircraft is displayed in green digits with an LB/KG units label. Gross weight has a resolution of 50 lb or 50 kg.

ID-0000763101

Invalid Data – When data is invalid for any of the items, the digits on that display are replaced with amber dashes (- - -). All data, except the flight number, is shown invalid.

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Electrical Batteries

The battery voltage is displayed in the gray box below the flight data display. The box is labeled ELEC .

ID-0000763102

Electrical Batteries – The electrical battery display monitors the voltage in the batteries. The batteries are labeled BATT1 and BATT2 . The voltage is displayed in green with a V for dc voltage with a resolution of 0.2 volts.

ID-0000763103

When battery data is invalid, the voltage display changes to three amber dashes (---).

Engine Oil

Engine Oil Quantities – The oil quantity available for each engine is displayed in graphic and digital forms. The scale is displayed as a vertical white line with a white tick mark at the top and an amber tick mark at the bottom. ENG OIL LEVEL is displayed on top, and a units label of quarts (QT) is displayed at the bottom. The digital numeric display is green.

ID-0000763104

When oil quantity is in the normal range, the display pointer and digital display are green.

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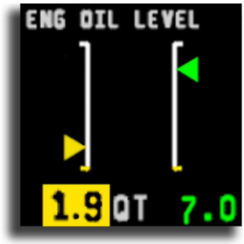
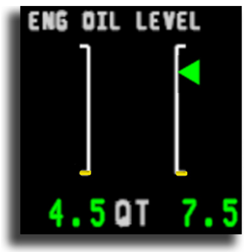


ID-0000763105

When the oil quantity is below the normal range, the display pointer and the digital display change to amber.



ID-0000763106

If oil quantity data is invalid for the analog gauge, the pointer is removed.

ID-0000763107

When oil quantity data is invalid for the digital display, the digital display is replaced with amber dashes (- - -).

NOTE: The vertical scale represents 0 to 100% oil level.

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Crew Oxygen Pressure

Crew Oxygen – The crew oxygen display consists of the oxygen pressure information required for crew awareness. The display is located below the flight data display and is outlined in gray and labeled OXY PRESS PSI . Pressure levels are listed in Table 8-2.

ID-0000763108

The normal pressure indication is green.

ID-0000763109

As the pressure decreases into the advisory range, the pressure indication is cyan.

ID-0000763110

When the pressure value moves into the caution range, the pressure indication is amber.

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When the crew oxygen data is invalid, the pressure display is removed, and the digital display value is replaced with four amber dashes (----).

Table 8-2 lists the crew oxygen pressure levels.

Table 8-2
Crew Oxygen Pressure Levels

Crew Oxygen Level Readout	Color
0 ≤ oxy press < 845 psig	Amber
845 ≤ oxy press < 1155 psig	Cyan
1155 ≤ oxy press ≤ 2500 psig	Green

An oxygen system of 55 minutes duration to serve routes over the China/Tibet region is included as an option. In this new condition, a new descent emergency profile consumes more oxygen. Therefore, the dispatch oxygen levels indication displayed on the Synoptic display requires new levels. Table 8-3 lists the crew oxygen pressure levels for the 55-minute oxygen duration option.

Table 8-3
Crew Oxygen Pressure Levels for 55-Minute Oxygen Duration

Crew Oxygen Level Readout	Color
0 ≤ oxy press < 1075 psig	Amber
1075 ≤ oxy press < 1500 psig	Cyan
1500 ≤ oxy press ≤ 2500 psig	Green

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Brakes

BRAKES is displayed in the upper-left corner of the display box. The brake display is divided into quarters. System one (**SYS 1**) is displayed on the left, and system two (**SYS 2**) on the right. The upper half of the brake display shows the accumulator pressure reserve available and is labeled **EMER ACCU** with the units **PSI** . The bottom half shows the temperature of each of the four main wheel brakes and is labeled **TEMP** .

The brake system display has four vertical scales, two for each system. The scales are divided into two segments. For the accumulator section, the top half of the scale is the white normal range. The bottom half is the amber caution range. For the temperature section, the top half of the scale is the amber caution range, and the bottom half is the white normal range. Each scale has three tick marks (two amber and one white) with associated pointers. The color of the pointers changes to the color associated with the location on the scale. The digital display located at the bottom of each scale is the same color as the pointer.

ID-0000763112

Brake Pressure – Adequate brake pressure is shown when the green pointer is in the white portion of the display. The digital pressure value is displayed in green below each vertical scale display. Refer to Table 8-4 for pressure levels.

ID-0000763113

Abnormal Pressure – When the accumulator pressure is below the acceptable level, the pointer changes to amber, and the digital display changes to amber reverse video.

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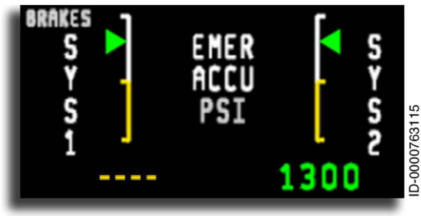
If brake pressure data is invalid for the analog gauge, the pointer is removed.



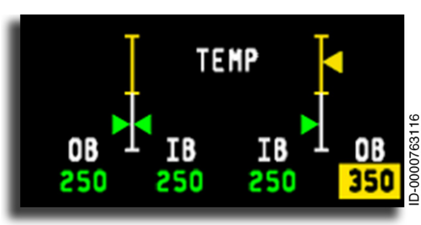
When brake pressure data is invalid for the digital display, the digital display is replaced with four amber dashes (----).

Table 8-4 lists the hydraulic brake pressure levels and colors.

Table 8-4
Hydraulic Brake Pressure

Brake Pressure (psi)	Color
> 1200	Green
≤ 1200	Amber reverse video

Brake Temperature – A digital display of the temperature on each wheel is labeled OB (outboard left and right) and IB (inboard left and right). Brake temperature is shown for each of the four main wheels on a vertical tape with the white normal range at the bottom and the amber caution range at the top. A green pointer is displayed when the temperature is in the normal range. Refer to Table 8-5 for temperature limits.



Abnormal Temperature – When the brake temperature is above an acceptable level, the pointer changes to amber.

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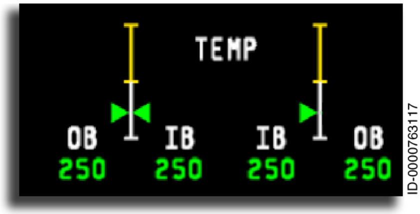

If brake temperature data is invalid for the analog gauge, the pointer is removed.

Table 8-5 lists the brake temperature limits.

Table 8-5
Brake Temperature

Brake Temperature °C	Color
< 310 °C	Green readout
310 °C ≤ Brake Temp < 520 °C	Amber reverse video readout

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FLIGHT CONTROLS SYNOPTIC PAGE

The flight control system (FCS) monitors the control surfaces for deflection and tracking of split or separate surfaces. When any irregularities are identified, CAS messages are generated, and the details are seen on the Flt Ctl synoptics page, shown in Figure 8-5. The Flt Ctl system synoptic page is invoked by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and selecting the **Flight Ctrl** radio button.

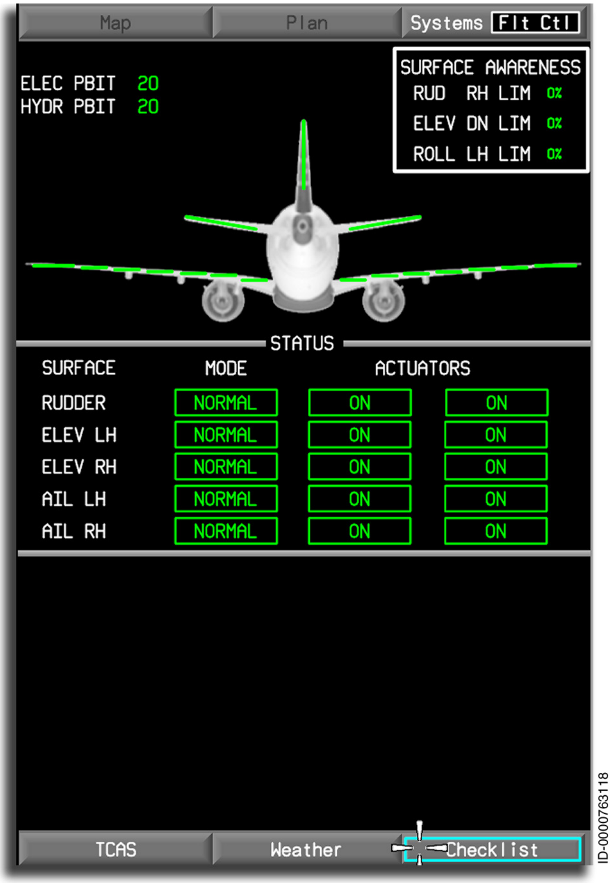

Figure 8-5
Flight Controls Synoptic Page Clean Configuration

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The flight control system shows the following status information:

- Power-up built-in test (electrical/hydraulic)
- Surface deflection readouts (only when the maintenance switch is on)
- Left and right elevator surfaces
- Left and right aileron surfaces
- Rudder surfaces
- Left and right multifunction spoiler status
- Left and right ground spoiler status
- Actuator status.

Flight Control Surface Indicators

The flight control surface indicators are positioned on a static aircraft icon rearview, as shown in Figure 8-6. The aircraft icon has a white outline with gray shading. The display shows control surfaces partially active. Fully-deployed control surfaces are solid green. Partially-deployed control surfaces are shown in black and green diagonal lines. Retracted surfaces are displayed as a solid green line.

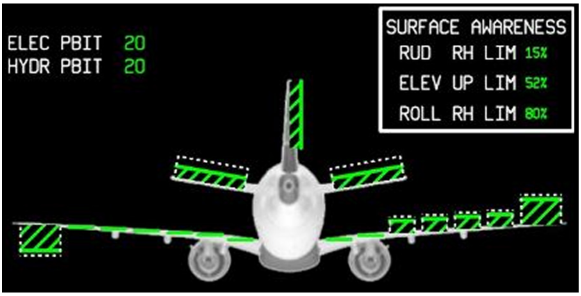

Figure 8-6
Aircraft Display

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Power-Up Built-In Test (PBIT) – The electrical and hydraulic PBIT countdown annunciators are displayed on the top-left corner of the Flt Ctl synoptic page. PBIT annunciators are used as timers for the flight controls. It is a mandatory safety check for the electrical and hydraulic systems integrity. When the status for the two counters is normal, it is represented by green or cyan numbers. Invalid data is represented by two amber dashes (- -). The Flt Ctl synoptic page shows the number of remaining hours for the electrical and hydraulic PBITs, starting at 50 hours and counting down to zero. When the number of hours for the PBITs is ≥ 5, the countdown color is green. If not, the countdown is cyan.

Surface Deflection Readout – The flight control system surface deflection readouts are displayed near the respective control surface symbol, as shown in Figure 8-6. The readouts represent the angular deflection of the rudder and elevator control surfaces.

Elevator Surfaces – Left and right elevator surfaces are monitored and verified to be moving together. The status of the elevator is determined by the position of the icons. Normal (0 degrees) deflection elevator position is shown as a solid green line indicator level with the horizontal stabilizer surface. Fully-deflected elevators are shown by a raised or lowered solid green surface indicator. Partially-deflected elevators are shown by black and green diagonal lines. Elevator position is monitored for full deflection.

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Table 8-6 lists the elevator position displays.

Table 8-6
Elevator Position Color-Coding

Color	Status	Elevator Position
Solid Green	Fully Deployed	≤-18° or ≥ 18°
Green Cross Hatch	Partially Deployed	Any other position than fully deployed
Green Line	Retracted	0°
Amber	Failed or Undetermined	X
Dashed White Box	ON	Deployed > 50% of full deflection
Dashed White Box	ON	Failure or position unknown
No display	OFF	Other (box removed)

Aileron Surfaces – Left and right aileron surfaces are monitored and verified to be moving in opposite directions. The status of the ailerons is determined by the position of the icons. Normal (0 degrees) deflection of aileron position is shown as a solid green line surface indicator level with the wing surface. Fully-deflected ailerons are shown by a raised or lowered solid green surface indicator. Partially-deflected ailerons are shown by black and green diagonal lines. Aileron position is monitored for full deflection of +15 degrees down to -25 degrees up travel.

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Table 8-7 lists the aileron position displays.

Table 8-7
Aileron Position Color-Coding

Color	Status	Elevator Position
Solid Green	Fully Deployed	≤-25° or ≥ 15°
Green Cross Hatch	Partially Deployed	Any other position than fully deployed
Green Line	Retracted	0°
Amber	Failed or Undetermined	X
Dashed White Box	ON	Deployed > 50% of full deflection
Dashed White Box	ON	Failure or position unknown
No display	OFF	Other (box removed)

Rudder Surface – The rudder surfaces are monitored to verify maximum deflection. The status of the rudder is determined by the position of the icons. Normal (0 degrees) deflection of rudder position is shown as a solid green line surface indicator level with the vertical stabilizer surface. A fully-deflected rudder is shown by a left or right solid green surface indicator. A partially-deflected rudder is shown with black and green diagonal lines. Rudder position or travel is monitored for full deflection of +30 degrees left to -30 degrees right.

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Table 8-8 lists the rudder position displays.

Table 8-8
Rudder Position Color-Coding

Color	Status	Elevator Position
Solid Green	Fully Deployed	-30° ≥ or ≥ 30°
Green Cross Hatch	Partially Deployed	Any other position than fully deployed
Green Line	Retracted	0°
Amber	Failed or Undetermined	X
Dashed White Box	ON	Deployed > 50% of full deflection
Dashed White Box	ON	Failure or position unknown
No display	OFF	Other (box removed)

Abnormal Control Surface Conditions

Figure 8-7 shows the possible abnormal primary control surface displays previously listed in the tables.

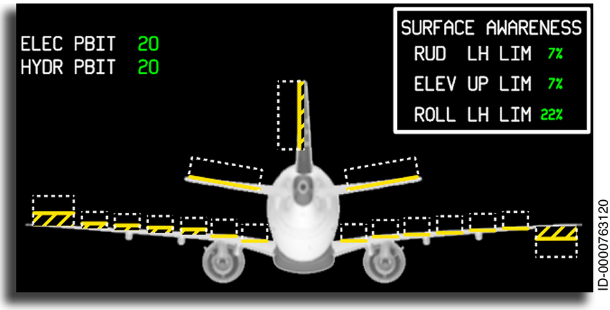

Figure 8-7
Abnormal Primary Control Surface Displays

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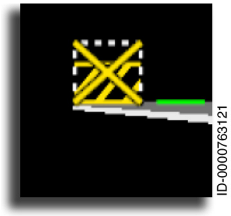
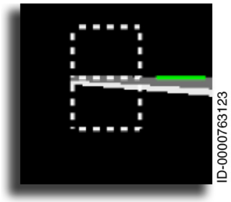
The following conditions use the left aileron to show the abnormal examples.



Failed Deployed – When a control surface fails and is deployed, the surface has black and amber diagonal lines with an X covering the surface inside a white-dashed box.

Failure Retracted – When a control surface fails and is retracted, the surface is removed and replaced with a solid amber line surface indicator and an X inside a white-dashed box.



Surface Position Unavailable – When a control surface position is unknown or invalid, and no failure is reported, the surface is removed, and only the white-dashed box showing the maximum deflection in both directions is displayed.

Spoiler Surfaces

Each wing contains six spoiler surfaces to perform the spoiler and speed brake tasks. The two inboard surfaces on each wing are used for ground spoilers. The four outer surfaces are used as ground spoilers, airspeed brakes, and for low-speed roll control. The four outer spoilers on each wing are called the multifunction spoilers pair 3, 4, 5, and 6, respectively. When spoilers are used to assist in roll control, only the spoilers on the down wing are proportionally raised. Spoiler position is monitored, and relative position is shown on the display.

The spoiler surface display shows the status of each multifunction spoiler surface and ground spoiler and also the information that follows:

- Spoiler deployment status

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- Multifunction spoiler pair 3 surface position
- Multifunction spoiler pair 4 surface position
- Multifunction spoiler pair 5 surface position
- Multifunction spoiler pair 6 surface position
- Inner groundspeed brake spoiler surface position
- Outer groundspeed brake spoiler surface position.

SPOILER DEPLOYMENT STATUS

The speed brakes are the five outboard spoiler panels on each wing, shown in Figure 8-8, and are deployed up to 30 degrees.

Figure 8-8
Speed Brakes Fully Deployed

Speed brakes that are partially deployed are shown as green cross-hatches, as shown in Figure 8-9.

Figure 8-9
Speed Brakes Partially Deployed

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The five surfaces on each wing function as a group for the speed brake function. The surfaces are monitored and verified to be moving together, except during roll control.

Table 8-9 lists the spoiler deflection colors.

Table 8-9
Outer, Middle, and Inner Spoiler Position Color-Coding

Color	Status	Elevator Position
Solid Green	Fully Deployed	≥ 30°, on the ground/in air
Green Cross Hatch	Partially Deployed	Any other position than fully deployed
Green Line	Retracted	0°
Amber	Failed or Undetermined	X
Dashed White Box	ON	Deployed > 50% of full deflection
Dashed White Box	ON	Failure or position unknown
No display	OFF	Other (box removed)

GROUND SPOILER DEPLOYMENT STATUS

The two ground spoiler panels on each wing, shown in Figure 8-10, are used solely as ground spoilers.

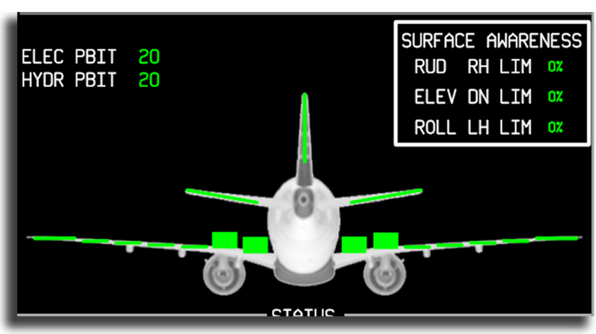

Figure 8-10
Ground Spoilers Deployed

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Ground braking spoilers are deployed when all ten spoilers are active, and all four ground spoilers are active. Figure 8-11 shows all ground spoilers fully deployed.

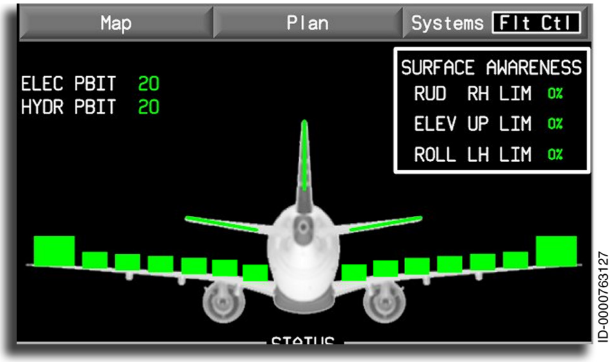

Figure 8-11
All Ground Spoilers Fully Deployed

Table 8-10 lists the ground spoiler color-coding.

Table 8-10
Ground Spoiler Position Color-Coding

Color	Status	Elevator Position
Solid Green	Fully Deployed	> 30°
Solid Green	Retracted	0°
Amber	Failed or Undetermined	X
Dashed White Box	ON	Failure or position unknown
No display	OFF	Not deployed

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Abnormal Spoiler Conditions

Figure 8-12 shows the failure or position unknown ground spoiler display on the right wing and a fully open ground spoiler on the left wing. These positions are associated with the color-coding tables describing the spoiler and speed brake color-coding.

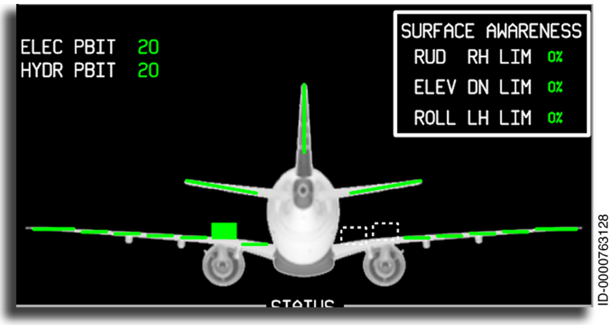
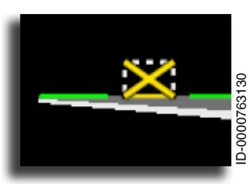


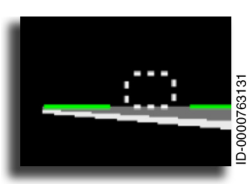
Figure 8-12
Abnormal Spoiler Displays

The following examples use the left outboard spoiler to show the abnormal multifunction spoiler.

Failed Deployed – When a spoiler fails and is deployed, an X covers the surface, and a white-dashed box showing the maximum deflection is shown.



Failure Retracted/Unknown – When a spoiler fails and the position is not known, the surface is removed and replaced with an X, and a white-dashed box is displayed, showing the maximum deflection.



Surface Position Unavailable – When a spoiler position is unknown or invalid, and no failure is reported, the surface is removed, and only the white-dashed box showing the maximum deflection is shown.

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Flight Control System Status Annunciators

The flight control STATUS box is shown in Figure 8-13. The flight control STATUS box is located on the bottom portion of the Flt Ctl synoptic page. A **STATUS** label is at the top of this section. The label associates airfoil surfaces with the controlling hydraulic system, mode, and two actuators for each surface. Under the **SURFACE** annunciator are the five surfaces being described: **RUDDER** , **ELEV LH** (for left-hand elevator), **ELEV RH** (for right-hand elevator), **AIL LH** for left-hand aileron, and **AIL RH** (for right-hand aileron). Under the annunciator are the modes of each surface. Possible modes include **NORMAL** , **DIRECT** , **FAIL** , and **- -** . Under the **ACTUATORS** are the status conditions **ON** , **ON** , and **- -** .

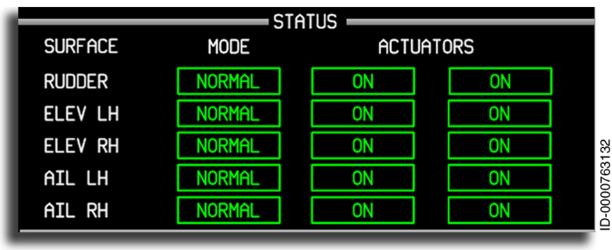

Figure 8-13
Status Box With Normal Indications

The **MODES** include:

- **NORMAL** – The surface is operating in the normal mode.
- **DIRECT** – The surface is operating in the direct mode. Direct mode is when the primary actuator control electronics (P-ACEs) are not using the augmentation information from the flight control modules (FCMs).
- **FAIL** – The system has failed for a known reason, and a CAS message has been generated.
- **- -** – A failure exists, but the source of the failed condition is unknown, and no CAS message has been generated.

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ACTUATORS status include the following status reports:

- ON – The actuator channel is engaged and operating in normal mode.
- ON – The actuator channel is engaged and operating in direct mode (normal mode functions have been lost).
- - - – The actuator channel has failed and is not operating.

Figure 8-14 shows the DIRECT mode is active on the rudder surface.

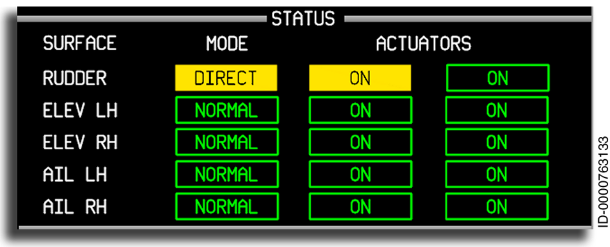

Figure 8-14
Rudder With DIRECT Mode Active

Figure 8-15 shows FAIL on the rudder surface. The rudder is failed and has an associated CAS message.

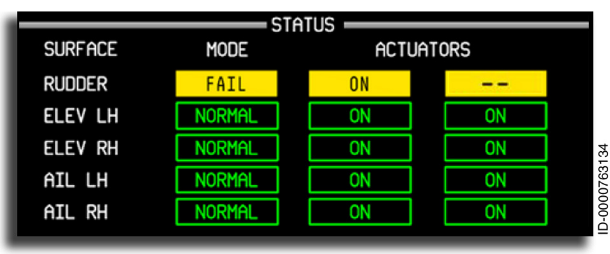

Figure 8-15
Rudder With FAIL Failure Mode

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Figure 8-16 shows the dashes (- -) on the rudder surface. The rudder actuator mode is invalid.

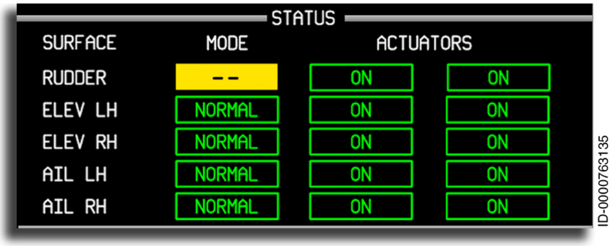

Figure 8-16
Rudder System With Dashes

Figure 8-17 shows the left side elevator has an ON status annunciator. The actuator is on, but a known failure has been detected, and a CAS message has been generated.

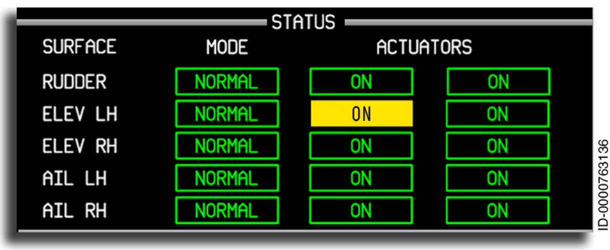

Figure 8-17
Left Side Elevator With ON Failure Status

Figure 8-18 shows the left side elevator has a dashed (- -) failed status annunciator. The elevator actuator has failed, and no CAS message has been generated.

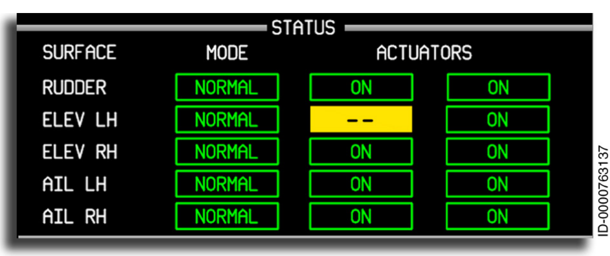

Figure 8-18
Left Side Elevator With Dashed Failure Status

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Surface Awareness Window

The SURFACE AWARENESS window, shown in Figure 8-19, is located at the top-right corner of the Flt Ctl synoptic page. A **SURFACE AWARENESS** label is at the top of this section. The window is displayed only when the maintenance switch is OFF. The SURFACE AWARENESS window is mutually exclusive with the surface deflection readout.

Figure 8-19
SURFACE AWARENESS Window

The SURFACE AWARENESS window indicates the absolute value of the perceptual deflection of surface position for the following surfaces:

- LH and RH ailerons
- LH and RH elevators
- Rudder.

The rudder authority has a **RUD LH LIM** or **RUD RH LIM** label. Next to the rudder authority label, the rudder awareness indication state is displayed.

The elevator authority has **ELEV DN LIM** or **ELEV UP LIM** label. Next to the elevator authority label, the elevator awareness indication state is displayed.

The aileron authority has a **ROLL LH LIM** or **ROLL RH LIM** label. Next to the roll authority label, the roll awareness indication state is displayed.

Rudder, elevator, and roll awareness indicators are green when in the normal range and amber when the surface is near full deflection.

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HYDRAULICS SYNOPTIC PAGE

The hydraulic system, as accessed by the Systems dropdown menu, is comprised of three active and totally independent hydraulic systems. The Hyd system synoptic page, shown in Figure 8-20, is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and selecting the Hydraulics radio button. For each of the hydraulic systems, a box encloses the fluid quantity readout with the vertical scale/pointer, the system pressure readout with the vertical scale/pointer, and the fluid temperature readout.

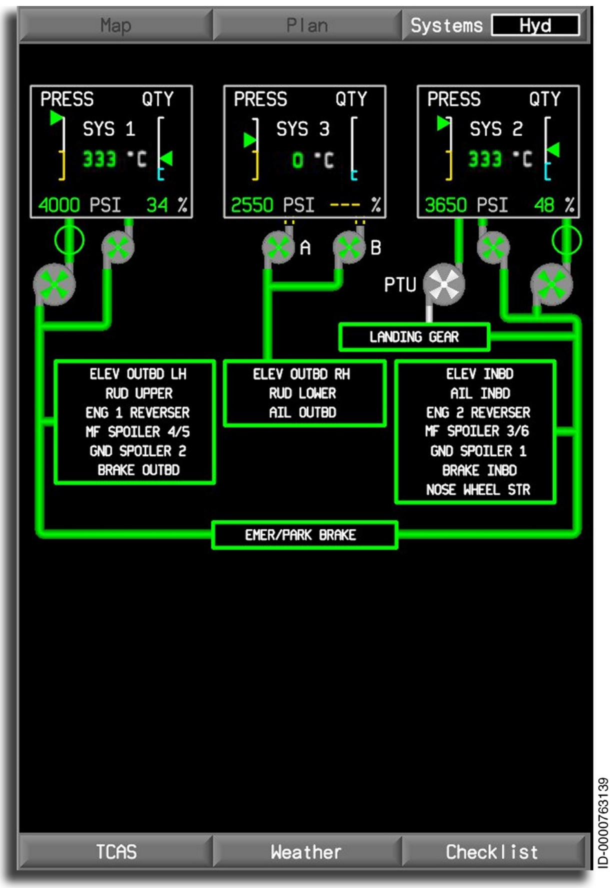

Figure 8-20
Hydraulic (Hyd) System Synoptic Page

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The Hyd system synoptic page shows the status of:

- System pressure
- Reservoir quantities and temperatures
- Valves
- Standard and auxiliary pumps
- Flow lines
- System users.

Hydraulic Reservoirs – Three hydraulic display reservoirs, one for each hydraulic system, are located at the top of the display. SYS 1 (System 1) is on the left, SYS 2 (System 2) is on the right, and SYS 3 (System 3) is in the center. The pressure, quantity, and temperature displays are contained in the gray-bordered reservoir boxes.

ID-0000763140

Hydraulic Pressure – The hydraulic pressure display is labeled PRESS and is located in the reservoir box at the top of the display page. The pressure range is from 0 to 4,000 psi with a resolution of 50 psi. The gauge is amber and white. The scale pointer is the same color as the digital readout. There are tick marks at the top (4,000 psi), 1,800 psi (amber region), and the bottom (0 psi) positions of the scale. A PSI label is located at the bottom of the box. Pressure values at or below 1,800 psi are displayed in amber reverse video. Values above 1,800 to 4,000 psi are displayed in green.

ID-0000763141

Values between 0 and 1,800 psi are displayed in amber reverse video, and the color of the pointer is amber.

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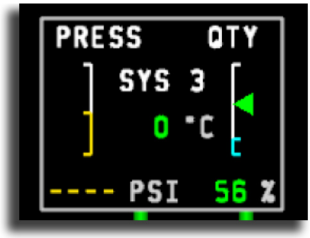

ID-0000763142

When pressure data is invalid or outside the displayable range, the dial pointer is removed, and the display digits are replaced with four amber dashes (----).

ID-0000763143

Hydraulic Quantity – The hydraulic quantity display is labeled QTY and is located in the reservoir box at the top of the display page. The digital display is displayed as a percentage of level from 0% to 100%, with a resolution of 2%. A % label is at the bottom of the box. The gauge is white and cyan. There are tick marks at the top level, low level, and bottom level positions of the scale. The scale pointers are the same color as the digital display. When the quantity is in the normal range, the pointer and display are green. The normal range values are different for each system.

ID-0000763144

When the quantity is low, the pointer is cyan, the display is cyan reverse video, and a CAS message is displayed in the CAS window.

ID-0000763145

When quantity data is invalid or outside the displayable range, the dial pointer is removed, and the display digits are replaced with three amber dashes (---).

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Reservoir Temperature – The reservoir temperature is displayed inside each reservoir tank icon. The temperature is in degrees Celsius with a resolution of 2 °C. The display digits are green with a °C label. Normal temperature display is green, high temperature is amber reverse video, and overheat is red reverse video. High and overheat temperatures generate a CAS message. When temperature data is invalid or outside of the displayable range, the digital display is replaced with amber dashes (- - -).

Hydraulic System Engine Firewall Shut-Off Valves

The hydraulic valves (FWSOVs) control the flow of hydraulic fluid from the reservoir tanks to the boost pressure pumps. The valves are located between the reservoir boxes and the boost pumps. The status of the valves is determined by the appearance of the icons.

Most valve icons used in the Hyd synoptic page are shown in Figure 8-21. Those not described are variations of the most commonly-used valve icons.

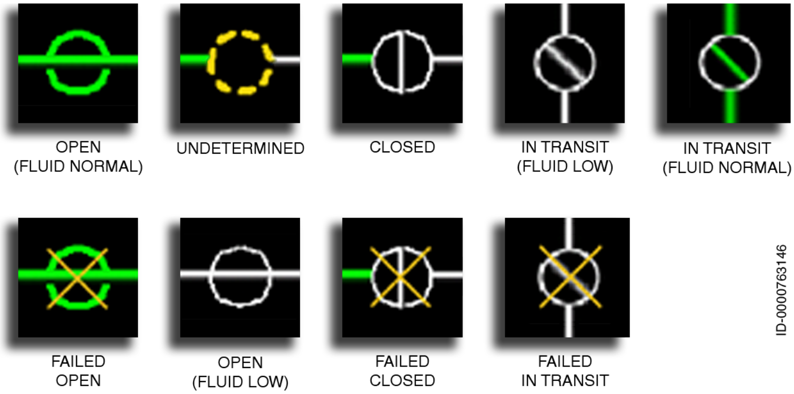

Figure 8-21
Valve Icons

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Valve Icon – The valve icon is shown in three of the 12 possible states in Figure 8-22. The valve icon is represented as a white circle with a gray flow tube across the center. For the open and in-transit states of the valve, the valve color is dependent on the hydraulic fluid quantity. When the fluid quantity is 6% or more, the valve and flow tube are displayed green. When the fluid quantity is less than 6%, the valve and flow tube are displayed in white. When the fluid quantity cannot be determined, the valve is displayed in white with an amber-dashed flow tube.

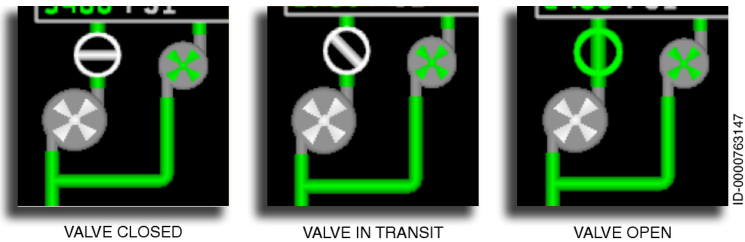
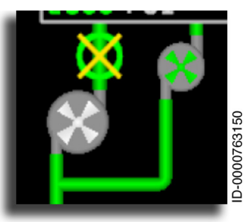
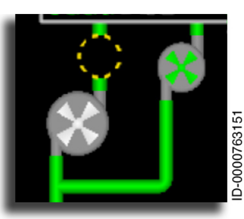


Figure 8-22
Valve State Icons



When the valve fails in any of the three states, a large X is placed over the valve icon, and an amber CAS message is generated.



When valve data is invalid or undetermined, the valve icon changes to an amber-dashed valve icon.

Valve Interconnects – Green interconnects indicate the hydraulic lines that connect the reservoir, pumps, and boxes. Green interconnects also indicate the presence of hydraulic pressure or flow. White interconnects indicate the absence of pressure or flow. Amber-dashed lines indicate flow is undetermined or invalid.

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Hydraulic Pump System – The system pumps supply pressure to each hydraulic system. The pump icon is represented as a circle with four blades in the center. The pump icons are located below the pressure gauges. The pump icon is normally shown ON (green) or OFF (white). The status of the pumps is determined by the display of the icons. Hydraulic System 1 pressure is generated from an engine-driven pump or an electrical pump. Hydraulic System 2 pressure is generated from an engine-driven pump and an electrical pump. An additional pump (the power transfer unit (PTU) pump) is available to supplement the landing gear hydraulic equipment. The PTU pump has a PTU label shown to the left of the icon. Hydraulic System 3 pressure is generated from two electrical pumps. The electrical pumps for System 3 have A and B labels shown to the right of the respective icon. The remaining pumps are not labeled since only one electrical pump is supplied for Hydraulic Systems 1 and 2.

When the pump fails in either state, a large X is placed over the pump icon, and an amber CAS message is generated.

When pump data is invalid or undetermined, the pump icon is changed to an amber-dashed icon border around amber blades.

Hydraulic System Flow Lines – The flow lines are represented on the Hyd system synoptic page by graphical icons. The state of the flow lines is determined by the appearance of the icons. A combination of the hydraulic fluid quantity, the status of the FWSOVs, and the status of various pumps determine the hydraulic flow line states.

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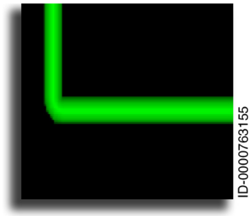
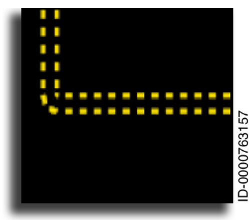


The flow line segment is displayed as a thick solid green line when reservoir fluid quantity is 6% or more.

The flow line segment is displayed as a thin white line when reservoir fluid quantity is less than 6%.



The flow line segment is displayed as an amber-dashed line (- - -) when fluid quantity cannot be determined or is invalid.

Hydraulic Users

Hydraulic system users are listed in the boxes in the center of the display area.

System 1 (left side) users are:

- **ELEV OUTBD LH** – Elevator outboard left side
- **RUD UPPER** – Upper portion of rudder
- **ENG 1 REVERSER** – Engine 1 reverser
- **MF SPOILER 4/5** – Multifunction spoiler 4 and 5
- **GND SPOILER 2** – Ground spoiler 2
- **BRAKE OUTBD** – Brakes outboard
- **EMER/PARK BRAKE** – Emergency/parking brakes.

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System 2 (right side) users are:

- **ELEV INBD** – Elevators inboard
- **AIL INBD** – Ailerons inboard
- **ENG 2 REVERSER** – Engine 2 reverser
- **MF SPOILER 3/6** – Multifunction spoiler 3 and 6
- **GND SPOILER 1** – Ground spoiler 1
- **BRAKE INBD** – Brakes inboard
- **NOSEWHEEL STR** – Nose wheel steering
- **LANDING GEAR** – Landing gear
- **EMER/PARK BRAKE** – Emergency/parking brakes.

System 3 (center) users are:

- **ELEV OUTBD RH** – Elevator outboard right side
- **RUD LOWER** – Lower portion of rudder
- **AIL OUTBD** – Aileron outboard.

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USER ICONS

User icons are represented by large rectangles containing white labels identifying the users of hydraulic power, as shown in Figure 8-23. The annunciators are always displayed and in white. The size of the icon text varies. When normal pressure is indicated for a system, the icons for that system get decreased text size. When non-normal pressure is indicated for a system, the icons for that system get increased text size. The status of the user icons is determined by the display of the icons.

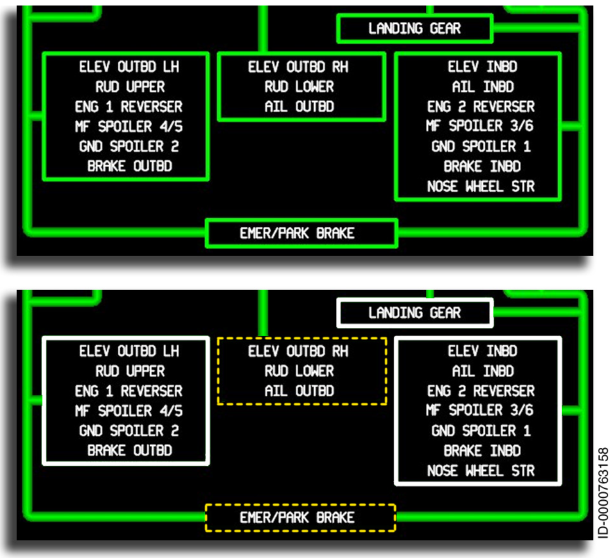

Figure 8-23
Hydraulic Pump Users

The icon border is green when the pressure is in the normal range. When the pressure is low, the icon border is white. When hydraulic pressure data is invalid or undetermined, the icon border changes to amber dashes ().

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FUEL SYNOPTIC PAGE

The Fuel system synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the **Fuel** radio button. The Fuel synoptic page contains symbols representing the fuel system components. Each wing section of the display outlined in gray represents a fuel tank, as shown in Figure 8-24. Inside each tank is a vertical gauge that shows fuel quantity. Also shown are pumps, valves, and plumbing requirements to manage fuel flow to the engines and APU.

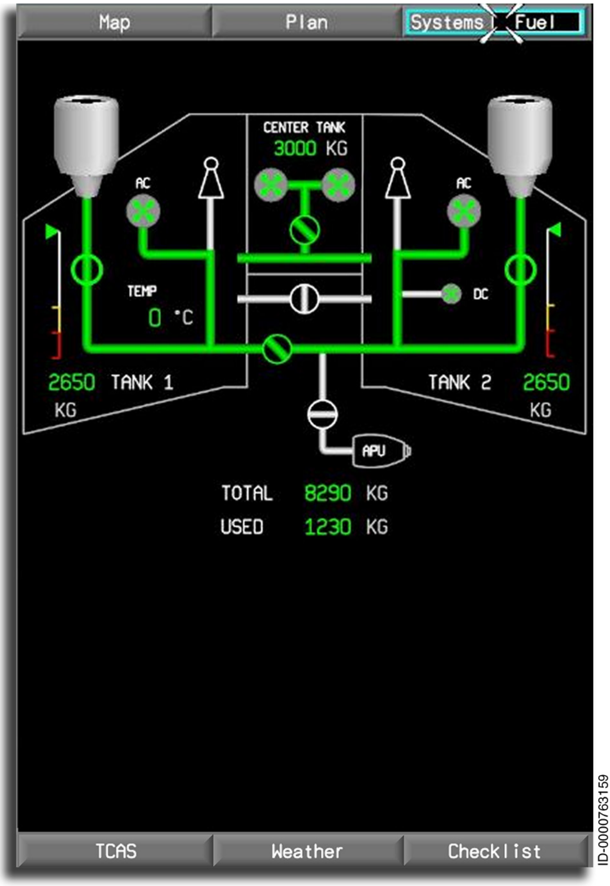

Figure 8-24
Fuel System Synoptic Page

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The fuel system shows the status of the following information:

- Total fuel-on-board the aircraft
- Total fuel used
- Fuel temperature (left tank)
- Left and right wing tank fuel quantity
- Left and right ejector pumps
- Left and right AC boost pumps
- DC pump (right wing)
- Fuel crossfeed valve
- Left and right engine shutoff valves
- APU shutoff valve
- Left and right center transfer pump
- Center tank shutoff valve
- Wing transfer shutoff valve.

The quantity displays are in LB (pounds) or KG (kilograms). The weight measure (pounds or kilograms) is selected on the Initialization page on the MCDU. The wing tanks are labeled TANK 1 and TANK 2 at the bottom portion of the wing. The center tank is labeled CENTER TANK and is displayed at the top center of the fuel synoptic page.

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Total Fuel Tank Digital Readout – The total fuel quantity digital readout is displayed under the APU icon on the Fuel synoptic page and is labeled TOTAL and is the sum of the left, right, and center fuel tank quantities with a resolution of 10 pounds. TOTAL is followed by the normally green total digital display, and then the units LB (pounds) or KG (kilograms). When the quantity is in the caution range, the display is amber reverse video, and when in the warning range, the display is red reverse video. Table 8-11 lists the total fuel quantity readout and color.

Table 8-11
TOTAL Fuel Quantity (Pounds)

Total Fuel Quantity Readout	Color
3,520 < total fuel qty	Green
1,760 ≤ total fuel qty ≤ 3,520	Reverse amber
0 ≤ total fuel qty ≤ 1,760	Reverse red

If TOTAL fuel data is invalid or outside the displayable range, the digital display is changed to five amber dashes (-----).

Used Fuel Digital Readout – The total fuel USED digital readout is displayed below TOTAL on the Fuel synoptic page. The USED annunciator is followed by the digital display in green, followed by the units LB (pounds) or KG (kilograms), and is displayed with a resolution of 10 pounds.

If USED fuel data is invalid or outside the displayable range, the digital display is changed to five amber dashes (-----).

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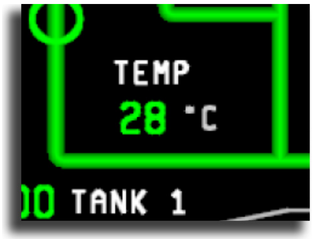
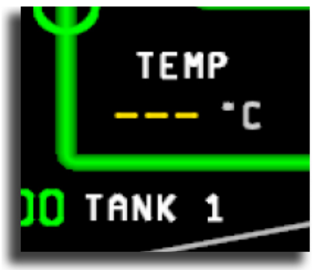
Fuel Temperature Digital Readout



ID-0000763163

The fuel temperature digital display is located in the center of the left wing tank area and is labeled TEMP . Temperature has a green digital display below the label, followed by the units °C , and has a resolution of 1 °C. When the temperature is in the caution range, the digital display changes to amber reverse video and a CAS message is generated.



ID-0000763164

When fuel temperature data is invalid or outside the displayable range, the digital portion of the display is changed to three amber dashes (- - -).

Fuel Tank Quantity Displays

A graphic representation of the quantity is shown by referencing the gauges for each wing tank. The quantity gauge has three ranges—normal (white), caution (amber), and warning (red). The gauge also has four tick marks located at the 0%, 20%, 40%, and 100% locations on the scales. Each scale also has an associated pointer the same color as the displayed readout. The fuel quantity digital readout is located in the gray wing icon at each tip below the analog display. The fuel quantity digits are labeled in LB or KG units and are displayed with a resolution of 10 lb or 10 kg.

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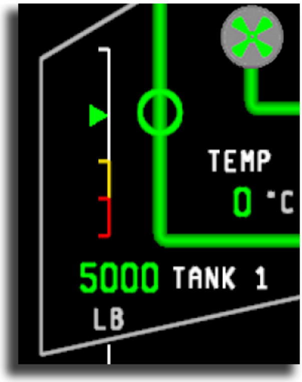
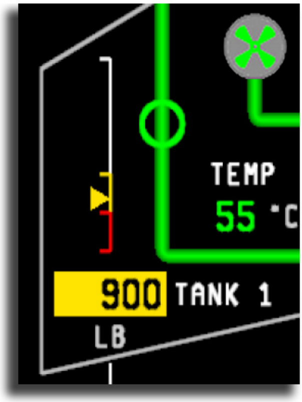


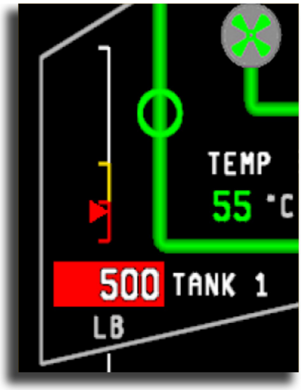
ID-0000763165

The normal (white) quantity range is located between the 40% and 100% tick marks. The pointer in this range is solid green and is positioned along the gauge to identify the percentage of fuel remaining.



ID-0000763166

The caution (amber) quantity range is located between the 20% and 40% tick marks. When the fuel level reaches the amber caution line, the pointer changes to amber, and the digital display changes to amber reverse video.



ID-0000763167

The warning (red) quantity range is located between the 0% and 20% tick marks. When the fuel level reaches the red warning line, the pointer changes to red, and the digital display changes to red reverse video. A red CAS message is also generated.

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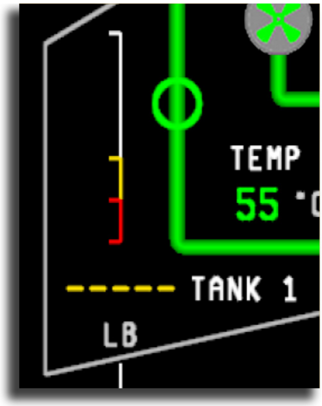
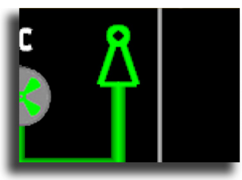


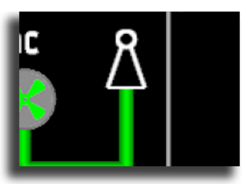
ID-0000763168

When fuel quantity data is invalid or outside of the displayable range, the pointer is removed, and the digital display is changed to five amber dashes (- - - - -) when the unit is LB or four amber dashes (- - - -) when the unit is KG.

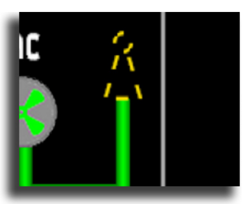
Fuel Ejector Pumps


ID-0000763169

The left and right ejector pumps are shown on the Fuel synoptic page. The status of the pumps is determined by the appearance of the icons. The ejector pumps supply fuel and fuel pressure from the fuel tanks to the remainder of the fuel system. The ejector pump icon is shown in three possible states—ON, OFF, or undetermined. The ejector pump icon is a hollow triangle with a small circle inserted on top. In the ON state, the ejector pump icon is green.


ID-0000763170

In the OFF state, the ejector pump icon is white.


ID-0000763171

When ejector pump data is invalid or undetermined, the pump icon changes to amber dashes (- - -).

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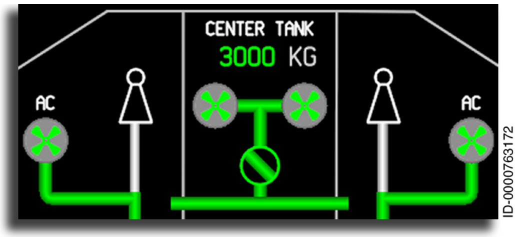
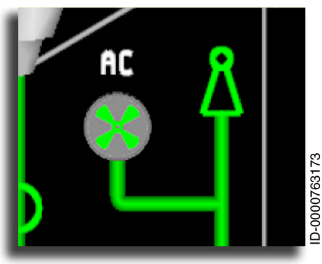
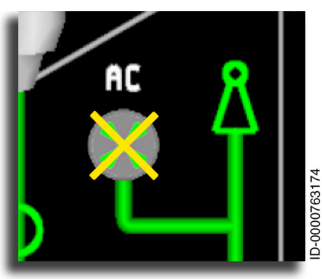
Fuel AC Boost Pumps



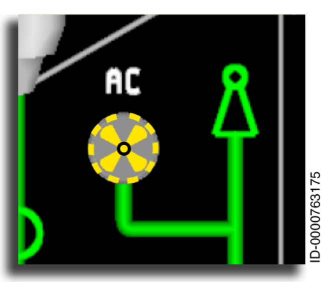
The left and right alternating current (AC) boost pumps are a secondary system activated when the ejector pump is failed or an XFEED is required. The pump icon is represented as a gray circle with four colored blades in the center. The AC boost pump icon is shown in four possible states—ON, OFF, failed, or undetermined. The pump icon blades are white in the OFF state and operate on aircraft generated power.



The pump icon blades are green in the ON state.



When the pump fails in any state, a large X is placed over the pump icon. An amber CAS message is generated for this condition.



When AC boost pump data is invalid or undetermined, the pump icon is changed to an amber-dashed (- - -) bordered icon with amber blades.

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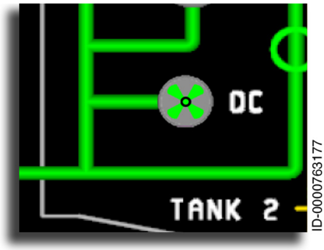
Fuel DC Start Pump

The direct current (DC) fuel pump is used to increase fuel pressure in the right fuel system for engine start, APU start-up, and APU running. The direct current fuel pump icon is represented as a gray circle with four colored blades in the center and is located inside the right wing. The direct current boost pump icon is labeled DC and operates on battery power.

The DC boost pump icon is shown in four possible states—ON, OFF, failed, or undetermined. In the OFF state, the pump icon is white.



In the ON state, the pump icon is green.

When the pump fails in any state, a large X is placed over the pump icon. An amber CAS message is also generated for this condition.

When DC boost pump data is invalid or undetermined, the pump icon is changed to an amber-dashed (- - -) bordered icon.

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Left Center and Right Center Transfer Fuel Pumps

The left center and right center transfer fuel pumps are displayed in top center of the Fuel synoptic page, as shown in Figure 8-25. These pumps are used when it is necessary to transfer the fuel from the center tank to left or right wing tank.

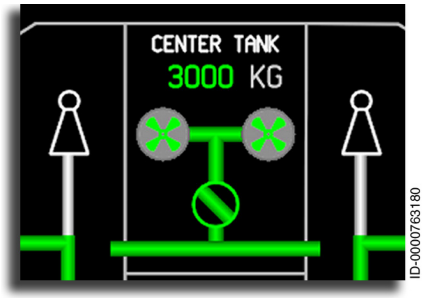

Figure 8-25
Left Center and Right Center Transfer Fuel Pumps

The pump icon is represented as a gray circle with four colored blades in the center. The left center and right center transfer fuel pump icon is shown in four possible states—ON, OFF, failed, or undetermined.

The pump icon blades are white in the OFF state and green in the ON state. When the pump fails in any state, a large amber X is placed over the pump icon. An amber CAS message is generated for this condition. When the pump data is invalid or undetermined, the pump icon is changed to amber dashes (- - -) with amber blades.

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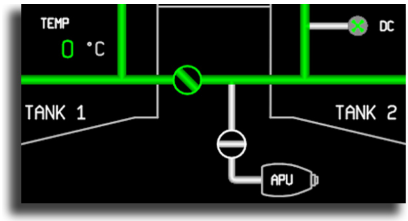
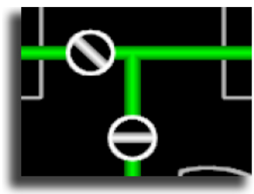
Fuel Crossfeed Valve

The crossfeed valve permits fuel flow from one wing tank to the other. This permits one fuel system (left, right, or center) to feed both engines or the APU. The crossfeed valve is located in the center of the Fuel page display.

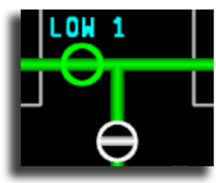


ID-0000763181

The valve icon is represented as a circle with a flow line across the center. The crossfeed valve icon is shown in one of four possible states—open, closed, in transit, and undetermined.

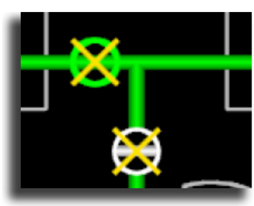

ID-0000763182

The valve icon is white when closed or when no fuel flow exists. The valve on top is shown in transit and the one on the bottom is closed.

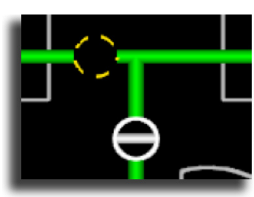


ID-0000763183

The valve icon is green when open or when fuel flow exists. The LOW 1 indication is displayed above the crossfeed valve when fuel is being transferred from the right wing tank to the left wing tank. LOW 2 indicates fuel transfer to the right wing tank.


ID-0000763184

When the valve fails in any of the four states, a large X is placed over the valve icon. An amber CAS message is also generated for this condition.


ID-0000763185

When valve data is invalid or undetermined, the valve icon changes to an amber-dashed (- - -) bordered icon.

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Engine and APU Fuel Shutoff Valves

The engine shutoff valves are located below each engine icon, as shown in Figure 8-26. The APU shutoff valve is located in the center of the Fuel page display above the APU icon. The engine fuel shutoff valves regulate the flow of fuel to the engine area. If an engine fire occurs, these valves are used to shut off the flow of fuel to the engine area.

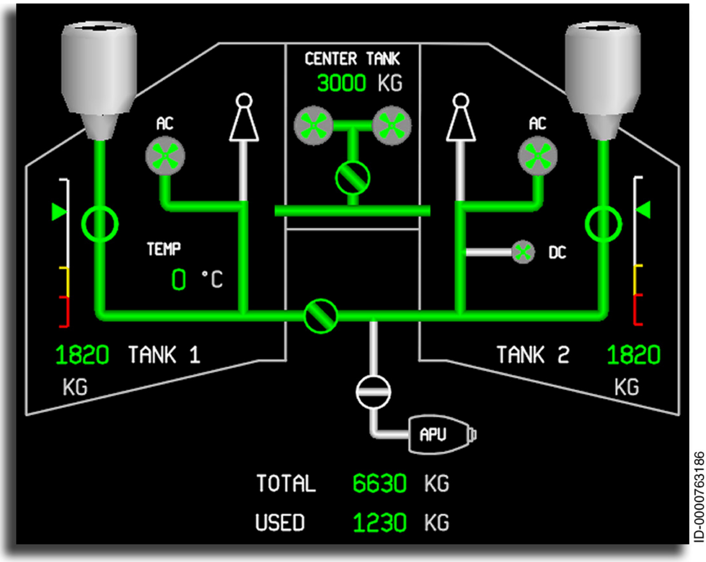

Figure 8-26
Shutoff Valve Locations

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The valve icon is represented as a white circle with a gray flow line across the center. The engine or APU shutoff valve icon is shown in one of four possible states—open, closed, in transit, and undetermined. In the in transit or open states, when fuel flow exists, the valve icon is green. In the closed states, the valve icon is white. When no fuel flow exists, the value icon is white when in the in transit or open states. In the undetermined state, the icon is amber. Figure 8-27 shows three possible states. Both valves give identical indications, even though only the engine shutoff valve is illustrated.

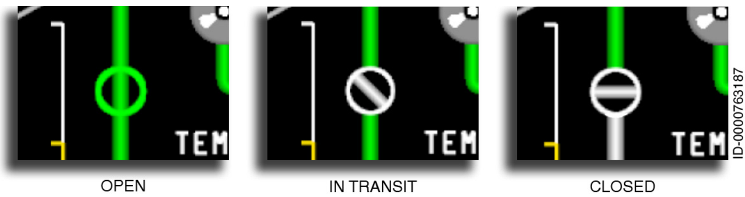
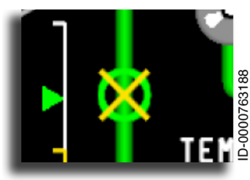
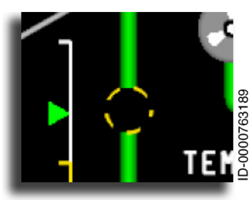


Figure 8-27
Shutoff Valve Icons



When the valve fails in any of the four states, a large X is placed over the valve icon. An amber CAS message is also generated for this condition.



When valve data is invalid or undetermined, the valve icon changes to an amber-dashed (- - -) icon.

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Wing Transfer Shutoff Valve

The wing transfer shutoff valve is located above the crossfeed valve, as shown in Figure 8-28. The wing transfer shutoff valve is only available for aircraft with ETOPS enabled and permits the fuel from one wing tank to be transferred to the other wing tank.

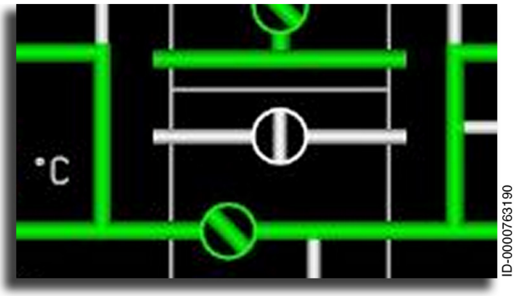

Figure 8-28
Wing Transfer Shutoff Valve

In the closed states, the valve icon is white. When no fuel flow exists, the value icon is white when in the in transit or open states. In the in transit or open states, when fuel flow exists, the valve icon is green.

If the valve fails in any of the four states, a large X is placed over the valve icon. An amber CAS message is also generated for this condition.

When valve data is invalid or undetermined, the valve icon changes to an amber-dashed (- - -) bordered icon.

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Fuel Flow Line Diagrams

Fuel flow lines represent the fuel flow and are shown in Figure 8-29.

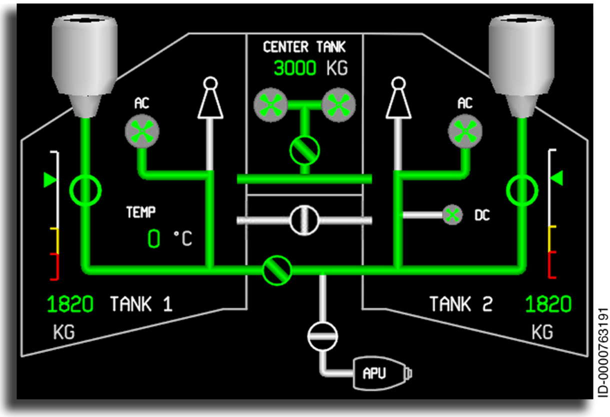
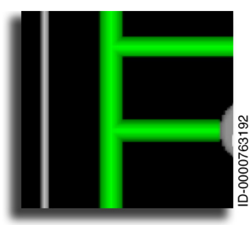
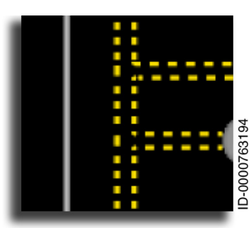


Figure 8-29
Fuel Flow Lines With Numbered Callouts



The fuel flow line segment is displayed as a thick solid green line when fuel is flowing.

The fuel flow line segment is displayed as a thin white line when no fuel is flowing.



The fuel flow line segment is displayed as a dashed amber line (---) when fuel flow cannot be determined or is invalid.

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ELECTRICAL SYSTEM SYNOPTIC PAGE

The Electrical (Elec) synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the **Electrical** radio button. The Elec synoptic page display, shown in Figure 8-30, includes the status of a number of electrical power sources and buses that are monitored and easily identified through various icons.

Unit Icons

A unit icon has a unique and logical shape to identify the function of the icon. A green outline indicates the source icon is producing or delivering power, and white indicates the icon is not producing power. An amber-dashed icon indicates an undetermined state. This means the unit has failed or unit data is not available.

The electrical system shows the status of:

- Buses
- Connections
- Engine generators
- Auxiliary power unit (APU)
- AC power cart
- DC power cart
- Ram air turbine (RAT)
- Transformer rectifier unit (TRU)
- Battery.

The connecting lines represent connections between power sources and load buses. The upper half of the display covers AC power, and the lower half covers DC power.

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The Elec display is decluttered when the aircraft is airborne. Ground available services are removed, as shown in Figure 8-30.

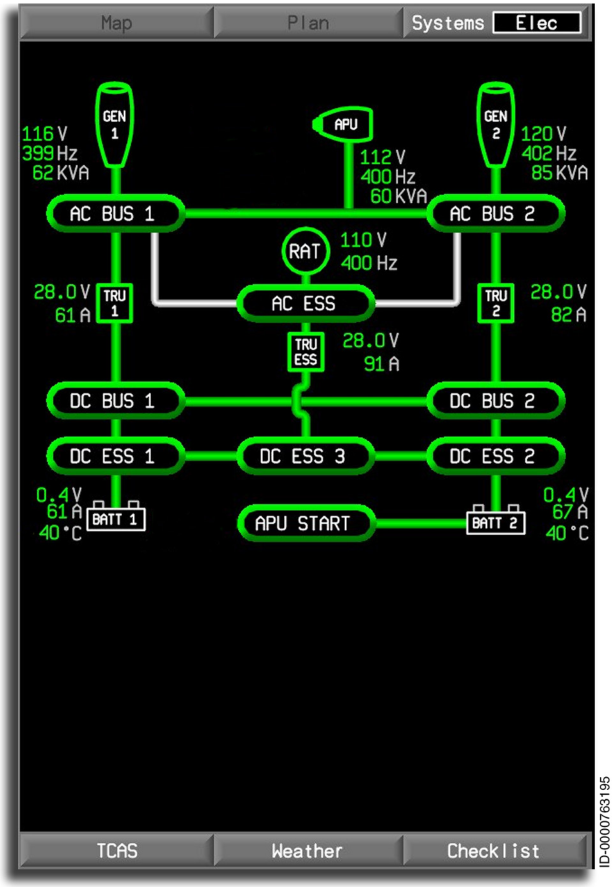

Figure 8-30
Electrical System Synoptic Page Without Ground Support

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Ground services like ground power units are shown on the synoptic only when connected to the aircraft, as shown in Figure 8-31.

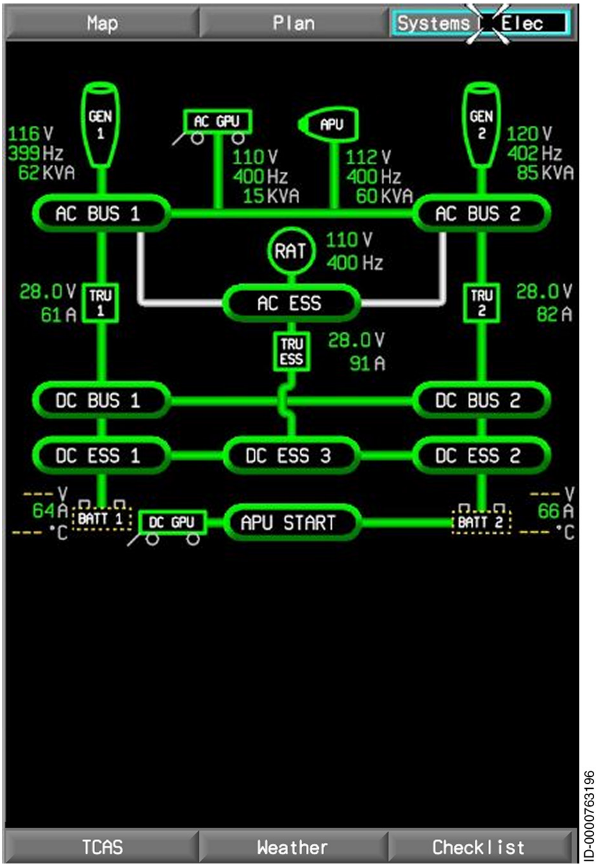

Figure 8-31
Electrical System Synoptic Page With Ground Support

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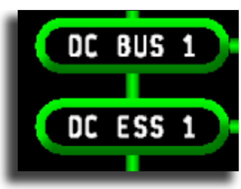
BUSES

Bus Displays – The buses distribute electrical power to the users or loads normally through circuit breakers. Electrical buses are represented as horizontal ovals with names in white letters inside.

Nine buses are in the electrical system and are labeled as follows:

- AC BUS 1
- AC BUS 2
- AC ESS
- DC BUS 1
- DC BUS 2
- DC ESS 1
- DC ESS 2
- DC ESS 3
- APU START .

The status of the buses is determined by color.



ID-0000763197

Buses are shown with solid green lines when current is flowing through the bus.

ID-0000763198

Buses are shown with narrow white lines when no current is flowing through the bus.

ID-0000763199

Buses are shown with amber-dashed lines (- - -) when the data for that bus is undetermined or invalid.

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The AC BUS icons are displayed in the OFF state until reaching a voltage higher than 90 volts. When 90 volts are reached, the AC BUS icons are displayed in the ON state. The AC BUS is displayed as ON and remains displayed until the voltage falls below 70 volts.

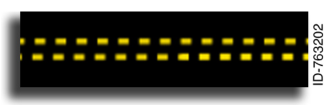
The DC BUS icons are displayed in the OFF state until reaching a voltage greater than 18 volts. When 18 volts are reached, DC BUS icons are displayed in the ON state. The DC BUS is displayed as ON and remains displayed until the voltage falls below 15 volts.

Connections

Connections – Flow line icons illustrate where contactors are closed and/or voltage is sensed. Connections or electrical system flow lines are green when current is flowing, white when no current is flowing, and amber dashes when current flow data is undetermined.

Flow lines are shown with solid green lines when current is flowing through the system.

Flow lines are shown with solid white lines when no current is flowing through the system.



Flow lines are shown with amber-dashed lines () when the current cannot be determined or is invalid in the system.

Generators

Engine Generators – The left and right engine generators, each with an identifiable icon, supply primary AC power to the aircraft and display the following information:

- Left and right engine generator AC voltage digital readouts
- Left and right engine generator AC frequency digital readouts
- Left and right engine generator AC load digital readouts.

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The left engine AC generator is located in the upper-left corner of the display page, and the right engine AC generator is in the upper-right corner, as shown in Figure 8-32. The engine generators are the main AC power source when the aircraft is on its own power. Connections to the AC buses are displayed below each generator. The generator icons are labeled GEN 1 and GEN 2 , respectively. Both icons operate identically.

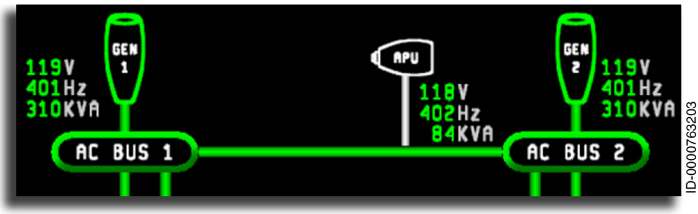
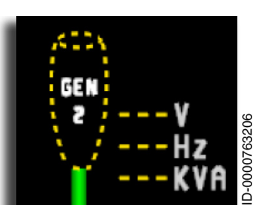


Figure 8-32
Generator 1 and Generator 2 Icons

Engine Generators – The engine generator icon is displayed in green when producing power, and the voltage is above 90 V AC. The normal AC voltage readout is displayed as a green voltage value, followed by V , with a resolution of 1 volt. The frequency is displayed in green, followed by Hz , and a resolution of 1 Hz. The load readout is displayed in green, followed by KVA , with a resolution of 1 kVA.

The generator icon is white when not producing power, or the voltage is below 70 V AC.



When the generator is invalid or the condition is undetermined, the generator icon changes to amber dashes (- - - -). When the digital data is invalid, three amber dashes are displayed (- - -).

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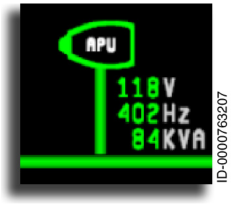
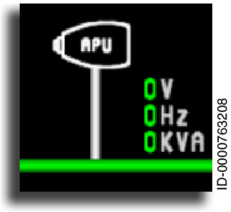
Auxiliary Power Unit (APU)

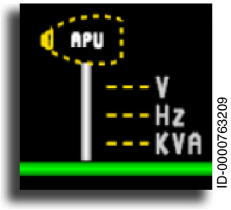
Auxiliary Power Unit (APU) Generator Icon – The APU generator is located in the upper center of the display page. The APU generates AC power for the aircraft when the engines are not supplying electrical power. The APU contactor connection to the AC BUS is displayed below the APU. The APU generator icon is labeled APU . The APU icon is removed from the display when the APU is not available for electrical loading. The readouts are only displayed when the icon is displayed.



The auxiliary power unit icon outline is green when producing power. The normal AC voltage readout is displayed as a green voltage value, followed by V , with a resolution of 1 volt. The frequency is green, followed by Hz , with a resolution of 1 Hz, and the load readout is green, followed by KVA , and a resolution of 1 kVA.



The APU icon is white when not producing power.



When the APU has failed, is invalid, or APU status is undetermined, the APU icon is changed to an amber-dashed APU icon. When the voltage, frequency, or load data is invalid, the digits are changed to three amber dashes (- - -).

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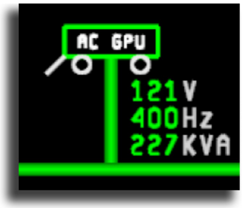
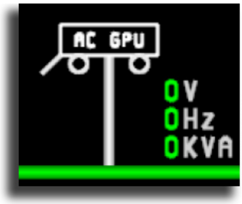
AC Power Cart

AC External Power Cart Icon – The external power icon, in the shape of a ground power cart, is located in the upper center of the Elec display page when the cart is connected to the aircraft while on the ground. The AC external power icon and connection are removed when the cart is disconnected. The external power connection supplies AC power for the aircraft when the engines or APU are not supplying power. The external power contactor connection to the AC buses is displayed below the external power icon.



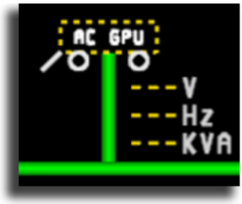
ID-0000763210

The external power cart icon is labeled AC GPU. The wheels and tongue are white. The external power cart icon is displayed in green when delivering power. The normal AC voltage readout is displayed as a green voltage value, followed by V, with a resolution of 1 volt. The frequency is green, followed by Hz, with a resolution of 1 Hz, and the load readout is green, followed by KVA, with a resolution of 1 kVA.



ID-0000763211

The external power cart is white when not producing power.



ID-0000763212

When external power has failed, or generator status is undetermined, the generator icon is changed to an amber-dashed (- - -) generator icon. When the voltage, frequency, or load data is invalid, the digits are changed to three amber dashes (- - -), as shown.

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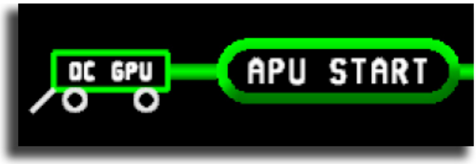
DC Power Cart

DC External Power Cart Icon – The DC external power cart icon is a ground cart image located in the lower center of the Elec system display when the aircraft is on the ground, and a ground power source is connected. The external power cart icon is green and labeled DC GPU , and the wheels and tongue are white. If no external DC connection is present, the external DC power icon is removed. The DC external power connector supplies ground available DC power to the aircraft. The external power contactor connection is displayed to the right of the icon.

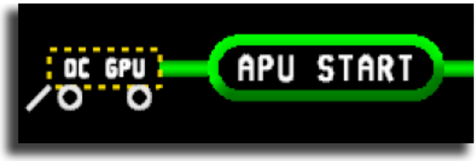


ID-0000763213

The external power cart icon is displayed in green when delivering DC power.

ID-0000763214

The cart is removed from the display when not supplying power.



ID-0000763215

When external DC power status is undetermined, the DC external power cart icon is changed to an amber-dashed (- - -) icon.

AC Emergency Power Ram Air Turbine (RAT)

RAT Icon – The RAT is used to supply emergency AC power to the aircraft. When the RAT is deployed into the slipstream, the slipstream airflow spins the turbine to drive the emergency AC generator. The AC emergency power icon is a circle located in the center of the display.

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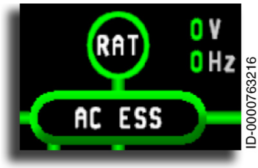
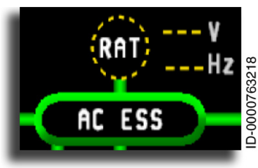


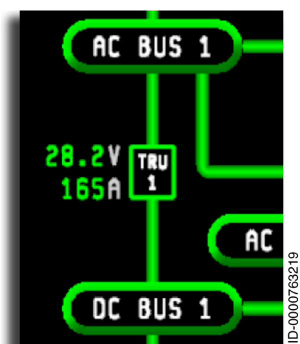
The AC emergency power icon is labeled RAT . The RAT icon outline is displayed in green when producing AC power. The output voltage is displayed in green, followed by V , with a resolution of 1 volt. The frequency is green, followed by Hz , with a resolution of 1 Hz.

The RAT icon is removed when not in use.



When AC emergency power status is invalid, the RAT icon is changed to an amber-dashed (- - -) icon. When the voltage or frequency is undetermined or invalid, the voltage digits are changed to amber dashes (- - -).

Transformer Rectifier Unit (TRU)



TRU Icon – The transformer rectifier unit (TRU) changes 120 V AC from the AC bus into 28 V DC to power the main DC 1 and DC 2 buses. The TRU icons are square and located on the left and right sides of the display below the engine generators and in the center of the display between the AC ESS* and DC ESS 3 bus bars. The DC voltage and load are digitally displayed to the left of the left TRU 1* and the right of the right TRU 2* and TRU ESS . TRU 1 connects to the *DC BUS 1* , and TRU 2 connects to the DC BUS 2 . TRU ESS* connects to the DC ESS 3 bus.

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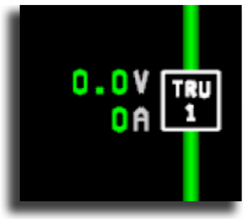
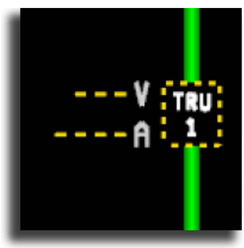
ID-0000763220

The TRU icons are green and labeled TRU 1 , TRU 2 , and TRU ESS . The TRU icon outline is displayed in green when converting AC power to DC. The normal DC voltage and load readouts are displayed as green digital values, followed by V , with a resolution of 0.2 volts, and an A , with a resolution of 1 amp.



ID-0000763221

The TRU icon is white when not producing power.



ID-0000763222

When the TRU status is undetermined or invalid, the TRU icon is changed to an amber-dashed (- - -) icon. When the voltage or amperage data is invalid, the digits are changed to amber dashes (- - -).

ID-0000763223

When a TRU has failed in any state, a large X is placed over the TRU icon, and a CAS message is generated.

Battery

Battery Icon – The general condition of the batteries is displayed in the battery area of the Elec synoptic page. The battery icons are located on the bottom-left corner (BATT 1) and the bottom-right corner (BATT 2) of the display page. Batteries 1 and 2 supply DC power to the aircraft. The status of the batteries is determined by color.

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The battery icons are labeled BATT 1 and BATT 2 . The BATT icon outline is displayed in green with white terminals on top when producing DC power, which is when battery voltage rises above 18 volts. The normal DC voltage and temperature readouts are displayed as green digital values, followed by V , with a resolution of 0.2 volts for voltage, followed by A , with a resolution of 0.1 Amps for current, and followed by °C , with a resolution of 1 for temperature.

The battery is white when off and not producing power. This occurs anytime battery voltage falls below 10 volts.

When battery status is invalid, the battery icon is changed to an amber-dashed (- - -) icon. When either the voltage, current, or temperature is invalid, the associated digits are changed to amber dashes (- - -).

When the battery temperature is at or above 70 °C for 2 seconds, the readout changes to red reverse video (71).

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ENVIRONMENTAL CONTROL SYSTEM (ECS) SYNOPTIC PAGE

The Environmental Control System (ECS) synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the ECS radio button. The ECS synoptic page shows the cabin and cockpit ventilation and air-conditioning system, including the cabin oxygen system. The ECS synoptic page is shown in Figure 8-33.

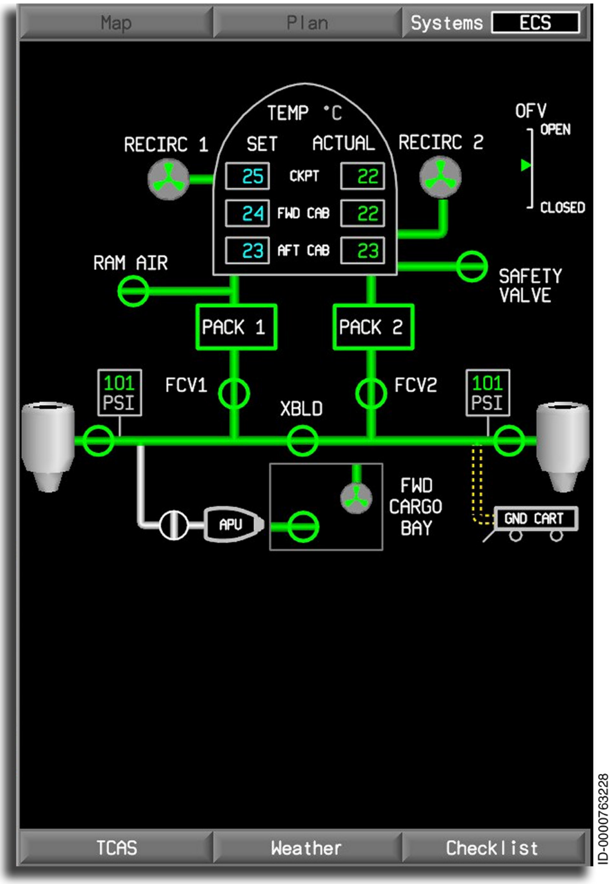

Figure 8-33
Cabin Environmental Control System Synoptic Page

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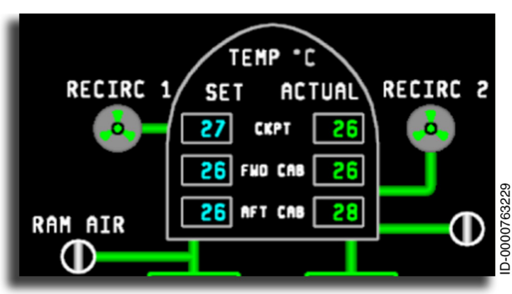
The display includes the following:

- Cabin and cockpit temperature displays
- Recirculation pumps
- Outflow valve (OFV)
- Manifold pressure
- Air shutoff valve
- Safety valve
- Ram air
- Air duct display
- Forward cargo display
- Crossover air duct display
- Pack
- Ground cart
- Line flow segments.

Cockpit and Cabin Temperature Displays

Cockpit and Cabin Temperature Displays – The cockpit and cabin temperatures are displayed in the gray fuselage outline. The temperature displays include the cockpit and cabin temperature digital readout and circulation pump status.



The labels TEMP °C , SET , and ACTUAL are located inside the icon. Digital temperature displays include the set value in cyan and the actual temperature value in green enclosed in gray boxes for the cockpit, forward, and aft cabin areas. The temperature is measured in °C .

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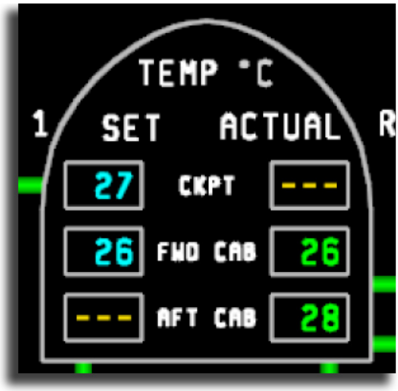
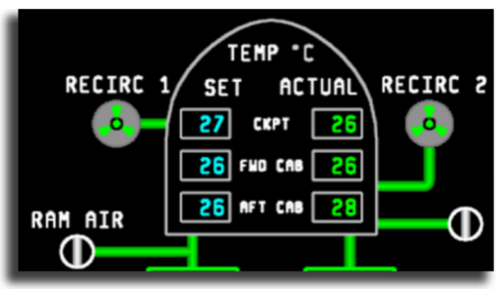


ID-0000763230

When temperature data is invalid or undetermined, three amber dashes (- - -) replace the temperature digits in the display.

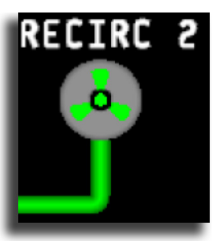
Recirculation Fans

The recirculation fans circulate the air in the cabin area to maintain uniform temperature.



ID-0000763231

The left recirculation fan system is labeled RECIRC 1 and is used for the cockpit. The right system is labeled RECIRC 2 and is used for the forward and aft cabin sections. A fan is also in the forward cargo bay labeled FWD CARGO BAY . The fan operates the same as the other two recirculation fans.



ID-0000763232

The recirculation fan is shown in green on a gray background when in normal operation.

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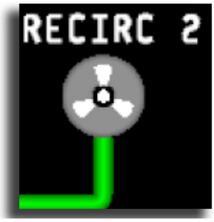
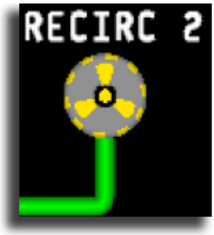


ID-0000763233

The recirculation fan is shown in white when off.



ID-0000763234

When the recirculation fan data is undetermined or invalid, an amber-dashed (- - -) icon is shown.

ID-0000763235

If the recirculation fan fails in any state, a large X is placed over the pump icon.

Outflow Valve

The outflow valve (OFV) is used with the air conditioning packs to control cabin pressure and ventilation. The outflow valve lets air exit the cabin while the air conditioning packs are supplying fresh air. The system maintains air circulation and pressurization. The outflow valve position is indicated by a vertical scale and pointer located in the upper-right corner of the ECS synoptic page. OFV is displayed above the vertical scale. There are tick marks placed at the upper and lower limits of the scale. OPEN is displayed to the right of the upper limit of the vertical scale. CLOSED is displayed to the right of the lower limit of the vertical scale.

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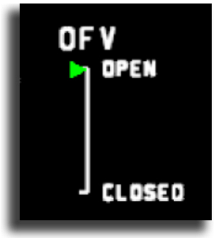


ID-0000763236

The green arrow indicates the open, partially open, or closed condition of the outflow valve. The arrow represents the degrees of open position. The valve is fully closed at 0 degrees and fully open at 90 degrees.

ID-0000763237

The valve is shown in the intermediate position for values between open and closed.

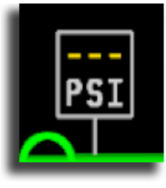
ID-0000763238

If valve data is invalid or undetermined, the arrow is removed.

Manifold Pressure

ID-0000763239

Manifold Pressure – A manifold pressure gauge is used to view the pressure on each side of the air control system. The value is displayed in green inside a gray box, with a PSI label and a resolution of 1 psi.



ID-0000763240

When the pressure value is undetermined or invalid, three amber dashes (---) are displayed.

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Air Shutoff Valves

The air shutoff valves are located on the ECS synoptic page. The air shutoff valves include the following:

- Left and right flow control valve
- Bleed isolation valve
- APU SOV
- Cargo SOV
- Left and right manifold PRSOVs
- Safety valve
- Ram air SOV.

Safety Valve – The safety valve automatically relieves the pressure in the system when exceeding the acceptable value. When the safety valve opens or fails, a CAS message is generated. The valve is labeled SAFETY VALVE .

ID-0000763241

The states of the safety valve are the same as the RAM air valve display, green for ON, white for OFF, and amber dashes (- - -) for undetermined or invalid.

Ram Air – Ram air supplies outside air to the cabin at lower altitudes if the PACK system is not functioning. The valve is labeled RAM AIR .

ID-0000763242

When shown in the normal closed state, the ram air valve is white.

ID-0000763243

The RAM AIR valve is shown open (green) when supplying outside ram air to the cabin.

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When the RAM AIR valve data is invalid or undetermined, the valve changes to an amber-dashed (- - -) valve.

When the RAM AIR valve fails in any of the possible states, an X is placed over the valve.

The remaining shutoff valves use the same icon display and operate in the same manner as the ram air shutoff valve previously discussed.

Bleed Air Duct Display

The bleed air duct system supplies ventilation air to the cockpit and cabin. The duct system, shown in Figure 8-34, is a dual-feed system with a crossover duct control valve labeled XBLD . The left engine bleed system feeds air through the left air conditioner PACK 1 to the cabin. The right engine bleed system feeds air through the right air conditioner PACK 2 to the cockpit. The duct air flow is shown in green. When no air flows, the duct is white.

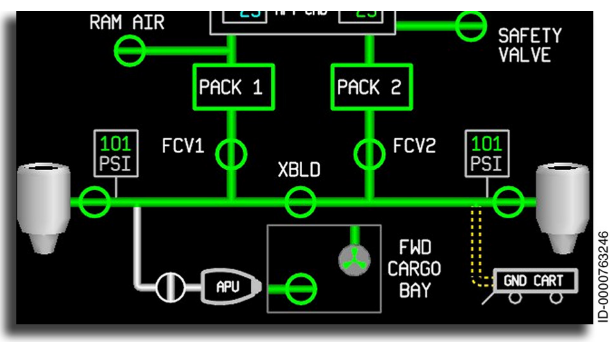

Figure 8-34
Air Duct System

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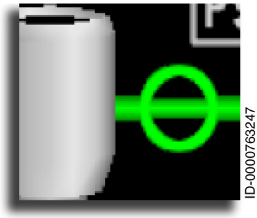
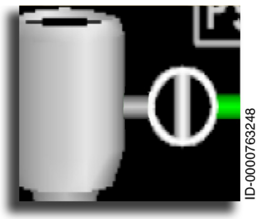
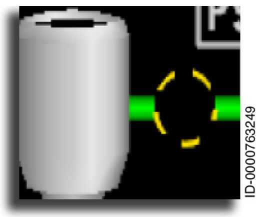


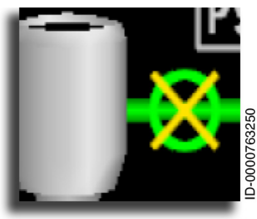
The engine valve is shown open (green) when supplying pressure through the system.



The engine valve is shown closed (white) when not supplying pressure through the system.



When the engine valve data is invalid or undetermined, the valve changes to an amber-dashed (- - -) icon, as shown.



When the engine valve fails in any of the possible states, an X is placed over the valve.

The forward cargo bay, labeled **FWD CARGO BAY** , is located at the bottom of the ECS display, as shown in Figure 8-35. The forward cargo bay contains a recirculating pump and shutoff valve operating in the same manner as those previously discussed.

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Crossover Air Duct

Crossbleed Valve (XBLD) – The crossbleed valve, labeled XBLD , is installed in the crossover air duct line. The crossbleed valve is closed (white) in normal operations. In the open position (green), both air duct systems are connected, permitting one of the engine bleed and air conditioner systems to supply the cabin and cockpit, as shown in Figure 8-35.

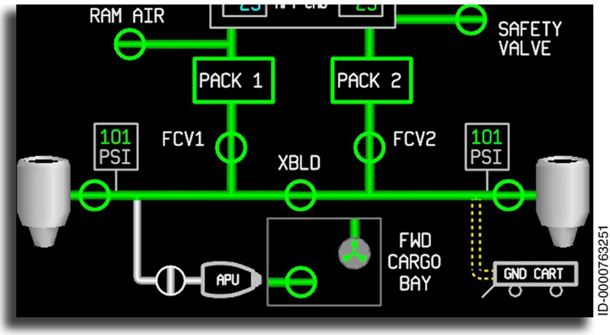
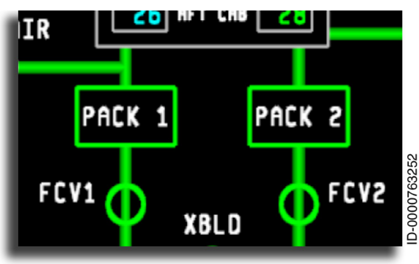
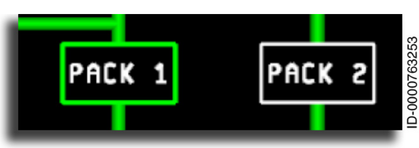


Figure 8-35
Bleed Air Manifold and Crossbleed Valve

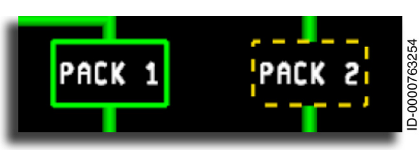
The engine bleed is shut off at the engine valve. The APU supplies cockpit air, or when connected, a ground cart supplies air.



Pack Icon – The air conditioner PACK icons are green rectangles with the label PACK 1 or PACK 2 inside when in normal operation.



A white border around the pack icon indicates OFF.



An amber-dashed border (- - -) indicates data about this pack is undetermined or invalid.

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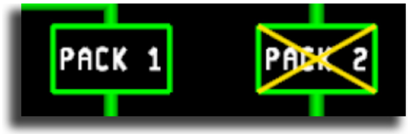
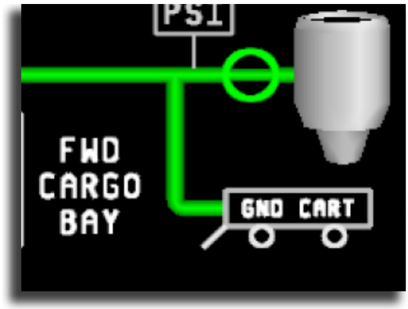


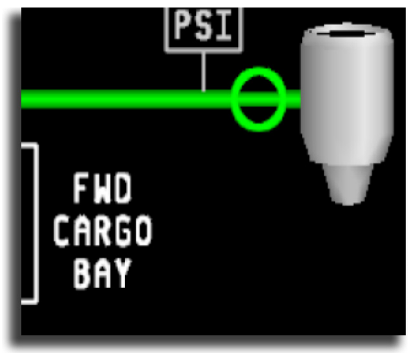
ID-0000763255

When a pack fails in any state, a large X is placed over the pack icon, and a CAS message is generated.



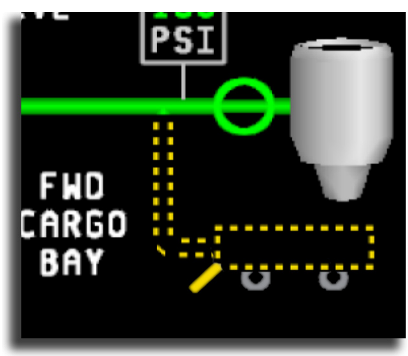
ID-0000763256

Ground Cart – The ground cart symbol, in gray with a GND CART label, is only displayed when a ground cart is attached and supplying air to the aircraft. The ground cart is shown connected and supplying air.



ID-0000763257

The ground cart icon is removed when not connected or not supplying air.



ID-0000763258

The ground cart icon is changed to amber-dashed lines (- - - -) when the status is undetermined or invalid.

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Line Flow Segments

The line flow segments are shown in Figure 8-36.

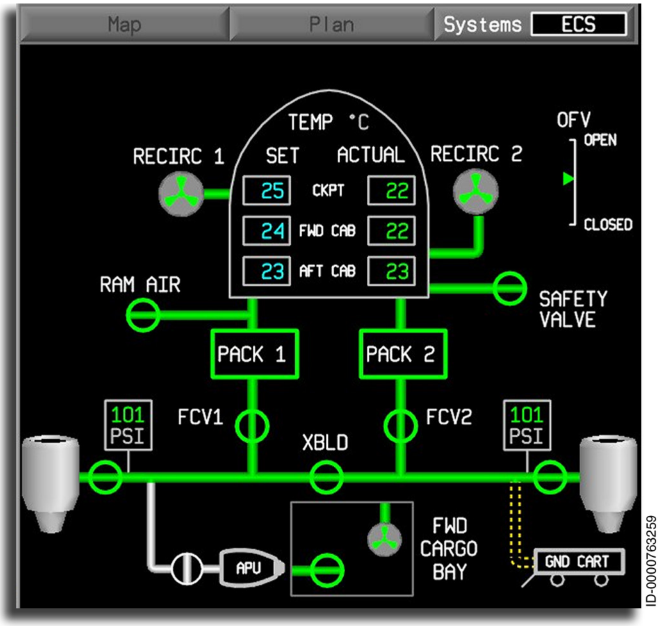
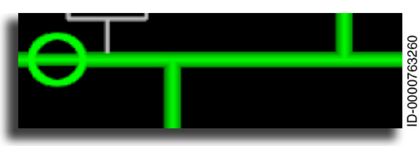
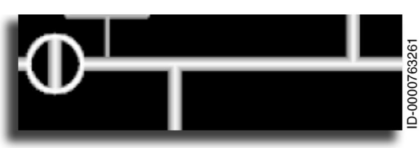


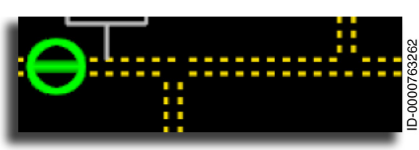
Figure 8-36
ECS Line Flow Segments



The flow line is displayed as a solid green line when air is flowing.



The flow line is displayed as a solid white line when air is not flowing.



The flow line is displayed as an amber-dashed line (- - - -) when the airflow is undetermined or invalid.

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ANTI-ICE SYNOPTIC PAGE

The Anti-Ice (A-Ice) system synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the **Anti-Ice** radio button. The bleed A-Ice synoptic page, shown in Figure 8-37, shows the engine bleed-air system used to supply anti-ice protection. Information is also shown regarding bleed-air system valve status to the crew.

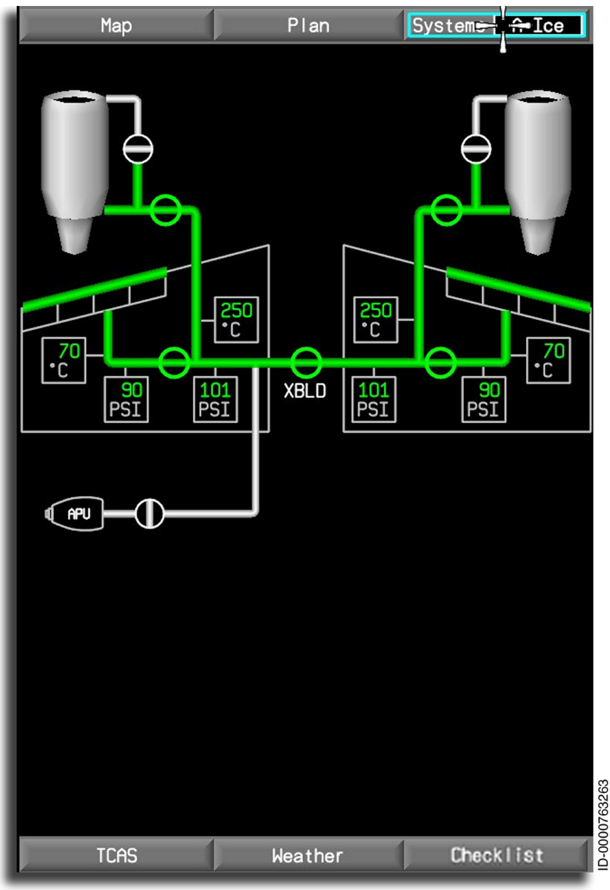

Figure 8-37
Bleed Anti-Ice Synoptic Page

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The bleed A-Ice system synoptic page shows the status of:

- Left and right bleed pressures
- Left and right bleed temperatures
- Bleed sources: left engine, right engine, or APU
- Bleed air isolation valve
- Control valves
- Icing (annunciator)
- Left and right wing anti-icing
- Left and right engine inlet anti-icing
- Left and right slat anti-ice pressure
- Left and right slat anti-ice temperatures.

Pressure Digital Readout

The left and right bleed manifold pressure and left and right wing anti-ice pressure is displayed, as shown in Figure 8-38. The normal digital pressure readout is displayed in green. The readout is enclosed in a gray box with a units label of PSI and a resolution of 1 PSI.

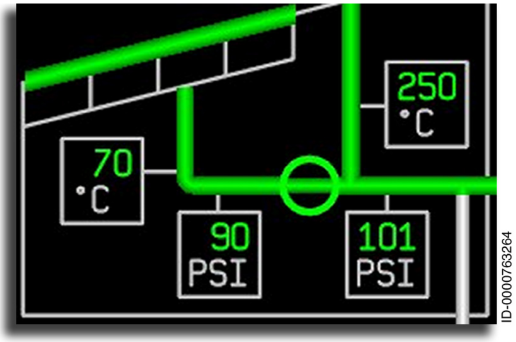

Figure 8-38
Pressure Digital Readout

When pressure data is invalid or beyond the displayable range, the display digits are replaced with three amber dashes (- - -). When the pressure exceeds the maximum limit, an amber CAS message is also generated for this condition.

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Temperature Digital Readout

The bleed-air temperature is displayed to the right and above the pressure display, and the slat anti-ice temperature is displayed to the left of the wing anti-ice pressure display, as shown in Figure 8-39. The temperature for both is in degrees Celsius and has a resolution of 1 °C. The display digits are green with a °C label.

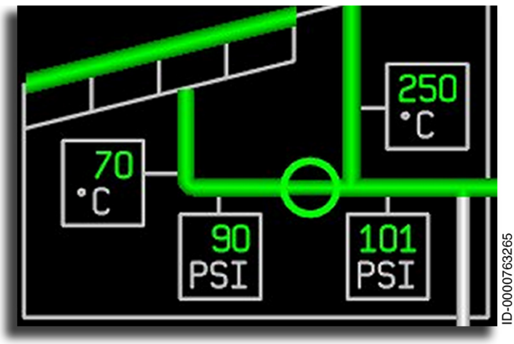
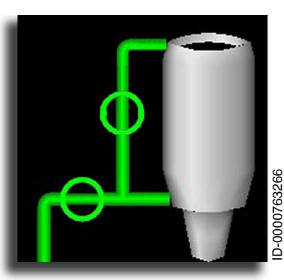


Figure 8-39
Temperature Digital Readout

When the temperature data is invalid or beyond the displayable range, the digital display is replaced with three amber dashes (- - -). When the temperature exceeds the upper limit, an amber CAS message is generated.

Engine Bleed Display

The engine icons are gray. The left and right engines supply anti-ice bleed air and show engine bleed valve icons, inlet de-ice, and bleed interconnects. The engine inlets supply heated air from the engine bleed through the valve from the high-pressure port of the engine.



The valve icon is shown in one of two possible states—open or closed. The valve icon is represented as a green circle with a green flow tube across the center. In the open state, the valve icon and flow tube are green.

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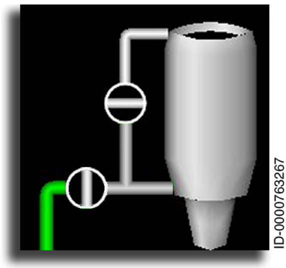
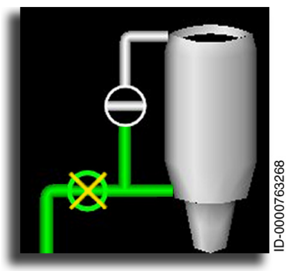
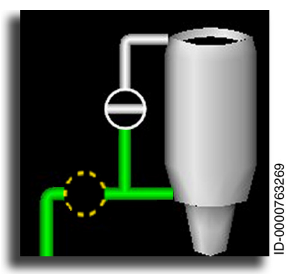


In the closed state, the valve icon and flow tube are white.



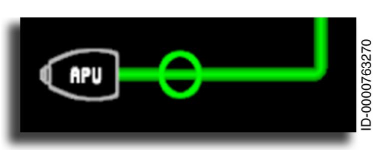
When the valve fails in either state, a large X is placed over the valve icon. A CAS message is generated for this condition.



When valve data is undetermined or invalid, the valve icon is replaced with amber-dashed lines (- - -) with the flow tube removed.

APU Bleed Air Display

The APU bleed air system is displayed in the lower-left corner of the bleed display page. The APU icon is a small APU engine symbol outlined in gray and labeled APU . The APU air shutoff valve is located to the right of the APU icon. The APU is only displayed when the aircraft is on the ground.



The valve icon is shown open or closed. The valve icon is represented as a green circle with a green flow tube across the center. In the open state, the valve icon and flow tube are green.

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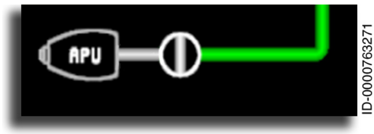
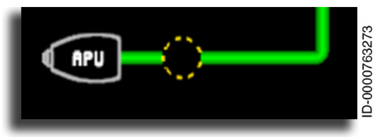


In the closed state, the valve icon and flow tube are white.

When the valve fails in either state, a large X is placed over the valve icon, and an amber CAS message is generated for this condition.

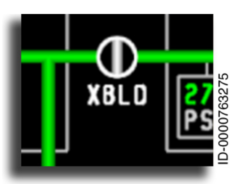


When valve data is undetermined or invalid, the valve icon is replaced with amber-dashed lines (- - -) with the flow tube removed.

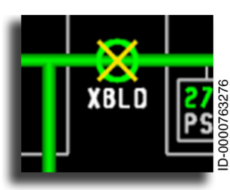
Bleed-Air Isolation Valve (Crossbleed Valve)

The bleed-air isolation (or crossbleed) valve connects the two bleed systems and is labeled XBLD . When open, the crossbleed valve connects both systems. When closed, the crossbleed valve isolates them. The crossbleed valve permits one engine to supply de-icing air to both sides of the system. The crossbleed valve is located in the center of the bleed-air display synoptic.

The valve icon is represented as a green circle with a green flow tube across the center. In the open state, the valve icon and flow tube are green.



In the closed state, the valve icon and flow tube are white.



When the valve fails in any of the states, a large X is placed over the valve icon. An amber CAS message is generated for this condition.

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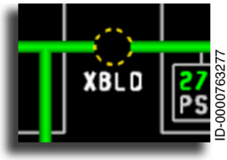
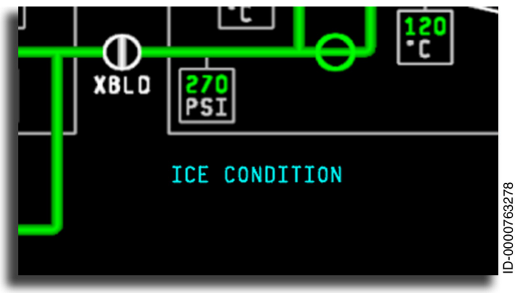


When the crossbleed valve data is undetermined or invalid, the valve icon is replaced with amber-dashed lines (- - -) with the flow tube removed.

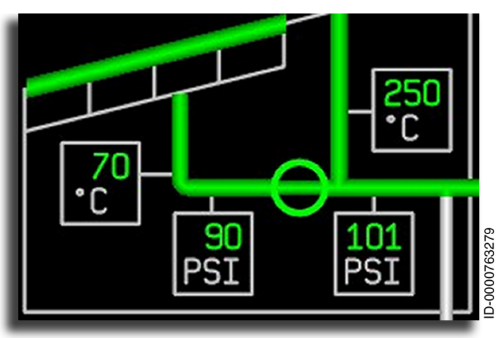
Icing Annunciator



When icing is present as determined by the presence of an icing CAS message, the ICE CONDITION annunciator is displayed in the lower-right area of the bleed A-Ice display synoptic.

Wing Anti-Ice Display

The left and right wing anti-ice valves and interconnects are positioned on static wing icons (outlined in gray) located near the top of the bleed A-Ice display page. The wing anti-ice system is monitored for temperature and overpressure conditions. When limits are exceeded, CAS messages are generated. The valves, when open, allow bleed air to the wing leading edge anti-icing system.



The left and right wing valve icons are open or closed. In the open position, the valve icon is displayed as a green circle with a green flow tube across the center.

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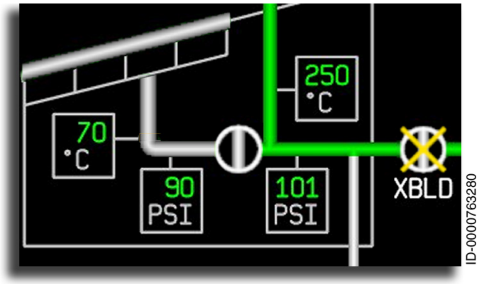
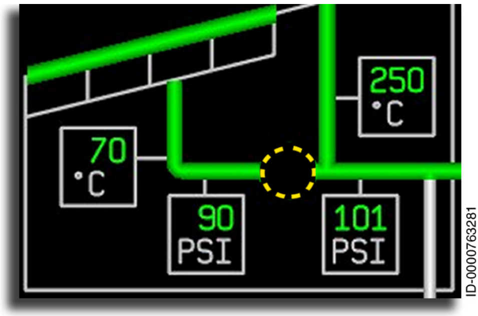


In the closed state, the valve icon and flow tube are white.

If the valve fails in either state, a large X is placed over the valve icon. An amber CAS message is generated for this condition.



If wing valve data is undetermined or invalid, the valve icon is replaced with amber-dashed lines (- - -) with the flow tube removed.

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Wing Anti-Ice Flow Lines

The flow lines are represented on the A-Ice synoptic page by graphical icons, as shown in Figure 8-40. The state of the flow lines is determined by the appearance of the icons. The anti-ice flow line states are defined by the states of the valves to each connected flow line. Amber annunciators for that line indicate the flow is undetermined, a leak has been detected for that line, or a failure condition exists not described in the table.

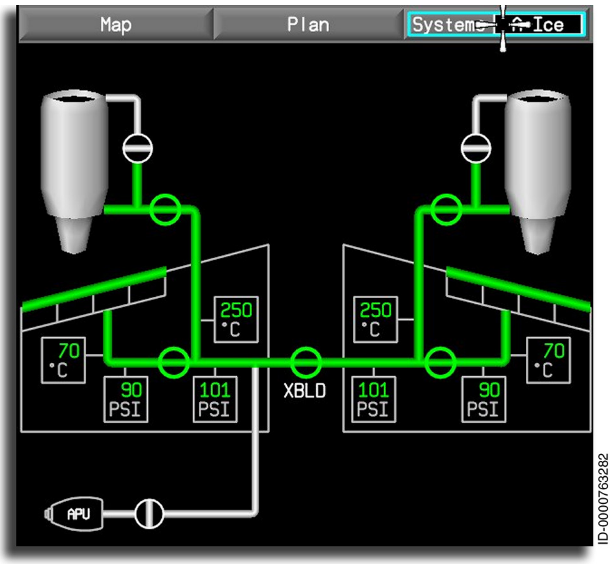

Figure 8-40
Anti-Ice Interconnects

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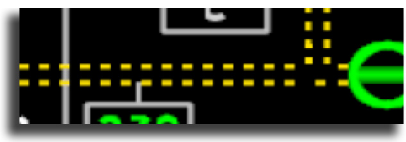
The flow lines are displayed as follows:


ID-0000763283

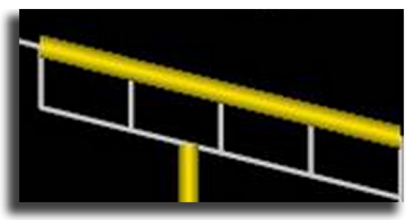
The flow line is displayed as a solid green line when air is flowing.


ID-0000763284

The flow line is displayed as a solid white line when air is not flowing.


ID-0000763285

The flow line is displayed as an amber-dashed line (- - - -) when the airflow is undetermined or invalid.


ID-0000763286

The flow line is displayed as a solid amber line when a failure is in the system.

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VIDEO/CAMERA DISPLAY

The external Video/Camera synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the **Video** radio button. The Video/Camera display synoptic page is shown in Figure 8-41.

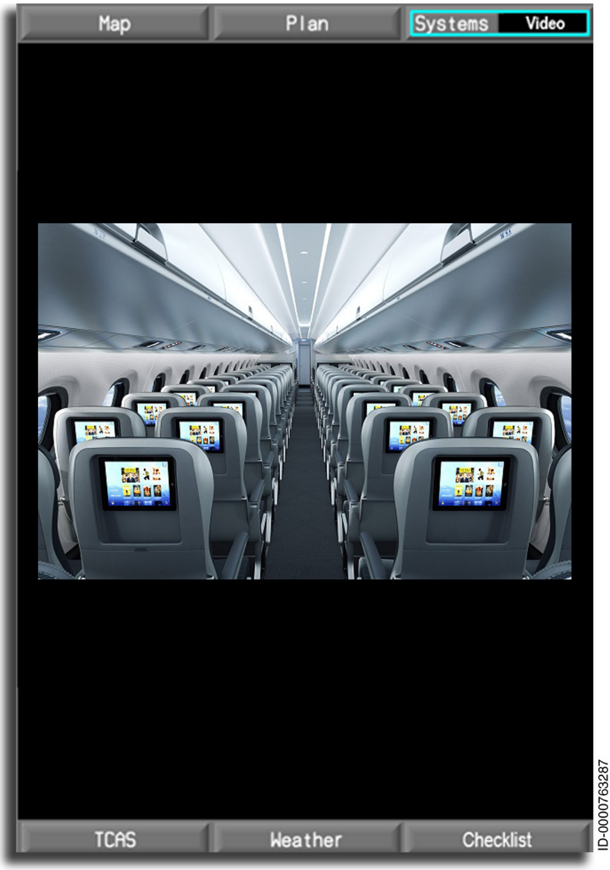

Figure 8-41
Video/Camera Display

The external Video/Camera display page displays images from an optional camera surveillance system (CSS). When the Video/Camera display page is activated, the portion of the display between upper and lower menus displays the video stream of the CSS attached to the AGM.

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Displaying video in the cockpit can take place on any DU that has a video stream connected to the respective AGM. Video from the input source is displayed in the selected 1/2 window on the DU-1310. When there is no CSS video device installed on the AGM, the dropdown menu selection **Video** is grayed out, preventing the selection of the Video/Camera display page.

When a video device is connected to an AGM, but either the device is broken, disconnected, or switched off, selecting the Video/Camera display synoptic page is displayed with the message **VIDEO DISPLAY NOT AVAILABLE** , as shown in Figure 8-42.

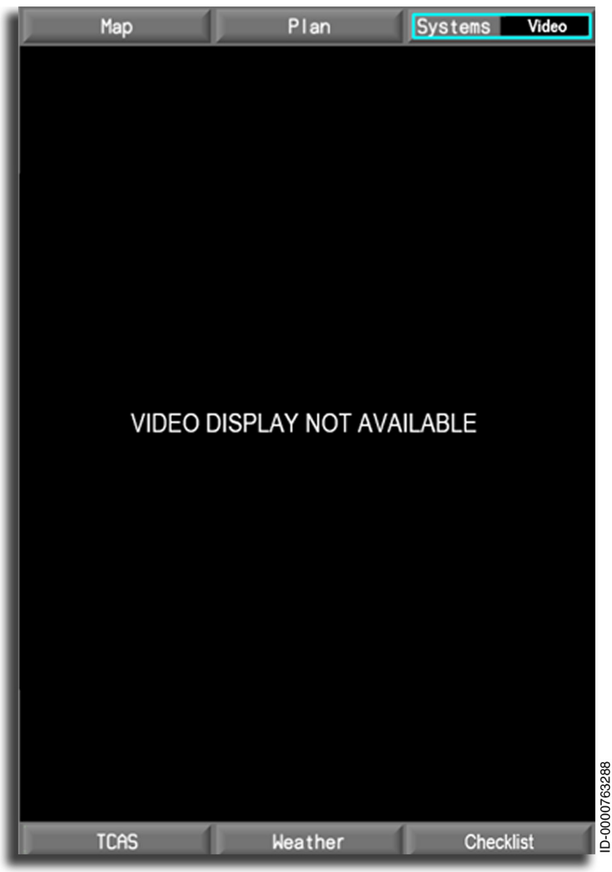

Figure 8-42
Video Display Not Available

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MAINTENANCE TOOLS MAIN MENU PAGE

The Maintenance (Maint) tools main menu page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the Maint Tool radio button. The Maint tools main menu page is shown in Figure 8-43.

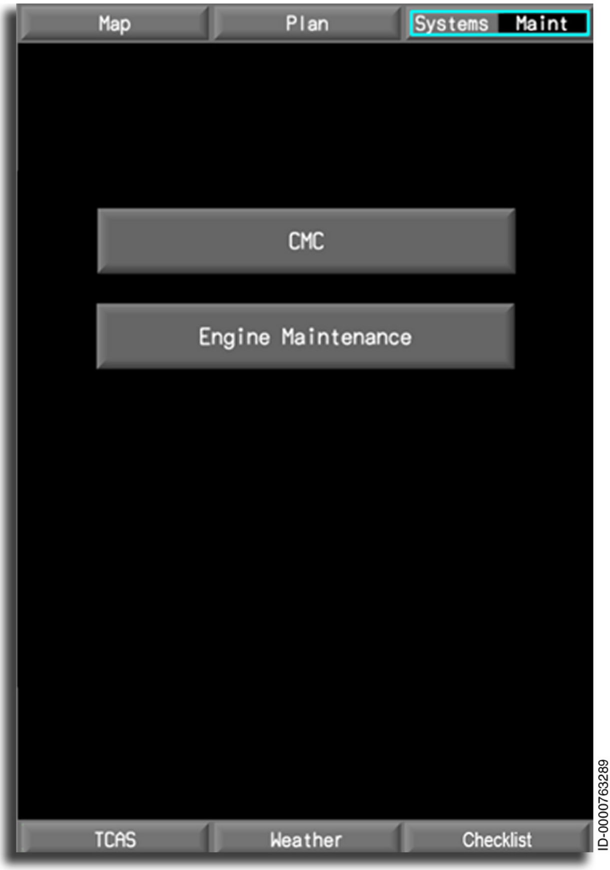

Figure 8-43
Maintenance Tools Page

The Maint tool main menu window consists of the following buttons:

- CMC
- Engine Maintenance.

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Each of these buttons is accessible using the CCD. When the **CMC** button is selected using the CCD, the CMC Maintenance window is displayed. When the **Engine Maintenance** button is selected using the CCD, the Engine Maintenance display window is displayed.

The **CMC** button is enabled only when the aircraft is on-ground, or the CMC window is configured to be used in-air. Otherwise, the **CMC** button is grayed out, preventing the selection of the CMC display window.

The **Engine Maintenance** button is enabled only when the aircraft is on-ground; otherwise, it is grayed out, preventing the selection of the Engine Maintenance display window. If the Engine Maintenance display window is displayed, and the aircraft transitions from on-ground to in-air, the Engine Maintenance display window is closed and returns to the Maint tool main menu window with the **Engine Maintenance** button grayed out.

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CMC Window

The CMC window, shown in Figure 8-44, displays the video information sent by the central maintenance computer (CMC) by way of the remote image bus (RIB).

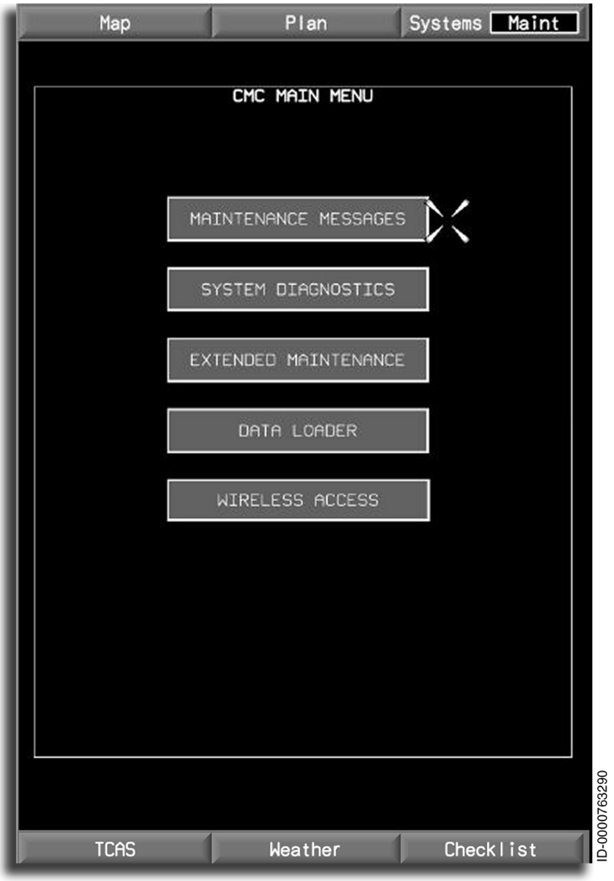

Figure 8-44
CMC Window

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When the CMC page is selected and the CMC RIB input becomes unavailable, a CMC DISPLAY NOT AVAILABLE indication is displayed in the center of the CMC RIB window, as shown in Figure 8-45.

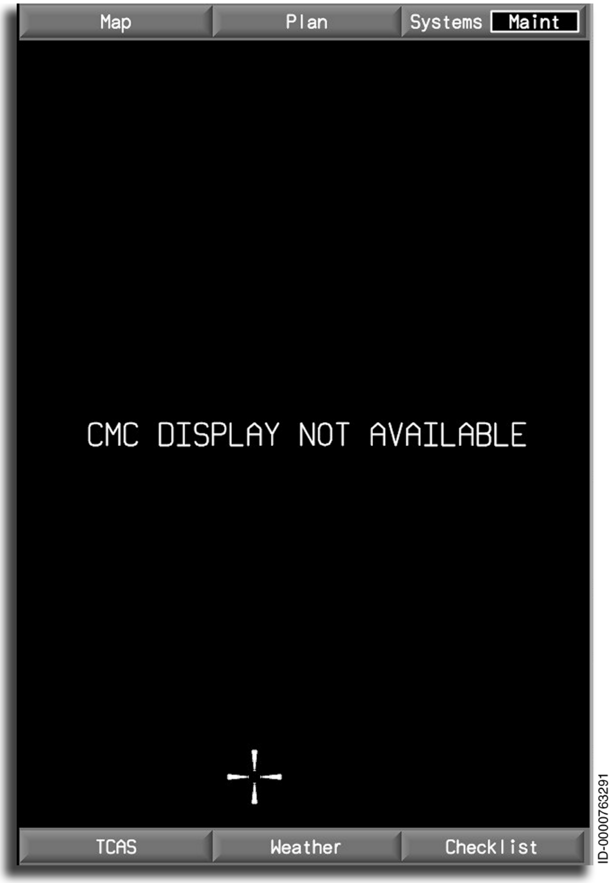

Figure 8-45
CMC Display Not Available

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Engine Maintenance Synoptic Page

The Engine Maintenance synoptic page, shown in Figure 8-46, displays dispatch level limitations for each engine. The engine exceedance information and FADEC channel faults are also displayed. **ENGINE / APU MAINTENANCE** is displayed at the top of the Engine Maintenance synoptic page.

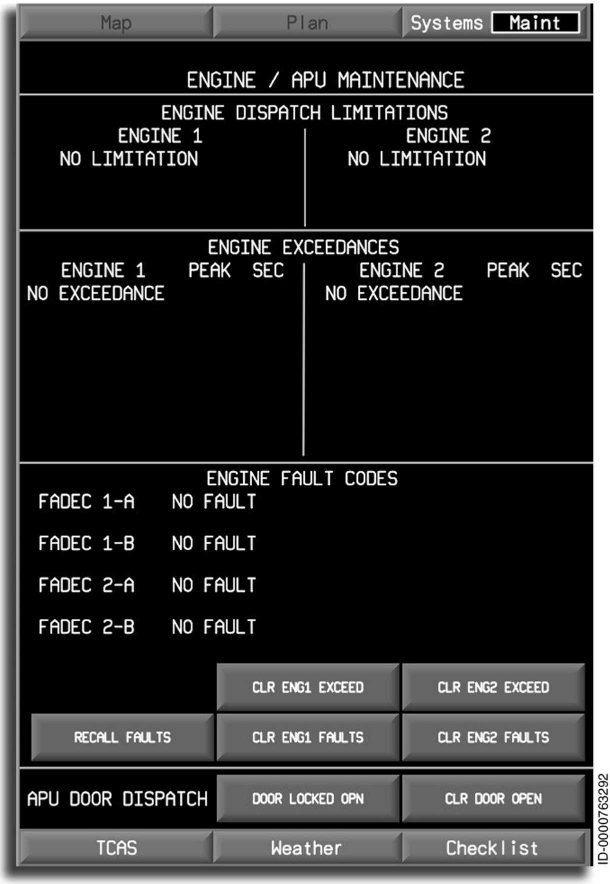

Figure 8-46
Engine Maintenance Synoptic Page

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ENGINE DISPATCH LIMITATIONS DISPLAY

The engine dispatch limitations window, shown in Figure 8-47, is displayed on the upper third of the Engine Maintenance synoptic display. The status of the dispatch limiting faults is displayed on the Engine Maintenance synoptic page to supply maintenance with the engine dispatch limitation status. The Engine 1 dispatch limitations are displayed on the left side of the window, while Engine 2 dispatch limitations are displayed on the right side.

Figure 8-47
Engine Dispatch Limitations

The Engine Maintenance synoptic is capable of showing up to four dispatch limitations. The limitations are displayed in the order listed below:

- NO DISPATCH
- SHORT TIME DISPATCH
- LONG TIME DISPATCH
- ECONOMIC DISPATCH .

When no dispatch limiting faults are active, the annunciator NO LIMITATION is displayed.

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ENGINE EXCEEDANCES DISPLAY

The **ENGINE EXCEEDANCES** window, shown in Figure 8-48, is displayed on the middle-third portion of the Engine Maintenance synoptic. The Engine Exceedance window provides maintenance with the engine exceedance status of each engine. The Engine 1 exceedance limitations are displayed on the left side of the window, while Engine 2 exceedance limitations are displayed on the right side.

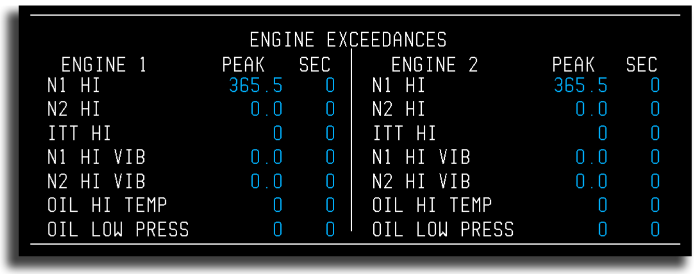

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Figure 8-48
Engine Exceedances Display

The Engine Exceedance synoptic shows data for nine engine parameters. The engine parameters are labeled as follows:

- **N1 HI** – N1 high speed
- **N2 HI** – N2 high speed
- **ITT HI** – Interturbine temperature high temperature
- **NFAN HI VIB** – NFAN high vibration
- **N1 HI VIB** – N1 high vibration
- **N2 HI VIB** – N2 high vibration
- **OIL HI TEMP** – Oil high temperature
- **OIL HI PRESS** – Oil high pressure
- **OIL LO PRESS** – Oil low pressure.

The engine exceedance maximum peak and duration are also displayed in cyan, permitting maintenance to know how high and how long a parameter was exceeded. With no detected exceedance, the annunciator **NO EXCEEDANCE** is displayed. Any negative values are displayed as amber dashes (- - -).

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All exceedances not used are removed from the display. For example, when **N1 HI VIB** is the only exceeded condition, the preceding conditions are removed from the display, and **N1 HI VIB*** is displayed on the first line.

ENGINE FAULT CODES DISPLAY

The **ENGINE FAULT CODES** window, shown in Figure 8-49, is displayed on the lower third of the Engine Maintenance synoptic. The Engine Maintenance page shows a maximum of 14 fault codes for each FADEC channel. When there are more than 14 codes, the additional fault codes are displayed only when actively displayed fault codes are cleared (removed).

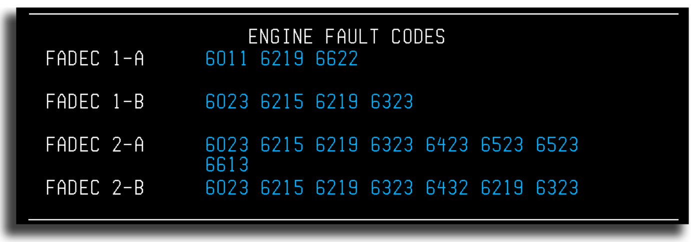

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Figure 8-49
Engine Fault Codes Display

The fault codes are displayed as follows:

- **FADEC 1-A**
- **FADEC 1-B**
- **FADEC 2-A**
- **FADEC 2-B** .

Each individual fault code is displayed in cyan. When there are no active faults for a FADEC channel, the annunciator **NO FAULT** is displayed.

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ENGINE MAINTENANCE DISPLAY

The function keys of the Engine/APU Maintenance synoptic, shown in Figure 8-50, are displayed on the Engine Maintenance synoptic page below the Engine Fault Codes display. The purpose of the function keys is to command the FADEC to clear memory.

Figure 8-50
Engine Maintenance Display

The function keys are displayed as follows:

- CLR ENG1 EXCEED
- CLR ENG2 EXCEED
- CLR ENG1 FAULTS
- CLR ENG2 FAULTS
- RECALL FAULTS .

The APU door dispatch function keys are displayed as follows:

- DOOR LOCKED OPN
- CLR DOOR OPEN .

The APU DOOR DISPATCH label is displayed to the left of the APU door dispatch function keys.

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A function key is activated by positioning the cursor on the desired function key (outlined in cyan) and selecting the **ENTER** button on the CCD. When an engine maintenance function key is activated, a pop-up window requiring confirmation of the request to clear the fault data memory is displayed, as shown in Figure 8-51. When YES is selected, the data is cleared, and the pop-up window is removed. When NO is selected, the pop-up window is removed.

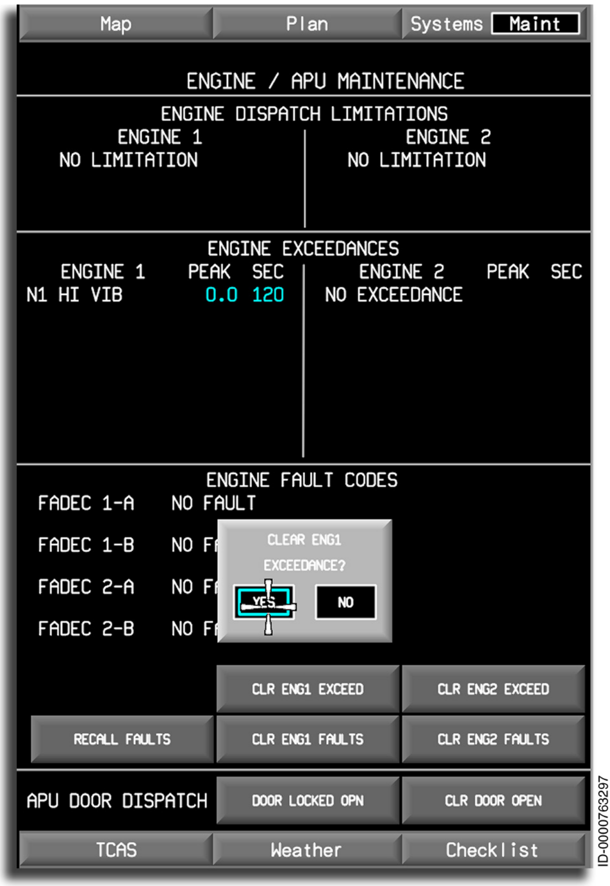

Figure 8-51
Exceedance Pop-Up Window Display

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When the DOOR LOCKED OPN APU door dispatch function key is activated, a pop-up window requiring confirmation to set the door locked open is shown. When the CLR DOOR OPEN APU door dispatch function key is activated, a pop-up window requiring confirmation to clear the door locked open status is shown. When YES is selected, the APU door locked open is set. When *NO* is selected, the pop-up window is removed.

The selection of the RECALL FAULTS function key results in a command being sent to the left and right engine FADEC requesting previous fault data to be shown in the Engine Fault Codes window. The RECALL FAULTS function key does not have a confirmation window.

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COMMUNICATION ERROR DISPLAY

The COMMUNICATION ERROR annunciator is displayed on the Engine Maintenance synoptic, as shown in Figure 8-52. The COMMUNICATION ERROR annunciator is displayed when both FADEC channels indicate a communication failure.

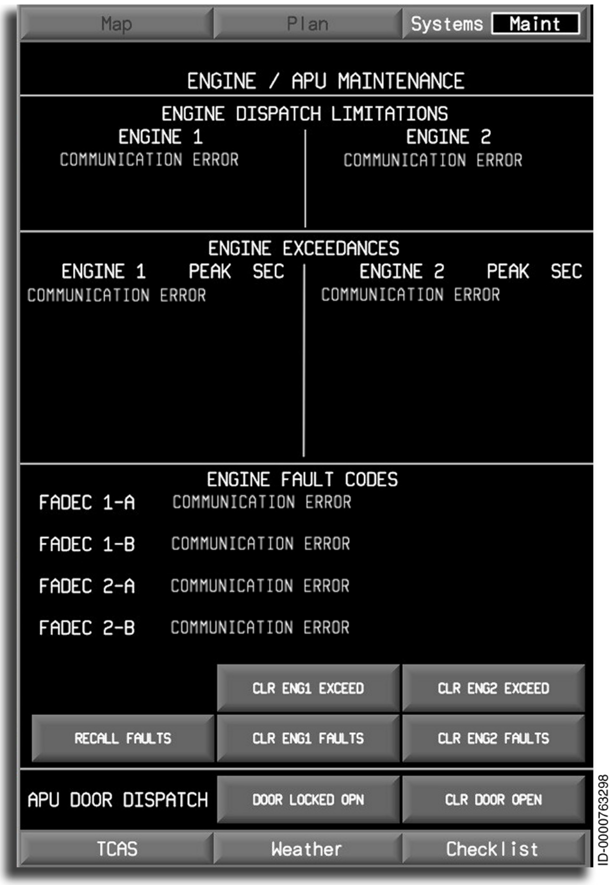

Figure 8-52
Communication Error Display

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SYSTEM CONFIGURATION SYNOPTIC PAGE

The System Configuration (SysCfg) synoptic page is displayed by positioning the cursor on the Systems menu on the MFD, selecting the **ENTER** button on the CCD, and then selecting the Sys Config radio button. The opening page is shown in Figure 8-53.

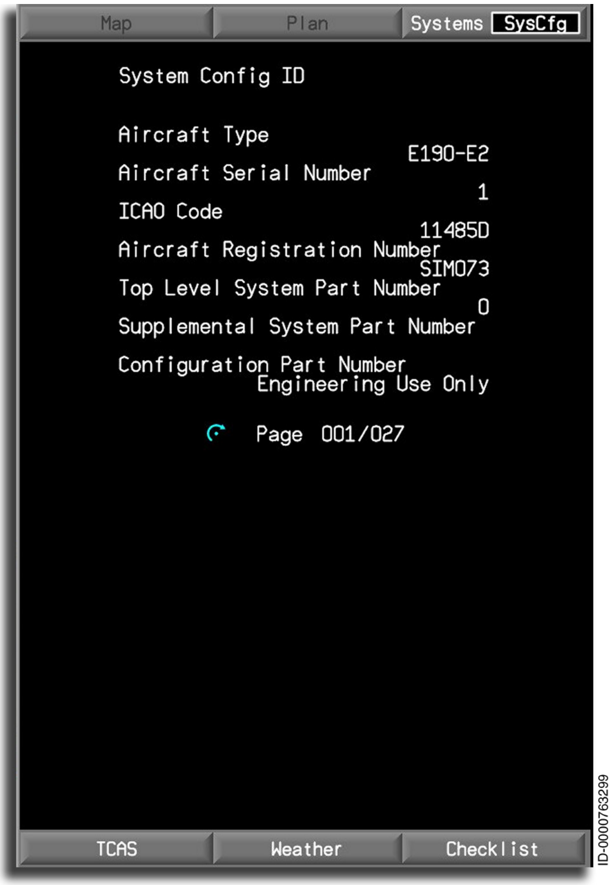

Figure 8-53
System Configuration Synoptic

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The SysCfg display shows a listing of hardware/software part numbers, serial numbers, equipment IDs, and destination identifiers received from member systems, supporting the central maintenance computer function (CMCF). The CMCF is a software application hosted on the CMC module that supplies a real-time collection of fault reports and the subsequent storage of maintenance messages and any associated correlation to flight deck effects. This application also supplies a central location where other maintenance functions are performed on member systems.

The SysCfg display is generated by real-time data transmitted from each participating member system to the CMCF. The configuration display is only used for noncritical determination of installed components. The CMCF gives commands only while the aircraft is on the ground, and test initiation is locked out while in-air.

There are multiple pages to select, as displayed by the cyan control knob icon. The pages are not displayed in this section since it is strictly a maintenance matter not involving the flight crew.

After reviewing the displayed software and/or database part numbers and other configurations, the confirmation is provided by selecting the **Confirm Configuration** button.

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Blank Page

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9. Engine Indication and Crew Alerting System (EICAS)

INTRODUCTION

This section describes the engine indication and crew alerting system (EICAS) window and each of the information display areas.

The EICAS, shown in Figure 9-1, shows critical engine instruments, systems information, and the crew alerting system data. The EICAS window default position is on DU2 inboard format. Both cursor control devices (CCDs) are used to control the display.

Figure 9-1
EICAS Window Functional Areas

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Reversion and Screen Brightness

When DU2 or DU3 display fails, the EICAS will automatically reconfigure to the other display. The pilot can initiate a display reversion by turning the Reversionary Panel switch to either the LEFT or RIGHT position. When one of the reversion controls is set to AUTO, the previous change is automatic for that side. See the subsection Reversionary Panel on page 3-29 in Section 3, Controllers, for more information.

EICAS Layout

The EICAS window is divided into ten areas. The areas are separated by thin gray lines. Some of the areas are identified by names in gray letters in the upper-left corner of the area. The areas are as follows:

- Crew alerting system (CAS) window
- Primary engine instruments (N1, N2, ITT, fuel flow, thrust reverse status, ignition, windmill, start icon, engine thrust rating annunciator, and automatic takeoff thrust control system (ATTCS) status)
- Fuel quantities (FUEL QTY)
- Engine oil pressure and temperature (OIL)
- Engine vibration—N1 and N2 (VIB)
- Slat, flap, spoiler, and speedbrake position (SLAT/FLAP/SPOILER)
- Landing gear position and autobrake status (LG/AUTOBRAKE)
- Auxiliary power unit (APU) output temperature, exhaust gas temperature (EGT), and revolutions per minute (RPM)
- Cabin pressure indications (CABIN)
- Trim position indicators – roll, pitch, and yaw (TRIMS).

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EICAS Declutter

An automatic declutter mode is used to remove the oil pressure/ temperature, vibration, slat/flap/speedbrake, APU, landing gear, and pitch trim green band displays from the EICAS. In flight, a timer function is set to 30 seconds after the landing gear and flaps/slats are retracted. At this point, the EICAS will auto declutter, as shown in Figure 9-2.

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Figure 9-2
Decluttered EICAS

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Declutter occurs 30 seconds after the following conditions are met:

- **EICAS FULL** button is not pushed
- Both engines are running
- All engine instruments are valid and in normal ranges
- All data for the decluttered fields are valid and in normal ranges
- APU and autobrake (when installed) are off
- Speedbrake surfaces are stowed.

Pushing the **EICAS FULL** button results in all of the previously listed inhibited information displaying, as shown in Figure 9-1.

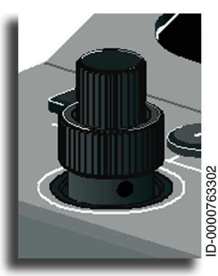
CREW ALERTING SYSTEM (CAS)

Two monitor warning function (MWF) computers in separate modular avionics units (MAUs) continually monitor the status of various aircraft and avionics systems.

One MWF has priority and alerts the flight crew by generating alert messages in the CAS window. Some warnings also have sounds (voice and/or tone). The other MWF is a backup. When the priority MWF fails, the display computer automatically selects and uses the data from the backup MWF.

Alert messages are prioritized and color-coded for display. The MWF also controls message timing, flight crew acknowledgment, and the scrolling of the CAS messages in the CAS window.

The CAS list message comparison monitor compares the list of CAS messages generated by the two MWFs. When the two CAS message lists are continuously different for 7 seconds, an amber miscompare indication is annunciated on the MFD.



The concentric (stacked) knobs on the CCD scroll or move the alert message list in the CAS window. The MCDU concentric knobs do not control the CAS scrolling function.

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Accessing the Crew Alert Window

The CCD is used to select the EICAS window and scroll through the alert messages in the alert CAS window, shown in Figure 9-3. The last CCD selecting the EICAS has control.

Figure 9-3
CAS Message Window

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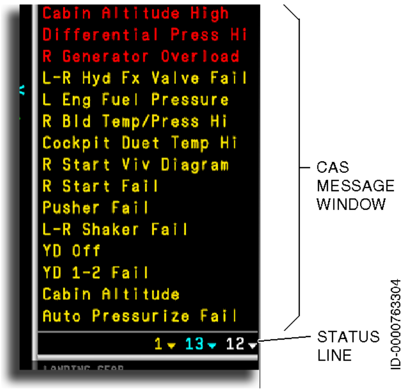
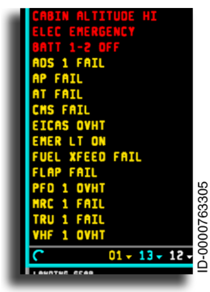
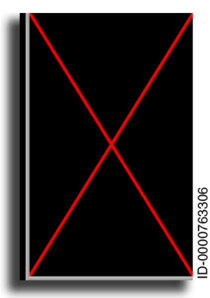


Unselected CAS Window – The crew alerting window, located in the upper right area of the EICAS, consists of two sections—the CAS message window and status line for indication of CCD focus and indication of out of view messages. All alert messages are shown in the CAS window. The status line indicates the number of off-screen messages. Arrows indicate that they are located above or below the window.



Selected CAS Window – The CAS message window has 15 lines of 22 characters each. The CAS message window shows four types of alert messages. The cyan outline indicates that the CAS message window is selected and in focus.



When CAS information is invalid, or the crew alert system is not operational, a large X is displayed over the full CAS window. No alert messages are displayed.

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CAS Messages

CAS messages consist of three elements: general header or system, specific subsystem or location, and nature of the problem. These elements are combined to create the CAS message, which is displayed in the CAS window. The basic functions of the CAS are to:

- Attract the attention of the flight crew and direct their attention to the alerting condition so that corrective action is taken, if necessary.
- Inform the flight crew of the location and nature of the alerting condition. Sufficient information is given to enable the crew to initiate timely, corrective action.
- Let the flight crew access aircraft status quickly and identify new alerts.
- Give necessary feedback to the flight crew regarding the results related to the actions taken by them.

CAS Message Types

Four types of CAS messages (highest priority at the top) are displayed in the CAS window. In order of priority, the types are:

- Warning messages
- Caution messages
- Advisory messages
- Status messages.

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CAS Message Lists

CAS messages are managed in two lists—the warning list and the stack list. The warning list contains all active red warning messages listed in chronological order (newest on top) at the top of the CAS window. Warning messages are not scrollable and remain at the top of the CAS window until the condition that resulted in the message is corrected.

The stack list is arranged in one continuous stack. Caution messages are at the top, advisory messages are in the middle, and status messages are at the bottom. New caution messages are inserted at the top of the caution section in the stack. New advisory messages are inserted at the top of the advisory section, and new status messages are inserted at the top of the status section. The last entry at the bottom of the stack list is the terminator (END) entry identifying the end (bottom) of the stack, as shown in Figure 9-4.

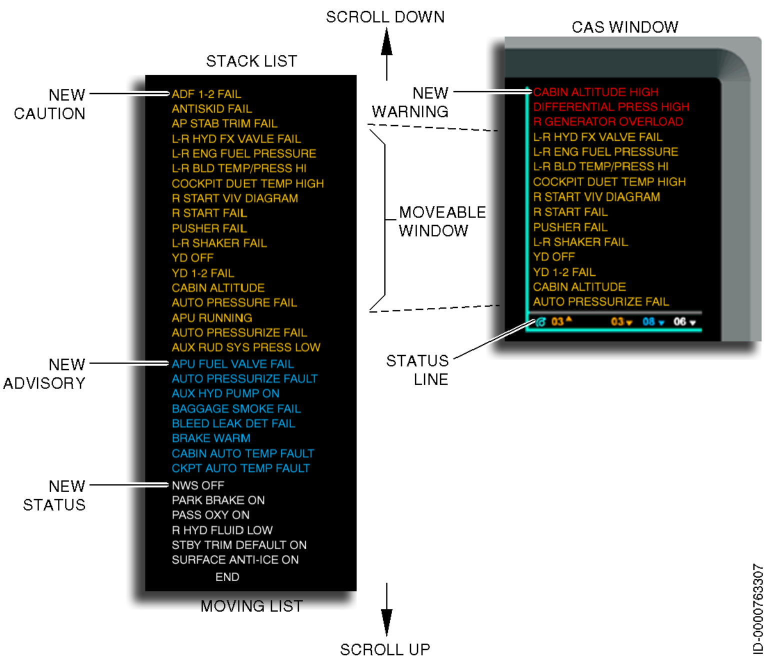

Figure 9-4
Crew Alerting System Window Operations Diagram

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Warning and caution messages flash until acknowledged by the crew. Advisory and status messages do not require acknowledgment. When the window is full, the older messages (except warning messages) at the bottom of the window are forced (scrolled) off the window.

Golden CAS Messages

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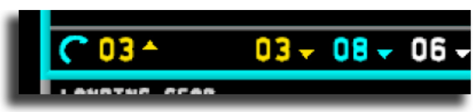
Golden CAS messages are used to help the pilot's decision-making process. Since CAS messages are in chronological order, golden CAS messages identify the CAS message that is the main result of the event, permitting the pilot to prioritize the steps that need to be taken. A greater than symbol (>) is displayed on the left side of the CAS message, indicating a golden CAS message.

Status Line



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The CAS window is in focus by a CCD when a cyan curl with an arrow icon (meaning knob adjustable data) is displayed, and the alert window border changes from gray to cyan. Turning the active CCD scroll knobs (one or both) scrolls the alert message stack list under the CAS window.

The status line indicates the number (count) and type (color) of messages out of the CAS window view and whether they are located above or below the window. Colored numbers on the left side of the status line have an up arrow appended to indicate messages of that color are located above the window. To retrieve the messages scroll DOWN. Colored numbers on the right side of the status line have a down arrow appended to indicate the messages are below the window and must be scrolled UP to be retrieved.

In the previous example, there are six caution messages (three above and three below) in the CAS window, eight advisory messages and six status messages below the CAS window. The out-of-view message display (digits and arrows) continuously flashes when there are unacknowledged messages out of view. If there are no out-of-view messages, the out-of-view message display is removed from the window.

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Warning messages are not scrolled out of the window. Caution, advisory, and status messages are scrolled off the window. The types of scrolled messages out of view are displayed at the bottom of the window on the status line, as shown previously in Figure 9-4.

Scrolling up is inhibited when the message at the top of the caution, advisory, or status message display queue is unacknowledged or the END message is at the top of the message queue. This is the same for scrolling down. New unacknowledged caution messages are inserted at the top of the caution message display queue. This also applies to advisory and status messages.

Acknowledging Messages

All warning and caution messages must be acknowledged when shown on the alert window. The messages flash until the crew acknowledges them using the master Caution and Warning switches, shown in Figure 9-5. The switches are located on the glareshield. The buttons also flash. Pushing the flashing master warning button on the pilot's or copilot's glareshield acknowledges one or more warning messages. The flashing stops and indicates the crew has seen and acknowledged all flashing warning messages. Flashing caution messages operate the same way by pushing the caution button.

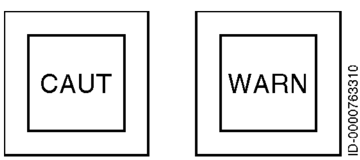

Figure 9-5
Master Caution and Warning Switches

No action is required to acknowledge advisory or status messages. Advisory messages are shown in the scrollable list. When visible in the CAS window, the messages flash for 5 seconds, then stop and are considered acknowledged. Status messages do not flash and are automatically considered acknowledged when shown in the scrollable list.

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CAS Message Inhibit

Under some conditions, the CAS system inhibits some messages. Inhibits are categorized as global or functional message inhibits. A global message inhibit function is required during flight phases where the flight crew has an increased workload compared with other flight phases and must not be distracted by messages not relevant to those flight phases. A global inhibit does not permit CAS messages to be added or removed from the display during that flight phase. Functional inhibits disable the CAS message. For example, if a CAS message is active and the associated functional inhibit becomes active, the message will be removed from the CAS window due to the logic being disabled by the inhibit. If the conditions resulting in the CAS message are still true after the takeoff or landing, the message is displayed.

- **Takeoff Inhibit** – The EICAS system uses the fault warning computer (FWC) to determine when the aircraft is in the takeoff phase of flight. The conditions used are as follows:
  - Pressure altitude ≤ takeoff altitude + 400 feet
  - Indicated airspeed (IAS) ≥ 80 knots
  - Weight-on-wheels (WOW) or aircraft is airborne for less than 25 seconds.

When these conditions are met, CAS messages marked with an asterisk (*) in Table 9-1 through Table 9-4 are permitted. All others are inhibited.

- **Landing Inhibit** – The EICAS uses the FWC to determine when the aircraft is ready for the landing phase of flight. The conditions used to make this determination are:
  - Radio altitude valid and less than 200 feet
  - Air data system (ADS) is valid
  - IAS > 50 knots
  - Gear indicates down and locked
  - WOW switch indicates airborne.

When these conditions are met, CAS messages marked with a pound sign (#) in Table 9-1 through Table 9-4 are permitted. All others are inhibited.

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WARNING (RED) MESSAGES

When a warning message is active, the following indications are given:

- A flashing warning message is displayed at the top of the CAS display.
- The red annunciator button on the master warning panel flashes.
- A triple chime aural tone is sounded.

When the master warning annunciator switch is pushed, the annunciator goes out, and the warning message stops flashing. The master warning annunciator switch is then re-armed to accept more incoming warning messages.

Table 9-1 lists the WARNING CAS messages.

Table 9-1
Warning CAS Messages

CAS Message	Description
A-I WING 1 LEAK A-I WING 2 LEAK	There is a bleed leakage downstream of left/right A-I wing valve or an over-temperature condition has been detected by left/right A-I temperature sensors, which exceeds 110 °C for 30 seconds or 130 °C for 2 seconds.
APU FIRE * #	An APU fire condition is detected.
BATT 1 OVERTEMP * # BATT 2 OVERTEMP * #	Battery 1 or 2 temperature is over 70 °C.
BATT 1-2 OFF * #	Battery 1 and 2 contactors are not closed.
BATT DISCHARGING * #	Battery 1 and 2 are discharging during electrical emergency.

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Table 9-1 (cont)
Warning CAS Messages

CAS Message	Description
CABIN ALTITUDE HI	If the cabin altitude exceeds 9,700 feet for airfield operations below 9,400 feet or the airfield altitude +500 feet for airfield operations above 9,400 feet, this CAS message is displayed and an aural warning, **CABIN**, sounds. The oxygen altimetric switch supplies an input to EICAS to set this warning message and aural sound when cabin altitude exceeds 14,500 feet (+250/-500 feet).
CRG AFT SMOKE * # CRG FWD SMOKE * #	Aft or forward cargo smoke is detected.
DOOR CRG AFT OPEN DOOR CRG FWD OPEN	Indicates aft or forward cargo door is open.
DOOR EMER LH AFT OPEN	Indicates left aftward overwing emergency door is open.
DOOR EMER LH FWD OPEN	Indicates left forward overwing emergency door is open.
DOOR EMER RH AFT OPEN	Indicates right aftward overwing emergency door is open.
DOOR EMER RH FWD OPEN	Indicates right forward overwing emergency door is open.
DOOR EMER LH OPEN	Indicates the left overwing emergency door is open.
DOOR EMER RH OPEN	Indicates the right overwing emergency door is open.
DOOR PAX AFT OPEN DOOR PAX FWD OPEN	Indicates aft or forward passenger door is open.
DOOR SERV AFT OPEN DOOR SERV FWD OPEN	Indicates aft or forward service door is open.

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Table 9-1 (cont)
Warning CAS Messages

CAS Message	Description
>ELEC EMERGENCY * #	All AC sources are not available in flight (no WOW and airspeed above 50 knots).
ELEV NML MODE FAIL	Normal mode computed airspeed gains failed to an erroneous high airspeed value (low gain value).
ENG 1 FIRE * # ENG 2 FIRE * #	An Engine 1 or Engine 2 fire condition is detected.
ENG 1 LIMIT	This message is set whenever any of the following left engine parameters exceed their limits: • N1 / N2 Speed • ITT • Maximum Oil Pressure • Maximum Oil Temperature.
ENG 2 LIMIT	This message is set whenever any of the following right engine parameters exceed their limits: • N1 / N2 Speed • ITT • Maximum Oil Pressure • Maximum Oil Temperature.
ENGINE 1 OIL LO PRESS	Low oil pressure is detected on Engine 1.
ENGINE 2 OIL LO PRESS	Low oil pressure is detected on Engine 2.
ENG 1 REV DEPLOYED * # ENG 2 REV DEPLOYED * #	Engine 1 or 2 reverser has deployed unexpectedly and has not stowed when commanded. All three permissives have failed, or FADEC cannot determine thrust reverser position.

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Table 9-1 (cont)
Warning CAS Messages

CAS Message	Description
FLT CTRL N-MODE FAIL	Indicates that the FCS is in Direct Mode.
FUEL 1 LO LEVEL FUEL 2 LO LEVEL	The wing fuel low level sensor or FCU has detected low fuel quantity in left/right wing tank.
GROUNDSPOILERS FAIL* #	One or more of the ground spoiler surfaces has extended inadvertently or has failed to extend when commanded, or a failure has occurred preventing ground spoilers from being used on landing.
HYD 1 OVERHEAT * # HYD 2 OVERHEAT * # HYD 3 OVERHEAT * #	The hydraulic system oil temperatures have overheated. There is a fire risk.
LAV SMOKE	The FWD or AFT lavatory smoke detector is in ALARM mode.
LG BAY FIRE * #	Indicates both loops A and B indicate fire or one of the loops indicates fire when there is a fault in the other loop.
LG LEVER DISAG * #	This warning indicates there is disagreement between the position of the landing gear control lever and at least one gear.
NO TAKEOFF CONFIG	The aircraft is not in a valid configuration for takeoff.
NOTE: All Warning CAS messages are inhibited during the takeoff or landing phases of flight, except those marked: * – Not inhibited during takeoff # – Not inhibited during landing	

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CAUTION (AMBER) MESSAGES

When a caution message is active, the following indications are given:

- The flashing caution message is displayed on the CAS window.
- The amber annunciator button on the glareshield panel is lit.
- A double chime aural tone is sounded.

When the master caution annunciator switch is pushed, the annunciator goes out, and the caution message stops flashing. The master caution annunciator switch is then re-armed for more incoming messages.

When the existing caution, advisory, and status messages scroll off the window and then return, the new message is displayed at the top of the caution list.

Table 9-2 lists CAUTION CAS messages.

Table 9-2
Caution CAS Messages

CAS Message	Description
>AC BUS 2 OFF	AC bus 2 has de-energized due to a failure.
>AC ESS BUS OFF	AC essential bus voltage is less than 70 V ac.
ADS 1 FAIL	ADS 1 has failed.
ADS 1 HTR FAIL*	ADS 1 heater has failed.
ADS 2 FAIL	ADS 2 has failed.
ADS 2 HTR FAIL*	ADS 2 heater has failed.
ADS 3 FAIL	ADS 3 has failed.
ADS 3 HTR FAIL	ADS 3 heater has failed.
ADS 4 FAIL	ADS 4 has failed.
ADS 4 HTR FAIL	ADS 4 heater has failed.
ADS MISCOMPARE*#	Air Data System is unreliable for CREW.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
AFT EBAY SMK DET FAIL	Aft E-Bay smoke detector is failed AND (E-Bay Backup smoke detector is failed OR Fwd E-Bay smoke detector is failed OR Mid E-Bay smoke detector is failed); OR Aft E-Bay Temperature Sensor is failed (two elements).
AFT EBAY SMOKE	Smoke is detected in the AFT E-Bay, OR Aft E-Bay Temperature Sensor indicates overtemperature, OR Aft E-Bay Smoke detector is failed, AND smoke is detected by the E-Bay Backup Smoke Detector, AND smoke is not detected by Fwd E-Bay Smoke detector, AND smoke is not detected by Mid E-Bay Smoke detector.
AHRS FAIL	AHRS fail or misleading information detected by Flight Control System.
A-I ENG 1 FAIL	Engine 1 NAI valve is closed or regulating low pressure or failure in the A-I duct when valve is commanded on. Anti-ice function lost on Engine 1.
A-I ENG 2 FAIL	Engine 2 NAI valve is closed or regulating low pressure or failure in the A-I duct when valve is commanded on. Anti-ice function lost on Engine 1.
A-I LO CAPACITY	Anti-ice is commanded on in flight, and the anti-ice thermal power capacity (pressure, temperature) is low (left or right side).

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
A-I WING FAIL	A failure has occurred in the system, which results in the loss of the anti-ice function (either left or right side).
A-I WING NO DISPATCH	The aircraft cannot be dispatched before a maintenance action since failure in the wing A-I system may prevent engine start.
A-I WING NOT AVAIL	Anti-Ice requested ON outside the operational envelope.
AILERON LH FAIL#	Both left aileron actuators are disengaged, or the surface is jammed.
AILERON RH FAIL#	Both right aileron actuators are disengaged, or the surface is jammed.
AMS CTRL 1 FAIL	Both control channels of the AMS controller 1 are not working. Consequently, all functions related to bleed and ECS of the left side of the aircraft will stop working, as well as one of the Outflow Valve AUTO Channels, the APS and the Emergency Ram Air Valve.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
AMS CTRL 2 FAIL	Both control channels of the AMS controller 2 are not working. Consequently, all functions related to bleed and ECS of the right side of the aircraft will stop working, as well as one of the Outflow Valve AUTO Channels. The crew will be aware that fine tuning of temperature control has been lost.
AP FAIL	The AP function has failed.
APM FAIL	Three or four APMs have failed. No dispatch relief.
APM MISCOMP	One or more APMs do not match.
APU ALTITUDE EXCEED	Maximum operating altitude of the APU has been exceeded.
APU FAIL	The APU has failed.
APU FAULT	The APU has an internal fault.
APU FIRE DET FAIL	Loss of APU fire detection capability.
APU FIREX FAIL	Low bottle pressure, or no bottle power supply available, or bottle cartridge internal resistance failure with no discharge command.
APU FUEL SOV FAIL	The APU fuel SOV is undetermined or does not match the command.
APU GEN OFF BUS	The APU generator is inoperative with the APU running.
APU OIL HI TEMP	APU indicating high oil temperature.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
APU OIL LO PRESS	APU indicating low oil pressure.
AT FAIL	Auto Throttle has failed. Selected AT function is unavailable due to a detected failure of one of the required inputs or internal failure.
AT NOT IN HOLD * #	A/T is not in TO hold following the transition above 60 knots during TO ROLL and until the aircraft transitions 400 feet above ground level (AGL).
AURAL WRN SYS FAIL	Both aural warning channels have failed.
AURAL WRN SYS OFF	The aural warning system has been disabled through the MCDU Aural page.
AUTOBRAKE FAIL #	Indicates a failure condition when autobrake is armed
AVNX ASCB FAULT	One or more ASCB buses have failed.
AVNX MAU 1 FAN FAIL	Set when either channel's NG-NIC monitor detects that any two or more fans cannot be turned on.
>AVNX MAU 1A FAIL	All functions hosted in MAU channel are unavailable.
AVNX MAU 1A OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.
>AVNX MAU 1B FAIL	All functions hosted in MAU channel are unavailable.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
AVNX MAU 1B OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.
AVNX MAU 2 FAN FAIL	Set when either channel's NG-NIC monitor detects that any two or more fans cannot be turned on.
>AVNX MAU 2A FAIL	All functions hosted in MAU channel are unavailable.
AVNX MAU 2A OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.
>AVNX MAU 2B FAIL	All functions hosted in MAU channel are unavailable.
AVNX MAU 2B OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.
AVNX MAU 3 FAN FAIL	Set when either channel's NG-NIC monitor detects that any two or more fans cannot be turned on.
>AVNX MAU 3A FAIL	All functions hosted in MAU channel are unavailable.
AVNX MAU 3A OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
>AVNX MAU 3B FAIL	All functions hosted in MAU channel are unavailable.
AVNX MAU 3B OVHT	The MAU has suffered an over temperature condition. Continued operation results in the loss of all functions hosted in MAU Channel.
BATT 1 DISCHARGING * #	Battery 1 is discharging.
BATT 1 OFF	Battery 1 contactor is not closed.
BATT 2 DISCHARGING * #	Battery 2 is discharging.
BATT 2 OFF	Battery 2 contactor is not closed.
BATT1 TEMP SENS FAULT	Indicates a battery 1 sensor fault.
BATT2 TEMP SENS FAULT	Indicates a battery 2 sensor fault.
BLEED 1 FAIL	Failure occurred in the system that results in the left bleed system being commanded off by the AMS controller.
BLEED 1 LEAK	Displayed any time a leakage is detected or loss of leak detection capability on Bleed 1, Pack 1, or APS loops have occurred, which results in the left bleed system being commanded OFF by the AMS controller.
BLEED 1 OVERPRESS	Overpressure is detected in left bleed that results in the left bleed system being commanded OFF by the AMS controller.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
BLEED 2 FAIL	Failure occurred in the system that results in the right bleed system being commanded off by the AMS controller.
BLEED 2 LEAK	Displayed any time a leakage is detected or loss of leak detection capability on Bleed 2, Pack 2, or APS loops have occurred, which results in the right bleed system being commanded OFF by the AMS controller.
BLEED 2 OVERPRESS	Overpressure is detected in right bleed that results in the right bleed system being commanded OFF by the AMS controller.
BLEED APU LEAK	Overheat is detected by the overheat detection system in the APU loop, or both APU ODS loops have failed.
BLEED LEAK DET FAIL	Both AMSC channels responsible for the ODS are failed.
BRK LH FAIL #	Loss of both wheel brakes (inboard and outboard) of left gear.
BRK OVERHEAT #	At least one BTMS indicates a temperature above 520 °C.
BRK RH FAIL #	Loss of both wheel brakes (inboard and outboard) of right gear.
CABIN DIFF PRESS FAIL	The cabin differential pressure is greater than 8.64 psid or less than -0.3 psid.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
CMS FAIL	Both CMSs have failed. There is no dispatch relief.
CREW OXY LO PRESS	Indicates that the pilot and copilot oxygen have low pressure or the oxygen pressure sensor has failed.
CREW WRN SYS FAULT	Monitor Warning 1 or 2 has failed.
CRG AFT FIRE SYS FAIL	Either all aft detectors have failed, or HI or LO bottle pressure is low (and EEDs are intact), or any early event detection (EED) is open, or any SPDA internal failures have made the extinguishing circuitry completely inoperative.
CRG FWD FIRE SYS FAIL	Either all forward detectors have failed, or HI or LO bottle pressure is low (and EEDs are intact), or any EED is open, or any SPDA internal failures have made the extinguishing circuitry completely inoperative.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
CRG FWD VENT FAIL	**DURING FLIGHT:** Displays any time the forward cargo fan is failed ON or forward cargo shutoff valve is failed OPEN. It is also required that there is an associated forward cargo fire signal or forward Ebay smoke detected, or either one of these signals invalid to set the message. This message is intended to inform the crew that a fire in the cargo bay may possibly not be able to be extinguished (inability to retain the fire extinguishing agent). **ON GROUND:** Displays if the Cargo Fan is failed either OFF or ON or the Cargo Shutoff Valve is failed either closed or open. This message is intended to inform the maintenance personnel and crew that Cargo Shutoff Valve shall be latched closed to permit aircraft dispatch. Giving Ventilation System is not available. No live animals on Cargo Compartment are permitted.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
>CTR EBAY FANS FAIL	Both Mid E-Bay Fans failed, AND aircraft is in-flight, OR Mid E-Bay Backup Fan failed, AND aircraft is on ground, OR Smoke is detected in any E-Bay, AND the normal Mid E-Bay fan fails to switch from high to low rotational speed AND the backup Mid E-Bay fan fails to switch from high to low rotational speed.
CTR EBAY SMK DET FAIL	Mid E-Bay smoke detector is failed AND (E-Bay Backup smoke detector is failed OR Fwd E-Bay smoke detector is failed OR Aft E-Bay smoke detector is failed) OR Mid E-Bay Temperature Sensor is failed (two elements).
CTR EBAY SMOKE	Smoke is detected in the Mid E-bay OR Mid E-Bay Temperature Sensor indicates overtemperature OR Mid Ebay Smoke detector is failed AND smoke is detected by the EBay Backup Smoke Detector AND smoke is not detected by Fwd EBay Smoke detector AND smoke is not detected by Aft EBay Smoke detector.
>DC BUS 1 OFF	DC bus 1 is de-energized with the AC source available.
>DC BUS 2 OFF	DC bus 2 is de-energized with the AC source available.
>DC ESS BUS 1 OFF	DC essential bus 1 voltage is less than 15 V dc.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
>DC ESS BUS 2 OFF	DC essential bus 2 voltage is less than 15 V dc.
>DC ESS BUS 3 OFF	DC essential bus 3 voltage is less than 15 V dc.
DISPLAY CTRL FAIL	There is a loss of all display controllers.
DISPLAY CTRL FAULT	There is a partial loss of display controllers.
DOOR CENTER EBAY OPEN	The center electronic bay door is open.
DOOR FWD EBAY OPEN	The forward electronic bay door is open.
DOOR HYD OPEN	The hydraulic compartment access door is open.
E2TS DISAGREE	Aircraft is not in the correct E2TS takeoff configuration.
E2TS FAIL	E2TS is failed.
ELEVATOR LH FAIL #	Both left elevator actuators are disengaged, or the surface is jammed.
ELEVATOR RH FAIL #	Both right elevator actuators are disengaged, or the surface is jammed.
EMER BRK FAIL #	Both brake accumulator pressures are low.
EMER LT NOT ARMED	Emergency lights are not armed.
EMER LT ON	Emergency lights are on.
ENG 1 BACV VLV FAIL	Indicates that the buffer air valve failed closed.
ENG 1 CONTROL FAULT	The pilot may be unable to control thrust in Engine 1, or the engine may respond slowly.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
ENG 1 FAIL #	An uncommanded shutdown of Engine 1 has occurred.
ENG 1 FAN COWL OPEN	MAU has detected that at least one of the fan cowl latches of the left engine is open.
ENG 1 FIRE DET FAIL	Loss of Engine 1 fire detection capability.
ENG 1 FUEL IMP BYPASS	Indicates fuel filter impending bypass is set for Engine 1.
ENG 1 FUEL LO PRESS	Indicates that Engine 1 fuel pressure is low.
ENG 1 FUEL SOV FAIL	The Engine 1 Fuel SOV is not in the commanded position.
ENG 1 NACELLE OVHT	Notify pilots about the following failure conditions: • Engine 1 HPC Bleed Stuck Open Both NAI valves are failed open above 60 °F • Engine 1 HOT AIR DET FAULT (Duct burst) and both NAI valves are failed open • Engine 1 FADEC OVERHEAT and both NAI valves are failed open • The Buffer Air Valve fails in full open position above 60 °F (Spinner Overheat)
ENG 1 NO DISPATCH	The FADEC has detected a NO DISPATCH fault condition on Engine 1.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
ENG 1 OIL LO LEVEL	Engine 1 has less than a sufficient oil level to complete the flight with worst-case oil consumption.
ENG 1 OIL LO TEMP*	The Engine Control System has detected a low oil temperature condition when engine is running, aircraft is on ground, and the correspondent TLA is above 50 degrees.
ENG 1 OIL SEAL FAULT	Variable Oil Reduction Valve has failed in the high flow position. At low power regimes, engine may present oil leakage that may reach the cabin.
ENG 1 REV FAIL	Engine 1 reverser is not available and must be locked out to prevent unexpected operation.
ENG 1 REV PROT FAULT	Engine 1 reverser fault is detected that does not inhibit reverser operation.
ENG 1 REV TLA FAIL	Indicates that the idle lock solenoid for the thrust lever actuator for Engine 1 has failed.
ENG 1 START VLV OPEN	The start valve is not closed when Engine 1 is running.
ENG 1 TLA FAIL	Engine 1 dual RVDT throttle failure.
ENG 2 BACV VLV FAIL	Indicates that the buffer air valve failed closed.
ENG 2 CONTROL FAULT	The pilot may be unable to control thrust in Engine 2, or the engine may respond slowly.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
ENG 2 FAIL #	An uncommanded shutdown of Engine 2 has occurred.
ENG 2 FAN COWL OPEN	MAU has detected that at least one of the fan cowl latches of the left engine is open.
ENG 2 FIRE DET FAIL	Loss of Engine 2 fire detection capability.
ENG 2 FUEL IMP BYPASS	Indicates fuel filter impending bypass is set for Engine 2.
ENG 2 FUEL LO PRESS	Indicates that Engine 2 fuel pressure is low.
ENG 2 FUEL SOV FAIL	The Engine 2 Fuel SOV is not in the commanded position.
ENG 2 NACELLE OVHT	Notify pilots about the following failure conditions: • Engine 2 HPC Bleed Stuck Open Both NAI valves are failed open above 60 °F • Engine 2 HOT AIR DET FAULT (Duct burst) and both NAI valves are failed open • Engine 2 FADEC OVERHEAT and both NAI valves are failed open • The Buffer Air Valve fails in full open position above 60 °F (Spinner Overheat)
ENG 2 NO DISPATCH	The FADEC has detected a NO DISPATCH fault condition on Engine 2.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
ENG 2 OIL LO LEVEL	Engine 2 has less than a sufficient oil level to complete the flight with worst-case oil consumption.
ENG 2 OIL LO TEMP*	The Engine Control System has detected a low oil temperature condition when engine is running, aircraft is on ground, and the correspondent TLA is above 50 degrees.
ENG 2 OIL SEAL FAULT	Variable Oil Reduction Valve has failed in the high flow position. At low power regimes, engine may present oil leakage that may reach the cabin.
ENG 2 REV FAIL	Engine 2 reverser is not available and must be locked out to prevent unexpected operation.
ENG 2 REV PROT FAULT	Engine 2 reverser fault is detected that does not inhibit reverser operation.
ENG 2 REV TLA FAIL	Indicates that the idle lock solenoid for the thrust lever actuator for Engine 2 has failed.
ENG 2 START VLV OPEN	The start valve is not closed when Engine 2 is running.
ENG 2 TLA FAIL	Engine 2 dual RVDT throttle failure.
ENG DUAL FUEL IMP BYP	The Engine Control System has detected an increased fuel filter delta pressure on both engines. This is intended to be an early indication of a filter clog or contamination.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
ENG EXCEEDANCE	One or both engines has exceeded the ITT limit.
ENG NO TAKEOFF DATA	The takeoff data has not been successfully entered.
ENG REF A-I DISAG	There is a disagreement between the REF anti-ice input and the actual anti-ice bleed configuration.
ENG REF ECS DISAG	There is a disagreement between the REF ECS input and the actual ECS bleed configuration.
ENG THR RATING DISAG	MAU detects a different thrust rating configuration between left and right engine, which could revert into an asymmetric thrust condition.
ENG TLA NOT TOGA * #	TLA is not at TOGA position when it was expected.
FD LATERAL MODE OFF #	Lateral FD mode has unexpectedly dropped due to invalid conditions.
FD VERT MODE OFF #	Vertical FD mode has unexpectedly dropped due to invalid conditions.
FLAP FAIL	Both flap electronic control channels are inoperative, or the flap system is not available because of any failures that result in the loss of the surface.
FLT CTRL BIT EXPIRED	Indicates that 50 hours or more have passed since the last time PBIT was activated.
FLT CTRL ELEV DN LIM	Elevator is near full downward deflection.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
FLT CTRL ELEV UP LIM	Elevator is near full upward deflection.
FLT CTRL HSTAB FAIL	Both Horizontal Stabilizer electronic control channels are inoperative.
FLT CTRL MAINT MODE	FCS Maintenance Switch left in maintenance mode when it should be in normal operation.
FLT CTRL NO DISPATCH	One of the components associated with the flight control system has failed and requires maintenance action prior to dispatching. (This CAS message is inhibited during the execution of PBIT.)
FLT CTRL PROT FAIL	FCS protection monitors are disabled for at least one aircraft control axis.
FLT CTRL ROLL LH LIM	The aircraft presents limited left roll control authority.
FLT CTRL ROLL RH LIM	The aircraft presents limited right roll control authority.
FLT CTRL RUD LH LIM	Rudder is near full deflection.
FLT CTRL RUD RH LIM	Rudder is near full deflection.
FMS 1 DEAD RECKONING	FMS 1 is in Dead Reckoning mode.
FMS 2 DEAD RECKONING	FMS 2 is in Dead Reckoning mode.
FMS FUEL DEST LOW	Indicates that there is insufficient usable fuel remaining to reach the destination.
FMS POS DISAG #	The two FMS positions do not agree with each filter.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
FMS1-GPS POS DISAG #	FMS 1 computed position does not agree with GPS position.
FMS2-GPS POS DISAG #	FMS 2 computed position does not agree with GPS position.
FUEL CTR XFR FAIL	Central fuel automatic transfer function has failed.
FUEL CTR XFR VLV FAIL	Forward and aft fuel transfer isolation valves are closed.
FUEL IMBALANCE	The FQMC is indicating an imbalance condition between wing fuel tanks.
FUEL LEAK SUSPECTED	There is the possibility that either one of the fuel tanks or a fuel line has a fuel leak.
FUEL TANK LO TEMP	Wing fuel tank temperature is at or below -37 degrees Celsius.
FUEL WING OVERFILL	Indicates that at least one fuel transfer pump is running and at least one wing has more than 4,100 liters of fuel.
FUEL WING XFER FAIL	The fuel WINGS transfer function is failed.
FUEL XFEED FAIL	The fuel XFEED function is failed.
>FWD EBAY FANS FAIL	Both Fwd E-Bay Fans failed AND aircraft is in-flight OR Fwd E-Bay backup fan is failed AND aircraft is on ground.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
FWD EBAY SMK DET FAIL	Fwd E-Bay smoke detector is failed AND (E-Bay Backup smoke detector is failed OR Mid E-Bay smoke detector is failed OR Aft E-Bay smoke detector is failed) OR Fwd E-Bay Temperature Sensor is failed (two elements).
FWD EBAY SMOKE	Smoke is detected in the FWD E-Bay OR Fwd E-Bay Temperature Sensor indicates overtemperature OR Fwd E-Bay Smoke detector is failed AND smoke is detected by the E-Bay Backup Smoke Detector AND smoke is not detected by Mid E-Bay Smoke detector AND smoke is not detected by Aft E-Bay Smoke detector.
GND PROX FAIL	The ground proximity function in EGPWS has failed.
GPU CONNECTED	The GPU is connected and the parking brake is released.
HF 1 FAIL	HF 1 has suffered a failure.
HF 2 FAIL	HF 2 has suffered a failure.
HSTAB LOCK FAULT	To inform no-back function of the Stabilizer Trim system is failed, and the system is relying on the Zero Velocity Hold function to hold stabilizer position.
HYD 1 EDP NOT D-PRESS	Engine driven pump (EDP) did not de-pressurize when commanded, inhibits windmill engine start.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
HYD 1 HI TEMP	Hydraulic 1 system oil temperature is hot.
>HYD 1 LO PRESS #	Hydraulic 1 pressure is low.
HYD 2 EDP NOT D-PRESS	EDP did not de-pressurize when commanded, inhibits windmill engine start.
HYD 2 HI TEMP	Hydraulic 2 system oil temperature is hot.
>HYD 2 LO PRESS #	Hydraulic 2 pressure is low.
HYD 3 HI TEMP	Hydraulic 3 system oil temperature is hot.
>HYD 3 LO PRESS #	Hydraulic 3 pressure is low.
HYD PTU FAIL	The power transfer unit (PTU) is not supplying hydraulic power to hydraulic system 2.
ICE DETECTOR FAIL	Both ice detectors are failed.
IDG 1 OFF BUS	IDG 1 is inoperative with the respective engine running, or GCU 1 failed.
IDG 1 OIL	IDG 1 oil low pressure or high temperature is indicated with the engine running.
IDG 2 OFF BUS	IDG 2 is inoperative with the respective engine running, or GCU 2 failed.
IDG 2 OIL	IDG 2 oil low pressure or high temperature is indicated with the engine running.
IFE RACK SMOKE	Smoke is detected in the In-Flight Entertainment Rack.
IRS 1 FAIL * #	IRS 1 has failed.
IRS 2 FAIL * #	IRS 2 has failed.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
IRS EXCESSIVE MOTION	In stationary alignment, excessive motion has been detected.
LAV SMOKE DET FAIL	The forward or aft lavatory smoke detector is not responding to test input.
LG DOOR OPEN	To indicate a landing gear door open condition, which is not adequate with landing gear position.
LG NO DISPATCH	Message to be activated when it is detected at least a PSEM fault, WOW system fault, NWS OVERTRAVEL or Maintenance Switch Fault.
>LG WOW SYS FAIL * #	Indicates a failure of the WOW indication system.
MFD 1 FAULT * #	The DU has failure conditions that affect functionality. Continued operation can result in the display of misleading information.
MFD 1 OVHT	The DU has an overtemperature condition. Continued operation can result in loss of DU.
MFD 2 FAULT * #	The DU has failure conditions that affect functionality. Continued operation can result in the display of misleading information.
MFD 2 OVHT	The DU has an overtemperature condition. Continued operation can result in loss of DU.
NAVCOM 1 FAIL	All functions hosted in MRC 1 are unavailable.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
NAVCOM 1 OVHT	The MRC NIM has an overtemperature condition. Continued operation can result in loss of ASCB communications from MRC 1.
NAVCOM 2 FAIL	All functions hosted in MRC 2 are unavailable.
NAVCOM 2 OVHT	The MRC NIM has an overtemperature condition. Continued operation can result in loss of ASCB communications from MRC 2.
NO ETOPS SEL	To ensure the pilot is aware of the mission profile before take-off. 10 sec debounce is added to the annunciation of this message.
PACK 1 FAIL	Failure within the pack which results in complete loss of the pack functionality.
PACK 2 FAIL	Failure within the pack which results in complete loss of the pack functionality.
PAX OXY NOT DEPLOYED	The cabin altitude is higher than 14,500 feet (+250/-500 feet), and no auto mask deployment occurs.
PFD 1 FAULT * #	DU1 has suffered failure condition(s) that affect the functionality. Continued operation may result in the display of misleading information.
PFD 1 OVHT	DU1 has an overtemperature condition. Continued operation can result in loss of the DU.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
PFD 2 FAULT * #	DU4 has suffered failure condition(s) that affect the functionality. Continued operation may result in the display of misleading information.
PFD 2 OVHT	DU4 has an overtemperature condition. Continued operation can result in loss of the DU.
PRESN AUTO FAIL	Both of the OFV auto channels OR their communication to the respective AMS controllers OR both channels A of the AMSCs are failed.
PRESN MAN FAIL	Both of the Safety Channels are Failed OR Both of the B Channels are Failed OR A combination of the Safety and B Channel which results in a total loss of Manual Control OR OFV Manual channel is Failed OR the communication to the respective AMS controllers to perform the Manual command is failed.
PRKG BRK NOT RELEASED	The parking brake is not released when WOW.
RAT FAIL	A failure was detected in the RAT system.
REACTIVE WSHEAR FAIL #	Reactive windshear function in EGPWS has failed.
RUDDER FAIL #	Both rudder actuators are disengaged, or the surface is jammed.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
RUDDER PEDAL FAIL	Rudder pedal sensors failures are detected, so commands through pedals are no longer possible.
SHAKER ANTICIPATED	The shaker activation angles have been advanced to conservative settings.
SLAT FAIL	Indicates that both Slats electronic control channels are inoperative or the slats system is not available due to any failure(s) that results in the loss of the surface.
SLAT-FLAP LEVER DISAG	Indicates that either Rat interlock or Flap/Slat interlock was violated.
SPOILER FAULT #	One or more Multi Function Spoiler panels have extended inadvertently or fail to extend or the inputs for the ground spoiler logics are unavailable.
STALL PROT FAIL #	The stall warning (shaker) function and stall protection (pusher or AOA limit) have failed.
STEEP APPR FAIL #	Steep approach function failed while armed or active or steep approach switch was pressed while steep approach function was not available.
STEER FAIL #	Indicates a failure of the steering system. This message is displayed when the landing gear is down.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
SYS CONFIG FAIL	Primus Epic automatic configuration monitoring system has found a non-dispatchable configuration error.
TCAS FAIL	TCAS has failed.
TERRAIN FAIL	Look ahead terrain and premature descent alerts in EGPWS have failed.
TRU 1 FAIL	TRU 1 is not supplying DC power to the system with respective AC bus power available.
TRU 2 FAIL	TRU 2 is not supplying DC power to the system with respective AC bus power available.
TRU ESS FAIL	The essential TRU is not supplying DC power to the system with respective AC bus power available.
VALIDATE CONFIG	The top-level system part number was updated.
VHF 1 OVHT	VHF COM 1 has an overtemperature condition. Continued operation can result in loss of MRC VHF COM.
VHF 2 OVHT	VHF COM 2 has an overtemperature condition. Continued operation can result in loss of MRC VHF COM.
VHF 3 FAIL	All functions provided by VHF 3 are unavailable.
VHF 3 OVHT	VHF COM 3 has an overtemperature condition. Continued operation can result in loss of MRC VHF COM.

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Table 9-2 (cont)
Caution CAS Messages

CAS Message	Description
WINDSHEAR FAIL * #	The windshear function of the EGPWS has failed.
WINDSHIELD 1 HTR FAIL	The SPDA has detected a failure.
WINDSHIELD 2 HTR FAIL	The SPDA has detected a failure.
XPDR 1 FAIL	MRC 1 has detected a transponder failure.
XPDR 1 IN STBY	MRC 1 has detected transponder mode changing to standby while in the air.
XPDR 2 FAIL	MRC 2 has detected a transponder failure.
XPDR 2 IN STBY	MRC 2 has detected transponder mode changing to standby while in the air.

NOTE: All Caution CAS messages are inhibited during the takeoff or landing phases of flight, except those marked:
* – Not inhibited during takeoff
# – Not inhibited during landing.

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ADVISORY (CYAN) MESSAGES

When an advisory message is active, the advisory message flashes on the CAS display for 5 seconds and then remains steady.

When advisory messages are already on the CAS display, and a new advisory message becomes active, the new message is displayed at the top of the advisory message list. When the existing caution or advisory messages are scrolled off the display, the caution and advisory message list is brought back on the CAS display with the new message shown at the top of the list. Messages are removed from the CAS display when the conditions resulting in the message are corrected. Table 9-3 lists ADVISORY CAS messages.

NOTE: When both FMSs are failed in air, all FMS CAS messages are cleared except for takeoff and landing data (TOLD) 1 FAIL and TOLD 2 FAIL.

Table 9-3
Advisory CAS Messages

CAS Message	Description
ADS 1 HTR FAULT	ADS 1 heater monitor has failed.
ADS 1 SLIPCOMP FAIL	ADS 1 side-slip compensation function has failed.
ADS 2 HTR FAULT	ADS 2 heater monitor has failed.
ADS 2 SLIPCOMP FAIL	ADS 2 side-slip compensation function has failed.
ADS 3 HTR FAULT	ADS 3 heater monitor has failed.
ADS 3 SLIPCOMP FAIL	ADS 3 side-slip compensation function has failed.
ADS 4 HTR FAULT	ADS 4 heater monitor has failed.
ADS 4 SLIPCOMP FAIL	ADS 4 side-slip compensation function has failed.
ADS-B IN NOT AVAIL	ADS-B In function is failed or not available.
ADS-B OUT NOT AVAIL	ADS-B function is not available due to the absence of data source.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
AFCS PANEL FAIL	Both CIOCALS have detected the AFCS control panel has failed.
AFCS PANEL FAULT	One CIOCAL has detected that the AFCS panel has failed. Full functionality remains but with a loss of redundancy.
A-I ENG 1 FAULT	Indicates that the pressure measured during the #1 Engine A-I System test is above the expected value or if the signal is identified by the MAU as out of range.
A-I ENG 1 INHIBIT	FADEC receives a command from aircraft (Ice Detector or Cockpit Switch) to turn on nacelle anti-ice system, and thermal inhibition is TRUE.
A-I ENG 2 FAULT	Indicates that the pressure measured during the #2 Engine A-I System test is above the expected value or if the signal is identified by the MAU as out of range.
A-I ENG 2 INHIBIT	FADEC receives a command from aircraft (Ice Detector or Cockpit Switch) to turn on nacelle anti-ice system, and thermal inhibition is TRUE.
A-I MODE NOT AUTO	Displayed when the anti-ice system has been manually activated. AUTO position is the default for the system normal operation.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
A-I SWITCH OFF	Displayed every time any of the anti-ice button switches are pushed out to the OFF position for longer than 10 seconds.
AILERON LH FAULT	Left Aileron operating at degraded rate.
AILERON RH FAULT	Right Aileron operating at degraded rate.
AIR CLEANER 1 FAIL	Left Air Cleaning System SOV is failed.
AIR CLEANER 2 FAIL	Right Air Cleaning System SOV is failed.
AMS CTRL 1 FAULT	One channel of AMS controller 1 has failed. This channel can be either for control or monitoring.
AMS CTRL 2 FAULT	One channel of AMS controller 2 has failed. This channel can be either for control or monitoring.
AP FAULT	Loss of redundancy of FCC AP Control.
APM FAULT	One or two APMs have failed, and dispatch relief is possible.
APPR 2 NOT AVAIL #	System is not capable of CAT 2 approach.
APU FIREXBTL DISCH	Extinguishing agent was released. Detected Low bottle pressure and internal cartridge resistance opened at same time.
APU FUEL HTR FAIL	Fuel heater valve stuck in bypass or direct position. Fuel filter may be blocked by icing if proper freezing conditions are met in flight or on ground.
AT FAULT	A single A/T channel has failed.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
AURAL WRN SYS FAULT	One aural warning channel has failed.
AUTOLAND 1 NOT AVAIL #	FCC not capable of performing Autoland.
AVNX MAU 1 FAN FAULT	Set when any channel NIC monitor detects that a fan cannot be turned on.
AVNX MAU 1A FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.
AVNX MAU 1B FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.
AVNX MAU 2 FAN FAULT	Set when any channel NIC monitor detects that a fan cannot be turned on.
AVNX MAU 2A FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.
AVNX MAU 2B FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.
AVNX MAU 3A FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.
AVNX MAU 3B FAULT	MAU has suffered failure condition(s) that does not affect the functionality but may result in the loss of redundancy.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
BLEED 1 OFF	Displayed any time the left bleed system is selected OFF, or any failure has occurred, which results in the left bleed system being commanded OFF by the AMS controller.
BLEED 2 OFF	Displayed any time the right bleed system is selected OFF, or any failure has occurred, which results in the left bleed system being commanded OFF by the AMS controller.
BLEED LEAK DET FAULT	One sensing element of any ODS loop is failed. Only displayed on the ground.
BRK CONTROL FAULT	One or both pairs are open loop due to push Xdcer fault either or inboard outboard module or BTMS fail.
BRK LH FAULT #	There is a loss of one wheel brake (inboard or outboard) of the left gear.
BRK PEDL LH SEAT FAIL #	One or both left seat pedals LVDT has failed.
BRK PEDL RH SEAT FAIL #	One or both right seat pedals LVDT has failed.
BRK RH FAULT #	Loss of one wheel brake (inboard or outboard) of the right gear.
CCD 1 FAULT	The CCD control of one or more DUs has been lost.
CCD 2 FAULT	The CCD control of one or more DUs has been lost.
CMC FAIL	The central maintenance computer (CMC) failed.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
CRG AFT FIREX HI ARM	High rate Cargo fire extinguisher system armed either automatically or manually.
CRG AFT FIREX LO ARM	Low rate Cargo fire extinguisher system armed after High rate bottle discharged.
CRG FIRE PROT FAULT	Failures of smoke detectors in a Cargo Compartment or any SPDA internal failure, which does not render the smoke detection completely inoperative.
CRG FWD FIREX HI ARM	High rate Cargo fire extinguisher system armed either automatically or manually.
CRG FWD FIREX LO ARM	Low rate Cargo fire extinguisher system armed after High rate bottle discharged.
CVR AFT FAIL	Aft DVDR CVR function has failed.
CVR FWD FAIL	Forward DVDR CVR function has failed.
DATALINK FAIL	CMF has failed.
DEFUEL SOV OPEN	The defuel transfer valve is open.
DISTRESS ACTIVATED	ELT Distress Tracking (DT) is actively transmitting.
DISTRESS FAIL	The ADT system is not capable of detecting the aircraft distress condition or ELT DT is not capable of transmitting, and the aircraft is on ground.
DISTRESS FAULT	The capacity of ADT system of detecting the aircraft distress condition is degraded, and the aircraft is on ground.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
DOOR FLT LOCK FAIL	Message to be activated when an OWE flight lock system failure is detected.
DOOR FUELING OPEN	The RDP door is open.
EBAY SMK DET FAULT	Forward Ebay smoke detector is failed, OR Mid Ebay smoke detector is failed OR Aft Ebay smoke detector is failed OR EBay Backup smoke detector is failed OR Smoke is detected by the EBay Backup Smoke Detector AND smoke is not detected by Fwd EBay Smoke detector AND smoke is not detected by Mid EBay Smoke detector AND smoke is not detected by Aft EBay Smoke detector.
ELEVATOR LH FAULT	Left elevator operating at degraded rate.
ELEVATOR RH FAULT	Right elevator operating at degraded rate.
EMER BRK FAULT	Pressure on one brake accumulator is low or when the inboard park brake pressure is in disagreement with outboard park brake pressure.
EMER LT BATT FAULT	One or more emergency lighting system batteries failed.
ENG 1 CHIP DETECTED	Alerts the maintenance crew that oil debris have been detected by the system.
ENG 1 FADEC FAULT	MAU has lost the reception of ARINC 429 data from only one FADEC channel in the left engine.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
ENG 1 FIREXBTL A FAIL	Low bottle pressure, no bottle power supply available, or bottle cartridge internal resistance failure with no discharge command.
ENG 1 FIREXBTL B FAIL	Low bottle pressure, or no bottle power supply available, or bottle cartridge internal resistance failure with no discharge command.
ENG 1 FUEL FLOW INCR	Indicates to the pilot that the corresponding engine may operate with an increased fuel flow.
ENG 1 FUEL SW FAIL	Indicates that Engine 1 fuel switch has failed.
ENG 1 OIL IMP BYPASS	Oil filter impending bypass on Engine 1.
ENG 1 SHORT DISPATCH	FADEC has detected a short-time dispatch fault condition on Engine 1.
ENG 2 CHIP DETECTED	This message alerts the maintenance crew that oil debris have been detected by the system.
ENG 2 FADEC FAULT	MAU has lost the reception of ARINC 429 data from only one FADEC channel in the right engine.
ENG 2 ENG 2 FIREXBTL A FAIL	Low bottle pressure, no bottle power supply available, or bottle cartridge internal resistance failure with no discharge command.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
ENG 2 ENG 2 FIREXBTL B FAIL	Low bottle pressure, no bottle power supply available, or bottle cartridge internal resistance failure with no discharge command.
ENG 2 FUEL FLOW INCR	Indicates to the pilot that the corresponding engine may operate with an increased fuel flow.
ENG 2 ENG 2 FUEL SW FAIL	Indicates that Engine 2 fuel switch has failed.
ENG 2 OIL IMP BYPASS	Oil filter impending bypass on Engine 2.
ENG 2 SHORT DISPATCH	The FADEC has detected a short-time dispatch fault condition on Engine 2.
ENG FIREXBTL A DISCH	Extinguishing agent was released. Detected Low bottle pressure and internal cartridge resistance opened at same time.
ENG FIREXBTL B DISCH	Extinguishing agent was released. Detected Low bottle pressure and internal cartridge resistance opened at same time.
ENG TLA TRIM FAIL	TLA Trim function is not available.
EVS FAIL	EVS has failed. Note: This message is enabled if EVS APM option is set.
FD FAIL	The FD failed.
FD FAULT	A single FD channel has failed.
FDR AFT FAIL	Aft DVDR FDR function has failed.
FDR FWD FAIL	Forward DVDR FDR function has failed.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
FLAP FAULT	There is a loss of flap system equipment, communication bus, power supply, or sensor, which reduces availability but still allows dispatch under MEL.
FLAP CTRL FAULT	There is a loss of equipment, communication bus, power supply, or sensor, which reduces availability but still allows dispatch under MEL.
FLT CTRL HSTAB FAULT	One (out of two) Horizontal Stabilizer electronic control channel is inoperative.
FMS 1 FAIL	FMS 1 has failed.
FMS 2 FAIL	FMS 2 has failed.
FMS FUEL ALTN LOW	Indicates that there is insufficient usable fuel remaining to reach the Alternate Destination.
FMS FUEL RESERVE LOW	Indicates that there is insufficient usable fuel remaining to reach the Alternate Destination, including RESERVES if the Alternate Destination is defined or to reach the Primary Destination, including RESERVES if the Alternate Destination is not defined.
FUEL AC PUMP 1 FAIL	AC Fuel Pump 1 is failed.
FUEL AC PUMP 2 FAIL	AC Fuel Pump 2 is failed.
FUEL CONTROL FAULT	Loss of redundancy of the Fuel System Control or Indication.
FUEL CTR XFR FAULT	A fault has been detected in transfer function.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
FUEL CTR XFR NOT AUTO	Indicates that the FUEL TRANSFER MODE switch is not in the AUTO position.
FUEL DC PUMP FAIL	DC Fuel Pump is failed.
FUEL EQUAL-XFEED OPEN	There is no fuel imbalance condition, and the XFEED SOV is open.
FUEL FEED 1 FAULT	Left hand Main Fuel Feed System is failed.
FUEL FEED 2 FAULT	Right hand Main Fuel Feed System is failed.
FUEL INERT SYS FAIL	Indicates that Inert System has failed.
FUEL KG-LB MISMATCH	Fuel quantity unit indication miscompare between Aircraft APM and FQMC configuration straps.
FUEL XFEED SW DISAG	The Xfeed SW is at Low 1 or Low 2 position, but the Xfeed valve is closed due to automatic protection.
GLS 1 FAIL	GLS 1 has failed.
GLS 2 FAIL	GLS 2 has failed.
GPS 1 FAIL	GPS 1 has failed.
GPS 2 FAIL	GPS 2 has failed.
GPS 1 NOT AVAIL	GPS 1 is not available.
GPS 2 NOT AVAIL	GPS 2 is not available.
HSTAB LO RATE	Indicates that the HSCU is operating in low trim rate.
HUD 1 A3 NOT AVAIL #	HUD1A3 is not available. NOTE: This message is enabled if DUAL HUD APM option is set.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
HUD 1 FAIL	HUD 1 has failed. NOTE: This message is enabled if DUAL HUD APM option is set.
HUD 1 LVTO NOT AVAIL	HUD 1 LVTO is not available. NOTE: This message is enabled if DUAL HUD APM option is set.
HUD 2 A3 NOT AVAIL #	HUD2A3 is not available. NOTE: This message is enabled if DUAL HUD APM option is set.
HUD 2 FAIL	HUD 2 has failed. NOTE: This message is enabled if DUAL HUD APM option is set.
HUD 2 LVTO NOT AVAIL	HUD 2 LVTO is not available. NOTE: This message is enabled if DUAL HUD APM option is set.
HUD A3 NOT AVAIL #	HUD A3 is not available. NOTE: This message is enabled if Single HUD APM option is set.
HUD FAIL	HUD has failed. NOTE: This message is enabled if Single HUD APM option is set.
HUD FAN FAIL	HUD fan is not operational. NOTE: This message is enabled if Single HUD APM option is set.
HUD 1 FAN FAIL	HUD 1 fan is not operational. NOTE: This message is enabled if Dual HUD APM option is set
HUD 2 FAN FAIL	HUD 2 fan is not operational. NOTE: This message is enabled if Dual HUD APM option is set

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
HUD LVTO NOT AVAIL	HUD LVTO is not available. NOTE: This message is enabled if Single HUD APM option is set.
HYD 1 EDP FAIL	Engine-driven pump is not supplying hydraulic power to the system.
HYD 1 ELEC PUMP FAIL	Electric motor pump is not producing hydraulic power as expected.
HYD 1 LO QTY	The hydraulic system reservoir is low and requires servicing.
HYD 1 SOV FAIL	The engine hydraulic firewall shutoff valve (FWSOV) did not go to the commanded position.
HYD 2 EDP FAIL	Engine-driven pump is not supplying hydraulic power to the system.
HYD 2 ELEC PUMP FAIL	Electric motor pump is not producing hydraulic power as expected.
HYD 2 LO QTY	The hydraulic system reservoir is low and requires servicing.
HYD 2 SOV FAIL	The engine hydraulic firewall shutoff valve (FWSOV) did not go to the commanded position.
HYD 3 LO QTY	The hydraulic system reservoir is low and requires servicing.
HYD 3 PUMP A NOT ON	The electric motor pump 3A control switch is not in the normal position.
HYD PTU NOT AUTO	The PTU control switch is not in the normal position.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
HYD PUMP NOT AUTO	One of the electric motor pump control switches is not in the normal position.
HYD TEMP SENS FAIL	One or more of the hydraulic temperature sensors has failed, and the system is unable to monitor the temperature in that system.
HYD3 ELEC PUMP A FAIL	An electric motor pump is not producing hydraulic power as expected.
HYD3 ELEC PUMP B FAIL	An electric motor pump is not producing hydraulic power as expected.
ICE CONDITION * #	An icing condition is detected in flight.
ICE DETECTOR FAULT	One ice detector is failed.
IRS 1 NAV MODE FAIL	The inertial reference unit (IRU) is in Attitude mode.
IRS 2 NAV MODE FAIL	The inertial reference unit (IRU) is in Attitude mode.
IRS ALIGNING	One or more IRSs are performing a stationary alignment.
IRS PRES POS INVALID	The IRS did not receive the position or received an invalid position.
LG BAY FIRE DET FAIL	Both detector loops are invalid or have failed in the associated LG bay. (APM Option)
LG TEMP EXCEEDANCE	The maximum acceptable temperature of the brakes has been exceeded.
LOAD SHED	Some essential AC loads were disconnected.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
LPV NOT AVAIL #	LPV approach is not available.
OBSERVER OXY LO PRESS	The pilot, copilot, and observer oxygen have low pressure.
PACK 1 OFF	PACK 1OFF message will display to indicate when the ECS cooling pack 1 is OFF regardless of the pilot switch position. The PACK 1 OFF message is displayed if the pack is commanded off, the associated FCV is in the close position, or Total Flow is less than 5 ppm, and a bleed source is available for 2 or more seconds. The PACK 1 OFF message will not be displayed if the pack is turned off as part of normal engine start sequence on ground. The indication is reset when the setting conditions are removed for 5 or more seconds. Also, the PACK 1 OFF message will display to reflect that the ECS cooling pack is OFF after a leak failure event has occurred. In the event that the pilot tries to select the ECS cooling pack back ON via the control panel switch but it has been latched OFF due to Bleed 1 leak or ECS cooling pack 1 failure, PACK 1 OFF message remains displayed to indicate that the ECS cooling pack 1 is latched OFF by the AMS controller regardless of the switch position.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
PACK 2 OFF	PACK 2 OFF message will display to indicate when the ECS cooling pack 2 is OFF regardless of the pilot switch position. The PACK 2 OFF message is displayed if the pack is commanded off, the associated FCV is in the close position, or Total Flow is less than 5 ppm, and a bleed source is available for 2 or more seconds. The PACK 2 OFF message will not be displayed if the pack is turned off as part of normal engine start sequence on ground. The indication is reset when the setting conditions are removed for 5 or more seconds. Also, the PACK 2 OFF message will display to reflect that the ECS cooling pack is OFF after a leak failure event has occurred. In the event that the pilot tries to select the ECS cooling pack back ON via the control panel switch but it has been latched OFF due to Bleed 2 leak or ECS cooling pack 2 failure, PACK 2 OFF message remains displayed to indicate that the ECS cooling pack 2 is latched OFF by the AMS controller regardless of switch position.
PACK TRIM AIR FAIL	Failure occurred in the Trim Air Pressure Regulating Valve (TAPRV) or in one of the Trim Air Valves (TAV), which results in the PACK TAPRV commanded off.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
PAX OXY SW NOT AUTO	The oxygen pack is not automatic.
PITCH CONTROL DISC	The control columns are disconnected from each other.
PITCH TRIM BKUP FAIL	The backup pitch trim switch is inoperative.
PITCH TRIM LO RATE	This indicates the HS-ACE is operating in low trim rate.
PITCH TRIM SW 1 FAIL	Pilot’s pitch trim switch is inoperative.
PITCH TRIM SW 2 FAIL	Copilot’s pitch trim switch is inoperative.
PREDCT WINDSHEAR FAIL	Predictive Windshear function in Weather Radar (RDR-4000) has failed.
PRESN AUTO FAULT	One of the AMSC Auto Channels (Ch A) is Failed OR one of the OFV auto channels is Failed OR the communication to the respective AMS controller is failed, but the other auto control is fully operational.
PRINTER FAIL	Printer is not available.
RAAS FAIL	RAAS function in EGPWS has failed.
RAAS NOT AVAIL*#	Runway is not RAAS qualified or one or more external signals required for the RAAS function are invalid (high precision latitude and longitude, groundspeed, true track or true heading) or position is uncertain (or not accurate enough to use for RAAS).
RALT 1 FAIL * #	Radio altimeter 1 has failed.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
RALT 2 FAIL * #	Radio altimeter 2 has failed.
RAM AIR FAULT	The emergency ram air ventilation valve failed closed.
REMOTE CB TRIP	Remote thermal or electronic CB trip indication.
RNP AR < 0.3 NOT AVAIL	AFCS not capable of performing RNP < 0.3 operation.
RNP AR NOT AVAIL#	AFCS not capable of performing RNP = 0.3 operation.
ROLL CONTROL DISC	To indicate disconnect of the control wheels.
RUDDER FAULT	Rudder operating at degraded rate.
SATCOM FAIL	SATCOM has failed.
SHAKER 1 FAIL	Shaker 1 is disabled using the SPS cutout or has failed.
SHAKER 2 FAIL	Shaker 2 is disabled using the SPS cutout or has failed.
SLAT FAULT	There is a loss of slat system equipment, communication bus, power supply, or sensor, which reduces availability but still allows dispatch under MEL.
SLAT LO RATE	One slat electronic control channel is inoperative, and the flap system operates at half speed.
SPDA FAIL	Failure was detected in the SPDA1, SPDA2, or both SPDAs.
SPDA FAULT	Non-safety related failure was detected in SPDA1, SPDA2, or both SPDAs.
SPDBRK FAIL	Speedbrake function is failed or unavailable.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
SPDBRK LEVER DISAG	The Speedbrake Lever is in a valid non-zero position, but the speedbrake function is not enabled.
STALL PROT ICE SPEED	FCC is indicating Ice Condition.
STEEP APPR NOT AVAIL	One more system failure prevents steep approach function from being available. Message requires Steep Approach APM option to be set.
STEER FAULT	The steering system is degraded: loss of hand wheel or rudder pedal steering control. This message is displayed on the ground.
TAILSTRIKE AVOID FAIL* #	Tailstrike avoidance function is failed.
TAT 1 FAIL	One or both Total Air Temperature 1 sensing elements have failed, or TAT 1 heater has failed.
TAT 2 FAIL	One or both Total Air Temperature 2 sensing elements have failed, or TAT 2 heater has failed.
TERRAIN NOT AVAILABLE	The navigation sensors do not provide the required RNP for the phase-of-flight, or the terrain database does not cover the current region where the aircraft is flying. Ground Proximity functions and Callouts are still available.
TOLD 1 FAIL	TOLD 1 has failed.
TOLD 2 FAIL	TOLD 2 has failed.

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Table 9-3 (cont)
Advisory CAS Messages

CAS Message	Description
XBLEED FAIL	Crossbleed valve has failed.
XBLEED SW OFF	The crossbleed switch is in the OFF position.
NOTE: All Advisory CAS messages are inhibited during the takeoff or landing phases of flight except those marked: * – Not inhibited during takeoff # – Not inhibited during landing.	

STATUS (WHITE) MESSAGES

An active status message is displayed on the EICAS with no additional annunciators. New status messages are added to the top of the CAS status message list. Messages are added the same way as advisory messages. Table 9-4 lists STATUS CAS messages.

Table 9-4
Status CAS Messages

CAS Message	Description
ADS-B NOT ON	This CAS message is displayed whenever the ADS-B function is selected to OFF in MCDU.
A-I ENG 1 VLV OPEN * #	The Engine 1 NAI valve is open.
A-I ENG 2 VLV OPEN * #	The Engine 2 NAI valve is open.
A-I WING VLV OPEN * #	Indicates wing A-I valves are open.
APU DOOR LOCKED OPEN* #	APU Air Inlet Door was pinned open during maintenance due to APU Inlet Door Actuation System failure in order to allow APU utilization.
APU FUEL SOV CLOSED	This message is displayed for 10 seconds after the shut-off valve is closed.

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Table 9-4 (cont)
Status CAS Messages

CAS Message	Description
APU SHUTTING DOWN	The APU is waiting to cool before shutting down after an OFF command.
AUTOLAND OFF #	FCC detecting Autoland as OFF. Message requires Autoland 1 or Autoland 2 APM option to be set.
BLEED APU VLV OPEN	APU Bleed valve is determined to be OPEN. The APU valve has position switch to indicate that the valve is OPEN.
CRG FIREX HI DISCH	The cargo firex high-rate bottle has been discharged.
CRG FIREX LO DISCH	The cargo firex low-rate bottle has been discharged.
E2TS ENABLED	E2TS selected by the pilot.
ENG 1 FUEL SOV CLOSED	The Engine 1 fire handle is pulled, and the Engine 1 fuel SOV is confirmed closed.
ENG 1 REV INHIBIT	The Engine 1 reverser has been inhibited by a maintenance action.
ENG 1 TLA NOT IDLE * #	The message is sent when the engine is started and TLA is not at idle, or when the pilot attempts an engine shutdown when the TLA is not at idle.
ENG 1 WARM UP	Indicates that the oil temperature is below 49C on ground.
ENG 2 FUEL SOV CLOSED	The Engine 2 fire handle is pulled, and the Engine 1 fuel SOV is confirmed closed.
ENG 2 REV INHIBIT	The Engine 2 reverser has been inhibited by a maintenance action.

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Table 9-4 (cont)
Status CAS Messages

CAS Message	Description
ENG 2 TLA NOT IDLE * #	The message is sent when the engine is started and TLA is not at idle, or when the pilot attempts an engine shutdown when the TLA is not at idle.
ENG 2 WARM UP	Indicates that the oil temperature is below 49C on ground.
ENG TDS REF A-I ALL	Engine and wing anti-ice are selected from TDS.
ENG TDS REF A-I ENG	Engine anti-ice is selected in the TDS.
FLT CTRL TEST IN PROG	FCS is running tests (PBIT/IBIT).
FUEL TRAPPED*#	Indicates that the quantity different than 0 has been entered in FUEL MGT page, and this amount of fuel cannot be used.
FUEL WING XFR VLV OPN	The fuel WING XFR SOV is open.
FUEL XFEED SOV OPEN	The crossfeed fuel SOV is open.
FUEL XFR ISOL CLOSED	The forward and aft fuel transfer isolation valves are closed.
HUD A3 OFF*#	HUD A3 mode is selected OFF on MCDU. NOTE: This message is enabled if Single or Dual HUD APM option is set. The message will be suppressed if the HUD OPC (Operational Program Configuration) is disabling the A3 guidance function.

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Table 9-4 (cont)
Status CAS Messages

CAS Message	Description
HYD 1 SOV CLOSED	The engine hydraulic firewall SOV is closed when the pilot manually armed the left engine fire extinguishing system or selected the HYD SOV closed with the cockpit switch, or when the temperature switch detects the system oil temperature is too hot.
HYD 2 SOV CLOSED	The engine hydraulic firewall SOV is closed when the pilot manually armed the right engine fire extinguishing system or selected the HYD SOV closed with the cockpit switch, or when the temperature switch detects the system oil temperature is too hot.
IDG 1 DISC CMD	IDG1 was manually commanded on the electrical cockpit control panel to be disconnected.
IDG 2 DISC CMD	IDG2 was manually commanded on the electrical cockpit control panel to be disconnected.
PRINTER FAULT	The printer is degraded.
RAAS INHIB	RAAS function is inhibited when the crew pushes the RAAS inhibit switch.
STEER OFF #	Displayed on the ground when the steering is disconnected. This message is displayed on ground.

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Table 9-4 (cont)
Status CAS Messages

CAS Message	Description
TERRAIN INHIB	The Terrain Inhibit button has been pushed.
NOTE: All Status CAS messages are inhibited during the takeoff or landing phases of flight except those marked: * – Not inhibited during takeoff # – Not inhibited during landing.	

PRIMARY ENGINE INSTRUMENTS

The primary engine instrument gauges, shown in Figure 9-6, are displayed in the upper-left portion of the EICAS window.

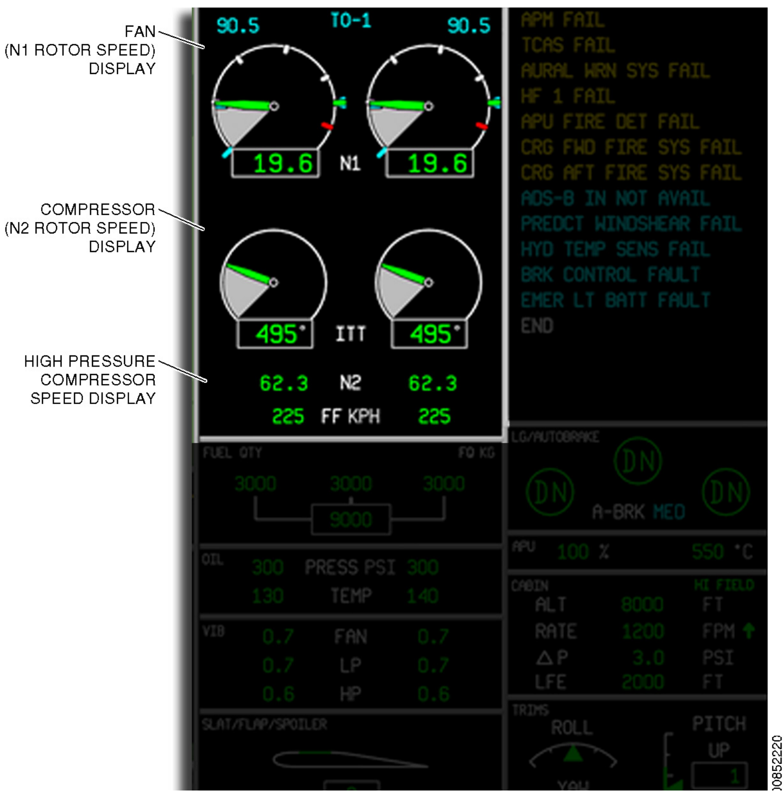

Figure 9-6
Engine Gauges

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The engine displays consist of the following instruments and annunciators:

- Engine instruments
  - N1 engine fan speed and digital readout
  - ITT (interstage turbine temperature) and digital readout
  - N2 digital compressor speed
  - Digital fuel flow
  - Fuel quantity
  - Engine oil
  - Engine vibration.
- Engine annunciators
  - Engine OFF
  - Engine FIRE
  - Engine W/M (windmill)
  - Engine START
  - Engine IGN (ignition)
  - Engine FAIL
  - Engine autothrottle modes
  - Engine thrust reversers
  - Engine anti-ice.

All displays on the EICAS are on a black background. The round engine gauges for N1 and ITT are fixed analog displays with moving pointers. Digital values are displayed below each gauge. N2 is a digital-only readout.

When required data is not available or is invalid for digital displays, the display digits are replaced with amber dashes (- - -), and the analog pointers are removed.

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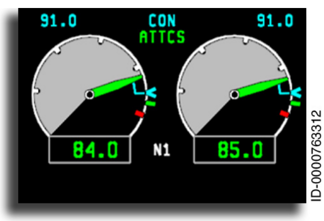
Each engine is directly controlled by a full authority digital engine control (FADEC) system. The FADEC receives command data from the autothrottle quadrant, the thrust rating system (TRS), and the power trim systems to control the engines. The FADEC supplies engine data to other aircraft systems for calculations and decisions based on engine variables.

The FADEC is energized for both engines when the START/STOP switch is set to RUN for any engine. After the aircraft is powered up, the FADEC is energized for 5 minutes to allow the BIT to be performed and any faults to be detected and annunciated. After an engine shutdown, the FADEC remains energized for 5 minutes. If any FADEC-related CAS messages are activated, the FADEC remains energized to allow the pilot to detect and report it to Maintenance.

When the FADEC is not energized due to the de-power function, the pilot can still perform the takeoff data set (TDS) procedure. TDS inputs will be put on hold by the avionics system until the FADEC is powered up prior to engine start.



Fan (N1 Rotor Speed) – The fan speeds of both engines are displayed on separate round analog dial gauges with digital readouts below each gauge. Speed is displayed as a percent of rated RPM. The gauges are identified by **N1** between the digital portions of the display.

Normal operation is displayed by a green pointer reflected in a white analog gauge with a gray shaded area between 0 and the dial pointer. Each gauge has white tick marks at 20, 40, 60, and 80% of scale. If the **N1** value is not between 0 and 999.9, the pointer is removed from the display.

The digital readout is normally green and has a range from 0 to 110 percent with a resolution of 0.1 percent.

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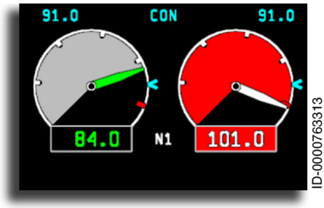
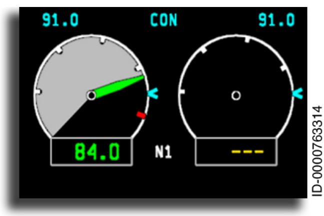
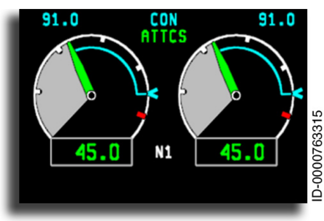


N1 Engine Red Line – One red tick mark on the inside of each dial indicates the red limitation points. The position on the dials is determined by the engine FADEC system. When N1 reaches the red limitation on the dial, the shading changes to red, the pointer turns white, and the digital readout changes to red reverse video. When the N1 value exceeds the range on the dial, the dial pointer remains at the upper-limit position. The digital readout continues to show the actual value.



N1 Gauge Invalid – When N1 data is invalid, the respective N1 dial pointer, shaded area, and red tick mark are removed, and the digital readout is replaced with three amber dashes ().



N1 Reference Arc – Commanded N1 is interpreted from the throttle quadrant and A/T trim systems by the FADEC. The N1 reference arc is displayed as a concentric cyan arc, extending from the N1 pointer to the N1 command value. The commanded value is determined by the FADEC. The commanded value is based on inputs from the active flight director mode and inputs set by the crew using the engine takeoff control pages on the MCDU. The reference arc is displayed during thrust transient or when actual N1 does not reach requested N1. If arc data is invalid or less than 0%, the N1 reference arc is removed from the display. When the value is greater than 110%, the arc is drawn from the pointer to the 110% indication on the display.

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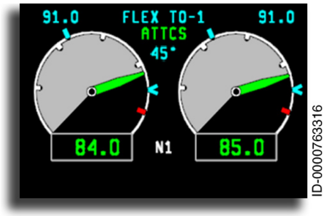
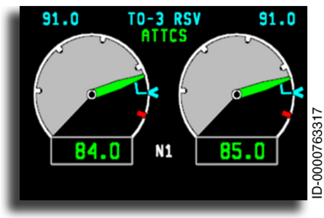
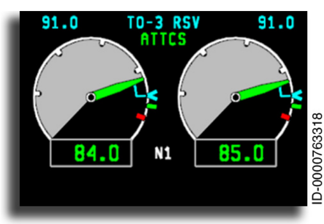


N1 Wing Anti-ice (WAI) Minimum Bug – The cyan N1 wing anti-ice minimum bug is displayed on the outside of the N1 dial. The N1 WAI bug indicates the minimum N1 value meeting the bleed requirements for the wing anti-ice system during the final approach. If the FADEC data is invalid, the bug is removed from the display.



Active Thrust Rating Bugs – When the autothrottle is engaged, a cyan open arrow symbol (<) on the outside of the dial is displayed on the N1 analog indicator. This reference bug indicates the commanded RPM, shown in cyan digits above each gauge. When the thrust rating is outside of the displayable range, the readout is replaced by three amber dashes (- - -), and the thrust rating bug stops at the applicable end of the dial. If data is invalid, the bug is removed from the display, and the readout is replaced by three amber dashes (- - -).



Max Thrust Rating Bugs – A green tick mark is placed along the outside of the dial to indicate the maximum allowed thrust in this mode. When thrust is beyond the range of the dial, the thrust mark stops at the applicable end of the dial. If data is invalid, the thrust mark is removed from the display.

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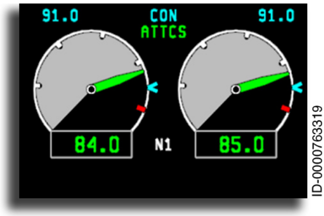
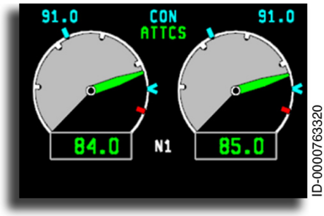


Automatic Takeoff Thrust Control System (ATTCS) – The ATTCS system automatically applies maximum power permitted on the operating engine when an engine fails during takeoff. The ATTCS annunciator is placed above and between the N1 gauges when the engines are set to the automatic takeoff thrust mode. The annunciator is white in the armed state and changes to green when the mode is captured. ATTCS is displayed in takeoff or go-around modes when the ATTCS is armed. If the ATTCS data is invalid, the annunciator is removed from the display. If the ATTCS is active in case of an engine failure, the ATTCS annunciator is removed, and TO-1 RSV, TO-2 RSV, TO-3 RSV, or GA RSV is displayed.



Thrust Rating Types and Values – The thrust rating type and digital rating values are displayed above the N1 gauges. The digital rating value (cyan) is calculated by the FADEC. The rating type is displayed between the two digital value displays in cyan.

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The thrust rating system (TRS) determines the applicable rating type for the particular phase of flight. The display uses the rating type from the AFCS to select the applicable rating values by the FADEC. Table 9-5 lists the autothrottle thrust rating annunciators. The crew has control over these parameters through the takeoff pages on the MCDU.

NOTE: The AFCS is where the Thrust Management System (TMS) is allocated.

Table 9-5
Autothrottle Thrust Rating Annunciators

Annunciator	Thrust Rating
GA	1 – Go-around
GA RSV	2 – Go-around
TO-1 RSV	3 – Takeoff
TO-1	4 – Takeoff
FLEX TO-1	5 – Takeoff
TO-2 RSV	6 – Takeoff
TO-2	7 – Takeoff
FLEX TO-2	8 – Takeoff
TO-3 RSV	9 – Takeoff
TO-3	10 – Takeoff
FLEX TO-3	11 – Takeoff
CON	12 – Continuous
CLB-1	13 – Climb
CLB-2	14 – Climb
CRZ	15 – Cruise

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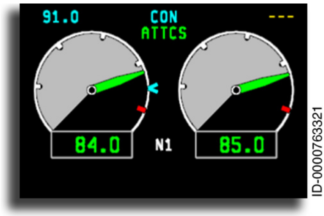
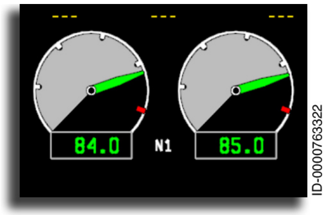
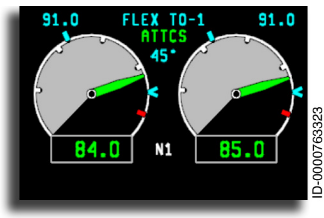


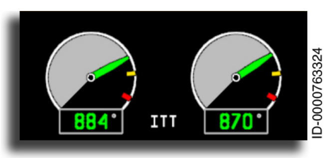
When FADEC data for one of the engines is invalid, the rating value is replaced with three amber dashes (- - -), and the cyan bug (<) is removed.



When thrust rating system data is invalid, the rating values for both engines and the rating types are replaced by three amber dashes (- - -), and all bugs are removed.



Flex Takeoff and Temperature – A flex takeoff is used to reduce the engine thrust to account for favorable takeoff conditions. The flex temperature limits thrust to a value less than the active takeoff rating when the entered flex temperature value is greater than the measured outside air temperature. Flex temperature is received by the FADEC and is displayed in cyan between the N1 dials below the ATTCS status annunciator. A degree (°C) label is displayed to the right of the flex temperature display with a resolution of 1 °C. Flex temperature is displayed when selected through the MCDU. The flex temperature value is only valid for the takeoff phase of the flight and is removed from the display at transition out of takeoff.



Interturbine Temperature (ITT) – The ITT is displayed as a dial, pointer, and digital readout for each engine. The display is labeled with ITT between the two digital portions of the ITT display. A red warning and an amber caution tick mark are placed on each dial by the engine FADEC system.

Under normal conditions, a green pointer is used in the white dial gauge with gray shading. The gauges have a range of 300 °C to 1,100 °C. The digital readout below each gauge is green with a gray degree symbol with a resolution of 1 °C.

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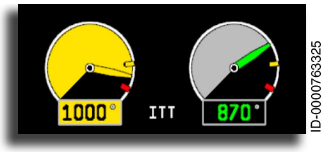
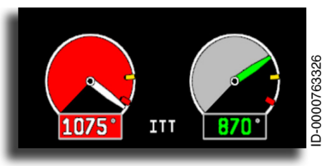
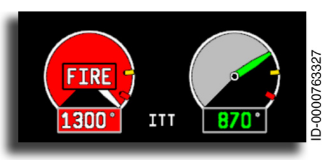
NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.



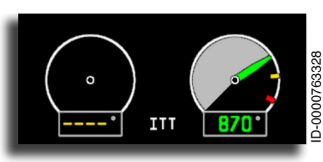
At the end of the takeoff phase, the amber tick mark is displayed on the EICAS only in flight. When ITT reaches the amber caution tick position on the dial, the shading and pointer are changed to amber and the digital readout changes to amber reverse video.



When ITT reaches the red warning tick mark on the dial, or the amber caution condition has been present for 2 minutes or longer, the shading changes to red, the dial pointer changes to white, and the digital readout changes to red reverse video. Once the dial changes to the exceedance display, it does not return to the amber range display. The dial remains in exceedance until the ITT value drops below the amber tick mark value. The display then returns to the normal ITT dial.



When ITT is beyond the displayable range, the pointer parks at maximum scale, while the digital readout continues to show the actual ITT value. When the engine sensors indicate a fire in the engine, FIRE is displayed in the center of that engine ITT gauge and an alert CAS message is displayed.



When ITT data is invalid, the respective ITT dial pointer, shading, and tick marks are removed, and the digital readout is replaced with four amber dashes (----).

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Compressor N2 Rotor Speed – The high pressure compressor speed N2 gauge is a primary engine instrument and is displayed to the crew as a digital readout for each engine. The N2 readouts are located below the ITT gauges and are labeled N2 . The digital turbine display gives the speed of the compressor as a percentage of rated rotation speed. The digital readout has a resolution of 0.1%. The N2 digital readouts are normally green with the N2 identifier between them.

NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.

When the N2 red line value is exceeded, the digital display changes to red reverse video. When N2 data is invalid or beyond the displayable range, the digital readout is replaced with three amber dashes (- - -).

Engine Fuel Flow (FF) – The digital fuel flow rate display gives the fuel usage for each engine in pounds or kilograms of fuel used per hour (pound/kilogram units are set at installation). The unit selection (pounds or kilograms) is not crew selectable. The digital readout has a resolution of 10 lb or 5 kg per hour. Fuel flow is displayed as a green four-digit digital readout for each engine. The FF readouts are located below the N2 and ITT gauges and are labeled FF . The readings are displayed in gray as kilograms per hour (KPH) or pounds per hour (PPH).

When fuel flow status is invalid or outside of the displayable range, the display digits are replaced with four amber dashes (- - - -).

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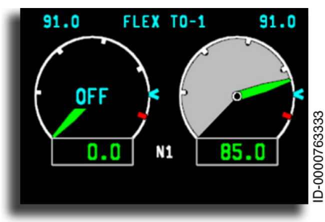
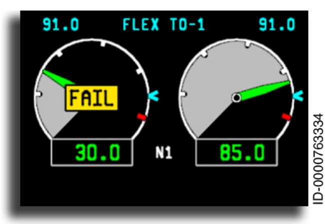
Engine Annunciators

The engine annunciators are contained in the engine instrument window area. The engine annunciators are as follows:

- Engine OFF
- Engine FAIL
- Engine ignition, IGN A, or IGN B, IGN A B, or IGN OFF
- Engine W/M (windmilling)
- Engine thrust reversers (REV).

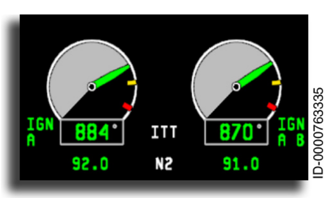


Engine OFF Annunciator – The OFF annunciator indicates the engine is shut down. The OFF annunciator is in a black box and is displayed when the FADEC indicates an engine has been shut down by the crew.



Engine Fail Annunciator – The FAIL annunciator indicates an engine failure was detected. FAIL is displayed when the FADEC indicates an engine has flamed out or shut down without crew action.

The engine IGN display gives the condition of the ignitors A and B for each engine. The possible annunciators are IGN A, IGN B, IGN A B, and IGN OFF.



IGN A is annunciated when ignitor A is active and removed when the ignitor is off. When both A and B ignitors are used, IGN A B is annunciated.

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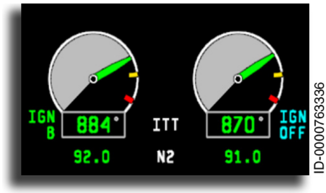
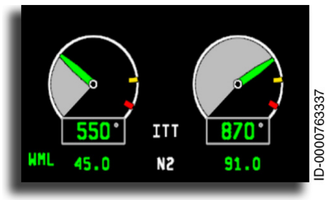
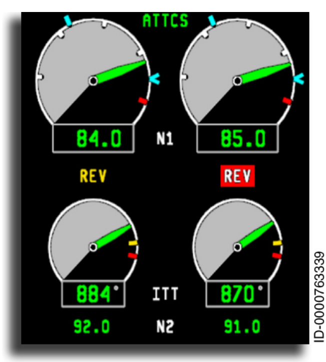


When only ignitor B is used, IGN B is annunciated. When the ignitors are off, IGN OFF is annunciated.



Windmill Annunciator – The windmill annunciator WML is displayed to the left and right of the two N2 digital readouts. WML is displayed when the condition of an engine flameout is detected and the engine has not been returned to running condition.

Thrust Reverser Annunciator – The REV annunciator indicates the thrust reverser is active and deployed correctly. The annunciators are located below the N1 gauge for each engine. The annunciators are removed when the reversers are fully stowed.



When the reversers do not deploy or stow properly, the REV annunciator changes to REV . When the thrust reversers deploy while airborne, REV is displayed, and an alert CAS message is displayed.

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FADEC

The FADEC is depowered when the aircraft is on the ground, and any of the following conditions are true:

- Five minutes after the aircraft powers up without the engine switch position being moved out of **STOP** position, or
- Five minutes after both engines are shut down.

FADEC power-off mode is deactivated as soon as one engine switch is moved to the RUN or START position or when the override switch is used.

When the FADEC is powered off (avionics ON/FADEC OFF), the pilot can complete the preflight system initialization steps associated with takeoff and thrust management.

The FADEC OFF feature supports the following flight deck functionality:

- TAKEOFF INIT page 1 and 2 allow the pilot to enter data when FADEC is depowered
- TAKEOFF INIT page 2 will not inhibit CONFIRM INIT when FADEC is depowered
- The TAKEOFF page will display calculated takeoff speeds and pitch trim when the FADEC is depowered
- Takeoff flight director mode is available to be armed
- Flight controls provide thrust rating values to the THRUST RATING SELECT page when the FADEC is depowered
- Flight controls TO pitch to the TAKEOFF page
- EICAS reflects pilot-selected data from the TDS MCDU page when the FADEC is depowered.

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Figure 9-7 shows the EICAS window when the FADEC is on.

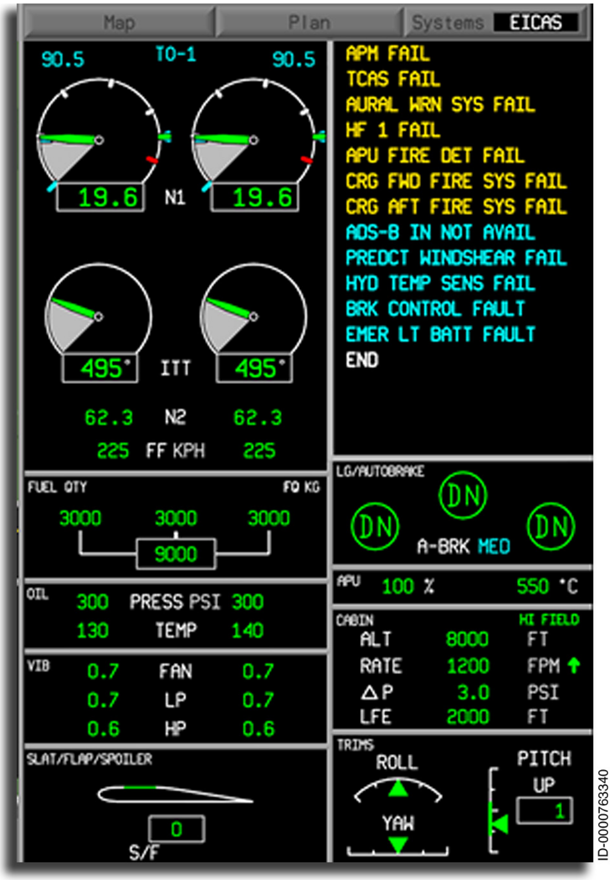

Figure 9-7
EICAS With FADEC On

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Figure 9-8 shows the EICAS window when the FADEC is off.

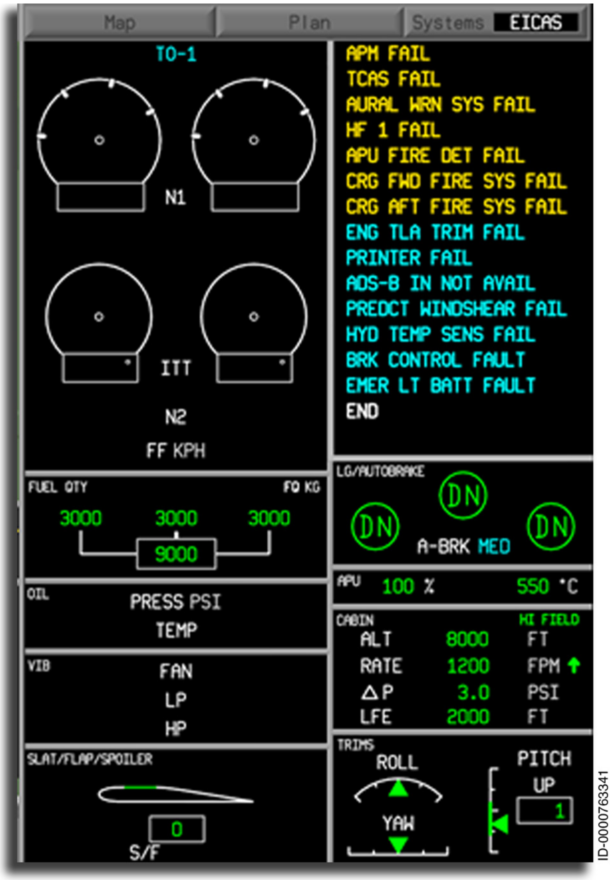

Figure 9-8
EICAS With FADEC Off

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FUEL QUANTITY

The fuel quantity window area shows left and right fuel quantity and total fuel. The window area is identified by the words **FUEL QTY** near the left edge of the display and gray dividing lines above and below the area, as shown in Figure 9-9.

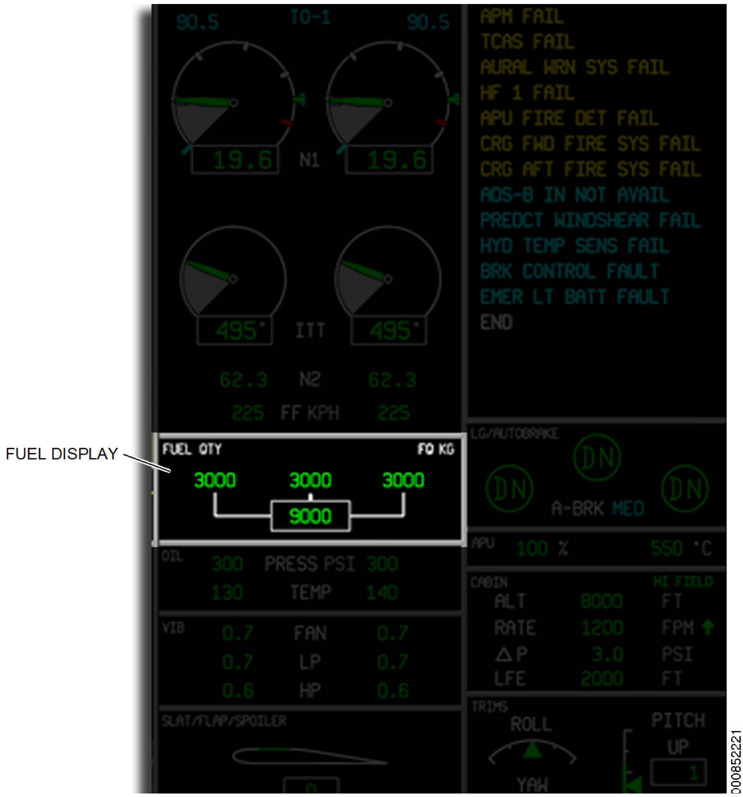

Figure 9-9
Fuel Quantity Display Location

Additional information about the fuel system is described in Section 8, Multifunction Display - Synoptics.

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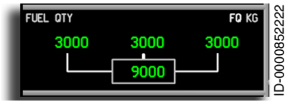
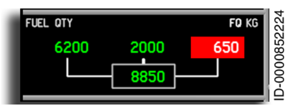


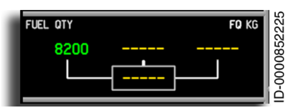
Fuel Tank Quantity – The digital fuel tank quantity display is given in pounds (LB) or kilograms (KG) and is not controlled by the crew. Two digital displays are used to represent the fuel quantity in each aircraft wing tank. The fuel tank quantity readouts have a resolution of 10 lb or 10 kg. The normal tank quantity is displayed in green.

NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.

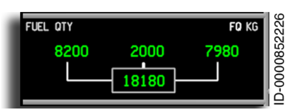
When the fuel tank level reaches the caution level, the digital display changes to amber reverse video.



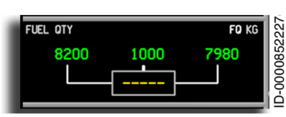
When the fuel level reaches the warning level, the digital display changes to red reverse video.



When left or right fuel quantity data is invalid, the respective digital readout is replaced with five amber dashes (- - - - -).



Total Fuel – A digital display of the TOTAL fuel onboard is displayed between the two fuel tank quantities. The value is contained in a gray box, and the color varies depending on the amount.



When data is invalid or outside of the displayable range, the total box display changes to five amber dashes (- - - - -).

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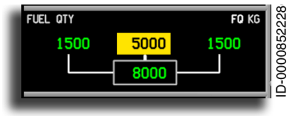

When the fuel quantity in the wings is not compatible with the central fuel tank due to a fuel transfer fail, the central fuel indication is displayed in amber.

ENGINE OIL

Oil pressure and oil temperature are displayed for each engine in the location shown in Figure 9-10. The area is identified with the OIL label on the left edge of the gray display line.

Figure 9-10
Engine Oil Readout Location

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Oil Pressure

ID-763350

Oil Pressure – The oil pressure digital readouts are identified by PRESS . The PSI units label is gray. The displays are green and represent the engine oil pressure. The digital readout is displayed with a resolution of 1 PSI. The color of the digital readouts is changed when pressure is out of the normal range.

NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.

ID-763351

When oil pressure is in the caution range, the display digits are changed to amber reverse video. When oil pressure is in the warning range, the display digits are changed to red reverse video.

ID-763352

When oil pressure data is invalid or outside of the displayable range, three amber dashes (- - -) are displayed in the digital display.

ID-763353

Oil Temperature – Oil temperature is displayed below the oil pressure display and is identified by the TEMP label. Oil temperature is measured in °C. The digital readout is green and has a resolution of 1 °C. The color of the digital readout temperature changes when out of the normal range.

ID-763354

When oil temperature is in the caution range, the display digits are changed to amber reverse video.

ID-763355

When oil temperature data for one or both of the engines is invalid, three amber dashes (- - -) are shown in the digital display.

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Engine Vibration

Engine vibration readouts are located just below the oil section, as shown in Figure 9-11.

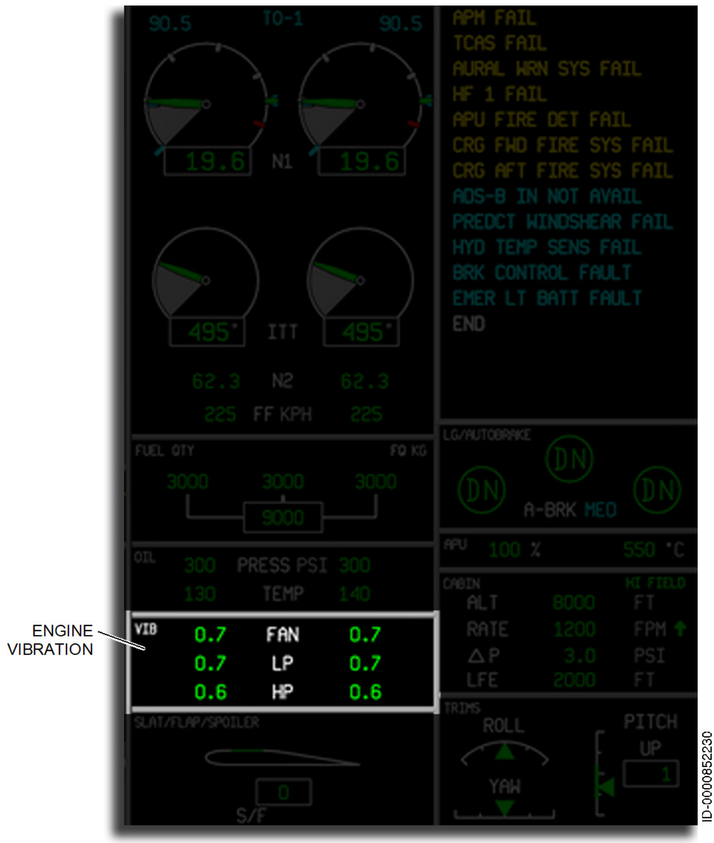
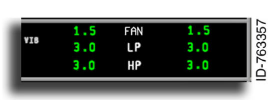


Figure 9-11
Engine Vibration Location



Fan Vibration – Fan vibration is identified by FAN . The displays are green to represent the vibration levels. The color of the display changes when vibration is detected out of the normal range by the FADEC.

> *NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.*

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ID-763358

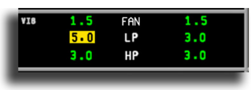
When fan vibration is in the caution range, the display changes to amber reverse video.

ID-763359

When fan vibration data is invalid, the display changes to four amber dashes (----).

ID-763360

Low Pressure (LP) Vibration – Low pressure vibration is identified by LP (low pressure). The displays are green to represent the engine LP vibration levels. The color of the display changes when vibration is detected out of the normal range by the FADEC.



ID-763361

When low pressure vibration is in the caution range, the display changes to amber reverse video.

ID-763362

When low pressure vibration data is invalid, the display changes to four amber dashes (----). If the data is outside of the displayable range, the digits are removed.

ID-763363

High Pressure (HP) Vibration – The high pressure vibration displays are identified by the HP label. The displays are green to represent the engine high pressure vibration levels. The color of the display changes when vibration is detected out of the normal range by the FADEC.

ID-763364

When vibration is in the caution range, the display changes to amber reverse video.

ID-763365

When HP vibration data for one or both of the engines is invalid, the display changes to four amber dashes (----). If the data is outside of the displayable range, the digits are removed.

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SLAT, FLAP, SPOILER, AND SPEEDBRAKE

The Flap, Slat, and Spoiler display is located in the lower-left corner of the EICAS window. The area is labeled SLAT/FLAP/SPOILER in gray, as shown in Figure 9-12.

Figure 9-12
Flap/Slat Display

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The wing icon, shown in Figure 9-13, is white with a moving flap, slat, and spoiler/speedbrake.

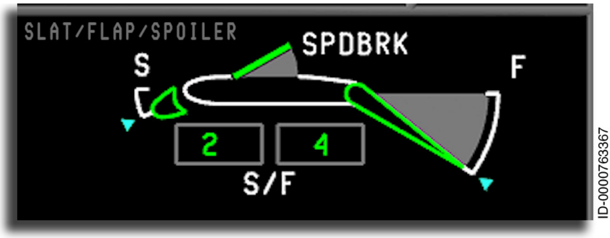

Figure 9-13
Slat, Flap, and Spoiler Display

Slat Position

Leading edge slat position is shown on the same wing section as the flap display. When the slats and flaps are retracted, and no spoilers are deployed, a plain wing section is displayed. Slats are displayed at the leading edge of the wing. An S is used to indicate the slats are deployed, and a bug and range arc with tick marks at 0 degrees and 25 degrees are used to show the position.

The slat digital readout, identified by the S label, is located below the wing display. The readout provides digital information corresponding to the slat lever position when the surface is within the tolerances specified for that position. The left gray box above the S/F shows the slat readout position. Table 9-6 lists possible slat/flap lever positions and the corresponding slat indications.

Table 9-6
Slat Position Display

Slat/Flap Lever Position	Slat Position Display
0	0°
1	11°
2	17°
3	20°
4	25°
5	25°
FULL	25°

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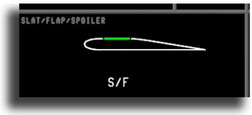
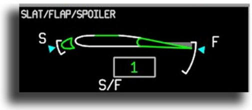
A cyan pointer is used to indicate the desired position for the slats. This pointer is set to 0, 11, 17, 20, or 25 degrees deflection by the slat control system. The pointer is located on the outside of the slat range arc.



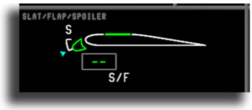
ID-763368

Normal Slat Displays – The slats are displayed on a sectional view of the wing. The normal display color is white. When the slats are retracted, the wing graphic represents a clean wing with no flap scale shown.



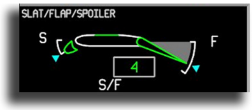
ID-763369

This normal display shows SF1 selected and the slats at 15 degrees. The slat handle bug (cyan triangle) and slats are at the same position.



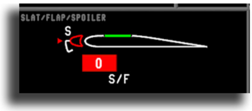
ID-763370

During transition, the digital readout is displayed with two green dashes (--).



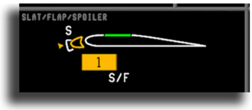
ID-763371

This normal display shows 25 degrees of slat deployment on the graphic and an equivalent position of 4 in the digital displays.



ID-763372

Abnormal Slat Displays – The slat pointer and bug change to red, and the digital display changes to red reverse video when an attempt is made to take off with the slats not set or when set in excess of takeoff position.



ID-763373

With a slat/flap lever disagreement, an invalid command, or a failed condition, the digital display changes to amber reverse video, and the pointer changes to amber.

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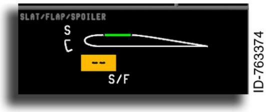

When actual slat position data is invalid, two reverse amber dashes (- -) are displayed at the flap position digital readout location, and the flap pointer and bug are removed.

Flap Position

The flap indicator gives a graphical representation of the flap position and a digital readout of the flap deflection. The digital display is located below the airfoil.

An airfoil and flap icon, in white, are used to show the flap position. The angle of flap deflection is from 0 to 35 degrees, with tick marks at 0 and 35 degrees. The F label (part of the S/F label) indicates the current position on the flap selection handle. A gray shaded area is shown between 0 degrees and the current flap position pointer.

The flap handle detent indicator (or bug) is displayed as a cyan arrow. As an operational example, when the flap handle is moved to detent position 3, the flap handle bug on the flap display moves to that position, and the flaps begin moving. When the flaps reach position 3, the flaps and pointer stop moving.

The flap digital readout, identified by the F label, is located below the wing display. The flap digital readout gives digital information that corresponds to the flap lever position when the surface is within the tolerances specified for that position. The flap readout is displayed in green during normal operations. Table 9-7 lists possible slat/flap lever positions and the corresponding flap indications.

Table 9-7
Flap Position Indicators

Slat/Flap Lever Position	Flap Position
0	0°
1	7°
2	13°
3	20°
4	25°
5	25°
FULL	35°

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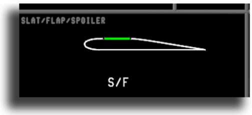
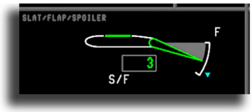


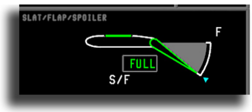
ID-763375

Normal Flap Displays – The flaps are displayed on a sectional view of the wing. The display color is white. When the flaps are retracted, the wing graphic represents a clean wing with no flap scale shown.



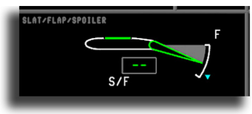
ID-763376

Normal display, showing 20 degrees selected by the flap handle detent, the flaps and pointer are positioned at 20 degrees, and the flap digital readout of 3 is displayed.



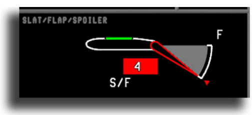
ID-763377

The normal display is showing 35 degrees of flaps on the graphic and FULL on the digital readout.



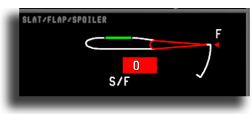
ID-763378

During transition, the digital readout is displayed with two green dashes (- -).



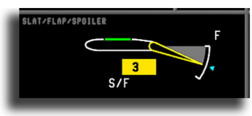
ID-763379

Abnormal Flap Displays – The flap pointer and flap bug change to red, and the digital display changes to red reverse video when an attempt is made to take off with the flaps set incorrectly.



ID-763380

When the flaps are not set, the flap pointer and flap bug are red, and the digital display changes to red reverse video.



ID-763381

When there is a slat/flap lever disagreement, an invalid command, or a failed condition, the digital display changes to amber reverse video, and the pointer changes to amber.

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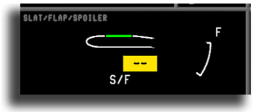
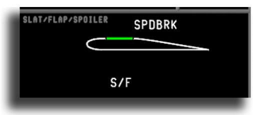


ID-763382

When actual flap position data is invalid, two reverse amber dashes (- -) are displayed at the flap position digital readout location, and the flap pointer and bug are removed.

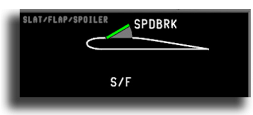
Speedbrake Indicator

The speedbrake indicator gives a graphical representation of the indicated speedbrake position. The speedbrake indicator is displayed on the same wing section as the flaps. The SPDBRK label is displayed above the wing when airborne.



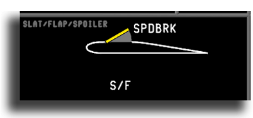
ID-873377

Normal Speedbrake Indications – When speedbrakes are retracted, the normally green speedbrake is flat with the wing.



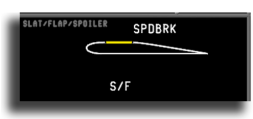
ID-763384

When speedbrakes are deployed, a green line (speedbrake) extending from the top of the wing graphic is displayed. The area between full-down and the speedbrake current position is shaded gray.



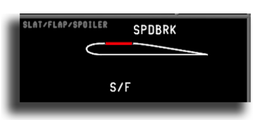
ID-763385

Abnormal Speedbrake Indications – The speedbrake symbol changes to amber when an open failure is detected.



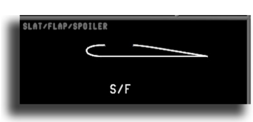
ID-873378

The speedbrake symbol changes to amber when a closed failure is detected.



ID-873379

The speedbrake symbol changes to red when out of takeoff configuration.



ID-763388

If speedbrake position data is invalid, the speedbrake section of the wing graphic is removed.

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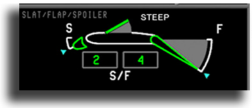
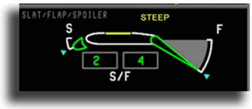
Steep Approach Indicator

The steep approach indicator gives a graphical representation of the position of the steep approach spoilers. When the steep approach spoilers are deployed, the wing surface segment is shown in the up position. When the steep approach spoilers are not deployed, the wing surface segment is shown flat with the upper wing surface. A STEEP indicator is displayed above the wing when deployed.



ID-763389

Normal STEEP Indication – When the spoilers are deployed, a green line (spoiler) extending from the top of the wing and a STEEP indicator are displayed.

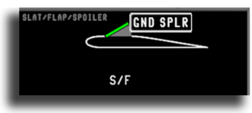


ID-763390

Abnormal STEEP Indication – If a failure occurs, a flat amber line and STEEP indication are displayed.

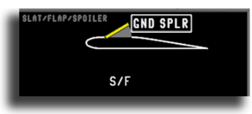
Ground Spoiler

The ground spoiler indication consists of a pointer indicating ground spoiler deployment. The ground spoiler indication is displayed using the same speedbrake icon. When the ground spoiler is deployed, the pointer is shown in the up position. When the ground spoiler is not deployed (stowed), the pointer is shown flush to the wing outline. The ground spoiler indication is displayed only when the aircraft is on the ground.



ID-763391

The GND SPLR label is displayed above the wing only when on the ground and any of the four ground spoilers are deployed. When ground spoilers are deployed, a green line (ground spoiler) extending from the top of the wing graphic is displayed. The area between full-down and the ground spoiler current position is shaded gray.



ID-763392

The ground spoiler symbol changes to amber when a failure is detected.

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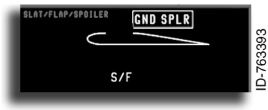

If ground spoiler position data is invalid, the ground spoiler section of the wing graphic is removed.

LANDING GEAR/AUTOBRAKE (OPTION)

The landing gear display area is located on the right side of the EICAS window, below the CAS window, as shown in Figure 9-14. The LANDING GEAR or LG/AUTOBRAKE label is in the upper-left corner of the area. The landing gear display shows the position and safety of the landing gear system.

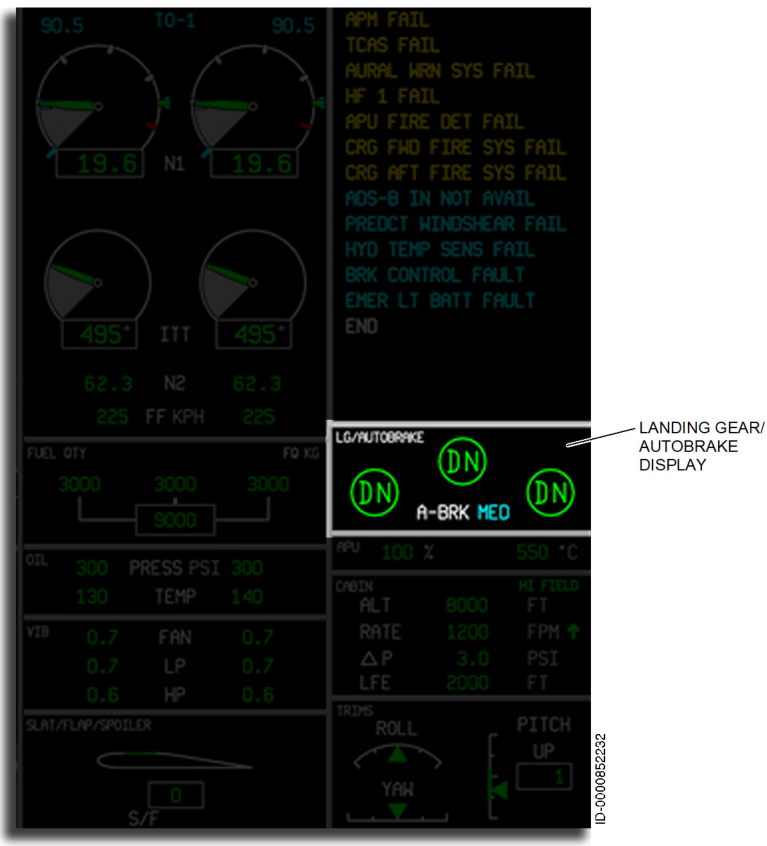

Figure 9-14
Landing Gear Status Location

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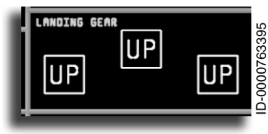
Gear Position

The display indicates the position (up, down, or in transit of each of the three landing gears), a locked condition, and the nose wheel gear doors.

Normal Gear Indications – Each of the three landing gears is represented by a rectangle indicating the gear is up or a large circle indicating the gear is down. The symbol is described for each of the display conditions.

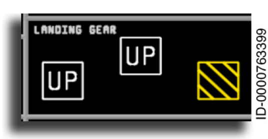


Normal indication that the gear is up and locked is a white box with a black background containing the word UP .

Normal indication that the gear is in transit and gear doors are open is an amber box with a black background containing amber cross-hatching.

Normal indication that the gear is down and locked is a green bordered circle containing the letters DN .

Unsafe Gear Indications – An indication the gear is unsafe is the symbol displayed in red reverse video.



When the gear is in transition during extension or retraction, the symbol is displayed in amber containing amber cross-hatching.

A red background with white cross-hatching is an indication that the gear is unsafe.

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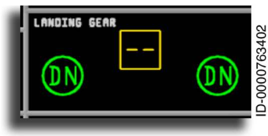
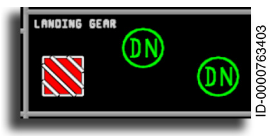
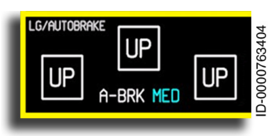
Landing gear or gear doors that fail to close after gear down are indicated in this display.



When landing gear data is invalid, the gear symbol box is changed to amber with two amber dashes inside (- -).



When an unsafe condition exists, a red background with white cross-hatching is displayed to indicate this condition.



Landing Gear Frame Flashing – When the crew intends to land the aircraft with at least one landing gear not down and locked, the landing gear warning aural alert is announced. When the aural alert is active, the landing gear frame flashes amber.

Autobrake (Option)

The autobrake system supplies braking at maximum deceleration rates, which can vary according to runway conditions for landings and rejected takeoffs. The system modulates hydraulic pressure to the brakes to supply a constant deceleration rate according to the level selected. When reverse thrust is activated, the autobrake system modulates the brake pressure to maintain a constant deceleration. When the autobrake option is installed, the window heading changes from Landing Gear to LG/AUTOBRAKE .

There are four autobrake levels of deceleration (RTO, LO, MED, HI) that are available using a selector knob on the cockpit main instrument panel. The two modes of autobrake control are as follows:

- Landing mode (LO, MED, and HI)
- Rejected takeoff mode (RTO).

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The autobrake display consists of a text indication A-BRK with an autobrake mode annunciator. The autobrake mode annunciator shows the selected autobrake deceleration rate. The flight crew controls the autobrake using the autobrake switch in the cockpit. The annunciators are in cyan and are displayed as LO, *MED*, HI, and RTO.

This display indicates the gear is up and locked, and the autobrake is LO.

When the autobrake mode is invalid, the mode annunciator is replaced with three amber dashes (---).

If the brake control module detects a fault, the autobrake switch returns to the OFF position, and the autobrake annunciator is removed.

The selector knob always returns automatically to the OFF position when the mode is armed, and any of the following disarming conditions are met:

- The selector switch is set to the OFF position.
- Pedal braking is applied while wheel speed is above 60 knots and RTO is selected.
- Brake control system failure is detected while wheel speed is below 60 knots when RTO is selected.
- One of the thrust levers is advanced beyond idle during autobrake application.

The aural message “**AUTOBRAKE”** is activated when the armed condition (LO, MED, HI, or RTO) is changed to disarmed by autobrake module (ABM) or brake control module (BCM) failure during parking, taxiing, takeoff, roll, or landing.

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AUXILIARY POWER UNIT (APU)

The APU section of the EICAS window is shown in Figure 9-15.

Figure 9-15
APU Location

The auxiliary power unit (APU) identifier, APU RPM %, and exhaust gas temperature (EGT) readouts are displayed below the landing gear window. The display area is labeled APU in gray at the left end of the gray box.

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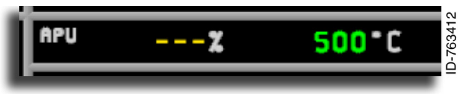
APU RPM % – The APU speed is displayed in green digits as a percent of RPM, followed by a gray percent sign (%). The APU speed has a resolution of 1%.

When APU RPM exceeds 100%, the percent digits change to amber reverse video.

When APU RPM exceeds 110%, the percent digits change to red reverse video.



When APU RPM data is invalid, the three digits change to three amber dashes (---).

APU Exhaust Gas Temperature (EGT) – The APU percent RPM is displayed, followed by up to four green digits of temperature and a gray degrees centigrade symbol. The display has a resolution 1 °C.

NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.

When APU EGT enters the caution range, the temperature digits change to amber reverse video.

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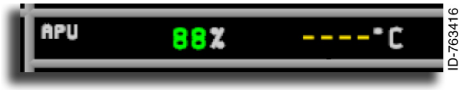
When APU EGT enters the warning range, the temperature digits change to red reverse video.



When temperature data is invalid or outside of the displayable range, the digits change to four amber dashes (----).

APU fan speed and/or temperature are removed from the display when the APU fan speed is less than 10%, and the APU master switch is selected OFF. The OFF annunciator replaces the APU fan speed and the temperature annunciators.

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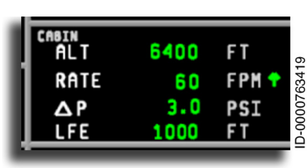
CABIN PRESSURIZATION

The cabin pressurization section is located on the lower right side of the EICAS window, as shown in Figure 9-16.

Figure 9-16
Cabin Pressurization Display



Cabin Pressurization – The cabin pressurization area shows cabin altitude, cabin altitude rate, cabin differential pressure, and landing field elevation. The area is identified by the CABIN label with a gray line above the area.

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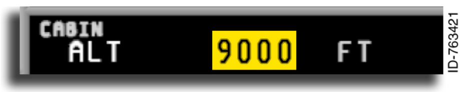
Cabin Altitude – Cabin altitude readout is an indication of the cabin altitude pressure. The cabin altitude display is labeled ALT , followed by the normal value in green and the units FT . Cabin altitude has a resolution of 100 feet, as per the inputs from the AMS system.

NOTE: Refer to the Aircraft Flight Manual (AFM) for your specific aircraft to determine the limits of normal, caution, and warning level annunciations.



When the cabin altitude is in the cation range, the cabin altitude indication changes to amber reverse video, as per the inputs from the AMS system.

When the cabin altitude is in the warning range, the cabin altitdude indication changes to red reverse video, as per the inputs from the AMS system. For airfield operations above 9,400 feet, the display changes to red reverse video when the cabin altitude is airfield altitude +500 feet.

When cabin altitude information is invalid, the value is replaced with six amber dashes (------).

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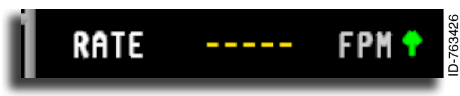
Cabin Altitude Rate – The cabin rate readout indicates the rate of change of the cabin altitude pressure. The cabin altitude rate change display is labeled RATE, followed by the value in green and the units FPM with a resolution of 50 fpm. When cabin altitude is going up, a green arrow pointing up (↑) is displayed to the right of the fpm. A green down arrow (↓) is displayed when the rate is going down. If altitude change is zero, the arrow is removed. The arrow is the same color as the cabin rate readout digits.

When the rate change is less than -2,000 fpm or more than 2,000 fpm, the digital portion of the display changes to amber reverse video, and the direction arrow changes to amber (↑).



When rate information is invalid or outside of the displayable range, the value is replaced with five amber dashes (-----).

Cabin Differential Pressure – The cabin differential pressure display is labeled ΔP, followed by the value in green and the units PSI with a resolution of 0.1 psi. The cabin differential pressure display indicates the difference between the cabin pressure and the outside ambient pressure. Improper differential pressure could indicate pressurization problems or the inability of the door to open when on the ground.

When the differential pressure is between -0.5 to -0.2 psi or 8.4 to 9.1 psi, the digit portion of the display changes to amber reverse video.

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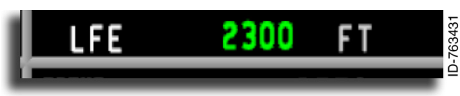
When the differential pressure is less than -0.5 psi or more than 9.1 psi, the digit portion of the display changes to red reverse video.

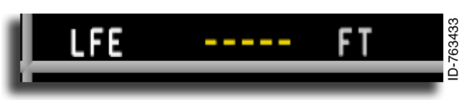
When differential pressure information is invalid, the value is replaced with three amber dashes (- - -).

Landing Field Elevation – The landing field elevation is labeled LFE , followed by the value in FT with a resolution of 100 feet. The value is entered automatically from FMS data or manually by the crew.

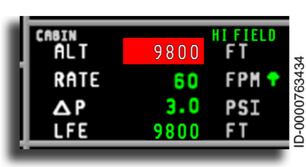


When the elevation is entered automatically, the digits portion of the display is green.

When the elevation is entered manually, the digits change to cyan with an M shown before the digits.



When landing field elevation information is invalid, or outside of the displayable range, the value is replaced with five amber dashes (- - - - -).



HI FIELD Annunciator – The HI FIELD annunciator is displayed when the selected airfield elevation is greater than or equal to 9,700 feet.

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TRIM POSITION INDICATORS

The trim position display area is in the lower-right corner of the EICAS window, as shown in Figure 9-17. The area is identified by the **TRIMS** label, and gray lines border the area.

Figure 9-17
Trim Position Location

The aircraft trim indicators show the position of the trim devices. For this aircraft, trim is performed in the roll axis by aileron trim, in the pitch axis by horizontal stabilizer trim, and in the yaw axis by rudder trim. The stabilizer trim indicator includes an indication of acceptable range during the takeoff phase of flight.

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Roll Trim (Aileron) – The position of aileron trim is displayed by a white horizontal analog arc with a green triangle pointer to indicate the amount and direction of aileron or roll trim. A **ROLL** label is located above the trim arc. The trim pointer is centered on the center tick mark for normal flight. When the roll trim is outside of the displayable range, the pointer parks at the applicable end of the scale. Five tick marks are displayed on the scale. The positions are -100, -50, 0, 50, and 100%.

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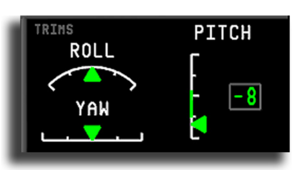
Invalid aileron trim data is indicated by the removal of the roll pointer.

Pitch Trim (Horizontal Stabilizer) – The analog pitch trim position of the horizontal stabilizer is displayed with a white vertical analog scale and a green triangle pointer representing the trim position labeled **PITCH** .

Stabilizer pitch or trim is measured in degrees in reference to the leading edge angle of the stabilizer. White tick marks are located at 4.4, .4, -3.6, -7.6, and -11.6 degrees. A green takeoff band is shown on the scale extending from -5.05 to +1.05 degrees, corresponding to the allowable pitch trim position for takeoff. The digital readout of pitch trim is located in a gray box to the right of the analog display with a resolution of 1 degree.



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The trim value is displayed in green while airborne or on the ground when the pitch trim value is within takeoff configuration. The trim value is displayed in the gray box, and the pointer shows the position on the vertical scale. The pitch trim pointer moves upward for decreasing trim and downward for increasing trim. When the pitch trim value is beyond the displayable range, the pointer parks at the applicable end of the scale.

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A pitch nose-up (UP) label is displayed above the digital readout box when the pitch value is less than or equal to 0.1 degrees. The pitch trim numerical readout and the UP label are annunciated at the same time to prevent confusion about the actual direction of trim. A green takeoff band is shown on the scale extending from -5.05 to +1.05 degrees, corresponding to the allowable pitch trim position for takeoff.

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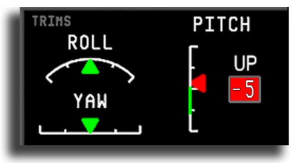
A pitch nose-down (DOWN) label is displayed below the digital box when the pitch value is greater than or equal to 0.1 degrees.



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When the trim value is out of the limits (-5.05 to +1.05 degrees) during takeoff with the takeoff configuration monitor active, the digital display changes to red reverse video, and the pointer changes to red. A warning message is also displayed in the CAS window.

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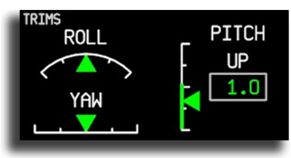
When the data is invalid, outside of the displayable range, or the aircraft type is undetermined, the pitch trim data is indicated by amber dashes (- -) in the digital display, the removal of the analog pointer, and the up or down labels.



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When E2TS is enabled, the green pitch trim band displays the E2TS pitch trim limits.

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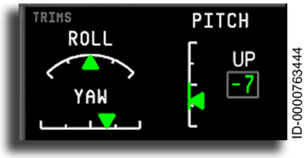
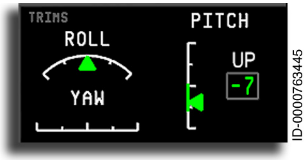
YAW TRIM (RUDDER)



Yaw Trim (Rudder) – Yaw or rudder trim is displayed by a white horizontal analog scale with a green triangular pointer to indicate the position and direction of yaw trim. The gauge is labeled YAW . There are five tick marks shown along the scale at the -100, -50, 0, 50, and 100% marks.



Invalid yaw trim data is indicated by the removal of the pointer. When yaw trim is outside of the displayable range, the pointer parks at the applicable end of the scale.

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10. Modes of Operation

INTRODUCTION

This section describes the flight director and autopilot (AP) modes of operation and approach status displays. Flight director (FD) modes are divided into lateral modes and vertical modes. The active and/or armed FD modes are displayed on the PFD in the flight mode annunciator (FMA). The FMA, shown in Figure 10-1, contains three rows (the top row is only displayed when an approach status is displayed).

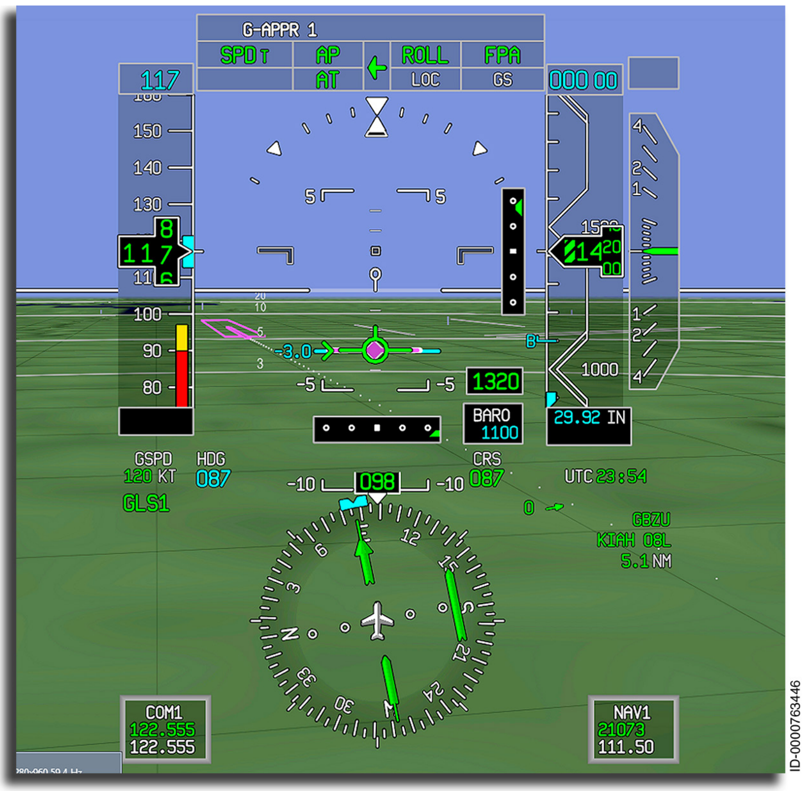

Figure 10-1
Flight Mode Annunciator

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Armed Modes

Armed modes are displayed in the lowest line on the FMA. Not all FD modes can be armed. When an FD mode is armed, the FD mode captures when the necessary criteria are met. The criteria depend on the FD mode.

Active Modes

Active modes are displayed on the middle line, and approach status modes are displayed on the top line. Active modes can be deactivated or canceled normally or abnormally. Normal cancellations include pilot actions with the intent of canceling the mode, landing the aircraft, etc. Abnormal cancellations include events such as equipment and NAVAID failure, etc.

NOTE: An FD mode will generally be canceled abnormally in the event of a failure of a required component. Every failure scenario that results in an abnormal mode cancellation is not listed.

Lateral FD Modes

The lateral FD modes control the aircraft bank angle to fly a corresponding bank angle, heading, or lateral course. The lateral FD modes are:

- ROLL (heading hold, < 6 degrees of bank)
- ROLL (bank angle hold, > 6 degrees of bank)
- HDG (Heading Select)
- LNAV (Lateral Navigation)
- LOC (Localizer)
- BC (Back Course).

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Vertical FD Modes

The vertical FD modes control the aircraft pitch to maintain a vertical climb or descent rate, path, airspeed, or angle-of-attack. The vertical FD modes are:

- FPA (Flight Path Angle)
- TO (Takeoff)
- VS (Vertical Speed)
- FLCH (Flight Level Change (displayed in green))
- FLCH (VNAV Flight Level Change (displayed in magenta))
- ASEL (Altitude Select)
- ALT (Altitude Hold)
- GS (Glideslope)
- GA (Go Around)
- VASEL (VNAV Altitude Select)
- VALT (VNAV Altitude Hold)
- PTH (VNAV Path)
- GP (VNAV Glide Path)
- WSHR (Windshear)
- OVSP (Overspeed).

Approach Status Indications

Approach status indications are displayed in the top row of the FMA and indicate the current approach capability of the aircraft. Approach status indications depend on the type of approach loaded and conditions present. Approach status conditions can be armed, active, or failed.

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LATERAL MODES

The lateral flight director modes adjust the bank angle of the aircraft to maintain a given lateral heading/course. Lateral FD modes are displayed in the lateral mode field on the FMA.

ROLL (Heading Hold) Mode

The basic lateral autopilot mode is ROLL (heading hold), shown in Figure 10-2. ROLL (heading hold) mode is annunciated as ROLL in the FMA. The ROLL (heading hold) mode is the basic (default) lateral mode and is generally activated when another lateral mode is canceled while the autopilot is ON. The autopilot enters ROLL (heading hold) mode when the following conditions are met:

- Autopilot is engaged (AP)
- No lateral flight director guidance mode is selected
- Bank angle is less than 6 degrees.

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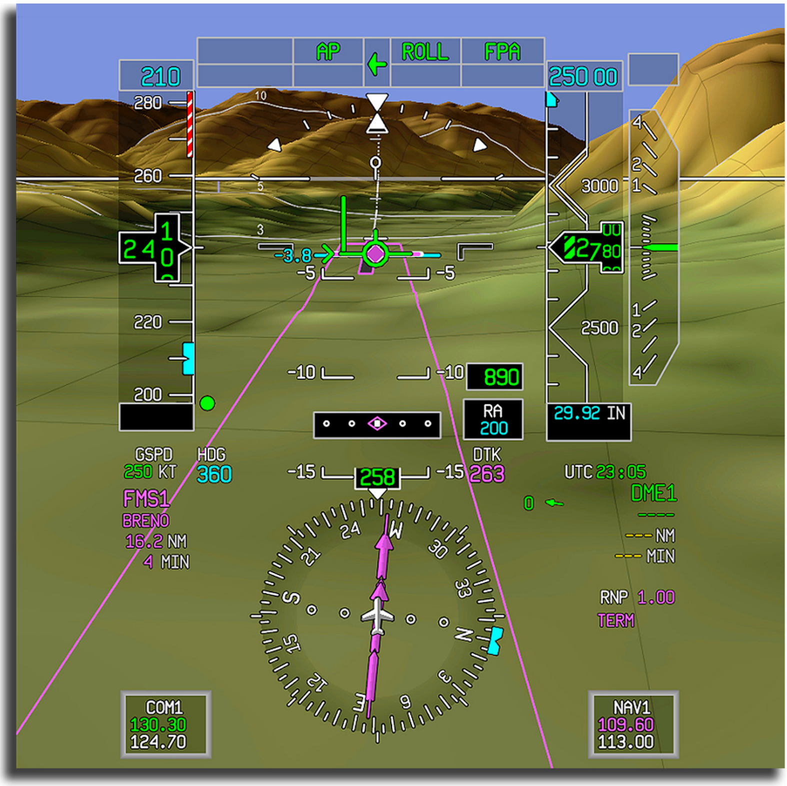

Figure 10-2
Roll (Heading Hold) Mode

When these conditions are met, the heading hold mode is automatically engaged. The autopilot rolls the aircraft to a wings-level attitude. When the aircraft bank angle is less than 3 degrees for 10 seconds, the autopilot maintains current aircraft heading. **ROLL** is annunciated on the primary flight display (PFD) as the lateral flight director mode.

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ROLL (Bank Angle Hold) Mode

The ROLL (bank angle hold) mode maintains the current bank angle. The ROLL (bank angle hold) mode is annunciated on the FMA as ROLL . The ROLL (bank angle hold) mode is the basic lateral mode when the aircraft is in a bank of greater than 6 degrees. The aircraft enters ROLL (bank angle hold) mode, as shown in Figure 10-3, when the following conditions are met:

- No lateral flight director mode is selected
- The aircraft bank angle is more than 6 degrees
- Autopilot is engaged (AP).

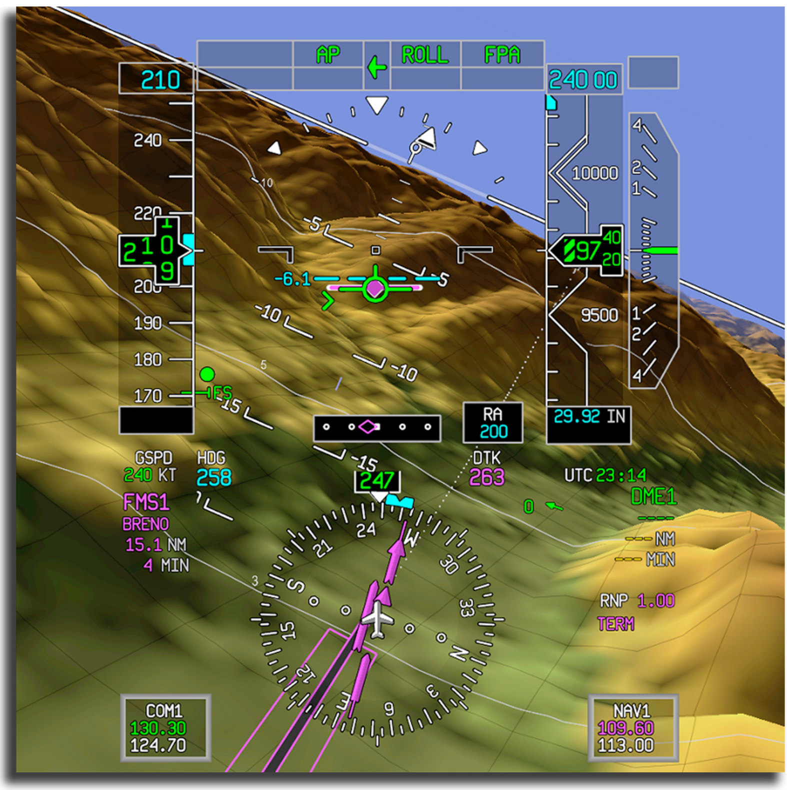

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Figure 10-3
Roll Hold Mode

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When these conditions are met, the autopilot maintains the established bank angle. The touch control steering switch can be used to change the bank angle. When the touch control steering switch is pushed, TCS replaces the AP annunciator.

HDG (Heading Select) Mode

The heading select mode, as shown in Figure 10-4, is used to intercept and maintain the selected heading. The HDG mode is engaged by pushing the **HDG** button on the guidance panel. When HDG mode is active, HDG is annunciated on the PFD.

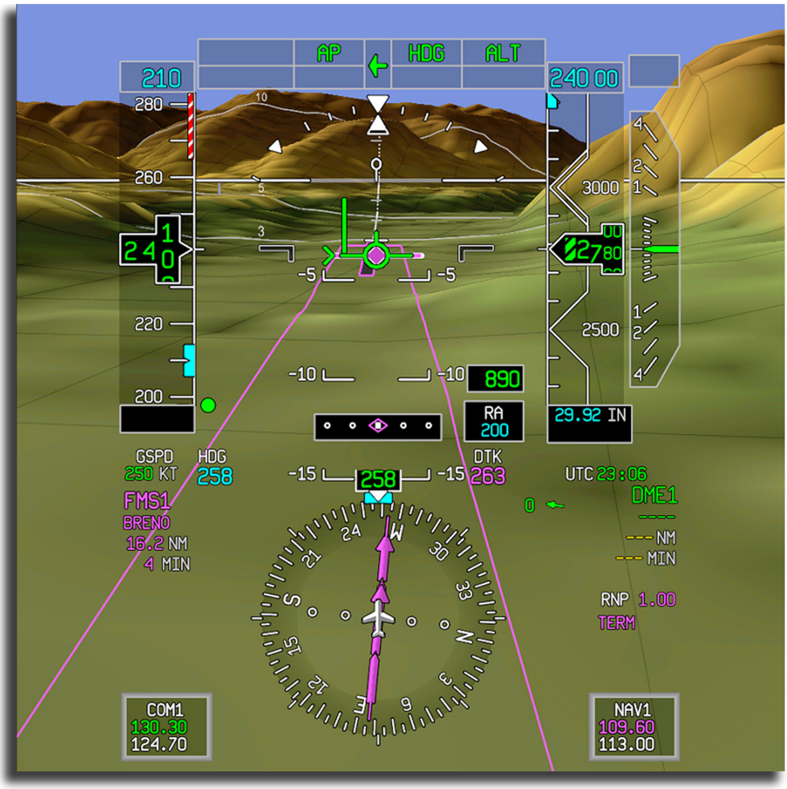

Figure 10-4
Heading Select Mode

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The following steps describe the procedure for the heading select mode:

1. Position the heading bug to the desired heading using the HDG SEL knob on the guidance panel.
2. Push the **HDG** button on the guidance panel. The PFD annunciates HDG and shows the flight director steering command to intercept and maintain the desired heading.

When the HDG mode is already selected and displayed and the heading bug is rotated more than 180 degrees, the aircraft turns in the same direction as the bug. For example, when the bug is turned to the right 270 degrees, the aircraft turns to the right 270 degrees instead of turning 90 degrees to the left. When the HDG mode is not already selected, and the heading bug is turned more than 180 degrees, the flight director guides to the selected heading target using the shortest arc.

The heading select mode limits the bank angle during heading captures using HIGH/LOW bank limits. The HIGH/LOW bank feature automatically or manually changes the bank angle limits used by the heading select mode by pushing the **BANK** button on the guidance panel. When LOW bank is active, a white arc is displayed on the roll pointer on the PFD to indicate a reduced bank.

NOTES: 1. Above 25,000 feet mean sea level (MSL), the bank angle in heading select mode automatically changes to the LOW limit of 15 degrees. When descending below 25,000 feet MSL, the bank angle returns to the HIGH bank limit of 30 degrees.

2. Each of the flight director modes is canceled by a variety of pilot (or system) actions. Only the most typical methods are described in this section.

The heading select mode is canceled by any of the following:

- Pushing the **HDG** button on the guidance panel
- Capture of any other lateral steering mode
- Selecting GA or WSHR mode
- Deactivation of FBW high speed protection.

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LNAV (Lateral Navigation) Mode

The flight management system (FMS) lateral navigation (LNAV) mode is engaged by pushing the **LNAV** button on the guidance panel with FMS selected as the displayed source on the coupled PFD. LNAV automatically engages during TO or GA if the Auto LNAV Arm APM option is enabled. The LNAV mode captures and tracks the FMS lateral course.

The following steps are required to utilize the LNAV mode:

1. Enter the data required for navigation into the FMS.
2. Select FMS as the navigation source on the coupled side PFD display controller. The **FMS** button selects FMS1 or FMS2. The NAV source annunciator is displayed as FMS1 or FMS2 .
3. Push the **LNAV** button to arm the LNAV track mode, annunciated as LNAV in the PFD mode box. The flight director directs the aircraft to the desired track intercept. When the FMS course is intercepted, LNAV is active and annunciated as LNAV .

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Figure 10-5 shows the PFD in FMS LNAV track mode.

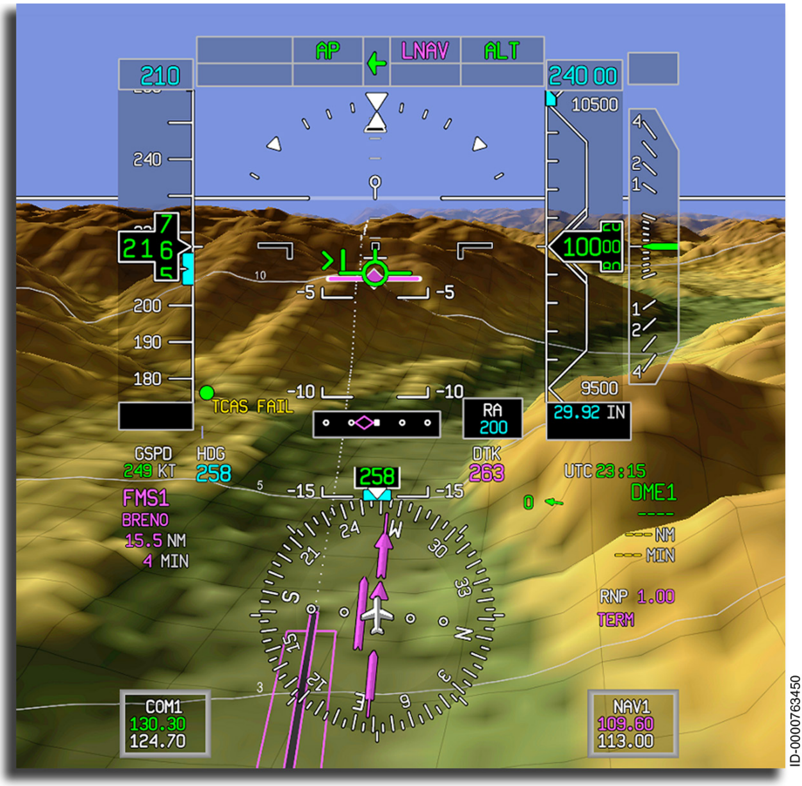

Figure 10-5
FMS LNAV Track Mode

The FMS LNAV mode is canceled normally when the following criteria are met:

- Pushing the **LNAV** button on the guidance panel
- Selecting another navigation source on the display controller
- Selecting heading mode
- Selecting GA or WSHR mode
- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel
- Capture of any other lateral steering mode (LOC, BC)
- Deactivation of FBW high speed protection.

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LOC (Localizer) Mode

The localizer mode captures and tracks the tuned localizer (front) course, as shown in Figure 10-6.

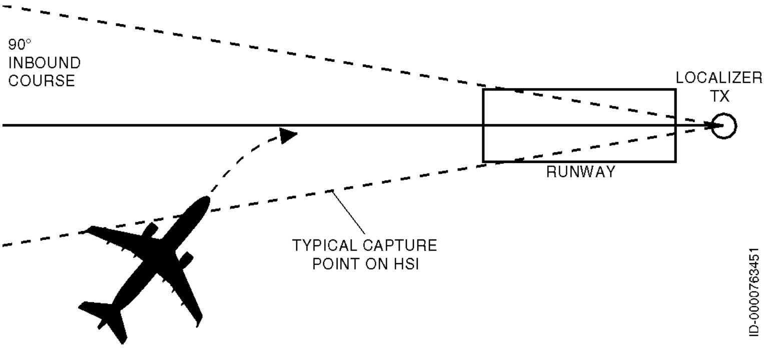

Figure 10-6
Localizer Mode Profile

The LOC mode can be used independently as a lateral mode or as part of an approach mode. The LOC mode can be armed or active.

The LOC mode is armed by pushing the **LNAV** button on the guidance panel. Pushing the **LNAV** button arms the LOC lateral mode only.

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When the LOC mode is armed, LOC is displayed in the armed field of the FMA, as shown in Figure 10-7.

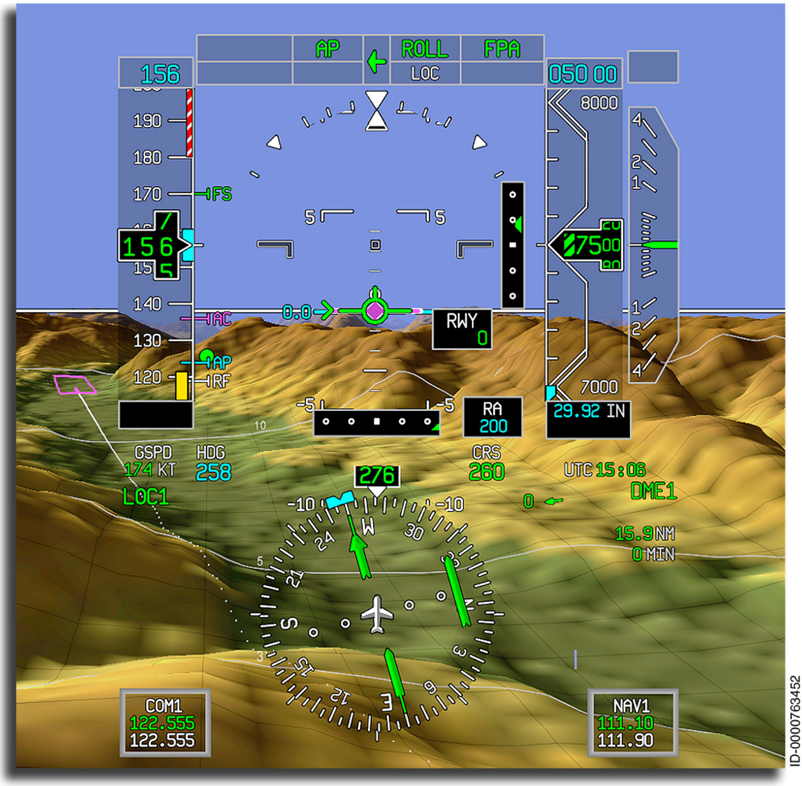

Figure 10-7
Localizer Mode Armed

In the localizer mode, the PFD shows the relative position of the aircraft to the center of the localizer beam and the selected inbound course.

When LOC mode is armed, and the aircraft approaches the localizer course, the flight director monitors localizer beam deviation, beam rate, and true airspeed. When the deviation is small enough, the localizer control mode is activated, replacing the previously active lateral mode, and captures the localizer beam to hold zero deviation.

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When the localizer mode begins to capture the localizer, LOC and LOC flash for 5 seconds until the localizer is captured. When the localizer is captured, LOC is displayed in the FMA, as shown in Figure 10-8.

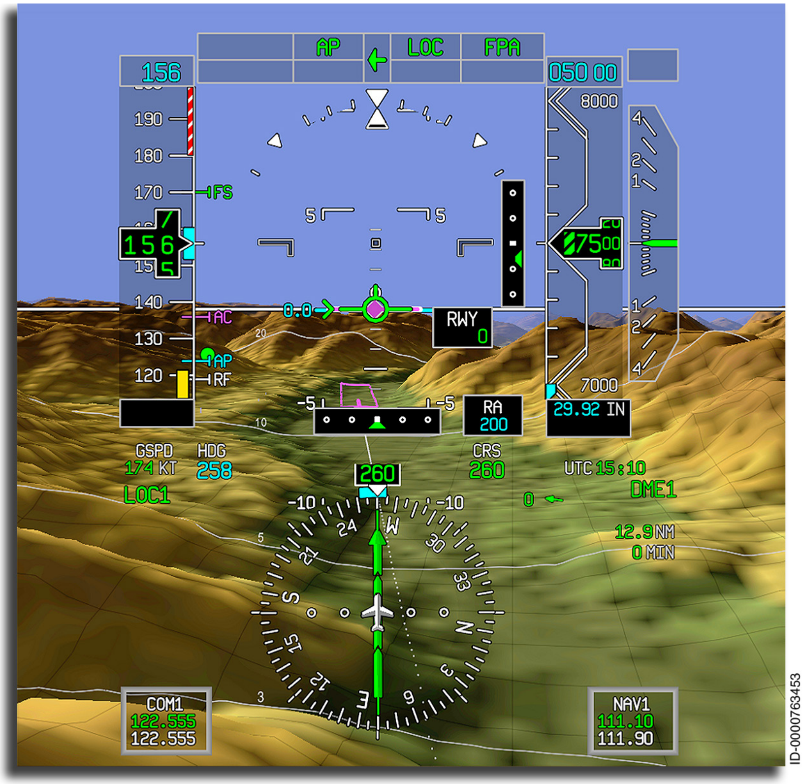

Figure 10-8
Localizer Mode Captured

NOTES: 1. When flying a localizer intercept, the optimum intercept angle is 45 degrees or less.

2. The pilot must not intercept the localizer at angles greater than 90 degrees. At angles greater than 100 degrees, the system automatically arms the back course.

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The lateral gain programming is based on radio altitude when valid and the aircraft is less than 2,500 feet AGL. If radio altitude is invalid (above 2,500 feet), gain programming is based first on the FMS-calculated distance, then if the FMS distance is invalid, DME distance is used when available. When radio altitude, FMS, or DME distance is not available, the gain programming is based on a default profile using true airspeed, a default LOC capture distance (10 NM), and time to estimate the distance from the airport.

The localizer mode is canceled by any of the following:

- Pushing the **LNAV** or **APPR** button on the guidance panel
- Selecting another navigation source on the display controller
- Selecting heading mode
- Selecting GA or WSHR mode
- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel
- Deactivation of FBW high speed protection.

BC (Back Course) Mode

The BC mode automatically intercepts, captures, and tracks the back course localizer signal. When flying a back course localizer approach, glideslope capture is automatically inhibited. The back course mode profile is shown in Figure 10-9.

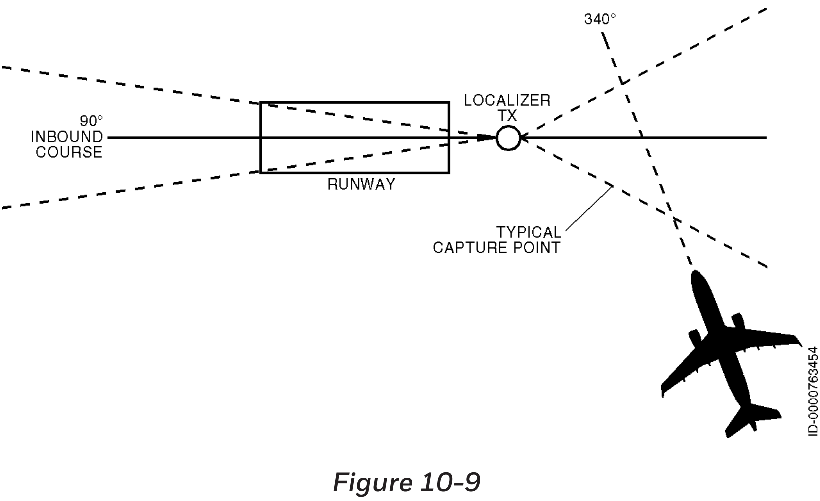

Figure 10-9
Back Course Mode Profile

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The back course mode is set up and flown as described in the following steps:

1. Toggle the **SRC** button on the guidance panel to direct the left or right arrow as the coupled side.
2. Tune the coupled-side navigation receiver to the localizer frequency for the runway in use.
3. Select LOC as the navigation source on the coupled-side display controller.
4. Rotate the CRS knob on the guidance panel to the localizer front course on the coupled PFD.
5. Set the heading bug to the desired beam intercept angle using the HDG knob on the guidance panel. Then push the **HDG** button to activate the HDG mode.
6. Push the **LNAV** button on the guidance panel to arm the BC mode. Back course armed is annunciated on the PFD as BC .

*NOTE: When the above setup is completed, and the **LNAV** button is selected while the aircraft is less than 100 ° off the front course heading,* LOC *arms but does not engage, and the armed mode automatically updates to* BC *when the aircraft heading becomes more than 100 ° off the front course heading.*

In back course mode, the system automatically reverses polarity of the course error and localizer signals. The BC mode performs the same computations as the localizer approach mode, except that a correction is made using the assumption that the transmitter is located 2,000 feet in front of the touchdown zone, and the sign of the localizer deviation is inverted.

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Figure 10-10 shows the back course armed mode.

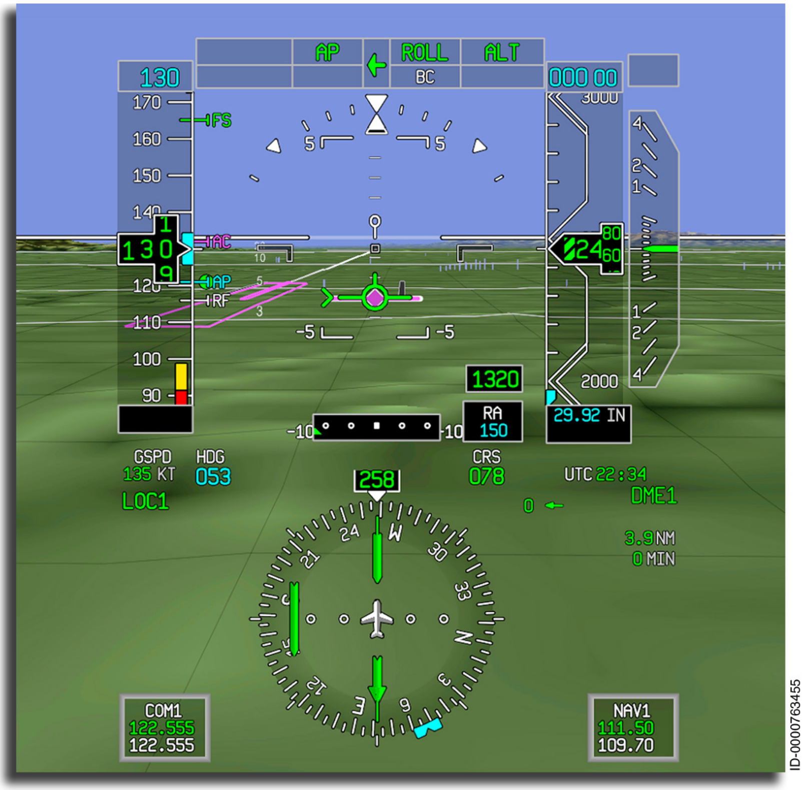

Figure 10-10
Back Course Armed Mode

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When the BC mode activates, the PFD annunciates BC , as shown in Figure 10-11. At capture, BC and BC flash for 5 seconds, and then BC remains steady.

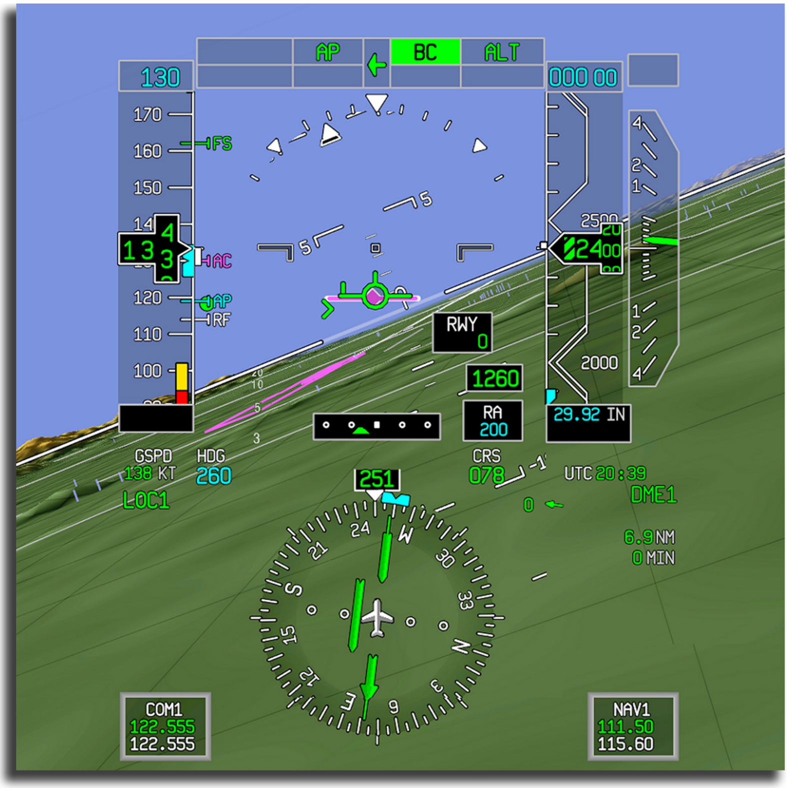

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Figure 10-11
Back Course Capture Mode

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Figure 10-12 shows the back course track mode.

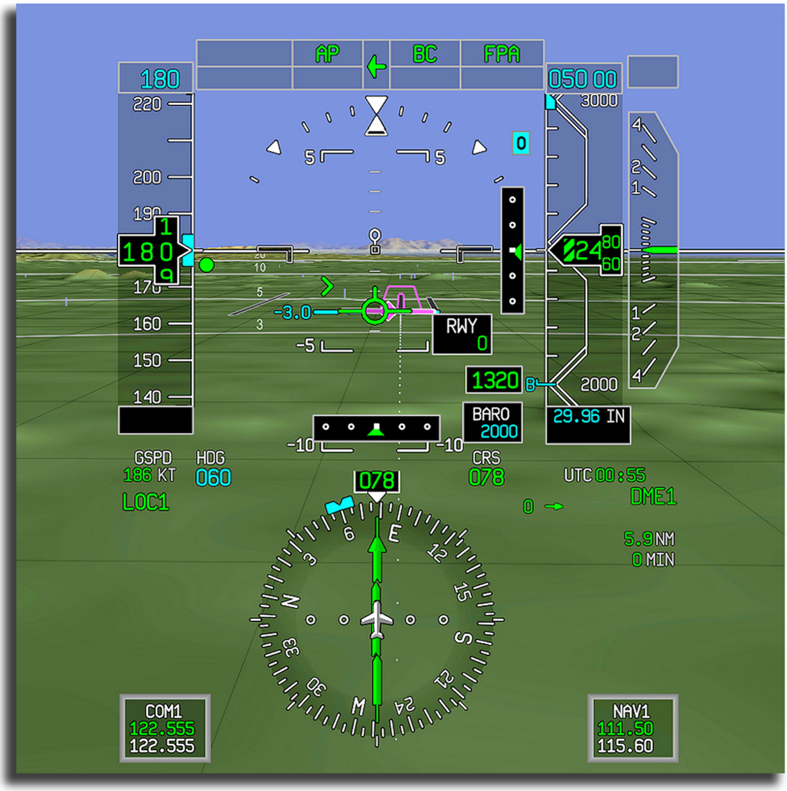

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Figure 10-12
Back Course Tracking Display

The back course mode is canceled by any of the following:

- Pushing the **APPR** or **LNAV** button on the guidance panel
- Selecting another navigation source on the display controller
- Selecting heading mode
- Selecting GA or WSHR mode
- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel
- Deactivation of FBW high speed protection.

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VERTICAL MODES

The vertical FD modes control the aircraft pitch to maintain a vertical climb or descent rate, path, airspeed, or angle-of-attack. Vertical FD modes are displayed in the vertical FD mode field in the FMA.

FPA (Flight Path Angle) Mode

The FPA mode maintains a pilot-selected flight path angle for climbs or descents. The FPA mode uses flight path angle information from the IRS to fly a vertical path at a pilot-selected angle. The FPA mode adjusts the pitch attitude of the aircraft to maintain the selected flight path angle. The flight path angle value can be set using the VS/FPA thumbwheel on the guidance panel or by pushing the **TCS** button and adjusting the pitch of the aircraft to a new FPA reference. FPA is displayed in the vertical mode field when FPA mode is active, as shown in Figure 10-13.

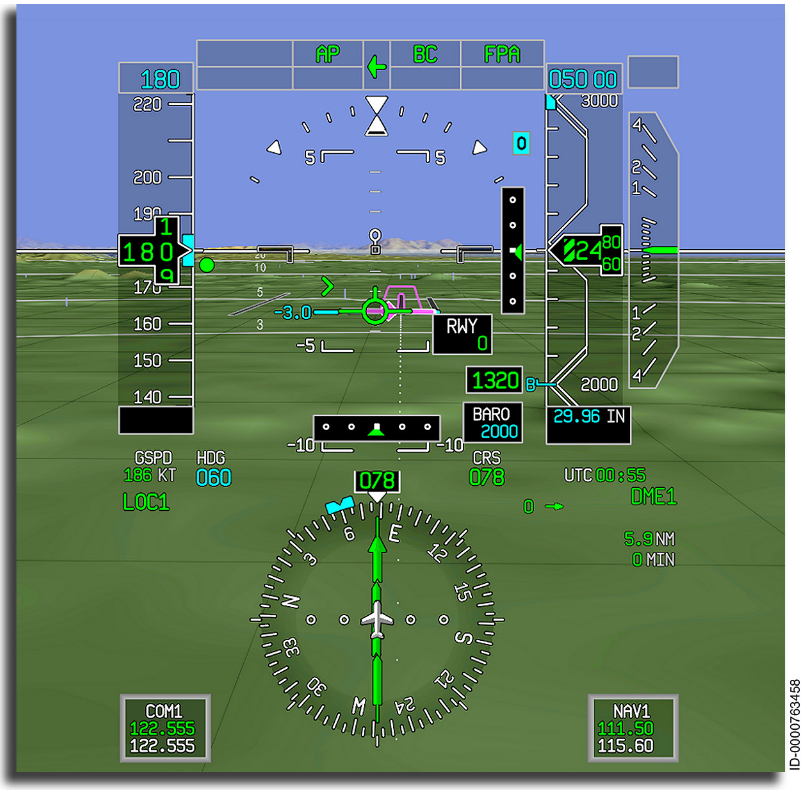

Figure 10-13
FPA Mode

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When the FPA mode is active, the selected FPA value is displayed in cyan on the PFD to the left of the pitch tape, as shown previously in Figure 10-13. In this example, the FPA mode is set at a standard 3-degree descent.

By pushing the **FPA** button, the GP activates the FPA mode. The FPA mode is the basic vertical mode and is generally activated when another vertical mode is canceled while the AP is engaged. The FPA mode is also automatically engaged if the FD is off and the AP is engaged.

The FPA mode is canceled by any of the following:

- Pushing the **FPA** button on the guidance panel
- Selecting (or capturing) another vertical mode.

NOTE: Airspeed protection is available in this mode. Refer to the speed hold mode description, Section 11, Autothrottle System.

TO (Takeoff) Mode

The takeoff mode is a flight director only mode (does not couple to the autopilot) that provides guidance throughout the takeoff portion of flight. Takeoff mode is enabled after 5 seconds on-ground (main gear weight-on-wheels) until passing through 400 feet AGL after takeoff. The flight director guidance cue during this phase of flight is a dashed horizontal command bar positioned relative to the aircraft pitch attitude. When the aircraft is on the ground, pushing the throttle-mounted TOGA switch sets the PFD command bars to a fixed pitch-up attitude. The amount of pitch is aircraft, speed factor, and flap setting dependent.

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Figure 10-14 shows the horizontal command bar as dashed (indicating the horizontal command bar is positioned at a higher pitch than what can be displayed), and the vertical mode annunciator is TO .

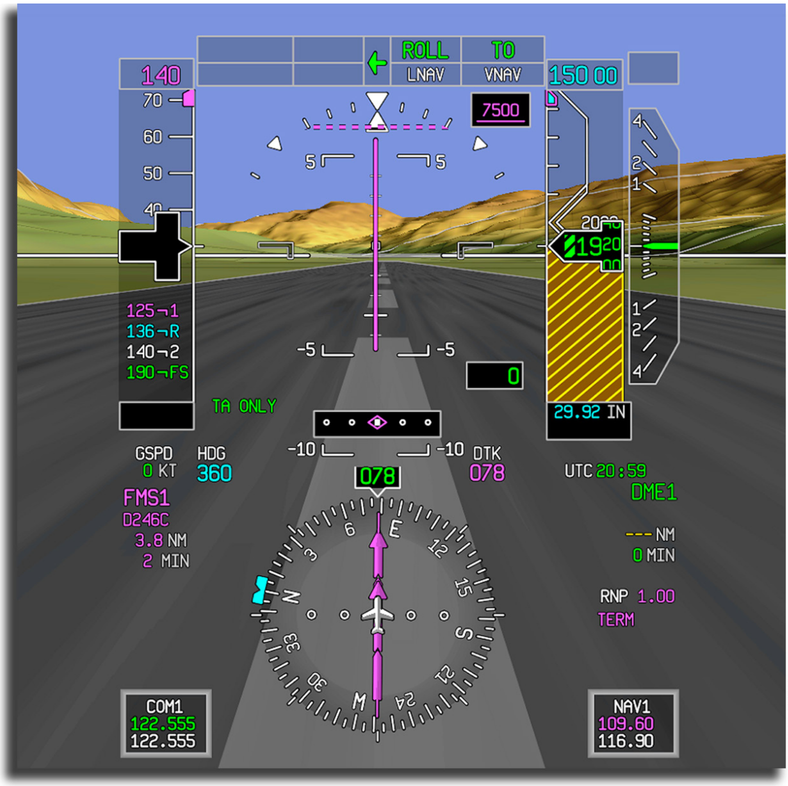

Figure 10-14
Takeoff Mode

NOTE: There is an optional mode (enabled by an APM parameter) that increases the fixed pitch-up attitude following takeoff while being limited by the tailstrike maximum pitch angle. The fixed pitch-up attitude guidance transitions to speed-based guidance once the airspeed increases above the FMS takeoff speed reference.

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The TO mode can be canceled by any of the following:

- Pushing the **TCS** button on the control wheel
- Selecting (or capturing) another vertical mode
- Deactivation of FBW high speed protection
- Failure of a required component
- Pushing the **SRC** button.

E2TS (Enhanced Takeoff System) (Option)

E2TS is an optional takeoff function developed by Embraer and implemented in the flight controls computers (FCC). When E2TS is engaged, the FCCs provide vertical and lateral guidance to the FD takeoff mode cross-bar indication in the PFD. In case the E2TS is disconnected, the FD reverts to standard guidance. The FCC also provides monitoring and engagement/disengagement logics for the E2TS function.

To enable the E2TS function, the E2TS prompt must be selected on the OPR CONFIG page. This selection is indicated by the status CAS message E2TS ENABLED .

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Once enabled, the E2TS is armed by the FCC when the pilot pushes the **TOGA** button with the aircraft in a takeoff configuration compatible with E2TS. **E2TS** is annunciated in the FMA, as shown in Figure 10-15.

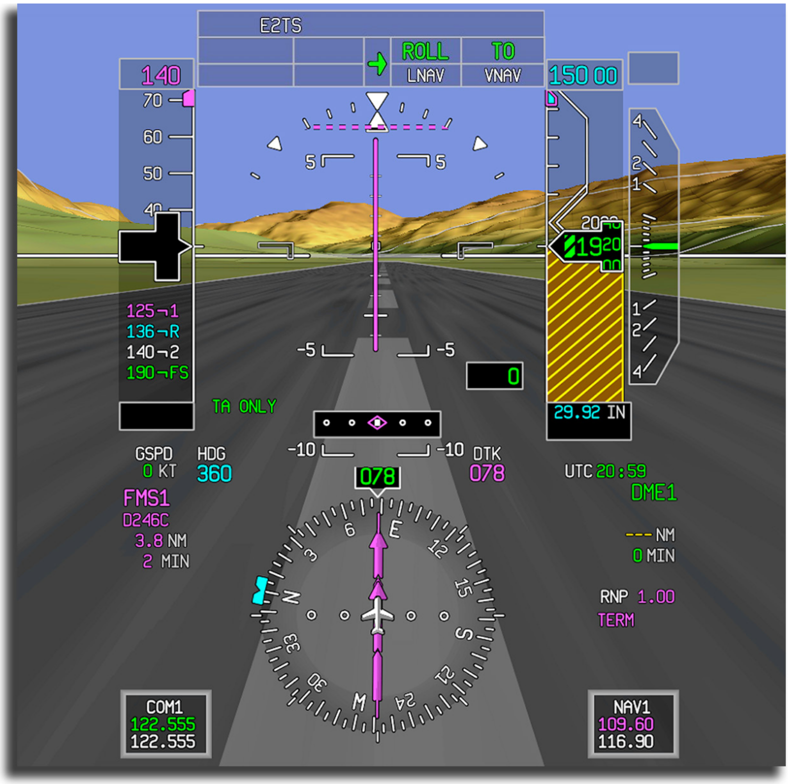

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Figure 10-15
E2TS Takeoff Mode – Armed

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When armed, the FCC engages the E2TS when the pilot advances the thrust levers to TOGA position. E2TS and AP are annunciated in the FMA, as shown in Figure 10-16.

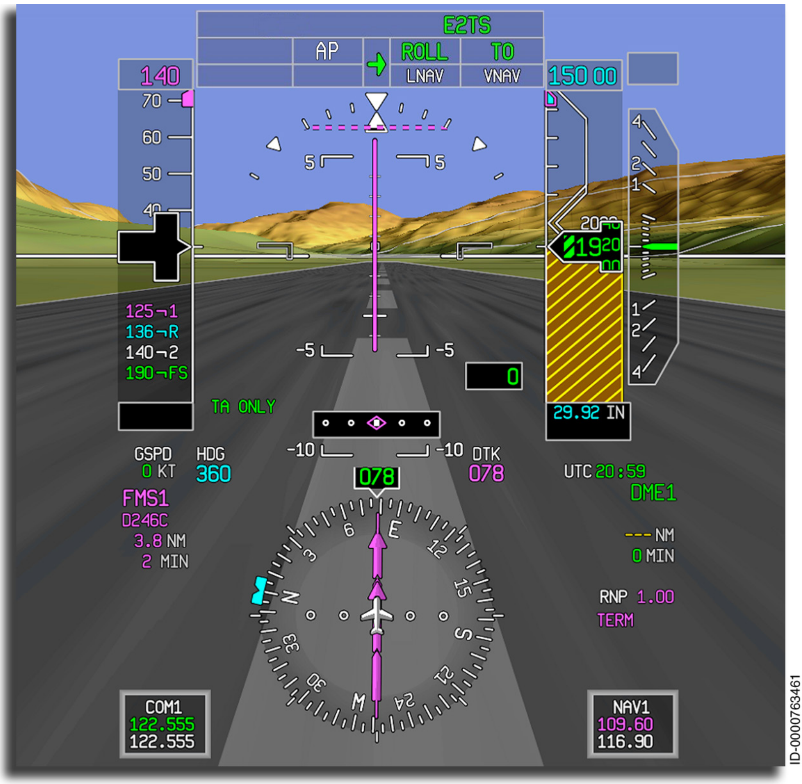

Figure 10-16
E2TS Takeoff Mode – Active

If the FCC detects that the E2TS cannot be armed or engaged, the caution CAS message E2TS DISAGREE is displayed.

During takeoff with E2TS, when the aircraft reaches 200 feet AGL, the FCC automatically engages the autopilot. If there is a failure or abnormal disengagement of the E2TS during takeoff, the FCC reports the NO E2TS alert, and the aural warning **“No E2TS, No E2TS”** is sounded. The caution CAS message E2TS FAIL is displayed as well as when the FCC detects a failure in the E2TS system.

Contact Embraer for further information related to the E2TS function.

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VS (Vertical Speed) Mode

The vertical speed mode automatically maintains the aircraft at a pilot-selected vertical speed reference. VS mode is activated by pushing the **VS** button on the guidance panel. The flight director commands a pitch attitude to maintain the vertical speed that exists when the **VS** button is pushed. With the vertical speed mode engaged, a new vertical speed reference is selected by pushing the TCS switch on the control wheel, maneuvering the aircraft to a new vertical speed reference, and releasing the TCS switch. When the autopilot is engaged, the vertical speed reference is also changed by rotating the VS/FPA thumbwheel on the guidance panel.

When the vertical speed mode is engaged, VS is annunciated as the flight director vertical mode, and the vertical speed target value and bug are displayed on the vertical speed display.

The VS mode is shown in Figure 10-17.

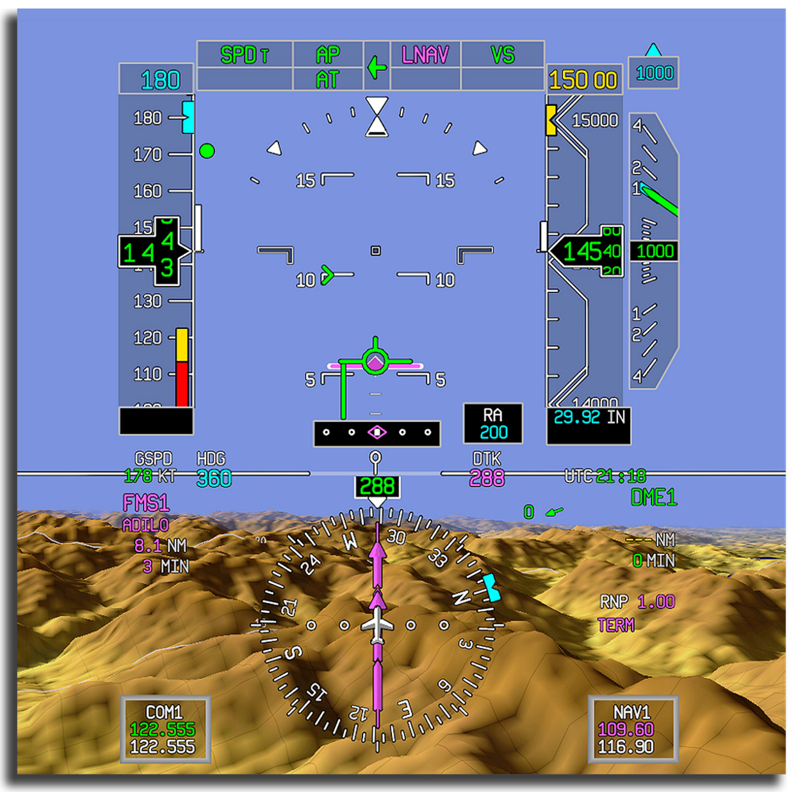

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Figure 10-17
Vertical Speed Mode

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When the vertical speed reference is changed using the VS/FPA thumbwheel on the guidance panel, the target value changes, and the vertical speed reference bug is repositioned. Actual aircraft vertical speed is displayed on the vertical speed indicator. When vertical speed mode is selected, all previously selected vertical modes are disengaged.

The vertical speed mode is canceled by any of the following:

- Pushing the **VS** button on the guidance panel
- Selecting (or capturing) another vertical mode
- Deactivation of FBW high speed protection.

NOTE: Airspeed protection is available in this mode. Refer to the speed hold mode description. Section 11, Autothrottle System, deals with autothrottle speed mode.

FLCH (Flight Level Change) Mode

Pushing the **FLCH** button on the guidance panel selects the flight level change mode. This mode uses preprogrammed climb/descent values. The flight level change mode is annunciated as FLCH , and the preprogrammed airspeed target is maintained. When the **FLCH** button is pushed, the speed hold and vertical speed hold modes are not available. The following describes the effects of pushing the **FLCH** button in various phases of flight.

- During a small flight level change climb, a reduced climb thrust is used during FLCH and VFLCH, and airspeed control is used for vertical speed.
- During a large flight level change climb, a full climb thrust is used during FLCH and VFLCH, and airspeed control is used for vertical speed.
- At the TOD, transition to idle thrust is used during FLCH and VFLCH, and airspeed control is used for vertical speed.
- During a descent, full idle thrust is used during FLCH and VFLCH, and airspeed control is used during vertical speed and VPATH.

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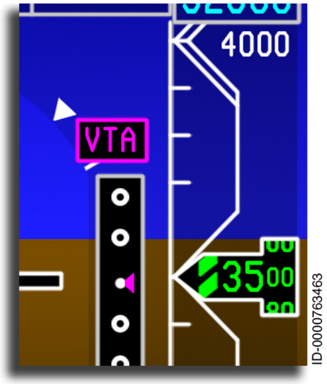
When the touch control steering switch is pushed and held, the autopilot pitch and roll is overridden, and the pilot can maneuver the aircraft. When the touch control steering switch is released, the autopilot pitch and roll re-engages, and the flight guidance system returns the aircraft to the preset flight level change target.

In the flight level change mode, all armed vertical flight director modes are permitted, but if any armed vertical mode is captured, the flight level change mode is disengaged.

The flight level change mode is canceled by any of the following:

- Pushing the **FLCH** button on the guidance panel
- Selecting (or capturing) another vertical mode, including windshear
- Deactivation of FBW high speed protection
- Low speed warning.

VERTICAL TRACK ALERT (VTA)



The vertical track alert (VTA) displays an annunciation of impending changes in vertical track. There is a VTA for all changes in climbing or descending to level flight and from level flight to climbing or descending. Vertical deviation is provided by VNAV for path-type descents. A VNAV vertical deviation indicator is displayed on the PFD in the same location the glideslope deviation indicator is displayed when an ILS is selected and tuned as the primary navigation source on the PFD. The VTA annunciator is displayed above the vertical deviation indicator on the attitude director indicator (ADI).

An aural warning is also provided for VNAV altitude captures. An altitude capture aural warning is provided with a vertical track alert when transitioning from a climb or descent to level flight.

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A VNAV vertical deviation indicator is displayed when the following conditions are satisfied:

- The FMS is selected as the primary navigation source
- A VNAV mode is the active FGCS vertical mode
- A path-type descent is defined in the active flight plan
- The vertical deviation and vertical speed are within the capture criteria for PTH mode.

Vertical deviation scaling is determined by the active LNAV flight mode. In the approach mode, vertical gains are increased. Table 10-1 lists the vertical deviation scaling values.

Table 10-1
Vertical Deviation Scaling

LNAV Mode	Vertical Deviation Scale
Approach	75 feet/dot
Terminal	250 feet/dot
En route	250 feet/dot
Oceanic/Remote	250 feet/dot

The VNAV vertical deviation is continuously updated to reflect the current vertical distance between the defined vertical path and the current aircraft altitude based on the FMS position relative to the lateral plane of the path. The VNAV vertical deviation indicator permits the flight crew to manually control the aircraft in the vertical plane of flight during a path-type descent.

When the FMS is selected as the primary navigation source, and VNAV is selected, a vertical track alert is given for any of the following conditions:

- **Climb/Descent Constraints** – The VTA is displayed at 1,000 feet prior and is removed 200 feet before a VNAV altitude constraint, which is not equal to the preselect altitude. Also, using the predicted altitude at a holding pattern waypoint that is part of a path descent, the predicted altitude is observed by VNAV as a constraint altitude in this special case.

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- One minute before the top-of-descent (TOD) and in VALT, when the VTA is issued for a given TOD, another VTA is not reissued because the aircraft is slowing near the TOD. One exception to this case is:
  - If a holding pattern fix is less than 1 minute from the aircraft current position, NO vertical track alert is issued. In the preceding case, if the holding pattern is deleted before entering the holding pattern, the vertical track alert is issued immediately.
- One minute prior to the resumption of climb or descent at a constrained vertical waypoint, the vertical track alert is displayed until the abeam point of the subject constrained waypoint. Two exceptions to this case are:
  - If within 1 minute of a climb at/above altitude constraint, NO vertical track alert is issued.
  - If a holding pattern fix is less than 1 minute from the aircraft current position, NO vertical track alert is issued. In the preceding case, when the holding pattern is deleted prior to entering the holding pattern, the vertical track alert is issued immediately.
- Prior to resuming VFLC descent after a speed restriction deceleration level off occurs when the mode is VALT and DCLRST (speed restriction deceleration) is true and CAS is less than RSTCAS (speed restriction CAS) + 5 KCAS and the aircraft altitude is within 100 feet of the restriction altitude. The VTA must remain on until the aircraft accelerates to RSTCAS + 8 KCAS or until VNAV transitions out of VALT.
- One minute prior to a step climb unless a holding pattern fix is also within 1 minute.
- One minute prior to a TOD, when in a holding pattern, the exit hold has been selected and in VALT.
- One minute prior to the hold fix with the hold fix at a climb altitude constraint and exit hold has been selected.

A vertical track alert is not produced for an intermediate level-off altitude defined using only the altitude preselector. The altitude capture aural warning is given in this situation.

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A vertical track alert is not produced when the aircraft passes more than 50 feet above an AT or ABOVE constraint.

A vertical track alert is not produced when the aircraft passes more than 50 feet below an AT or BELOW constraint.

ASEL (Altitude Select) Mode

The ASEL mode is a transitionary mode. The ASEL mode transitions between the selected vertical mode and the altitude hold mode. As the aircraft approaches the target altitude, the ASEL mode activates and adjusts the pitch of the aircraft as necessary to capture the altitude. The ASEL mode is annunciated in the vertical mode field of the FMA, as shown in Figure 10-18.

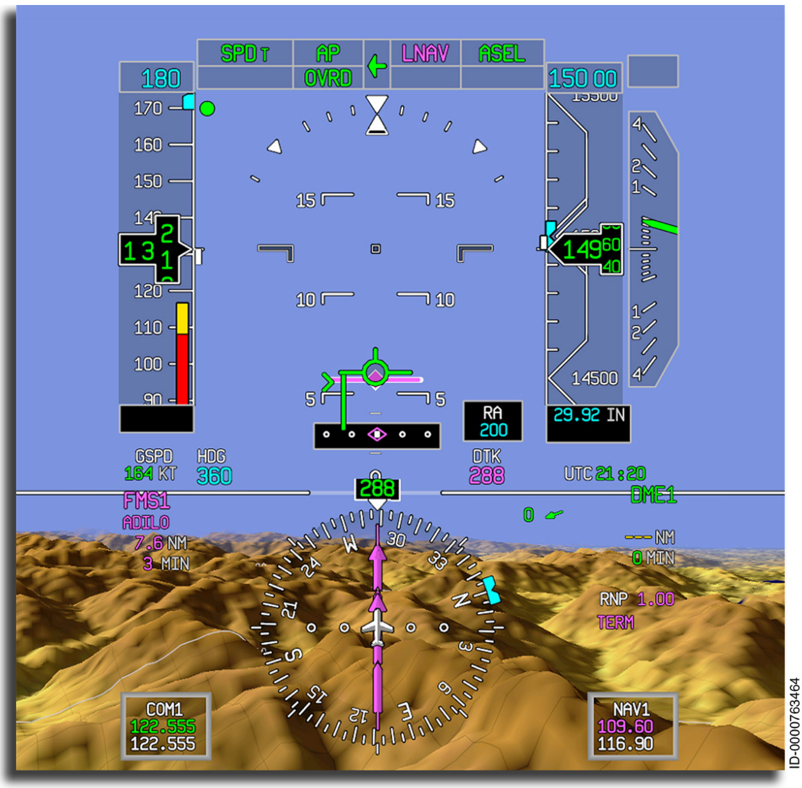

Figure 10-18
ASEL Mode

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The ASEL mode automatically activates when the aircraft climbs or descends towards the alert altitude, and the following conditions are met:

- During a climb when the selected altitude is within 2,000 feet of the current aircraft altitude
- During a descent when the selected altitude is within 10,000 feet of the current aircraft altitude
- The selected altitude is more than 100 feet from the current altitude
- One of the following modes is active: FPA, FLC, VS, GA, TO
- Altitude rate required to fly a constant 0.05g capture curve is less than the current aircraft climb or descent rate. For single engine conditions, a 0.12g capture curve is assumed.

The ASEL mode is canceled by one of the following:

- Selecting or capturing another vertical mode (most common is automatically transition to altitude hold mode after the desired altitude is achieved)
- Turning FD off by pushing the **FD** button on the guidance panel if AP is disengaged
- Deactivation of FBW high speed protection
- Selecting a new altitude target by ALT SEL knob.

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ALT (Altitude Hold) Mode

The altitude hold mode is a vertical flight director mode that maintains the barometric altitude shown on the coupled PFD at the altitude reference. Altitude hold mode is activated by the way of the **ALT** button on the guidance panel or automatically following a preselected altitude capture. Altitude hold mode is displayed in the active vertical mode field as ALT , as shown in Figure 10-19.

Figure 10-19
Altitude Hold Mode

When altitude hold mode is activated by pushing the **ALT** button on the guidance panel, the FD syncs the altitude hold reference to the barometric altitude displayed on the coupled PFD at the time the **ALT** button was pushed.

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When altitude hold is the active FD mode, the reference altitude can be changed by pushing the touch control steering (**TCS**) button on the control wheel, maneuvering the aircraft to a new altitude, and releasing the **TCS** button.

When AP engagement occurs while altitude hold is the active FD mode and the altitude error is greater than 200 feet, the altitude reference is synced to the current altitude.

Selecting the altitude hold mode cancels any other previously selected vertical mode.

The reference altitude can also be changed by rotating the ALT SEL knob on the guidance panel.

The altitude hold mode is canceled by one of the following:

- Pushing the **ALT** button on the guidance panel
- Selecting (or capturing) another vertical mode
- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel.

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GS (Glideslope) Mode

The GS mode adjusts the pitch of the aircraft to intercept, capture, and track the vertical path (glideslope) of an ILS or GLS approach. The GS mode is used in conjunction with the LOC lateral mode to fly an ILS or GLS approach. The GS mode is annunciated in the vertical mode field as GS , shown in Figure 10-20. When the GS mode is active, the altitude preselector is ignored, permitting the pilot to set the missed approach altitude in the altitude preselector.

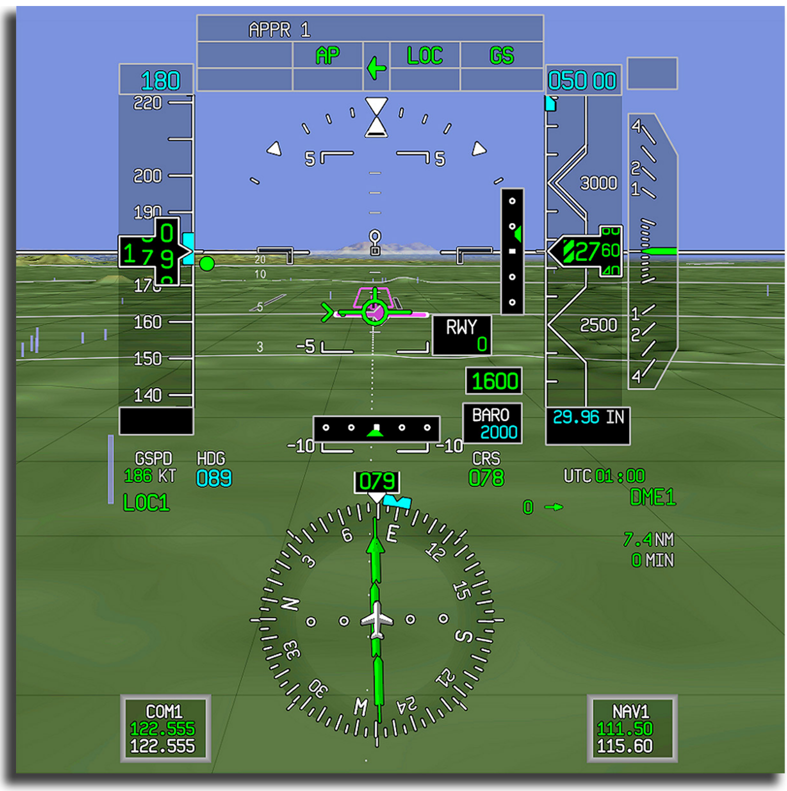

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Figure 10-20
GS Mode

The GS mode is armed by pushing the **APPR** button when the appropriate approach is selected/tuned.

The GS mode captures when the glideslope capture criteria are met.

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GA (Go Around) Mode

The go-around mode is used to transition from an approach to landing to a climb out when a missed approach or balked landing is initiated. Vertical guidance is provided to capture and track a fixed angle or preset go-around reference speed. The pilot selects the go-around mode by pushing the **TOGA** button located on the throttle quadrant assembly. If the autopilot is engaged before go-around is selected, the autopilot remains engaged. When the GA mode is active, GA is shown in the vertical field of the FMA, as shown in Figure 10-21. The lateral mode during a go-around is LNAV , TRACK , or ROLL , depending on the go-around scenario.

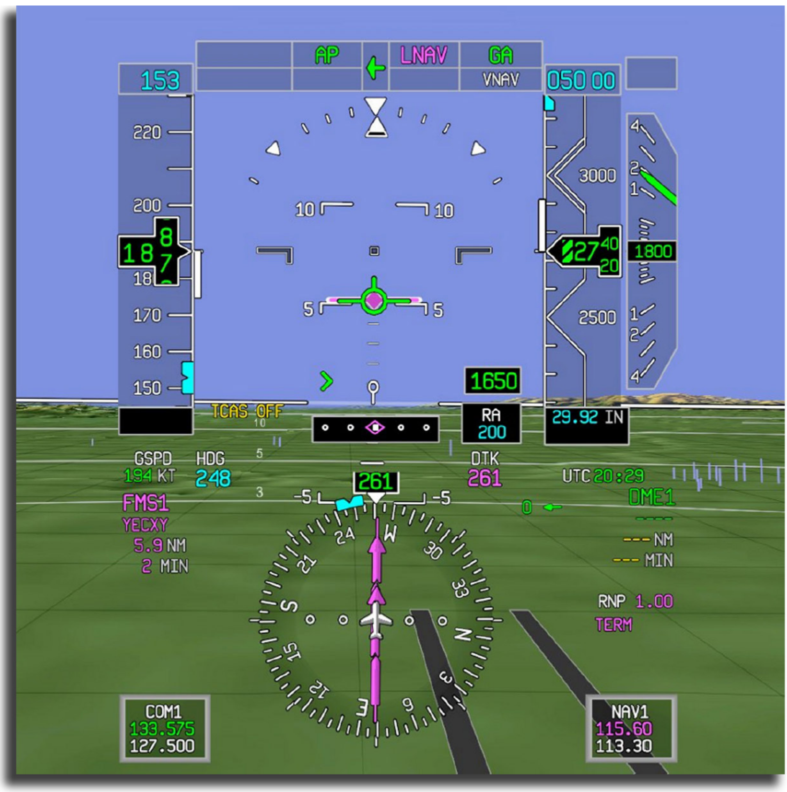

Figure 10-21
Go Around (GA) Mode

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GA MODE VERTICAL BEHAVIOR

When the landing gear is down, the flight director initially commands a fixed pitch angle of 8 degrees. After the landing gear is retracted, the fixed pitch angle is set to 7 degrees.

NOTE: In some heavyweight conditions and with an engine-out scenario, this fixed pitch command does not prevent height loss; hence the flight director can increase the fixed pitch angle up to 11 degrees. The flight director limits a pitch angle.

When a valid V_{REF} has been entered on the approach page of the MCDU, the GA mode transitions from the fixed pitch to speed hold control on reaching the go-around speed reference, which is V_{REF} + 20 kts (normal) and V_{AC} (one engine inoperative).

Go-around is enabled when the **TOGA** button is pushed and the following conditions are met:

- After climbing 400 feet above ground level until 5 seconds after landing (main gear weight-on-wheels)
- When radio altitude is valid and less than 2,500 feet, or radio altitude is invalid and barometric altitude is less than 17,000 feet.

NOTES:

1. *The GA mode ensures minimal altitude is lost during the maneuver.*
2. *The maximum pitch angle is 18 degrees, and the minimum pitch angle is 7 degrees.*

The go-around mode is canceled by:

- Selecting or capturing another pitch mode
- Coupling to the cross-side PFD
- Deactivation of FBW high speed protection
- Pushing the TCS switch on the control wheel.

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GO-AROUND MODE LATERAL BEHAVIOR

If the necessary APM option is enabled, and a published missed approach exists for the approach selected in the FMS, the lateral mode automatically transitions from short-range navigation (LOC) to LNAV during a go-around. In this case, LNAV automatically arms and captures above 50 feet AGL.

NOTE: If radio altitude is invalid or miscomparing, the LNAV will activate automatically when the aircraft has climbed at least 50 feet pressure altitude from the altitude at which the go-around mode was engaged.

The auto transition to LNAV during a go-around is shown in Figure 10-22.

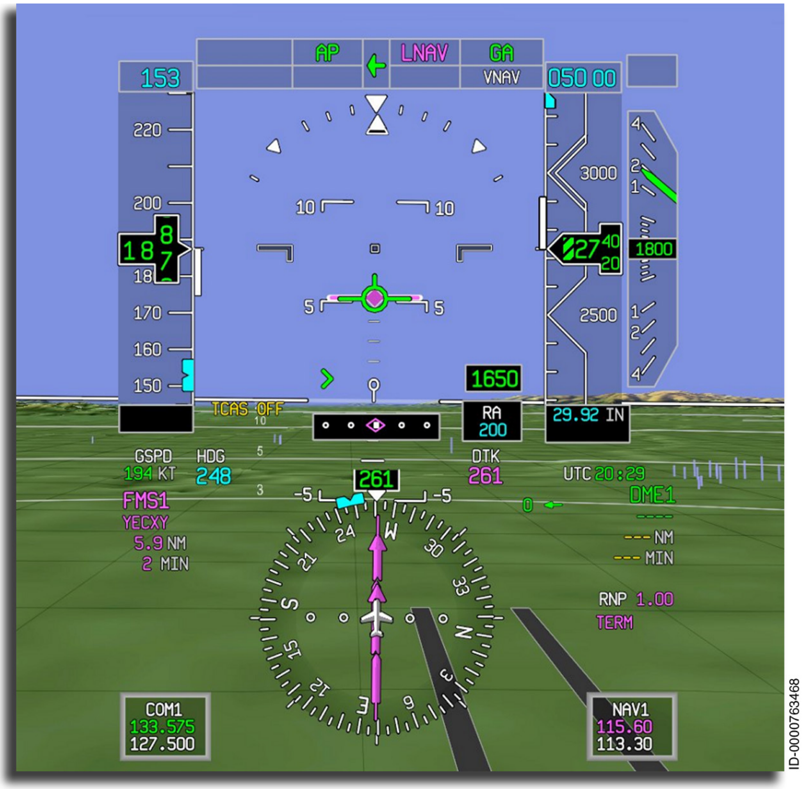

Figure 10-22
Go-Around Mode (With LNAV)

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If the auto transition to LNAV is not available (e.g., APM not enabled), and the go-around mode is activated, the lateral mode changes to TRACK when the roll angle is less than 3 degrees and the airspeed is greater than 100 knots. TRACK mode during a go-around is shown in Figure 10-23.

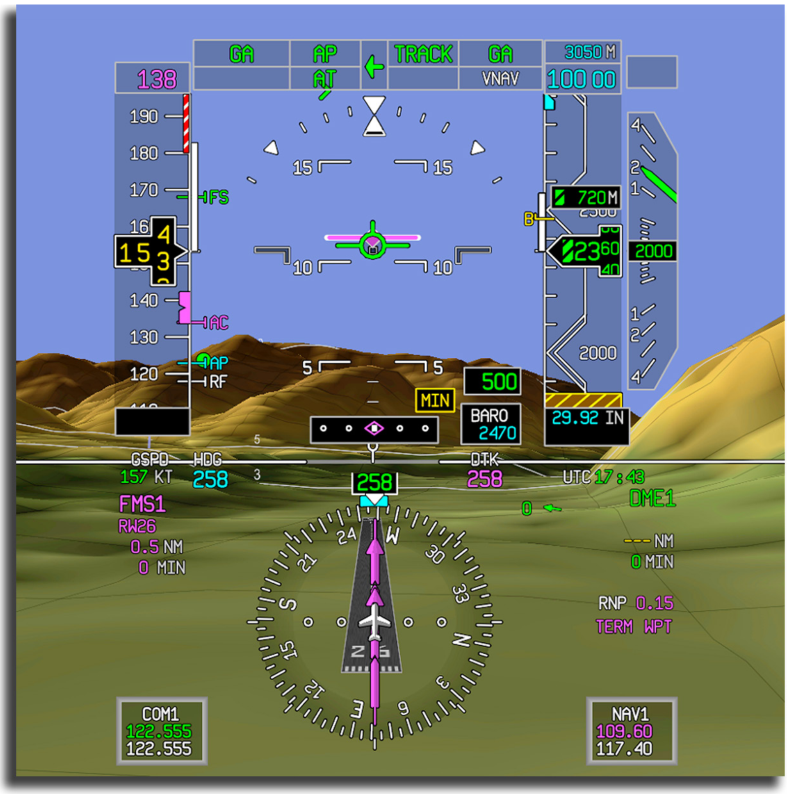

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Figure 10-23
Go-Around Mode (With TRACK)

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If the roll angle is greater than 3 degrees or the airspeed is less than 100 knots, and the go-around mode is activated, the lateral mode changes to ROLL until the conditions for TRACK mode are satisfied. ROLL mode during a go-around is shown in Figure 10-24.

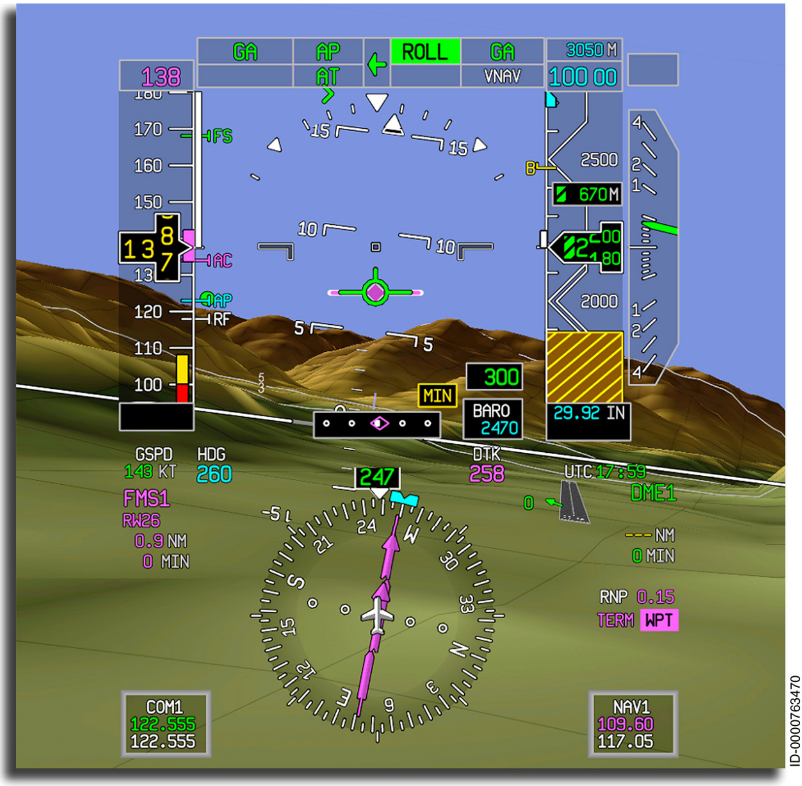

Figure 10-24
Go-Around Mode (With ROLL)

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VFLCH (VNAV Flight Level Change) Mode

VFLCH mode is the FMS equivalent to the FLCH mode. In VFLCH mode, the flight director provides guidance commands based on the altitude target received from the FMS.

The FMS limits the altitude target by the preselected altitude when the preselected altitude is between the present aircraft altitude and the FMS flight plan altitude while VFLCH mode is active.

The speed target in VFLCH mode is from the FMS or is manually selected with the FMS/MAN switch on the guidance panel.

When in VASEL, VALT, GP, or PTH modes, pushing the **FLCH** button on the GP transitions to VFLCH, and FLCH is displayed on the PFD. The VFLCH mode can also be activated automatically by the FMS.

The VFLCH mode is canceled by any of the following actions:

- Deselecting VNAV mode by pushing the **VNAV** button on the guidance panel
- Selecting or capturing any other vertical mode
- Coupling the cross-side PFD by pushing the **SRC** button on the guidance panel
- Low speed warning
- Deactivation of FBW high speed protection.

VASEL (VNAV Altitude Select) Mode

VASEL mode is the FMS equivalent to the ASEL mode. The flight director arms VASEL mode the same way as ASEL with the exception that the altitude target comes from the preselected altitude provided by the FMS.

ASEL is displayed in the FMA when captured. FMS-provided altitude is based on the entered flight plan or by the manually-selected altitude.

The flight director ignores VS/FPA thumbwheel inputs while VASEL mode is active.

VASEL mode permits the GS or GP vertical mode to be armed without deactivating VASEL mode.

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VASEL mode uses the selected altitude and the BARO-corrected altitude shown on the coupled PFD for closed-loop control.

The VASEL mode automatically captures when the aircraft climbs or descends towards the preselected altitude provided by the FMS, and the following conditions are met:

- Flight director active vertical mode is VFLC or PTH
- Preselected altitude provided by the FMS is within 2,000 feet of current altitude if aircraft is ascending OR within 10,000 feet if descending
- Preselected altitude provided by the FMS is more than 100 feet from the current altitude
- Altitude rate required to fly a constant 0.05g capture curve is less than the current aircraft climb or descent rate. For one engine inoperative conditions, a 0.12g capture curve is assumed.

The VASEL mode is canceled by any of the following:

- Selecting or capturing another vertical mode (most common is automatically transition to VALT mode after the desired altitude is achieved)
- Deselecting VNAV mode by pushing the **VNAV** button on the guidance panel
- If AP is disengaged, FD is turned off by pushing the **FD** button on the guidance panel or reducing CAS below 60 knots after landing
- Deactivation of FBW high speed protection.

VALT (VNAV Altitude Hold) Mode

VALT mode is the FMS equivalent to the ALT mode. The flight director transitions to VALT mode following a VNAV altitude select capture of the preselected altitude received from the FMS. Once engaged, VALT mode maintains the FMS-provided BARO altitude.

VALT mode becomes the active vertical mode once VASEL mode has been captured and has leveled the aircraft at the selected altitude. VALT mode can also be activated from the ALT mode by pushing the **VNAV** button on the guidance panel. The VALT mode is annunciated on the PFD with ALT .

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VALT mode permits the GS or GP vertical mode to be armed without deactivating VALT mode.

The VALT mode is canceled by any of the following actions:

- Deselecting VNAV mode by pushing the **VNAV** button on the guidance panel
- Selecting or capturing another vertical flight director mode
- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel.

PTH (VNAV Path) Mode

The VNAV Path (PTH) mode intercepts and tracks a vertical descent path constructed by the FMS. The PTH mode adjusts the pitch of the aircraft to track a descent path using aircraft position data and barometric altitude.

PTH mode permits any of the following vertical modes to be armed without deactivating PTH mode:

- GS
- GP
- VASEL.

The PTH mode is used to descend to a new flight level at a prescribed angle not always entered into the FMS. The PTH mode engages when the FMS initiates a path descent, which can occur while in VFLCH or VALT modes.

Figure 10-25 shows the elements of a typical path descent.

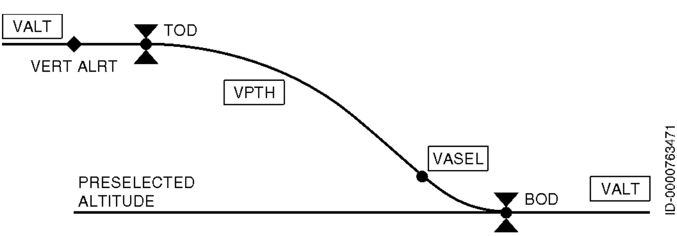

Figure 10-25
Vertical Navigation Path Descent Profile

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The FMS calculates a TOD based on the altitude constraints entered into the FMS flight plan. One minute before TOD, and with a default or entered VNAV descent angle active, a flashing magenta VTA annunciator is displayed on the PFD. When the mode captures, PTH is annunciated on the PFD, as shown in Figure 10-26. From the TOD to the bottom-of-descent (BOD), the FD is engaged in a path descent mode. The magenta path deviation scale pointer is displayed on the PFD (in the same location as the LOC vertical deviation scale) when the NAV source is FMS.

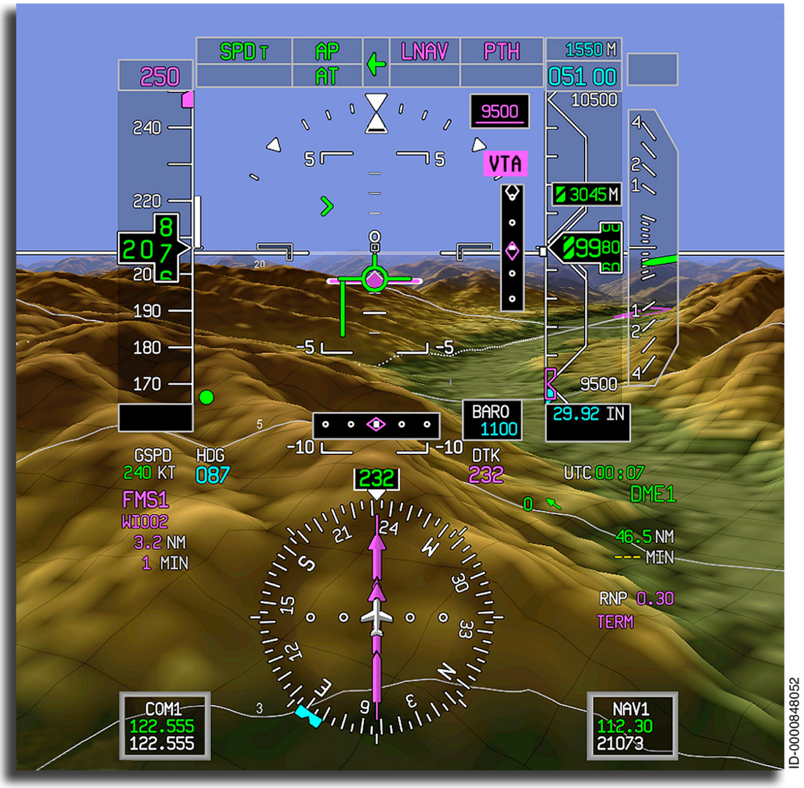

Figure 10-26
VNAV Path Mode (PTH)

The PTH mode is canceled by any of the following actions:

- Deselecting VNAV mode by pushing the **VNAV** button on the guidance panel
- Selecting or capturing another vertical flight director mode

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- Coupling to the cross-side PFD by pushing the **SRC** button on the guidance panel.
- If AP is disengaged, FD is turned off by pushing the **FD** button on the guidance panel or reducing CAS below 60 knots after landing.
- Deactivation of FBW high speed protection.

GP (VNAV Glide Path) Mode

The GP mode permits the pilot to dial the altitude selector to the missed approach altitude while performing an approach in VNAV. The GP is essentially the VPATH mode with the altitude preselector position being ignored. While VNAV respects the altitude preselector and levels off appropriately, a descent in GP submode ignores the altitude preselector, similar to a glideslope descent.

In order to arm GP, the **APPR** button on the guidance panel must be pushed, and the following conditions must be met:

- FMS is the selected navigation source.
- LOC preview mode is inactive on the PFD.
- A non-localizer based approach is selected from the navigation database.
- The aircraft is not in DR (dead reckoning) mode.
- An NDB (navigation database) angle to the MAP exists.
- No vertical Direct-To the MAP has been executed.

Once armed, a GP annunciator is displayed in the vertical mode field of the flight mode annunciators located at the top of the PFD.

NOTE: The GP mode can be armed anytime after takeoff. Because the GP mode ignores the altitude preselector, caution should be used when arming the GP mode as the aircraft will continue a descent past the altitude set in the preselector when the GP mode is active.

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GP is disarmed when any of the following conditions are met:

- VNAV is deselected by a subsequent push of the **VNAV** button on the guidance panel.
- Approach is deselected by a subsequent push of **APPR** button on the guidance panel.
- FMS disarms GP mode (for example, if the FMS does not have valid GP information and cannot provide vertical deviation).
- ILS is selected as the previewed NAV source.
- FMS is not selected as the primary navigation source on the coupled PFD.

To engage GP, the following conditions must be met:

- FMS is indicating GP capture request.
- LNAV is active.
- The aircraft is able to capture the final approach slope.
- The active waypoint is the FAF or along track distance to the FAF is less than 5 NM.
- GP is armed.
- The aircraft, when holding, must be established on the inbound course to the FAF.

Once engaged, a GP annunciator is displayed in the vertical mode field of the FMA located at the top of the PFD.

GP is disengaged when any of the following conditions are met:

- FMS is no longer sending GP capture request.
- FMS VPATH references and V/S are no longer valid.
- Another vertical flight director mode is selected.
- VNAV is deselected by a subsequent push of the **VNAV** button on the guidance panel.
- Approach is deselected by a subsequent push of **APPR** button on the guidance panel.

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- Approach is deselected by a subsequent push of the **APPR**, **HDG**, **LNAV**, **VNAV**, **FLCH**, **ALT**, **VS**, or **FPA** buttons.
- ILS becomes the active NAV source.
- FMS is not selected as the primary navigation source in the coupled PFD.
- Deactivation of FBW high speed protection.

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WSHR (Windshear) Mode

The purpose of the windshear escape guidance mode is to minimize altitude loss while maintaining a safe margin from stall. Windshear escape flight director guidance is given by the flight guidance control system (FGCS) and is annunciated as WSHR in the vertical flight mode annunciator field when active. ROLL becomes the active lateral mode when windshear escape guidance is initially activated and is annunciated in the lateral flight mode annunciator field, as shown in Figure 10-27. The windshear detection function is performed by the enhanced ground proximity warning function (EGPWF) and is enabled between 10 feet and 1,500 feet AGL. Windshear caution and warning are annunciated in amber and red, respectively, on the PFD at the top and center of the ADI (refer to Section 5, Primary Flight Display (PFD), for more details).

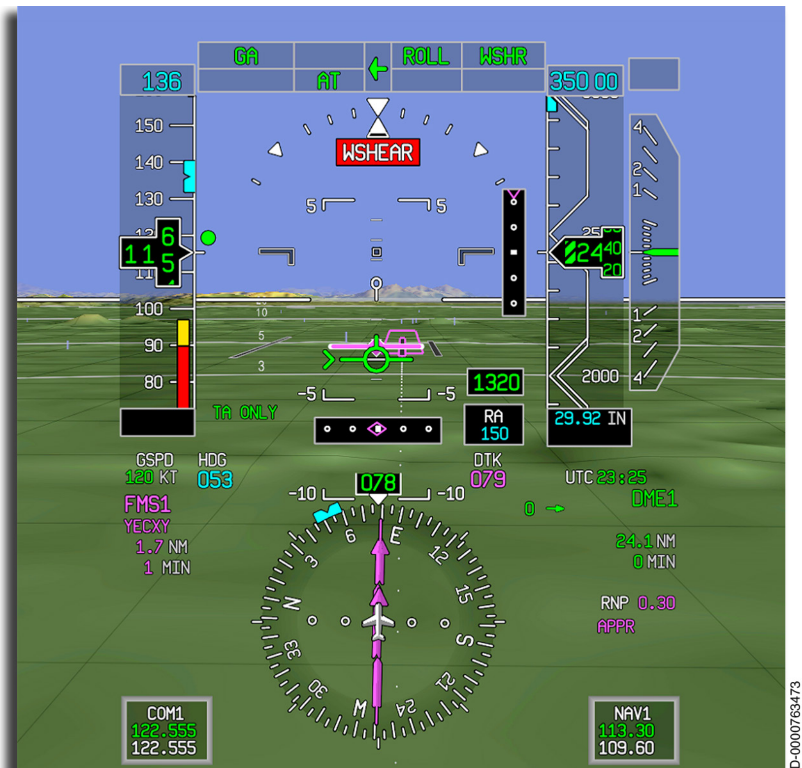

Figure 10-27
Windshear Mode With Autothrottle Engaged

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Windshear escape guidance is initiated when any of the following conditions are met:

- When a windshear caution or warning is issued and the pilot pushes the **TOGA** button.
- Automatically when E2TS is not engaged when in TO or GA mode, and a windshear warning is issued, or when E2TS is not enabled, the thrust lever angle is more than 70 degrees, and a windshear warning is issued.

NOTE: TLA position of more than 70 degrees is considered to be the TOGA detent.

When windshear escape guidance activates, vertical and lateral flight director modes that were armed prior to activating windshear escape guidance are disarmed. Altitude select mode (ASEL) is inhibited while windshear escape guidance mode (WSHR) is the active vertical flight director mode. The selection of another vertical mode while in windshear escape guidance mode results in that mode being activated when the criteria for entering the windshear escape guidance mode are not satisfied. The flight path reference line and readout are removed from the ADI when windshear escape guidance mode (WSHR) becomes the active vertical flight director mode. The selection of another lateral mode while in windshear escape guidance mode results in that mode being armed/captured.

Automatic reversion to any other vertical or lateral flight guidance mode is inhibited while windshear escape guidance is the active vertical flight director mode. Loss of the windshear escape guidance mode when WSHR is the active vertical mode results in the removal of the command cue, clearing the vertical and lateral flight mode annunciator field, and posting of the applicable information on EICAS, indicating the result of the failure. The windshear escape guidance command is limited to pitch attitudes less than or equal to 27 degrees.

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If already engaged, the autopilot disengages when windshear escape guidance mode becomes active. Autopilot disconnect is indicated by the applicable visual and aural alerts. When the autothrottle is already engaged when windshear escape guidance is activated, the autothrottle positions the thrust levers to the TOGA detent. If not engaged, the pilot can engage the autothrottle or manually position the thrust levers at the TOGA detent.

OVSP (Overspeed) Mode

Overspeed protection mode (OVSP) detects and minimizes the possibility of unintentional long-term operation at an airspeed above V_{MO}/M_{MO} (red/white barber pole on airspeed indicator as discussed in Section 5, Primary Flight Display (PFD). Overspeed protection mode is enabled when the following vertical modes are active:

- ASEL
- VASEL
- FPA
- FLCH (During descents)
- VS
- VFLCH (During descents)
- PTH
- WSHR (during performance increasing windshear conditions).

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When the active vertical mode is FPA, VS, or PTH, and the autothrottle is engaged and not at the idle limit, the FGCS delays activating the overspeed protection mode until the autothrottle can no longer prevent the overspeed condition. Figure 10-28 shows OVSP in the active mode.

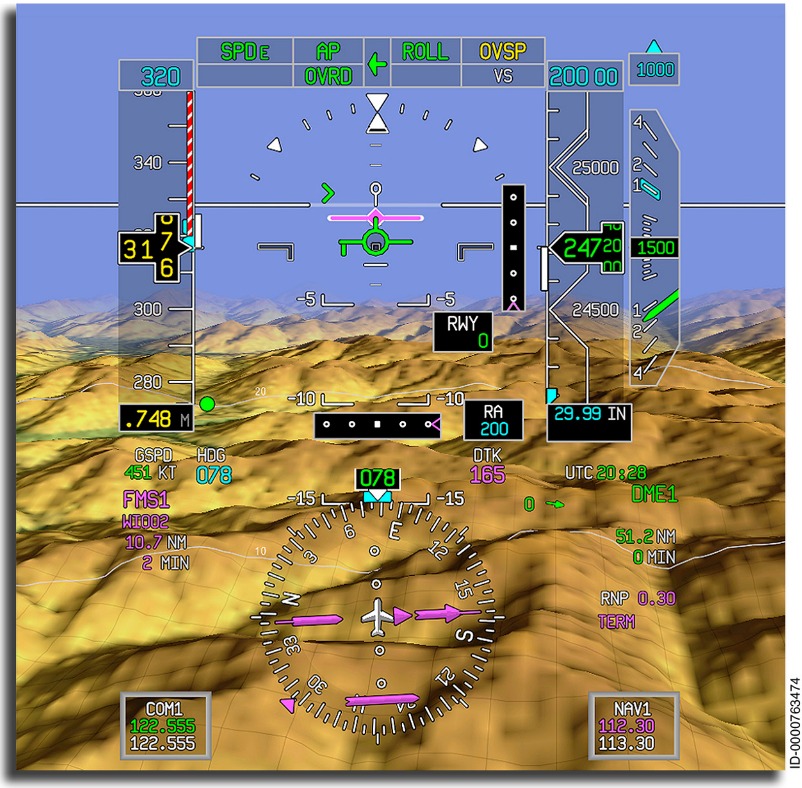

Figure 10-28
Overspeed Mode

When OVSP is active, the flight director generates guidance commands to minimize long-term, steady-state exceedances and large excursions beyond the maximum operating speed. Small excursions of the maximum operating speed that are short term or transient in nature are permitted. When the FGCS detects an overspeed condition is imminent, the FGCS produces guidance commands to maintain airspeed within ±5 knots or ±0.02 Mach of V_{MO} or M_{MO}, as applicable.

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APPROACH STATUS INDICATIONS AND AP MODES

The approach status field in the FMA indicates the current approach capability of the aircraft. The approach status field displays the armed, active, and failure status of the selected approach. The approach status field is displayed in the FMA above the active FD modes, as shown in Figure 10-29.

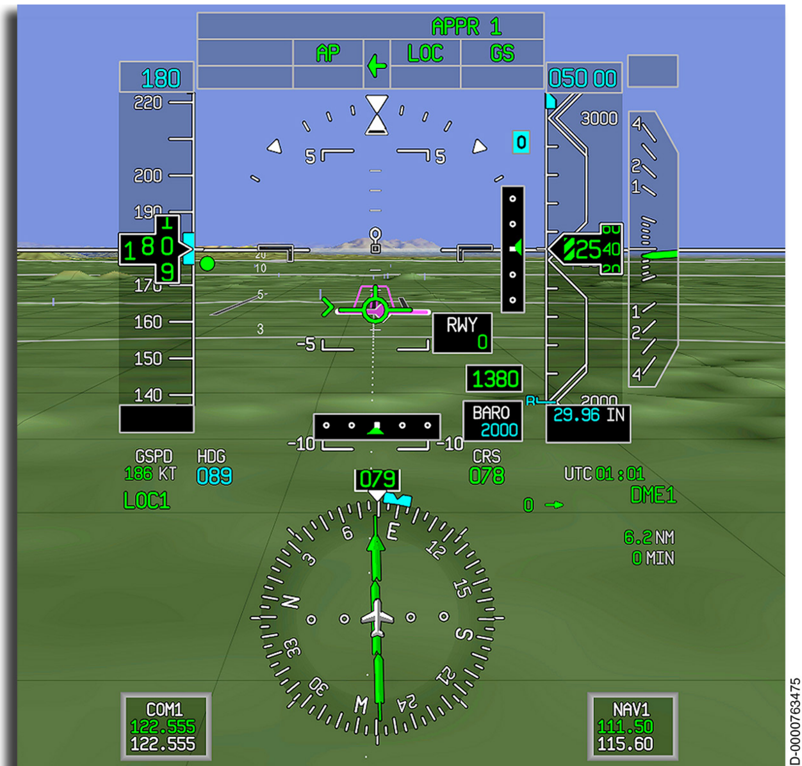

Figure 10-29
Approach Status Field

The approach status field displays the approach status for the following types of approaches:

- CAT1 ILS (APPR 1)
- CAT2 ILS (APPR 2)
- CAT3 ILS (AUTOLAND)

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- GBAS (G-APPR 1)
- RNAV – SBAS (LPV)
- RNAV – RNP (RNP 0.XX).

ILS (CAT1) Approach

The instrument landing system (ILS) approach mode automatically intercepts, captures, and tracks the front course localizer and glideslope signals, so that a fully coupled ILS approach is flown. The ILS mode is set up and flown similar to the localizer mode. The ILS mode is interlocked so that the glideslope capture is inhibited until the localizer is captured. As with the localizer mode, heading select is used for the localizer approach intercept.

The ILS approach mode localizer intercept profile is shown in Figure 10-30.

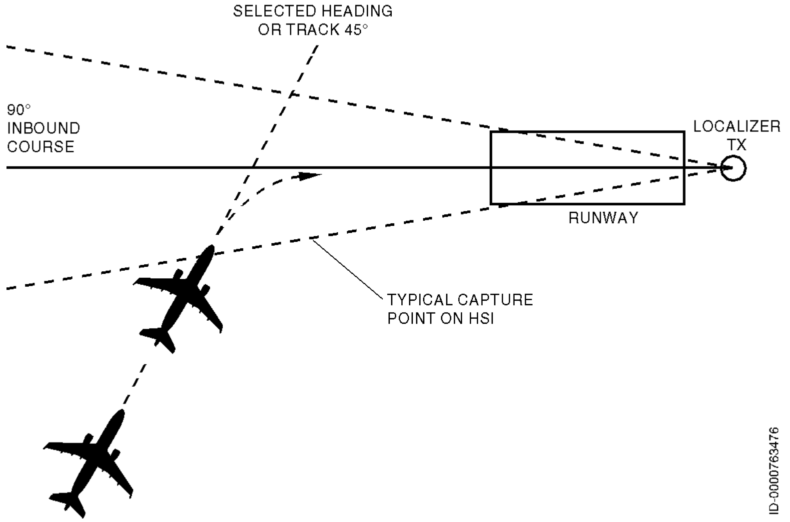

Figure 10-30
ILS Approach Mode Localizer Intercept Profile

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Three categories of ILS approaches are Category 1 (APPR 1), Category 2 (APPR 2), and Category 3 (AUTOLAND). APPR 1 and APPR 2 are standard features, while AUTOLAND is an option. Approach category indications are always displayed on a third line above the flight mode annunciators section on the PFD when an ILS approach is selected. An **APPR 1** , **APPR 2** , or **AUTOLAND** indication is displayed depending on the type of approach selected and whether or not the aircraft has met the criteria necessary to execute the approach.

The procedure for an ILS approach is described in the following steps:

1. Ensure the AP/FD is coupled to the proper side. If necessary, toggle the **SRC** button on the guidance panel left or right to direct the arrow as the coupled side.

2. Verify that the system has autotuned the proper localizer frequency. If necessary, manually tune the coupled-side navigation receiver to the localizer frequency. For APPR2 or AUTOLAND, both navigation receivers must be tuned to the localizer frequency. APPR1 only permits the coupled side to be tuned.

3. Select LOC as the navigation source on the coupled-side display controller. For APPR2 or AUTOLAND, LOC must be selected on both display controllers.

4. Set the baro altitude decision height (minimum altitude) on the PFD with the BARO knob on the display controller for APPR 1 or set the radio altitude decision height (minimum altitude) on the PFD with the RA knob on the display controller for APPR 2 and AUTOLAND.

5. Verify that the appropriate course has been set (the course is automatically set when the system is in autotune and the LOC preview is activated). If necessary, manually rotate the CRS knob on the guidance panel to set the inbound localizer course on the coupled PFD. Both courses must be set for APPR2 or AUTOLAND.

6. Set the heading bug to the desired beam intercept angle using the HDG knob on the guidance panel, then activate the HDG mode by using the **HDG** button.

7. Push the **APPR** button on the guidance panel to arm the LOC/GS modes.

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The localizer and glideslope armed modes are shown in Figure 10-31.

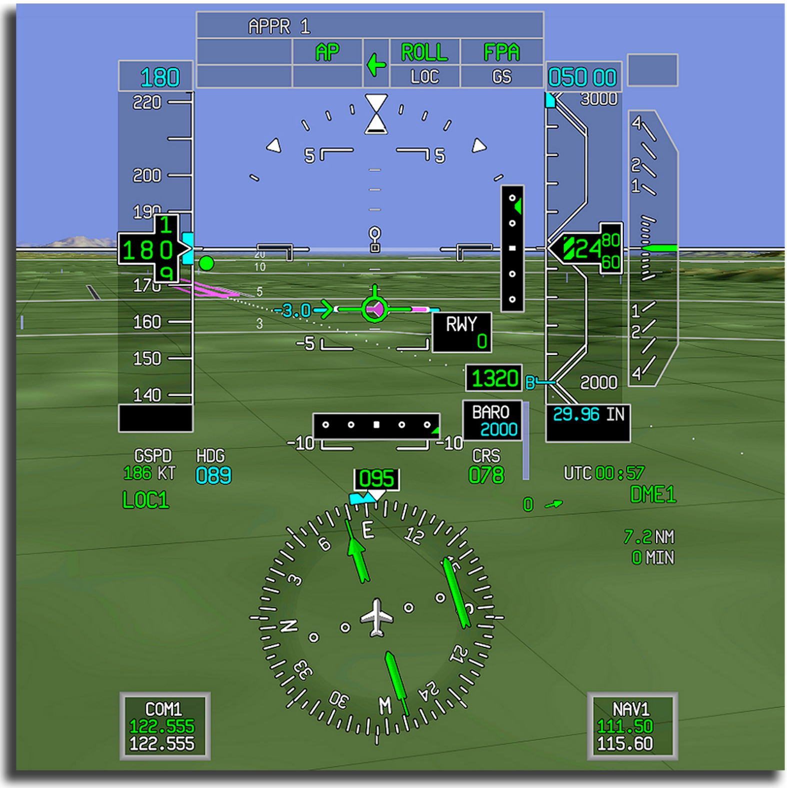

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Figure 10-31
ILS Approach Mode – Localizer and Glideslope Armed

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ILS LOC CAPTURE AND GS ARMED

The flight director generates a roll command to capture and track the localizer signal. At capture, LOC and LOC flash for 5 seconds, and then LOC remains, as shown in Figure 10-32.

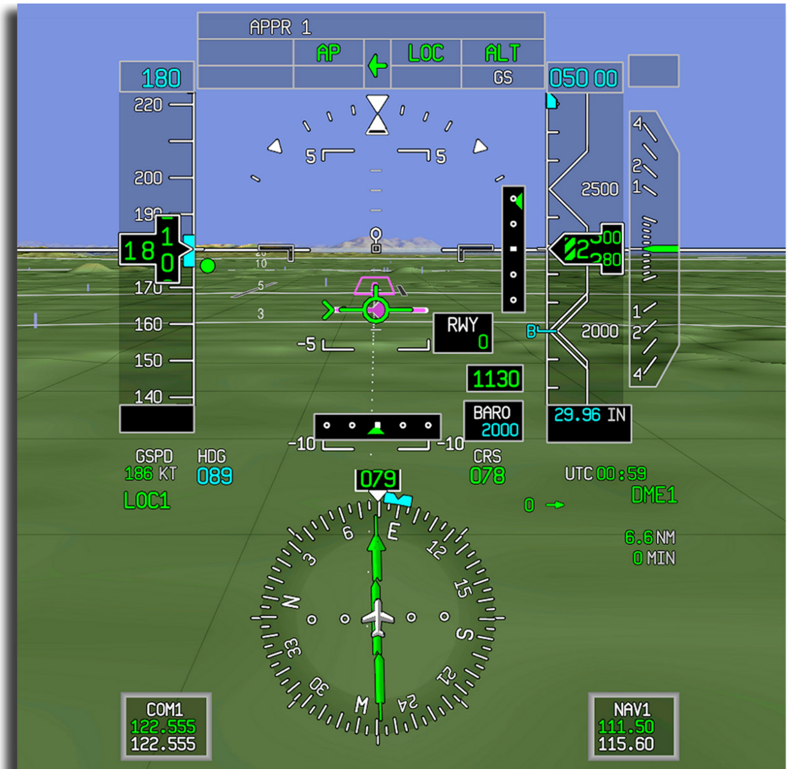

Figure 10-32
ILS Approach Mode – Localizer Captured and Glideslope Armed

The glideslope part of the approach mode is used to automatically intercept, capture, and track the glideslope beam. Typical glideslope beam angles vary between 2 and 3 degrees, depending on local terrain. Glideslope capture is inhibited until localizer capture has occurred.

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ILS GS Capture

The glideslope part of the approach mode intercepts, captures, and tracks the glideslope beam.

As the aircraft approaches the glideslope beam, the flight director monitors CAS, vertical speed, and glideslope deviation to determine the correct capture point. At glideslope capture, GS replaces the active vertical mode, and the flight director generates a pitch command to track the glideslope. The annunciator flashes reverse video GS / GS for 5 seconds, and then the GS annunciator remains steady, as shown in Figure 10-33.

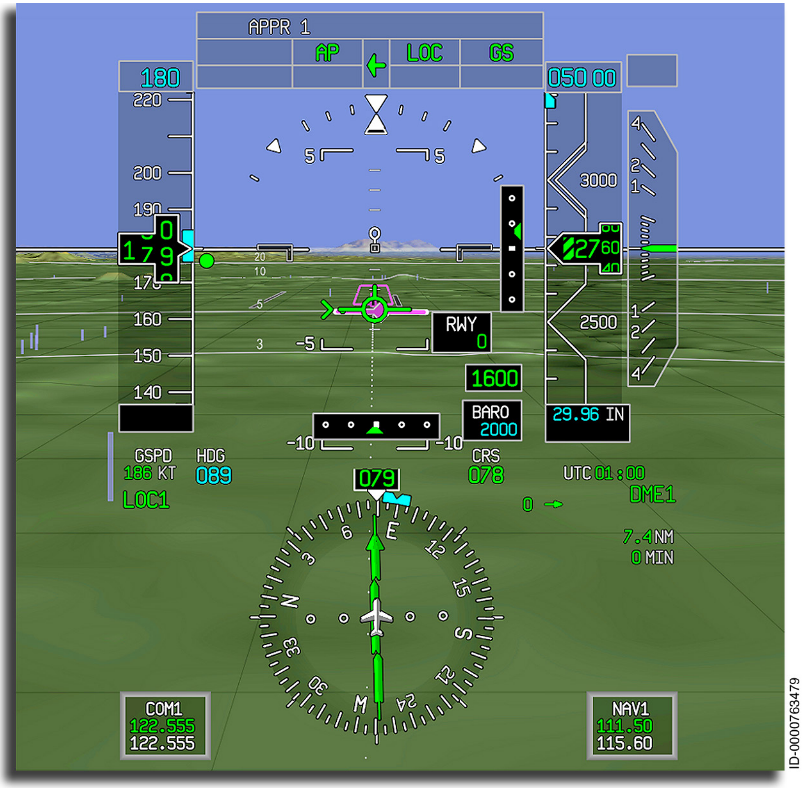

Figure 10-33
ILS Approach Mode (GS Captured)

NOTE: Glideslope capture is inhibited until localizer capture has occurred.

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The ILS glideslope intercept profile is shown in Figure 10-34.

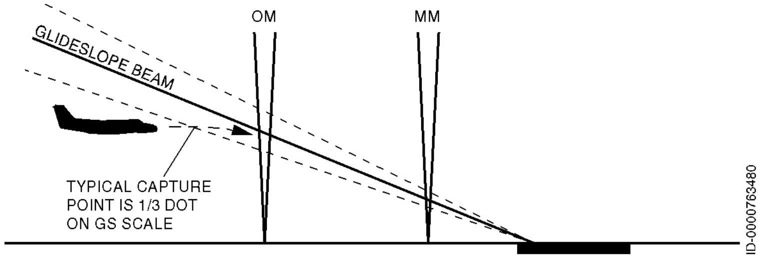

Figure 10-34
ILS Approach Mode Glideslope Intercept and Capture

When the approach is engaged, the **APPR 1** annunciator on the PFD moves to the right side of the display field and is annunciated in green (**APPR 1**).

ILS Approach Mode Tracking

The vertical guidance control sensitivity is adjusted as the aircraft approaches the transmitter/runway using radio altitude and distance from the runway.

If radio altitude is not available, vertical gain programming is based on the submode phase, vertical speed, middle marker beacon, and an assumed initial altitude of 1,500 feet. The beamwidth is based on the estimated distance, glideslope deviation, airspeed, and an assumed glideslope angle of 3 degrees.

CAT1 Approach Status (APPR 1)

When the PFD minimums are set to BARO for a Category 1 approach, **APPR 1** is displayed as an armed mode. This occurs when all of the following conditions are met:

- The coupled PFD NAV radio is tuned to an ILS station
- The localizer and glideslope modes are armed or active
- The AUTOLAND mode is not engaged or armed
- The APPR 2 mode is not engaged or armed
- The APPR 1 mode is not engaged.

If one of the PFD minimums is not correctly set for Category 1 approach, **APPR 1 ONLY** is displayed in place of **APPR 1** (armed).

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If **APPR 1** engages and one of the PFD minimums is not correctly set for Category 1 approach, **APPR 1 ONLY** is displayed in place of **APPR 1** (armed).

APPR 1 is engaged when all of the following conditions are met:

- The Approach 1 is armed
- Any valid radio altimeter is displaying less than 1,500 feet, or all radio altimeters are invalid
- The localizer and glideslope modes are active.

Figure 10-35 shows the localizer and glideslope track modes.

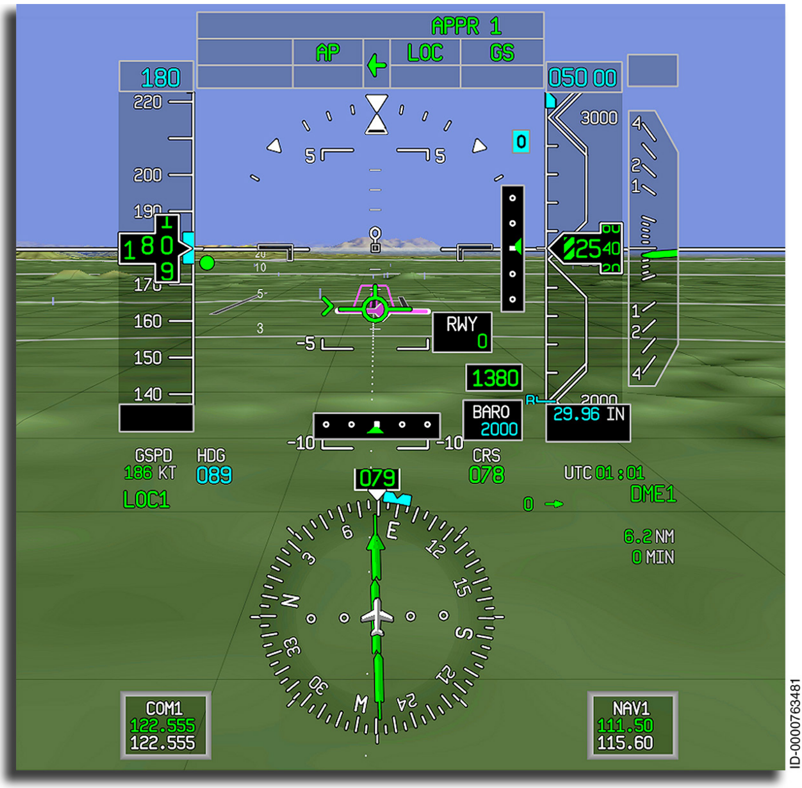

Figure 10-35
ILS Approach Mode Tracking

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NOTE: For Category 1 approaches, the autopilot must be disengaged before reaching 50 feet AGL.

APPR 1 MODE CANCELLATION

The APPR 1 mode can be canceled normally or abnormally. The following actions cancel the APPR 1 mode normally:

- Pushing the **APPR** or **LNAV** buttons on the guidance panel
- Selecting another navigation source on the coupled-side display controller
- Changing the vertical mode to any mode other than GS (e.g., FLC, VS, GA)
- Selecting HDG mode
- Aircraft is on the ground
- Any flight director button is pushed, and the autopilot is not engaged.

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If the APPR1 mode is canceled abnormally, NO APPR is displayed in the approach status field on the PFD, as shown in Figure 10-36. The APPR 1 mode is canceled abnormally if any of the following conditions occur while the aircraft is above 100 feet AGL or RADALT is invalid:

- The coupled-side LOC NAV source is failed for more than 5 seconds
- **SRC** button is pushed on the guidance panel
- The GS mode transitions to basic vertical mode (FPA or FD Off), and the active lateral mode is not HDG.

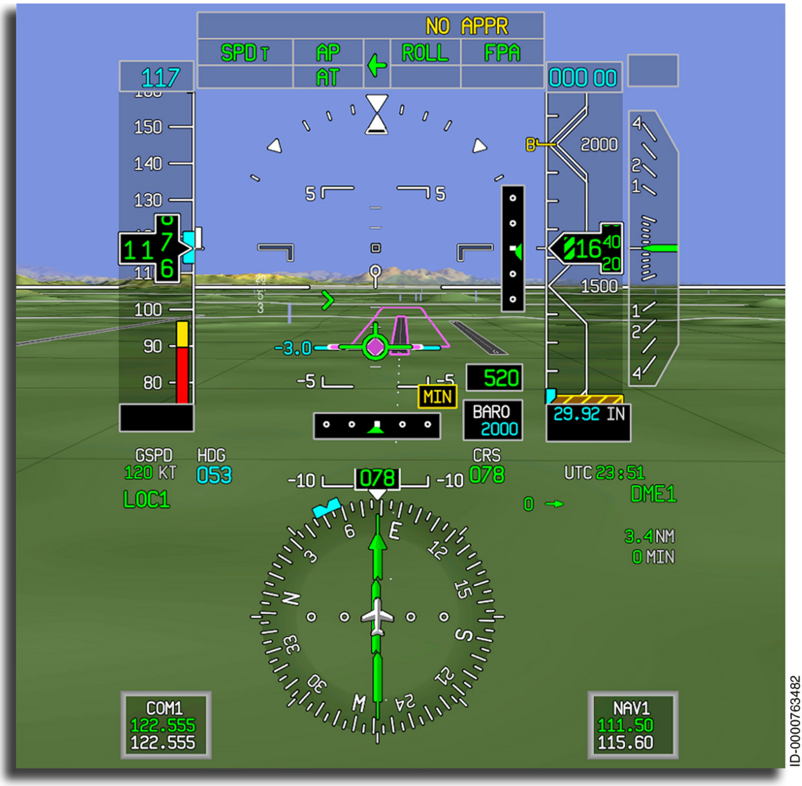

Figure 10-36
NO APPR Annunciation

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If the approach mode is canceled, and the NO APPR annunciator is displayed, the NO APPR annunciator is removed when the following occurs:

- The **APPR** or **LNAV** button is pushed
- The aircraft is on the ground
- The NAV source on the coupled PFD is changed
- The lateral or vertical modes are changed
- Any **FD** button is pushed, and the AP is not engaged.

ILS (CAT 2) Approach

During the tracking phase of an ILS (APPR 2) approach, shown in Figure 10-37, the system uses landing aid flight path information from the pilot and copilot PFDs. This flight segment of the approach phase is automatically initiated and occurs between 1,500 and 800 feet radio altitude.

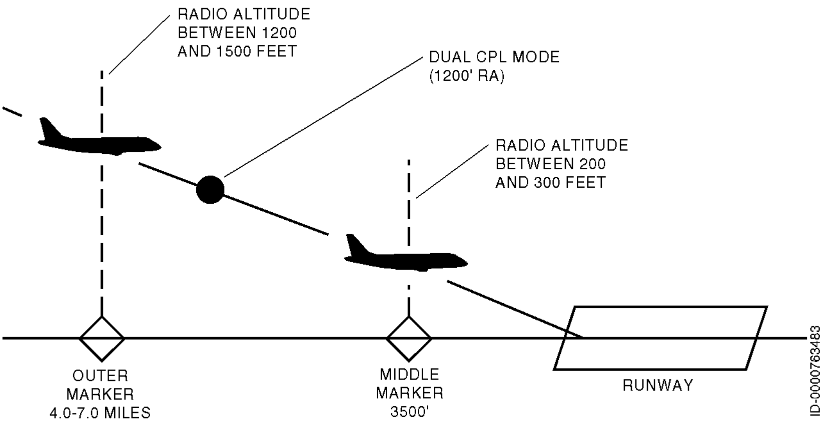

Figure 10-37
ILS (APPR 2) Approach

The aircraft is capable of APPR 2 (CAT 2) approaches when all of the following conditions are met:

- The high priority flight director is available
- At least one radio altimeter is valid
- The radio altitude miscompare monitor is inactive

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- The pilot and copilot have valid PFD displays
- The two PFDs are driven by independent air data sources and two independent inertial reference system (IRS) sources
- The altitude, airspeed, pitch, roll and heading, and FPA miscompares are inactive
- There are at least two valid NAV sources.

When APPR 2 is not capable, the APPR 2 NOT AVAIL CAS message is displayed.

The APPR 2 mode is armed when all of the following conditions are satisfied:

- The aircraft is IN-AIR
- The aircraft is APPR2 capable
- The minimums shown on both PFDs are set to RA and valid
- No displayed radio altitude is less than 800 feet
- The localizer and glideslope modes are armed or active from the high priority FD channel
- Automatic flight control system (AFCS) is setting the AFCS APPR 2 ARM parameter from the high priority FD channel
- The STEEP approach is not armed or engaged.

Once armed, APPR 2 is displayed in the line above the flight mode annunciators on the PFD.

When either of the PFD minimums is not correctly set for Category 2 approach, APPR 2 ONLY is displayed in place of APPR 2 armed. When APPR 2 engages and one of the PFD minimums is not correctly set for Category 2 approach, APPR 2 ONLY is displayed in place of APPR 2 .

The APPR 2 mode is engaged when all of the following conditions are satisfied:

- The APPR 2 is armed
- At least one displayed radio altitude is valid and less than 1,500 feet

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- AFCS is setting the AFCS APPR 2 ACTIVE parameter from the high priority FD channel
- The crew selected a valid APPR 2 flap position
- The CAS message SLAT - FLAP LEVER DISAGREE is not displayed.

At APPR 2 transition, the command bars are in view on both pilot and copilot PFDs.

APPR 2 is displayed when engaged, as shown in Figure 10-38. Once engaged, APPR 2 remains engaged until one of the following conditions occur:

- Radio altitude is invalid
- The aircraft is no longer APPR2 capable
- The AFCS is no longer setting the AFCS APPR 2 ACTIVE parameter from the high priority FD channel
- The crew selects an invalid APPR 2 flap position (a setting other than SLAT/FLAP 5)
- The CAS message SLAT - FLAP LEVER DISAGREE is active
- Either minimum indication changes from RA to BARO, with a value other than zero, or OFF
- AUTOLAND is engaged
- The aircraft lands
- Steep approach is either armed or engaged.

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The APPR 2 annunciator is displayed in Figure 10-38.

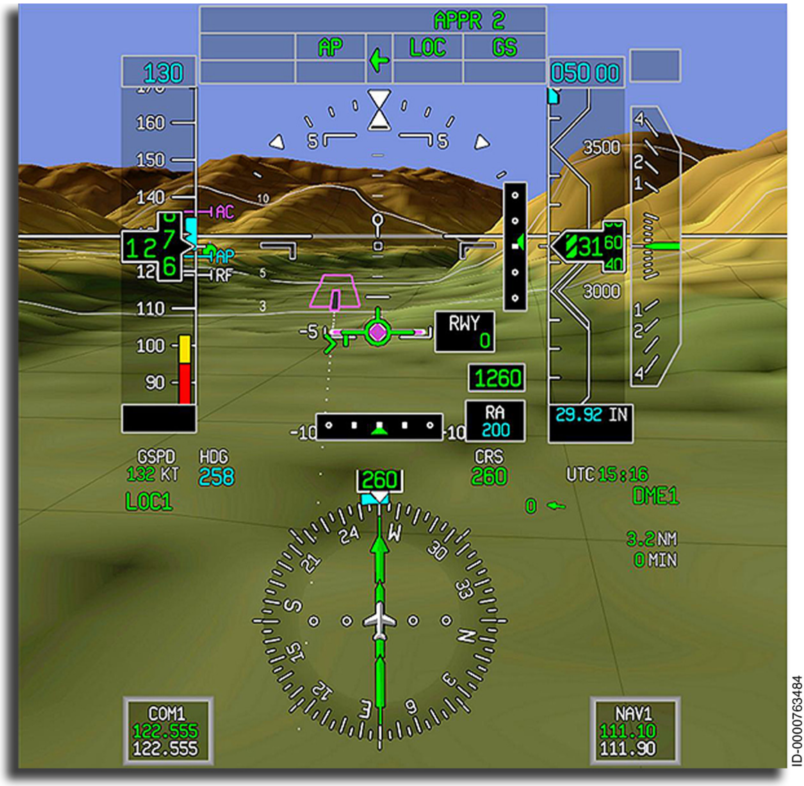

Figure 10-38
ILS Approach (CAT 2) Mode

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GBAS Landing System (GLS) (Option)

GBAS landing system (GLS) is an option that provides a precision approach and landing solution utilizing the GPS constellation and ground-based augmentation system (GBAS) ground station. GLS improves landing capabilities in any weather conditions increasing safety, reducing risk of diversion, cancellation, go-around and/or excess fuel uplift that enhances an operator's capability and dispatch reliability.

A GLS approach can be entered into the flight plan by selecting a GLS approach in the FMS or manually tuning the NAV radio to a valid GLS channel number. A GLS approach is initiated by pushing the **APPR** button on the guidance panel.

A GLS approach can also be selected using INAV graphical flight planning.

NOTE: GLS approach capability is an option. If the GLS approach option is not selected, GLS approaches are not displayed on the FMS Approach page, and the NAV radios cannot be tuned to the GLS channel number.

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Once the GBAS channel is tuned and previewed, pushing the **APPR** button arms the GLS approach. An armed GLS approach is shown in Figure 10-39.

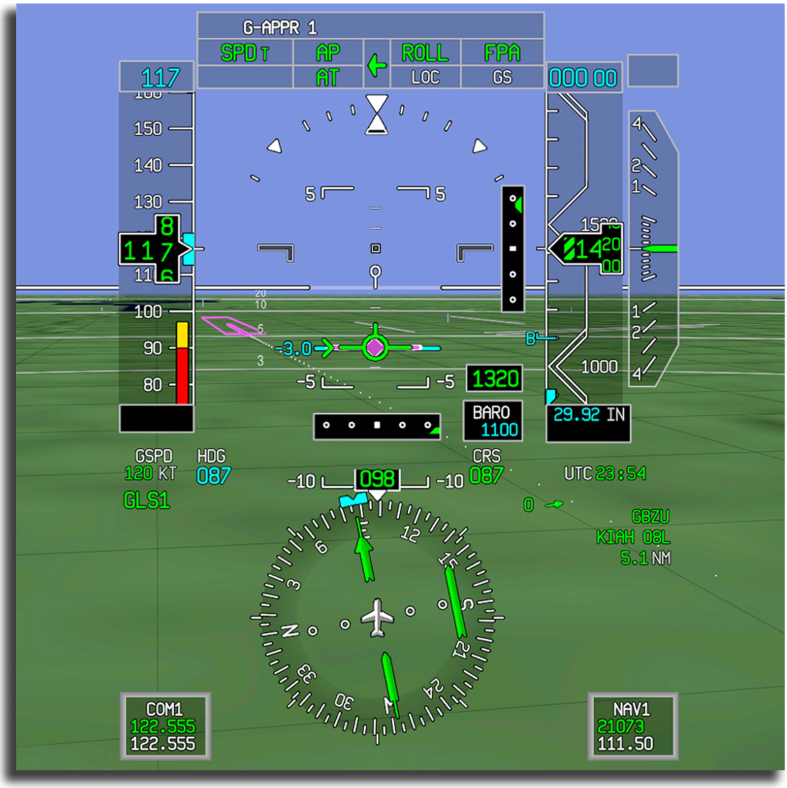

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Figure 10-39
GLS Approach Armed

The G-APPR1 mode is armed when the **APPR** button on the guidance panel is pushed while a GLS approach is tuned and GLS is the selected primary or preview NAV source.

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An example of an engaged GLS approach is shown in Figure 10-40.

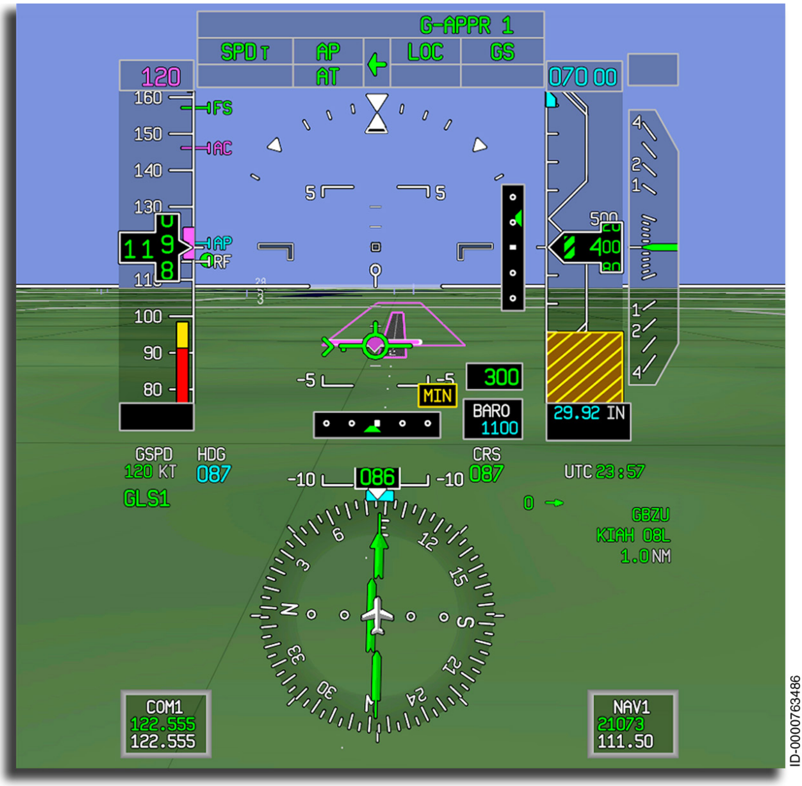

Figure 10-40
GLS Approach Active

The G-APPR 1 mode annunciator is displayed as active when the LOC and GS are the active FD modes, and the GLS is captured. The GLS is the primary NAV source.

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G-APPR1 MODE CANCELLATION

The G-APPR1 mode can be canceled normally (pilot disengagement) or abnormally (system failure etc.). The G- APPR1 mode is canceled normally if any of the following conditions are met:

- The **APPR** or **LNAV** button is pushed
- The GLS NAV source is changed to another source on the coupled PFD, except for GLS NAV source automatic reversion
- The vertical mode is changed to any mode other than GS (e.g., FLCH, VS, GA)
- The lateral mode is changed to HDG
- Aircraft is on the ground (lands)
- Any flight director button is pushed, and the autopilot is not engaged.

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If the G-APPR1 mode is canceled abnormally, NO G-APPR is displayed in the FMA on the PFD, as shown in Figure 10-41. The G-APPR 1 mode is canceled abnormally if any of the following conditions occur:

- The coupled-side NAV source is failed for more than 5 seconds (except for GLS NAV source automatic reversion)
- **SRC** button is pushed on the guidance panel
- The GLS vertical mode (GS) transitions to basic vertical mode (FPA or FD Off), and the active lateral mode is not HDG
- The GLS is failed (GLS1/2 FAIL displayed in CAS window).

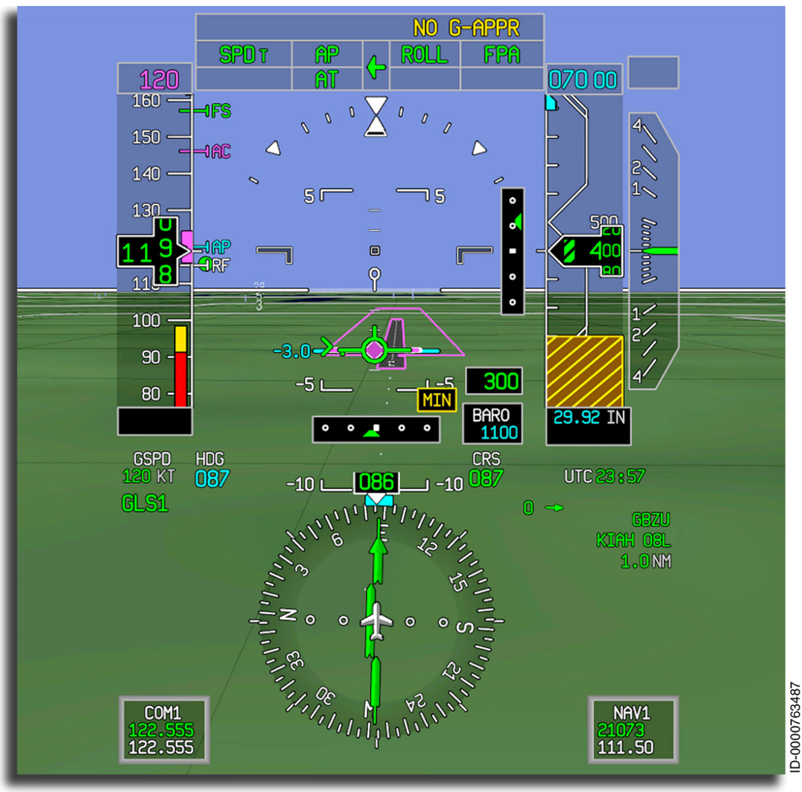

Figure 10-41
NO G-APPR Annunciator

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RNAV SBAS Approaches (LPV)

The RNAV localizer performance with vertical guidance (LPV) approach mode automatically intercepts, captures, and tracks GPS signals so that a fully coupled RNAV approach is flown. The LPV mode is set up and flown similar to the ILS mode. The LPV mode is interlocked so that the glide path capture is inhibited until the LNAV is captured.

RNAV approaches with LPV minimums are normally conducted utilizing the LNAV and GP flight director modes. The FMS lateral navigation (LNAV) function is utilized to provide lateral guidance by the way of roll steering commands to the AFCS to capture and maintain the lateral course by the way of the LNAV flight director mode.

The FMS glide path (GP) function computes the approach geometry and sends it to GPS. GPS, in turn, computes deviations and provides them to the displays and the AFCS. The AFCS computes the steering commands to maintain the GPS linear glide path until the flight path control point (FPCP).

NOTE: When the displayed deviations are received directly from the GPS, the HSI navigation source indicators remain FMS.

NOTE: Refer to company-specific manuals/MEL documents to determine LPV approach capability based on MEL items.

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The following steps describe the procedure for LPV mode:

1. Select an RNAV approach with LPV minimums in the MCDU. Figure 10-42 shows an ARRIVAL page with an RNAV approach (with LPV minimums) selected.

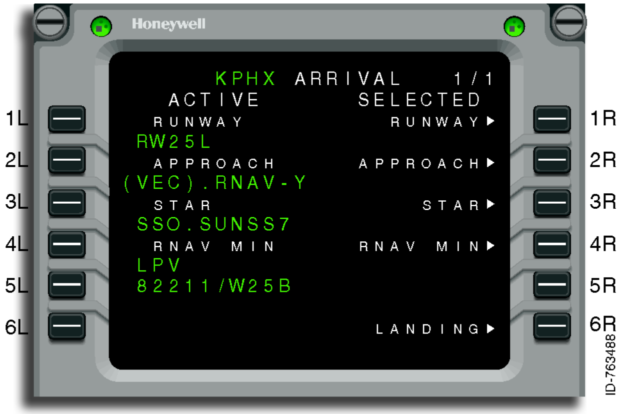

Figure 10-42
RNAV Approach With LPV Minimums Selected

2. Toggle the **SRC** button on the guidance panel to direct the left or right arrow as the coupled side.

3. Select the PFD NAV source to FMS on the coupled side.

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4. Push the **APPR** button on the guidance panel to arm the LPV mode. The LPV armed annunciator is displayed when the LNAV and GP modes are armed or active. Figure 10-43 shows the LPV armed annunciator.

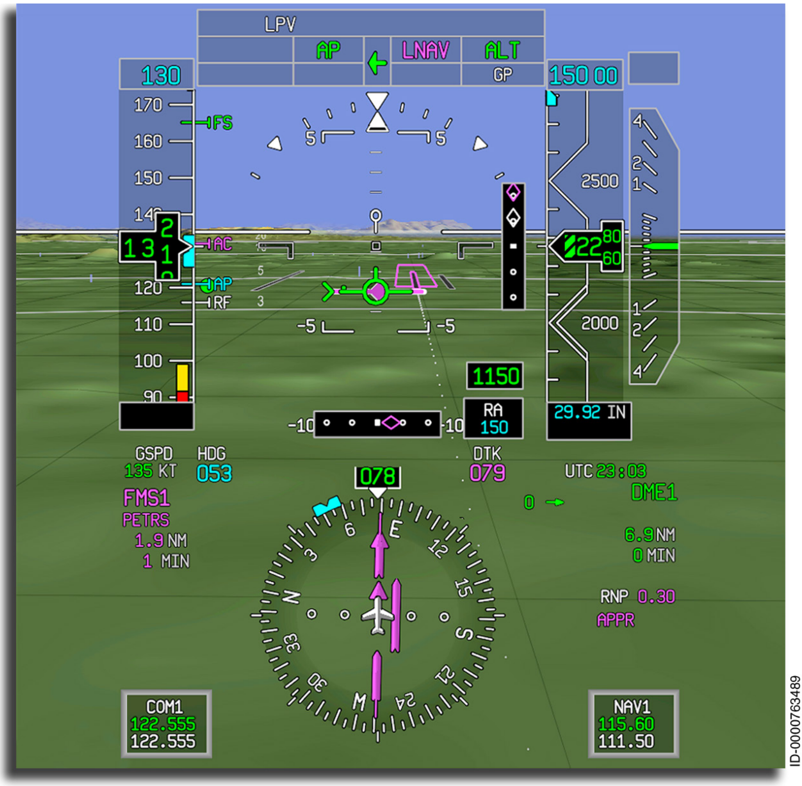

Figure 10-43
LPV Armed

The GP mode is armed once the FMS determines the GP mode arm criteria have been met and the **APPR** button on the guidance panel is pushed. The **APPR** button also arms the FMS LNAV .

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Once the GP mode is armed, LNAV is captured, and the GP pointer moves toward the center of the scale and enters the FMS capture criteria, the FMS captures the GP mode. Figure 10-44 shows the GP mode captured.

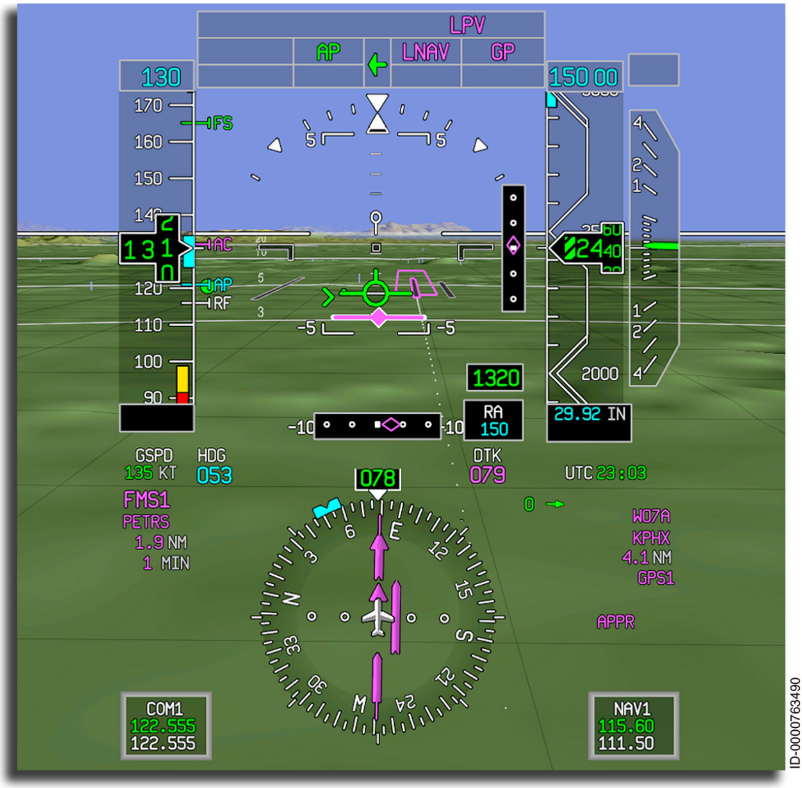

Figure 10-44
LPV Captured

Once the LPV capture criteria are met, the LPV captured annunciator is displayed. This indicates the system is now using angular deviations directly from the GPS.

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In the case of a system failure, NO LPV is annunciated in the FMA, as shown in Figure 10-45.

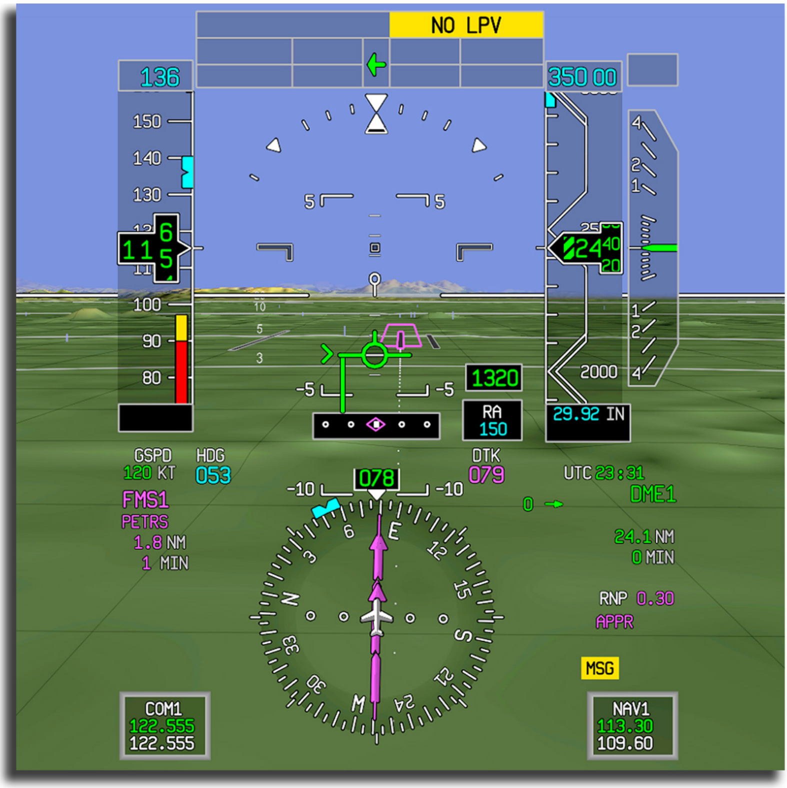

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Figure 10-45
NO LPV Annunciator

If external factors result in the LPV approach not being available, the message LPV NOT AVAIL is displayed in the CAS window. Refer to company-specific procedures for appropriate pilot action.

LPV mode is described in the section FMS SBAS Approaches on page 5-85.

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RNAV RNP Approaches

RNP is a statement of the navigation performance, accuracy, integrity, continuity, and availability necessary for operations within a defined airspace.

RNP refers to a concept in which routes and instrument procedures are not restricted to the location of ground-based navigation aids. RNP is an area navigation capability intended to enable reduced lateral separation for all phases of flight. RNP airspace includes areas, routes, and procedures designed such that the aircraft must maintain the position within the designated accuracy for that airspace (taking into account navigation accuracy and flight technical error). The aircraft is required to maintain positional accuracy to within a specified radius for the current airspace 95% of the time. RNP provides for system designed-in performance assurance in the form of two times the RNP containment limit. The RNP containment limit is intended to serve, at a minimum, the following two purposes in the development of airspace:

1. Supply a means to facilitate the safety assessments for separation and obstacle clearance in the development of routes, areas, and procedures.
2. Supply an additional boundary on error performance that enables reduction in separation buffers derived from traditional collision risk methods.

Procedures having RNP values associated with them are:

- SIDs (standard instrument departures)
- SID transitions
- STARs (standard terminal arrival routes)
- STAR transitions
- IAP (instrument approach procedure) transition
- IAP final approach segment
- IAP missed approach segment.

NOTE: The final approach segment is defined as the flight path from the final approach fix (FAF) to the missed approach point (MAP).

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RNP values are also displayed on the PERF PLAN pages only for legs as defined in the NAV DB.

RNP AR Approach Requirements – RNP instrument approaches with AR (authorization required) are instrument approach procedures that require specific approval from the certification authorities prior to being flown. Prior to conducting an RNP AR approach, the aircraft has to have approval, as documented in the Aircraft Flight Manual (Supplement). In addition, the flight crew has to have the required training.

NOTE: For more information on RNP, refer to the Flight Management System (FMS) for the Embraer E2 E-Jets E190/E195-E2 Pilot's Guide (Pub. No. D202012001536).

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RNAV RNP approaches are instrument-approach procedures having associated RNP values. Each leg of the approach procedure can have different RNP requirements, as shown in Figure 10-46. The RNP values are stored in the aircraft navigation database. The RNP values change as the aircraft is flown past the associated waypoints on the approach up to the final approach segment.

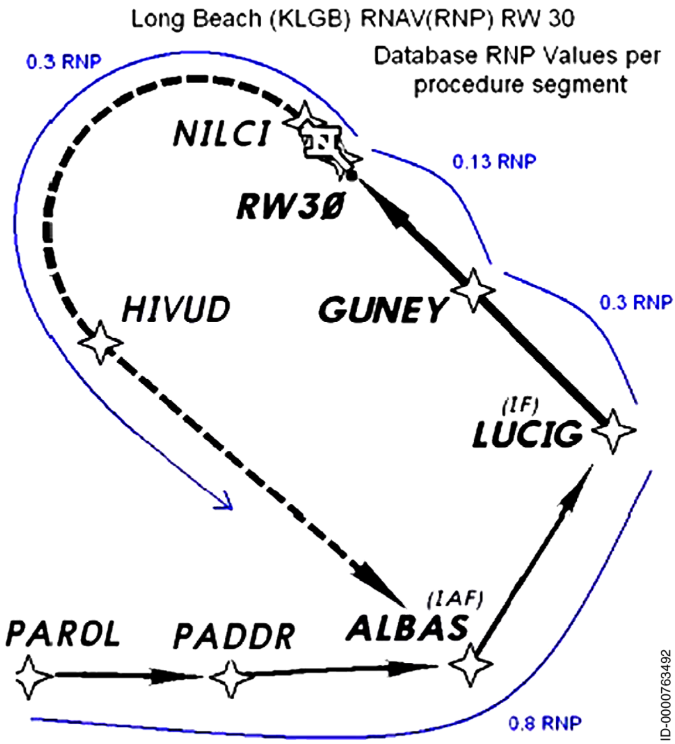

Figure 10-46
KLGB RNAV (RNP) Y RWY 30

The final approach segment can have up to three RNP values associated with different approach minimums with the RNP option. The different minimums (associated with the different RNP values) are depicted in the minimums section of the approach plate, as shown in Figure 10-47.

Figure 10-47
RNAV RNP Approach Minimums

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An approach can have multiple RNP minima. Starting from the FAF and extending to the MAP, the RNP value changes to the RNP minimum value selected by the pilot when the approach is selected on the ARRIVAL page.

When the pilot does not manually select an RNP minimum value, a default RNP value is automatically selected. The default RNP value is associated with the lowest approach minimums.

When a missed approach is initiated at the MAP, the RNP value automatically changes to the RNP value associated with the missed approach course. When a missed approach is initiated prior to the MAP (e.g., between FAF and MAP), the current RNP value remains until reaching the MAP. At the MAP, the RNP value changes to the missed approach RNP.

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RNP APPROACH DISPLAY

The final segment of RNP approaches is flown using the LNAV and GP modes. The approach status display contains the RNP value, as shown in Figure 10-48.

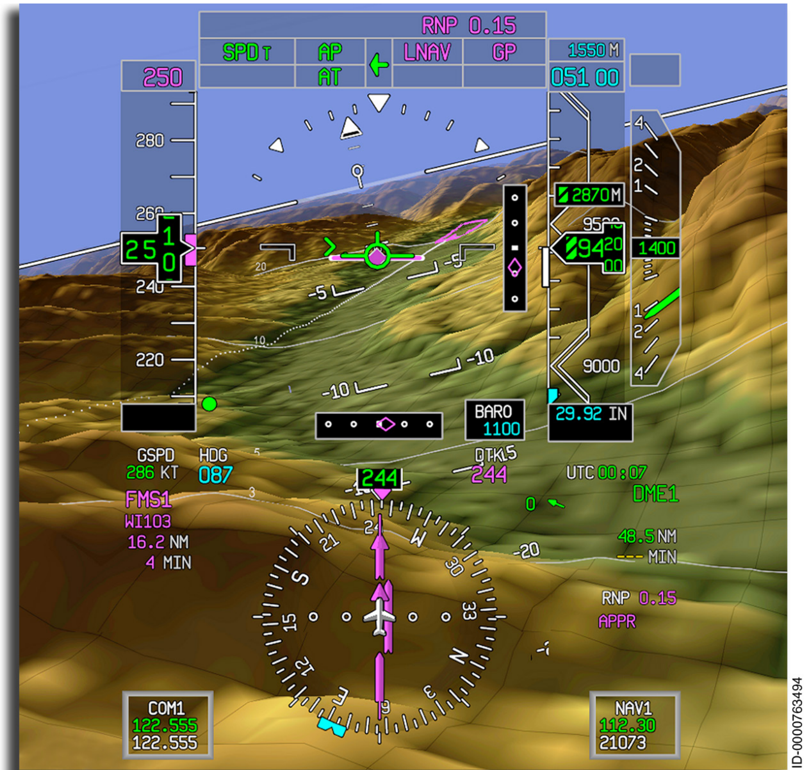

Figure 10-48
RNP Approach

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11. Autothrottle System

INTRODUCTION

This section describes the function and operation of the autothrottle (A/T) system.

THRUST MANAGEMENT SYSTEM (TMS)

The thrust management system (TMS) computer works with the flight guidance control system (FGCS) to control aircraft speed and thrust. The TMS system helps reduce fuel consumption and increase engine life by limiting thrust, speed, and temperatures required for different phases of flight.

The baseline TMS consists of the following subfunctions:

- Thrust rating system (TRS)
- Takeoff dataset selection (TDS)
- Autothrottle (A/T)
- Electronic thrust trim system (ETTS).

The TRS receives the thrust ratings from the flight management system (FMS) or the multifunction control and display unit (MCDU) (thrust rating selection page) by way of the full authority digital engine control (FADEC) system. The thrust ratings indicate the percentage of the maximum available thrust for certain phases of flight. The FADEC system for each engine determines the maximum thrust rating for the engine under the current conditions and settings. The throttles are positioned by the autothrottle system while following FADEC dictated engine ratings.

The takeoff dataset entry menu is the only user interface page that allows the user to change FADEC settings. FADEC settings are variable and can be adjusted to help extend engine life. This is done by entering the desired parameters in the MCDU.

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The TMS configuration consists of a dual-channel (one active and one standby) TRS and a dual-channel (one active and one standby) AT/ETTS. The priority channels are selected automatically by the system or manually by the flight crew. The MCDU SETUP page, shown in Figure 11-1, is used to select the priority channels—either TRS channel A or B and AT/ETTS channel A or B. The TRS channels are in an active/standby configuration. When the selected TRS is inoperative, the TMS automatically switches to the standby channel and continues to provide TRS functions.

Figure 11-1
SETUP Page

The AT/ETTS is also configured with auto channel priority reversion. When the selected AT/ETTS channel is inoperative, a priority manager automatically detects the system issue and, without loss of the function, switches the AT/ETTS function to the other functioning channel. The pilots have the ability to manually select the priority AT/ETTS channel on the SETUP page by selecting 4R. The TLA/ETTS TRIM function can be enabled or disabled by selecting 6R on the TRS page on the MCDU when A/T is not engaged. When A/T is engaged, TLA/ETTS trim is always enabled.

The following manually changes the TRS priority channel as well as selects the AT/TLA TRIM channel:

1. Pushing the **MISC MENU** button, then **SETUP** shows the SETUP page.
2. Pushing line select key (LSK) 5R selects the other channel. The green letter A or B is the channel selected.

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3. Pushing 4R changes the A/T and ETTS channels.

The A/T system automatically positions the thrust levers to control the aircraft thrust throughout all phases of flight. The A/T system keeps the aircraft within the thrust and speed envelopes and controls the engine thrust in synchronization with the active FGCS modes.

The thrust lever quadrant consists of the main throttle levers for setting forward thrust and finger lift levers for thrust reverser operation. The system also uses takeoff/go-around (TOGA) buttons, an A/T engage/ disengage button on the guidance panel, and autothrottle quick disconnect buttons.

The following A/T annunciators are displayed on the primary flight display (PFD): A/T system annunciator, A/T active mode annunciator, A/T armed status annunciator, and A/T system failure annunciator. System parameters are controlled by the TRS pages on the MCDU.

The ETTS automatically trims the aircraft thrust using the FADEC to permit one of the following based on crew selection and flight phase:

- Tighter speed control (during A/T operation)
- Equalizing thrust of both engines to the active TRS rating.

The ETTS is designed to command limited authority thrust changes for engine synchronization and trimming to the A/T computed thrust (N_1) reference. A/T can be enabled or disabled by the crew when it is OFF. When A/T is ON, it remains ON.

To engage the autothrottle, push the **A/T** button on the guidance panel. The AT annunciator is shown above the ADI at the top of the PFD.

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Thrust Rating System (TRS)

The TRS determines the proper thrust rating upper limit based on the phase of flight when in auto-rating mode or based on pilot selection when in manual-rating mode. The selected thrust rating and thrust rating values are displayed on the engine indication and crew alerting system (EICAS) window, as described in Section 9, Engine Indication and Crew Alerting System (EICAS). The active thrust rating bug, shown in Figure 11-2, sets the upper limit thrust rating for the A/T system.

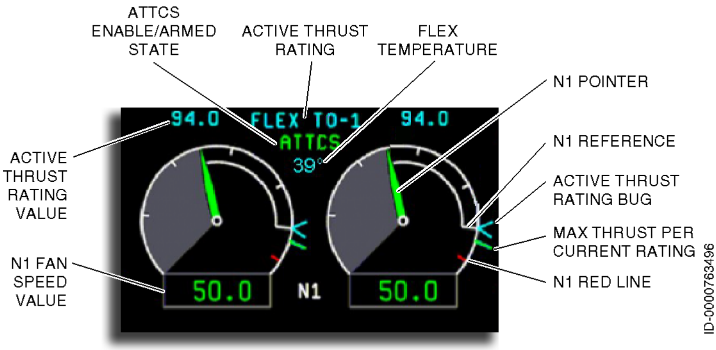

Figure 11-2
Active Thrust Rating on EICAS

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The crew selects the auto rating or one of the manual ratings using the MCDU THRUST RATING SELECT 1/1 page, shown in Figure 11-3. The selected (active) thrust rating/mode is indicated in green, and the option not selected (standby) is shown in white.

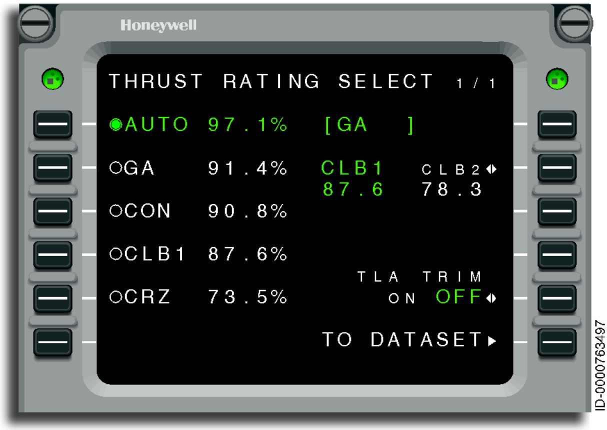

Figure 11-3
THRUST RATING SELECT Page

The possible selections are:

- **1L AUTO** – (Automatic mode) Thrust rating is automatically selected by the system based on the current phase of flight when in auto-rating mode.
- **2L GA** – Go-around mode (field can also be TO mode, which is only available on-ground and is automatically selected by the system).
- **3L CON** – Maximum continuous power mode
- **4L CLB1** – Climb modes—CLB1 or CLB2
- **5L CRZ** – Cruise mode
- **2R CLB1/2** – Toggle control
- **5R TLA TRIM** – Enables automatic TLA trim function
- **6R TO DATASET** – Shows Takeoff Dataset page.

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Pushing LSK 2R toggles between CLB1 and CLB2. The selected CLB rating (CLB1 shown in Figure 11-3) is displayed in the 4L location.

When activated, the pilot-selected thrust rating (that is, AUTO , *GA* , CON , CLB , and CRZ) is displayed in green font, and the circular button next to the active rating is filled in green with a white outline. When not inhibited, all inactive thrust ratings are displayed in white font, and the circular radio button is hollow with a white outline. When the AUTO thrust rating mode is selected, the active rating that is automatically selected by the TRS is displayed in green font within green brackets next to the AUTO thrust rating selection, as shown in Figure 11-3. The selection of takeoff (TO) is possible only in the AUTO thrust rating mode.

When a manually-selected rating is active, the TRS transitions to AUTO mode when a single engine inoperative condition is initially sensed. Following this transition into AUTO mode, manual selection of thrust rating is permitted. When a manually-selected rating is active, the TRS transitions to AUTO mode when the Flight Director mode transitions to go-around or windshear. Following this transition into AUTO mode, manual selection of thrust rating is permitted if Flight Director GA or WS mode is no longer active. When a manually-selected rating is active, and the aircraft is In-Air, the TRS transitions to AUTO mode when the landing gear and flaps are extended.

Takeoff Dataset (TDS)

The takeoff dataset selection page lets the crew set various parameters for takeoff, such as temperature, status of ATTCS, Anti-Ice, and ECS systems. The takeoff dataset selection page is configured based on the type of engine installed. The TO DATASET MENU 1/1* page is used for changing the takeoff thrust rating to accommodate for the different takeoff conditions. There are three possible takeoff dataset selections:

- TO-1
- TO-2
- TO-3.

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Each is selected on the **TO DATASET MENU 1/1** page, shown in Figure 11-4. Not all TO-x are displayed if they are not available for the engines installed in the aircraft. The TO header is the thrust value labeled as 13K0 and read as 13,000 lbs of thrust.

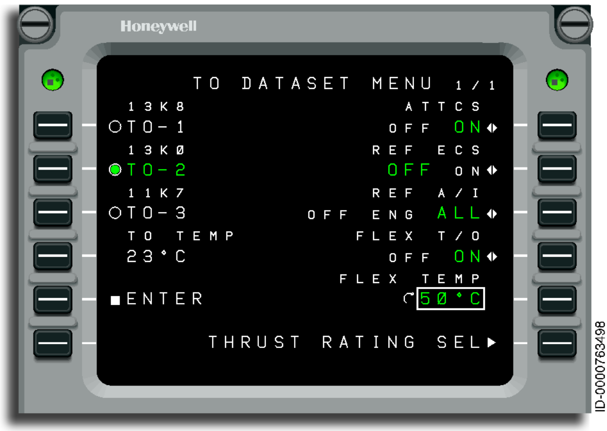

Figure 11-4
Takeoff Dataset Menu

Table 11-1 lists the LSKs shown in Figure 11-4 with selections and functions.

Table 11-1
Takeoff Dataset Menu Button Selections

LSK	Selection	Function
1L	13K8 TO-1 (T/O Rating 1)	Selects Takeoff Dataset 1 as the default takeoff thrust schedule. Header is available thrust value.
2L	13K0 TO-2 (T/O Rating 2)	Selects Takeoff Dataset 2 as the default takeoff thrust schedule. Header is available thrust value.
3L	11K7 TO-3 (T/O Rating 3)	Selects Takeoff Dataset 3 as the default takeoff thrust schedule. Header is available thrust value.
4L	TO TEMP (Take Off Temperature)	Used to manually correct the measured probe temperature. Entered temperature is used by the FADEC until 1,700 feet above takeoff altitude.

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Table 11-1 (cont)
Takeoff Dataset Menu Button Selections

LSK	Selection	Function
5L	ENTER (ACCEPT DATA)	Transmits all data from Takeoff Dataset Menu to FADEC. No data is transmitted to the FADEC until the **Accept** button is pushed.
1R	ATTCS	Turns Automatic Takeoff Thrust Control System (ATTCS) On or Off.
2R	REF ECS (ECS Bleed Configuration)	Turns Environmental Control System Bleed On or Off.
3R	REF A/I (Anti-Ice Bleed Configuration)	Toggles Anti-Ice Bleed Configuration between: OFF (Wing off; Nacelle off), ENG (Wing off; Nacelle on), ALL (Wing on; Nacelle on).
4R	FLEX T/O (Flex Takeoff)	Turns Flex Takeoff On or Off.
5R	FLEX TEMP (Flex Temperature) Not displayed if FLEX T/O is off.	Limits thrust to a value less than the active takeoff rating when the entered Flex Temp value is greater than the measured outside air temperature. Push 5R, then adjust value with the knob.
6R	Thrust Rating Select	Pushing this LSK switches the screen to the Thrust Rating Select page on the MCDU.

The crew selections are displayed in green. The takeoff data is displayed on the Takeoff Dataset page with the currently active selection in green and the ENTER selection shown in white. When the crew uses the ENTER LSK to enter the selected Takeoff Data Set on the page, the selected data is transmitted to the FADEC, and the Enter selection is blacked out with the LSK disabled. The transmitted Takeoff Data is echoed back by the FADEC.

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The active TDS, as indicated by the FADEC, is monitored by the monitor warning function to verify equivalence in the two engines. When a mismatch is detected, the monitor warning function issues an ENG THR RATING DISAG CAS message.

If the crew makes a change to the takeoff dataset menu page and the change is not accepted (value is out of range), the message CHANGE NOT ACCEPTED is displayed in the scratchpad area, as shown in Figure 11-5. When new acceptable data is entered, ENTER (LSK 5L) is again displayed, and the CHANGE NOT ACCEPTED message is removed. Changes to one TDS input do not affect other TDS inputs, except when a different TO mode is selected, FLEX T/O is set to OFF. Changing the TO TEMP also results in FLEX T/O being set to OFF.

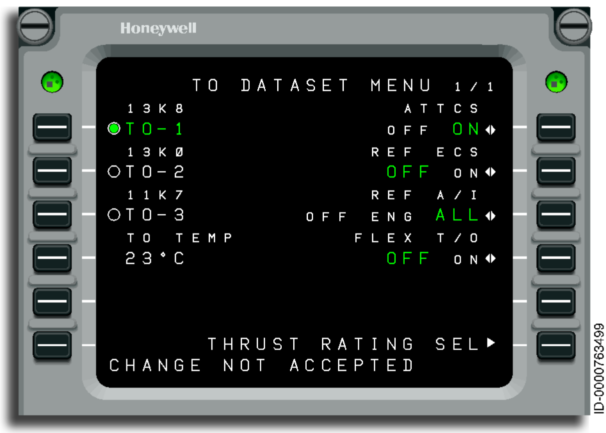

Figure 11-5
CHANGE NOT ACCEPTED Scratchpad Message

Autothrottle (A/T) Operational Description

The A/T system is designed to be compatible with the active pitch mode, determined by either the FGCS or the FMS. Thrust control compatibility is maintained when speed is controlled by pitch. The A/T is designed to use sensor data from the coupled PFD when possible to assure compatible operation with the FGCS.

The A/T system provides the speed and thrust envelope limiting. Thrust envelope limiting is based on the active N_1 rating. Speed envelope limiting is based on minimum speed limits as well as placard and structural speed limits.

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In-line monitoring is incorporated into the A/T design to ensure control integrity. The A/T monitoring consists of validity, servo response, and crew override monitoring. The validity monitoring ensures all parameters required for A/T control during a specific phase of flight are present and valid. In addition, the validity monitoring detects engine out, engine reversion, and thrust reverser deployment.

The servo response monitor compares the servo response with the commanded thrust lever rate of movement to ensure the integrity of the servo control system.

The pilots can override the autothrottle system by making manual adjustments and holding the throttles at a desired location. The autothrottle system can also be overridden while in the TOGA position or at idle. The pilots can feel the servo systems trying to reposition or return the controls to the A/T settings. When the throttles are released, the system returns to the autothrottle commanded positions. If the movements are to either of the limits while going beyond the TOGA detent, the A/T system disconnects.

Autothrottle Modes

The following are the A/T modes:

- Takeoff thrust control mode
- Takeoff thrust hold mode
- Speed on thrust mode (denoted SPDt)
- Speed on elevator mode (denoted SPDe)
- Engine out driftdown
- Engine out auto
- Retard mode
- Go-around thrust control mode.

TAKEOFF THRUST CONTROL MODE

In takeoff thrust control mode, the A/T advances the throttles to the thrust set position to command takeoff thrust. The takeoff thrust control mode remains active as airspeed increases to 60 knots. Above 60 knots, the A/T transitions to the takeoff throttle hold mode.

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TAKEOFF THRUST HOLD MODE

The A/T activates takeoff thrust control hold mode to ensure that no thrust reductions are experienced during this critical phase of the takeoff. The takeoff throttle hold control mode deactivates as the aircraft transitions beyond 400 feet AGL during climb out and transitions to the correct A/T mode following the activation of any vertical flight director mode.

SPEED ON THRUST CONTROL MODE

Speed on thrust (SPDT) is the basic default control mode of the A/T. The speed on thrust setup displayed on the PFD is shown in Figure 11-6. The A/T is set to Speed on Thrust mode when engaged in the air (assuming that thrust is not in takeoff or retard) with no FGCS mode active, or when the A/T and FGS are engaged with a complementary A/T Speed on Thrust mode. If the active A/T mode transitions to speed on thrust and no speed target has been selected, the A/T disconnects automatically.

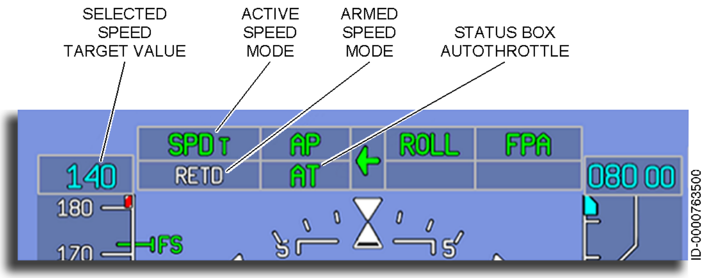

Figure 11-6
Speed Target Annunciator on PFD

The airspeed/Mach targets are set manually by the pilot on the guidance panel or by the FMS during FMS speed control. When the active A/T mode is Speed on Thrust, and the A/T has established the aircraft on the current speed target, the A/T maintains the aircraft on the current speed target to within ±5 knots. Manual (MAN) mode or FMS (AUTO) speed mode is selected using the two-position switch knob on the guidance panel.

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In manual speed mode, the crew controls the airspeed/Mach target using the SPEED knob on the guidance panel. The knob sets the selected speed value in the speed target box. The crew controls whether the A/T is following calibrated airspeed or Mach by pushing the PUSH CAS-MACH switch, which is colocated with the speed knob.

When the A/T Speed on Thrust mode is following an FMS speed target, the FMS automatically controls whether the A/T uses airspeed or Mach.

- **Speed Envelope Protection** – The Speed on Thrust mode provides both high and low speed envelope protection. The electronic display system (EDS) limits the pilot-selected airspeed by V_{MO}/M_{MO}, flap/gear placards, and low speed awareness (LSA). The autothrottle lower speed limit is equal to 1.08 V_{STALL}. When the flaps are extended, the autothrottle limits the autothrottle speed target to 1.08 V_{STALL}.
- **N_1 Rating Protection** – The Speed on Thrust mode gives N_1 rating protection. If a speed target is selected that requires an engine N_1 higher than the active upper N_1 rating or lower than the active lower N_1 rating, the A/T limits the commanded throttle position to the correct N_1 rating. Monitoring is performed by the A/T to detect when the selected speed target cannot be reached because the A/T is N_1 rating limited (and LIM is posted on the FMA).

SPEED ON ELEVATOR CONTROL MODE

The Speed on elevator control mode is active when the crew selects the FGCS flight level change mode or when the FMS engages into vertical flight level change (VFLC) mode. The A/T controls thrust levers to drive command to the FADEC to rev up/down the engines to acquire new altitude selection and hold selected airspeed.

For small flight level change climbs and descents, the A/T changes the thrust of the engines to attain a programmed rate of climb or descent. The rate of climb or descent is proportional to the magnitude of the selected altitude change.

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Full power climbs and full idle descents are used when the target climb or descent rate increases beyond the capability of the aircraft for the active upper or lower N_1 rating. This system assures passenger comfort is maintained throughout the small altitude change maneuvers where maximum climb and idle power are undesirable.

In large flight level change climbs, the A/T advances the throttles to the active upper N_1 rating. During large flight level change descents, the A/T retards the throttles to the active lower idle N_1 rating. The ratings are computed by the FADEC and selected by the TMS based on the phase of flight or are set by the pilot using the N_1 rating menu on the MCDU.

ENGINE OUT MODE (DRIFTDOWN AND AUTO)

The engine out driftdown and auto modes provide engine out guidance and control. Engine out driftdown and auto modes have normal and abnormal disengagement conditions. A normal disengagement condition occurs by a pilot action, and the driftdown or auto mode annunciations are removed. An abnormal disengagement condition occurs when an unexpected degrade or loss of system performance occurs. When an abnormal disengagement condition occurs, the annunciator flashes for 5 seconds and then clears.

Engine Out Driftdown Mode

Engine out driftdown mode is used when the aircraft is above the single-engine ceiling altitude and allows the pilot to perform the entire driftdown maneuver automatically between the autothrottle, FGCS, and FMS. When driftdown mode is engaged, the autothrottle drives the thrust lever of the operational engine to maximum continuous thrust (MCT). DD is annunciated as the active autothrottle mode when driftdown is active, as shown in Figure 11-7.

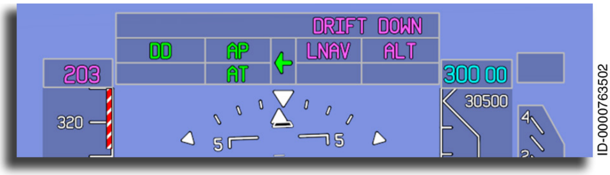

Figure 11-7
Driftdown Mode

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Driftdown mode is entered when an engine out condition is detected, and the active vertical mode is VNAV with FMS speeds. When in driftdown mode, DRIFT DOWN is displayed on the top-right corner of the FMA field. The active thrust rating has to be CRZ, and FMS has to target to CRZ speeds.

The following are the operational steps involved in the driftdown mode:

1. Engine out is detected.
2. FMS lowers speed target from cruise to driftdown speed.
3. FLCH FD mode is activated.
4. Autothrottle drives the thrust lever of the operational engine to the position corresponding with active MCT rating, so the aircraft loses minimal kinetic energy.
5. Due to lack of thrust, airplane is slowing down while still in cruise altitude despite other engine being at maximum continuous thrust.
6. When the aircraft slows down to driftdown speed, the target aircraft begins the descent to the newly selected altitude target.
7. During descent, the operational engine still maintains the active MCT thrust rating.

Driftdown mode is removed when VNAV is deselected, engine operation is regained, or manual speeds is selected.

If driftdown mode is lost, NO DRIFTDWN is displayed (flashes for 5 seconds and then clears), and the pilot has to assume full control when any of the following conditions occur:

- Flight director vertical mode fails
- Autothrottle fails
- Coupled FMS fails
- No valid speed target.

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Engine Out Auto Mode

Engine out auto mode is used to control the speed of the aircraft during an engine out condition right after takeoff to:

1. Assist in climb performance
2. Accelerate aircraft once it reaches altitude
3. Manage aircraft climb rate during climb phase with one engine inoperative when the aircraft is below the single-engine ceiling altitude.

Engine out auto (EO AUTO) mode is automatically armed with FMS takeoff speeds selected when an engine fails. Engine out auto (EO AUTO) mode becomes engaged when VNAV engages, as shown in Figure 11-8.

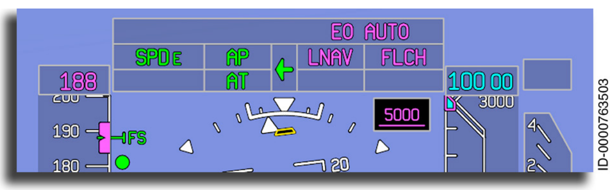

Figure 11-8
EO AUTO Mode

Due to VNAV being inhibited close to the ground, an arm state is created and displayed when an engine is lost before VNAV is engaged.

NOTE: Engine out auto mode in takeoff and missed approach is an APM option.

If VNAV mode, FMS, or speed target data is lost, the EO Auto automatic control is lost, and NO EO AUTO is displayed (flashes 5 seconds and then clears) to alert the pilot automatic control is lost.

Engine out auto automatic control stops when VNAV is deselected, manual speeds is selected, engine function is regained, or an approach mode becomes active.

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NOTE: Though EO Auto is removed when an approach becomes active, the system still automatically controls the throttle and speed properly for the engine out condition.

RETARD MODE

The retard mode is a fixed rate throttle retard of both throttle levers to the idle thrust position during aircraft flare on landing. Once the aircraft touches down and both thrust levers are set in the idle thrust position, the A/T automatically disconnects in preparation for reverse thrust application by the pilot.

The retard mode is available for both an FGCS coupled approach as well as a non-coupled approach, and activates based on the conditions that either the radio altitude is valid and less than 30 feet while the aircraft is in a landing configuration (gear down and landing flap handle position = 5 or 6) or with weight-on-wheels, and both wheels are spun up. Once the A/T retard mode is activated, the throttles are retarded to the idle thrust position.

If the retard mode is not activated while in the air, the AT will activate the retard mode after touchdown and will disengage the autothrottle once levers are retarded to the idle stop position before automatically disconnecting. The A/T remains engaged until touchdown to ensure go-around thrust is available when a go-around is initiated during flare.

The retard mode is inhibited by the activation of go-around mode and remains inhibited until the aircraft transitions 400 feet above the altitude where go-around was initiated. The retard mode is also inhibited by the activation of takeoff mode.

GO-AROUND THRUST CONTROL

The go-around thrust control mode moves the thrust levers to the TOGA position at a rate that ensures positioning of the thrust levers at go-around thrust set position in less than 4 seconds.

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- **Single Engine Operation** – When either FADEC indicates an engine failure or engine not running condition, the A/T remains engaged and continues to command the thrust lever of the operational engine. On detection of the engine failure or shutdown, the A/T de-powers and inhibits engagement of the thrust lever servo of the failed engine. During the single engine operation, the A/T disregards the position of the failed engine throttle to avoid disengagement due to the throttle split. The pilot's responsibility is to move the non-operational engine thrust lever to the idle position and shut down the engine.

Autothrottle Integration With FGCS

The A/T system permits the A/T mode operations and thrust setting to complement the pitch control being performed by the FGCS. The A/T monitors the active vertical FGCS mode to complement the active FGCS mode, except in takeoff and retard modes. Table 11-2 lists the A/T mode selections. The correct A/T mode is selected based on the FGCS mode in use.

Table 11-2
A/T Mode Selection

FGCS Active Vertical Mode	AT Mode Selected
ALT ASEL APP GS GLS VERT VS FPA VALT VASEL VPATH SBY	Speed Control Mode - SPDt (Speed on Thrust)
FLCH VFLCH	Flight Level Change Thrust Control Mode SPDe (Speed on Elevator)
GA WSHR	Go-Around Thrust Control Mode

When no FGCS vertical mode is active (i.e., STANDBY FD mode), the A/T sets independent throttle control based on the internally-computed mode.

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FGCS and A/T Modes and Operation

AT can have armed or active modes. When a mode is selected or transitions from the armed condition to active, the annunciator on the PFD flashes for 5 seconds. The flight director and autopilot modes automatically select the proper autothrottle mode.

The following are the Autothrottle armed modes:

- SPDt (Speed on thrust) – Armed when LIM is active
- TO (TAKEOFF) – Armed by pushing **A/T** button on guidance panel while on-ground
- RETD – Retard.

The following are the Autothrottle active modes:

- T/O – Takeoff thrust control mode
- Hold – Takeoff thrust hold mode
- SPDt – Speed on thrust mode
- SPDe – Speed on elevator mode
- GA – Go-around mode
- LIM – Autothrottle limit mode
- DD – Driftdown mode
- RETD – Throttle retard mode.

Table 11-3 lists the integrated functional control supplied by the A/T and FGCS for the various control modes of the AP/FD and FMS for specified phases of a typical flight.

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Table 11-3
Typical Flight Control by the A/T and FGCS

Flight Phase	AP/FD Pitch Mode	FMS Pitch Mode (VNAV)	Autothrottle Function	AP/FD/FMS Function
Takeoff Roll	Takeoff	N/A	Sets T/O rated thrust or FLEX reduced thrust by controlling to the MAX or FLEX N1 rating. Throttle servos de-power when airspeed reaches 60 knots.	Pitch Control
Takeoff Climb Out	Takeoff HOLD	N/A	Throttle servos remain de-powered until 400 ft AGL.	Pitch Control
Small Flight Level Changes (Climb)	Flight Level Change (FLCH), Vertical Speed (VS)	VNAV Flight Level Change (VFLCH)	Reduced climb thrust during FLCH and VFLCH. Airspeed control for VS.	Airspeed control during FLCH and VFLCH. Vertical speed control during VS.
Large Flight Level Changes (Climb)	FLCH, VS	VFLCH	Full climb thrust during FLCH and VFLCH. Airspeed control for VS.	Airspeed control during FLCH and VFLCH. Vertical speed control during VS.
Top-of-Climb (TOC)	Altitude Capture	VNAV Altitude Capture	Airspeed Control	Altitude Capture Control
Cruise	Altitude Hold	VNAV Altitude Hold	Airspeed Control	Altitude Control
Top-of-Descent (TOD)	FLCH or VS	VFLCH	Transition to idle thrust during FLCH and VFLCH. Airspeed control for VS.	Airspeed control during FLCH and VFLCH. Vertical speed control during VS.
FLCH (Descent)	FLCH, VS	VFLCH or VNAV Path Descent (VPATH)	Full idle thrust during FLCH and VFLCH. Airspeed control during VS and VPATH.	Airspeed control during FLCH and VFLCH. Vertical speed control during VS and VPATH.
Approach	Glideslope Track or GLS VERT	N/A	Airspeed Control	Glideslope Control
Flare	Glideslope Track or GLS VERT	N/A	Thrust retard to idle stop	Disengaged
Landing Roll	N/A	N/A	Disengaged	Disengaged
Go-Around	Go-Around	N/A	Sets Max Rated Thrust	Pitch Control
Windshear	Windshear	N/A	Sets Max Rated Thrust	Pitch Control

Autothrottle Controls

Autothrottle controls are located on both the guidance panel and the thrust (throttle) control quadrant (TCQ). The following are used to manually disengage the A/T:

A/T Button – Pushing the **A/T** button toggles between engaging and disengaging the A/T. The A/T is engaged when the indicator above the **A/T** button is on and when AT is annunciated on the flight modes annunciator section of the PFD.

Pushing the **A/T** button while on the ground arms the TO mode as long as the aircraft speed is less than 50 knots for 30 seconds and the A/T quick disconnect is inactive. Advancement of the throttles beyond 50 degrees TLA engages the A/T, which moves the thrust levers to the correct thrust settings for takeoff.

When the aircraft is airborne and above 400 feet AGL, pushing the **A/T** button engages the system into a control mode compatible with the active AP/FD mode. When no AP/FD mode has been selected, the A/T engages into basic speed control mode. A speed target must have been previously set. Engagement is inhibited if a fault is detected.

Two A/T switches (quick disconnect buttons/TOGA buttons), shown in Figure 11-9, are used to control the A/T system manually.

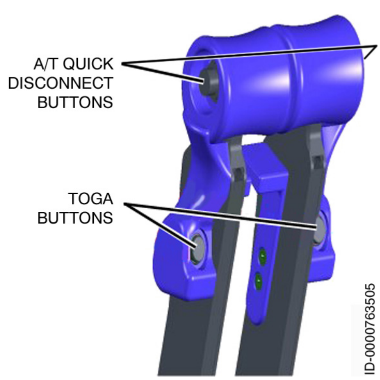

Figure 11-9
Thrust Lever Control Buttons

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- **Quick Disconnect** – Pushing the **quick disconnect** button on the thrust lever disconnects the A/T and is accompanied by a **“THROTTLE“** aural warning.

- **TOGA Button** – When the **TOGA** button on the thrust lever is pushed, the takeoff or go-around mode engages, and the A/T moves the throttles to the TOGA position.

  The go-around buttons are active at radar altitudes less than 2,500 feet or BARO altitudes above 2,500 feet up to 17,000 feet MSL - 17,000 feet of coupled side baro altitude.

- **Manual Movement of the Thrust Lever** – The pilot can override the autothrottle system by manually moving the thrust levers to any position between idle and TOGA without disconnecting the AT provided the A/T T/O mode is inactive. An OVRD message is annunciated on the PFD, as shown in Figure 11-10.

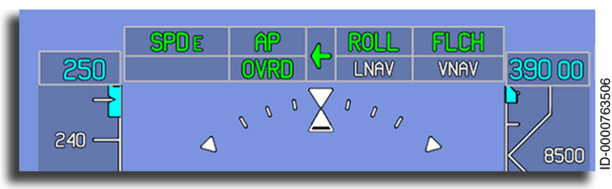

Figure 11-10
Autothrottle Override Annunciator on PFD

If the manual override reaches any of the following conditions, the A/T disconnects:

- The pilot overrides the thrust levers to the MAX power position (TLA > 78 degrees). (The system lets the A/T re-engage after the pilot moves the thrust levers below the MAX position.)

- The asymmetric thrust monitor detects an unacceptable amount of split between the thrust lever positions.

- The pilot positions or overrides the thrust levers below idle (TLA <40 degrees) while A/T TO mode is active below 400 feet.

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DISENGAGEMENT

The autothrottle annunciator (AT / AT) is shown in Figure 11-11. AT is annunciated when the A/T is engaged. The fault warning computer (FWC) sends a signal to the aural warning system for manual and automatic autothrottle disconnects.

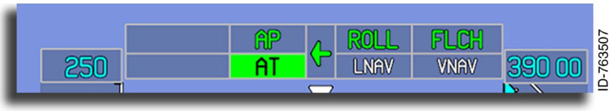

Figure 11-11
AT Annunciator on PFD

- **Normal A/T Disengage** – Pushing the quick disconnect buttons when the A/T system is engaged or in an on-ground armed state disengages the A/T. The quick disconnect switches are also used to acknowledge the A/T disconnect annunciator, and when held, disengages the autothrottle.

A normal disengage or disconnect results in the AT annunciator changing to a green reverse video AT and flashing for 5 seconds while sounding a **"THROTTLE"** aural warning. The AT annunciator is then removed from the PFD, and the aural warning stops.

- **Abnormal A/T Disconnect** – Overriding the system by manually positioning the thrust levers beyond the TOGA detent when A/T is engaged disconnects the A/T system. Movement of the thrust levers when in an on-ground T/O armed state does not disconnect the system unless there is asymmetric thrust detected.

An abnormal disconnect results in the AT annunciator changing to a red reverse video AT and flashing continuously. Also, a **"THROTTLE"** aural warning is sounded until the crew confirms the abnormal disengagement by pushing the quick disconnect button.

The following conditions also result in the system disengaging the A/T:

- The system determines A/T is not required for the current phase of flight (that is, touchdown).
- The A/T transitions to speed control mode, and no speed target has been selected.
- The system senses fault conditions from one or more sources (invalid sensors).

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LIMITED CONDITION ANNUNCIATOR

When thrust or speed is a limiting factor, LIM is displayed in the A/T active box on the PFD. The aircraft is thrust limited. A thrust limited condition occurs either when throttle is full forward, and the speed or thrust target is still greater than the actual speed or thrust, or when the throttle is at idle, and the speed or thrust target is still less than the actual speed or thrust.

AUTOTHROTTLE IN-LINE MONITORS

The autothrottle function availability is independent of ETTS and TRS availability. The A/T supplies control as long as the data necessary to perform the selected control is present and valid. The in-line monitors incorporate a monitoring system that verifies the following:

- System validity
- Servo response
- Asymmetric thrust.

Any abnormal conditions detected result in the A/T disconnecting and system failure messages being displayed on the CAS window.

Electronic Thrust Trim System (ETTS)

The ETTS gives limited authority thrust trimming over the full flight regime by using electronic trim commands to the FADEC. The ETTS is available to the crew in both on-ground and in-air conditions.

The ETTS also supplies thrust matching. Thrust matching is used to bias the engine thrust of each engine as necessary (within the authority limits of the ETTS) to match the thrust of both engines. ETTS is also used to bias the N_1 of each engine to match the N_1 of the selected thrust rating (that is, when the thrust lever is placed near the CLIMB position within the authority limits of the ETTS, the TMS supplies thrust for the selected CLIMB).

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12. Stall Warning Protection System (SWPS)

INTRODUCTION

This section describes the components and operation of the stall warning protection system (SWPS).

DESCRIPTION

The SWPS has a two-stage system that warns and protects the aircraft from stall conditions.

Normal Operation

The first stage of the SWPS warns the pilot of the impending stall in the following ways:

- Activates the stick shaker motor on each control column, which results in each control column shaking (simulating the aircraft buffeting).
- Displays a low speed awareness indication on the airspeed tape.
- Displays a pitch limit indication on the attitude direction indicator (ADI) on the primary flight display (PFD).
- Generates a low speed aural warning.

The second level, provided by the fly-by-wire (FBW) system, is an angle-of-attack (AOA) limiter protection system, which limits the maximum AOA to a safe value below the predicted aerodynamic stall (preventing a stall). The FBW system also has an enhanced protection function (EPF) that provides additional protection during operation at low speed or the AOA limit. For more information on EPF, refer to Section 11, Autothrottle System. The SWPS executes these two stages of stall protection based on comparisons made between the normalized AOA measurements and predefined thresholds for AOA limits for each stage of stall protection.

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The AOA limit interlock is computed in the same manner as the stick shaker command. AOA limit function is operational outside the normal operating aircraft envelope, so the AOA limit function is only activated after the stick shaker is engaged. The AOA limit function is deactivated when the SWPS is invalid or when operating in the stall protection system (SPS) anticipated mode.

Stick shaker commands are sent from the automatic flight control system (AFCS) to the shaker motors through the SPS panel.

Angle-of-Attack (AOA) Computation

The SWPS has four air data smart probes (ADSPs), each giving AOA information. These measurements give the local AOA and aircraft body AOA information to the system, which is used in the following activities:

- Compensation of the sideslip
- Upwash and pitch rate effects
- Computation of the EGPWF reactive windshear function
- Computation of windshear flight director guidance.

Stick Shaker Function

The SWPS consists of two independent stick shakers (left stick shaker and right stick shaker). Each stick shaker has a motor physically mounted to a respective control column. When activated, the motor provides a tactile warning by shaking the control column. The SWPS compares the aircraft computed body AOA with predefined threshold values. Once the threshold is reached or exceeded, the SWPS sends the proper signals to activate the stick shakers on the control columns.

The SWPS also uses actual aircraft flap and slat position information to determine AOA threshold.

Deactivation of the stick shaker motor occurs once the AOA is reduced below the deactivation threshold. As in the activation threshold case, deactivation threshold is also a function of flap, slat, and ice condition and ice protection system state.

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SYSTEM EQUIPMENT

The stall warning protection system consists of the following equipment.

Stick Shaker

The stick shaker actuator consists of the following three main sub-assemblies:

- DC motor
- Stick shaker housing
- DC motor housing.

The DC motor is mounted to the stick shaker housing assembly. The DC motor is driven by +28 V dc power and operates at approximately 12,500 RPM. The motor shakes the stick to warn the pilot of an impending stall condition.

Angle-of-Attack Sensors

Two AOA sensors, one on each side of the aircraft, are part of the ADSP system that provides data to the SWPS. Four ADSPs are installed in the aircraft: (ADSP1, ADSP2, ADSP3, and ADSP4).

STALL WARNING TEST

Preflight test capabilities are included in the SWPS to verify the status of the SWPS components and functions. The SWPS test is active when the following conditions are set:

- Weight-on-wheels
- Gear down locked
- Calibrated airspeed less than 40 knots
- STALL TEST prompt is selected in the multifunction control and display unit (MCDU), shown later in Figure 24-7.

The SWPS test activates the shaker from each control stick while the test is active. The SWPS test period lasts for 5 seconds. The pilot is responsible for verifying the shaker actuation. In the event of a system failure, a CAS message is generated.

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STALL WARNING PROTECTION SYSTEM (SWPS) CONTROLS AND INDICATORS

The SPWS consists of the following controls and stall protection indicators.

Stall Protection System (SPS) Panel

The SPS panel is located on the forward part of the center pedestal in the cockpit. The SPS panel has two functional buttons—Shaker 1 cutout button and Shaker 2 cutout button, as shown in Figure 12-1 in block diagram form. The Shaker 1 cutout button inhibits Shaker 1, and the Shaker 2 cutout button inhibits Shaker 2. A diagram of the SPS system is shown in Figure 12-1.

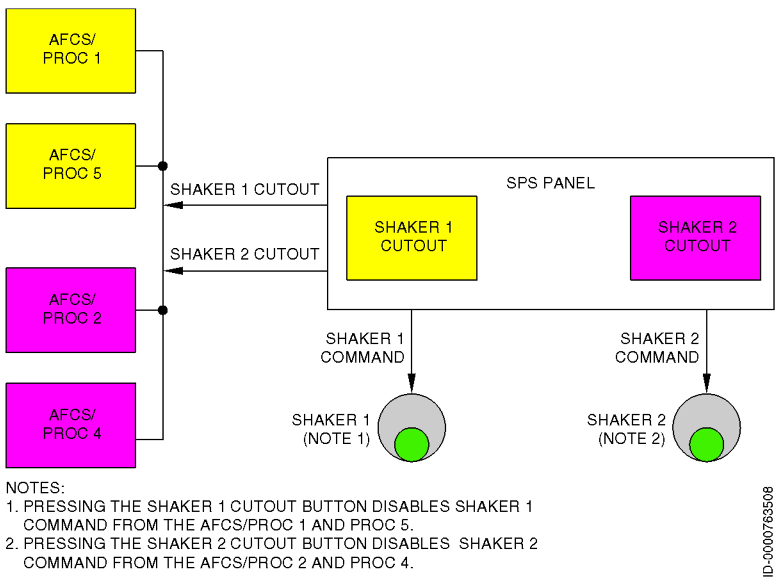

Figure 12-1
Stall Protection System Diagram

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PITCH LIMIT INDICATOR

The SWPS computes a pitch limit indicator (PLI) based on the shaker AOA threshold. The yellow PLI, shown in Figure 12-2, indicates the margin between stick shaker angle-of-attack and aircraft pitch attitude. The PLI margin is calculated continuously and shown when the current airspeed is less than 1.15 V_{STALL}.

The PLI is pitch-based and is displayed with the following conditions:

- When airspeed is higher than 1.15 V_{STALL}, the PLI is not displayed.
- When airspeed is less than or equal to 1.15 V_{STALL} but greater than 1.08 V_{STALL}, the PLI is displayed in green.
- When airspeed is less than or equal to 1.08 V_{STALL} but greater than V_{SHAKER}, the PLI is displayed in yellow.
- When the airspeed is less than or equal to V_{SHAKER}, the PLI is displayed in red.

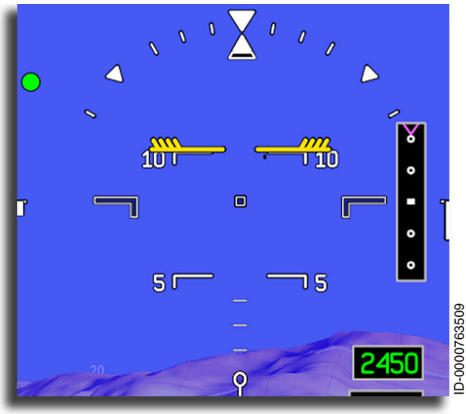

Figure 12-2
Pitch Limit Indicator on PFD

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Low Speed Awareness Indicator

A low speed awareness bar, shown in Figure 12-3, is displayed along the lower-right side of the airspeed tape. The bar position is based on airspeed, aircraft configuration, and angle-of-attack. The bar rises from the bottom of the tape to the calculated stall or stick shaker speed and has two colored ranges.

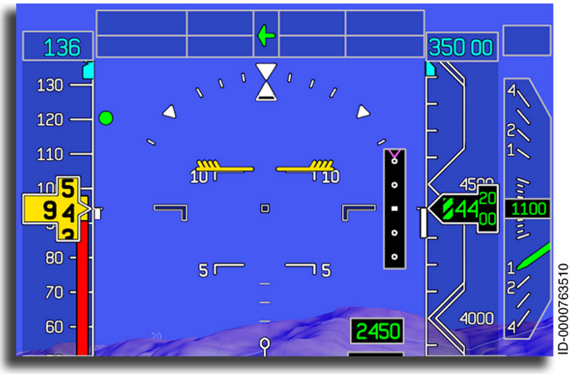

Figure 12-3
Low Speed Awareness Cue

The amber range is from V_{SHAKER} speed to 1.08 V_{STALL}. If the speed of the aircraft approaches the amber range, a low speed aural warning is generated, alerting the pilot of the low kinetic energy of the aircraft. When the amber section of the bar reaches the rolling digits readout, the rolling digits change to amber. The red STALL range is displayed when the airspeed is less than V_{SHAKER}. The stall warning system shakes the control yokes to warn of a potential stall. When the top of the red bar reaches or passes the pointer, the rolling digits change to red reverse video. If the indicated airspeed, angle-of-attack, or stall warning detection data is invalid, the bar is removed, and associated CAS messages are posted to enhance crew awareness.

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SYSTEM FAILURES

The following paragraphs describe potential system failures.

SWPS Failures

There are three types of abnormal operations that can result in system failures. The abnormal operations and consequences are listed in increasing order of importance:

- The first type of abnormal operation is due to flagged failure, miscompare, undetected failure, or electrical failure of the air data. In these cases, the SWPS automatically takes corrective action and supplies continuous stall protection. If the failure has an associated CAS message, it will be displayed.
- The second and more severe abnormal operation is when a single SWPS channel or both SWPS channels are inoperative. If spurious commands are being sent to the stick shaker system, the cutout buttons on the SPS panel can be used to cut out the failed channel. When both channels are inoperative, or the SWPS has failed, the pilot is notified by CAS messages. The pilot must then manually operate the aircraft to avoid a stall and use other methods of stall detection.
- The third and most severe type of abnormal operation is a malfunctioning SWPS. When a failure is known by the SWPS, the system automatically disengages all operations and annunciates SWPS failure in the display system. However, if the malfunction is not detected by the SWPS, the system can activate the stall warning and protection measures in non-stall conditions, possibly resulting in loss of aircraft control. The cutout buttons on the SPS panel can be used to cut out each channel. If both SWPS channels exhibit the same abnormal conditions, the pilot must ignore stall warning (shaker) measures and detect stall characteristics with other methods.

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Air Data Smart Probe (ADSP) Failures

During normal operations, the flight control computer (FCC) provides aircraft AOA information to the SWPS. However, during operation in the FBW direct mode, the SWPS uses data directly from the ADSPs. Flagged failures occur when there is no signal from one of the ADSPs or when the measurements of the ADSPs are out of range. In case of a flagged failure, when operating in FBW direct mode, the SWPS receives AOA information from ADSP3 and ADSP4 instead of ADSP1 and ADSP2. When data from the ADSP3 and ADSP4 are also invalid, the SWPS automatically discontinues processing and sends a STALL PROT FAIL CAS message.

Icing Conditions

When either ice detector is valid and indicates an ice condition, the SPWS sends a signal to post the STALL PROT ICE SPEED CAS message. The SWPS inhibits the ICE condition while the aircraft is weight-on-wheels.

The SWPS inhibits the ICE condition for 5 minutes after transitioning from weight-on-wheels to weight-off-wheels.

CAS Messages

Refer to Section 9, Engine Indication and Crew Alerting System (EICAS), for a description of SWPS-related CAS messages listed in this section:

- ADS 1/2/3 FAIL
- ADS 1/2/3/4 HTR FAIL
- SHAKER ANTICIPATED
- STALL PROT FAIL
- ADS 1/2 HTR FAULT
- ADS PROBE 1/2/3/4 FAIL
- ADS 1/2/3/4 SLIPCOMP FAIL
- SHAKER 1/2 FAIL
- STALL PROT ICE SPEED .

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13. Radio System

INTRODUCTION

This section describes the operation and components of the radio system.

SYSTEM DESCRIPTION

The radio system, shown as a block diagram in Figure 13-1, contains two modular radio cabinets (MRC). Each major function has its own module with a self-contained power supply, radio frequency (RF) receivers/transmitters, signal processing, and all other circuitry required for the radio system to operate. For example, the VOR ILS Datalink - GPS (VIDL-G) module has a power supply, the VOR receiver and converter, the localizer receiver and converter, glideslope receiver and converter, marker beacon receiver, and GPS airborne receiver.

Each module is isolated from system power using an independent circuit breaker. MRC communication is done through a radio control bus (RCB). Communication with the digital audio bus, digital microphone (MIC) bus, ARINC 429 radio control bus, and the avionics standard communications bus (ASCB) is through the network interface module (NIM).

The multifunction control and display unit (MCDU) is the primary method to select and tune the radios. The cursor control device (CCD) also supplies radio control via the PFDs and MFDs (graphical radio tuning). When the aircraft is operating on emergency batteries, the MCDU is the primary source for tuning the radios.

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SYSTEM ELEMENTS

The radio system consists of the following elements.

Digital VHF Data Radio (VDR)

The VHF communications system provides two-way, air-to-air, and air-to-ground communication in the frequency range of 118.000 to 136.975 MHz with 8.33 or 25 kHz channel spacing (selectable through the MCDU). The system has an automatic transmit time-out function to prevent blockage of a communication channel if a push-to-talk (PTT) switch is stuck closed. Also, an analog audio backup control is available (headphones only) by selecting the backup button on the audio panels.

The VHF COM system consists of the following equipment:

- One VDR module per MRC
- One VDR antenna per module
- One (third COM option) mini-cabinet with VDR module connected to the third COM antenna.

NOTE: An option for a third communication system also provides data capability. This unit is located in the mini-cabinet and acts as a third COM function.

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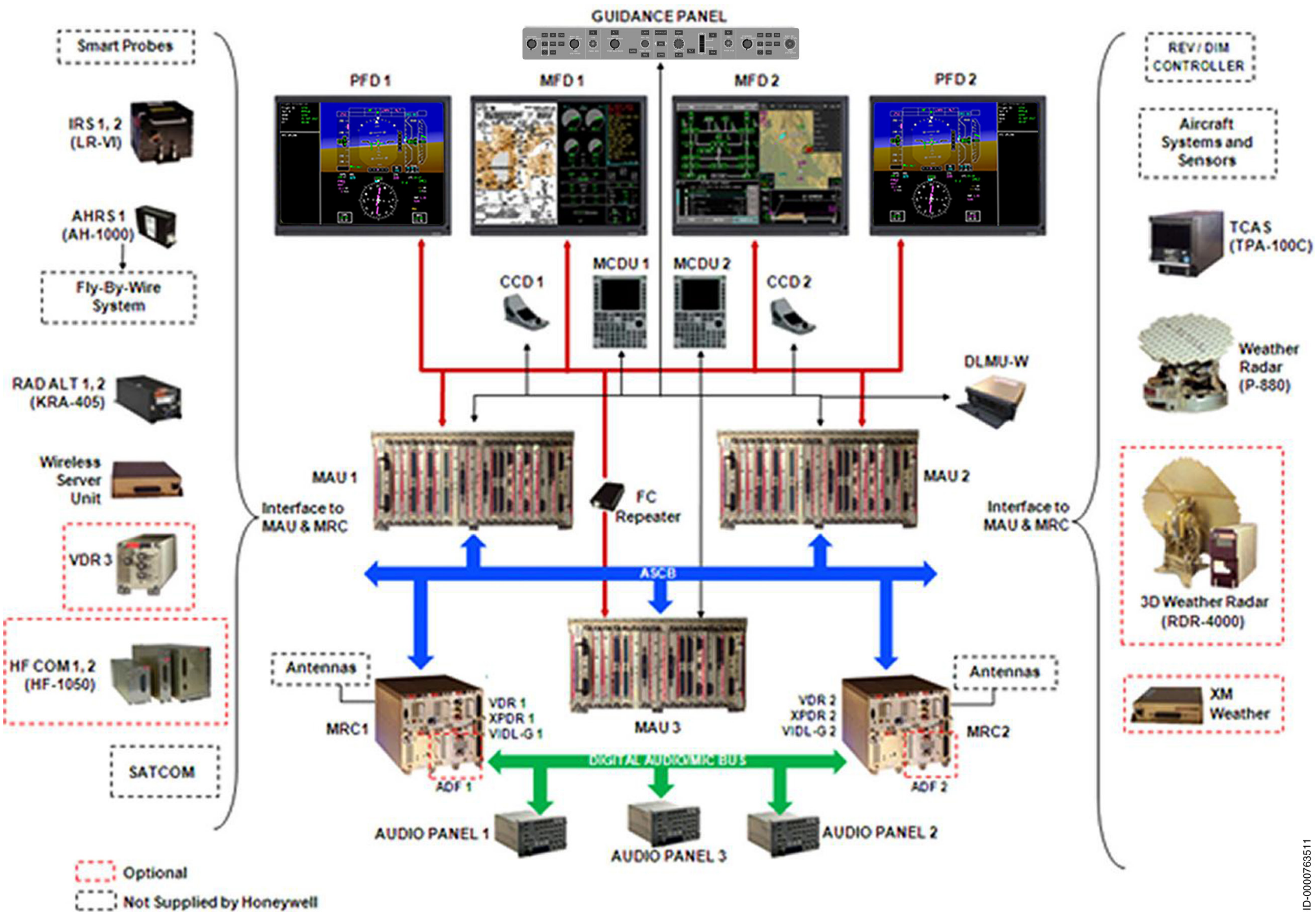

Figure 13-1
Embraer Primus Epic Radio System Block Diagram

VHF Omni-Directional Radio and Instrument Landing With GPS Receiver (VIDL-G)

The VHF navigation system enables the following:

- En route navigation
- Terminal navigation
- Aircraft approach/landing phase navigation guidance using localizer (LOC), glideslope (GS), and marker beacon (MKR BCN) distance to runway threshold information
- The GPS receiver determines position, velocity, time, and system integrity by receiving a series of signals from four or more satellites.

One dual VOR/LOC antenna is installed on the tail of the aircraft. The VOR/LOC receiver operates over the frequency band 108.00 to 117.95 MHz in 50-kHz increments and the LOC from 108.10 to 111.95 MHz in 50-kHz increments. The GS receiver operates over the frequency band 329.15 to 335.0 MHz in 150-kHz increments. The receiver system automatically pairs localizer and glideslope channels to assigned frequencies. The marker beacon receiver operates at 75 MHz.

The VHF NAV system consists of the following equipment:

- One VIDL-G module in each MRC
- One dual GS antenna
- One MKR BCN antenna with a diplexer
- One dual VOR/LOC antenna per module
- One GPS antenna per module.

NAV audio signals from the module are routed by the NIM and transmitted on the digital audio bus. NAV identifier and MKR BCN tone audio signals are transmitted from the digital audio bus to each of three audio panels in the system.

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The VIDL-G is an airborne navigation receiver that operates in ILS, VOR, GPS, and VHF data broadcast receiver modes. The VIDL provides the following radio functions:

- The VHF omni-range receiver for providing bearing in degrees to/from the ground station and is used as navigation means for the aircraft.
- The ILS provides approach and landing navigation guidance information. The radio components of this system include the LOC, GS, and MKR BCN. These radio functions give azimuth, elevation angular deviation, and discrete position fixes relative to the runway threshold.
- The GPS determines position, velocity, and time.

When the VIDL is configured with GPS capability, the GPS function operates with any of the above NAV modes.

Transponder (XPDR)

One Mode S Diversity XPDR is installed in MRC 1 and another in MRC 2. Each transponder provides conventional air traffic control (ATC) functions. The dual Mode S XPDR system enables secondary surveillance by transmission of aircraft identification information, altitude (barometric) and coded message data to ATC ground stations, and traffic collision and avoidance system (TCAS) installations on other aircraft. The XPDR also supports Level 3 Com A, B, and C datalink capability and interfaces to an airborne datalink processor (ADLP). The XPDR supports basic downlink aircraft parameters and is TCAS Change 7 compatible.

The XPDR receives altitude information from the ADS. Flight ID information is supplied by the flight management system (FMS) or is entered by the pilot through the MCDU on the XPDR detail page. The XPDR also receives the ICAO address programmed into the aircraft personality module (APM). The pilot enters the ATC assigned squawk code.

The transponder system consists of the following equipment:

- One XS-858B Mode S Diversity transponder module in each radio cabinet
- Dual transponder antennas (top and bottom, diversity) for each transponder module.

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- The ADLP interface supports the following:
  - COM-A/B messages
  - COM-C/D messages
  - Altimeter interface
  - TCAS interface.

Automatic Direction Finder (ADF)

The ADF module enables en route and terminal navigation and area guidance. The ADF module operates over the frequency band 190.0 to 1799.5 kHz in 500-Hz increments in normal operation. The ADF system can receive in the frequency band of 2181 to 2183 kHz for maritime emergency listening and can tune frequencies in the range of 190 down to 100 kHz. The ADF has two selectable bandwidths. A narrow band mode reduces noise during navigation. A wideband mode improves clarity when listening to voice signals. The selectable modes are as follows:

- Antenna (ANT) – Receives ADF static signal only
- ADF – Receives static signal and computes bearing to station
- Voice – Permits voice to be received and transmitted over radio speakers
- BFO – Adds a beat frequency oscillation for reception of signals.

The ADF receiver interfaces to a dedicated active antenna.

The ADF function is contained in the MRC and includes the following:

- One ADF module (option)
- One ADF antenna for each module (option).

The ADF module has the following features:

- High frequency (HF) keying input prevents interference when the HF radio is transmitting. When the HF is keyed, the ADF needle freezes for 10 seconds, then is driven to the 3 o'clock park position, then is removed.
- Synchronous detection and a 16-bit processor for digital filtering provide the cleanest signals possible.

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Distance Measuring Equipment (DME)

The baseline Embraer installation is a dual-DME system. The DME system enables en route and terminal navigation and area guidance. The DME system operates over the frequency band 960.0 to 1215.0 MHz in 1-MHz increments and has six channels. The DME can track four channels to provide the following data:

- Slant range
- Groundspeed
- Time-to-station (TTS)
- Station identification.

Two additional channels track station identification of preset channels for rapid acquisition. Frequency tuning is automatically paired with VHF NAV. The DME also operates in the HOLD mode. The frequency is not automatically paired with VHF NAV when this occurs. When the FMS is active, two DME channels are dedicated to the FMS for distance, TTS, identification, and control. Two other channels are DME IDENT preset channels, and two channels are for flight crew control and distance, TTS, and IDENT display. With two DMEs installed, each DME tracks the IDENT of the on-side active frequency and the on-side preset NAV frequency.

The DME system consists of the following equipment:

- Two DME modules
- Two DME antennas (one antenna for each module).

The DME module has the following features:

- Accuracy to within 100 feet
- Digital audio IDENT transmission to audio panels
- IDENT decoding of audio Morse code for alpha display.

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MULTIFUNCTION CONTROL AND DISPLAY UNIT (MCDU) RADIO CONTROL AND DISPLAY

The MCDUs are the primary radio controllers. The primary flight display (PFD) and CCD can give quick and convenient access for changing configured COM and NAV frequencies.

The MCDU, shown in Figure 13-2, controls all communications, navigation, and transponders in the system. The face of an MCDU is shown in Figure 13-2. Pushing the **RADIO** button accesses the radio system.

Figure 13-2
Multifunction Control and Display Unit

In addition to the MCDU, the FMS can also tune the radios. For detailed FMS operations, refer to the applicable FMS operating procedures.

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Radio frequencies can also be shown on each PFD and controlled using the on-side CCD. Radio frequencies are displayed along the bottom edge of both PFDs, as shown in Figure 13-3. The radio frequencies are accessed and changed by first selecting the PFD with the CCD. Then select the radio to be changed with the cursor touchpad. Changes to the frequency are made using the stacked concentric knobs on the CCD. Radios shown on the PFD are configured on the radio setup pages in either MCDU.

Figure 13-3
PFD Radio Tuning Boxes

If any of the components of the radio system are not supplying valid data to the MCDU or PFD, the frequencies or operating commands of those components are removed from the display and replaced with dashes.

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MCDU Operation

The MCDU is the primary controller for the radio system. Line select keys (LSKs) adjacent to the display are used to simplify the operation. Any selectable parameter, such as a VOR frequency, can be changed. The corresponding LSK is pushed to place the cursor box around the desired parameter on the display. The dual-concentric tuning knobs are rotated for changes to the boxed parameter value.

The MCDU radio tuning pages control frequencies, memory selections, operating modes, and options. Color is used with two font sizes. The active choice is shown in the larger font and normally in a color other than white. Display pages are normally white. Selections are in larger green characters, and annunciators are in magenta, yellow, cyan, red, or amber .

Display Icons

Display icons help the pilot navigate through the pages and indicate what action is required. Display icons give some indication of the expected result once the icon is activated. The icons are located in the display columns immediately next to the LSKs. The icons are white, as shown in Figure 13-4.

Figure 13-4
Examples of Display Icons

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When the scratchpad is empty, pushing an LSK either moves the format cursor to the adjacent field or performs the function indicated by the icon shown near the key. The icons and the functions are described as follows:


ID-763515

Swap Frequencies – The swap frequencies symbol indicates the active and preset frequencies can be exchanged. This effectively saves the currently active frequency in the preset memory and tunes the radio to the frequency previously stored as the preset.


ID-763516

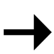
Page Indicator – When the page indicator icon is displayed, pushing the adjacent LSK changes the display to another page. The page displayed is either labeled explicitly or is a detail page for the radio in the current field.


ID-763517

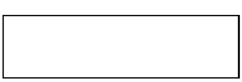
Exclusive Selection – The exclusive selection icon is displayed next to a list of mutually exclusive options. Each time the adjacent LSK is pushed, the next item on the list is selected, wrapping around to the first when the last option is reached. The selected value is displayed in green, large font. The unselected items are displayed in small white characters.


ID-763518

Immediate Function – The immediate function icon does the function identified in the field immediately after the LSK is pushed.


ID-763519

Copy Value – The copy value icon is used on the memory pages to indicate the frequency highlighted by the cursor is copied into the active frequency for the radio.


ID-763520

Cursor – The cursor box highlights the value in the active field.


ID-763521

Tuning Curl – The tuning curl icon indicates the data value highlighted by the format cursor is changed by turning the MCDU tuning knob.

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Frequency Swapping Operation

Three types of radio frequencies shown are as follows:

1. **Active** frequency is the current setting for receiving and transmitting.
2. **Standby** frequency is the frequency waiting to be used next. The standby frequency is normally changed using the tuning knobs or the scratchpad.
3. **Memory** frequency is a saved list of frequencies.

Two swap functions are used. The first one uses the standby frequency. The second one uses the memory frequency. To swap the active frequency with the standby frequency, the standby frequency must be selected with the cursor box.

1. With the cursor around the standby frequency and the swap icon shown, pushing the LSK swaps the standby and active frequencies.
2. With the cursor around the memory frequency and the swap icon shown, pushing the LSK swaps the memory and active frequencies.

Pushing LSK 4L next to the active COM frequency makes the standby frequency active; this swaps the standby and active frequencies, as shown in Figure 13-5.

NOTE: Expect a short delay for the changes to the display to take place.

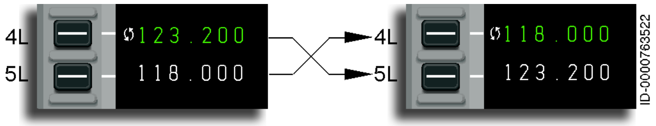

Figure 13-5
Swapping the Active and Standby Frequencies

VHF COM and HF COM radio pages use active, standby, and memory frequencies. Using the tuning knobs is not permitted for changing the active frequency.

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Page Organization

The radio tuning function is accessed by pushing the **RADIO*** function button on the MCDU. The **RADIO 1/2** page is displayed. All other pages are accessed from **RADIO 1/2** using the LSKs or the NEXT and PREV function keys, as shown in Figure 13-6.

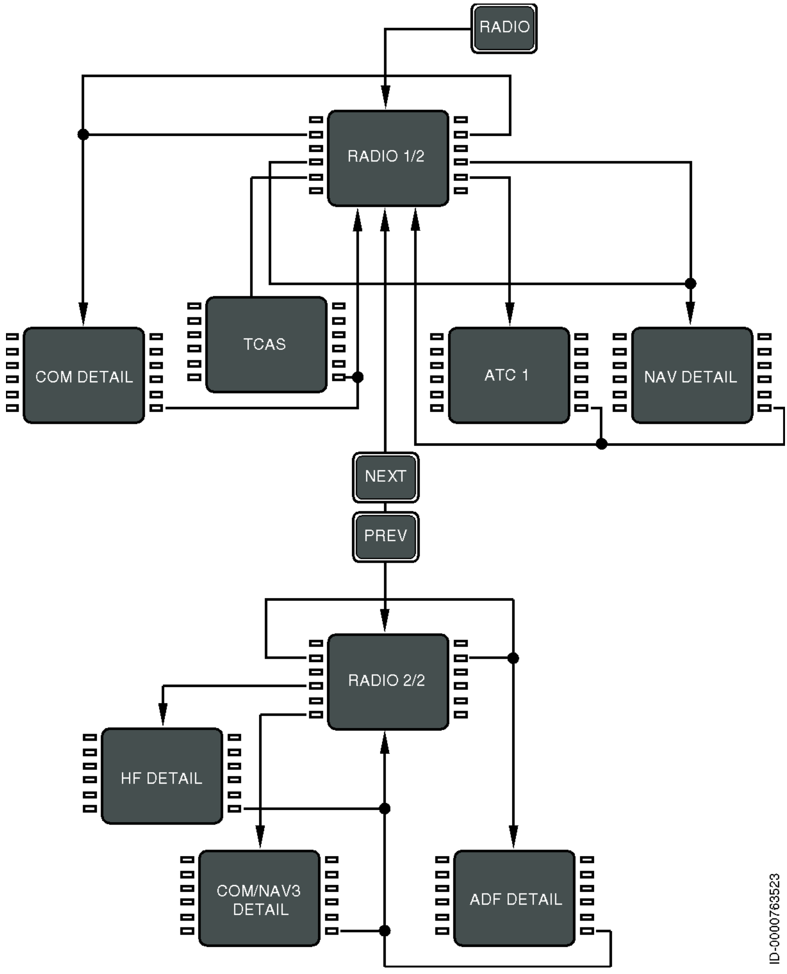

Figure 13-6
Radio Tuning Logic Diagram (Single HF Configuration)

Access to the **COM DETAIL**, **TCAS**, and **NAV DETAIL** pages is by the LSKs from the **RADIO 1/2** page. Access to the **HF DETAIL*** and **ADF DETAIL** pages is by the LSKs from the **RADIO 2/2** page.

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BASIC OPERATION

The bottom line on each page shows the characters entered on the MCDU keypad and is called the scratchpad. The scratchpad is shared across all MCDU functions and is not under the control of the radio tuning function.

The text area adjacent to each LSK on the MCDU is referred to as a field and is identified by the LSK. For example, the active frequency for VHF COM radio 1 (shown in Figure 13-7 as COM1, 123.200) on the **RADIO 1/2** page is in field 1L.

Figure 13-7
MCDU Button Example

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Pushing the NEXT or PREV key when the **RADIO 1/2** page is displayed shows the **RADIO 2/2** page shown in Figure 13-8.

Figure 13-8
NEXT/PREV Example

In Figure 13-9, when LSK 2R is pushed, the cursor box and tuning curl move from 2L COM1 to field 2R COM2. Similarly, pushing LSK 3L moves the format cursor to the active frequency for VHF NAV 1 radio. After the cursor box is positioned on a field, the tuning knob changes the highlighted frequency.

Figure 13-9
Cursor Box Example

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When an icon is displayed next to an LSK, the icon function box supersedes the cursor box. For example, pushing LSK 1L swaps the active and preset frequencies for VHF COM1 radio without moving the cursor box. Consequently, tuning the active frequency for a radio is not possible using the tuning knob.

The exception to this rule occurs when a preset frequency is not shown for the associated radio. This can happen when a VHF navigation radio is in DME HOLD, which results in the preset frequency being removed in order to show the separately tuned DME frequency (refer to fields 3L and 4L).

When one or more characters are present in the scratchpad, the icons adjacent to fields accepting text entries are removed to indicate pushing those LSKs enters the scratchpad data into the field. Entering the contents of the scratchpad into a field or manually clearing the scratchpad restores the icons and the normal functions of the LSKs.

Scratchpad entries are made into any editable field at any time. Making a scratchpad entry into an active frequency field moves the previously active frequency into the preset field for that radio.

Frequency Tuning

HF frequency values are displayed in the format of XX.YYYZ (e.g., 13.0500). The frequency is changed using either the scratchpad or the tuning knob on the MCDU.

When changing a frequency value with the scratchpad, the keypad is used to enter the new frequency value. The LSK next to the frequency to be modified is then pushed. This transfers the value from the scratchpad to the selected frequency. The data does not transfer when an entry is invalid. A valid scratchpad entry is any of the following:

- XX.YYYZ
- XXYYYZ (no decimal point)
- XXYYY (last character not entered, assumed to be zero).

The range of valid HF frequency values is 2.0000 to 29.9999 MHz.

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When changing a frequency using the MCDU tuning knobs, the LSK next to the frequency to be changed needs to be pushed. This puts the cursor box around the first digit of the frequency. The inner tuning knob changes the value. Clockwise turns increase the value, and counterclockwise turns decrease the value. For changing the next digit, the outer tuning knob is turned clockwise, moving the cursor to the next digit. The inner knob then changes the value. Similarly, to change the next digit, the outer knob is turned clockwise, moving the cursor box to the next digit, and the inner knob changes the value. Figure 13-10 shows how the inner and outer knobs are used for changing frequencies.

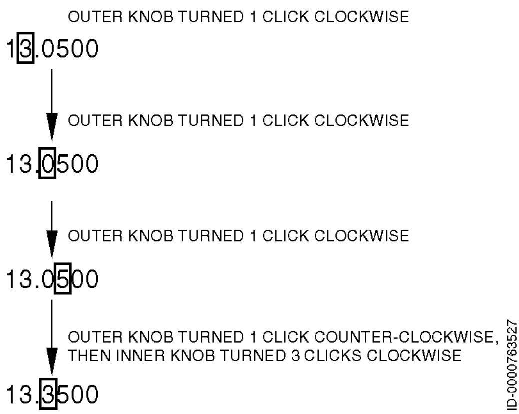

Figure 13-10
HF Frequency Control

NOTE: When the cursor box is located around the Z digit, turning the outer knob clockwise does not move the cursor back to the XX digits. The cursor parks at the Z digit until the outer knob is turned counterclockwise.

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RADIO PAGES

The following radio pages are displayed on the MCDU.

RADIO 1/2 Page

RADIO 1/2 , shown in Figure 13-11, is displayed by pushing the RADIO function button on the MCDU containing the following radio data:

- VHF COM1 and COM2 radios
- VHF NAV1 and NAV2 radios
- The currently selected TCAS/transponder mode
- The aircraft identification (ID) (when available)
- The current transponder code and status.

Toggle between **RADIO 1/2** and **RADIO 2/2** by using the NEXT or PREV function buttons.

Figure 13-11
RADIO 1/2 Page

- **1L VHF COM 1 Active Frequency** – Pushing 1L swaps the active and preset frequencies for VHF COM 1. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.

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- **2L VHF COM 1 Preset Frequency** – This is the default field for the cursor box when the RADIO function key is pushed. This section shows the standby COM 1 frequency. Pushing 1L when the cursor box is already in the field shows the COM 1 page.
- **3L VHF NAV 1 Active Frequency** – When DME HOLD for NAV 1 is OFF, pushing 3L swaps the active and preset frequencies for VHF NAV 1. When DME HOLD for NAV 1 is ON, pushing 3L moves the cursor to field 3L or shows the NAV 1 page when the cursor is already in the field. A scratchpad entry into 3L replaces the preset frequency with the previous active frequency.
- **4L VHF NAV 1 Preset Frequency** – When DME HOLD for NAV 1 is OFF, this section shows the VHF NAV 1 preset frequency. When DME HOLD is ON, this section shows the active DME frequency for NAV 1. The cursor box is used in field 4L in either case. When 4L is pushed with the cursor in the field, the NAV 1 page is displayed.
- **5L TCAS/XPDR** – Pushing this key shows TCAS/XPDR 2/2 page.
- **6L STBY TA/RA** – Pushing this LSK alternately selects STBY or the selected mode as the active mode. The active condition is green, and the inactive condition is white.
- **1R VHF COM 2 Active Frequency** – Pushing 1R swaps the active and preset frequencies for VHF COM 2. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2R VHF COM 2 Preset Frequency** – This section shows the COM 2 standby frequency. Pushing 2R when the format cursor is already in the field shows the COM 2 page.
- **3R VHF NAV 2 Active Frequency** – Pushing LSK 3R when DME HOLD for NAV 2 is OFF, swaps the active and preset frequencies for VHF NAV 2. Pushing LSK 3R when DME HOLD for NAV 2 is ON moves the cursor box to field 3R or shows the NAV 2 page when the cursor was already in the field. A scratchpad entry into 3R replaces the preset frequency with the previous active frequency.

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- **4R VHF NAV 2 Preset Frequency** – When DME HOLD for NAV 2 is OFF, the VHF NAV 2 preset frequency is displayed. When DME HOLD is ON, the active DME frequency for NAV 2 is displayed. The cursor box highlights the field 4R in either case. Pushing 4R when the cursor box is in the field shows the NAV 2 page.
- **5R Active Transponder Code and Reply Indicator** – This section shows the active transponder code and reply indicator. The header for field 5R shows the flight ID that was entered by the crew. The reply indicator () lights when the transponder is replying to a RADAR or TCAS interrogation. Pushing 5R moves the cursor box to the field or shows TCAS1/1 when the cursor is already in the field.
- **6R** – To transmit an IDENT reply when requested by the ATC, the LSK 6R next to the IDENT label needs to be pushed.

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RADIO 1/2 Annunciators

Table 13-1 lists the annunciators on the **RADIO 1/2** page.

Table 13-1
RADIO 1/2 Page Annunciator Descriptions

Annunciator	Description
25K	Indicates the associated VHF COM radio is set to 25 kHz frequency spacing. When not present, the radio is tuning with 8.33 kHz frequency spacing. This is selected on the COM 1/2 page.
DME H xxx	DME Hold - Indicates the VHF navigation radio is tuning the corresponding DME receiver independently of the primary navigation frequency.
IHB	Indicates tuning of the radio is inhibited, normally from a remote source (such as an emergency tuning function).
MICST	Indicates the microphone button on the radio has been down long enough that the radio has identified it as stuck in the transmit position.
S	Indicates the squelch feature for the radio is active. Squelch is turned on and off by the COM 1/2 page.
T	Indicates the radio is currently transmitting.

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RADIO 2/2 Page

The **RADIO 2/2** page, shown in Figure 13-12, is described in the following paragraphs. The **RADIO 2/2** page shows the following radio data:

- ADF1 and ADF2 radios
- HF1
- COM/NAV 3 radios (option).

Access to the **RADIO 1/2** page is by the NEXT or PREV function keys.

Figure 13-12
RADIO 2/2 Page

- **1L Active ADF Frequency** – This is the ADF 1 active frequency. Pushing 2L swaps the active and preset frequencies for the ADF. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2L Preset ADF Frequency** – This is the ADF 1 preset frequency. Pushing 1L when the cursor box is already in the field shows the **ADF 1/1** page.
- **3L Active HF COM 1** – This is the HF COM 1 active frequency. Pushing 4L swaps the active and preset frequencies for HF COM 1. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.

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- **4L Preset HF COM 1** – This is the HF COM 1 preset frequency. HF COM 1 is the default field for the cursor box when the **RADIO 2/2** page is displayed. Pushing 4L when the cursor is already in the field shows the **HF 1** page.
- **5L Active COM 3, NAV 3, COM/NAV 3 (Option)** – This is the active COM 3, NAV 3, or COM/NAV 3 frequency. Pushing 5L swaps the active and preset frequencies for the installed radio. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **6L Preset COM 3, NAV 3, COM/NAV 3 (Option)** – This is the COM 3, NAV 3, or COM/NAV 3 preset frequency. Pushing 6L when the cursor box is already in the field shows the detail page for the installed radio.
- **1R Active ADF 2 Frequency** – This is the ADF 2 active frequency. Pushing 3R swaps the active and preset frequencies for the ADF. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2R Preset ADF 2 Frequency** – This is the ADF 2 preset frequency. Pushing 2R when the cursor box is already in the field shows the **ADF 2** page.

RADIO 2/2 Annunciators

A variety of annunciators display on the radio tuning pages. Some of the annunciators are shown in Figure 13-13.

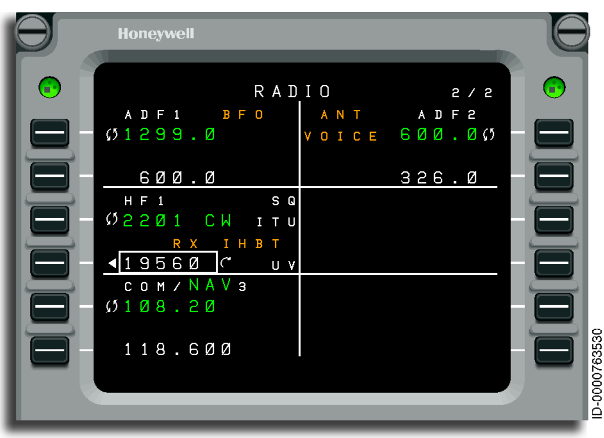

Figure 13-13
RADIO 2/2 Page Annunciators

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Table 13-2 lists the annunciators on the RADIO 2/2 page.

Table 13-2
RADIO 2/2 Annunciator Descriptions

ALERT	Description
ANT	The ADF radio is in antenna mode.
BFO	The ADF radio is operating in Beat Frequency Oscillator (BFO) mode.
CW	The radio is currently transmitting.
IHBT	The radio tuning is inhibited, normally from a remote source (such as an emergency tuning function). Transmitting and/or receiving can be inhibited periodically when the other HF radio has recently performed a transmit operation.
ITU	The radio is currently transmitting.
LO	The radio is set to low squelch.
MED	The radio is set to medium squelch.
RX	The radio is currently receiving.
SQ	The squelch feature for the radio is active.
TX	The radio is currently transmitting.
TX MIN	The radio is transmitting with low power.
TX MED	The radio is transmitting with medium power.
VOICE	The ADF radio is in voice mode.

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COM1 Page

Figure 13-14 shows the pages associated with VHF COM radios.

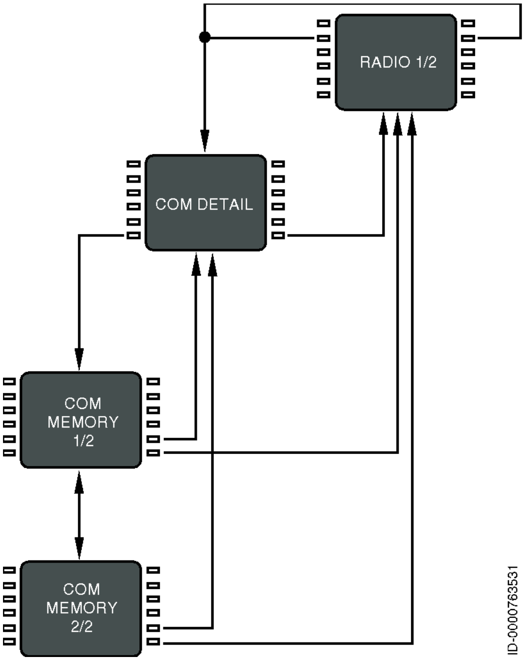

Figure 13-14
VHF COM Radio Tuning Logic Diagram

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The COM 1 page, shown in Figure 13-15, is used to access the controls specific to VHF communications radios. The controls include squelch, operating mode, and frequency spacing. The COM 1 page also supplies a quick method for retrieving frequencies from memory. The cursor box defaults to the memory tuning field (3L), giving quick access to stored frequencies. This page also provides access to the COM memory pages.

Figure 13-15
COM 1 Page

- **1L Active VHF COM Frequency** – Active VHF COM frequency on the selected radio (the page title shows which COM radio was selected). Pushing 1L swaps the active and preset frequencies (when the cursor box is on field 2L) or copies a frequency stored in memory (when the cursor box is on field 3L) for the selected COM radio. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.

- **2L Preset VHF COM Frequency** – This section shows the VHF COM preset frequency.

- **3L MEM TUNE** – This section is the COM memory display. This is the default field for the cursor box when the COM 1 or COM 2 pages are displayed. Turning the tuning knob while field 3L is selected cycles through the frequencies stored in memory, by location, showing the associated label and the stored frequency below.

- **6L MEMORY** – Pushing this key shows the COM MEMORY 1/2 page.

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- **1R SQUELCH** – This key toggles the squelch feature for the selected VHF COM radio on and off. The selected state is green.
- **3R FREQ** – This key toggles the frequency spacing selection for the selected VHF COM radio between 8.33 kHz and 25 kHz. The selected spacing is green.
- **6R RETURN** – Pushing this key shows the RADIO 1/2 page.

COM MEMORY 1/2 and 2/2 Pages

The radio tuning function supports 12 memories per radio type (for example, COM, NAV, HF COM) shown on two pages each. In addition to entering or dialing-in frequencies for each memory, a text label containing up to eight characters is entered for each stored frequency except for the HF COM memory page. The HF COM MEMORY page, shown in Figure 13-16, does not support labels due to display area limitations. The default label for each memory is MEMORY, a dash, and the memory number (MEMORY - 6), with the memory number always on the outboard edge of the display.

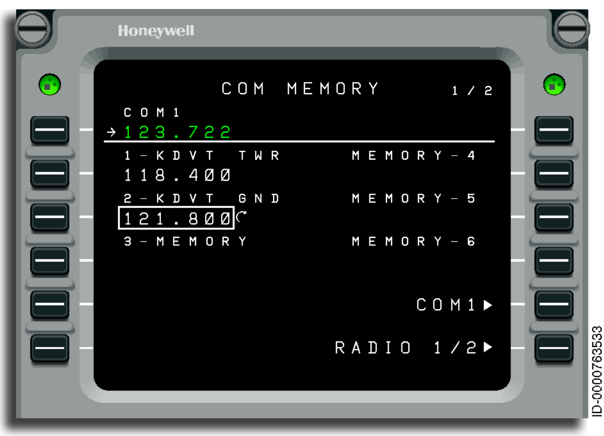

Figure 13-16
COM MEMORY 1/2 Page

- **1L Active VHF COM Frequency** – Active VHF COM frequency is displayed in green, and the selected radio title is white. Pushing 1L copies the field containing the cursor into the active frequency and moves the previously active frequency into the preset field (not shown on this page). A scratchpad entry into the field replaces the preset frequency with the previously active frequency.

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- **2L, 3L, 4L** – These are VHF COM 1 memories 1 through 3.
- **2R, 3R, 4R** – These are VHF COM 1 memories 4 through 6.
- **5R COM1** – Pushing this LSK shows the COM 1 detail page.
- **6R RADIO 1/2** – Pushing this LSK shows the RADIO 1/2 page.

Labels are entered by typing into the scratchpad and pushing the LSK adjacent to the desired frequency. When the radio tuning function determines the entry is a valid frequency for the radio, the entry goes into the frequency field. When the data is not a valid frequency, the entry is recognized as a label and is entered into the label field above the frequency. A label is replaced by making another scratchpad entry into a memory field or pushing the DEL key. Pushing the DEL key puts the text DELETE in the scratchpad. When DELETE is entered on a memory field, the LSK deletes the associated text label, returning to the default. If the DEL key is used on a memory where there is no user-entered label, the frequency is deleted from the memory.

The COM MEMORY 2/2 page, shown in Figure 13-17, is accessed by the NEXT and PREV function buttons. The COM MEMORY 2/2 page operates identically to the COM MEMORY 1/2 page.

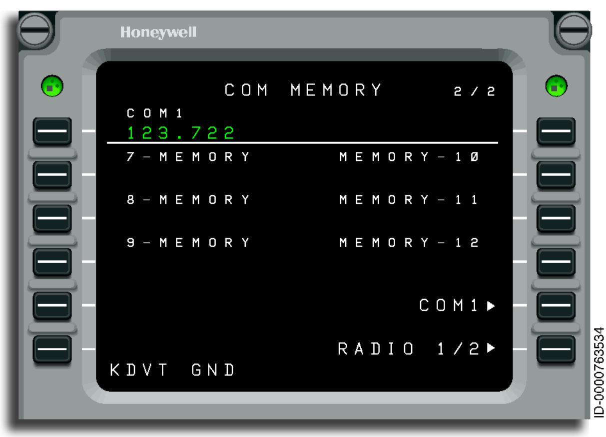

Figure 13-17
COM MEMORY 2/2 Page

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- **1L Active COM 1 Frequency** – Active VHF COM frequency is displayed in green, and the selected radio title is white. Pushing 1L copies the field highlighted by the cursor box into the active frequency and moves the previously active frequency into the preset field. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2L, 3L, 4L** – VHF COM memories 7 through 9.
- **2R, 3R, 4R** – VHF COM memories 10 through 12.
- **5R COM 1** – Pushing this key shows the COM 1 detail page.
- **6R RADIO 1/2** – Pushing this key shows the RADIO 1/2 page.

NAV1 Page

Figure 13-18 shows the pages associated with VHF NAV radios.

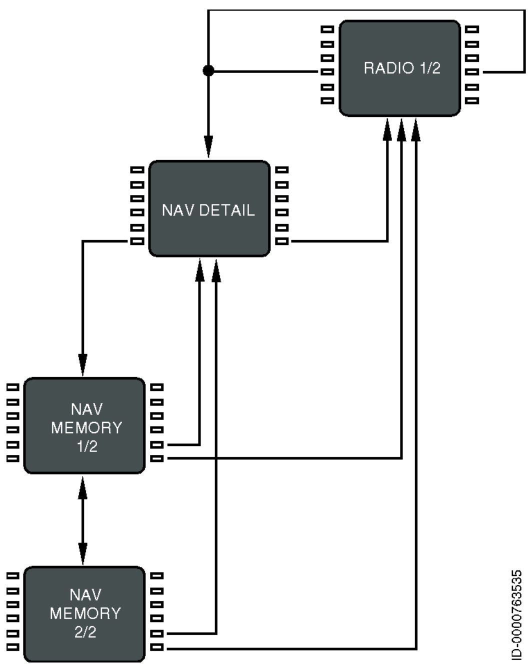

Figure 13-18
VHF NAV Radio Tuning Logic Diagram

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The **NAV1** page, shown in Figure 13-19, is used to access and control VHF navigation radios, FMS automatic tuning, and DME hold mode. The cursor box defaults to the memory tuning field (4L) and supplies quick access to stored frequencies. The **NAV1** page also accesses the NAV memory pages.

Figure 13-19
NAV 1 Page

- **1L Active VHF NAV Frequency** – The active VHF NAV frequency is displayed in green. The white page title shows which NAV radio was selected. Pushing 1L swaps the active and preset frequencies (when the cursor is on field 2L). LSK 1L copies a frequency stored in memory when the cursor is on field 4L. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.

- **2L Preset VHF NAV Frequency** – This is the VHF NAV preset frequency.

- **4L MEM TUNE** – This is the NAV memory display. This is the default field for the cursor box when the **NAV1** or **NAV2** page is displayed. Turning the tuning knob while field 4L is selected cycles through the frequencies stored in memory by location, showing the associated label and the stored frequency.

- **6L MEMORY 1/2** – Pushing this key shows the **NAV MEMORY 1/2** page.

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- **2R DME HOLD** – Pushing this key toggles the DME hold mode ON and OFF for the selected VHF NAV radio. The selected state is green and is annunciated on the **RADIO 1/2** page.
- **4R TEST** – Pushing this key toggles the TEST mode ON and OFF. The selected state is green.
- **5R FMS AUTO** – Pushing this key toggles the FMS autotune feature ON and OFF for the selected VHF NAV radio. The selected state is green and is annunciated on the **RADIO 1/2** page.
- **6R RETURN** – Pushing this key shows the **RADIO 1/2** page.

NAV MEMORY 1/2 and 2/2 Pages

The radio tuning function supports 12 navigation radio memories shown on two pages. In addition to entering or dialing in frequencies for each memory, a text label of up to eight characters is entered for each stored frequency. The default label for each memory is MEMORY, a dash, and the memory number (**MEMORY - 4**), with the memory number always on the outboard edge of the display. The **NAV MEMORY 1/2** page is shown in Figure 13-20.

Figure 13-20
NAV MEMORY 1/2 Page

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- **1L Active NAV COM Frequency** – The active NAV COM frequency on the selected radio is displayed in green. The white field title shows which NAV radio was selected. Pushing 1L copies the field highlighted by the cursor box into the active frequency and moves the previously active frequency into the preset field. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2L, 3L, 4L** – These locations store NAV memories 1 through 3.
- **2R, 3R, 4R** – These locations store NAV memories 4 through 6.
- **5R NAV1** – Pushing this key shows the NAV detail page.
- **6R RADIO 1/2** – Pushing this key shows the RADIO 1/2 page.

Labels are entered by typing into the scratchpad and pushing the LSK adjacent to the desired frequency. When the radio tuning function determines the entry is a valid frequency for that radio, the entry goes to the frequency field. If the frequency is invalid, the entry is recognized as a label and is entered into the label field above the frequency. A label is replaced by making another scratchpad entry into a memory field or pushing the DEL key. Pushing the DEL key puts the text DELETE in the scratchpad. When DELETE is entered on a memory field, the LSK deletes the associated text label and returns to the default. If the DEL key is used on a memory where there is no user-entered label, the frequency is deleted from memory.

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The **NAV MEMORY 2/2** page, shown in Figure 13-21, is accessed by way of the NEXT and PREV function buttons.

Figure 13-21
NAV MEMORY 2/2 Page

- **1L Active NAV COM Frequency** – The active NAV COM frequency on the selected radio is displayed in green. The white field title shows which NAV radio was selected. Pushing 1L copies the field containing the cursor into the active frequency and moves the previously active frequency into the preset field. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2L, 3L, 4L** – These locations store NAV memories 7 through 9.
- **2R, 3R, 4R** – These locations store NAV memories 10 through 12.
- **5R NAV1** – Pushing this key shows the NAV detail page.
- **6R RADIO 1/2** – Pushing this key shows the **RADIO 1/2** page.

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COM 3 Page (Option)

The COM3 page, shown in Figure 13-22, is selected from the RADIO 2/2 page by selecting the RADIO function button on the MCDU and selecting the NEXT function key to get to RADIO 2/2, and then selecting 6L twice to show the COM3 page.

Figure 13-22
COM 3 Page

- **1L Active VHF COM Frequency** – Active VHF COM frequency on the selected radio is displayed in green, and the white page title shows which COM radio is selected. Pushing 1L swaps the active and preset frequencies when the cursor is on field 2L. The LSK 1L copies a frequency stored in memory (when the cursor is on field 3L) for the selected COM radio. A scratchpad entry into the field replaces the preset frequency with the previously active frequency.
- **2L Preset VHF COM Frequency** – This shows the VHF COM preset frequency.
- **3L MEM TUNE** – This is the COM memory display. This is the default field for the cursor when the COM3 page is displayed. Turning the tuning knob while field 3L is selected cycles through the frequencies stored in memory, by location, and shows the associated label and the stored frequency below.
- **6L COM MEMORY** – Pushing this key shows the NAV MEMORY 1/2 page.

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- **1R SQUELCH** – This key toggles the squelch feature for the selected VHF COM radio. The selected state is green and is displayed on the **RADIO 2/2** page.
- **2R MODE** – This key toggles between voice and data mode for the selected VHF COM radio. The selected mode is green and is displayed on the **RADIO 2/2** page.
- **3R FREQ** – This key toggles the frequency spacing selection for the selected VHF COM radio between 8.33 kHz and 25 kHz. The selected spacing is green. The selected state is displayed on the **RADIO 2/2** page.
- **6R RETURN** – Pushing this key shows the **RADIO 2/2** page.

TCAS/XPDR

Figure 13-23 shows the pages associated with the TCAS/XPDR.

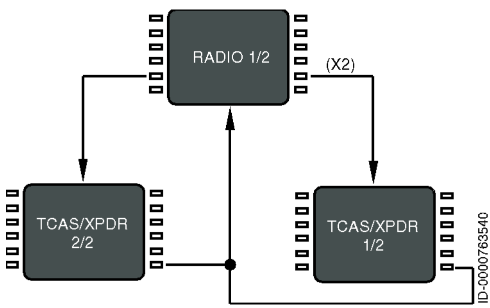

Figure 13-23
TCAS/XPDR Page Logic Diagram

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The **TCAS/XPDR 1/2** detail page, shown in Figure 13-24, is described in detail in Section 19, Traffic Alert and Collision Avoidance System (TCAS). The **TCAS/XPDR 1/2** page accesses the controls and data specific to the transponder and TCAS systems and operating mode.

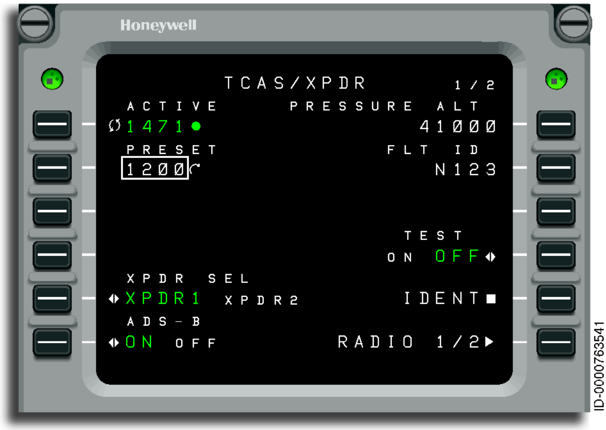

Figure 13-24
TCAS/XPDR 1/2 Page

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HF COM 1/1

Figure 13-25 shows the sequence of screens associated with high frequency (HF) communication radios.

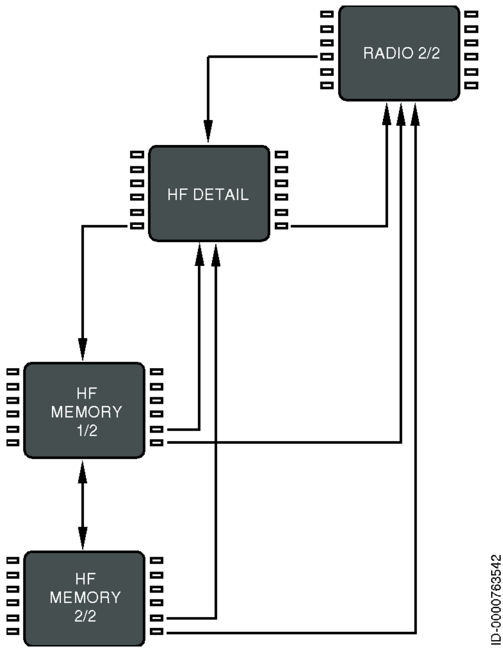

Figure 13-25
HF COM Radio Tuning Logic Diagram

The **HF1** communications detail pages are described in this section. Simplex mode is shown in Figure 13-26. Split mode is shown in Figure 13-27. Emergency mode is shown in Figure 13-28. ITU mode is shown in Figure 13-29. The **HF1** detail pages control the following functions:

- HF tuning (manual and memory)
- HF tuning mode selection
- Transmit power selection
- Squelch
- Operating mode selection.

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The tuning functions work just like the VHF COM selections. In addition, each of the tuning modes supplying HF radios is also selected on this page. The tuning modes are:

- Simplex
- Split (duplex)
- Emergency
- International Telecommunications Union (ITU) channel numbers.

Figure 13-26 shows the Simplex mode page.

Figure 13-26
HF1 Simplex Mode Page

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Figure 13-27 shows the split mode page.

Figure 13-27
HF1 Split Mode Page

Figure 13-28 shows the emergency mode page.

Figure 13-28
HF1 Emergency Mode Page

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ITU mode is shown in Figure 13-29.

Figure 13-29
ITU Mode Page

- **1L ACTIVE Simplex Operation** – LSK 1L shows the active frequency and active emission mode (EM). Pushing LSK 1L puts the cursor box around the first digit of the active frequency and puts the tuning curl symbol to the right of the active frequency. The frequency is changed using the tuning knobs.
  - **Split Operation** – LSK 1L shows the active receive/transmit frequency and active emission mode. Pushing this key once puts the cursor box around the first digit of the active receive frequency and puts the tuning curl symbol to the right of the active receive frequency. The inner tuning knob changes the digit, and the outer tuning knob moves the cursor box to the next digit that has to be changed. The active emission mode is displayed to the right of the active receive frequency.
  - **ITU Operation** – LSK 1L shows the active ITU channel, corresponding receive and transmit frequencies, and the active emission mode. Pushing this key puts the cursor box around the active ITU channel and the tuning curl to the right of the active ITU channel. The inner tuning knob changes the digit, and the outer tuning knob moves the cursor box to the next digit that has to be changed.

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- **Emergency Operation** – LSK 1L shows the active EMRG channel, corresponding ITU channel (when available), and corresponding receive and transmit frequencies. Pushing this key puts the cursor around the active EMRG channel and the tuning curl to the right of the active EMRG channel. The outer tuning knob and inner tuning knob are used to scroll through the six available EMRG channels.

Pushing the LSK a second time switches the EMRG channel to simplex format so that the receive and transmit values are the same.

- **2L TRANSFER** – The active and preset values for frequency/channel, active mode, and emission mode are swapped by pushing the 2L key. This transfers the values entered for the preset to the active frequency/channel, active mode, and active emission mode of the HF radio. The values set for the HF radio are moved to the preset.

- **3L Simplex Operation** – LSK 3L shows the preset frequency and preset emission mode. Pushing LSK 3L puts the cursor box around the first two characters of the preset frequency and the tuning curl symbol to the right of the preset frequency.

  - **Split Operation** – LSK 3L shows the preset receive/transmit frequency and preset emission mode. Pushing 3L once puts the cursor box around the first digit of the preset receive frequency and the tuning curl symbol to the right of the preset receive frequency. The inner tuning knob changes the digit, and the outer tuning knob moves the cursor box to the next digit that has to be changed.

  - **ITU Operation** – LSK 3L shows the preset ITU channel and the preset emission mode. Pushing LSK 3L puts the cursor box around the preset ITU channel and the tuning curl to the right of the preset ITU channel. The outer tuning knob changes the first two digits, and the inner knob changes the last two digits.

  - **Emergency Operation** – LSK 3L shows the preset EMRG channel, corresponding ITU channel (when available), and corresponding receive and transmit frequencies. Pushing LSK 3L puts the cursor box around the preset EMRG channel and the tuning curl to the right of the preset EMRG channel. The outer tuning knob and inner knob are used to scroll through the six available EMRG channels.

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- **4L Monitor Transmit** – LSK 4L is functional when the active operational mode is SPLT, ITU, or EMRG. Pushing LSK 4L sets the receive frequency to the transmit frequency. The pilot can listen on the transmit frequency before talking on the transmit frequency. When LSK 4L is pushed, the active receive and transmit frequency shows at 1L without changing, but the MONITOR XMIT annunciator is displayed. Pushing 4L again sets the receive frequency back to the value shown at 1L and changes the annunciator to MONITOR XMIT .

- **5L Set Operational Mode** – The operational mode for the active or preset is modified by toggling LSK 5L. The operational mode cycles through the four choices—SMP (Simplex), SPLT (Split), EMER (Emergency), or ITU. The currently-selected mode is green. The non-selected modes are white.

When the cursor box is located on the active frequency, pushing 5L changes the active operational mode. When the cursor box is located on the preset frequency, pushing 5L changes the preset operational mode. If the cursor box is not located on either the active or preset frequency, 5L is not operational.

- **6L MEMORY/EMRG SETUP** – When the active operational mode is Simplex (SMPL), Split (SPLT), or ITU, pushing 6L shows the HF MEMORY 1/2 page. When the active operational mode is Emergency (EMRG), pushing 6L shows the EMERGENCY SETUP page.

- **1R Set Squelch Type** – LSK 1R cycles through the different squelch types. The selected type is green. Each push of the key changes the next selection from white to green. Four possible choices for squelch type are SQL, SQH, SBL, and SBH. The squelch types are as follow:

  – **SQL** - Signal Strength Squelch: Supplies a low noise and high signal environment.

  – **SQH** - Audio Noise Squelch: Supplies a low noise environment.

  – **SBL** - Audio Frequency Syllabic Content Squelch: Supplies low-level voice signals.

  – **SBH** - Audio Frequency Syllabic Content To Noise Squelch: Supplies normal level voice signals.

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- **3R Squelch Level** – The squelch level for the HF radio is set by pushing LSK 3R. The squelch level entries vary depending on the squelch type selected with LSK 1R.
  - **SQL or SQH** – For these two types, the squelch level is a numeric value between 0 and 31. This value is entered two ways:
    - Enter the value in the scratchpad, then push LSK 3R. The value must be between 0 and 31 for the entry to be valid.
    - Push LSK 3R, then the tuning knob is used for changing the value. Either knob is used. One click clockwise increases the squelch level by one, and one click counterclockwise decreases the squelch level by one. The squelch level value (0 to 31) is displayed in large white font.
  - **SBL or SBH** – For these types of squelch, LSK 3R is used to cycle through the different squelch levels. The selected level is green. Each push of the key changes the next selection from white to green. There are four possible choices for squelch level—OFF, LO, MED, and HI.
- **5R** – LSK 5R is used to cycle through the different emission modes. The selected level is green. Each push of the key changes the next selection from white to green. There are six possible choices for emission modes. The emission modes are as follows:
  - Upper sideband voice (UV)
  - Lower sideband voice (LV)
  - Upper sideband data (UD)
  - Lower sideband data (LD)
  - Amplitude modulation (AM)
  - Reduced carrier (RC).

  The selected mode is green.
- **6R RETURN** – Pushing this key shows the **RADIO 1/2** page.

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HF Detail Page

The **HF1 2/2** page, shown in Figure 13-30, is used to select a clarifier value, transfer HF control, and set the power level for the HF radio.

Figure 13-30
HF 1 Detail 2/2 Page

- **1L CLARIFY** – The listener uses the clarify function to slew the receiver frequency up and down 250 Hz from the displayed frequency in 10-Hz increments. This compensates for minor frequency shifts between the transmitter and receiver due to propagation, Doppler shift, and other factors. The clarifier level for the HF radio is set by pushing LSK 1L. The value is entered through the scratchpad or by using the tuning knob. The value must be between -250 and 250 to be valid.
- **6L MEMORY** – Pushing LSK 6L shows the HF MEMORY page described in the following paragraphs.
- **1R TX POWER** – The TX power for the HF radio is set by pushing LSK 1R. The TX power only affects upper and lower sideband operation. AM and Data modes are not affected. Pushing 1R cycles through the three choices—LO, MED, and HI. The active setting is green, and the others are white. When the HF radio is invalid, all three choices are displayed in small white font.
- **6R RADIO 2/2** – Pushing 6R returns the MCDU to the **RADIO 2/2** page.

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HF MEMORY 1/2 and 2/2

The HF MEMORY consists of two pages. **HF MEMORY 1/2**, shown in Figure 13-31, is described in the following paragraphs. The pages function identically. The functions are the same as the VHF COM and VHF NAV memory pages. The displays are different from the VHF COM and VHF NAV pages so that two line frequencies are displayed (for split mode tuning). Display screen space does not permit labels for HF memory locations.

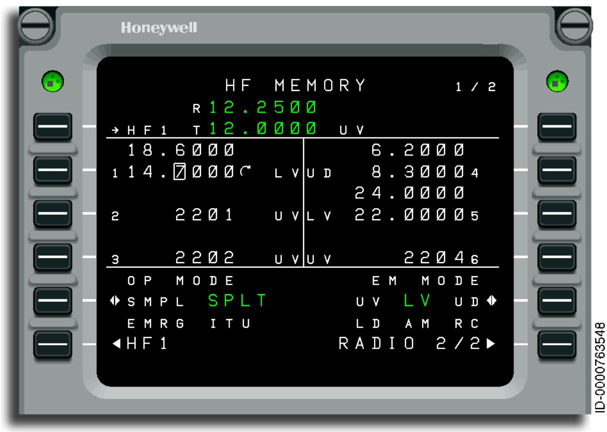

Figure 13-31
HF MEMORY 1/2 Page

The HF memory pages contain the active HF frequency, six stored frequencies, and controls for changing the tuning and operating modes for each memory.

Access to **HF MEMORY 2/2** is by the NEXT or PREV function buttons.

- **1L** – LSK 1L is pushed to tune the HF radio with the values in the currently-selected memory location. This includes the frequency/channel, operational mode, and emission mode.
- **2L, 3L, 4L, 2R, 3R, 4R** – Pushing these keys puts the cursor at the selected memory location. The first push puts the cursor around the first digit of the frequency value. When the memory location is in a split mode, the cursor goes around the first digit of the receive frequency. Pushing the key again when the memory channel is in split mode moves the cursor to the first digit of the transmit frequency.

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- **5L OP MODE** – The operational mode for the selected memory location is modified by pushing LSK 5L. The key cycles through the four choices—SMPL, SPLT, EMRG, and ITU. The active setting is green, and the others are white.

  The cursor location on the mode determines which memory location mode changes.

- **5R EM MODE** – The emission mode for the selected memory location is changed by pushing LSK 5R. The key cycles through the six choices—UV, LV, UD, LD, AM, and RC. The active setting is green, and the others are white.

  The cursor location on the mode determines which memory location mode changes.

- **6L HF1** – Pushing this key shows the **HF1 DETAIL PAGE** (shows **HF EMRG CHAN SETUP 1/1** if the selected operating mode is EMRG), defined in the following paragraphs.

- **6R RADIO 2/2** – Pushing this key shows the **RADIO 2/2** page.

HF Emergency Channel Setup Page

The **HF EMRG CHAN SETUP** page, shown in Figure 13-32, is used for changing preprogrammed emergency channels. The emergency frequency information in emergency channel 1 cannot be changed. Changes to the emergency channels are stored like the memory values so as not to be lost between power cycles.

Figure 13-32
Emergency Channel Setup Page

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- **3L, 5L, 1R, 3R, and 5R** – Pushing these keys puts the cursor at the selected emergency channel. The first push puts the cursor box around the first digit of the frequency value. When the emergency channel is in split mode, the cursor is placed around the first digit of the receive frequency. Pushing the key again when the emergency channel is in split mode moves the cursor to the first digit of the transmit frequency.
- **6L** – Pushing LSK 6L toggles the emergency channel highlighted by the cursor between SMPL and SPLT. When the cursor is on an emergency channel in simplex mode, pushing LSK 6L changes the emergency channel to split mode. The active setting is green, and the other is white.
- **6R** – Pushing LSK 6R shows the **HF1 DETAIL** page.
- **DEL Key** – Pushing the DEL key returns the value of the emergency channel highlighted by the cursor to the preprogrammed emergency channel. This means the emergency channels are returned to the initial values.

HF Emergency Channel Abnormal Operation

In the event of a main generator failure, the remaining operational generator supplies both direct current (DC) buses through the transformer rectifier units (TRU) without affecting the HF communication system. The auxiliary power unit (APU) generator can also take over the failed main generator and feed the DC bus, and the HF communication system is not affected. In the case of a single TRU failure, the remaining operational TRU supplies both DC buses without affecting the HF communication system.

If both TRUs fail, or when the HF communication system does not operate, the crew can use the VHF communication system for shorter ranges.

The HF fail is annunciated with an amber dashed line on the HF frequency on the MCDU.

When the HF coupler pressurization fails to support operation, the HF reduces power, which is displayed on the power settings of **HF DETAIL 2/2** page.

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ADF 1 Page

Figure 13-33 shows the pages associated with the automatic direction finder (ADF) system.

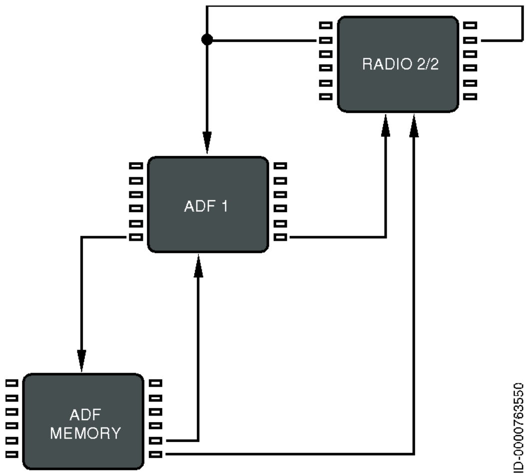

Figure 13-33
ADF Radio Tuning Logic Diagram

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The **ADF 1** page, shown in Figure 13-34, shows the active, preset, and selected memory frequencies for the automatic direction finders. The **ADF 1** page shows the controls for the active mode (antenna, ADF, BFO, and voice). The page is also used to access the ADF MEMORY pages or return to the **RADIO 2/2** page.

Figure 13-34
ADF 1 Page

- **1L Active ADF Frequency** – This shows and controls the active ADF frequency on the selected radio in green. The white page title shows which ADF was selected. Pushing 1L swaps the active and preset frequencies when the cursor is on field 2L. Pushing 1L copies a frequency stored in memory when the cursor is on field 3L for the selected ADF radio. A scratchpad entry into the field replaces the preset frequency with the previous active frequency.
- **2L Preset ADF Frequency** – This shows the ADF preset frequency.
- **3L MEM TUNE** – This shows and controls the ADF memory. This is the default field for the cursor box when the ADF page is displayed. Turning the tuning knob while field 3L is selected cycles through the frequencies stored in memory by location and shows the associated label and the stored frequency below.
- **6L MEMORY** – Pushing this key shows the **ADF MEMORY 1/2** page.
- **4R TEST** – Pushing this key toggles the test mode ON or OFF.

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- **5R MODE** – Pushing this key toggles the ADF operating mode for the selected ADF. The active mode is in green.
- **6R RETURN** – Pushing this key shows the **RADIO 2/2** page.

ADF MEMORY Page

The radio tuning function supports 12 ADF memories shown on two pages. In addition to entering or dialing in frequencies for each memory location, a text label of up to eight characters is entered for each stored frequency. The default label for each memory is MEMORY, a dash, and the memory number (**MEMORY - 3**), with the memory number always on the outboard edge of the display. The **ADF MEMORY 1/2** page is shown in Figure 13-35 and is described in the following paragraphs.

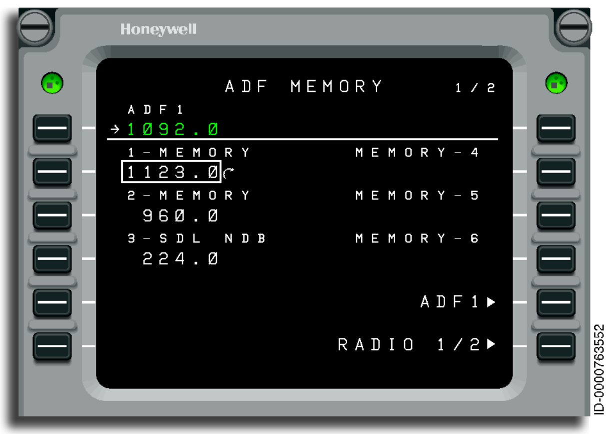

Figure 13-35
ADF MEMORY 1/2 Page

Labels are entered by typing into the scratchpad and pushing the LSK adjacent to the desired frequency. When the radio tuning function recognizes a valid frequency for the radio, the scratchpad data goes into the frequency field. When the entry is invalid, the entry is recognized as a label and is entered into the label field above the frequency. A label is replaced by making another scratchpad entry into a memory field or pushing the DEL key. Pushing the DEL key puts the text **DELETE** in the scratchpad. When **DELETE** is entered on a memory field, the associated text label is deleted and returns to the default label. If the DEL key is used on a memory where there is no user-entered label, the frequency is deleted from memory.

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- **1L ADF1** – This shows and controls the active ADF frequency on the selected radio in green. The white title shows which ADF was selected. Pushing 1L copies the field highlighted by the cursor into the active frequency and moves the previously active frequency into the preset field. A scratchpad entry into the field replaces the preset frequency with the previous active frequency.
- **2L, 3L, 4L** – These show the ADF memories 1 through 3 (7 through 9 on ADF MEMORY 2/2).
- **2R, 3R, 4R** – These show the ADF memories 4 through 6 (10 through 12 on ADF MEMORY 2/2).
- **5R ADF1** – Pushing this key shows the ADF DETAIL page.
- **6R RADIO 1/2** – Pushing this key shows the RADIO 1/2 page.

Access to the ADF MEMORY 2/2 page is by the NEXT and PREV function buttons.

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PFD Radio Setup

Radio navigation information (ADF, VOR, DME, ILS, and MB) is displayed on the PFD, as shown in Figure 13-36. The PFD is a secondary method to tune the radio. The PFD uses the CCD to tune two VHF and NAV channels.

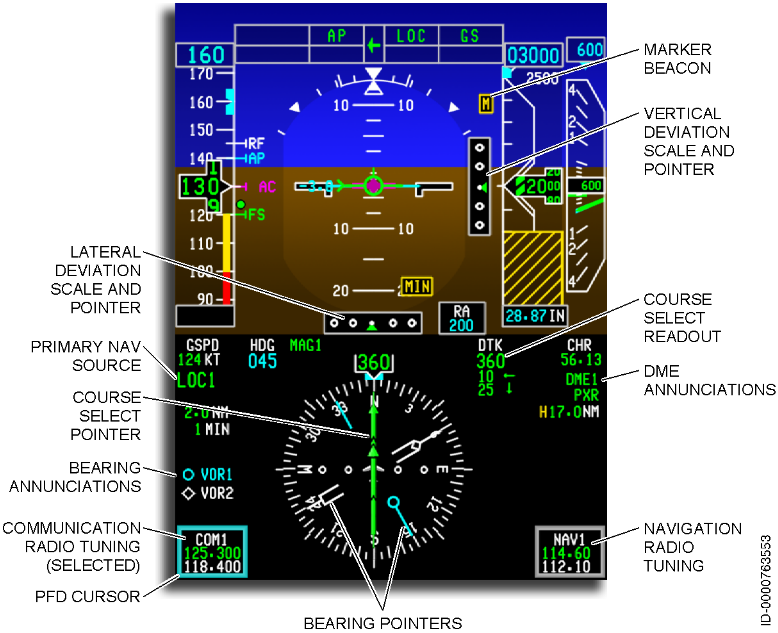

Figure 13-36
PFD Radio Displays

The COM and NAV active and standby frequencies are shown in boxes in the bottom left and right corners of the PFD, as shown in Figure 13-36. The active frequency is displayed in green, and the standby is displayed in white.

The frequencies are selected using the CCDs. The item that is currently selected by the CCD is shown in an enlarged and highlighted cyan box (the PFD cursor). The frequencies are tuned using the CCD knobs. The outer concentric knob tunes the digits to the left of the decimal point. The inner concentric knob tunes the digits to the right of the decimal point. The CCD **ENTER** button selects a tuned frequency and swaps the active and standby frequencies.

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The radios shown on the PFD are set by accessing the **PFD RADIO SETUP** page from the **SETUP** page on the MCDU, shown in Figure 13-37. The **SETUP** page is described in detail in Section 24, Multifunction Control and Display Unit (MCDU) Menu Pages.

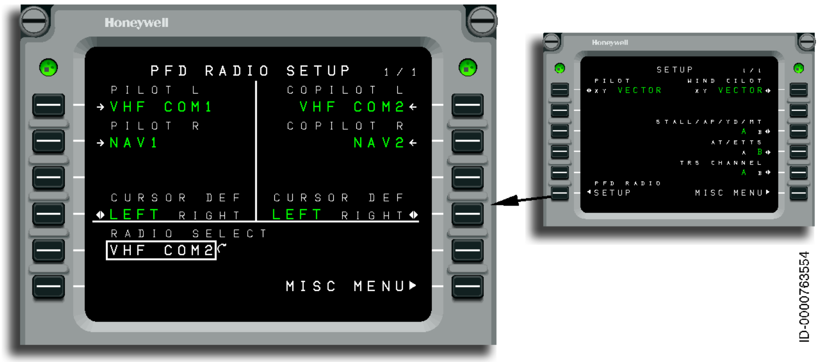

Figure 13-37
PFD Radio Setup Page

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The PFD RADIO SETUP page is only used to substitute aircraft radios into the right and left radio tuning displays on the two PFDs. Frequency values cannot be changed. The CCD is used for changing frequency values. The screen is divided into two parts. The left half controls the pilot's side, and the right half controls the copilot's side. The following description is based on the MCDU and HSI sections of the PFD, shown in Figure 13-38. The pilot and copilot sections of the **PFD RADIO SETUP** page operate identically.

Figure 13-38
MCDU and PFD for Radio Setup

- **1L Pilot Left Side Radio** – The **PILOT L** title identifies the left side radio box on the HSI. The green radio name identifies the radio assigned to that box.
- **2L Pilot Right Side Radio** – The **PILOT R** title identifies the right side radio box on the HSI. The green radio name identifies the radio assigned to that box.

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- **4L Cursor Definition** – LSK 4L toggles between LEFT or RIGHT. The selected side is green, and the unselected side is white. When LEFT is selected, the cyan cursor box is displayed around the left side radio box on the HSI. The size of the box and the alphanumerics in the box increase, as shown in Figure 13-38.
- **5L Radio Select** – When LSK 5L is pushed, the white cursor surrounds the radio name, and the tuning cursor is displayed to the right side of the box. The tuning knob is used to scroll through the radios available for display. When the correct radio is in the cursor box, pushing 1L or 2L replaces the existing radio with the radio shown in the cursor box.
- **6R Miscellaneous Menu** – Pushing 6R returns the MCDU display to the SETUP menu.
- **1R Copilot Left Side Radio** – The COPILOT L title identifies the left side radio box on the HSI. The green radio name identifies the radio assigned to that box.
- **2R Copilot Right Side Radio** – The COPILOT R title identifies the right side radio box on the HSI. The green radio name identifies the radio assigned to that box.

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RADIO INTERACTIONS

The radio tuning function expects to receive an acknowledgment when the radio is successful in completing each tuning command. The MCDU sends the correct tuning command to the specified radio and waits for confirmation. When no confirmation is received within the timeout period, the frequency display on the page changes to amber, and a scratchpad message is issued, as shown in Figure 13-39. The pilot can try to tune the radio again if the fault was transient or was cleared by crew action.

Figure 13-39
Amber Radio Indications

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Blank Page

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14. Audio System

INTRODUCTION

This section describes the operation and components of the audio system.

The cockpit audio system consists of the following items:

- Three AV-900 audio panels
- Radio modules within the modular radio cabinets (MRCs)
- Stand-alone communication line replaceable units (LRUs)
- Cockpit loudspeakers
- Headsets
- Microphones.

The passenger address system also interfaces with the digital audio system.

The cockpit audio system supplies communication to air traffic control (ATC) along with on-aircraft communication through transceiver radios between the following endpoints:

- Aircraft and ground
- Cockpit and cabin
- Flight crew and ramp crew
- Flight crew in the cockpit.

The cockpit audio system also converts digitized navigation radio audio and aural warning audio to analog audio for distribution to the flight crew's headphones and cockpit speakers. Digitization of all audio signals occurs in the MRC. The system interfaces are divided between the radio cabinets.

The audio selected and used by the pilot's audio panels are also sent to and recorded in the two digital cockpit voice recorders (CVR/DVR).

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The audio panel gives audio selection and control for the following functions:

- VHF and HF COM radios
- PA and interphone system
- SATCOM (satellite communication)
- RAMP
- Cabin interphone operation
- Emergency radio system
- NAV radios
- ID filter
- DME and marker beacons
- SELCAL (selective calling)
- Crew aural warning system.

Each audio panel is used to select channels from the digital audio bus to generate headphone and speaker signals. This permits the system to individually select the radio function the crewmember wants to hear.

The cockpit audio system has three modes of operation:

- Normal operational mode
- Configuration mode
- Backup mode.

Normal Operational Mode

In the normal operational mode, the cockpit audio system supplies selection and volume control on each audio panel for the following:

- All ATC transceiver communication channels
- Routing of the microphone-in-use to the selected transmitter
- All radio navigation channels
- Master cockpit speaker

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- Headphones
- Microphone switching to different radios
- Warning tones in the cockpit with input of up to five audio warning channels available
- Amplifiers to drive headphones and speakers
- Cockpit speaker ON/OFF switch.

The cockpit audio system is equipped with the following equipment at each crew station:

- A headset, including boom microphone
- An oxygen mask microphone
- Inputs for push-to-talk (PTT) switches
- Dedicated PA PTT
- A handheld microphone with PTT
- A dedicated cockpit speaker.

Backup Mode

Each audio panel has a backup mode that is selected if the audio panel power fails or the digital audio bus fails. The backup mode supplies microphone switching directly to the VHF COM and VHF COM audio directly to the headphones. No power is required.

The backup mode is active when one or more of the following conditions are satisfied:

- Power to the audio panel is lost
- The BKUP switch-pot is set to the BKUP position (the switch-pot latched in the OUT position).

NOTE: When the BKUP switch-pot is latched IN, the audio panel operates normally when there is power to the audio panel.

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In backup mode, the audio panel does the following functions:

- Directs the microphone signal directly to the COM designated as the backup or emergency radio for that particular audio panel.
- Directs the headphone output from the backup or emergency radio to the pilot's headphone outputs without amplification.
- Controls the headphone volume by way of the potentiometer on the BKUP VOL switch-pot when the BKUP switch-pot is set to the BKUP position.
- Lights the backup volume control by the backlight when the BKUP switch-pot is set to the backup position, and there is power to the audio panel.
- Permits selection of the MASK or BOOM microphone with the MIC switch-pot and ignores button pushes for all other buttons on the panel.

Audio Panel Controls

A front panel drawing of the audio panel is shown in Figure 14-1.

Figure 14-1
AV-900 Audio Panel With VHF3 and NAV3

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The controls include the following:

- Nine microphone selections (**MIC** – horizontal rectangles)
- Two function selections (**ID** and **SELCAL** – square)
- Fourteen audio selection buttons (**VOL** – small round with center dot)
- One multiplexed master volume control (**VOL** – large round)
- One backup volume control (**BKUP VOL** – medium size round with center arrow)
- One Auto/Mask microphone switch (**MIC AUTO/MASK** – medium size round with center dot).
- One display to show the volume of the last active microphone or configuration detail.

Other Audio Cockpit Controls

PTT Switch – The push-to-talk (PTT) switches, shown in Figure 14-2, are located at the far left on the pilot's dimming panel and the far right on the copilot's dimming panel. When pushed, the PTT switch directs the active microphone to the selected output channel.

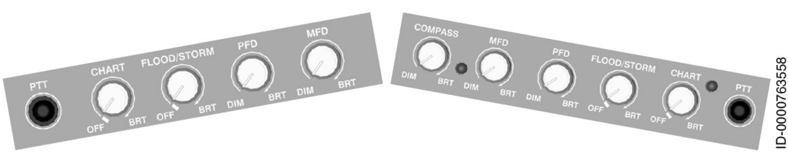

Figure 14-2
Dimming Panels

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Public Address (PA) Push To Talk (PTT) Switch – The PA switch, shown in Figure 14-3, is located on the aft center pedestal. The PA switch is a PTT switch that directs the active microphone to the public address system.

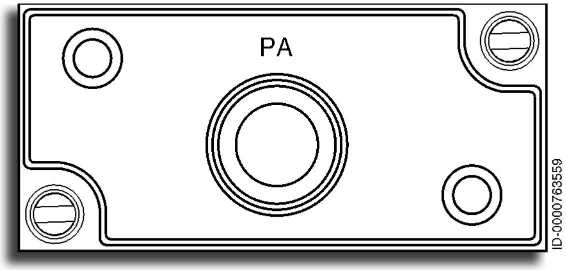

Figure 14-3
PA Switch

Observer Jack Panel – The jack panel, shown in Figure 14-4, is located at the observer station and is used only by the observer. The jack panel is used to connect the observer headset into the audio system and to select PTT and hot MIC applications by the observer.

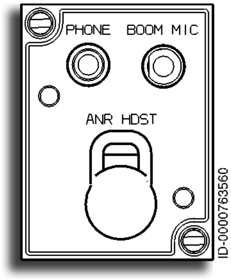

Figure 14-4
Observer Jack Panel

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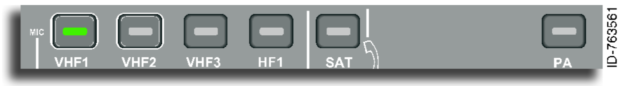
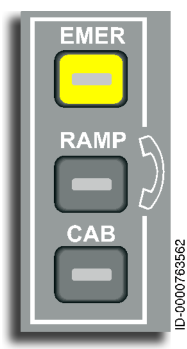
Control Descriptions

The audio panel control functions are as follows:

Crew Intercom – When PTT is pushed, the microphone audio from the selected panel is transmitted over the intercom system. The main volume control adjusts the on-side headphone audio level when the intercom function is active (such as when talking with the other pilot).



Microphone Selection TX Buttons – When a microphone button is selected, the operator's microphone signals are directed to the selected radio (or PA when the **PA PTT** button on the console is pushed). Microphones can only be selected one at a time. When selected, a green LED on the microphone button annunciator lights. Each push of the microphone button toggles the microphone on and off. For radios without telephony features, the microphone is deselected by pushing another microphone button. When a microphone button is pushed, and the audio is OFF, the audio selector button below is also enabled.



Telephony Buttons (except SATCOM) – When a telephony button is pushed (emergency (**EMER**), cabin (**CAB**), or **RAMP**), the operator can listen to the selected function. In order to route the microphone audio to one of these radios, the **ICS PTT** must be pushed. When selected, the annunciator button flashes for EMER and CAB or will light for RAMP. One radio microphone button can be selected together with one or more telephony buttons. The telephony button requires the use of the ICS PTT. Selecting the **EMER** button when **CAB** has already been selected results in the **CAB** MIC button being deselected. When an **EMER**, **CAB**, or **RAMP** button is selected, the operator can talk and listen on the selected function. All microphones are hot MIC (no PTT). The **CAB** and **RAMP** telephony buttons can be selected at the same time.

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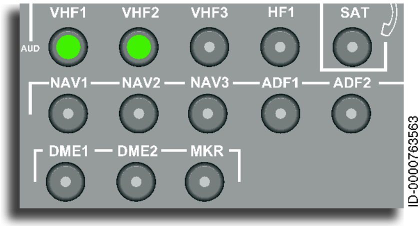

Audio Selection Buttons – When an audio selection button is pushed, the LED turns ON, and the audio panel decodes the selected digital audio bus data for the corresponding radio and converts the data to analog audio, and also enables the audio to be summed into the output on the headphone and cockpit speaker outputs. Any number of audio buttons can be active at the same time. When pushed, the round annunciator lights. Each audio button is selected by a push. When an audio button is already selected, and the selection button is pushed, the audio remains selected, and the volume for that audio is adjusted using the volume control knob. To deselect an audio button, the button is pushed two times. One push makes the audio active and a second push inactive.

Volume Control – The volume control knob adjusts the volume of the most recently selected audio or the audio shown in the display window. Adjusting the knob clockwise increases the volume. The relative volume is shown as a number between 0 and 99 on the display.

AUTO/MASK Microphone Switch – The AUTO/MASK microphone switch is a latching switch that is latched out by pushing it and latched in by pushing again. When there is power to the audio panel, the dot on the MIC AUTO/MASK switch is lit by the backlight when the control is latched out. When latched in and the pilot puts on the oxygen mask and starts the airflow, an automatic switch is performed from the headset boom microphone to the oxygen mask microphone. If the auto mode fails, the oxygen mask microphone is activated by pushing the AUTO/MASK switch out.

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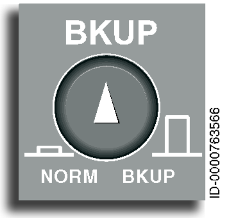
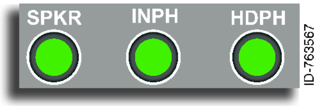


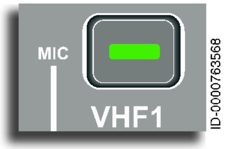
BKUP Knob – In an emergency power loss situation, this knob controls the emergency VHF receiver volume to the user's headset. The backup volume control is both a latching switch and volume control. It is latched out (BKUP) by pushing it and latched in (NORM) by pushing again. The BKUP knob is rotated to adjust the volume of the emergency COM when latched out. The arrow points to the volume with minimum volume shown by the most counterclockwise position and the maximum volume indicated by the most clockwise position. No audio panel power is required for the feature to function. Power for the emergency transceiver is necessary.



SPKR, INPH, HDPH Buttons – These three buttons control the master volume levels for the speaker, headphones, and the interphone system.

- **Speaker (SPKR)** – The **SPKR** button lights when pushed, and SPKR shows in the display with a volume level number. Adjusting the volume control sets the speaker volume level for all audio inputs. Each can still be individually controlled when the audio button is pushed and ID displayed.
- **Interphone (INPH)** – This button operates the same as the **SPKR** button and controls the interphone system.
- **Headphone (HDPH)** – This button operates the same as the **SPKR** button and controls the headphone system.

Audio Panel Annunciators and Displays



Microphone TX Selection Button (all ATC radios and PA) – A green light-emitting diode (LED) annunciator is used on each microphone transmit (TX) button. The LED is on when the microphone is selected. For SATCOM, the LED flashes for incoming calls or to annunciate a HOLD status. The flashing for incoming calls is at a slower rate than the flashing to annunciate hold status.

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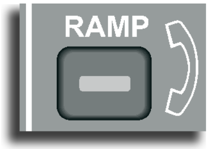
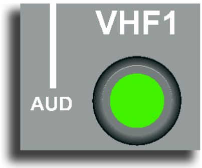


Telephony Buttons (except SATCOM) – A green LED annunciator is used on each button. The LED is on when the button is selected. The LED also flashes for an incoming call.



Audio Selection Buttons – The green LED is on when the audio channel is selected. For channels with telephony features (such as SATCOM), the LED flashes for incoming calls. The LED does not flash to annunciate hold status. When a channel is on hold, this LED is off.

Active Channel and Volume Display – An eight-character alphanumeric display shows the active channel ID and volume setting. In normal conditions, the display shows the volume of the last active microphone selected. When another microphone selection button is pushed or an audio selection button is activated, the display shows a four-character code for the selected system and a number between 0 and 99 to show the volume setting. The display defaults back to the last active microphone after 15 seconds.

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AUDIO PANEL OPERATION

The audio panel, shown in Figure 14-5, does the following functions:

- Receives digitized audio from the network interface modules (NIM)
- Decodes the audio
- Controls the gain (volume) and routing of the various channels
- Filters audio signals to various speakers and headphones
- Controls microphone inputs to various radios, intercom, and passenger address systems.

Figure 14-5
AV-900 Audio Panel

Amplifiers are included for driving headphones and speakers.

The audio panel also has inputs for intercom, crew annunciator, crew communication, hot microphone, and full-time emergency warning inputs from aircraft systems.

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The microphone input selection controls are located along the upper edge of the audio panel. The controls are rectangular buttons that, when pushed, toggle the state of the button. These buttons result in the AV-900 directing the selected microphone audio to the corresponding transceivers or available intercom channels. The received audio is routed to the speakers and headphones at an internally preset minimum level. The level is adjusted with the audio source selector buttons located below each microphone button. During night-flying operations, the microphone buttons are lit with a bar in the center of the button that is selected.

VHF and HF Audio/MIC Operation

When a radio microphone is selected, and PTT is enabled, the operator's microphone signal is routed to that radio microphone input.

The aural feedback to the pilot is controlled by the audio selector button immediately below the microphone button for that radio. When a radio microphone is selected, the aural feedback is limited to a minimum level. The volume set by the audio selector button cannot be zero. This assures that the operator can always hear the received audio.

In normal conditions, the display shows the radio ID and a number between 0 and 99 to show the volume level for that audio channel.

When a radio is selected, and PTT is pushed, the display shows the characters representing that radio and TX (for transmitting). If PTT is enabled for longer than the time-out time (fixed between 30 seconds to 2 minutes through the configuration file), the radio transmit function is disabled, and the display shows stuck microphone (STK MIC).

If a microphone button that is off is selected and the corresponding audio button is OFF, the AV-900 automatically turns ON the corresponding audio button when the microphone button is turned ON.

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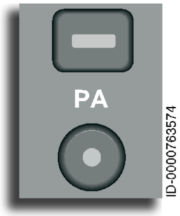
When a microphone selector button is deselected by either pushing on or selecting another microphone button, and the corresponding audio button is turned ON by the AV-900, the microphone annunciator, the audio selector annunciator below the button, and the audio from that channel turn OFF.

If a microphone button that is OFF is selected, and the corresponding audio button is already ON, then the AV-900 will merely turn on the selected microphone button.

When a microphone selector button is deselected by either pushing on or selecting another microphone button, and the corresponding audio button was not turned ON by the AV-900, only the microphone annunciator for that channel will be turned OFF. The audio button will remain ON as it was on prior to selecting the corresponding microphone.

Passenger Address (PA) Operation



The passenger address (PA) function permits the user to make an announcement to the cabin using the selected microphone. A user can transmit on the PA output by keying the PA PTT on the pedestal or by selecting the PA microphone and keying the PTT (yoke, glareshield, or hand microphone). When the PA microphone is selected and PA PTT is enabled, the pilot microphone signal is routed to the PA amplifier. No other radio transmissions are permitted, and none are selected. See the detailed description in this section.

The audio feedback to the pilot is controlled by the round audio selector button immediately below the microphone button for PA.

In normal conditions, the display shows the radio ID and a number between 0 and 99 to show the volume level for that audio channel.

When the **PA** button is selected and PTT is enabled, the display shows the characters that indicate PA and TX. If PTT is enabled for longer than the 2-minute time-out period, the PA function is disabled, and the display shows STK MIC.

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The function of the PA with the headset microphone is as follows:

- The pilot pushes the PA PTT (on the pedestal), and a VHF microphone button is on, the following occurs:
  - The pilot microphone (boom) is transferred to the PA function while the PA PTT is pushed and the PA microphone on the audio panel light is on.
  - The audio panel display shows PA TX.
  - The VHF microphone and audio lights that were active turn off.
  - After releasing the PA PTT, the VHF microphone that was active becomes active again, and the audio panel display shows VHF number.
- When the pilot selects the PA microphone on the audio panel and pushes the PA PTT, the following occurs:
  - The pilot microphone (boom) is transferred to the PA function.
  - The audio panel display shows PA TX.

When the pilot selects the PA microphone on the audio panel and pushes the control wheel or dimming panel PTT, the following occurs:

- The pilot microphone (boom) is transferred to the PA function
- The audio panel display shows PA TX.

The function of the PA with the hand microphone is as follows:

- The pilot selects PA microphone on the audio panel, and the following occurs:
  - With the hand microphone PTT pushed, the display shows PA TX, and the transmission is established.
  - The speaker is automatically activated.
- The pilot selects the PA microphone on the audio panel and pushes the PA PTT:
  - With the PA PTT pushed, the pilot microphone is transferred to the PA system, and the PA microphone light turns on.

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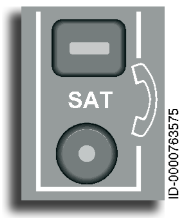
– The audio panel display shows PA TX, and the active pilot microphone is the boom (headset microphone).

The function of the PA with the mask microphone is as follows:

- Same as headset operation except that the pilot's microphone (**MIC** button) is manually or automatically transferred to the mask, and the speaker is automatically activated.

SATCOM Operation (Option)



The SATCOM system supplies multichannel voice and data functions. The SATCOM supplies the cockpit crew with both airline operational control services (AOC), future air traffic control (ATC) services, as well as passenger services (voice, FAX, and PC). This SATCOM system is designed for use with the INMARSAT satellite network. The operation of telephony devices (SATCOM) selected through the audio panel is the same as radio (VHF and HF) selection except for the following differences described in this section.

When a call is received at the SATCOM unit, a signal is relayed to the audio panel. The annunciators on both the microphone button and the audio selector button for the SATCOM start to flash. The aural message "**SATCOM**" is sounded. When the microphone selector buttons are pushed, both annunciators stop flashing and stay lit. The SATCOM LEDs remain OFF on all other panels. A signal is output to the SATCOM unit to answer the call. The pilot can then talk to the caller.

NOTE: When the SAT microphone button is selected, both SAT annunciators turn on, and a discrete is output to the SATCOM to answer the call. The headset or mask microphone is then a hot microphone, and the use of PTT is not required unless the hand microphone is used. The pilot may talk and listen as desired.

During the call, if another microphone button is pushed while the SATCOM call is in progress, the call is placed on hold and the microphone annunciator flashes. The audio annunciator goes off.

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When the SATCOM microphone button is pushed again, both annunciators are lit, and the call is taken off hold.

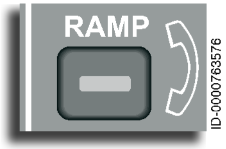
When the SATCOM microphone is deselected by pushing the button again, the call is terminated, and both annunciators go off.

To start a call, the multifunction control and display unit (MCDU) must be used to set up the call, and then the microphone button is pushed. Pushing the **SATCOM** microphone button results in the cockpit audio system initiating a SATCOM call by telling the satellite data unit (SDU) to dial the number that was previously selected on the MCDU. Another SATCOM call must not be currently active. The SATCOM microphone and audio annunciators flash until the call is answered.

When the call is terminated by something other than pushing the microphone button, the annunciator on the microphone select button, and the audio select button go off. The display defaults to the last active microphone.

More than one person can talk on the SATCOM channel.

RAMP Interphone Operation



Pushing the **RAMP** button turns the **RAMP** button ON and sounds a horn in the nose wheel well to summon ramp personnel. When **RAMP** is selected on the audio panel, the hot microphone or the ICS PTT is used to route the pilot microphone signal to the passenger address and cabin interphone system (PACIS). There are provisions for three ramp service (maintenance) interphone connections.

When **RAMP** is selected, the display shows RAMP and a number between 0 and 99 to show the volume level.

When the pilot selects another radio, the RAMP annunciator on the RAMP select button remains lit. RAMP audio is still provided. In order to communicate on the RAMP channel, the ICS PTT must be pushed.

For an incoming RAMP call, the RAMP annunciator flashes. To pick up the call, the **RAMP** select button is pushed. The annunciator light stays lit, and the display shows RAMP and a number between 0 and 99 to show the volume level. After the call is terminated, the display defaults to the last active microphone.

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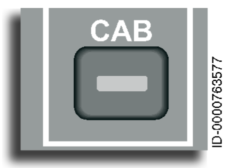
Cabin (CAB) Interphone Operation

The digital audio system interfaces with the passenger address system and PACIS to permit the flight crew in the cockpit to make passenger announcements, communicate with the flight attendants, and give call chimes. The call chimes are annunciated at the beginning of the call from the cockpit to the flight attendants and vice-versa. The chimes are also annunciated before the pilots or flight attendants make announcements to the passengers. When **CAB** is selected, the hot microphone or the ICS PTT is used to route the pilot microphone signal to the passenger address and PACIS.



When **CAB** is pushed, the display shows CAB, a number between 0 and 99 to show the volume, and the annunciator button flashes until the call is picked up by the flight attendant.

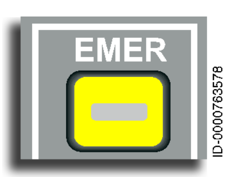
The pilot can select another radio. When the pilot selects another radio, the cabin annunciator on the cabin select button remains lit, and CAB audio is still provided. In order to communicate on the CAB channel, the ICS PTT must be pushed.

For an incoming call, the cabin annunciator flashes. To pick up the call, the cabin select button is pushed. At this time, the annunciator is steady on, and the display shows the characters that indicate CAB and a number between 0 and 99 to show the volume level.

After terminating the call, the display defaults to the last active microphone.

Emergency (EMER) Interphone Operation

When emergency (EMER) is selected, either the hot microphone or ICS PTT is used, and the microphone signal is routed to the PACIS.



When the yellow **EMER** button is pushed, the display shows EMER, and a number between 0 and 99 displays the volume level. The annunciator button flashes, and a chime sounds in the cabin until the call is picked up by the flight attendant.

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When the pilot selects a different radio, the emergency annunciator on the cabin select button remains lit. EMER audio is still provided. In order to communicate on the EMER channel, the ICS PTT must be pushed.

For an incoming call, the emergency annunciator flashes. To pick up the call, push the emergency select button. The annunciator light remains steady on, and the display shows the characters, indicating EMER, and a number between 0 and 99 to show the volume level.

The EMER call is terminated when the pilot pushes the **EMER** button or when the cabin crew terminates the call on the flight attendant's handset. When an EMER call is inactive, or when the EMER call is terminated, the **EMER** microphone button light is OFF. After terminating the call, the display defaults to the last active microphone.

When EMER is selected, headphone volume is controlled by the on-side headphone volume control.

Emergency Operation

The pilot and copilot audio panels have a backup (emergency) mode selectable if the audio panel power fails or the digital audio bus fails. The pilot's microphone and headphones directly connect to the on-side VHF COM radio.

The backup volume control (BKUP) is a latching switch. Volume control is latched out by pushing BKUP and latched in by pushing again. When latched out, the volume control is rotated to adjust the volume of the emergency COM. No power is required for this feature to function.

NAV Audio Operation

NAV radios (radios without transmitters) are controlled by the audio volume control only. The volume is set the same way as the other radios. After a predetermined time, the display defaults to the last active microphone.

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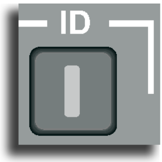
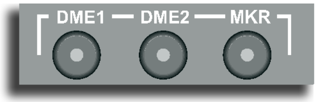
Ident (ID) Filter (or Switch) Operation



ID-0000763579

When the ID filter is enabled by pushing the **ID** button, a filter activates to eliminate the voice on VOR and ADF audio. The annunciator on the button is ON when the filter is active. When the ident filter is deselected, voice and ident are available, and the annunciator is OFF.

Distance Measuring Equipment (DME) and Marker (MKR) Beacon Controls



ID-763580

When the **MKR** button is pushed, the annunciator is turned ON, and the display shows MKR along with a number between 0 and 99 to show the volume level. The MKR audio to the speaker/headphone is turned ON. To deselect MKR, push the **MKR** button once if the audio panel display shows the audio level. Otherwise, push the **MKR** button twice. The MKR volume cannot be adjusted below an internally preset minimum level.

The **DME** buttons are used to select the specified DME radio (channel 1 or 2) for monitoring. Pushing either button turns the corresponding annunciator ON and displays the DME along with a number between 0 and 99 to show the volume level. To deselect the DME, push the button twice.

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Selective Calling (SELCAL) Operation

Selective call is a feature where audio tones are sent over VHF and HF radios that selectively address a particular aircraft programmed to decode those tones. Each aircraft has a designated SELCAL code (consisting of four letters and four audio tones) assigned prior to takeoff. This permits the crew to receive calls from the ground station designated to their aircraft.

An incoming call is displayed when the SELCAL annunciator flashes and the aural message "**SELCAL"** is sounded. Also, the microphone and the audio button for the called radio flash. Pushing the **SELCAL** button turns off the flashing annunciator. The **SELCAL** button, when pushed, shows the SELCAL code on the audio panel display.

To answer a call, select the microphone button for the called radio.

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15. Micro Inertial Reference System (IRS)

INTRODUCTION

This section describes the operation and components of the micro inertial reference system (IRS).

The IRS provides accurate attitude, heading, and position information to aid navigation.

Two IRSs are included in the baseline system. The main components of the IRS are the micro inertial reference units (IRUs). Both IRUs operate continuously.

The Micro IRU processes and outputs inertial reference information. The Micro IRUs differ from other generations of IRUs, mainly through the addition of the following three new features:

1. Align-in-motion capability.
2. Automatic mode control logic (eliminating the need for mode control unit).
3. Electronic tray alignment.

Each Micro IRU processes and outputs inertial reference data. The inertial reference (IR) component of the Micro IRU contains three accelerometers and three-ring laser gyros. The accelerometers measure linear motion along the longitudinal, lateral, and vertical axes. The ring laser gyros measure angular motion about the longitudinal, lateral, and vertical axes.

In normal operation, the Micro IRUs operate only from the primary input power source when the primary input power is between 18 and 36 V dc. When the primary input power source voltage is less than 18 V dc, the Micro IRUs switch to and operate from the secondary input power source when the secondary input power source is between 18 and 36 V dc.

When the Micro IRUs are operating on the secondary input power source, and the primary input power source increases to a voltage greater than 19 V dc, the Micro IRUs switch back and operate (normally) from the primary input power source.

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INERTIAL REFERENCE UNIT (IRU)

Each IRU outputs digital data that includes the following:

- Primary aircraft attitude in pitch and roll
- Magnetic and true heading
- Body linear accelerations
- Body angular rates
- Inertial velocity
- Navigation position
- Wind data
- Calculated data
- Hybrid output data.

POSITION INITIALIZATION

The NG FMS automatically initializes and does not require manual position initialization. The POSITION INIT page is used to initialize the FMS position when the GPS position is not available. The FMS POSITION INIT page, shown in Figure 15-1, is accessed from the NAV IDENT page when the GPS position is not available at power-up or from the NAV INDEX 2 page.

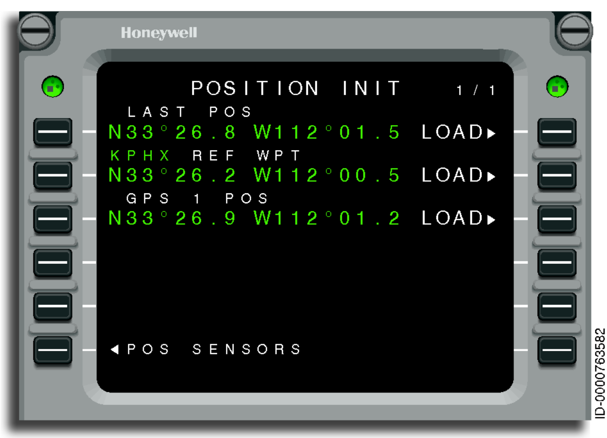

Figure 15-1
FMS POSITION INIT Page

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Any positions listed can be used for the initialization, or the pilot can enter the correct latitude/longitude or reference waypoint using line select key (LSK) 2L.

Pushing 6L (POS SENSORS) displays the POS SENSORS 1/2 page, shown in Figure 15-2. The POS SENSORS 1/2 page contains sensor information for the two hybrid IRS (hybrid data calculated by the IRS hybrid function based on GPS data and air data).

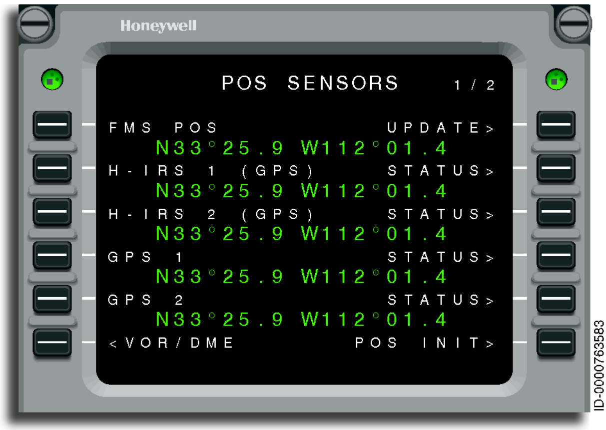

Figure 15-2
FMS POS SENSORS 1/2 Page

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Pushing the NEXT or PREV function keys displays the POS SENSORS 2/2 page. The POS SENSORS 2/2 page, shown in Figure 15-3, contains information for the two IRSs (not hybrid, pure data measured by the IRS without GPS and air data calibration).

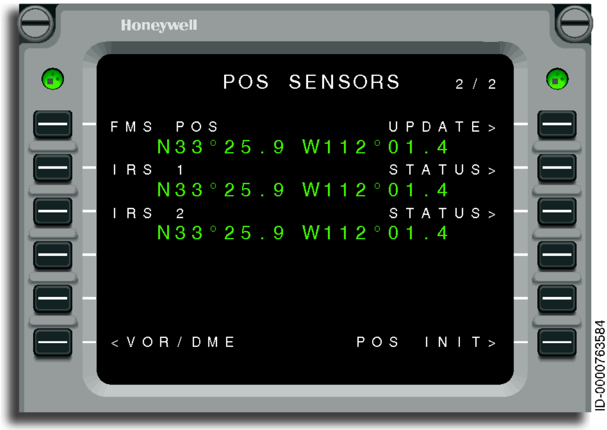

Figure 15-3
FMS POS SENSORS 2/2 Page

In addition, the IR component receives air data such as pressure altitude, altitude rate, and true airspeed from the air data system (ADS), as well as GPS autonomous data on high speed input buses. The Micro IRUs use this data for computing flight path angle, flight path acceleration, inertial vertical speed, inertial altitude wind speed, and wind direction. The Micro IRUs also produce the parameters for body frame, local level frame, and earth frame described in the following paragraph.

Body Frame

Body frame produces the following parameters:

- Longitudinal, lateral, and normal accelerations
- Pitch, roll, and yaw rates.

Local Level Frame

Local level frame produces the following parameters:

- Pitch and roll angles
- Pitch and roll attitude rates

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- Flight path angle and flight path acceleration
- Inertial vertical speed and inertial vertical acceleration
- Platform heading.

Earth Frame

Earth frame produces the following parameters:

- Latitude and longitude
- North - South velocity, East - West velocity, and groundspeed
- Inertial altitude
- True and magnetic heading
- Track angle true and track angle magnetic
- Track angle rate
- Wind speed and wind direction true
- Drift angle
- Along track and crosstrack accelerations
- Along heading and crossheading accelerations.

Hybrid Outputs

The GPS hybrid function uses existing hardware components in the IRU to receive GPS data from one or two GPS receiver systems and provide more accurate position information. Hybrid IRS data is used by the FMS and FCC. The IRU receives a one Hz nominal RS-422 time mark signal unique for each GPS receiver input and ARINC 429 GPS high-speed satellite measurement and autonomous data. The GPS hybrid function blends received GPS autonomous pseudo range with inertial and air data altitude data to achieve optimal position, velocity, and attitude performance. The GPS hybrid function provides the following output parameters:

- Hybrid latitude and longitude
- Hybrid N/S velocity, E/W velocity, and groundspeed
- Hybrid altitude and vertical velocity
- Hybrid true heading, track angle, and flight path angle

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- Hybrid horizontal and vertical figure of merit
- Hybrid horizontal integrity limit and satellite fault detection
- Hybrid health/status.

Interfaces

The IRS interfaces with the following systems/components to transmit inertial output data to:

- The Electronic Display System (EDS) and other aircraft systems.
- Flight Control Computers (FCCs) 1, 2, and 3.

The IRS receives input data from:

- Both GPSs
- Avionics system, including initial position and air data.

Flight Management System (FMS)

The FMS receives the positional information transmitted from the IRS. The FMS MCDU shows the alignment status of the IRS on the IRU status page.

Electronic Display System (EDS)

The attitude information is transmitted to the EDS and is displayed for the crew on the primary flight displays (PFDs).

- **Attitude Display Indicator (ADI)** – The ADI consists of an artificial horizon, pitch tape, roll pointer/scale, and aircraft symbol. The artificial horizon consists of a horizon stabilized blue sky/brown ground solid color crossing the entire display. A reference aircraft symbol is displayed in the ADI.
- **Pitch Tape** – A linear pitch tape is displayed through the center of the attitude display. The pitch tape is horizon stabilized. The pitch tape goes behind the aircraft symbol and the radio altitude digits when visible.
- **Roll Scale** – A linear roll scale is displayed on the top of the truncated ADI sphere.

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- **Air Data Module (ADM)** – The Micro IRU receives air data information such as altitude, altitude rate, and true airspeed from an ADM. These parameters are used to correct output to other avionics systems.
- **Global Positioning System (GPS)** – The Micro IRUs receive GPS autonomous data. The Micro IRUs gather this information and check GPS integrity. GPS information is used for position initialization and elimination of long-term sensor drift.
- **Automatic Flight Control System (AFCS)** – The AFCS receives accelerations, attitudes, and attitude rates data from IRS.

Modes of Operation

The Micro IRUs have the following operational modes:

- Power-up
  - Warm start power-up
  - Normal operation power-up
- Alignment
  - Stationary alignment
  - Align in motion (AIM)
  - Auto realign
- Navigation
  - Hybrid IRS
  - GPS
  - DME/DME
  - VOR/DME
  - IRS
- Attitude
  - Reversionary
  - AIM
- End of flight.

Control of these modes is automatic. No input is required from the pilot to select or to enter a mode.

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INTERACTION BETWEEN OPERATIONAL MODES

References in this section relate to the IRUs in the following conditions:

- On-ground
- Motionless
- In the air
- In motion
- In-flight.

The IRUs define on-ground or motionless as a groundspeed of less than 60 knots in the navigation mode or an ADS true airspeed of less than 110 knots in the reversionary attitude.

The IRUs define in-flight, in the air, or in motion as a groundspeed of greater than 80 knots in the navigation mode or an ADS true airspeed of greater than 130 knots in the reversionary attitude.

A flight occurs when the IRUs transition from the on-ground state to the in-flight state. In the navigation mode, a flight occurs when inertial groundspeed transitions from less than 80 knots to greater than 80 knots. In the attitude modes, a flight occurs when true airspeed transitions from less than 130 knots to greater than 130 knots.

Power-Up Mode

The IRUs initiate the power-up mode when the IRUs are energized or when the IRUs are reset as a result of an IRS reset command being issued.

During the power-up mode, the IRU performs the power-up BIT. Power-up mode does not exceed 7 seconds in duration under ground cold start conditions or 5 seconds under air cold start conditions.

Following completion of the power-up mode, the Micro IRUs automatically enter one of the alignment modes.

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Alignment Mode

The Micro IRUs automatically select the correct alignment mode. The three possible modes are:

- Stationary align
- Align in motion (AIM)
- Auto realign.

Stationary alignment and align in motion modes are performed in conjunction with the attitude mode prior to the entry into navigation mode. The auto realign mode is performed in conjunction with the navigation mode.

STATIONARY ALIGNMENT

The stationary alignment mode is the primary method of alignment. This mode is selected when the aircraft is on the ground and not moving. The normal procedure is to perform a stationary alignment only once at the beginning of each day.

The IRU requires a valid input of initial latitude and longitude from either pilot entry on the MCDU or one of the GPS input buses to complete the stationary alignment mode. The IRU accepts present position data at any time during the stationary alignment mode. With each successive latitude and/or longitude entry, the IRU uses the new entry in place of the previous entry. When latitude and longitude are not entered by the end of stationary alignment, a cockpit indication goes to the pilot. If a valid position is entered, the cockpit indication is cleared.

The time required to complete a stationary alignment varies as a function of latitude. The variable alignment time ranges from 5 to 17 minutes. A position can come from the onboard NAV systems or entered by the pilot. Excessive aircraft movement during the stationary alignment mode results in an automatic full realignment beginning 30 +/- 1 seconds after the cessation of excessive motion. Time To NAV is reset to 17.0 minutes or less based on entered or stored latitude at the detection of excessive motion. If excessive motion continues, Time To NAV does not count down until excessive motion is no longer detected.

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NOTES: 1. The alignment can fail if the Micro IRU senses excessive motion during the initialization process or if the Micro IRU fails to receive an initialization position.

2. The IRU is certified for stationary alignments up to 78.25 degrees.

ALIGN IN MOTION (AIM)

The AIM mode initializes the IRS while in the air to recover full IRU navigation capability. This mode is selected if power is lost in flight.

The time required to complete an AIM varies as a function of aircraft latitude and motion and ranges from 15 to 30 minutes. When the Micro IRUs are performing an AIM, the flight crew is notified by a CAS message. The message is cleared when the AIM is completed.

The IRU requires valid GPS inputs throughout the AIM period to complete the alignment. At the end of the alignment time, the IRU conducts an AIM performance test to validate the integrity of the IRU alignment. When the AIM performance test fails, the IRU resets the AIM processing to 17 minutes and repeats the AIM procedure. When the AIM performance test passes, the IRU transitions to the navigation mode and the AIM cockpit indication is cleared.

If the AIM fails, the Micro IRUs are left in the attitude mode (attitude data available, positional data unavailable).

Stationary alignment and AIM modes are performed in conjunction with the attitude mode before entering the navigation mode.

AUTO REALIGN

The auto realign mode is performed in conjunction with the navigation mode when the aircraft is stationary to maintain optimal performance. The three auto realign submodes are:

- Extended auto realign
- Preflight auto realign
- Postflight auto realign.

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The first auto realign activation is called an extended auto realign, which maintains optimal IRS attitude and navigation performance when the aircraft is motionless prior to flight. While the system is in the extended or preflight auto realign mode, the time in navigation remains constant and is not incremented.

The second auto realign activation condition is referred to as preflight auto realign, where auto realign updates are performed when the aircraft becomes stationary for the period of time after motion was experienced, prior to the first flight in a power cycle. Following both an alignment to navigation mode transition and the presence of previous motion, and the aircraft is on-ground prior to first flight taken in navigation mode, the IRU enters preflight auto realign if motion was not detected over the auto realign motionless time period.

The third auto realign activation is called the postflight auto realign mode. This occurs following a flight when the aircraft has been motionless for 7.5 to 15 minutes. The GPS position is used to automatically reinitialize the Micro IRUs when the GPS position is available and valid. This mode is equivalent to a stationary alignment, and a postflight auto realign resets the time in navigation to zero.

Auto realign mode automatically realigns the Micro IRU between flights. The auto realign mode is performed in conjunction with the navigation mode.

Navigation Mode

The FMS uses a performance-based sensor-selection function, with the estimated position uncertainty (EPU) of each sensor used to decide which sensor is performing best. The GPS sensors and the Hybrid IRS function produce a figure-of-merit (FOM), which is used to compute the EPU value for those sensors (data latency is included for EPU computation). The EPU is modeled by the FMS for the IRS, DME/DME, and VOR/DME sensors.

The FMS receives navigation data from various sensors onboard the aircraft. From the available sensors, the FMS determines the best navigation mode and combination of sensors to provide the most accurate aircraft position. The selected sensor for the FMS position is chosen by comparing the EPU values of all available and not deselected sensors and choosing the sensor with the lowest value.

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Once a sensor is chosen, it remains selected until another sensor's EPU is better than the selected sensor's EPU by 5%.

Changing from one navigation mode to another is not instantaneous. For example, each time the radios are tuned, the radio position is lost for some time. However, the FMS annunciates the navigation mode as radio updating. Some mode changes require several minutes to complete.

Attitude Mode

The attitude mode primarily functions to rapidly establish pitch and roll attitudes and body rotational rates, and linear accelerations after the power-up mode. Attitude mode runs concurrently with the alignment modes (either stationary alignment or align in motion). The two modes in the attitude mode are:

- Reversionary attitude mode
- Align in motion attitude mode.

REVERSIONARY ATTITUDE MODE

Following a normal operation power-up, the IRU enters the erect attitude submode and then the reversionary attitude mode. Following a warm start power-up, the erect attitude submode is bypassed, and the IRU enters the reversionary attitude mode. This mode operates in conjunction with the stationary alignment mode.

The reversionary attitude mode computes platform heading and requires an initial set heading entry for valid output of magnetic heading. The reversionary mode operates independently of GPS measurements. After 4 to 10 minutes, this mode is completed, and the system automatically enters AIM attitude mode.

ALIGN IN MOTION (AIM) ATTITUDE MODE

From the start of reversionary attitude mode, the IRU continuously tests for the AIM entry conditions, and when met, preempts the stationary alignment mode and switches to the align in motion mode. The AIM operates in conjunction with the AIM attitude mode. This mode provides significantly improved attitude and heading performance. The GPS-based AIM attitudes are continuously compared with the reversionary mode attitudes to ensure the integrity of the Micro IRU attitudes. When a miscompare is detected, the Micro IRU automatically reverts to the reversionary attitude mode.

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End of Flight

This mode is performed in conjunction with the navigation mode. The Micro IRUs automatically enter this mode after a flight when the aircraft has been motionless for 5 to 15 seconds.

The end of flight mode stores navigation performance records, autocal data, and other miscellaneous information after each flight. Data considered important in repairing the IRUs are stored in a nonvolatile memory at the end of flight. End of flight mode requirements are performed while the Micro IRUs are either in navigation or attitude mode.

The inertial reference system takes less than 5 seconds to perform the functions of the end of flight mode. Power is removed from the unit at any time without risk of record corruption.

ABNORMAL OPERATION

The IRS has been designed such that in the event of a normal aircraft power interrupt or power transient, no degradation in performance occurs due to switching or operating from the backup power source. The two Micro IRUs receive power from different primary and secondary power sources. When one Micro IRU loses power, the other Micro IRU continues to operate because the primary and secondary power sources are different.

In the unlikely event that both Micro IRUs fail or lose power concurrently, a CAS message is annunciated indicating the Micro IRUs have failed, and they must rely on other navigation instruments and systems.

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Micro Inertial Reference System Aircraft Personality Module (APM)

The Micro IRS APM, shown in Figure 15-4, is programmed to contain configuration and installation data.

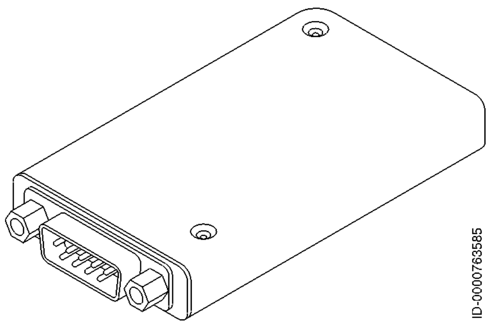

Figure 15-4
Micro IRS Aircraft Personality Module

Information contained in the APM file includes the following:

- Aircraft type/serial number/SDI
- Program MAGVAR select
- Program dedicated IRU battery select
- Mount misalignment Euler angles
- Output filter characteristics
- Other A/C specific data.

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Inertial Reference System (IRS) Reversion

The primary source for the pilot PFD is IRS1, and the copilot is IRS2. Source reversion is done by pushing the **IRS** button on the on-side REVERSIONARY PANEL, shown in Figure 15-5. The button lights, indicating that the button is in the non-normal position for flight.

Figure 15-5
IRS REVERSIONARY PANEL

The left side reversionary panel manually switches the IRS source from IRS1 to IRS2 or back to IRS1. The right side reversionary panel manually switches the IRS source from IRS2 to IRS1 and back to IRS2. The reversion is annunciated on the top left side of the ADI.

Attitude Source Annunciator – The attitude reference source is not annunciated when it is the normal on-side source for that PFD indicator. When the reversionary panel changes the source, so the pilot and copilot are using the same attitude source, the annunciator is displayed on both PFDs in amber. For example, when IRS1 is selected as the attitude source using the right side reversionary panel, IRS1 is displayed to the upper left of the attitude sphere on both PFDs.

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NOTE: Manual reversion to a failed IRS is not possible.

If the selected IRS fails, the cross-side IRS is automatically selected.

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16. Global Positioning System (GPS)

INTRODUCTION

This section describes the operation and components of the global positioning system (GPS).

The GPS is a satellite-based navigation system offering greater accuracy and reliability than conventional means of navigation. Greater global coverage and accessibility are also provided.

The GPS consists of one receiver (two receivers are an option) and one antenna (two antennas are an option). The GPS operates continuously and updates the flight management system (FMS) position. The GPS receiver is contained in the modular radio cabinet (MRC) as part of the VIDL-G radio. The GPS sensor module calculates and sends the following types of data:

- Navigation data
- Satellite measurement data
- Receiver autonomous integrity monitoring (RAIM) data
- Predictive RAIM (PRAIM) data.

The GPS module also performs the following functions:

- Manages the sign status matrix (SSM)
- Manages satellite status
- Does built-in test equipment (BITE) functions
- Does dataloader functions
- Transmits custom data.

The GPS module has a maximum of 24 channels, each capable of tracking NAVSTAR GPS satellite signals. The GPS module computes a pseudo-range to the satellites by timing the arrival of the GPS signal. The GPS module then uses the pseudo-range to compute the internal clock offset and a three dimensional position fix. From this data, the module creates position, velocity, time, and integrity parameters that are sent to the FMS and IRS.

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The GPS module also receives data from satellite-based augmentation system (SBAS), which can improve the accuracy. SBAS corrections are used to provide improved performance during RNAV operations and enables localizer performance with vertical guidance (LPV) approaches. In addition, the GPS module can also receive data from VHF data broadcast (VDB) for ground-based augmentation system (GBAS) to provide improved position accuracy and guidance for GBAS landing system (GLS) approaches.

The performance of both GPSs is monitored (GPS 1 STATUS 1/2 , GPS 1 STATUS 2/2 , GPS 2 STATUS 1/2 , GPS 2 STATUS 2/2) by selecting the MCDU NAV menu button and selecting the POS SENSORS prompt. The GPS 1 STATUS 1/2 page is shown in Figure 16-1. This is useful in extended over-water operations.

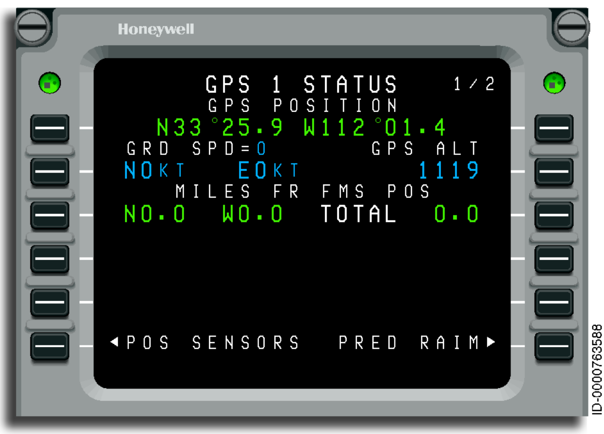

Figure 16-1
GPS 1 STATUS 1/2

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The **GPS 1 STATUS 2/2** page is shown in Figure 16-2.

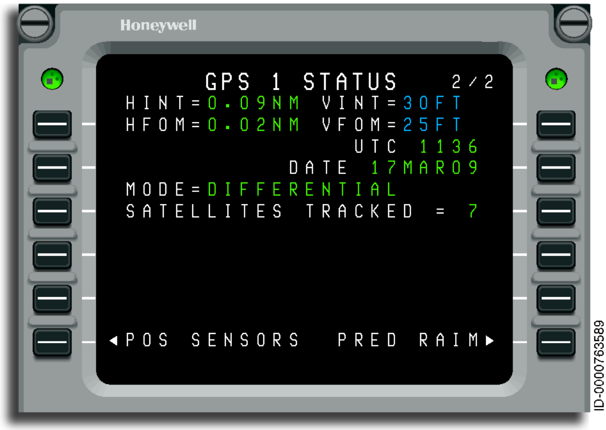

Figure 16-2
GPS 1 STATUS 2/2

RECEIVER AUTONOMOUS INTEGRITY MONITORING (RAIM)

The GPS module executes a receiver autonomous integrity monitoring (RAIM) algorithm to ensure the integrity of the data transmitted by the satellite. RAIM is a software function supplying a timely alert to system users that the GPS module outputs cannot be used for navigation for integrity reasons. The GPS has a continuous integrity level (limit) to the FMS that determines when the GPS navigation data is used for the current phase of flight. The GPS RAIM function also detects satellite failures. The function isolates and removes failed satellites when tracking a sufficient number of satellites for measurement redundancy.

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In addition to current RAIM conditions, the GPS receiver also supplies RAIM predictions that calculate whether the satellite geometry is acceptable for approach at the expected destination at the estimated time of arrival (ETA). Predictive RAIM uses an almanac function that is updated when the GPS is tracking satellites. The GPS supplies horizontal integrity limit (HINT) predictions for a requested time/position and vertical integrity limit (VINT) predictions for the approach area on a continuous basis. Line 3L shows the computed destination RAIM. Line 3R shows the computed pilot select RAIM, as shown in Figure 16-3. If no value is available, the line is blank. RAIM is displayed as YES when horizontal integrity limit is 0.3 or smaller; otherwise, RAIM is displayed as NO.

Figure 16-3 shows the **PREDICTIVE RAIM** page.

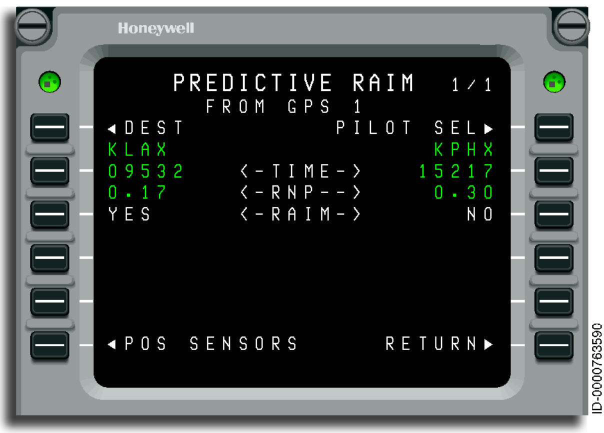

Figure 16-3
PREDICTIVE RAIM

Each GPS sensor not only outputs HINT/VINT but also horizontal and vertical figure-of-merit (HFOM/VFOM), which are shown on the GPS STATUS MCDU page in Figure 16-2.

Figure-of-merit consists of horizontal FOM and vertical FOM. FOM provides an accuracy level estimate and must have a minimum 95 percent confidence level. The FOM is required to be under 2 NM en route. The FOM is displayed on line 1L of the GPS STATUS page. If the FOM is invalid, the line is blank.

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OPERATION

The operation of the GPS consists of the following modes.

GPS Operating Modes

The GPS has the following nine operating modes:

- Self–test
- Initialization
- Acquisition
- Navigation
- Aided
- Fault
- Altitude aiding
- GBAS
- SBAS.

SELF-TEST MODE

The GPS is in the self–test mode for a maximum of 5 seconds from when power is received until all internal power-up built–in tests (BITs) are completed. When the initialization is completed, the GPS enters the self-test mode or the fault mode.

INITIALIZATION MODE

The GPS enters initialization mode immediately after power-up.

ACQUISITION MODE

The GPS enters the acquisition mode to acquire satellites. The GPS enters the acquisition mode from the initialization mode or other modes such as NAV or aided.

The GPS acquires satellites based on the information available when entering the acquisition mode. To acquire satellites, the GPS uses the following data:

- **Almanac Data** – Almanac data determines the coarse satellite orbits. The GPS stores almanac data in nonvolatile memory, not requiring an internal or external battery for operational support.

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- **Time** – Time is used with almanac data to estimate the present position of the satellites and orbits.
- **GPS Location** – The approximate GPS location helps predict which satellites are visible.

When the GPS has the necessary information to acquire satellites, the system predicts which satellites are visible and then acquires those satellite signals. The GPS collects satellite predicted orbital data by decoding the satellite downlink data message. When each satellite is acquired, the GPS begins to transmit the satellite measurement data for that satellite. When the GPS is tracking at least five satellites, the GPS computes position and velocity and enters the NAV mode.

When the GPS does not have almanac and/or initialization data, a Search the Skies acquisition is done. To do this, the GPS tries to acquire all of the satellites in the GPS constellation. When the first satellite is acquired, the GPS decodes the satellite orbital data from a downlink message. When five satellites are acquired, the GPS enters the navigation mode. Without valid initialization data, the time-to-first-fix (TTFF) of a satellite is less than 10 minutes. With initialization and almanac data available, the TTFF of a satellite is less than 75 seconds.

NAVIGATION (NAV) MODE

The GPS enters the NAV mode when a navigation solution is computed containing position, velocity, and time measurements. The GPS enters the NAV mode from the acquisition mode, aided mode, or altitude aided mode. NAV mode has three possible submodes, autonomous navigation, SBAS, and GBAS.

NOTE: The FMS does not accept GPS data based on inputs from fewer than five satellites.

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AIDED MODE

The GPS enters the aided mode when less than four satellites are available. As in the NAV mode, the FMS does not use GPS data in computing a blended navigation solution unless five satellites are available to compute RAIM. The pilot can access a GPS-computed latitude/longitude from a minimum of three satellites by selecting the **POS SENSOR** from the FMS NAV menu, but this information is only useful to compare with IRU positions for dead reckoning navigation.

The aided mode uses inertial velocities to extrapolate the navigation solution and integrity monitoring during extended periods of insufficient satellite coverage and geometry.

The GPS enters the aided mode and altitude aiding mode only when insufficient satellites are tracked to remain in the NAV mode.

FAULT MODE

The GPS enters the fault mode when the outputs are affected by one or more critical system faults. This mode supersedes all other modes of operation and remains active until the next power-up cycle.

ALTITUDE AIDING MODE

When satellite measurements are not sufficient for the GPS sensors to maintain integrity or remain in navigation mode but are sufficient when altitude information is available, the GPS is in altitude aiding mode. This mode uses external altitude information to aid the navigation solution and integrity monitoring during extended periods of insufficient satellite coverage and geometry. The GPS enters the altitude aiding mode only after the pressure altitude has been calibrated with a geometric altitude solution using the GPS with sufficient integrity. When the calibrated pressure altitude standard deviation estimate is out of limits, the GPS reverts to the aided mode. The altitude aiding mode is entered from the navigation mode or aided mode and exits to the navigation, aided, or fault modes.

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17. Radar Altimeter System

INTRODUCTION

This section describes the operation, components, and displays of the radar altimeter system.

The purpose of the radar altimeter is to measure the absolute height of the aircraft above the terrain. This is done by transmitting a frequency modulated continuous wave signal to the ground and processing the received signal into a period proportional to range.

By the time the transmitted signal has been reflected from the terrain and back to the receive antenna, the transmitter has shifted to a new frequency; therefore, when the instantaneous transmitted signal is mixed with the delayed received signal, an intermediate frequency is produced, which is directly proportional to the time delay for the round trip. The intermediate frequency is processed to produce a period proportional to the altitude. This is used to generate the digital output for display and for other systems.

In a dual installation, the radar altimeter is wired with a strap that changes the modulation rate from 100 to 105 Hz.

The radar altimeter receive and transmit antennas are designed to function between 4.2 and 4.4 GHz. In a single radar altimeter system installation, the same radio altitude displays height above the ground (AGL) on the two primary flight displays (PFDs) as a digital readout. In a dual radar altimeter system installation, the pilot's PFD shows the system 1 radio altitude, and the copilot's PFD shows the system 2 radio altitude.

The radar altimeter can monitor absolute altitude up to 2,500 feet.

The radar altimeter displays include a digital readout on the attitude director indicator (ADI) sphere and a ground proximity warning display on the altitude tape. The radar altimeter includes a subsystem that calculates and shows decision height digital readouts, indicators, and annunciators.

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RADAR ALTIMETER INFORMATION DISPLAY

The radar altimeter system is a continuous service system that supplies the pilots with absolute altitude from -20 to +2,500 feet AGL during the approach and landing phases of aircraft operation.

The radio altitude readout (RALT) is located in a cutout box near the lower-right corner of the altitude display, as shown in Figure 17-1. The radio altitude readout shows only when the radio altitude is valid or in test. At radio altitudes above 2,500 feet, the cutout box and digits are removed.

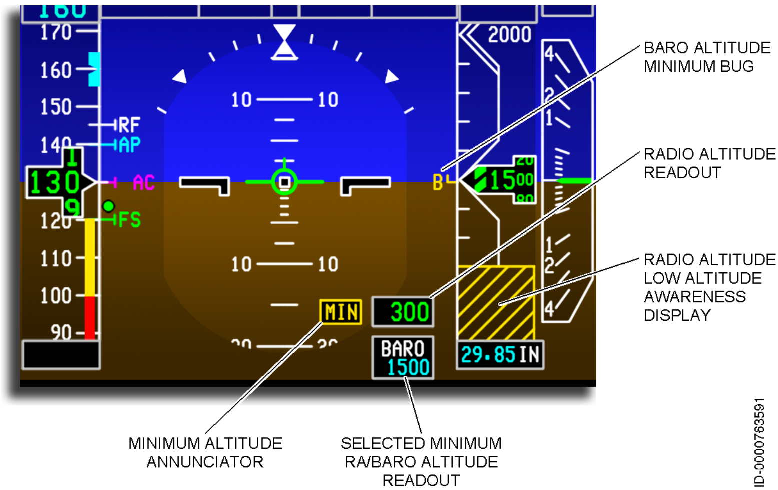

Figure 17-1
Radio Altitude Displays on the PFD

For single RALT installation, the two PFDs show the same valid RALT data in green. If the radar altimeter fails, the cutout box and readout are removed from both displays. A failure annunciator (-RA-) is shown, and a crew alerting system (CAS) message indicating the RALT has failed is generated.

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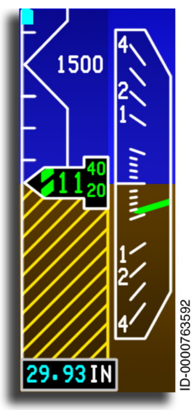
For a dual RALT installation, RALT 1 supplies data to the pilot PFD, and RALT 2 supplies data to copilot PFD. When both PFDs receive valid data from the normal RALT, RALT data is shown in green. When one RALT fails while the other is operable for more than 5 seconds, a CAS message is generated for the invalid RALT, and the valid RALT becomes the source for the associated PFD. In this condition, the RALT readout for both PFDs changes to amber. When both RALTs fail, -RA- is shown, and CAS messages indicating both RALTs have failed are generated.

The RALT readout resolution is as follows:

- Five feet when the RALT is less than 200 feet
- Ten feet when the RALT is between 200 and 1,500 feet
- Fifty feet when the RALT is over 1,500 feet.



Radio Altitude Low Altitude Awareness Display – The radio altitude low altitude awareness indicates the ground proximity using a brown and yellow hatched shading is shown on the lower portion of the altitude tape. When the radio altitude is less than +550 feet, the lower half of the altitude tape shading begins to change, and the brown and yellow hatched shading displays. The lower half of the altitude tape changes linearly for radio altitudes between zero and +550 feet.

Radio altitude low altitude awareness uses radio altitude data from the same radar altimeter that is sending data to the PFD radio altitude readout. If there is a failure in the system, the low altitude awareness indications are removed.

Radio Altitude Approach Minimums – The pilot can select barometric or RA minimum altitudes using the two-position RA/BARO switch that is part of the MINIMUMS knob on the guidance panel. When the switch is in the RA position and the MINIMUMS knob is rotated, the RA cutout box shows the selected RA with cyan digits below.

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When the RA minimums is not displayed, and the RA/BARO switch is in the RA position, rotating the MINIMUMS knob one click in either direction displays the RA minimums annunciation.

The following are two adjustment rates for the RA MIN value:

- **Slow** – Increases or decreases the RA value by 1 foot per knob click.
- **Fast** – Increases or decreases the RA value by 10 feet per knob click.

When the current RA MIN value reaches the maximum of 990, additional clockwise turns show OFF . At this time, the knob is used to decrease the value. If OFF stays in view for 5 seconds (that is, an RA MIN of 990 or less is not selected), the display RA MIN box and readout are removed from the display. The same is true at the lower end when the RA value is 0, and additional decreasing of the value is attempted.

When the radio altitude is equal to or less than the approach minimum set value, MIN (in an amber box) is displayed next to the RA set value and the radio altitude display.

NOTE: The MIN *annunciator is inhibited on the ground and during climb-out until the aircraft is more than 50 feet above the minimums set value.*

When APPR 1 ONLY or APPR 2 ONLY are displayed (in amber), or NO AUTOLAND is displayed (in red) in the flight mode annunciator armed status field, the decision height (BARO or RA) on the two PFDs flashes in amber reverse video for 5 seconds and then shows in steady amber.

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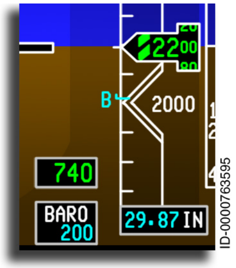

BARO Approach Minimums – The BARO altitude minimums display is located in the lower-right corner of the attitude sphere. When the barometric altitude is within 50 feet of the set value, a black box is displayed. The box contains the label BARO and the set altitude value in cyan. The value is set using the PFD Controller MINIMUMS control when the RA/BARO switch is set to the BARO position. The BARO minimums operates the same way as the RA minimums when at the maximum and minimum values. If the maximum (16,000) or minimum (0) is exceeded, OFF is annunciated for 5 seconds, then the box, readout, and label are removed from the display.

When the BARO minimums is not displayed, and the RA/BARO switch is in the BARO position, rotating the MINIMUMS knob one click in either direction displays the BARO minimums annunciation.

The two rates of adjustment are as follows:

- **Slow** – Increases or decreases the BARO MIN value by 10 feet per knob click.
- **Fast** – Increases or decreases the BARO MIN value by 200 feet per knob click.

On takeoff, the MDA annunciator is inhibited. The display is removed if the value is set to less than 10 feet.

The minimums bug is labeled with a cyan B, with a horizontal L that protrudes from the altitude tape left edge. The bug marks the set altitude and is only displayed when the aircraft is within ±550 feet of the current altitude.

When barometric altitude is equal to or less than the approach minimums set value, MIN is displayed in a black box. The minimum altitude bug becomes the same color and with similar action as the minimum altitude annunciator (MIN), with the MIN annunciator in view.

The minimum altitude bug is removed from the display when a minimum altitude value is not displayed.

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Radio Altitude Self-Test

A pilot-initiated self-test is selected on the MCDU, as shown in Figure 17-2, for the radar altimeter operational check. The self-test can only be accomplished when the aircraft is on the ground. When the test is run, the results are as follows:

- Under normal operation, the self-test generates a radio altitude of 50 ± 5 feet
- When 100 feet is displayed, the system receiver/transmitter unit has failed
- When 200 feet is displayed, the CM 2000 configuration module has failed.

Figure 17-2
MCDU TEST Page With Radio Altitude Self-Test

Radio Altitude System Failure and Miscompare

With a single radar altimeter system installation, when there is a failure of the system, -RA- is displayed in place of the radio altitude digital readout.

With a dual radar altimeter system installation, when a failure occurs in one of the radar altimeters, the remaining operational radar altimeter supplies data to the two PFDs. The radio altitude digital readout on the PFDs is displayed in amber instead of green.

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When the altitudes from the two radar altimeters in a dual configuration do not agree, a miscompare occurs, and **RA** is annunciated on the ADI sphere above the radio altitude digital readout.

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18. Weather Radar Systems

INTRODUCTION

The Primus 880 and RDR-4000 (option) weather radar systems are lightweight, X-band digital radars designed for weather detection and ground mapping.

The primary purpose of the systems is to detect storms along the flight path and give the crew a visual color indication of rainfall intensity and turbulence content. The RDR-4000 (discussed later in this section) also provides predictive windshear display and alerting.

WEATHER RADAR OVERVIEW

The following paragraphs provide an overview of common functionality between the Primus 880 and RDR-4000 weather radar systems.

Radar Displays

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Weather radar returns are displayed on the on-side horizontal situation indicator (HSI) in arc mode, as shown in Figure 18-1, using the **WX** button on the display controller section of the guidance panel. Pushing the **WX** button toggles the weather radar overlay on and off.

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Figure 18-1
HSI Arc With Weather Radar Displayed

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Weather radar is displayed on the MFD map by selecting the Map menu dropdown and then selecting the Weather radio button, as shown in Figure 18-2.

NOTE: Weather and SA Terrain selections on the Map menu dropdown are mutually exclusive.

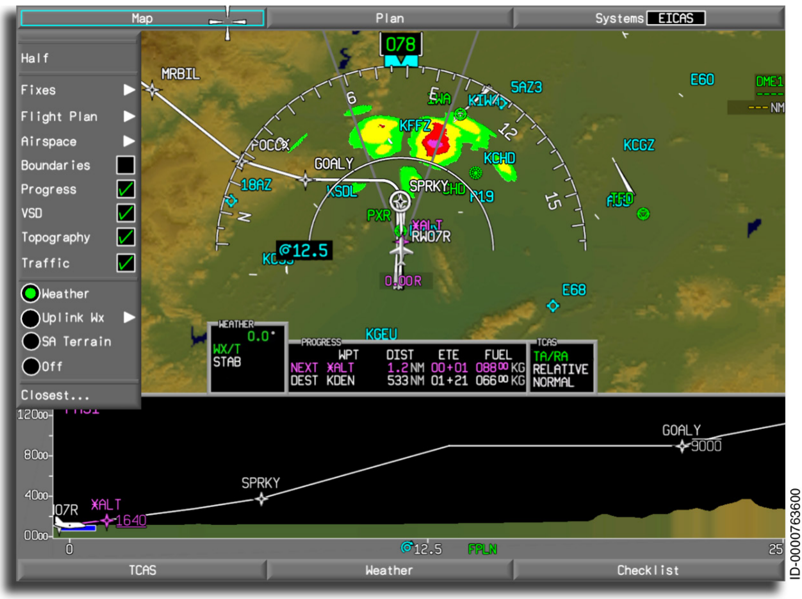

Figure 18-2
MFD Map Title Button Dropdown Menu

The weather radar configuration uses dual controllers. When dual controllers are used, and neither is turned off, weather radar displays are controlled by the on-side controller. When one controller is turned off, the radar displays are controlled by the active controller.

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Range Control

When the Map page is displayed, and the on-side CCD has selected the MFD, the cyan knob prompt is displayed at the range value. The map and weather range are controlled by the outer concentric knob on the CCD, shown in Figure 18-3. The range selections for the Primus 880 are 10, 25, 50, 100, 200, and 300 NM (full scale). Clockwise rotation increases the range, and counterclockwise rotation decreases the range. The number below the MFD inner-range ring is the half-range of the selected value (i.e., 50).

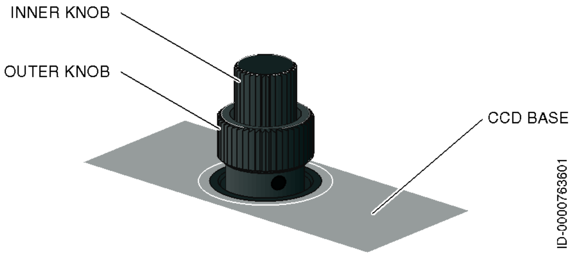

Figure 18-3
Outer Knob Range Control on CCD

The range selections for RDR-4000 are 5, 10, 25, 50, 100, 300, 500, 1,000, and 2,000 NM (full scale). Clockwise rotation increases the range, and counterclockwise rotation decreases the range. The number below the MFD inner-range ring is the half-range of the selected value (i.e., 50).

The MFD and HSI range scales are synchronized, so they always display the same range. The HSI cannot have a range independent of the MFD. In order to change the range on the HSI, the pilot must change the range on the MFD.

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Mode Annunciator Box

The mode annunciator box is displayed on both the MFD and PFD to indicate the various modes of the weather radar. The MFD mode box is located on the left side of the display above the WX menu under the WEATHER header, as shown in Figure 18-4.

Figure 18-4
MFD Mode Annunciator Box

The PFD mode annunciator box is displayed at the bottom right of the HSI, as shown in Figure 18-5.

Figure 18-5
PFD Weather Annunciator Locations

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Slave Mode Annunciator

The SLAVE annunciator is displayed when the on-side controller or control process has failed. The annunciator shows that the on-side is a slave to the other side. The SLAVE annunciator displays in the HSI of the on-side PFD, as shown in Figure 18-6.

Figure 18-6
Slave Annunciator

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PRIMUS 880 WEATHER RADAR

The Primus 880 Weather Radar is a lightweight X-band digital color radar designed for weather detection, analysis, and ground mapping. This radar uses a magnetron with a 10 kW nominal power output. The system consists of the following:

- WU-880 integrated receiver/transmitter/antenna (RTA) unit
- Two virtual weather radar controllers.

The RTA is mounted in the nose of the aircraft and uses a 24-inch antenna.

Weather data can be displayed on any of the four displays and gives the appearance of having multiple radar systems on the aircraft when in fact, there is only one. The radar on the pilot's PFD and MFD are tied together, and the radar on the copilot's PFD and MFD are tied together. This allows the pilot and copilot to select independent ranges on their respective display.

The WX system shows two different radar pictures with separate and independent detail on each (this means the pilot's MFD can, for example, show weather at 100 NM, while the copilot's MFD can show weather at 25 NM).

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Weather Radar Important Concepts

One of the most important aspects of weather radar is understanding the antenna beamwidth. To make a proper interpretation of what is being seen on the display, it must be understood what the radar beam **is seeing**. Figure 18-7 shows a side view of the radar beam with a storm depicted at a distance that causes the size of the storm to just fill the 3 dB beamwidth. The points on either side of the beam where the antenna gain is down 3 dB (50%) relative to the maximum gain defines the 3 dB beamwidth. The cone formed by the 3-dB beamwidth is where most of the radar energy is concentrated, and this is considered the weather beamwidth. It is 4.2 degrees for a 24-inch antenna.

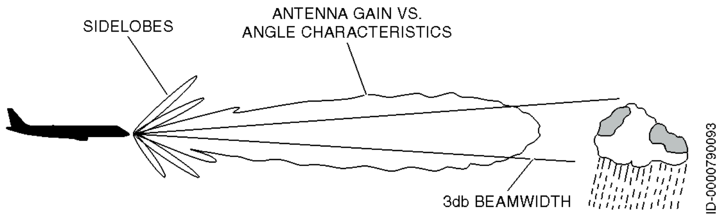

Figure 18-7
Beamwidth and Ground Return Detection

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Figure 18-7 shows that there is also energy beyond the 3-dB points. Unfortunately, reflections from ground clutter (ground, cities, buildings, highways, bridges, and mountainous terrain) reflect energy extremely well and can show up outside of the weather beamwidth. This is called ground beamwidth and is 7.44° for a 24-inch antenna installed on the Embraer E-Jet E-2 E190/E195-E2 series aircraft. Figure 18-8 shows an end and side view with weather and ground beamwidths.

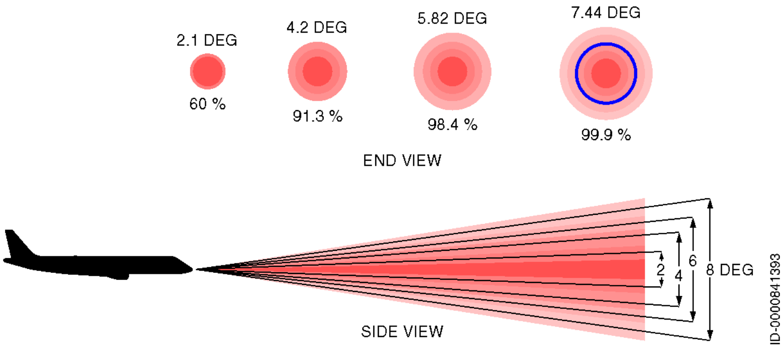

Figure 18-8
Weather and Ground Beamwidths

Table 18-1 lists the weather and ground beamwidths for a 24-inch antenna. At 80 NM, the weather beamwidth is over 5 NM in diameter, and the ground beamwidth is over 9 NM in diameter.

Table 18-1
Weather Beamwidth vs. Ground Beamwidth – 24-Inch Antenna

	Beam Size (in feet)	
Range Selected (in NM)	**Weather Beamwidth 4.2 Degrees**	**Ground Beamwidth 7.44 Degrees**
10	4,200	7,440
20	8,400	14,800
40	16,800	29,760
80	33,600	59,520
160	67,200	119,040
320	134,400	238,080

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To view the maximum reflectivity of a cell, point the most intense (center) part of the beam at the most intense part of the cell, which is normally around the freezing level. However, this will also show a significant amount of ground returns. As a result, proper tilt settings are a compromise between detecting weather while minimizing ground returns. Operation can be broken into detection, analysis, and avoidance. It is best to select a tilt setting that detects all weather but minimizes ground returns. For analysis, it is best to lower the tilt to observe the maximum reflectivity.

Figure 18-9 shows the beamwidth relationship for a 24-inch antenna. For illustrative purposes, the aircraft is shown at approximately 40,000 feet, and the tilt is set at 0°. At 0° tilt setting and 40,000 altitude, the weather beam will intersect the ground at 192 NM and the ground beamwidth at 107 NM.

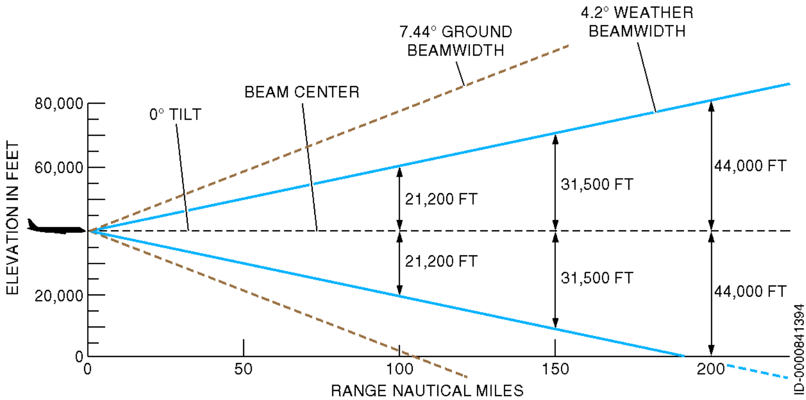

Figure 18-9
Radar Beam Illumination High Altitude – 24-Inch Radiator

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GROUND RETURNS

The amount of ground return depends on several factors, including the incident angle, smoothness or roughness, and dielectric constant (wet/dry), as shown in Figure 18-10. A smooth surface like a field or a calm lake shows little to no returns. Rough surfaces like terrain or a forest canopy scatter energy in all directions providing stronger returns. Strong returns can also be caused by waves in a lake or ocean that are perpendicular to the aircraft.

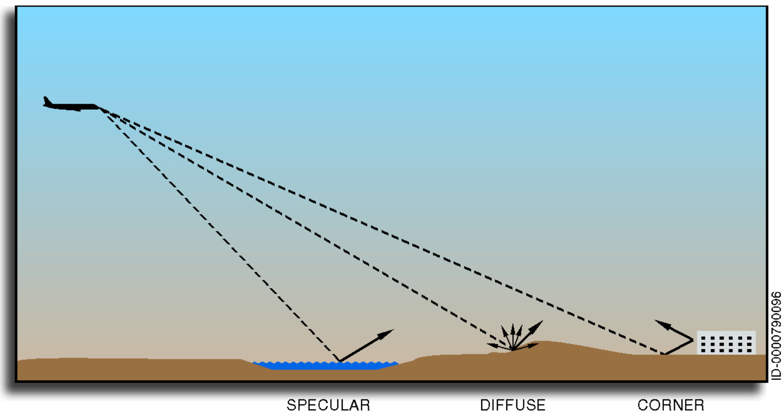

Figure 18-10
Ground Return Factors

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The strongest returns occur from flat objects at shallower angles. Mountains and cities with tall buildings provide significant radar returns, as shown in Figure 18-11. Fortunately, buildings and most mountains are not that tall and can be identified in several ways. Because of the sharp angle and strong reflectivity of the returns, mountains and cities show up as very hard, sharp-edged returns in contrast to the weather cells. Also, weather cells tend to be much taller and will continue to be displayed as the tilt is raised while ground clutter disappears.

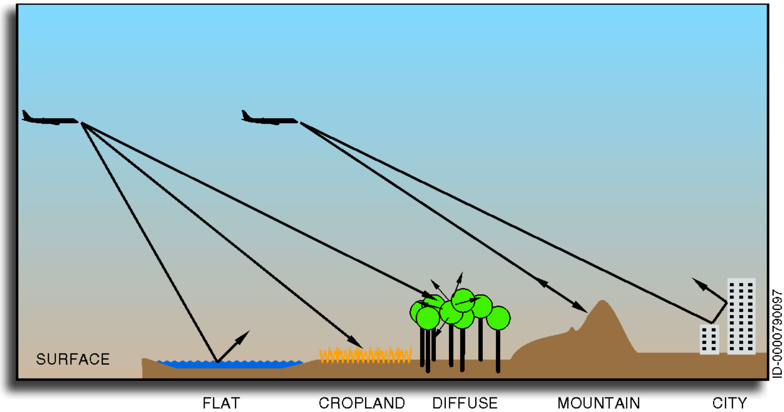

Figure 18-11
Ground Returns From Various Surfaces

One good rule of thumb for knowing how much to raise or lower the beam in feet is that 1-degree in feet at any range is found by adding two zeros to the range. For example, raising the beam 1 degree at 40 NM is 40+00 or 4,000 feet. Also, using MAP mode and tilting down to look for areas of stronger returns and/or shadows can help identify strong ground returns that might be perceived as weather. Large mountains also show a shadow behind them because they have reflected all of the energy back to the radar.

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An example of ground returns (or ground clutter) is shown in Figure 18-12 on a generic display. In this example, cities and mountains are displayed as ground clutter. The mountain shown in this example is located forward of the radar shadow, and a radar shadow behind the mountain is being caused by attenuation. Also shown in this example are the ground returns of cities. Notice how there is no radar shadow shown as a result of ground return from cities.

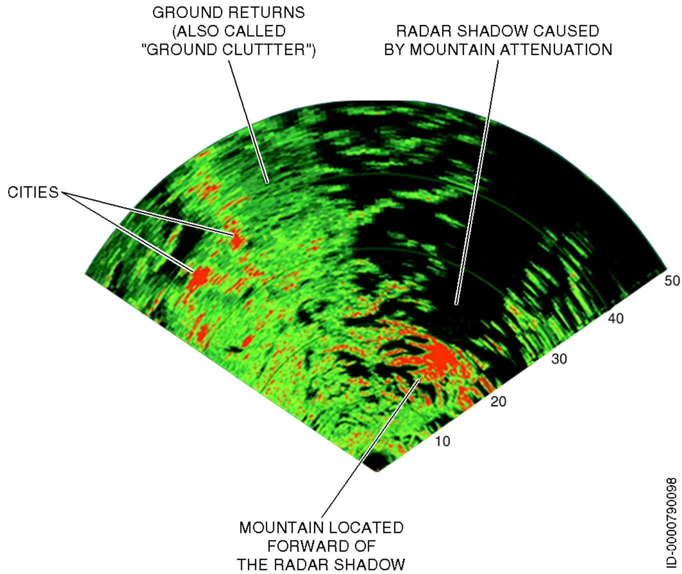

Figure 18-12
Ground Returns

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Another example of a generic aircraft type display of ground returns is shown in Figure 18-13. In this example, a city is shown without a radar shadow behind it, and a thunderstorm is shown with a radar shadow behind it.

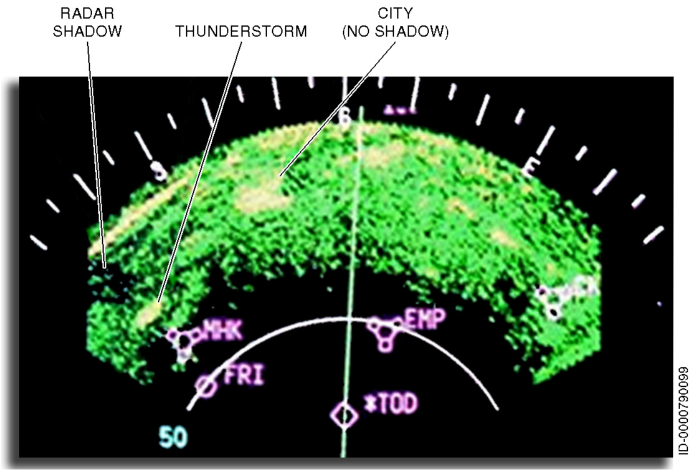

Figure 18-13
Thunderstorm and Radar Shadow

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Primus 880 Radar Controller

The Primus 880 radar is controlled from the **Weather** menu on the MFD map, as shown in Figure 18-14.

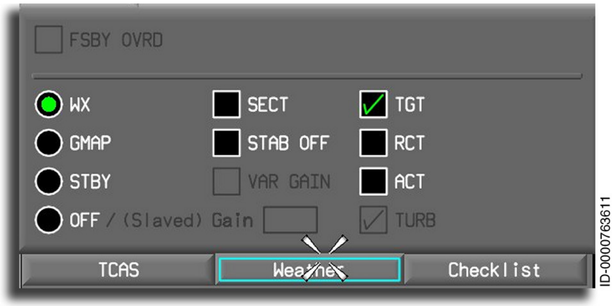
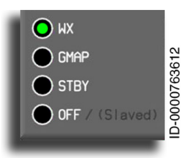


Figure 18-14
Primus 880 Weather Radar Controller

The following paragraphs describe the components of the Primus 880 weather radar controller.



WX – When the pilot selects the WX radio button, the weather mode is activated. In the weather mode, the system is fully operational, and WX is displayed in the mode field.

If WX is selected before the initial RTA warm-up period is over, WAIT is displayed in the mode field. In the wait mode, the transmitter and antenna scan are inhibited, and the display memory is erased. When the warm-up is complete, the system automatically switches to the weather mode.

When both pilots have selected the WX mode, the left to right sweep of the RTA displays weather detection based on the selections made by the pilot-side WX controller. The right to left sweep display is based on settings made on the copilot WX controller. A slaved condition exists, defined under the sector (SECT) section in the following paragraphs, when one pilot has WX selected, and the other has OFF selected. In this configuration, the WX controller with WX selected controls the display and both sweeps of the RTA.

WARNING: Weather type targets are not calibrated when the radar is in the GMAP mode. Because of this, do not use the GMAP mode for weather detection.

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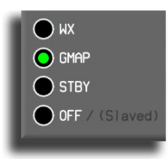
In weather mode, storm intensity levels are displayed in bright colors contrasted against a brown background or a terrain background when SVS is selected ON. Areas of **intense to extreme rainfall** are displayed in magenta, **strong to very strong rainfall** in red, **moderate rainfall** in yellow, **weak rainfall** in green, and little or no rainfall in the background color. Table 18-2 lists the storm intensity colors and associated rainfall rates for Primus 880 installations while in calibrated gain mode.

Table 18-2
Primus-880 Rainfall Rate Color – Calibrated Gain

Color	Rainfall Rate (inches/hour)	Rainfall Rate (mm/hour)
Green	0.04 to 0.16	1 to 4
Yellow	0.16 to 0.47	4 to 12
Red	0.47 to 2	12 to 50
Magenta	> 2	> 50

When weather is selected for display, and video data is lost, the annunciator WX is displayed in the middle of the MFD.



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GMAP – When the GMAP radio button is selected, the radar is placed in the ground mapping mode. In this mode, the system is fully operational, and GMAP is displayed in the mode field.

The ground mapping function optimizes system parameters to improve resolution and enhance the identification of ground targets at short ranges. A reflected signal from ground surfaces is displayed as video levels of increasing reflectivity in the ground map mode. Red is not used as a display color in the ground map mode.

As a constant reminder that the system is in the ground mapping mode, the color scheme changes to cyan, yellow, and magenta. Cyan represents the least reflective return, yellow is a moderate return, and magenta is a strong return.

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When the ground mapping mode is selected before the initial RTA warm-up period is complete, WAIT is displayed in the mode field. When the warm-up period is complete, the system automatically switches to the ground mapping mode. GMAP, when selected on the ground, is in the armed mode. GMAP is active when airborne.

NOTE: RCT cannot be selected when in the ground mapping mode.

Standby (STBY)/Forced Standby (FSBY) – STBY or FSBY is displayed for this menu item when the aircraft is in the air (STBY) or on the ground (FSBY). When this item is selected, the system deselects all other previously-selected modes, and places the system in standby (that is, all selections are dimmed on the weather menu, so that trying to select them has no effect). In STBY, the WX system remains in a ready state with the antenna scan stopped. The antenna is stowed in the tilt-up position, the transmitter is inhibited, the display memory is erased, and STBY is displayed in the mode field. For the system to be completely in standby, both controllers must have the STBY mode selected. If only one controller has STBY selected, the WX RTA is on during one sweep and off during the second sweep.

FSBY is displayed when the weight-on-wheels (WOW) switch indicates the aircraft is on the ground. The RTA is in forced standby mode when the aircraft is on the ground, the transmitter and antenna scan are both inhibited, display memory is erased, and FSBY is displayed in the mode field.

WARNING: Forced standby mode must be verified by the operator to ensure safety for ground personnel.

Overriding the forced standby requires that both pilots select the FSBY OVRD menu item on the respective controllers. This is the only selectable item on the menu. All other items are grayed out to indicate they are not selectable.

The forced standby mode is a safety feature that inhibits the transmitter on the ground to eliminate the X-band microwave radiation hazard.

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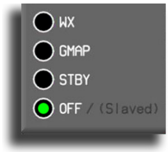

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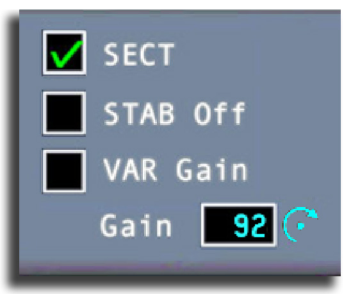
OFF – When OFF is selected on both MFD weather controllers, the WX system is turned off. The system no longer radiates power, and the antenna is stowed. When OFF is selected in the air, all the square function boxes are grayed out to indicate they are not selectable. The circular radio buttons are white to indicate they are selectable.

When one of the pilots has OFF selected, and the other pilot has WX selected, the weather display that is off is slaved to the WX pilot, and the other WX menu selections control the display of weather on both PFD HSI and MFD map/arc displays. In the slaved mode, an S is displayed in the WX mode box, and Slaved is annunciated on the WX controllers next to OFF .

FUNCTION SELECTIONS

The function items with a square box mean any or all of the boxes can be selected at one time. The function selections are described in the following paragraphs.



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Sector (SECT) – The normal radar sweep is ±60 degrees from the nose of the aircraft at a rate of 12 sweeps a minute. When the SECT box is selected (checked), the angle of the sweep is reduced to ±30 degrees, and the rate is increased to 24 sweeps a minute. Removing the check returns the sweep to the normal setting. When one of the pilots selects the reduced angle (that is, the box is checked), the reduced scan applies to both displays.

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Stabilization Off (STAB Off) – When this box is checked, attitude stabilization is off, and when it is unchecked, attitude stabilization is on. When stabilization is on, STAB is displayed. When stabilization is off, the STAB annunciator is removed.

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Variable Gain (VAR Gain) – When the VAR Gain box is not checked, the system is at the normal (calibrated) preset gain, which is recommended for weather avoidance. When this mode is not in use, the Gain box is blank, and no cyan tuning cursor is displayed since gain cannot be manually changed. When calibrated gain is selected, no annunciation is displayed in the mode field.

When the VAR Gain box is checked, the system is in the variable (VAR) gain mode. When variable gain is selected, VAR is displayed in the position of the TGT annunciator in the mode field.

Variable gain is useful for additional weather analysis. In WX mode, variable gain increases receiver sensitivity over the calibrated level to show very weak targets or is reduced below the calibrated level to eliminate weak returns. When the box is checked, Gain annunciates a cyan digital value that is adjusted using the concentric knobs on the CCD.

The system is forced into calibrated gain when RCT or TGT are selected.

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Gain Control – Both map and weather gain values are controlled by the outer concentric knob on the CCD, shown in Figure 18-15. Clockwise (CW) rotation increases gain, and counterclockwise (CCW) rotation decreases gain. The gain value is displayed in the WX mode box in the lower-left corner of the MFD WX display. When TGT or RCT is selected, the weather radar is set to calibrated gain, and VAR Gain and Gain are grayed out.

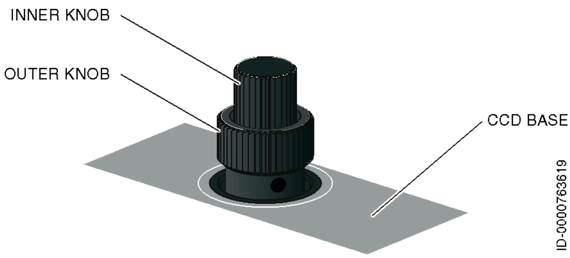

Figure 18-15
Outer Knob Gain Control on CCD

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Target (TGT) – When the TGT box is not checked, the target alert mode is off. When checked, the TGT mode is on, and TGT is displayed in the mode field. Target alert is selectable except in the 300-NM range. When selected, the system monitors beyond the selected range and 7.5 degrees on each side of the aircraft heading. When a return with target alert characteristics (red or magenta) is detected in the monitored area, the target alert annunciator changes from the green (TGT) armed condition to the amber alert condition (TGT). The TGT annunciator flashes, advising the pilot of potentially hazardous targets directly in front of the aircraft outside the selected range. When an amber alert is received, the pilot must select longer map range to view the questionable target. (Note that target alert is inactive in the selected range.)

Selecting target alert forces the system to preset gain. Target alert is selectable only in the weather mode, and selection does not affect the cross-side MFD.

To activate the target alert warning, the target must have the depth and range characteristics listed in Table 18-3.

Table 18-3
Target Alert Characteristics

Selected Range (NM)	Target Depth (NM)	Target Range (NM)
5	5	> 5 to 55
10	5	> 10 to 60
25	5	> 25 to 75
50	5	> 50 to 100
100	5	> 100 to 150
200	5	> 200 to 250
300	Inactive	--
FP (Flight Plan)	5	> 5 to 55

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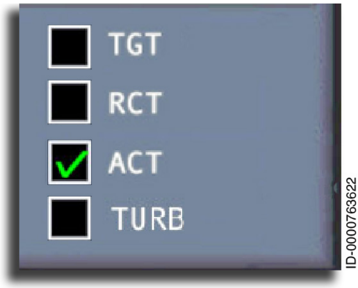
REACT (RCT) – RCT is a submode of the weather detection mode. Selecting RCT puts the system in preset gain, and RCT is displayed in the WX mode fields. The rain echo attenuation compensation technique (REACT) circuitry compensates for attenuation of the radar signal as it passes through rainfall. This is done by increasing the gain of the receiver as weather is detected.

Cyan indicates areas where further compensation is not possible. Any target detected in the cyan field is not calibrated and must be considered dangerous.

The RCT button selects and deselects the cyan field display that indicates the receiver is at maximum gain and the reference levels are at final values. Selecting RCT prevents variable gain from operating.



Altitude Compensated Tilt (ACT) – When this box is checked, the ACT mode is selected. In this mode, the system automatically tilts the RTA in relationship to the current altitude and currently-selected range. The tilt function (inner concentric circle knob on the CCD) is still used by the pilots for fixed offset compensations up to 2 degrees. When active, an A is displayed in the WX mode fields. The digital tilt readout always shows the commanded tilt of the antenna, regardless of the tilt command source (ACT or manual tilt), only affecting the on-side controller.

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CAUTION: Honeywell recommends that operators discontinue the use of the ACT function per Service Information Letter D201806000021 for all Primus 880 Weather Radar systems that have Modification S installed on part number 7021450-801 receiver/transmitter units because there is insufficient tilt range in the ACT mode. The radar antennas beam can skim over the tops of weather cells at high altitudes, which can produce an inaccurate representation of weather conditions ahead of the aircraft. Alternatively, Honeywell recommends that operators only use the manual tilt function when operating the Primus 880 Weather Radar system. If an operator does continue to use the ACT function, it should be done so with caution.

Turbulence (TURB) – When this box is checked, the turbulence detection mode is active. The turbulence mode is available only when the system is in the WX mode and the range is 50 NM or less. Areas of moderate, severe, or extreme turbulence are displayed in soft white. When the turbulence detection mode is selected, WX/T is displayed in the mode field.

CAUTION: Turbulence is only detected within areas of rainfall. The Primus 880 Weather Radar system does not detect clear air turbulence.

WARNING: Undetected turbulence can exist in any storm cell.

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Manual Tilt Control

WARNINGS: 1. To avoid flying under or over storms, frequently select manual tilt to scan above and below the aircraft flight level.

2. Always use manual tilt for weather analysis.

When the Map page is displayed, radar tilt is controlled by the inner concentric knob on the CCD, as shown previously in Figure 18-3, except when ACT is enabled. The TILT knob selects the tilt angle of the antenna beam relative to the horizon. Clockwise rotation tilts the beam upward to +15 degrees, and counterclockwise rotation tilts the beam downward to -15 degrees. The most used range (-5 degrees to +5 degrees of tilt) is expanded for ease of operation.

The following figures show the relationship between tilt angle, flight altitude, and selected range. Figure 18-16 shows the distance above and below aircraft altitude that is lit by the flat-plate radiator during level flight with 0-degrees tilt.

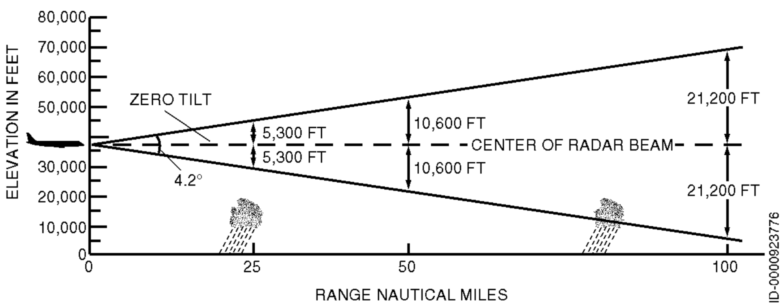

Figure 18-16
Radar Beam Illumination High Altitude

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Figure 18-17 shows a representative low-altitude scan with the antenna adjusted for a 2.8-degree up-tilt.

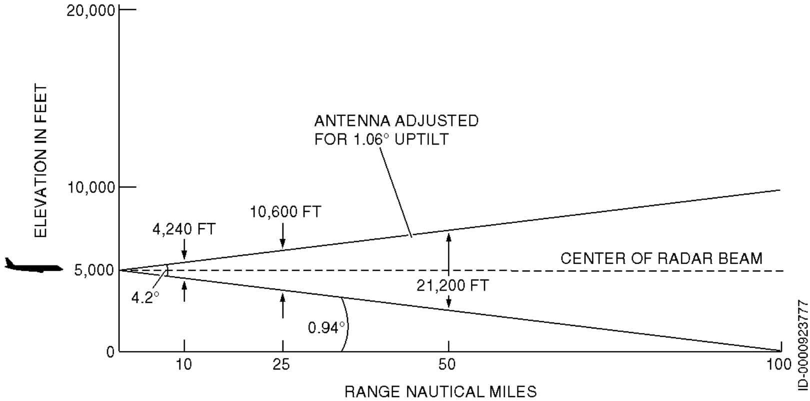

Figure 18-17
Radar Beam Illumination Low Altitude

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Weather Radar Self-Test

WARNING: Output power is radiated in TEST mode.

The Primus 880 Weather Radar system has a self-test mode and a maintenance function. The WX test mode is selected by selecting the WX prompt on the MCDU TEST page, shown in Figure 18-18. The key toggles between ON and OFF with the selected state in larger green font and the unselected state in smaller white font.

Figure 18-18
MCDU TEST Page

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Figure 18-19 shows the MFD test pattern for Primus 880 installations.

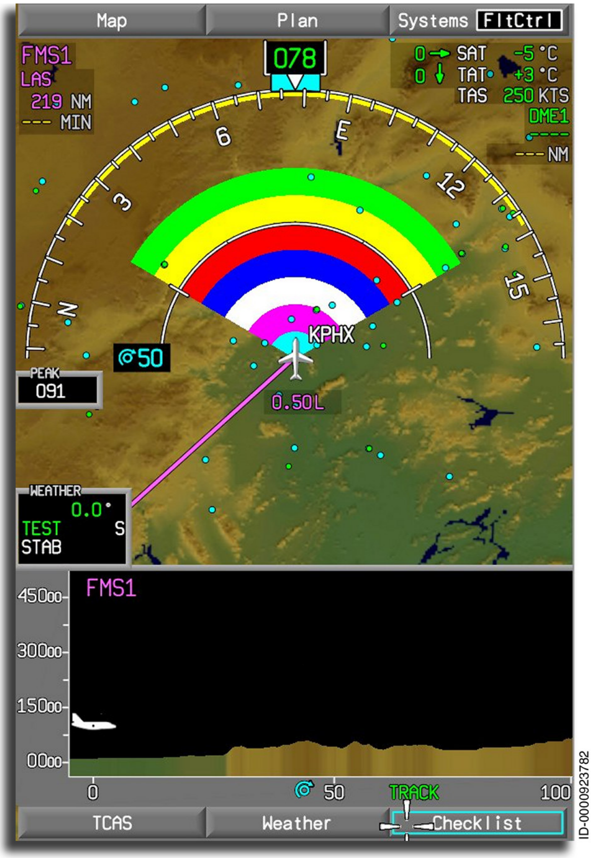

Figure 18-19
Primus 880 MFD Test Pattern

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The test pattern for the HSI is shown in Figure 18-20.

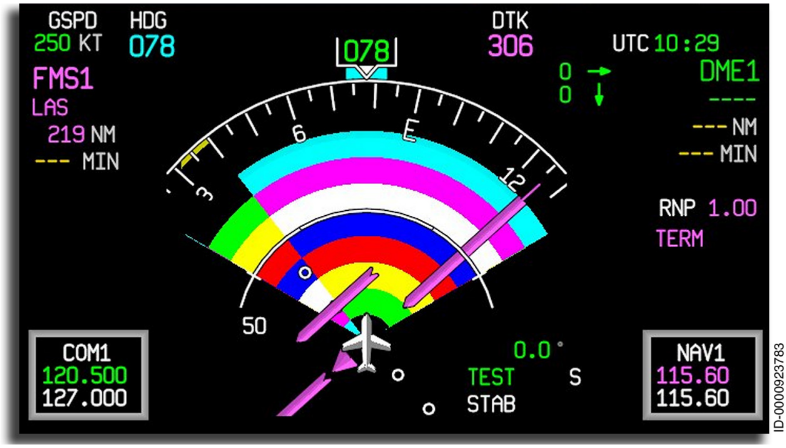

Figure 18-20
Primus 880 HSI Test Pattern

Follow Procedure 18-1 to conduct a complete WX self-test.

Procedure 18-1
Primus 880 WX Self-Test

1. Verify that the test pattern, shown in Figure 18-19, has the following:
   - Half-range mark and alphanumerics are displayed in white.
   - Half-range distance is 50 NM.
2. Use the touchpad on the pilot's CCD to select the **SECT** button on the WX menu. Push the CCD **ENTER** button to reduce the scan from +60 degrees to ±30 degrees.
   - Verify that the change is made to both MFD radar screens.
   - Verify that the sweep rate increases from 12 to 25 scans per minute.
3. Push the CCD **ENTER** button to deselect the **SECT** button.

   Verify that both screens and scans are returned to the ±60 degrees sweep and 12 times per minute scan rate.

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4. Select FSBY (on the ground) or STBY (in the air), or select the **OFF** button on the WX menu to remove the test and weather display from the MFD.

When detected, fault codes are displayed in the Weather mode field. Fault codes are defined in the maintenance manual.

After the self-test is complete, the displays return to the previous range and orientation.

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Antenna Position Indicator (API)

When the weather radar is selected for display and WX, GMAP, or TEST is the current mode, the antenna position indicator (API) is displayed as an indication that the antenna scan is active. A yellow line is drawn just below the outer heading arc, indicating the current antenna position and the limits of the weather radar sector where the weather data is displayed. The line also indicates that the image is being updated, as shown in Figure 18-21.

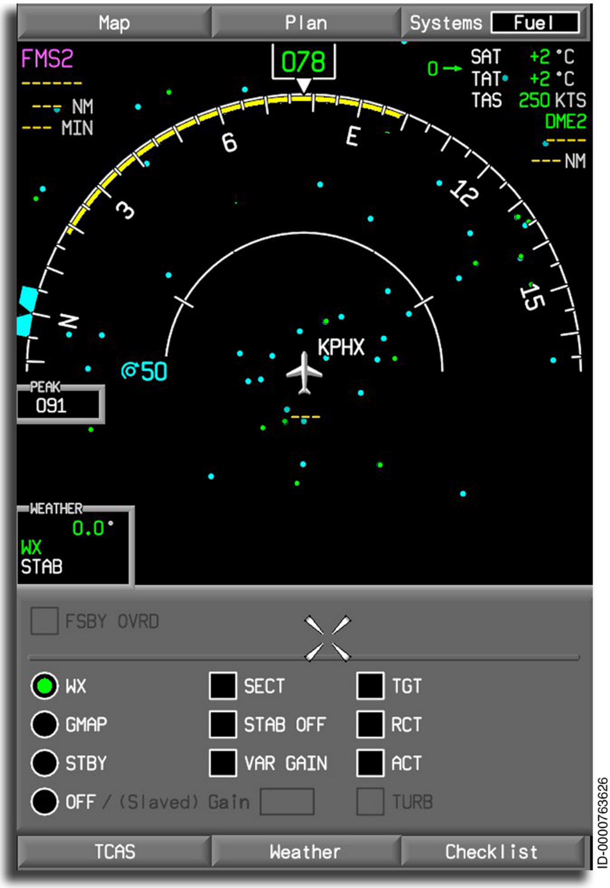

Figure 18-21
API Indicator

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Precautions

If the radar system is to be operated in any mode other than standby while the aircraft is on the ground:

- Direct the nose of aircraft so that the antenna scan sector is free of large metallic objects such as hangars or other aircraft, for a distance of 100 feet (30 meters), and fully tilt the antenna.
- Operating personnel must be familiar with FAA AC 20-68B.

WARNING: Do not operate the radar during aircraft refueling or during refueling operations within 100 feet (30 meters).

WARNING: Do not operate the radar when personnel is standing too close to the 270-degree forward sector of the aircraft.

Power-Up

On power-up, select the standby or test mode. When power is first applied, the radar is in wait mode up to 60 seconds to let the magnetron warm up. Power sequences ON-OFF-ON lasting less than the initial wait period result in a 6-second wait period.

After warm-up, follow the test procedure previously described.

Standby

When STBY (or FSTBY) is selected, the antenna is stowed in a tilt-up position and is not scanning or transmitting. When two controllers are installed, both must be selected to STBY for the system to be in standby.

Standby must be selected whenever the operator wants to keep the system powered on without transmitting.

Radar Mode – Weather

For purposes of weather avoidance, pilots review FAA Advisory Circular AC 00-24B (1-20-83), Subject: THUNDERSTORMS, or comparable EASA document.

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To assist the pilot in categorizing storms as described in the guidance material, the radar receiver gain is calibrated in the WX mode with VAR Gain not selected in the WX menu. The radar is not calibrated when variable gain is being used (that is, VAR Gain selected on the WX menu), but calibration is restored when RCT or target alert is selected.

Radar Mode – Ground Mapping

When the ground mapping mode is selected, the TILT control is turned down until the proper amount of terrain is displayed. The degree of down-tilt depends on the aircraft altitude and the selected range.

RDR-4000 WEATHER RADAR SYSTEM (OPTION)

As an option, the aircraft can be equipped with the RDR-4000 3D Automatic Weather Radar System with forward-looking windshear detection. The RDR-4000 is an airborne, solid-state, X-Band weather radar system. The function of the RDR-4000 is to increase situational awareness by detecting and annunciating hazardous weather conditions such as heavy precipitation, turbulence, lightning, hail, and windshear.

The RDR-4000 has the following functions:

- Automatic weather detection
- Turbulence detection
- Windshear detection
- Ground mapping
- Vertical profile weather display
- Easy weather analysis mode
- Earth curvature correction
- Hazard detection
- Terrain-based ground clutter suppression.

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The RDR-4000 system has automatic weather detection, which refers to the presentation of reflectivity data with no interaction from the pilot other than display range. The auto weather feature replaces some of the traditional manual radar controls (such as tilt) with automatic operation and provides automatic reduction of ground clutter.

In weather mode, the RDR-4000 detects precipitation reflectivity and sends the data to a volumetric buffer that stores data in three dimensions. This 3D volumetric buffer stores weather and terrain data that can be retrieved in either horizontal or vertical slices.

ADDITIONAL RESOURCES: 3D VOLUMETRIC BUFFER

Video

ID-0000787588

For a detailed description of the 3D Volumetric Buffer explained, access the link or scan the QR code for the associated video.

https://youtu.be/ciN7lg9KjXQ

ADDITIONAL RESOURCES: CONSTANT ALTITUDE SLICES

Video

ID-0000787530

For a detailed analysis on using Constant Altitude Slices on the RDR-4000, access the link or scan the QR code for the associated video.

https://youtu.be/XtDtqqW8_zg

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Using the data from the 3D volumetric buffer, the RDR-4000 displays multiple views of the weather data simultaneously and is more accurate due to the reduction of ground clutter. This process is shown in Figure 18-22.

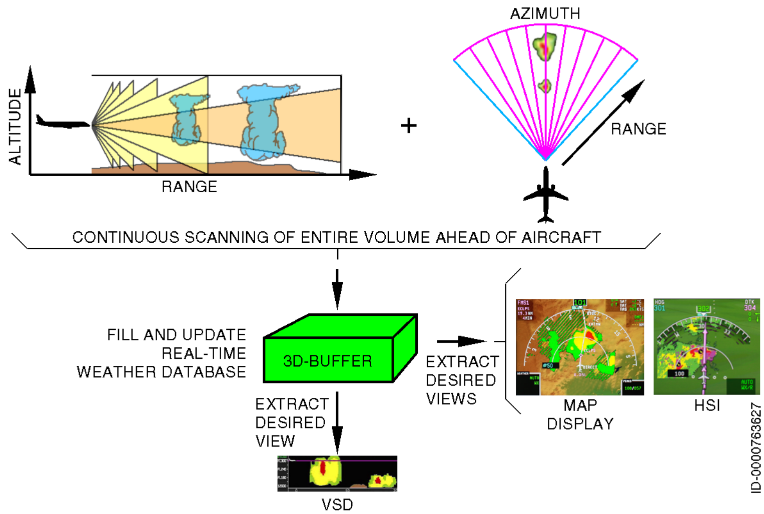

Figure 18-22
RDR-4000 3D Volumetric Buffer

Lateral views of the weather data are viewed on the map and HSI displays and differentiates weather on and off the flight path in different patterns in auto mode (or sections of altitude in manual mode).

Vertical profile views of weather are displayed on the VSD and are along the flight path in auto mode or along a selected azimuth in manual mode.

The RDR-4000 system contains an internal worldwide terrain database. The terrain database enables the RDR-4000 to reduce ground clutter without the significant losses associated with signal-based ground clutter suppression techniques.

NOTE: The 3D volumetric buffer extends from 0 to 60,000 feet in altitude and out to 300 NM in front of the aircraft horizontally. The buffer also contains historical data; once the target passes outside of the 120° sweep, the data is stored for 5 minutes.

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RDR-4000 Weather Radar Controller

The RDR-4000 weather radar controller, shown in Figure 18-23, is displayed on each MFD to allow the pilot to control the RDR-4000 Weather Radar System and modes. The weather controller is displayed by selecting the Weather tab from the MFD.

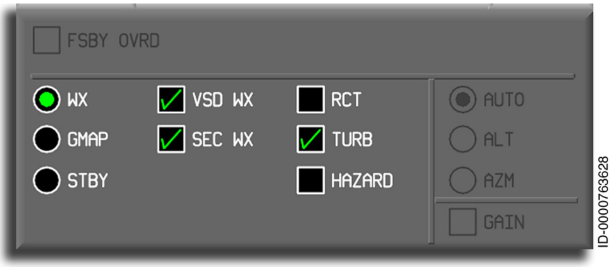
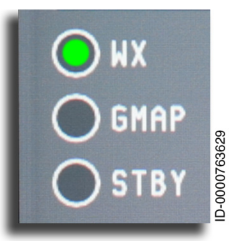


Figure 18-23
RDR-4000 Weather Radar Controller

The following paragraphs describe the components of the RDR-4000 weather radar controller.



WX – Selecting the WX radio button activates the weather mode. In the weather mode, the system is fully operational, and WX is displayed in the mode field. The weather mode can provide weather, turbulence, and predictive windshear (PWS) detection. The system processes the data to fill the 3D buffer and extracts the selected data for display. Returns determined to be ground clutter are not shown.

The RDR-4000 uses a solid-state transmitter, so there is no warm-up period. If WX is selected before the radar is initialized, STBY is displayed in the mode field.

When both pilots have selected weather mode, the radar scans the entire volume in front of the aircraft and produces a three-dimensional buffer that is used to display the weather for both the pilot and copilot. The weather controller for each side determines the weather data displayed for that side.

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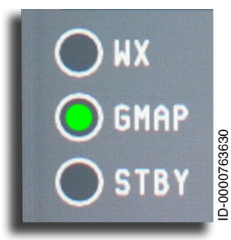
The display correlation to approximate rainfall rate (with Gain set to 0) for RDR-4000 systems is listed in Table 18-4.

Table 18-4
RDR-4000 Reflectivity Color Codes (Gain at 0)

Color	Returns	Reflectivity	Rainfall Rate
Green	Light	20-30 dBz	0.7-4 mm/hr (0.028-0.16 in/hr)
Yellow	Medium	30-40 dBz	4-12 mm/hr (0.16-0.47 in/hr)
Red	Strong	40 dBz or greater	Greater than 12 mm/hr (0.47 in/hr)



GMAP – Selecting the GMAP radio button activates the GMAP mode, which displays ground map data on the lateral map and on the HSI. When GMAP is selected, the display of weather is suppressed. GMAP data presented on HSI is shown in Figure 18-24.

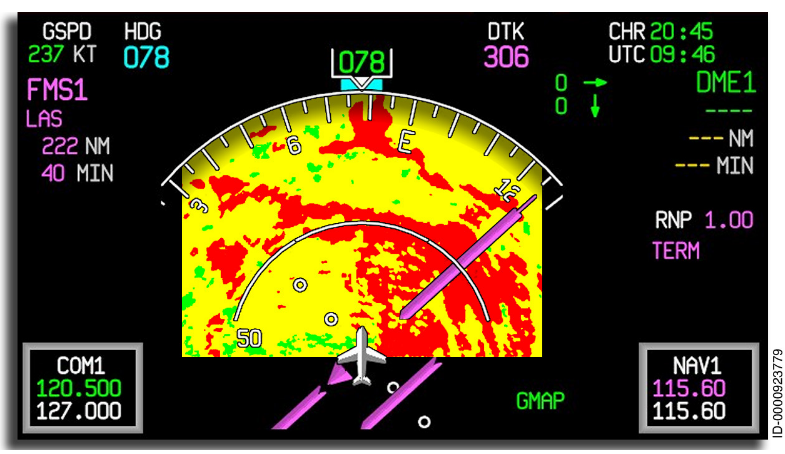


Figure 18-24
GMAP Data on the HSI

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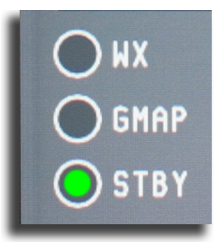
WARNING: Weather-type targets are not calibrated when the radar is in GMAP mode. Because of this, do not use the GMAP mode for weather detection.

As a constant reminder that the system is in the ground mapping mode, the color scheme is green , yellow , and red . These colors are different from the previously described Primus 880 weather radar system. Green represents the least reflective return, yellow is a moderate return, and red is a strong return.

The purpose of the GMAP mode is to aid in identifying prominent terrain features such as coastlines, lakes, and large built-up urban areas. GMAP mode provides an extended ground map picture by piecing together individual scans and combining them in the buffer for display. Reflectivity data that is considered ground clutter (and removed from the weather views) is the basis for the ground map. Data from the terrain database is not used, providing independent verification of position. The ground map is generated automatically and simultaneously with weather.



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STBY – Selecting the STBY radio button activates the standby mode. When the RDR-4000 is in standby mode, the system is still energized, but it is not transmitting. STBY is displayed in the weather mode annunciator window. Auto activation will not occur when STBY is selected.

Forced Standby Mode – Forced standby mode is activated when WX mode is selected while on the ground. Forced standby mode prevents aircraft from emitting RF pulses on the ground.

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FSBY OVRD – Overriding the forced standby requires that both pilots select the FSBY OVRD menu item on the respective weather controllers.

The RDR-4000 automatically exits forced standby mode and selects WX mode ON when any of the following conditions are met:

- RAAS (when installed) indicates the aircraft is on runway
- Groundspeed from IRS > 30 knots

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- Longitudinal acceleration from IRS > 0.07 G
- On-ground to in-air transition occurs (pitch > 5 degrees, RA > 25 feet, or CAS > 90 knots).

WARNING: Forced standby mode must be verified by the operator to ensure safety for ground personnel.

VSD WX – Selecting VSD WX displays a profile view of the radar returns on the vertical situation display (VSD) depicted by color intensity patterns above, below, and ahead of the aircraft in the direction of the flight plan or selected azimuth (AZ). An example of weather radar returns displayed on the VSD is shown in Figure 18-25.

NOTE: The VSD must be displayed in order to display VSD weather. The VSD is displayed by selecting the VSD checkbox in the Map or Plan dropdown menus.

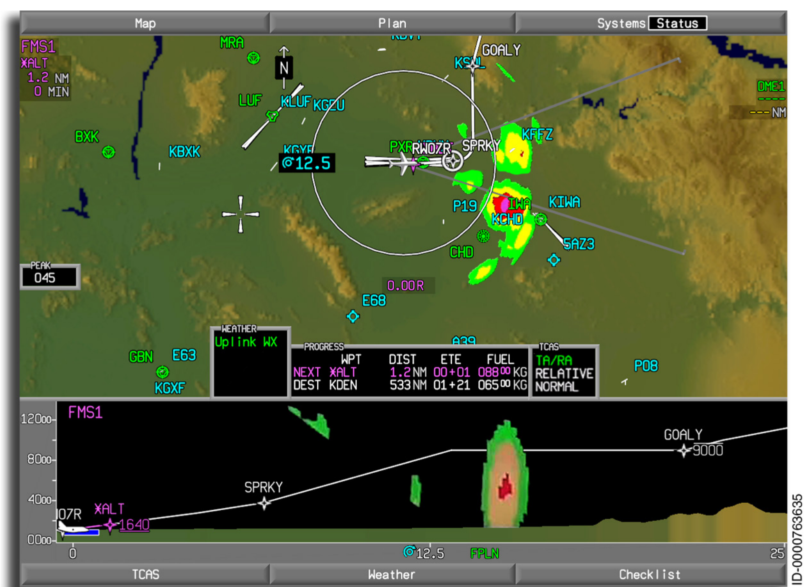

Figure 18-25
VSD WX Display

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When a track is specified, only the weather along that specified track is displayed in the vertical display. Terrain data along that track is also displayed in the vertical display. The lateral views continue to show the weather data they were previously showing.

Weather radar is removed from the VSD, and the WX UNVL annunciator, shown in Figure 18-26, is displayed on a dark gray background during any of the following flight plan segments:

- Heading to a manual termination
- Fix to manual termination
- Radial intercept leg
- Vector intercept leg
- Flight plan discontinuity portions.

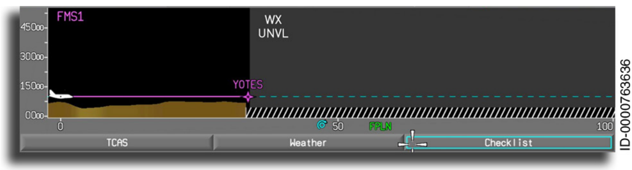

Figure 18-26
WX UNVL on VSD

SEC WX – Selecting SEC WX displays secondary weather returns on the MFD and HSI. At Power-up, Secondary Weather is selected by default. When enabled, SEC WX is displayed in the weather mode window.

NOTE: *When the* SEC WX *checkbox is not selected, only on-path radar returns are displayed. This is useful to declutter widespread areas of stratus above or below the aircraft.*

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Secondary weather, or off-path weather, is weather detected outside of the flight plan or flight path altitudes and is displayed as a transparent striped pattern of weather. In most cases, flight plan or flight path altitudes can be considered to be a +/- 4,000-foot envelope around the vertical flight plan or vertical flight path altitude, as shown in Figure 18-27.

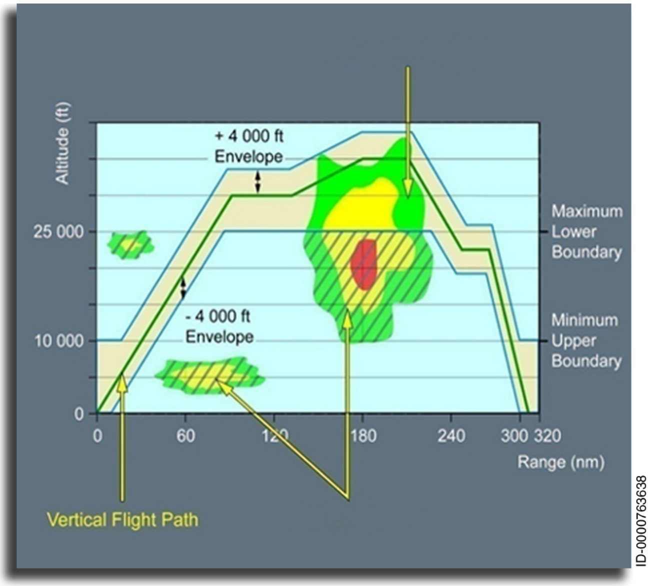

Figure 18-27
Secondary Weather Envelope

The RDR-4000 uses vertical flight plan. If it is unavailable or invalid, the system uses the vertical flight path. The flight path is computed based on the ratio of vertical speed to groundspeed. The expected flight path altitude is extrapolated out to 60 NM. Beyond 60 NM, level flight at the calculated altitude is assumed.

The upper boundary never goes below 10,000 feet. During takeoff, initial climb and approach and landing provide about a 10-minute look ahead and show weather that may be above the aircraft.

At 6,000 feet, the upper boundary is 4,000 feet higher or 10,000 feet. So, when the path is above 6,000 feet, the upper boundary will always be 4,000 feet higher.

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The nominal value for the lower envelope is -4,000 feet. In the absence of convective weather, the bottom of the envelope will remain 4,000 feet below the flight path. So, the envelope will be +/- 4,000 feet around the flight path all the way up to the final cruise altitude. However, if an area of convective weather is detected, the envelope lower boundary is extended down to 25,000 feet in that area.

This allows the system to show the lower, more reflective part of a cell but not fill the screen with solid (on-path) returns in areas of high stratus.

The special conditions just described do not fall under the general +/- 4,000-foot envelope. Table 18-5 lists the envelope boundary limits.

Table 18-5
Envelope Boundary Limits

<table>
<tr><th>Aircraft Altitude (ft MSL)</th><th>Lower Envelope Boundary</th><th>Upper Envelope Boundary</th></tr>
<tr><td>>29,000</td><td>25,000 ft MSL or flight altitude minus 4,000 ft</td><td rowspan="2">Flight altitude plus 4,000 ft (max 60,000)</td></tr>
<tr><td>29,000 to 6,000</td><td rowspan="2">Flight altitude minus 4,000 ft (min ground)</td></tr>
<tr><td><6,000</td><td>10,000 ft MSL</td></tr>
</table>

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An example of secondary weather patterns is shown in Figure 18-28.

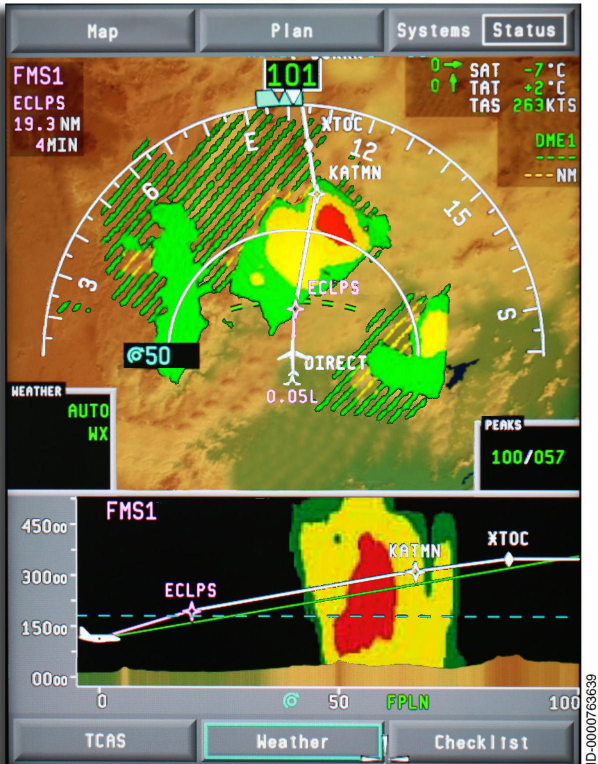

Figure 18-28
Primary and Secondary Weather

NOTE: No distinction between primary and secondary weather is made on the VSD. All weather displayed on the VSD is displayed as primary weather in solid colors.

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REACT (RCT) – RCT is a submode of the weather detection mode and defaults to off. Selecting RCT displays WX/R in the weather mode fields. REACT (Rain Echo Attenuation Compensation Technique) provides for the detection and display of severe attenuation or radar shadowing.

As the transmitted radar signal travels through heavy rain, it loses power or becomes attenuated. If this attenuation is severe enough, weather behind a storm cell may not be detectable, or it may be displayed as being less severe than it actually is. For example, green instead of yellow.

This feature automatically indicates areas where the radar signal has been attenuated. These areas are shown as magenta arcs superimposed over the reflectivity in the areas where the signal attenuation is significant, as shown in Figure 18-29. These arcs indicate that there could be severe weather in that area, even though only mild or no reflectivity is shown. In areas where the REACT field is shown, expect the possibility of weather that may need to be avoided and must be considered dangerous.

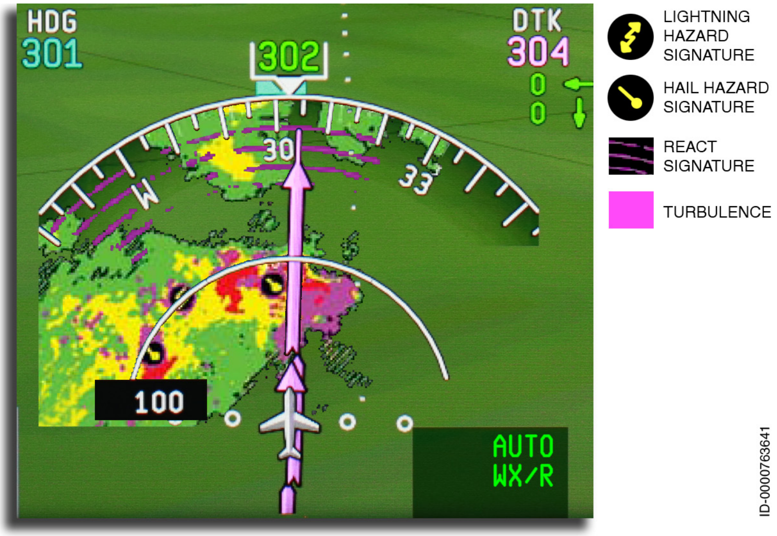

Figure 18-29
Typical Display of Hazard Information

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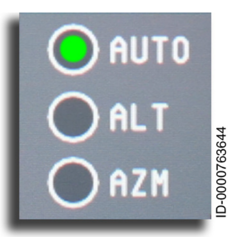
Turbulence (TURB) – When this box is checked, the turbulence detection mode is active. Turbulence is defaulted to ON. The turbulence mode is available only when WX is selected. Turbulence information is limited to the first 60 NM for any range selection. Turbulence is shown on the display in magenta, as shown in Figure 18-29. When the turbulence detection mode is selected, WX/T is displayed in the weather mode field and only affects the on-side controller.

HAZARD – When the HAZARD box is checked, hazards such as hail and lightning are displayed. Hazard is defaulted to off. When the selected mode is WX, only traditional reflectivity and turbulence are displayed. When the selected mode is WX/H, the radar overlays hazard icons where lightning or hail is predicted. Hazards are shown in Figure 18-29.

When HAZARD is selected, and in the event a hazard region is determined to likely contain both a lightning and hail hazard, only the hail icon is displayed to avoid cluttering the display.

When the ground map display mode is active, the hazard display mode and REACT display selections are ignored, and the hazard icons and REACT information are suppressed.



AUTO – The FMS compares the FMS vertical flight plan to the scanned weather in the 3D buffer. When AUTO is selected and the vertical flight plan is not available or not being followed, the system calculates the vertical flight path based on vertical rate and groundspeed. Weather that intersects the flight path envelope is shown in solid colors, and if enabled, weather secondary to the flight path is displayed in a hashed pattern.

AUTO is the power-up default.

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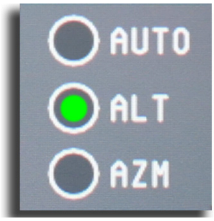

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ALT (Manual Altitude Select) – When ALT is selected, the pilot can select an earth curvature corrected altitude slice of weather for display on both the lateral map and HSI. This is referred to as manual altitude select mode (ALT). Once selected, the initial altitude is set to the 1,000-foot increment nearest the current aircraft altitude and is changed using the outer knob on the CCD.

When in manual altitude select mode, a solid gray line extends the length of the vertical display and shows the selected altitude, as shown in Figure 18-30.

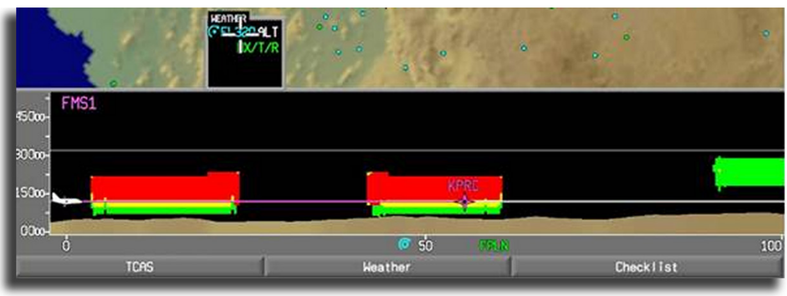

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Figure 18-30
Vertical Display With Altitude Select Line

The **ALT** selection value is displayed in the weather readout window. On the MFD, the selected altitude value is displayed in the weather window. When an altitude is specified, the display of weather data in the lateral views depicts weather at that altitude.

AUTO is the automatic detection mode of the radar. ALT is the manual analysis mode. This mode is used to evaluate weather that may need avoidance. It allows the crew to look at the vertical extent of the weather and how much reflectivity is carried aloft. Stronger cells carry more reflectivity aloft, and this mode allows the crew to make effective deviation decisions.

NOTE: The ALT mode will time out and be removed 180 seconds after the last crew initiated ALT change.

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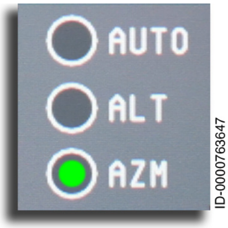

AZM (Azimuth Mode) – Auto azimuth mode displays weather along the current flight plan or the aircraft track when a current flight plan is not available. Auto azimuth mode is enabled when AZM is not selected.

Manual azimuth mode is enabled when AZM is selected. When manual azimuth mode is enabled, AZM is displayed in the weather window, and the crew can select an azimuth line using the inner knob on the CCD, along which a vertical weather slice is extracted for display in the VSD. This is referred to as VSD azimuth mode (AZM).

A gray line is displayed in the lateral display corresponding to the selected azimuth, as shown in Figure 18-31.

Figure 18-31
MFD With Specified Azimuth Select Line

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While the azimuth is being selected by the pilot using the range knob, the input is interpreted as up to 179 degrees left (negative) or 179 degrees right of current aircraft heading. While the pilot is still selecting the azimuth, that value is maintained even as the aircraft turns. As the pilot completes the value entry by exiting the mode on the weather controller, the value is converted to a selected track originating at the current aircraft position. The weather controller continues to display the selected azimuth, but the mode annunciation on the lateral display shows the current difference between the aircraft heading and the selected track (±180). The AZM mode times out after 180 seconds of inactivity.

This gray azimuth line is displayed only if the weather information is selected for display in that view and remains displayed as long as AZM is selected.

GAIN – When transitioning from auto to manual gain, the controller initializes to 0 dB so that no change is observed in weather reflectivity (in auto mode, the RDR-4000 uses a gain of 0 dB). The crew can adjust the gain between -16 dB and +10 dB (0%–100%). The gain value is adjusted using the inner knob on the CCD and the gain display in the weather window.

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Weather Radar Self-Test

WARNING: Output power is radiated in TEST mode.

The RDR-4000 Weather Radar System has a self-test mode and a maintenance function. The WX test mode is selected by selecting the WX prompt on the MCDU TEST page, shown in Figure 18-32. The key toggles between ON and OFF with the selected state in larger green font and the unselected state in smaller white font.

Figure 18-32
MCDU TEST Page

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The test mode is activated on both sides, regardless of which MCDU it is selected. When in TEST mode, the test pattern is displayed on the MFD and VSD if weather is selected for display on the map. In the self-test mode, a special test pattern is displayed. Figure 18-33 shows the test pattern on the MFD.

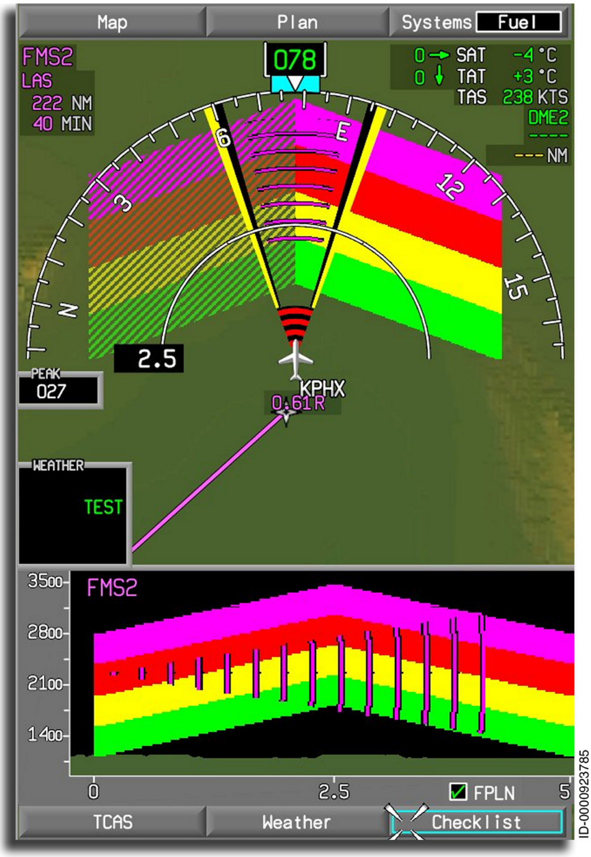

Figure 18-33
RDR-4000 MFD Test Pattern

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The test pattern on the HSI is shown in Figure 18-34.

Figure 18-34
RDR-4000 HSI Test Pattern

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Predictive Windshear

The RDR-4000 detects windshear ahead of the aircraft and displays windshear icons on the lateral map and HSI, as well as annunciators on the attitude director indicator (ADI).

The predictive windshear (PWS) icon is a series of red and black bands in the area of the windshear event, followed by searchlights (yellow lines outside of black lines) extending from the far edge of the windshear event. Multiple events are possible. An example of a predictive windshear icon is shown in Figure 18-35.

Figure 18-35
Predictive Windshear Display on the Lateral Map

If a predictive windshear caution or warning event is encountered, it is automatically brought into view on the lateral map or MFD. The PWS icon is displayed with searchlights not to exceed 20 degrees either side of centerline. The HSI is automatically displayed in the 90-degree display mode (arc mode).

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When a predictive windshear caution is received, a predictive WSHEAR AHEAD caution annunciator is displayed on the ADI in a reverse video, as shown in Figure 18-36. The annunciator does not flash.

Figure 18-36
Predictive Windshear Caution Annunciator on the ADI

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When a predictive windshear warning is received, a predictive WSHEAR AHEAD warning annunciation is displayed on the ADI in a reverse video, as shown in Figure 18-37. This annunciator flashes for the entire alert.

Figure 18-37
Predictive Windshear Warning Annunciator on the ADI

If a predictive windshear warning is received, the following aurals are heard:

- "**WINDSHEAR AHEAD, WINDSHEAR AHEAD**" (takeoff)
- "**GO AROUND, WINDSHEAR AHEAD**" (landing and go around).

The priority of windshear display annunciators on the ADI from highest to lowest is as follows:

- Reactive windshear warning from EGPWS
- Predictive windshear warning from RDR-4000
- Predictive windshear caution from RDR-4000
- Reactive windshear caution from EGPWS (not active when predictive windshear option is installed on aircraft).

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WINDSHEAR ALERT REGIONS

The PWS mode can generate caution and warning alerts. These depend on the location of the windshear event, not the strength. When a windshear event is encountered below an altitude of 1,500 feet AGL, the appropriate alert is issued, and the icon automatically shows on the display. Figure 18-38 shows the regions for caution and warning windshear alerts during takeoff.

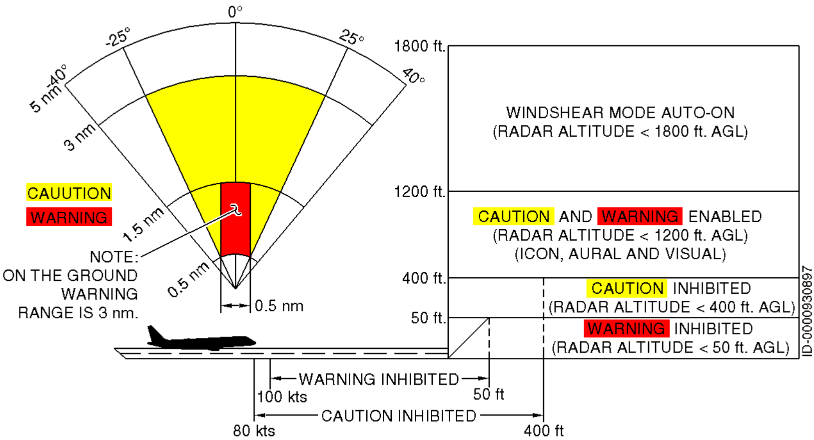

Figure 18-38
Takeoff Alert Regions

Figure 18-39 shows the regions for caution and warning windshear alerts during approach.

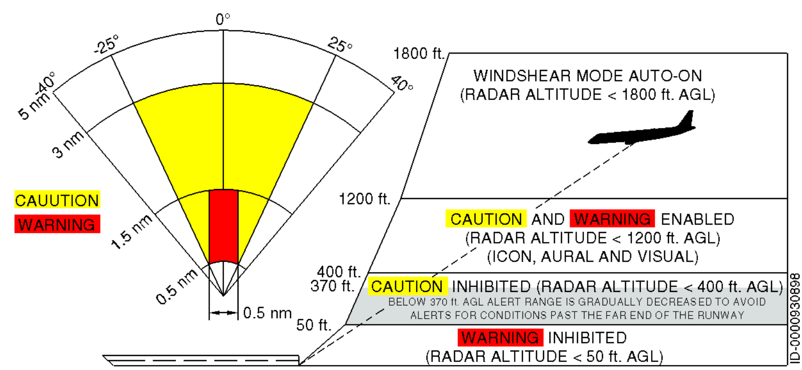

Figure 18-39
Approach Alert Regions

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Operational Limitations and Considerations

All of the limitations of the radar system have been consolidated here because of their importance. This section should be read thoroughly and frequently as a reminder of weather radar limitations.

- Airborne weather systems are not intended as a terrain or traffic collision avoidance system. Weather detection, analysis, and avoidance are the primary functions of the radar system.
- The RDR-4000 weather radar is a weather avoidance tool. It should never be used for weather penetration. The RDR-4000 helps the pilot see and plan avoidance maneuvers around significant weather encountered during flight.
- Radar detects raindrops and wet hail, not clouds, fog, dry hail, ice crystals, or snow.
- Radars detect the presence of precipitation. Storm-associated turbulence without precipitation can extend several thousand feet above a storm and outward more than 20 NM.
- Turbulence detection requires the presence of precipitation. Clear-air turbulence is not detected or displayed.
- The weather display corresponds to the selected range while the turbulence display is overlaid for the first 60 NM (regardless of range selected).
- Hail and lightning icons indicate that conditions are conducive to the development of hail or lightning. Since this technology is predictive, icons often display prior to the actual formation of hail or lightning. Hence, the presence of icons does not guarantee that hail or lightning will be present. Similarly, the absence of an icon does not guarantee that the condition will not be present.
- Below 1,800 feet AGL, the windshear and weather scans alternate. The windshear detection operation is transparent to the crew unless an alert is issued.
- While on the ground, the radar is automatically placed in forced standby mode unless ground override is selected, or any qualifiers (e.g., groundspeed, aircraft is on the runway, etc.) indicate takeoff is imminent. There is no radiation hazard to nearby personnel while in forced standby mode.

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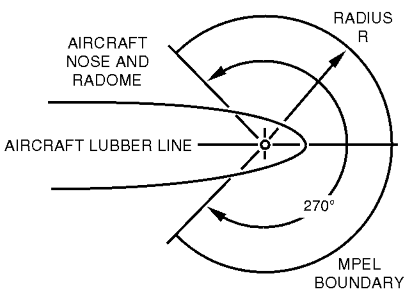
- Reference the following Federal Aviation Administration (FAA) Advisory Circulars or applicable EASA documents:
  - AC 00-24B Thunderstorms
  - AC 00-6A Aviation Weather
  - AC 00-50A Low Level Windshear
  - AC 20-68B Recommended Radiation Safety Precautions.

MAXIMUM PERMISSIBLE EXPOSURE LEVEL (MPEL)

Heating and radiation effects of weather radar are hazardous to life. Personnel must remain at a distance greater than the distance to the maximum permissible exposure level boundary from the radiating antenna in order to be outside the envelope in which radiation exposure levels equal or exceed 10 mW/cm^2, the limit recommended in FAA Advisory Circular AC No. 20-68B, August 8, 1980, Subject: Recommended Radiation Safety Precautions for Ground Operation of Airborne Weather Radar.

Honeywell recommends operators follow the 5 mW/cm^2 standard described in the guidance material. Figure 18-40 shows the MPEL for Primus 880 Weather Radar power.



DIAMETER OF FLAT-PLATE RADIATOR	10 mW/CM RADIUS R OF MPEL BOUNDARY	5 mW/CM RADIUS R OF MPEL BOUNDARY
24 IN. / 61.0 CM	10.5 FT / 320 CM	13 FT / 396 CM

ID-0000923778

Figure 18-40
MPEL for Primus 880 Installations

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Figure 18-41 shows the MPEL region for the RDR-4000 weather radar power.

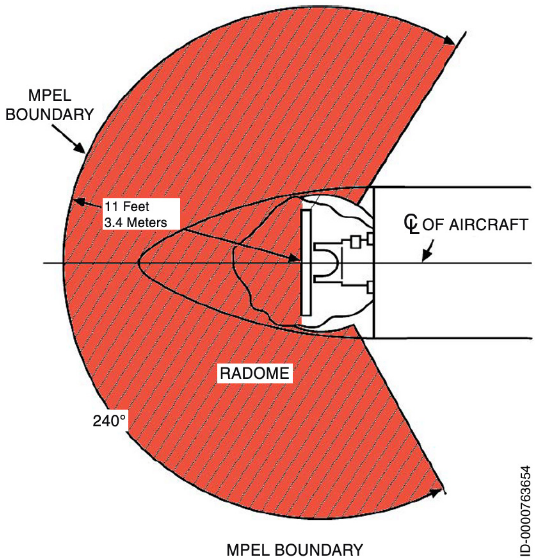

Figure 18-41
MPEL for RDR-4000 Installations

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19. Traffic Alert and Collision Avoidance System (TCAS)

INTRODUCTION

Traffic alert and collision avoidance system (TCAS) is an airborne collision avoidance system (ACAS). ACAS/TCAS is an aircraft system based on secondary surveillance radar (SSR) transponder signals and operates independently of ground-based equipment to provide information to the pilot about potential conflicting aircraft equipped with SSR transponders. The terms TCAS and ACAS are used interchangeably, with TCAS being the more common term in North America and ACAS being the more common term in Europe.

TCAS operates by radio communication between aircraft equipped with a functioning transponder. Each TCAS-equipped aircraft interrogates all other aircraft within a defined range, as shown in Figure 19-1, to determine positions (via the 1030 MHz radio frequency), and all other transponder-equipped aircraft reply to interrogations (via the 1090 MHz). This interrogation-and-response cycle can occur several times per second. The frequencies used are the same as used for ground-to-air SSR interrogation.

The TPA-100C is standard equipment and is change 7.1 compliant. The traffic computer with SmartTraffic has all the functionality of a TPA-100B and provides the mandated ARINC 735B compatible TCAS II functionality with RTCA/DO-300 hybrid surveillance.

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System Description

Cockpit display of traffic information (CDTI) (installation option) is the flight-crew display-interface of the aircraft surveillance applications (ASA), shown in Figure 19-1. ASA defines an entire system over multiple participants, including the ownship system. Each ownship system contains the two major component functions, the traffic computer providing a ADS-B/TIS-B receiver and airborne surveillance and separation assurance processing (ASSAP) and CDTI. ASSAP is performed largely in the TCAS traffic computer and CDTI by the electronic displays system (EDS), although some functions defined in the standards as ASSAP may actually be implemented by CDTI.

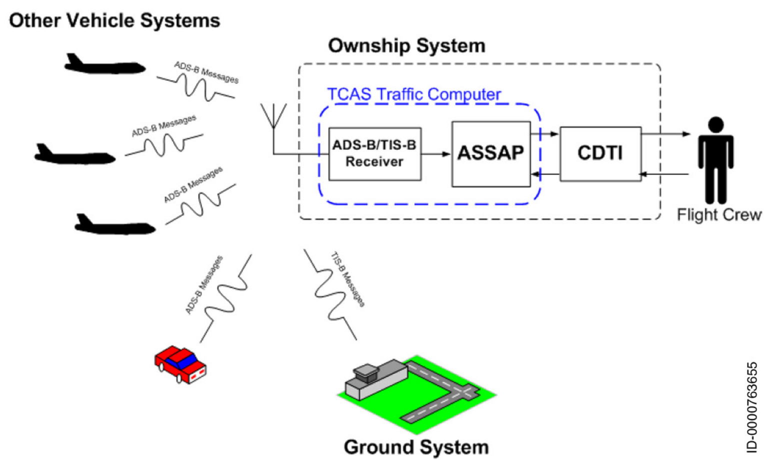

Figure 19-1
Transponder Interrogation Capabilities

CDTI does not fully replace the existing TCAS functionality. The current TCAS function supports two of the outputs of the traffic computer, the display of the intruder data on the cockpit displays and the display of the resolution advisories on the cockpit displays. CDTI only replaces the display of the intruder data on the cockpit displays using the display traffic information file (DTIF) instead of the intruder labels to support rendering both TCAS and ADS-B In traffic data. The resolution advisory information, which provides the pilot with conflict avoidance information on the PFDs such as **"Climb," "Don't Climb," "Descend," "Don't Descend,"** etc., are still supported by the TCAS function. CDTI will also not impact the present interfaces for aural outputs of the traffic computer.

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TCAS Operation

Vertical guidance to avoid midair collisions is computed using the following two levels of advisories:

- **TA (Traffic Advisories)** – TAs indicate the range, bearing, and relative altitude of the intruder to aid in visual acquisition of the intruder.
- **RA (Resolution Advisories)** – RAs indicate what vertical maneuver must be executed to make a safe separation.

Each type of advisory has a corresponding aural message that is sounded by the TCAS computer and broadcast in the cockpit.

Mode A-equipped intruders are only detected and shown as TAs. Intruders not equipped or not using the transponder are invisible to TCAS.

TCAS generates TAs and RAs when the TA/RA mode is selected on the **MCDU RADIO 1/2** page. The two types of advisories correspond to time-based protection zones around the aircraft. The airspace around the TCAS aircraft, where an RA is annunciated, represents the warning area, while the larger airspace resulting in a TA being annunciated is the caution area.

Only one Mode S transponder in the protected aircraft is required for TCAS operation. When two Mode S transponders are installed, the selected transponder is used by TCAS. The other operates as a backup. The TCAS receiver/computer uses a directional antenna to show intruder bearing.

A TCAS map overlay and a TCAS zoom format are displayed on the multifunction display (MFD). The two formats are mutually exclusive. The traffic symbols are shown in order of highest-priority intruders to avoid clogged displays with low-priority intruders.

Each pilot controls their on-side TCAS display, independent of the selected controls on the other side.

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TCAS Theory of Operation

TCAS monitors the airspace surrounding the aircraft by interrogating the transponders of nearby aircraft (intruders). The reply from the transponders of the intruder enables TCAS to compute the following information about the intruder:

- Range between the aircraft and the intruder
- Relative bearing to the intruder
- Altitude and vertical speed of the intruder when the intruder is reporting altitude
- Closure rate between the intruder and the aircraft.

Using this data, TCAS predicts the time to and the separation at the closest point of approach (CPA) of the intruder. When TCAS predicts certain safe boundaries are being violated, a TA or RA is issued to alert the crew that closing traffic presents a threat nearby.

The TCAS must sense four valid replies from the other aircraft transponder to establish a track on a target. Beginning with the fifth valid reply, the TCAS begins to display the other aircraft on the MFD.

Using this constant back-and-forth communication, the TCAS builds a three-dimensional map of aircraft in the surrounding airspace, incorporating their bearing, altitude, and range. Then, by extrapolating current range and altitude difference to anticipated future values, it determines if a potential threat exists.

TCAS Sensitivity Level

TCAS has various sensitivity levels for issuing TAs and RAs. Sensitivity levels are not pilot-controllable and automatically change during different phases of flight. For example, a less sensitive threshold level is active during the approach phase of flight to prevent unnecessary advisories in the higher traffic densities anticipated at these areas.

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TCAS Surveillance Volumes

Surveillance volume is the volume of airspace within which other aircraft with functioning transponders are tracked by the TCAS. The display range controlled by the pilot using range (map scale) controls for the MFD is not the same as the surveillance volume. The pilot cannot control the surveillance volume. The pilot can only control the range of traffic displayed.

Range Tracking Volumes

The size of the range tracking volume is dependent on whether tracking is occurring using the directional (upper) or monopole (lower) antenna and on the attenuation levels affecting the pulses transmitted from the TCAS processor transmitter.

TCAS scans a maximum of 40 NM in front of and 9,900 feet above and below the aircraft. TCAS reduces range tracking volumes in high-density areas to reduce the number of receptions needing to be processed by the TCAS and limit interference with ground SSR equipment. The range tracking volume may be reduced to approximately 15 NM in front of the aircraft.

TCAS II can track as many as 60 aircraft and display up to 30 tracked aircraft, and can coordinate a resolution advisory for up to three intruders at once. Resolution advisories are always based on the least amount of deviation from the flight path while providing safe vertical separation.

TCAS SYSTEM COMPONENTS

TCAS requires the following components to function:

- A TCAS processor (which is part of the TPA-100C). The processor receives inputs from other components within the avionics system, including barometric altitude, aircraft speed, and radar altitude.
- A functional transponder.
- Two antennas, one each on the top and the bottom of the aircraft, at least one of which is directional.

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TCAS also requires other aircraft (potential intruders) to be equipped with a functional transponder. This can be a Mode A, Mode C, or Mode S transponder.

WARNING: TCAS cannot detect any aircraft unless the other aircraft is equipped with an operating transponder and that transponder is turned on.

Automatic Dependent Surveillance – Broadcast (ADS-B) Out

ADS-B Out is a feature of the transponder function that provides broadcast data with respect to the aircraft position, aircraft state data, and aircraft vector data of high frequency and accuracy over 1,090 MHz. Air traffic controllers are provided for a more accurate display of traffic data using satellites. The traffic displays are in real-time and do not degrade with distance or terrain.

NOTE: When CDTI airborne situational awareness (AIRB) is enabled as an installation option, ADS-B targets are displayed on aircraft display units.

ADS-B out is selected ON or OFF by way of the TCAS/XPDR 1/2 page. The ADS-B mode status is displayed on the RADIO 1/2 page.

Automatic Dependent Surveillance – Broadcast (ADS-B) In

ADS-B In is a feature of the transponder that provides basic AIRB. Traffic is displayed as CDTI when CDTI-AIRB functionality is enabled at installation. Otherwise, a basic traffic symbology is displayed.

AIRBORNE SITUATIONAL AWARENESS (AIRB)

The traffic computer provides a graphical display of airborne ADS-B intruder information relative to own aircraft along with supporting information. This information assists the pilots in integrating radio communications with visually acquired aircraft and ADS-B surveillance information. The unit provides airborne situational awareness to the flight crew, as described in RTCA DO-317A.

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TCAS SYSTEM CONTROLS

The transponder and TCAS radios are controlled using the two MCDUs mounted on the center pedestal as well as menus on the MFD. The XPDR/TCAS system supports one or two transponders. The controls are described in the following paragraphs.

MCDU Controls

Three types of display pages are used to control the transponders—RADIO 1/2 page, TCAS/XPDR 1/2 page, and TCAS/XPDR 2/2 page.

RADIO 1/2 PAGE

The RADIO 1/2 page, shown in Figure 19-2, is displayed by pushing the RADIO function key on the MCDU. The RADIO 1/2 page displays TCAS/transponder controls.

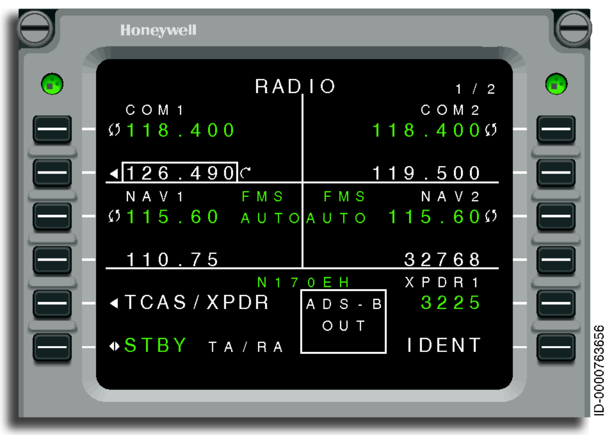

Figure 19-2
RADIO 1/2 Page, COM Tuning, ADS-B (ON)

The TCAS/transponder display controls are listed in the following paragraphs:

- **5L TCAS/XPDR** – Pushing this key displays the **TCAS/XPDR 2/2** page.

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- **6L** STBY TA/RA – Pushing this key alternately selects STBY or the selected active mode. The active condition is green, and the inactive annunciator is white. The possible modes selected on TCAS/XPDR 2/2 are listed as follows:
  - TA/RA
  - TA
  - ALT-ON
  - ALT-OFF.
- **5C ADS-B Status Indicator** – When ADS-B is on, and the transponder is on, ADS-B OUT is displayed in green. When ADS-B is on, and the transponder is off (standby), ADS-B OUT* is displayed in white. When ADS-B is off, ADS-B OUT OFF* is displayed in white. When ADS-B is invalid, ADS-B OUT is displayed in amber.
- **5R Active Transponder Code and Reply Indicator** – This section shows the active transponder code and reply indicator. The header for field 5R shows the flight ID, when available, or was entered by the crew. The reply indicator (●) lights when the transponder is replying to a RADAR or TCAS interrogation. Pushing line select key (LSK) 5R moves the format cursor to the field or shows TCAS/XPDR 1/2 when the cursor is already in the field.
- **6R** IDENT – To transmit an IDENT reply when requested by ATC, LSK 6R next to the IDENT label is pushed.

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TCAS/TRANSPONDER DETAIL 1/2 PAGE

The TCAS/XPDR 1/2 page is displayed by selecting the **TCAS/XPDR** prompt (LSK 5L) on the RADIO 1/2 page, shown previously in Figure 19-2, and then selecting the NEXT or PREV function keys. The TCAS/XPDR pages control the active transponder. The reply code and identifiers are on the left side of the display, with mode controls on the right and page transfers at the bottom. Figure 19-3 shows the TCAS/XPDR 1/2 page.

Figure 19-3
TCAS/XPDR 1/2 Page–Transponder Tuning

- **1L ACTIVE** – The adjustable active transponder reply code is displayed in green. The tune key indicates the code is adjustable using the tuning knob on the MCDU. Refer to the following procedures for operating instructions for the **ACTIVE** and **PRESET** fields.

  To enter a new reply code directly using the scratchpad, use the following procedure:

  1. Type the 4-digit code into the scratchpad using the numeric keypad.
  2. Push 1L at the ACTIVE transponder code. The cursor box does not have to be on the intended destination field.

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The MCDU checks the scratchpad for a valid transponder code. When valid, the MCDU transfers the scratchpad code to the active transponder code field and clears the scratchpad. The original active transponder code is moved to the PRESET code field at 2L. If the code is invalid, an error message is displayed in the scratchpad, and no transfer takes place.

Direct tuning of the transponder code using the knobs is not permitted. The standby tuning procedure must be used as follows.

- **2L PRESET** – The preset transponder code is displayed here. When the cursor box surrounds the display, the curl icon is displayed to indicate the code is adjustable using the tuning knob on the MCDU.

  The preset and active transponder codes can be swapped by pushing LSK 1L.

- **5L XPDR SEL** – This key toggles between XPDR1 and XPDR2 as the active transponder. The selected transponder turns green, and the font is larger. The unselected sources are white in a smaller font.

- **6L ADS-B OUT** – This key toggles ADS-B ON or OFF. The active mode is displayed in large green font, and the inactive is displayed in small white font.

  The status CAS message **ADS-B OUT NOT ON** is displayed when ADS-B is selected OFF, and the selected transponder mode is not STBY. When the selected transponder mode is STBY, and the aircraft is in-air, the caution **XPDR 1(2) IN STBY** CAS message is displayed and inhibits the status **ADS-B OUT NOT ON** CAS message. When the selected transponder mode is STBY, and the aircraft is on-ground, the status **ADS-B OUT NOT ON** CAS message is not displayed.

- **1R PRESSURE ALT** – The pressure altitude digital value is displayed in white. This is the altitude that the transponder is sending to ground stations and other transponder-equipped aircraft.

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- **2R FLT ID** – This location shows the loadable flight ID.

  The FLT ID displayed in this field is synchronized between the RTE page and is repeated on the following ATS request pages:

  – DCL REQUEST (1L)

  – OCEANIC REQUEST (3R)

  – PUSHBACK CLX REQ (1L)

  – TAXI CLX REQUEST (1L)

  – ATC NOTIFY/STATUS (2L).

  Any change to the FLT ID field on the TCAS/XPDR page changes the FLIGHT ID on the RTE page. Any change to the FLIGHT ID field on the RTE page changes the FLT ID on the TCAS/XPDR page. The ATS request pages are described in the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide, Pub. No. D202012001536.

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- 4R **TEST** – Pushing 4R initiates the TCAS self-test. The TCAS self-test can only be initiated when the aircraft is on the ground. Pushing the TCAS TEST button starts the test cycle and displays the TCAS test screen. Figure 19-4 shows the MFD TCAS test annunciations when CDTI is not enabled.

Figure 19-4
MFD TCAS Test

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Figure 19-5 shows the MFD TCAS test annunciations when CDTI is enabled.

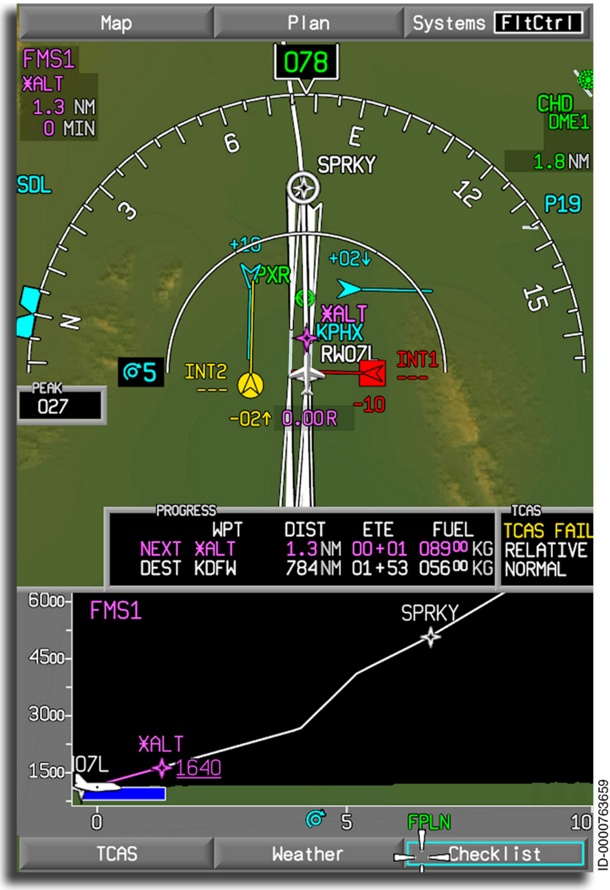

Figure 19-5
MFD TCAS Test With CDTI Enabled

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Figure 19-6 shows the PFD TCAS test annunciations.

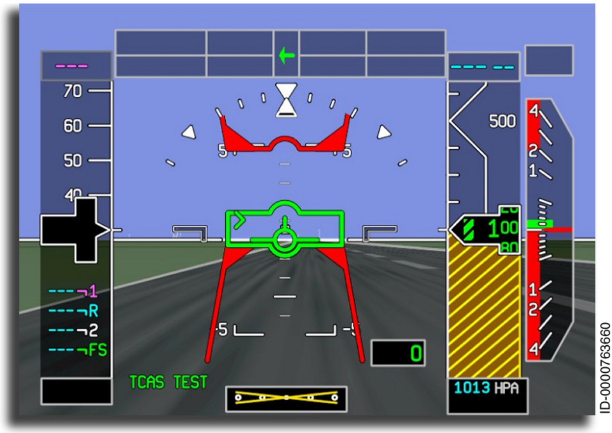

Figure 19-6
TCAS Test PFD

When the test is complete, the test display reverts to the original displays. This test does not require crew intervention to exit, and the test turns off automatically.

- **5R** – To transmit an IDENT reply when requested by ATC, the LSK at 5R next to the **IDENT** label is pushed. When the test is complete, the aural **"TCAS SYSTEM TEST OKAY"** is announced.
- **6R RADIO 1/2** – Pushing this key returns the display to the RADIO 1/2 page.

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TRANSPONDER DETAIL 2/2 PAGE

The TCAS/XPDR 2/2 page, shown in Figure 19-7, is displayed by selecting the **TCAS/XPDR** prompt (LSK 5L) on the RADIO 1/2 page, shown previously in Figure 19-2, or by pushing the NEXT or PREV function key when the TCAS/XPDR 1/2 page is displayed. The TCAS/XPDR 2/2 page is used to control the TCAS/transponder mode.

Figure 19-7
TCAS/XPDR 2/2 Page – Transponder Tuning

- 1L **TCAS/XPDR MODE** – Pushing this key toggles from TA/RA, TA, ALT-ON, and ALT-OFF. The selected mode is shown in a larger green font, and the others are smaller white font.
- 6R **RADIO 1/2** – Pushing this key returns the display to the **RADIO 1/2** menu.

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MFD Controls

Additional TCAS controls are displayed on the Map and Plan dropdown menu as well as the TCAS pop-up menu, shown in Figure 19-8.

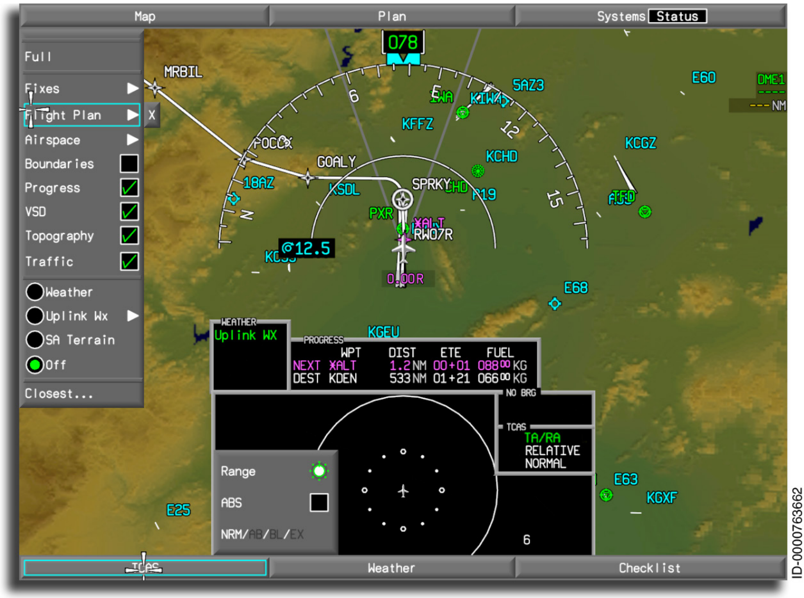

Figure 19-8
MFD TCAS Controls

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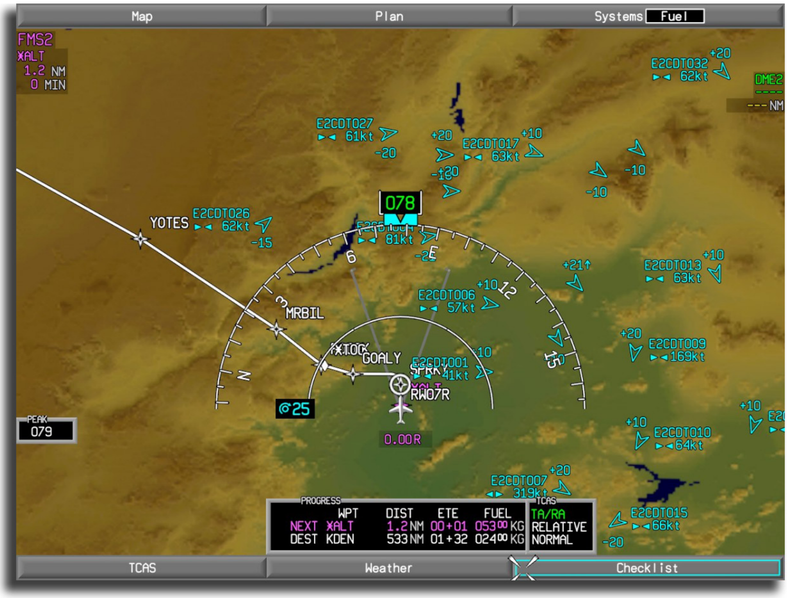
MAP AND PLAN DROPDOWN MENU CONTROLS

The Map and Plan dropdown menus are used to control the traffic overlay on the MFD. Selecting the Traffic checkbox, shown in Figure 19-8, overlays traffic information on the MFD, as shown in Figure 19-9.



ID-0000763663

Figure 19-9
TCAS Targets Displayed on the MFD

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TCAS POP-UP MENU CONTROLS

The TCAS pop-up menu, shown in Figure 19-10, is displayed when the TCAS menu button is selected using the CCD. The following paragraphs describe the TCAS pop-up menu controls.

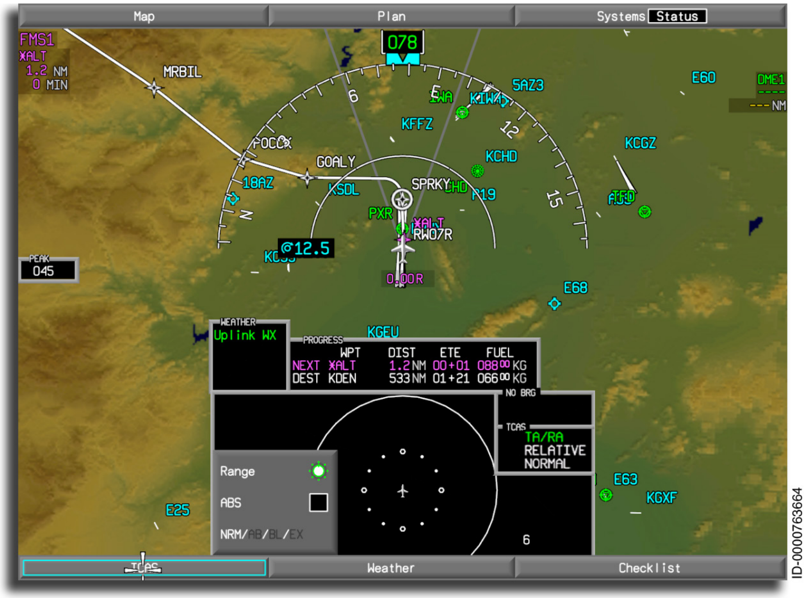

Figure 19-10
TCAS Pop-Up Menu

- **TCAS Range** – The range control is only for the zoom or pop-up display. Range control is adjustable by first selecting the range function on the menu using the touchpad on the CCD. The range is only changed when the cyan prompt is on the range display. Set the range value using the inner concentric knob on the CCD, as indicated by the knob button prompt on the menu. The range value is displayed to the lower right of the TCAS circle on the bottom of the MFD display. Ranges available are 6, 12, 20, 40, 80, and 120 miles. The default value is the 6-mile range. This range control does not control the display range for TCAS on the map overlay.

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- **ABS** – The default altitude display is relative to the aircraft. When ABS (absolute) is selected, the absolute altitude of the targets is displayed. To show absolute altitude, select the ABS checkbox using the CCD touchpad and activate it by pushing the **ENTER** button. The green checkmark indicates that absolute altitude is being displayed. Removing the checkmark returns to the relative altitude display. The display automatically reverts to the relative altitude display when a TA or RA intruder is displayed or after 15 seconds.

- **Normal, Above, Below, or Expanded** – Vertical range is selected by the toggle button on the pop-up menu. Select the toggle button using the touchpad. Change the state of the NRM/AB/BL/EX selection by using the **ENTER** button. Select Normal, AB (above), BL (below), or EX (expanded) and push the **ENTER** button. The selected function is displayed in white, and the unselected option is displayed in gray.

TCAS SYMBOLS

Up to a maximum of 32 airborne TCAS symbols are displayed on the MFD overlay when selected for display in order from highest to lowest priority. The type of symbol displayed by TCAS is based on the intruder location and closing rate. Relative bearing and distance to the intruder are shown by the position of the intruder symbol in relation to the aircraft symbol on the MFD.

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Directional and Non-Directional Symbols

CDTI intruder traffic symbols can be directional or non-directional. Directional traffic is displayed with an arrowhead shape, as shown in Figure 19-11. The direction of the directional traffic symbol is orientated to the direction of travel indicated by the traffic computer (ground track or airborne traffic and heading for surface traffic) adjusted to display orientation using the current local magnetic deviation. The actual intruder position is located at the tip of the arrowhead.

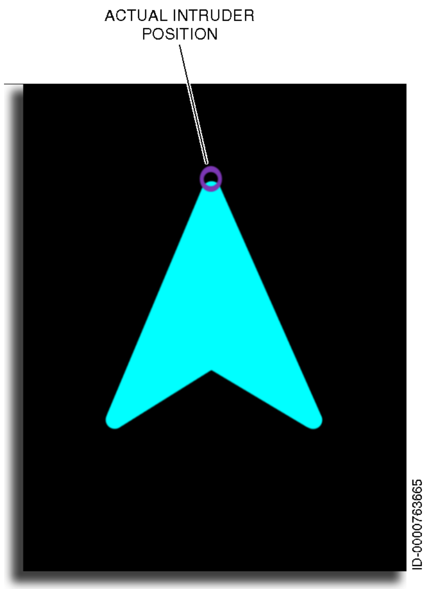

Figure 19-11
Directional CDTI Traffic Symbol

NOTE: If the TCAS computer cannot provide CDTI-capable data (invalid data), the ADS-B IN NOT AVAIL *CAS message is displayed.*

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Non-directional TCAS traffic is displayed as a diamond, circle, or square symbol, as shown in Figure 19-12. The direction of the traffic is not indicated by the symbols. The actual intruder position is in the center of each symbol.

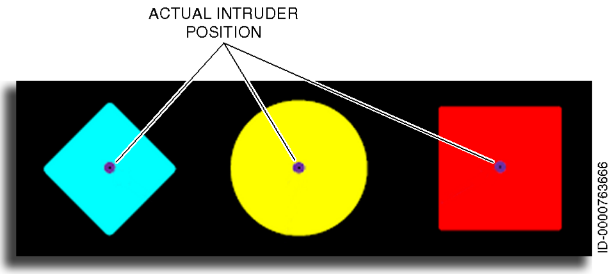

Figure 19-12
Non-Directional TCAS Traffic Symbol

Flight ID and Data Symbols

The traffic computer provides a graphical display of airborne ADS-B intruder information relative to ownship along with supporting information. This information assists the pilots in integrating radio communications with visually acquired aircraft and ADS-B surveillance information.

With the addition of information provided by ADS-B, CDTI traffic symbols are displayed that provide the flight crew with quick and pertinent information about a target. The CDTI AIRB traffic symbol, shown in Figure 19-13, can contain the traffic symbol and direction, predicted flight path, relative altitude, vertical sense, aircraft flight ID, and closure rate. The data is displayed in the same color as the target icon.

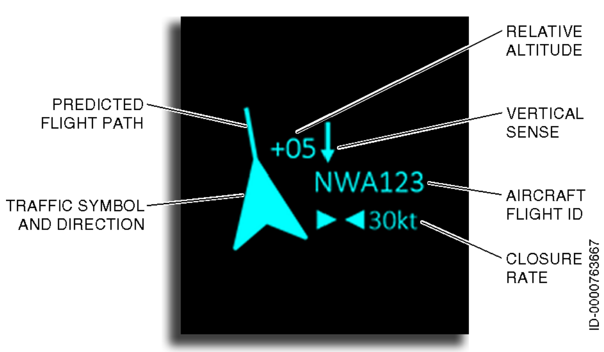

Figure 19-13
CDTI Flight ID and Data Symbol

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Traffic Symbol and Direction – The directional traffic shape is oriented to the direction in which the intruding traffic is moving and is adjusted to the orientation of the display (using the current local magnetic deviation).

Predicted Flight Path – The predicted flight path extends from each intruder when data is available and represents 30 seconds of prediction along the reported track for airborne targets.

Relative Altitude – The relative altitude value is displayed in hundreds of feet, rounded to the nearest 100 feet either above or below the intruder symbol (when altitude data is available). When the intruder aircraft is located below the present aircraft altitude, the relative altitude is displayed below the intruder symbol. When the intruder aircraft is located above the present aircraft altitude, the relative altitude is displayed above the intruder symbol. The altitude value consists of a minimum of two digits with a leading zero as necessary. The value is preceded by a + sign for traffic above ownship and a - sign from traffic below ownship. Traffic the same altitude is displayed as 00 with no preceding symbol.

Vertical Sense – An upward or downward arrow indicates whether or not the aircraft is climbing or descending at least 500 feet per minute. When no arrow is displayed, the traffic is climbing/ descending at less than 500 feet per minute. The vertical speed arrow is based on change in absolute altitude and does not indicate climbing toward or descending away from the flight crew.

Aircraft Flight ID – When available, the flight ID label is displayed. The flight ID displays the flight ID or tail number associated with the intruder. A maximum of eight alphanumeric characters can be displayed in this field.

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Closure Rate – The display of the closure rate between the ownship and an intruder includes a pair of triangular symbols to indicate whether the aircraft are converging or diverging, as shown in Figure 19-14. Arrows pointing outward indicate diverging traffic, arrows pointing inward indicate converting traffic, and no arrows indicate the same speed as ownship.

Figure 19-14
CDTI Closure Rate Display

When multiple traffic symbols are colocated on the display and their data tags overlap, the traffic symbols with lower priority are displayed in the background with their data tags inhibited.

The symbols change shape and color as separation decreases between the aircraft and intruders to represent increasing levels of urgency.

If TCAS direction-finding techniques fail to locate the azimuth (relative bearing) of another aircraft, a No Bearing target (described later in this section) is shown on the screen when the intruder becomes a traffic advisory.

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Non-Proximate Traffic Symbols

An open cyan diamond or arrowhead, shown in Figure 19-15, indicates an intruder's relative altitude is greater than +1,200 feet or distance is greater than 5 NM. This distance is not considered a threat. This symbol is called non-proximate traffic.

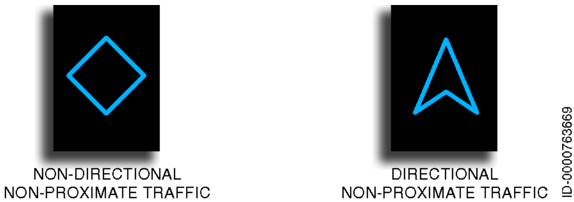

Figure 19-15
Non-Proximate Traffic Symbols

Proximate Traffic Symbols

A filled cyan diamond or arrowhead, shown in Figure 19-16, indicates the intruding aircraft is within +1,200 feet relative altitude and within 5 NM but is still not considered a threat. This diamond symbol is called proximate traffic.

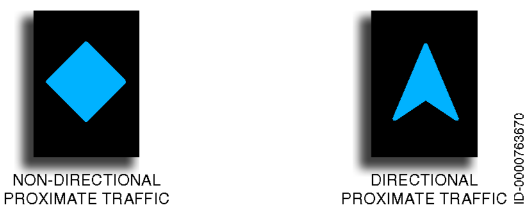

Figure 19-16
Proximate Traffic Symbols

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Traffic Advisory (TA) Symbols

Traffic advisories are displayed as a yellow-filled symbol, as shown in Figure 19-17. Traffic advisories indicate the intruding aircraft is considered to be potentially hazardous. Depending on the TCAS sensitivity level, a TA is displayed when the time to CPA (closest point of approach) is 20 to 48 seconds. Under normal conditions, a TA precedes an RA by 15 seconds. The crew should attempt to gain visual contact with the intruder and be prepared to maneuver should an RA be sounded 10 to 15 seconds later. The **"TRAFFIC, TRAFFIC"** aural notification is announced when a TA is displayed.

Figure 19-17
Traffic Advisory Symbols

WARNING: Traffic symbols on the MFD are shown to aid in visual acquisition of aircraft but do not provide adequate resolution for avoidance. ATC procedures, visual acquisition, aural advisories, and pitch cues presented on the PFD are the primary means for avoidance.

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Resolution Advisory (RA) Symbols

Resolution advisories are displayed as a red-filled square, as shown in Figure 19-18. Resolution advisories indicate an intruding aircraft is projected to be a collision threat. The TCAS system calculates that the intruder has reached a point where an RA is necessary and the time to closest approach with the intruder is now between 15 and 35 seconds, depending on aircraft altitude.

Figure 19-18
Resolution Advisory Symbols

RAs are available when TA/RA is the active XPDR mode. An RA is an automatic display indication given to the pilot recommending a maneuver to increase vertical separation relative to an intruding aircraft.

The symbol is displayed together with an appropriate audio warning and a vertical maneuver indication on the attitude display indicator (ADI).

The pilot should smoothly but firmly initiate any required vertical maneuver within 5 seconds (2.5 seconds for an increase RA or reversal RA) from the time the RA is posted.

The intruder must be reporting altitude in order to generate an RA. Therefore, the RA symbol will always have an altitude tag.

There are two types of RAs—preventive and corrective.

TCAS Avoidance Zones – The preventive RA consists of one or two red trapezoid avoidance zones depicted on the PFD. The crew must not fly in the red avoidance zone.

Fly-to Zone – A corrective RA adds a corrective green fly-to zone to the red trapezoid avoidance zones. When the green fly-to zone is shown, the aircraft must be maneuvered in that direction to avoid the threat.

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The up avoidance zone is displayed when a down advisory (descend corrective) is received. The down avoidance zone is displayed when an up advisory (climb corrective) is received. When a single corrective is received, the fly-to zone is displayed on the end of the avoidance zone symbol unless a preventive is indicated. When a preventive command is indicated, the fly-to zone symbols are not displayed.

The aircraft symbol is displayed in green when the aircraft is outside the avoidance zone. The aircraft symbol is displayed in red when the aircraft is within the avoidance zone, as shown in Figure 19-19.

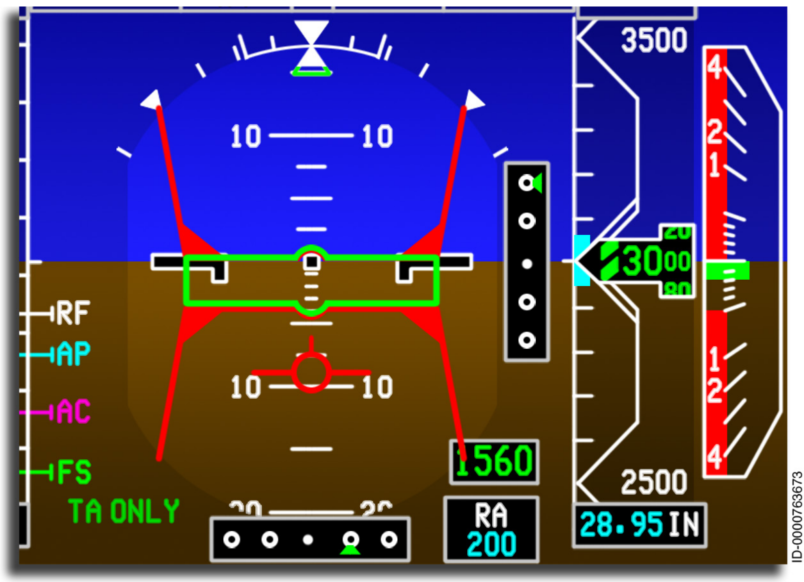

Figure 19-19
TCAS ADI Pitch Target Symbology

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Figure 19-20 shows the TCAS pitch target symbology of all possible avoidance zone and fly-to zone combinations.

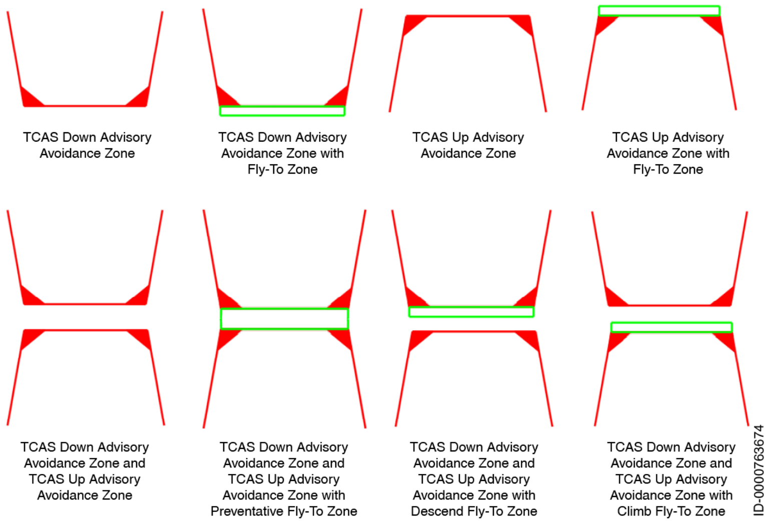

Figure 19-20
TCAS Pitch Target Symbology

NOTE: When an RA advisory condition exists, the FD command bars are removed, although the autopilot engagement status remains unchanged.

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RAs are also displayed on the vertical speed indicator (VSI), as shown in Figure 19-21. The RA consists of one or two red bands and up to one green band located on the inside of the VSI. The down avoidance zone extends from the bottom of the VSI up to the vertical speed corrective guidance supplied by the TCAS. The up avoidance zone extends from the top of the VSI down to the vertical speed corrective guidance supplied by the TCAS.

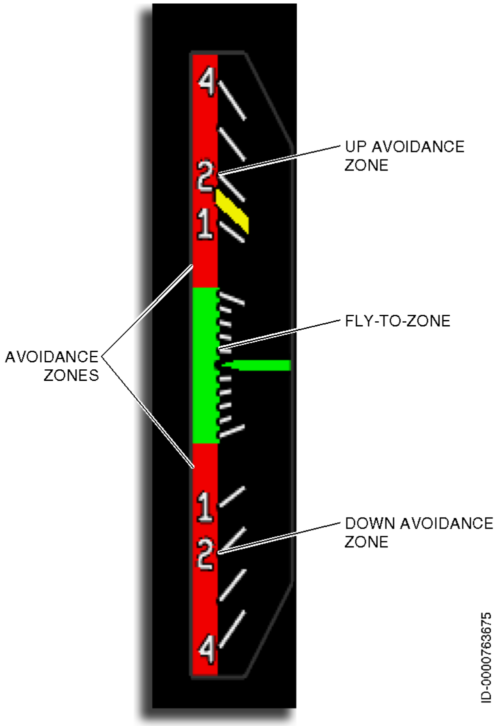

Figure 19-21
Vertical Speed Corrective Upper and Lower Threats

When a TCAS resolution advisory is active, the vertical speed digital readout is removed, and the color of the vertical speed pointer changes when the displayed vertical speed is in an avoidance zone.

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Off-Scale Symbols

A TA or RA beyond the selected MFD display range is indicated by one-half of the traffic advisory symbol parked at the edge of the display area, as shown in Figure 19-22. The position of the half-symbol represents the bearing of the intruder.

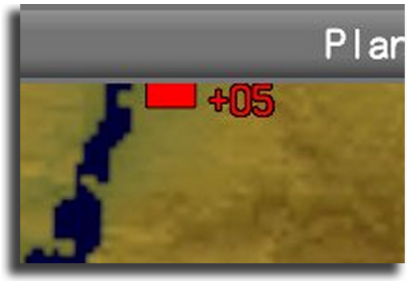

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Figure 19-22
Off-Scale Traffic

The partial non-directional symbol displayed for traffic outside of the lateral display area matches the color and shape appropriate for the status of the intruder.

TCAS POP-UP DISPLAY

The TCAS pop-up display is displayed on the lower portion of the MFD screen by selecting the **TCAS** button on the MFD. The TCAS map overlay uses the map range setting.

When a TA or RA is encountered, and the map format is not in view at a range of less than 50 NM, the TCAS zoom format automatically comes into view. The TCAS zoom format has display priority over the weather and checklist formats when an automatic pop-up occurs.

When a TCAS alert is received, the window on which the TCAS pop-up display can be displayed is as follows:

- Any DU window (inboard or outboard) that is not displaying the PFD auxiliary window
- Any DU window (inboard or outboard) that is not displaying both half PFD and EICAS window
- Outboard window on any DU with only EICAS window inboard and no PFD window outboard

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- Inboard window on any DU with only half PFD window outboard and no EICAS window inboard
- Any DU window (inboard or outboard) with a full map/plan
- Map/plan window (inboard or outboard) when two half windows are available with one window having map/plan
- Outboard window when two half windows are available with none of them displaying map/plan, EICAS, or PFD.

When the TCAS pop-up display, shown in Figure 19-23, is activated, TCAS shown on the INAV portion of the MFD window is removed as long as the pop-up display is active. The map display returns when the pop-up deactivates, and the Traffic box on the Map or Plan dropdown menu is reselected. The TCAS pop-up format is also deactivated by selecting the checklist display using the **Checklist** button on the map pop-up menu.

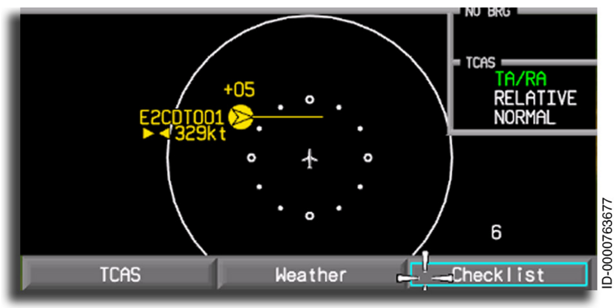

Figure 19-23
Pop-Up Display

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A range ring is displayed in the TCAS pop-up format. A spatial reference is given for the distance of the displayed intruders. The range ring is positioned in the center of the zoom display and is positioned horizontally and vertically, so the top of the ring is in view at the top of the zoom display, but only 240 degrees of arc are shown. The range readout is displayed in the lower-right corner of the display (6 in Figure 19-23). The range readout is adjusted by selecting the TCAS menu, moving the cursor to Range, and rotating the CCD inner concentric knob, as shown in Figure 19-24.

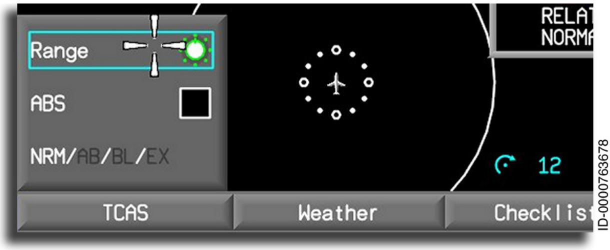

Figure 19-24
Range Control

The CCD inner concentric knob icon is displayed to the left of the TCAS zoom range readout when the CCD inner knob is used to set range. Only one rate of adjustment is used to adjust the range, and the value increases or decreases in one-range increments for each click of the knob. Clockwise rotation increases the TCAS zoom range value. Counterclockwise rotation decreases the value. The TCAS zoom range is a linear scale where the maximum and minimum values are the limits of the scale. When the range value reaches the maximum or minimum value, the readout stays at that value. Knob turns above the maximum and below the minimum have no effect. The first knob click in the opposite direction begins to increase or decrease back through the available ranges.

NOTE: The zoom range selection affects only the zoom format.

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The 3-NM range ring gives a unique symbolic reference to determine the proximity of the traffic targets. The 3-NM range ring is a ring of 12 small circles (or dots) positioned in the center of the TCAS zoom format, placed in a radius of 3 NM around the aircraft symbol. The circles are arranged so that one circle is positioned every 30 degrees (e.g., 0, 30, and 60 degrees). The circles placed at 0, 90, 180, and 270 degrees are larger in diameter than the remaining circles. The diameter of the 3-NM range ring is scaled to reflect the selected zoom range.

The 3-NM range ring is displayed when the TCAS zoom range is 6 NM, 12 NM, or 20 NM and not labeled. The range of the zoom format defaults to 6 NM each time the TCAS pop-up window is displayed. When an RA or TA is detected, the range is automatically reset to 6 NM when the zoom format is displayed at a range of more than 12 NM.

The TCAS menu and CCD are used to select TCAS range, normal, expanded, above, or below modes, and absolute or relative altitude for the on-side displays.

NO-BEARING TARGETS

When the direction of intruder traffic cannot be determined or is invalid, a No Bearing TA or No Bearing RA is given.

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When the TCAS display on the MFD is active, a No Bearing TA and No Bearing RA can be displayed above the TCAS status callout on the MFD. The associated image depicts a TA intruder 12 NM away, 400 feet below, climbing at more than 500 FPM. It also depicts an RA intruder 9.0 NM away, 600 feet above, descending at more than 500 FPM.

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TCAS AURAL ALERTS

Aural alerts are announced over the aircraft audio system, listed in Table 19-1 and Table 19-2. The aural alert audio levels are preset and not crew-adjustable. The alerts accompany the visual TA and RA displays, and the audio is softened or strengthened based on the urgency of the situation.

Traffic Advisory Aural Alerts

Table 19-1 lists the TA aural alert messages.

Table 19-1
TA Aural Alert Messages

TA Aurals	Meaning
TRAFFIC - TRAFFIC	This alert occurs when TCAS predicts an intruder enters the collision area in 35 to 45 seconds. At the same time, the TCAS traffic display shows the location of the intruder.

Resolution Advisory Aural Alerts

Table 19-2 lists the RA aural alert messages.

Table 19-2
RA Aural Alert Messages

RA Aurals	Meaning
MONITOR VERTICAL SPEED	Certain changes in vertical speed are not safe.
MAINTAIN VERTICAL SPEED, MAINTAIN	Maintain current vertical rate.
MAINTAIN VERTICAL SPEED, CROSSING MAINTAIN	Promptly adjust vertical speed to the rate indicated.
CLIMB - CLIMB	Immediately begin to climb at the rate indicated.
DESCEND - DESCEND	Immediately begin to descend at the rate indicated.
ADJUST VERTICAL SPEED, ADJUST	Smoothly adjust the vertical speed to the rate indicated.

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Table 19-2 (cont)
RA Aural Alert Messages

RA Aurals	Meaning
CLIMB, CROSSING CLIMB – CLIMB, CROSSING CLIMB	Start a climb at the indicated rate. The flight paths of this aircraft and the intruder cross at present altitude.
DESCEND, CROSSING DESCEND – DESCEND, CROSSING DESCEND	Start a descent at the indicated rate. The flight paths of this aircraft and the intruder cross at present altitude.
INCREASE CLIMB – INCREASE CLIMB	Immediately increase climb rate.
INCREASE DESCENT – INCREASE DESCENT	Immediately increase descent rate.
CLIMB, CLIMB NOW! – CLIMB, CLIMB NOW!	This message follows a descent advisory when TCAS has determined that a reversal of vertical speed is necessary to give adequate separation.
DESCEND, DESCEND NOW! – DESCEND, DESCEND NOW!	This message follows a climb advisory when TCAS has determined that a reversal of vertical speed is necessary to give adequate separation.
CLEAR OF CONFLICT	Confirms the encounter has ended and the separation is increasing.

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Aural Warning Inhibit Conditions

Certain TCAS warnings are inhibited under the following conditions:

- No increase descent commands are issued at altitudes less than 1,450 feet above ground level (AGL) when the aircraft is descending or at altitude less than 1,650 feet AGL when the aircraft is climbing.
- No descent commands are issued at altitudes less than 1,000 feet AGL when the aircraft is descending or at altitudes less than 1,200 feet AGL when the aircraft is climbing.
- No RAs are issued at altitudes less than 900 feet AGL when the aircraft is descending or at altitudes less than 1,100 feet AGL when the aircraft is climbing.
- No TAs are issued when the intruder altitude is less than 380 feet AGL.
- No aural advisories are issued at altitudes less than 400 feet AGL when the aircraft is descending or at altitude less than 600 feet AGL when the aircraft is climbing.

NOTE: The altitudes previously discussed are determined using the radio altimeter system.

- No “**CLIMB**” or “**INCREASE CLIMB**” RAs are issued above 34,000 feet.

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20. Enhanced Ground Proximity Warning System (EGPWS)

INTRODUCTION

The purpose of the enhanced ground proximity warning system (EGPWS) is to prevent accidents that are a result of controlled flight into terrain (CFIT) or severe windshear. It also provides terrain threat data to other aircraft systems.

In addition, the EGPWS provides alerts for excessive deviation from ILS glideslopes, radio altitude callouts during final approach, and **"Too Low"** alerts when flaps or gear are not in landing configuration.

As an option, bank angle and altitude callouts are provided based on system configuration.

The system operates by accepting a variety of aircraft parameters as inputs, applying alerting algorithms, and supplying the flight crew with auditory and textual display annunciations. For terrain conflicts, the system also indicates (graphically) the height of the nearby terrain in the event that any of the boundaries of the alerting envelopes are exceeded.

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The system is comprised of the following groups of components:

- Aircraft sensors and other systems providing input signals.
- The enhanced ground proximity warning function (EGPWF) hosted as a software function on a line replaceable module (LRM) within the module avionics unit (MAU). The EGPWF block diagram is shown in Figure 20-1.

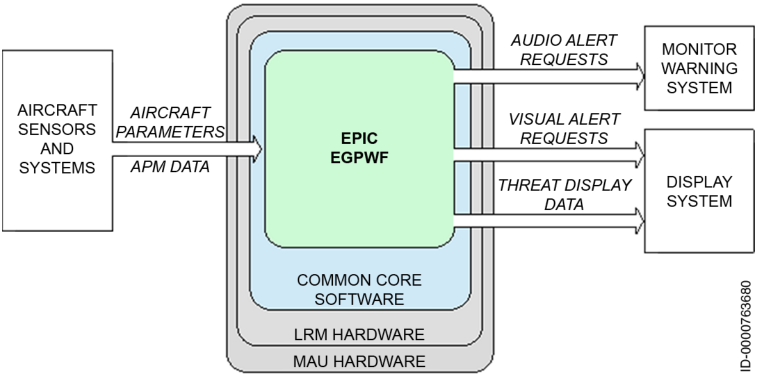

Figure 20-1
EGPWF Block Diagram

NOTE: References throughout this guide to the software functional areas and features not specific to the hardware component will be referenced as the enhanced ground proximity warning system (EGPWS).

- Flight deck audio systems (speakers and intercom) driven by the monitoring warning system (MWS) receive voice requests from the EGPWF and pass the requests to the audio system for generating the voice alerts.
- Flight deck visuals through displays for alert and system status messages.
- INAV and VSD display of terrain/obstacle threat data.

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Several main alerting functional areas are integrated into the EGPWS. The functional areas are:

- Basic ground proximity warning
- Terrain clearance floor (TCF)
- Terrain/obstacle awareness and alerting and warning
- Altitude awareness callouts (option)
- Excessive bank angle alert (option)
- Windshear detection and alerting (option)
- SmartRunway/SmartLanding (SR/SL) (option).

NOTE: SmartRunway/SmartLanding will continue to be called runway awareness and advisory system (RAAS) from a cockpit/pilot perspective with new monitors such as approach monitor, takeoff flaps monitor, and altimeter monitors added.

In addition to the main functions, the EGPWS also performs the following auxiliary functions:

- Input signal processing (including filtering and signal monitoring)
- Alert output processing (including alert processing, voice message requests, and display visual annunciation requests)
- Built-in test (BIT) and monitoring (including cockpit-activated self-test)
- Interface with central maintenance computer (CMC) maintenance systems when the aircraft is on the ground
- Interface for downloading flight warning and fault history through maintenance local area network (LAN).

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Figure 20-2 shows a simplified block diagram of the EGPWS.

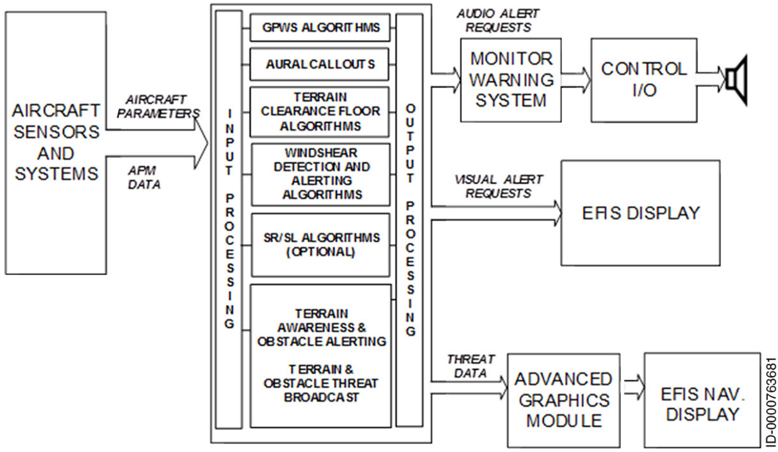

Figure 20-2
EGPWS Simplified Block Diagram

The EGPWS contains a worldwide terrain database. The resolution of the database varies not only with location around the world but also relative to the proximity to airports. The database also contains the locations of all runways longer than 3,200 feet that have a published instrument approach. The system uses this database and position data to supply enhanced terrain awareness computations, which, in turn, supply enhanced terrain awareness information to the pilots.

The display interface is shown in Figure 20-3.

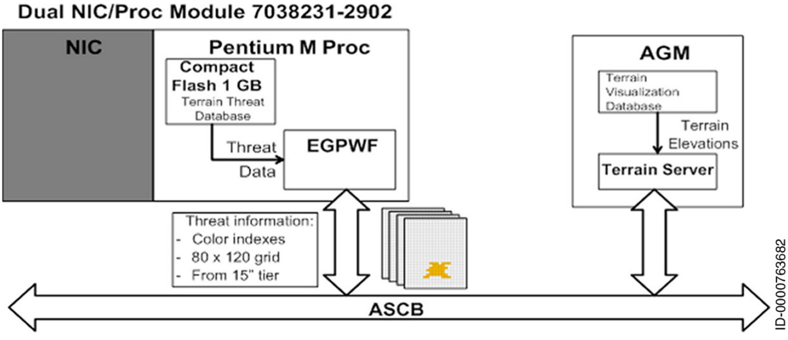

Figure 20-3
EGPWS Display Interface

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AUDIO REQUESTS

The EGPWS always generates an aural notification when a caution or warning condition exists. Numerous different aural notifications are possible. More than one aural alert can be active at a time (e.g., when more than one caution or warning condition is active at one time). When more than one notification is active at the same time, the notification with the highest priority takes precedence.

The following defines the tones, aural priority, and voices required for the EGPWS.

Tones

Two tones are used in the system (selectable based on the EGPWS audio menu APM option):

- **"WHOOP - WHOOP"** – A linearly swept tone (frequency and amplitude)
- **"SIREN"** – A European-style alternating tone siren.

Aural Priorities

In case more than one warning condition exists, the following aural prioritization, starting with the highest, is used within the EGPWS to drive the voice request output:

- Windshear warning (Mode 7)
- Sink rate pull-up warning (Mode 1)
- Terrain closure pull-up warning (with preface – Mode 2)
- Terrain or obstacle awareness pull-up warning (with preface – terrain awareness display – TAD)
- Terrain (Mode 2B/Mode 2A Altitude Gain)
- Minimums type (Mode 6)
- Terrain or obstacle awareness caution (TAD)
- Too low terrain (Mode 4)
- Too low terrain (TCF)
- Altitude callouts (Mode 6)

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- Too low gear (Mode 4)
- Too low flaps (Mode 4)
- Sink rate (Mode 1)
- Don't sink (Mode 3)
- Glideslope (Mode 5)
- Approaching minimums type (Mode 6)
- Bank angle (Mode 6)
- Windshear caution (Mode 7 voice option)
- SR/SL (option).

SR/SL Voice Messages

The SR/SL voice messages are issued based on the following priority:

- Approach Monitor Caution
- Takeoff Flap Alert
- Long Landing Monitor
- RAAS Cautions
- Approach Monitor Advisories
- Corrected Altimeter Monitors
- RAAS Advisories.

RAAS advisories are mutually exclusive in annunciation. In the event that multiple RAAS advisories occur at the same time, the advisories are issued in the following order:

- Approaching runway (in-air)
- Approaching short runway (in-air)
- On runway (on-ground)
- Intersection departure – insufficient runway length
- Approaching runway (on-ground)

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- Taxiway takeoff
- Extended holding
- Runway end.

The taxiway takeoff advisory is the only RAAS advisory that can interrupt another RAAS advisory. The advisory does not interrupt other EGPWS cautions and warnings.

The distance remaining advisories are not included in the advisory priority list previously. These advisories cannot be enabled when the previously listed advisories are enabled.

Table 20-1 lists the EGPWS modes and aural warnings.

Table 20-1
EGPWS Modes and Voice Outputs

Mode	Name	Voice Outputs (Based on Audio Menu Option Selected)
1	Excessive descent rate	**SINK RATE** (pause) **SINK RATE** **SINK RATE** (Whoop-Whoop) **PULL UP** (pause) **PULL UP** (pause)
2	Excessive terrain closure rate	**TERRAIN TERRAIN** (then continuous) **PULL UP...** **TERRAIN TERRAIN** (then continuous) (Whoop-Whoop) **PULL UP...**
3	Sink after takeoff	**DON'T SINK** (pause) **DON'T SINK**
4/TCF	Too close to terrain/operation around the airport	**TERRAIN** (pause) **TERRAIN** **TOO LOW-TERRAIN**
5	Excessive deviation below glideslope	**GLIDESLOPE** **GLIDESLOPE GLIDESLOPE** (3-second pause)

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Table 20-1 (cont)
EGPWS Modes and Voice Outputs

Mode	Name	Voice Outputs (Based on Audio Menu Option Selected)
6	Excessive bank angle Decision height Minimums/ Approaching minimums	**BANK ANGLE** (pause) **BANK ANGLE** **BANK ANGLE BANK ANGLE** **DECISION HEIGHT** **MINIMUM** **MINIMUMS** **MINIMUMS MINIMUMS** **DECIDE** (female) **APPROACHING DECISION HEIGHT** **APPROACHING MINIMUMS**
	Altitude callouts	**PLUS HUNDRED** **FIFTY ABOVE** (female) **RADIO ALTIMETER** (male) **RADIO ALTIMETER** (female) **TWENTY FIVE HUNDRED** **ONE THOUSAND** **FIVE HUNDRED** **FOUR HUNDRED** **THREE HUNDRED** **TWO HUNDRED** **ONE HUNDRED** **EIGHTY** **SIXTY** **FIFTY** **FORTY** **THIRTY FIVE** **THIRTY** **TWENTY** **TEN** **FIVE**

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Table 20-1 (cont)
EGPWS Modes and Voice Outputs

Mode	Name	Voice Outputs (Based on Audio Menu Option Selected)
7	Windshear	Siren (option) **WINDSHEAR WINDSHEAR WINDSHEAR** **WINDSHEAR WINDSHEAR WINDSHEAR** **CAUTION WINDSHEAR**
TAD	Terrain Awareness Alerting with threat data provided to the Display	**CAUTION TERRAIN** (pause) **CAUTION TERRAIN** (repeat every 10 seconds) **CAUTION OBSTACLE** (pause) **CAUTION OBSTACLE** (repeat every 10 seconds) **OBSTACLE AHEAD** (pause) **OBSTACLE AHEAD** (repeat every 10 seconds) **TERRAIN AHEAD** (pause) **TERRAIN AHEAD** (repeat every 10 seconds) **TERRAIN TERRAIN** (then continuous) **PULL UP...** **TERRAIN TERRAIN** (then continuous) (Whoop-Whoop) **PULL UP...** **OBSTACLE OBSTACLE** (then continuous) **PULL UP...** **OBSTACLE OBSTACLE** (then continuous) (Whoop-Whoop) **PULL UP...** **TERRAIN AHEAD PULL UP** (pause) **OBSTACLE AHEAD PULL UP** (pause)

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Table 20-1 (cont)
EGPWS Modes and Voice Outputs

Mode	Name	Voice Outputs (Based on Audio Menu Option Selected)
SR/SL	SmartRunway/ SmartLanding	The following words can be included in an SR/SL aural message phase, depending on SR/ SL APM selections: **UNSTABLE-UNSTABLE**, **FLAPS** (pause) **FLAPS**, **LONG LANDING** or **DEEP LANDING**, **TOO HIGH-TOO HIGH**, **TOO FAST-TOO FAST**, **FLAPS** (pause) **FLAPS** or **FLAPS-FLAPS**, **ALTIMETER SETTING**
RAAS	Runway Awareness and Advisory	The following words can be included in a RAAS advisory message phrase with all phrases being either a male or female voice, depending on the RAAS APM selections: **ZERO**, **ONE**, **TWO**, **THREE**, **FOUR**, **FIVE**, **SIX**, **SEVEN**, **EIGHT**, **NINE**, **TEN**, **ELEVEN**, **TWELVE**, **THIRTEEN**, **FOURTEEN**, **FIFTEEN**, **SIXTEEN**, **SEVENTEEN**, **EIGHTEEN**, **NINETEEN**, **TWENTY**, **THIRTY**, **FORTY**, **FIFTY**, **SIXTY**, **SEVENTY**, **EIGHTY**, **NINETY**, **HUNDRED**, **THOUSAND**, **APPROACHING**, **AVAILABLE**, **CENTER**, **LEFT**, **RIGHT**, **ON RUNWAY**, **ON TAXIWAY**, **REMAINING**, **RUNWAY**, **TRUE**, **FEET**, **METERS**.

NOTES
1. The numbering of the modes is derived from the history of the development of GPWS and does not imply any special hierarchy.
2. An audio declutter feature, which is standard, activates the voice alert once, then not again, unless the situation has degraded by 20%. This feature applies to modes 1, 3, 4, and 5.
3. Unless otherwise indicated, (pause) listed in the table implies a 0.75-second quiet period.

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Self-Test Aural Notifications

The following aural notifications are used to report system status during the system self-test:

- “GPWS Inop”
- “Glideslope Inop”
- “Terrain INOP”
- “Bank Angle INOP
- “Callouts INOP”
- “Runway Awareness INOP”
- “Approach Monitor INOP”
- “Takeoff Flaps Monitor INOP”
- “Altimeter Monitor INOP”
- “GPWS Inhibited”
- “Terrain Inhibited”
- “Self Test Inhibited”
- “Runway Awareness Inhibited”
- “Approach Monitor Inhibited”
- “Takeoff Flaps Monitor Inhibited”
- “Altimeter Monitor Inhibited”
- “Steep Approach Activated”
- “Runway Awareness OK, Feet (or Meters)”
- “Runway Awareness Not Available”
- “Approach Monitor Not Available”
- “Takeoff Flaps Monitor Not Available”
- “Altimeter Monitor Not Available.”

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EGPWS ENHANCED FEATURES

The enhanced GPWS adds to the seven basic functions with the ability to compare the aircraft position to an internal database and provide additional alerting and display capabilities for enhanced situational awareness and safety. The EGPWS incorporates several enhanced features:

- **Terrain Alerting and Display (TAD)** – TAD provides a graphic display of the surrounding terrain on the EFIS display. Based on the aircraft position and the internal database, the terrain topography (within the display range selected) is presented on the system display.
- **Obstacles** – Obstacles is a feature utilizing an obstacle database for obstacle conflict alerting and display. EGPWS caution and warning visual and audio alerts are provided when a conflict is detected. Obstacles are graphically displayed, similar to terrain.
- **Envelope Modulation** – Envelope modulation is a process feature that utilizes the internal database to tailor EGPWS alerts at certain geographic locations to reduce nuisance alerts and provide added protection. This feature is automatic and requires no flight crew action. Modes 4, 5, and 6 are expanded at certain locations to provide alerting protection consistent with normal approaches. Modes 1, 2, and 4 are desensitized at other locations to prevent nuisance alerts that result from unusual terrain or approach procedures. In all cases, very specific information is used to correlate the aircraft position and phase of flight (POF) prior to modulating the envelopes.
- **Terrain Clearance Floor (TCF)** – TCF adds an additional element of protection by alerting the pilot of possible premature descent. This is intended for nonprecision approaches and is based on the current aircraft position relative to the nearest runway.
- **Runway Field Clearance Floor (RFCF)** – RFCF is similar to the TCF feature except that RFCF is based on the aircraft position and height above the destination runway based on geometric altitude (see the following description). This provides improved protection at locations where the destination runway is significantly higher than the surrounding terrain.

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- **SmartRunway/SmartLanding (SR/SL)** – SR/SL is an enhancement that uses GPS position data and the EGPWS database to provide aural advisories and some cautions that supplement flight crew awareness of position during ground operations and on approach to landing. When enabled, SR/SL operates automatically without any action required by the flight crew.
- **Aural Declutter** – The aural declutter feature reduces repetition of warning messages. This feature is always enabled.
- **Geometric Altitude** – Geometric altitude, based on GPS altitude, is a computed pseudo-barometric altitude designed to reduce or eliminate altitude errors resulting from temperature extremes, nonstandard pressure altitude conditions, and altimeter mis-sets. This ensures an optimal EGPWS alerting and display capability.

EGPWS DATABASES

The following databases are stored in nonvolatile memory within the LRM hosting the EGPWF:

- Terrain (Threat) Database
- Envelope Modulation Database.

Updates are accomplished by the aircraft LAN using a compact disk (CD) dataloader (onboard or portable). The status of each database is accessible by the CMC.

Terrain Database

The terrain database (also referred to as the threat database) contains terrain, obstacle, runway, and magnetic variation information used by the TAD and TCF/RFCF warning functions.

This database can be updated without affecting the customer-] certified system part number.

TERRAIN DATA

EGPWS terrain processing extracts and formats local topographic terrain data from the terrain database for use by the terrain threat detection. This terrain database divides the earth’s surface into grid sets referenced horizontally on the geographic (latitude/longitude) coordinate system.

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Elements of the grid sets record the highest terrain altitude (MSL) in that element's respective area. Grid sets vary in resolution depending on geographic location. Higher resolution grids are used around airports because the overwhelming majority of controlled flight into terrain (CFIT) accidents occur near airports, and aircraft operate in closer proximity to terrain near an airport. Lower resolution grids are used outside airport areas where aircraft altitude en route makes CFIT accidents unlikely, and detailed terrain features are not important to the flight crew.

Digital elevation models (DEMs) are available for most airports around the world today. In cases where the data are not currently available, DEMs are generated in-house from available topographic maps, sectional charts, and airline approach plates. The process of acquiring, generating, assembling, and updating the database is governed by strict configuration controls to ensure the highest level of data integrity. DEMs from external sources are inputs to this process and are checked and formatted for generation of the terrain database.

The global EGPWS terrain database is organized in a flexible and expandable manner. The complete database is stored in nonvolatile memory within the LRM hosting the EGPWF.

OBSTACLE DATA

In addition to terrain surface data, the terrain database contains obstacle data location and height. Only obstacles deemed to pose a threat are included in this database.

NOTE: The obstacle database is obtained from the National Oceanic and Atmospheric Administration (NOAA). It includes obstacles in the United States and parts of Canada, Mexico, and the Bahamas. It continues to be updated for other parts of the world as data becomes available.

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RUNWAY DATA

The terrain database includes runway data containing the position of airport runway center points along with 1/2 the runway length. The database includes the following:

- All published runways, including some grass fields and hard surface runways that are 3,200 feet or greater in length
- Runway orientation and elevation.

OVERVIEW OF THE EGPWS MODES

The following paragraphs provide functional descriptions of the EGPWS basic and enhanced functions and features and system input and output requirements.

The EGPWS incorporates the functions of the basic GPWS. This includes the following alerting modes:

- **Mode 1** – Excessive descent rate
- **Mode 2** – Excessive terrain closure rate
- **Mode 3** – Altitude loss after takeoff
- **Mode 4** – Unsafe terrain clearance
- **Mode 5** – Excessive glideslope deviation
- **Mode 6** – Advisory callouts
- **Mode 7** – Windshear alerting.

An overview of the functions of the GPWS alerting modes is given in the following paragraphs.

Mode 1 – Excessive Descent Rate

Mode 1 provides alerts when the aircraft has excessive descent rate close to terrain. Mode 1 is active regardless of the POF whenever radio altitude is valid and tracking less than 2,450 feet AGL. Lower level cutoff when using inertial vertical speed (IVS) occurs at 10 feet radio altitude during landing. With IVS, the mode is re-enabled at 30 feet radio altitude during takeoff. The presence of ground effect on the barometric rate data prevents the use close to the ground due to the potential for nuisance warnings. Consequently, Mode 1 is cut off at 30 feet radio altitude and re-enabled at 65 feet radio altitude when this input is used.

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As shown in Figure 20-4, if the aircraft penetrates the outer alert boundary, the voice aural **"SINKRATE"** is generated, and alert discretes are output by the module for driving visual annunciators. The alert aural for penetration of the outer boundary is repeated twice, then remains silent unless the excessive descent rate condition degrades by approximately 20%, as determined by the computed time to impact, in which case, an additional two aurals are given, and the cycle repeats. This situation continues until the alert boundary is exited or until the Mode 1 inner boundary is penetrated.

As shown in Figure 20-4, if the aircraft penetrates the inner boundary, the voice aural **"PULL UP"** (or, as an option, a continuous (**"WHOOP-WHOOP"**) **"PULL UP"**) is generated, and visual alert discretes are also output. The alert boundaries are defined in terms of aircraft vertical speed (barometric vertical speed supplemented by inertial vertical speed when available) and radio altitude.

The graph in Figure 20-4 indicates the actual Mode 1 alert/warning curves considering filter lags and time delays for constant descent rates initiated from 2,450 feet radio altitude over water or flat terrain using IVS for descent rate information. Both the outer and inner curves are shown. There is a 0.8-second delay for the **"SINKRATE"** alert to minimize nuisance warnings as a result of momentary penetration of the outer boundary. There is a delay for the **"PULL UP"** warning to guarantee that at least one **"SINKRATE"** aural is given before the **"PULL UP"** aural starts.

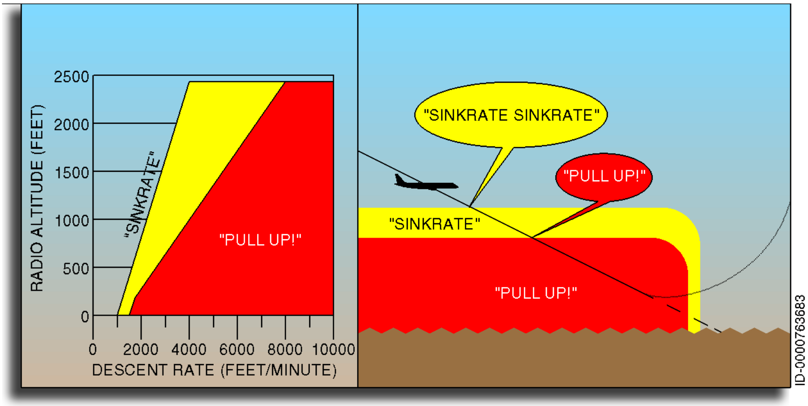

Figure 20-4
Mode 1 - Excessive Descent Rate

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NOTES:

1. *The envelope modulation feature provides improved alerting protection at key locations throughout the world while improving nuisance margins at others. This is made possible with the use of navigational signals from the GPS or FMS. All position data is cross-checked to ground-based navigational aids, altimeter and heading information, and stored terrain characteristics prior to being accepted for envelope modulation purposes. This guards against possible navigational position errors.*

2. *The Mode 1 outer boundary alert (**"SINKRATE"**) is desensitized when the aircraft is above the glideslope beam. This prevents unwanted alerts when the aircraft is safely capturing the glideslope (or repositioning to the centerline) from above the beam.*

3. *Radio altitude excessive rate detection helps prevent warnings as a result of erroneous radio altitude tracking conditions. Sudden changes in radio altitude can occur when the altimeter starts tracking the ground after being out of range or during overflight of another aircraft. If not ignored, these conditions can result in nuisance Mode 2, Mode 4, or TCF alerts. All radio altitude inputs are independently monitored and are set invalid if the computed radio altitude rate exceeds specified limits.*

4. *Outer curve violations activate the* **GND PROX** *annunciator. Inner curve violations activate the* **PULL UP** *annunciator. Note that the actual display text is independent of the EGPWS.*

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Mode 2 – Excessive Terrain Closure Rate

Mode 2 provides alerts when the aircraft is closing in with the terrain at an excessive rate. Mode 2 is active regardless of the POF whenever radio altitude is valid and tracking less than 2,450 feet AGL. It is not necessary for the aircraft to be descending in order to produce a Mode 2 alert. Level flight (or even a climb) towards obstructing terrain can result in a hazardous terrain closure rate. The terrain closure rate variable is computed within the EGPWS module by combining radio altitude and vertical speed in a nonlinear complementary filter.

Mode 2 has two submodes, referred to as Mode 2A and Mode 2B, the active submode being determined by aircraft configuration. The Mode 2A alerting envelope is shown in Figure 20-5.

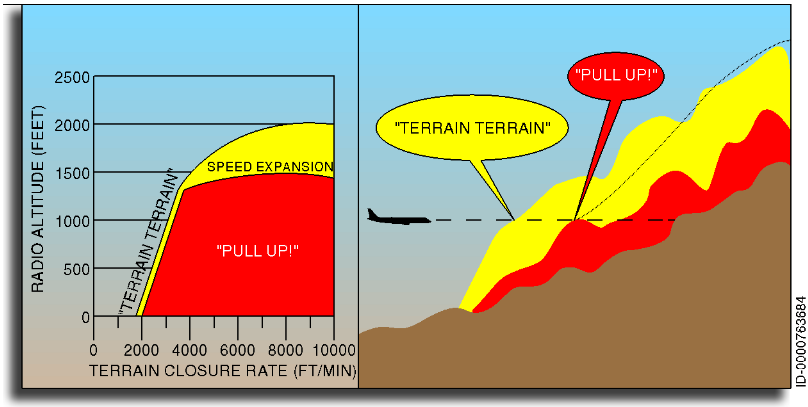

Figure 20-5
Mode 2A - Excessive Terrain Closure Rate

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NOTES:

1. *Outer curve violations activate the* **GND PROX** *annunciator. Inner curve violations activate the* **PULL UP** *annunciator. Note that the actual display text is independent of the EGPWS.*

2. *The Mode 2A upper limit is reduced to 950 feet for all airspeeds when the TAD function is enabled and available. This is due to the enhanced alerting capability provided with TAD, resulting from high-integrity GPS altitude and geometric altitude data. The Mode 2A envelope is lowered in order to reduce the potential for nuisance alerts during an approach.*

3. *The maximum upper boundary is 1,650 feet radio altitude for speeds below 220 knots. As the aircraft speed increases up to 310 knots, the upper boundary increases linearly to a maximum value of 2,450 feet radio altitude. For speeds above these values, the upper limit remains at 2,450 feet.*

MODE 2A

Mode 2A is active during climbout, cruise, and initial approach (flaps not in landing configuration and the aircraft is not on glideslope centerline). If the aircraft penetrates the Mode 2A alerting envelope, the voice aural **“TERRAIN TERRAIN”** is generated initially, and the visual cockpit EGPWS **CAUTION** annunciators are activated.

If the aircraft continues to penetrate the envelope, the visual cockpit EGPWS **WARNING** annunciators are activated, and the voice aural **“PULL UP”** is repeated continuously until the warning envelope is exited (**”PULL UP”** may be preceded by the Whoop-Whoop sound in some configurations based on the audio menu option selected).

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MODE 2A ALTITUDE GAIN

When the Mode 2A envelope is exited after being violated for more than 3 seconds, an altitude gain feature is automatically activated. Altitude (MSL) is sampled at this time to compute subsequent changes in altitude. The alert visual remains on, and if the terrain is still closing, the voice aural is **"TERRAIN"** or equivalent.

On exiting the warning envelope, if terrain clearance continues to decrease, the aural reverts to **"TERRAIN TERRAIN"** and is given until the terrain clearance stops decreasing. The visual alert remains on until the aircraft has gained 300 feet of barometric altitude or 45 seconds have elapsed. At that point, all visual alerts stop. The altitude gain requirement can also be canceled by momentarily selecting the flap override switch. If the terrain starts to fall away during this altitude gain time, the aural shuts off. In addition, if the radio altimeter goes out of track (no computed data - NCD), then both the altitude gain visual and aural are disabled.

If another envelope penetration occurs during this altitude gain time and it lasts long enough to restart the **"PULL UP"** warning plus 3 seconds, then the whole process begins again with a new reference point for the 300-foot gain feature. In this manner, the aircraft is directed up and over the terrain to a safer altitude.

MODE 2B

Mode 2B provides a desensitized alert envelope permitting normal landing approach maneuvering close to the terrain without producing unwanted alerts. Mode 2B is automatically selected under the following four conditions:

- When flaps are selected to the landing position
- If the aircraft is performing an ILS approach and the glideslope and localizer deviations are less than ±2 dots
- If the aircraft is within 10 miles and 3,500 feet of the destination runway and the terrain awareness function is enabled and of high integrity
- For the first 60 seconds after takeoff.

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If the aircraft penetrates the Mode 2B envelope, as shown in Figure 20-6, with either gear or flaps not in landing configuration, the voice aural **"TERRAIN TERRAIN"** is generated initially, and visual cockpit EGPWS **CAUTION** annunciators are activated. If the aircraft continues to penetrate the envelope, then the voice aural **"PULL UP"** is repeated continuously until the warning envelope is exited. If the aircraft penetrates the Mode 2B envelope with both gear and flaps in landing configuration, the voice aural **"TERRAIN"** is repeated until the envelope is exited.

Lowering the flaps to the landing position automatically switches to Mode 2B. This static envelope is the same as the Mode 2A envelope, except the upper boundary has been lowered to 789 feet due to a maximum allowed closure rate of 3,000 FPM.

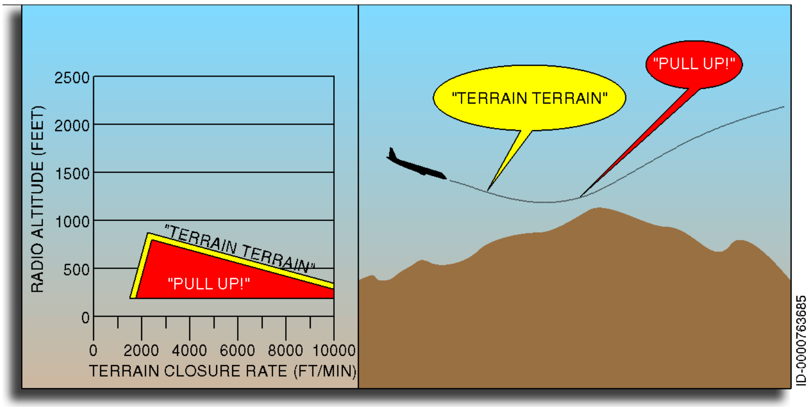

Figure 20-6
Mode 2B – Excessive Terrain Closure Rate

The Mode 2B envelope is selected automatically during the first 60 seconds after takeoff. This is to eliminate the false terrain warnings that can occur during certain cases of erroneous low range radio altitude (LRRA) tracking after takeoff. What occurs is typically a sharp increase, followed by a sharp decrease in the altitude output between 1,000 and 1,500 feet AGL. This Mode 2 takeoff mode effectively prevents Mode 2 warning for altitudes above 789 feet AGL.

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Mode 3 – Altitude Loss After Takeoff

Mode 3 provides alerts when the aircraft loses a significant amount of altitude immediately after takeoff or go-around when landing gear or flaps are not in landing configuration. Mode 3 stays enabled until the EGPWS detects that the aircraft has gained sufficient altitude that it is no longer in the takeoff POF.

The altitude loss variable is based on the altitude (MSL) value from the time of the beginning of the inadvertent descent. The amount of altitude loss, which is permitted before an alert is given, is a function of the height of the aircraft above the terrain, as shown in Figure 20-7.

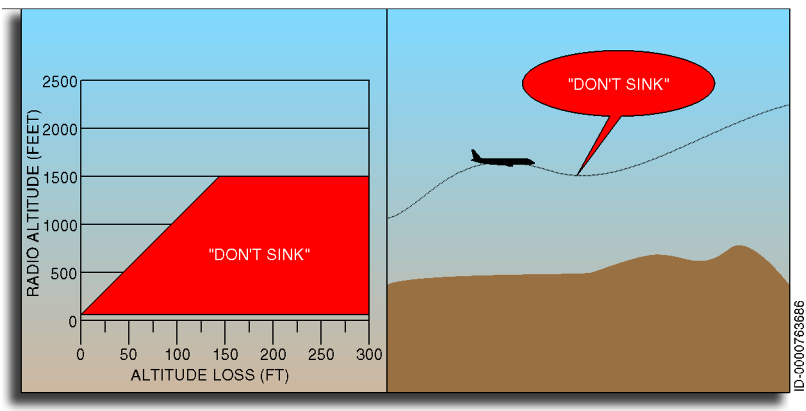

Figure 20-7
Mode 3 – Altitude Loss After Takeoff

If the aircraft penetrates the Mode 3 boundary, the voice aural **"DON'T SINK DON'T SINK"** is generated, and alert discretes are provided for activation of visual annunciators. The visual annunciators remain until a positive rate of climb is re-established.

NOTES: 1. *A curve violation activates the* **GND PROX** *annunciator. Note that the actual display text is independent of the EGPWS.*

2. *As an option, Mode 3 may be configured to say* ***"SINKRATE SINKRATE."***

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Mode 4 – Unsafe Terrain Clearance

Mode 4 provides alerts for insufficient terrain clearance with respect to POF and speed. Mode 4 exists in three forms—4A, 4B, and 4C.

- Mode 4A, shown in Figure 20-8, is active during cruise and approach with gear not in landing configuration
- Mode 4B, shown in Figure 20-9, is also active in cruise and approach, but with gear in landing configuration
- Mode 4C, shown in Figure 20-10, is active during the takeoff POF with either gear or flaps not in landing configuration.

Mode 4 alerts activate the visual EGPWS **CAUTION** annunciators and aural messages.

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MODE 4A

Mode 4A is active during cruise and approach with gear and flaps up. This provides alerting during cruise for inadvertent flight into terrain where terrain is not rising significantly, or the aircraft is not descending excessively. It also provides alerting for protection against an unintentional gear-up landing.

As shown in Figure 20-8, the standard upper boundary for Mode 4A is at 500 feet radio altitude. If the aircraft penetrates this boundary with the gear still up, the voice aural is **"TOO LOW GEAR."** Above190 knots, the upper boundary increases linearly with airspeed to a maximum of 1,000 feet radio altitude at 250 knots or more. Penetrating this boundary produces a **"TOO LOW TERRAIN"** aural.

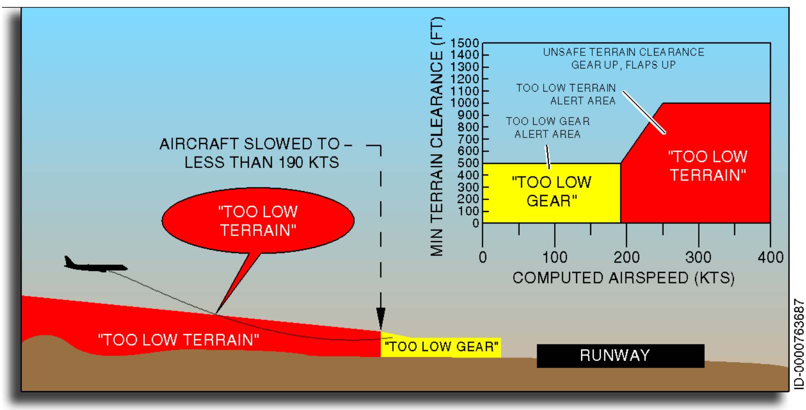

Figure 20-8
Mode 4A – Unsafe Terrain Clearance – Gear Up

For either Mode 4A alert, subsequent alert messages occur only if penetration of the envelope increases by 20%. The visual EGPWS **CAUTION** annunciators deactivate and aural messages cease when the Mode 4A alert envelope is exited.

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MODE 4B

Mode 4B is active during cruise and approach, with gear down and flaps not in the landing configuration.

When the landing gear is lowered, the upper boundary decreases to 245 feet. This is reduced to 150 feet on those aircraft types that routinely delay full flap deployment until the airfield is within approximately 1 NM. Penetration below 159 knots results in the **"TOO LOW GEAR"** message with gear up or the **"TOO LOW FLAPS"** message with gear down and flaps not in landing configuration, while above 159 knots, the message is **"TOO LOW TERRAIN**," as shown in Figure 20-9.

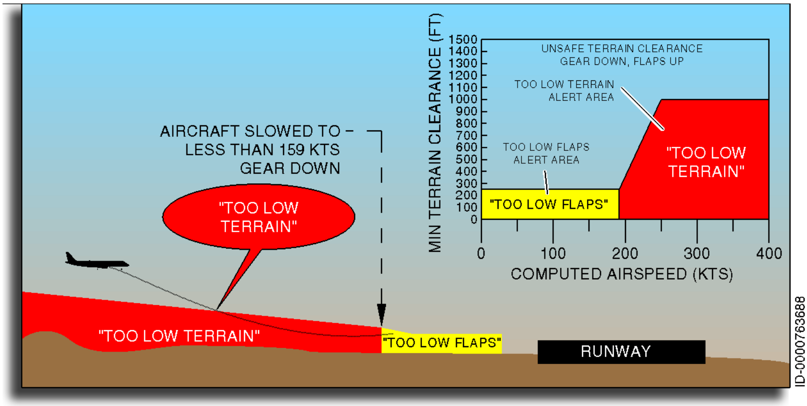

Figure 20-9
Mode 4B – Unsafe Terrain Clearance – Gear Down

As an option, the Mode 4B envelope can be selected by setting flaps to landing configuration for installations selecting the alternate Mode 4B APM option. This allows additional maneuvering room for marginal performance go-arounds (e.g., engine out) by selecting flap override.

For either Mode 4B alert, subsequent alert messages occur only if penetration of the envelope increases by 20%. The visual EGPWS **CAUTION** annunciators deactivate and aural messages cease when Mode 4B alert envelope is exited.

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The Mode 4A and 4B maximum altitudes are reduced under different circumstances to help reduce nuisance alerts. First, through envelope modulation, lower maximums are used at certain airports where operational procedures and terrain characteristics may result in potential nuisance warnings. Second, the maximums are reduced when terrain inhibit is not selected, and either of the following is true:

1. Terrain clearance floor function is fully operational (in track valid radio altitude), or
2. Terrain awareness high integrity is true. Terrain awareness high integrity is indicated when the terrain awareness function is fully operational (horizontal position is valid, vertical position [by way of terrain awareness VFOM] is of sufficient accuracy, and terrain data is of sufficient quality).

The Mode 4A and Mode 4B boundary logic are described in further detail as follows:

- With flaps up and flap override not selected and terrain awareness high integrity false and terrain clearance floor not operational, the upper boundary increases linearly with airspeed to a maximum value of 1,000 feet radio altitude at 250 knots or more. Penetration of this airspeed expanded boundary produces a **“TOO LOW TERRAIN”** aural.
- With flaps up and flap override not selected and terrain awareness high integrity true or terrain clearance floor operational, the upper boundary stays constant to a value of 500 feet radio altitude. Penetrating this airspeed expanded boundary produces a **“TOO LOW TERRAIN”** aural.
- With Flaps Down or with Flap Override selected, there is no airspeed expansion. In this case, the upper boundary stays at 500 feet, and the aural is always **“TOO LOW GEAR**.”

NOTE: The flaps down effect for Mode 4A only occurs if APM option Alternate Mode 4B is not selected; because if Alternate Mode 4B is selected, lowering the flaps terminates Mode 4A and results in a switch to Mode 4B.

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When the landing gear is lowered, or landing flaps are set with Alternate Mode 4B APM option selected, the transition is made to Mode 4B, and the upper boundary decreases to 245 feet. This action is latched and recorded in nonvolatile memory to prevent inadvertent reactivation of the 500-foot boundary during power loss. When the switch is made to Mode 4B (or Alternate Mode 4B), it remains in effect until the aircraft lands or transitions to takeoff mode (as in a touch-and-go).

To maintain the same airspeed expansion function up to 1,000 feet nominal at 250 knots, the lower level corner for Mode 4B is set at 159 knots. Penetration below 159 knots results in the **"TOO LOW GEAR"** aural with gear up, or **"TOO LOW FLAPS"** aural with gear down and flaps not in landing configuration. Above 159 knots, there are two aurals available:

- For Alternate Mode 4B: If landing gear is up and flaps are down, the aural is **"TOO LOW GEAR."** The upper boundary stays constant to a value of 245 feet.
- For Normal Mode 4B: If flaps are up, the aural is **"TOO LOW TERRAIN."** The upper boundary stays constant to a value of 245 feet if terrain awareness high integrity true or terrain clearance floor operational. If terrain awareness high integrity is false, and terrain clearance floor is not operational, the upper boundary increases linearly with airspeed to a maximum value of 1,000 feet radio altitude at 250 knots or more.

Since airspeed expansion is disabled by selecting landing flaps, aircraft configured for Alternate Mode 4B have no airspeed expansion if the switch to Mode 4B was the result of setting the flaps to landing configuration. In this case, the Mode 4B curve is constant at 245 feet, and the gear up alert is **"TOO LOW GEAR."** All Mode 4A/4B alerts are disabled when the aircraft is in full landing configuration.

MODE 4C

The Mode 4C alert is intended to prevent inadvertent controlled flight into the ground during takeoff climb into terrain that produces insufficient closure rate for a Mode 2 alert. After takeoff, Mode 4A and 4B provide this protection.

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Mode 4C is based on a minimum terrain clearance (MTC) floor that increases with radio altitude. It is active after takeoff when the gear or flaps are not in the landing configuration. It is also active during a low altitude go-around if the aircraft has descended below 245 feet AGL.

At takeoff, the MTC is zero feet. As the aircraft ascends, the MTC is increased to 75% of the aircraft radio altitude (averaged over the previous 15 seconds). This value is not allowed to decrease and is limited to 500 feet AGL for airspeed less than 190 knots. Beginning at 190 knots, the MTC increases linearly to the limit of 1,000 feet at 250 knots.

If the aircraft radio altitude decrease to the value of the MTC with gear or flaps up, the visual EGPWS **CAUTION** is annunciated, and the voice aural is **“TOO LOW TERRAIN**.” Mode 4C is shown in Figure 20-10.

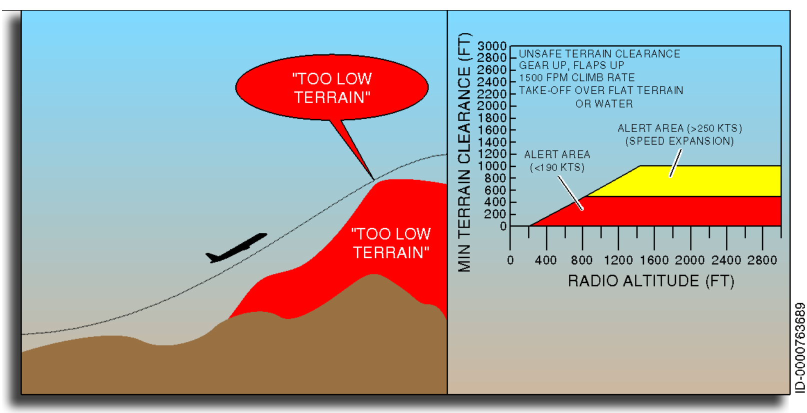

Figure 20-10
Mode 4C – Unsafe Terrain Clearance – At Takeoff

The visual EGPWS **CAUTION** annunciators deactivate, and aural messages cease when Mode 4C alert envelope is exited.

NOTE: To keep Mode 3 versus Mode 4C clear, Mode 3 protects against the aircraft gradually sinking down to terrain, and Mode 4C protects against terrain that is gradually rising.

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MODE 4 BIAS CONDITIONS

Mode 4 alert boundaries can be desensitized as follows:

- **Envelope Modulation** – Through envelope modulation, the standard Mode 4 maximum altitude of 1,000 feet AGL is reduced at certain airports where operational procedures and terrain characteristics may result in potential nuisance warnings.

  Envelope modulation is a feature that provides improved alerting protection at key locations throughout the world while improving nuisance margins at others. This is made possible with the use of navigational signals from the GPS or FMS. All position data is cross-checked to ground-based navigational aids, altimeter and heading information, and stored terrain characteristics prior to being accepted for envelope modulation purposes. This guards against possible navigational position errors.

- **Terrain Awareness High Integrity** – The Mode 4 maximum altitude is reduced to 500 feet when both of the following functions are active and considered to be functioning with high integrity:

  - Terrain awareness
  - Geometric altitude.

- **Overflight Detection** – Current holding patterns can allow a 1,000-foot separation between aircraft. Due to barometric altitude errors, this separation can even be somewhat less than 1,000 feet. If the airspeed is greater than 250 knots, the aircraft is not in landing configuration, an aircraft overflight occurs with less than 1,000-foot separation, a sudden change in radio altitude is detected, and the radio altimeter tracks the overflown aircraft, then a nuisance Mode 4 terrain clearance (**“TOO LOW TERRAIN”**) would normally be activated.

  To prevent these nuisance warnings from occurring, the Mode 4 maximum altitude is lowered from 1,000 to 800 feet of radio altitude when an overflight is detected to ensure that a nuisance warning is not issued. If the high integrity bias is in effect, the maximum altitude is still 500 feet.

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- Mode 4A/B speed expansion is disabled (upper limit held at lowest airspeed limit) when TCF alerting is enabled, or the TAD function is available and of high integrity. This is due to the enhanced alerting capability provided with TAD, resulting from high integrity GPS altitude and geometric altitude data. This change to the Mode 4 envelope reduces the potential for nuisance alerts when the aircraft is not in the landing configuration.

NOTES: 1. A curve violation activates the **GND PROX** *annunciator. Note that the actual display text is independent of the EGPWS.*

*2. As an option, Mode 4 voice aurals can be configured to say **"TERRAIN** (pause) **TERRAIN**."*

Mode 5 – Excessive Glideslope Deviation

Mode 5 provides two levels of alerting when the aircraft flight path descends below the glideslope beam on front course ILS approaches, resulting in the activation of the visual EGPWS **CAUTION** annunciators and aural messages.

The first alert activation occurs whenever the aircraft is below 1,000 feet radio altitude and is more than 1.3 dots below the beam. This turns on the caution annunciations and is called a soft alert because the aural message **"GLIDESLOPE"** is announced at half the volume of the other alerts. The soft alert is suppressed after one aural has been given, but follow-on alerts are permitted when the aircraft descends lower on the glideslope beam by approximately 20% of the Mode 5 curve or 1.56 dots.

NOTE: The actual volume level is not controlled by the EGPWS. The CIO/MWS function recognizes the voice code for the soft alert and issues it at half volume.

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A second alert boundary occurs below 300 feet radio altitude with greater than 2 dots deviation and is called loud or hard glideslope alert because the aural message **"GLIDESLOPE GLIDESLOPE"** is announced at full volume. It is repeated approximately every 5 seconds. Mode 5 is shown in Figure 20-11.

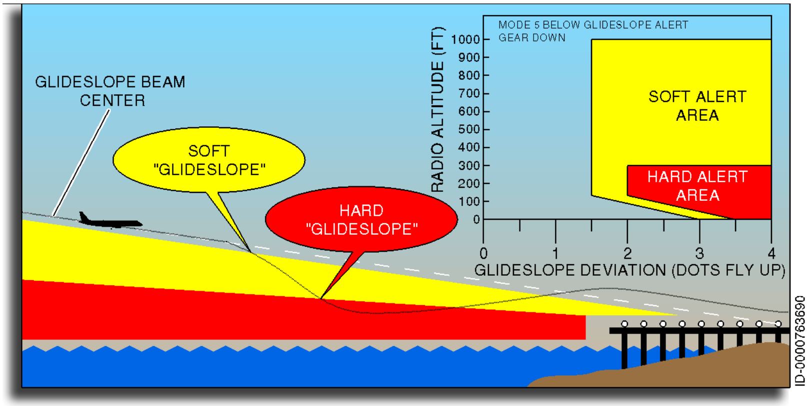

Figure 20-11
Mode 5 – Excessive Glideslope Deviation

MODE 5 BIAS CONDITIONS

Mode 5 alert boundaries can be desensitized (or sensitized) as follows:

- **Envelope Modulation** – Through envelope modulation, the standard Mode 5 maximum altitude of 1,000 feet AGL is increased at certain airports that are significantly higher than the terrain under the approach. In addition, the gear down requirement to enable Mode 5 can be bypassed through the envelope modulation.

- **Localizer Intercept and Minimum Descent Rate** – Unwanted glideslope alerts while capturing the localizer typically occur while laterally capturing the localizer below 1,000 feet and during straight-in level flight intercepts of the localizer. In both cases, localizer capture is occurring inside the outer marker.

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To solve the lateral capture problem when above 500 feet AGL, glideslope warnings are only enabled if the glideslope is within ±2 dots. This reduces nuisance warnings when initially capturing the ILS. Below 500 feet, the glideslope requirement is overridden. Envelope modulation can raise the 500-foot level such that it is 500 feet below the modulated Mode 5 limit.

To solve the level flight intercept problem, the upper altitude limit for the glideslope alert is modulated with vertical speed. For normal descent rates above 500 FPM, the upper limit is maintained at the normal 1,000-foot level. This is then linearly reduced to a bottom limit of 500 feet for level flight or climb rates. For a level flight intercept of the localizer, no glideslope alert is possible until 500 feet AGL is reached. In all cases, if the altitude rate is invalid, then the nominal 1,000-foot AGL Mode 5 enable altitude is used. Note that this change also has the additional benefit of shutting off the glideslope alert when the pilot corrects the flight path back up towards the glideslope after receiving an alert.

NOTE: The inhibit panel, shown in Figure 20-12, is used to inhibit EGPWS terrain awareness alerting (using GND PROX TERR INHIB) and EGPWS Mode 5 glideslope (using GND PROX G/S INHIBIT).

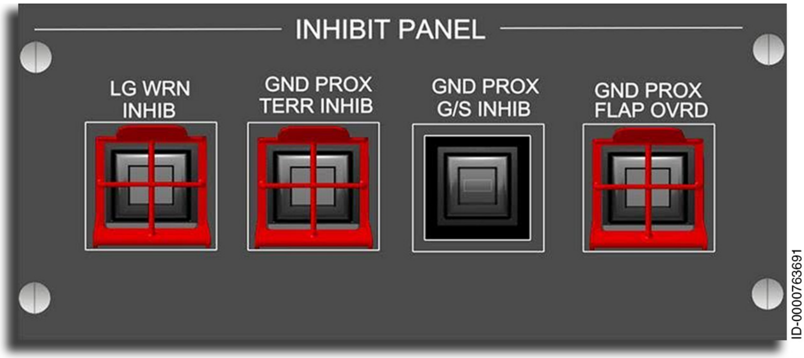

Figure 20-12 Inhibit Panel

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- **Glideslope Cancel** – There are two ways that this switch can be configured to operate:
  - Standard Glideslope Cancel – The **"GLIDESLOPE"** alert can be manually canceled by the crew by momentarily activating the GND PROX G/S INHIBIT button any time below 2,000 feet AGL. The cancel is automatically reset when the aircraft descends below 30 feet or climbs above 2,000 feet AGL.
  - Alternate Glideslope Cancel APM option – With the alternate glideslope cancel option selected, the **"GLIDESLOPE"** alert can be manually canceled by the crew by momentarily activating the GND PROX G/S INHIBIT button at any time and altitude. The cancel can then be manually reset by the pilot by pushing the cancel switch any time after 5 seconds have elapsed. The 5-second delay prevents an inadvertent double-hit on the switch from turning the cancel back off. The cancel automatically resets once back on the ground or if the aircraft configuration changes (i.e., flaps or gear up for a go-around). As an option, an automatic altitude reset can be selected when the aircraft climbs through this altitude. The default application disables the altitude reset feature.

NOTES: 1. The use of the alternate glideslope cancel feature requires that there be a cockpit annunciator that the cancel is in effect.

2. The state of the glideslope cancel selection is always retained during the loss of system power.

- **Back Course Inhibit** – To prevent Mode 5 nuisance alerts due to false fly up lobes during back course approaches, an automatic ILS glideslope back course inhibit is provided when selected course and magnetic track angle (or heading) are greater than 90 degrees apart.

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Mode 6 – Advisory Callouts

Mode 6 provides alerts and callouts for descent below predefined altitudes, decision altitude (DA), minimums, approaching decision altitude, and approaching minimums. These callouts consist of predefined radio altitude based callouts or tones and excessive bank angle warning. There is no visual alerting provided with these callouts. Table 20-1, discussed previously, lists Mode 6 callouts.

In some cases, a callout is stated twice (i.e., **“MINIMUMS MINIMUMS”**), but in all cases, a given callout is only announced once per approach.

MINIMUMS/APPROACHING MINIMUMS TYPE CALLOUTS

DA-based callouts (**“APPROACHING MINIMUMS**,” **“MINIMUMS**,” etc.) require the landing gear to be down and occur when descending through the radio altitude corresponding to the selected DA. These also have priority over other altitude callouts when overlapping. For example, if DA is set to 200 and both **“TWO HUNDRED”** and **“MINIMUMS”** are valid callouts, then only **“MINIMUMS”** is called out at 200 feet AGL.

ALTITUDE CALLOUTS

Altitude callout messages, as shown in Figure 20-13, are enabled based on the callout set selected. The GND PROX TERR INHIB button on the Inhibit panel permits the crew to deactivate the aural callouts.

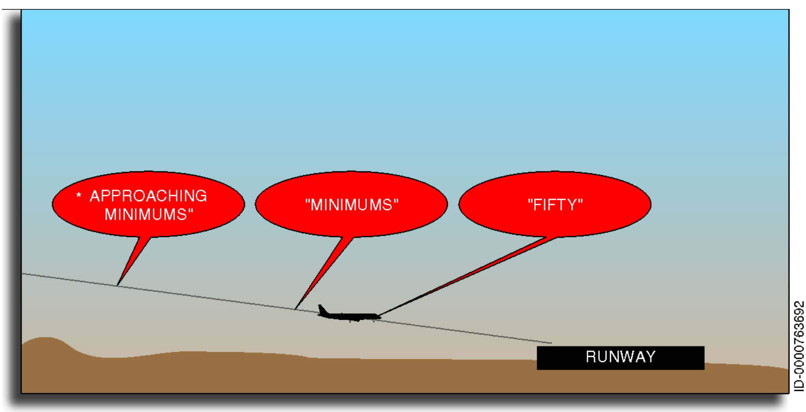

Figure 20-13
Mode 6 – Altitude Callouts

Table 20-1, discussed previously, lists altitude callouts.

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SMART ALTITUDE CALLOUT

When enabled, the smart callout assists pilots during a nonprecision approach by announcing **“FIVE HUNDRED”** feet. It is only active during a nonprecision approach. The smart callout feature functions with (or without) any of the normal altitude callouts. If the smart callout is enabled, it is given during an approach if one or more of the following conditions are met:

- If the flight path is not within ±2 dots of a valid glideslope beam
- If the flight path is not within ±2 dots of a valid localizer beam
- If a back course approach is detected
- If glideslope cancel is selected.

BANK ANGLE ALERTS

The callout **“BANK ANGLE, BANK ANGLE”** advises of an excessive roll angle. The EGPWS uses excessive bank angle envelopes to determine excessive roll angles at various altitudes.

The bank angle envelope for air transport aviation is shown in Figure 20-14. Bank angles in excess of the following produce the bank angle advisory (shaded area):

- + or - 10 degrees between 5 and 30 feet
- + or - 10 to 40 degrees between 30 and 150 feet
- + or - 40 degrees above 150 feet.

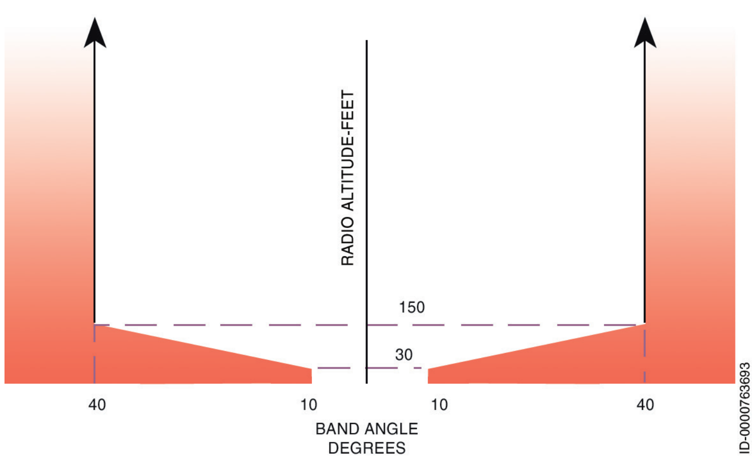

Figure 20-14
Excessive Bank Angle Envelope (Air Transport)

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Mode 7 – Windshear Alerting

As an option, Mode 7 produces alerts for flight into an excessive windshear condition during takeoff or final approach. The windshear caution (pre-alert) provides visual and aural output indications. The aural output indications are an option. The windshear warning produces visual and aural output indications.

Windshear detection is active between 10 and 1,500 feet AGL during the initial takeoff and final approach POF. Alerts are provided when the level of windshear exceeds predetermined threshold values. The actual windshear value measured represents the vector sum of inertial versus air mass accelerations along the flight path and perpendicular to the flight path. These shears result from vertical winds and rapidly changing horizontal winds.

Windshear caution alerts are given for increasing headwind (or decreasing tailwind) and severe updrafts (typically associated with the leading edge of a microburst). Windshear warning alerts are given for decreasing headwind (or increasing tailwind) and severe vertical downdrafts (typically associated with the trailing edge of a microburst). These are characteristics of conditions within or exiting an encounter with a microburst.

A windshear caution activates the WSHEAR annunciator if enabled through APM, and the single aural message **"CAUTION WINDSHEAR"** is announced. The visual remains on for as long as the aircraft is exposed to conditions in excess of the caution alert threshold, or as a minimum, 8 seconds (in order to prevent multiple alerts for a given event due to turbulence). The windshear caution envelope is shown in Figure 20-15.

Windshear warning activates the WSHEAR annunciator and an aural siren (aural siren is an option), followed by the message **"WINDSHEAR WINDSHEAR WINDSHEAR."** The visual remains on for as long as the aircraft is exposed to conditions in excess of the warning alert threshold, or as a minimum, 8 seconds (in order to prevent multiple alerts for a given event due to turbulence). The aural message does not repeat unless another separate windshear event is encountered. The threshold is adjusted as a function of available climb performance, flight path angle, airspeeds significantly different from normal approach speeds, and unusual fluctuations in static air temperature. The windshear warning envelope is shown in Figure 20-15.

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Mode 7 windshear alerting is active under the following conditions.

- During takeoff, from rotation until an altitude of 1,500 feet AGL is reached
- During approach, from an altitude of 1,500 feet down to 10 feet AGL
- During a missed approach, until an altitude of 1,500 feet AGL is reached.

The windshear microburst phenomenon and windshear caution and warning levels are shown in Figure 20-15.

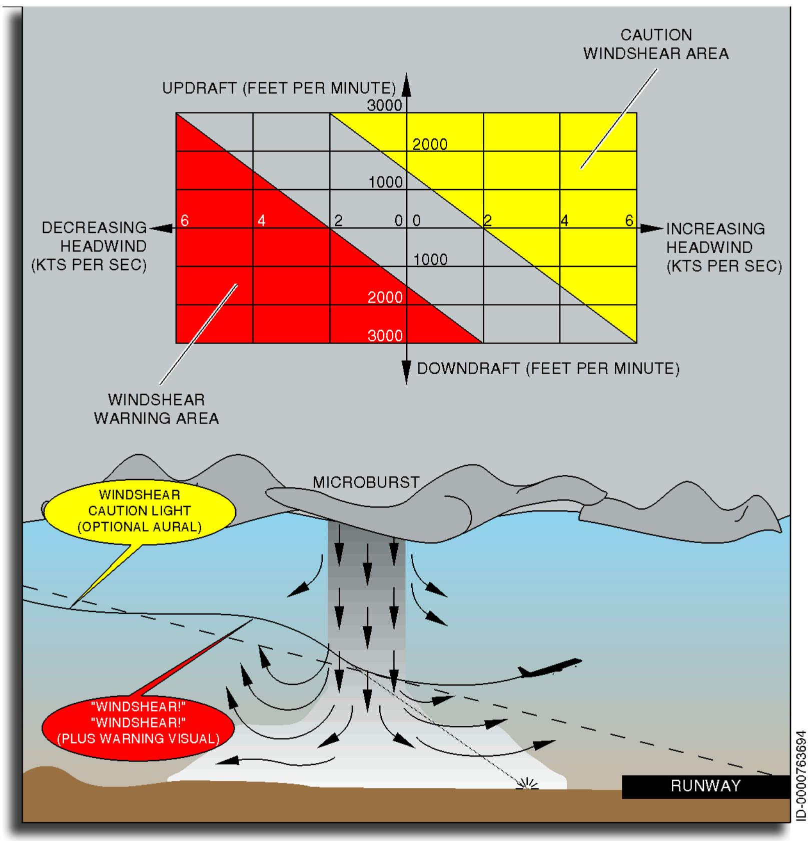

Figure 20-15
Mode 7 – Excessive Windshear Detection

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The IRS provides acceleration values along the body axis. These accelerations are transformed to the air mass axis by using body angle-of-attack (AOA) and are then compared to the atmospheric data from altitude rate and airspeed. The resultant windshear output is gain controlled as a function of altitude and roll attitude before producing the detected shear output for the caution/warning logic.

NOTES: 1. The caution and warning conditions are mutually exclusive.

2. The actual display message text is independent of the EGPWS.

MODE 7 BIAS CONDITIONS

Mode 7 alert boundaries can be desensitized (or sensitized) as follows:

The nominal windshear warning threshold is adjusted, or biased, as a function of numerous conditions:

- Air mass flight path angle is used to bias the threshold, as are abnormal temperature conditions in the atmosphere. In addition, excess lift above V_{REF} (during approach) is also used to bias the threshold. This modulation provides improved immunity against turbulence-induced nuisance alerts and advanced recognition of microburst windshear events.
- Aircraft type is used to select the proper nominal windshear threshold before the bias values are applied. Windshear enable logic determines the validity and suitability of the resultant windshear caution or warning that is observed through the output logic.
- The shear signal is modulated by radio altitude and roll angle in order to provide further margin against unwanted alerts that could potentially result from turning into and out of winds.
- Logic is provided to distinguish between the takeoff and approach POF. Slightly different enable logic and gain curves are used for detection in each of these POF. The threshold value is increased by 0.01 g's for takeoff POF reflecting the lower performance of the aircraft during this phase.

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MODE CONTROL

The EGPWS uses mode control to enable specific features in the EGPWS modes. The current POF of the aircraft is identified, such as takeoff or approach, and is used to select the modes of the EGPWS. The various phases of flight are described in the following paragraphs.

Air/Ground Mode

The system must be able to determine if the aircraft is airborne to control alert modes, maintenance functions, and fault isolation logic.

- The aircraft is considered not airborne (i.e., on the ground) when the computed airspeed drops below 60 knots and the radio altitude becomes less than 25 feet. This permits ground testing.
- The aircraft is considered airborne when the aircraft exceeds 90 knots computed airspeed, 25 feet of radio altitude, and pitch is greater than 5 degrees. However, if pitch is invalid, or remains less than 5 degrees while airspeed and radio altitude both indicate in-air conditions for more than 10 seconds, then the system goes in-air.

NOTE: The air/ground state is stored in nonvolatile memory and is immune to power interruptions to prevent inadvertent changes of state during power loss.

GPWS Takeoff/Approach Mode

Takeoff/approach GPWS mode status is used to control portions of Modes 3, 4, 5, and 6. Modes 3 and 4C are only active during the takeoff POF, while Modes 4A and 4B are only active during the cruise and approach POF. Mode 5 is active during the approach mode with gear down and can be active in the takeoff mode with both gear and flaps in landing configuration. Mode 6 uses the takeoff to approach mode switching to re-enable callouts.

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Approach mode to takeoff mode switching is accomplished when the aircraft passes below the 245-foot Mode 4B floor without an alert (i.e., gear down and flaps in full landing configuration). At this time, the Mode 3/Mode 4C alert logic is activated. The state of this switching function is maintained in nonvolatile memory to avoid an inadvertent selection of an improper mode during power loss.

Windshear Takeoff/Approach Mode

Separate logic is used to control the takeoff/approach mode switching for Mode 7 windshear detection. The takeoff state actually reflects takeoff or go-around. The approach state reflects final approach. The state of this latch is maintained in nonvolatile memory in order to prevent inadvertent mode switching as a result of power loss.

The takeoff state is selected when the aircraft is determined to be on-ground, or the flaps are selected (transition) to less than landing flap (e.g., during go-around), or the gear is up, and the flaps are less than landing configuration (e.g., go-around prior to selection of full landing flap).

The mode latch is changed to the approach state whenever the flaps are selected to the landing configuration or when the gear is selected (transition) to the down position.

Mode 2 Takeoff

A Mode 2 takeoff latch is provided to enable Mode 2B for the first 60 seconds following a takeoff. This latching function is not power saved, and a system reset forces it false. This feature addresses certain false **“TERRAIN”** alerts that occur just after takeoff as a result of false radio altimeter excursions between 1,000 and 1,500 feet AGL. These typically are a sharp increase, followed by a sharp decrease in radio altitude. Activating Mode 2B for the first 60 seconds after takeoff solves this problem. Limiting the Mode 2 closure rate to +3,000 FPM effectively prevents the **“TERRAIN”** alerts in the same manner as is used on approach.

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TERRAIN CLEARANCE FLOOR (TCF)

The terrain clearance floor (TCF) function includes two features—basic TCF and runway field clearance floor (RFCF). Basic TCF creates an increasing terrain clearance envelope, using radio altitude, around the intended airport runway directly related to the distance from the runway. The RFCF function provides alerts based on height (MSL, not AGL) above the destination runway, also directly related to the distance from the runway.

TCF is active whenever valid radio altitude is present, and RFCF is active whenever the aircraft is within 5 NM of the runway.

Basic TCF

The TCF function (enabled with TAD) enhances the basic GPWS modes by alerting the pilot of descent below a defined terrain clearance floor, regardless of aircraft configuration. It creates an increasing terrain clearance envelope around the intended airport runway directly related to the distance from the runway.

The TCF alert is a function of the aircraft radio altitude and distance (calculated from latitude/longitude) relative to the center of the nearest runway in the database (all hard surface runways greater than 3,500 feet in length). TCF is active during takeoff, cruise, and final approach. This alert mode complements existing Mode 4 protection by providing an alert based on insufficient terrain clearance even when in landing configuration. Alerts for TCF light EGPWS cockpit lights and produce aural alerts.

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The TCF envelope is defined for all runways, as shown in Figure 20-16, and extends to infinity, or until it meets the envelope of another runway. The envelope bias factor is typically 1/2 to 2 NM and varies as a function of position accuracy.

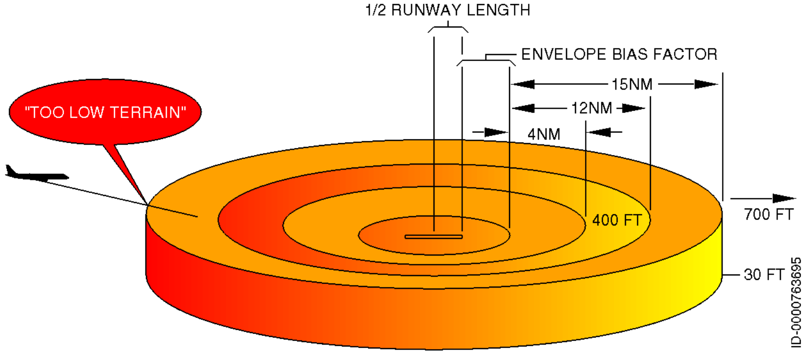

Figure 20-16
Terrain Clearance Floor

When an aircraft penetrates the TCF alert envelope, the voice aural **"TOO LOW TERRAIN"** is given. The voice aural occurs once when the initial envelope penetration occurs and one time thereafter for each 20% degradation in radio altitude. At the same time, warning lights light and remain on until the alert envelope is exited.

NOTE: TCF alerts activate the **GND PROX** *visual. The actual display text is independent of the EGPWS.*

With audio declutter enabled (default), the voice aural occurs once when the initial envelope penetration occurs and one time thereafter for each 20% degradation in radio altitude. At the same time, the EGPWS warning lights light. The lights remain on until the alert envelope is exited. With audio declutter disabled through the audio declutter disable program pin, the voice aural is continuous until the alerting envelope has been exited.

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With the improved TCF alert envelope and envelope bias factor, the alert envelope is limited to a minimum of 245 feet AGL adjacent to the runway, as shown in Figure 20-17. The envelope bias factor is moved closer to the runway when higher accuracy aircraft position and runway position information are available. This is typically 1/4 to 1 NM, providing greater protection against landing short events. In addition, runway selection logic is improved to better identify the destination runway. Comprehensive aircraft position and navigation information are used to evaluate proximity runways and determine the most likely destination runway for all alerting purposes.

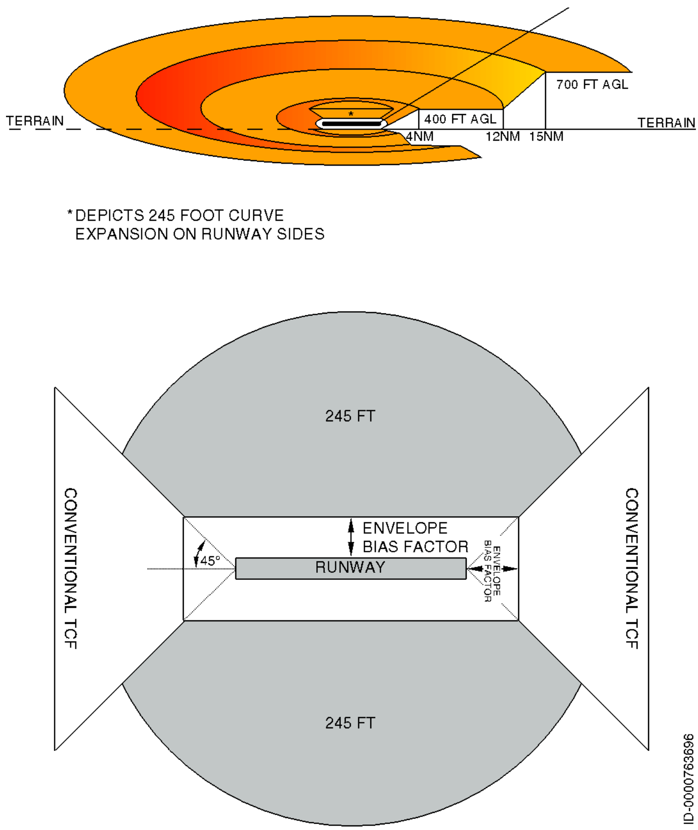

Figure 20-17
TCF Envelope Cutaway and Plan View

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Figure 20-18 shows the TCF alert area as viewed along the runway track.

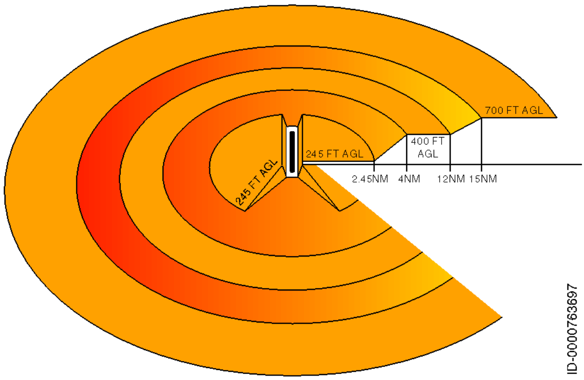

Figure 20-18
TCF Alert Area Viewed Along Runway Track

Runway Field Clearance Floor (RFCF)

The TCF function includes a runway field clearance floor (RFCF) alert function based on current aircraft position and height (MSL, not AGL) above destination runway using geometric altitude (in lieu of radio altitude) and destination runway center point position. This provides improved alerting at locations where the runway is significantly higher than the surrounding terrain, as shown in Figure 20-19.

The RFCF alert envelope is a circular band centered over the selected runway. But unlike the radio altitude based TCF envelope, the RFCF envelope only extends 5 NM past the end of the runway. The bias factor (where the protection starts) is equal to the TCF bias factor plus an additional offset proportional to the geometric altitude FOM.

In cases where the runway is at a high elevation compared to the terrain below the approach path, the radio altitude may be large enough to inhibit normal TCF operation, but the aircraft could actually be below the runway elevation. Field clearance (height above the runway) is determined by subtracting the elevation of the selected destination runway from the current altitude (MSL).

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Figure 20-19 shows the shape of the alert envelope and an example of a runway with lower surrounding terrain.

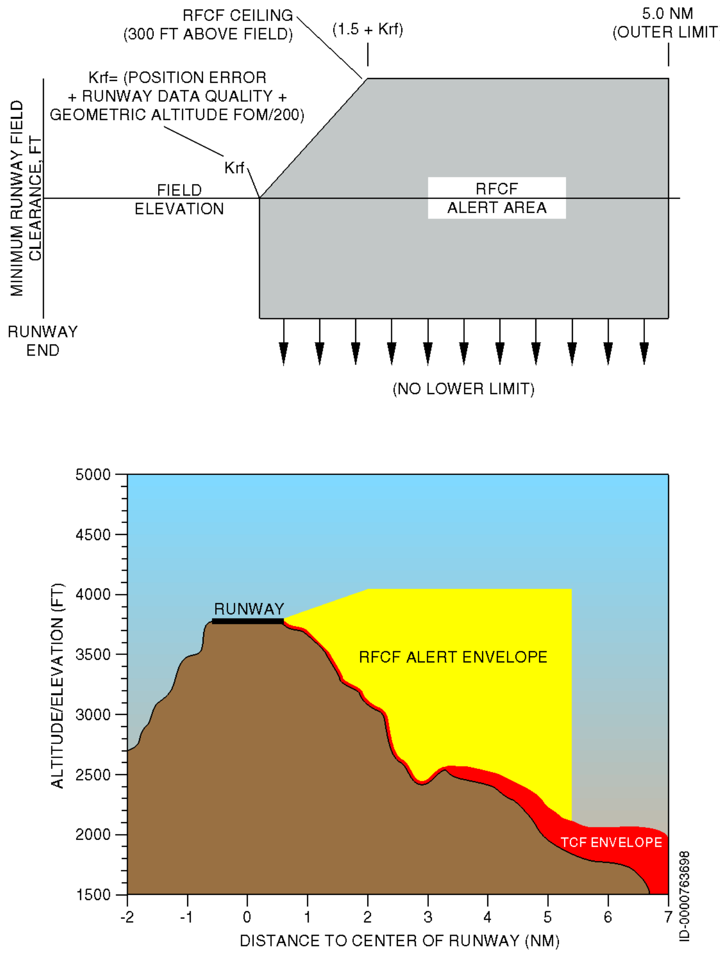

Figure 20-19
RFCF Alert Area

When an aircraft penetrates the RFCF alert envelope, the voice aural **“TOO LOW TERRAIN”** is given. The voice aural occurs once when the initial envelope penetration occurs and one time thereafter for each 20% degradation in radio altitude. At the same time, warning lights light and remain on until the alert envelope is exited.

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SMARTRUNWAY/SMARTLANDING (SR/SL)

SmartRunway/SmartLanding (SR/SL) is an EGPWS enhancement that provides the flight crew with aural and visual alerts that increase situational awareness during ground operations and takeoff and landing. SR/SL also provides alerts regarding the stability of an approach.

SR/SL uses the Honeywell EGPWS terrain database and GPS position date to determine the alerting conditions. SR/SL provides various alert options. When enabled, SR/SL operates automatically, without any action required from the flight crew. The flight crew can inhibit all functions using the **RAAS INHIBIT** button in the cockpit. SR/SL availability is verified by the flight crew. EGPWS protection and operation are unaltered with the addition of SR/SL.

Alerts are generated based on the current aircraft position when compared to the location of the airport runways.

SmartRunway/SmartLanding functions include:

- RAAS Advisories/Cautions
- Stabilized Approach Monitor Advisories
- Altimeter Monitor Advisories
- Takeoff Flaps Configuration Monitor Advisories
- Long Landing Monitor Advisories.

RAAS functions include:

- Approaching Runway On-Ground Advisory
- On Runway On-Ground Advisory
- Approaching Runway In-Air Advisory
- Distance Remaining Landing and Rollout Advisory
- Runway End Advisory
- Extended Hold On Runway Advisory
- Insufficient Runway Length On-Ground Advisory
- Distance Remaining During Rejected Takeoff Advisory
- Taxiway Takeoff Advisory
- Approaching Short Runway In-Air Advisory.

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The stabilized approach monitor function includes the following:

- Landing Flap Monitor
- Excessive Approach Angle Monitor
- Excessive Approach Speed Monitor
- Unstable Approach Monitor.

Altimeter monitors are also provided to provide crew advisories of improper altimeter settings.

RAAS Routine Advisories

The following paragraphs describe the SmartRunway/ SmartLanding RAAS routine advisories.

APPROACHING RUNWAY – ON-GROUND ADVISORY

The approaching runway (on-ground) routine advisory gives the flight crew awareness of a proximate runway edge that the aircraft is approaching during taxi operations, as shown in Figure 20-20.

> *NOTE: When the FMS runway is selected, it can be used to inhibit the advisory when the runway is the expected departure runway.*

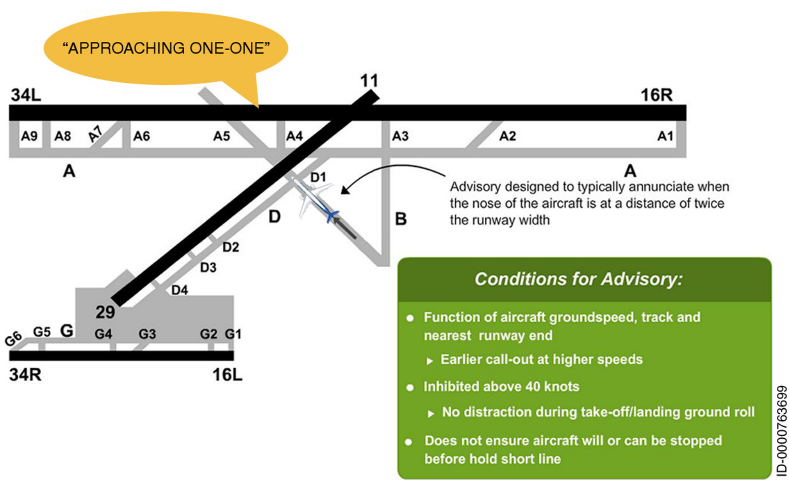

Figure 20-20
Approaching Runway - On-Ground

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The aural alert **"APPROACHING XX"** (XX is the runway identifier) is announced when the aircraft is on the ground and groundspeed is less than 40 knots. The aural alert is only announced once each time the aircraft approaches a runway when the requirements that enable the logic are satisfied.

When the aircraft is approaching two runways within ±20 degrees of each other, the aural alert, **"APPROACHING RUNWAYS"**, is announced.

ON RUNWAY – ON-GROUND ADVISORY

The on runway advisory gives the crew awareness of which runway the aircraft is lined up with during ground operations, as shown in Figure 20-21.

NOTE: When the FMS runway is available and selected, it can be used to inhibit the advisory when the aligned runway is the expected departure runway.

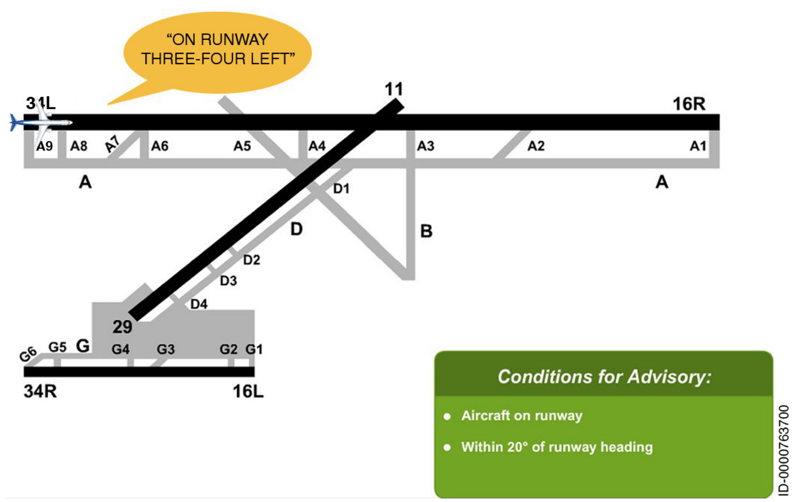

Figure 20-21
On Runway

The aural alert **"ON RUNWAY XX"** (XX is the runway identifier) is announced when the aircraft is on the runway and is within 20 degrees of the runway heading. The aural alert is only announced once each time the aircraft enters a runway when the requirements that enable the logic are satisfied.

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When more than one runway meets the qualifying conditions (i.e., two runways within ±20 degrees of each other), the aural alert "**ON RUNWAY RUNWAYS**" is announced.

APPROACHING RUNWAY – IN-AIR ADVISORY

The approaching runway in-air advisory gives the crew awareness of which runway the aircraft is lined up with on approach, as shown in Figure 20-22.

> *NOTE: When the FMS runway is available and selected, it can be used to inhibit the advisory if the aligned runway is the expected destination runway.*

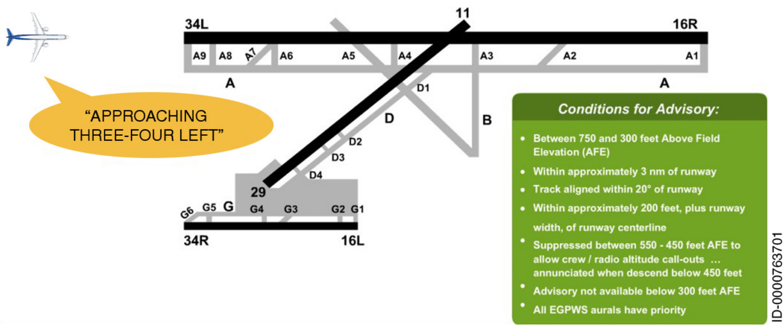

Figure 20-22
Approaching Runway – In-Air Advisory

The aural message **"APPROACHING XX"** (XX is the runway identifier) is announced under the following conditions:

- The aircraft is between 750 and 300 feet above field elevation (AFE)
- Within 3 NM of the runway
- The aircraft track is aligned within 20 degrees of the runway
- The aircraft is within 200 feet, plus runway width of runway centerline.

The aural message occurs only once for each runway alignment when the requirements that enable the logic are satisfied. The aural message is suppressed between 550 and 450 feet AFE to allow normal 500-foot callouts and/or crew procedures without conflict.

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If more than one runway meets the qualifying conditions (two runways within 20 degrees of heading of each other), the message **"APPROACHING RUNWAYS"** is announced.

DISTANCE REMAINING – LANDING AND ROLLOUT ADVISORY

The purpose of the distance remaining landing and rollout advisory is to enhance crew awareness of aircraft along-track position relative to the runway end, as shown in Figure 20-23.

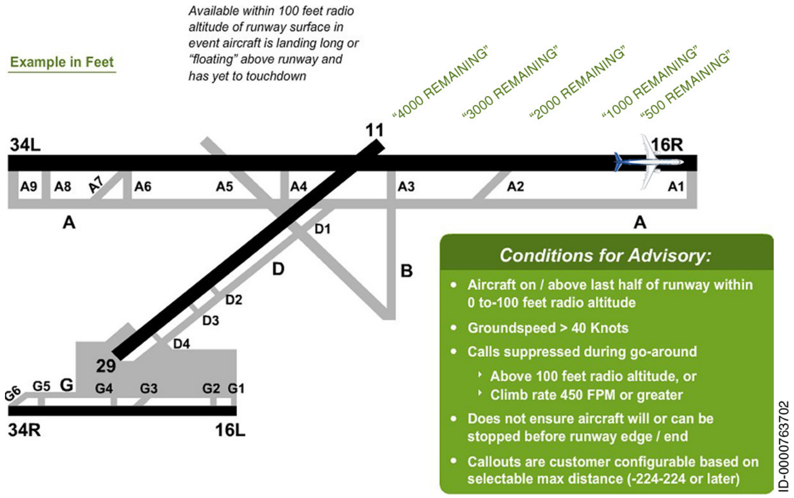

Figure 20-23
Distance Remaining - Landing and Rollout

The distance remaining for landing and rollout aural advisories are activated during the following conditions:

- Aircraft is less than or equal to 100 feet radio altitude
- The climb rate is less than 450 FPM
- Aircraft is passing the landing distance threshold specified by the APM parameter from runway end and every 1,000 feet (or 300 meters) interval thereafter
- Aircraft groundspeed is greater than or equal to the APM parameter for landing distance remaining threshold.

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NOTE: *The landing distance threshold can be set as 50% of the runway length or a specified length from the runway end.*

An example of a distance remaining for landing and rollout aural message is **“YY REMAINING”** (YY is the distance). When units are set to feet, the aural alerts are sounded in thousand-foot intervals, except the last possible advisory occurs at 500 feet.

When units are set to meters, the aural alerts are sounded in 300-meter intervals, except the last possible advisory occurs at 100 meters.

RUNWAY END ADVISORY

The runway end advisory is intended to improve flight crew awareness of the position of the aircraft relative to the runway end during low visibility conditions, as shown in Figure 20-24.

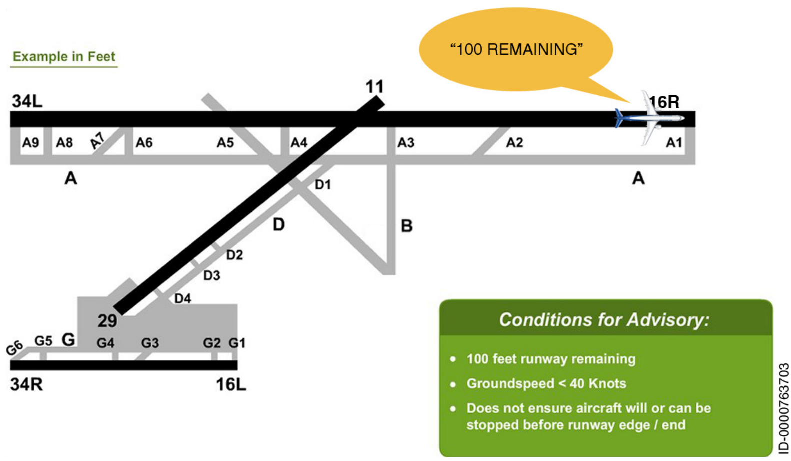

Figure 20-24
Runway End

The runway end aural advisory is activated during the following conditions:

- Aircraft is on a runway
- Radio altitude is less than 5 feet
- Aircraft heading is within 20 degrees of the runway heading

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- Aircraft approaches within 100 feet (or 30 meters) of the runway end
- Aircraft groundspeed is less than 40 knots.

The runway end advisory is announced as **"100 REMAINING"** when feet is selected and **"30 REMAINING"** when meters is selected. The runway end advisory is annunciated once when the requirements that enable the logic are satisfied.

RAAS Non-Routine Advisories

The following paragraphs describe the SmartRunway/ SmartLanding RAAS non-routine advisories.

EXTENDED HOLD ON RUNWAY

The extended holding on runway advisory gives crew awareness of an extended holding period on the runway, as shown in Figure 20-25.

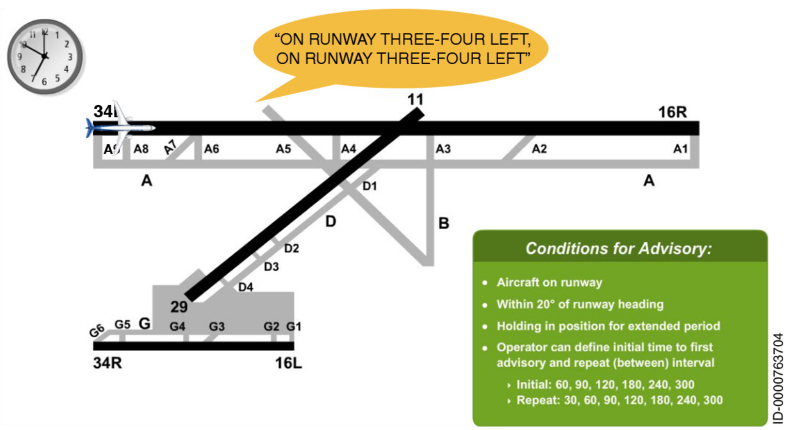

Figure 20-25
Extended Hold On Runway

The aural message **"ON RUNWAY XX, ON RUNWAY XX"** (XX is the runway identifier) is announced when the aircraft is within 20 degrees of the runway heading, and the aircraft along-track distance does not change more than 100 feet in a time considered to be an extended holding period. An extended holding period time is defined by APM parameter.

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If the aircraft continues to hold for another period of time based on the repeat extended hold time APM parameter, the aural message is repeated. The initial extended holding time on runway and repeat holding time on runway may be the same time interval or a different time interval.

The extending holding time advisory is not announced after a rejected takeoff. The advisory is reset when the aircraft leaves the runway.

INSUFFICIENT RUNWAY LENGTH – ON-GROUND ADVISORY

The insufficient runway length advisory gives the crew awareness of which runway the aircraft is lined up with and that the runway length available for takeoff is less than the defined nominal takeoff runway length, as shown in Figure 20-26.

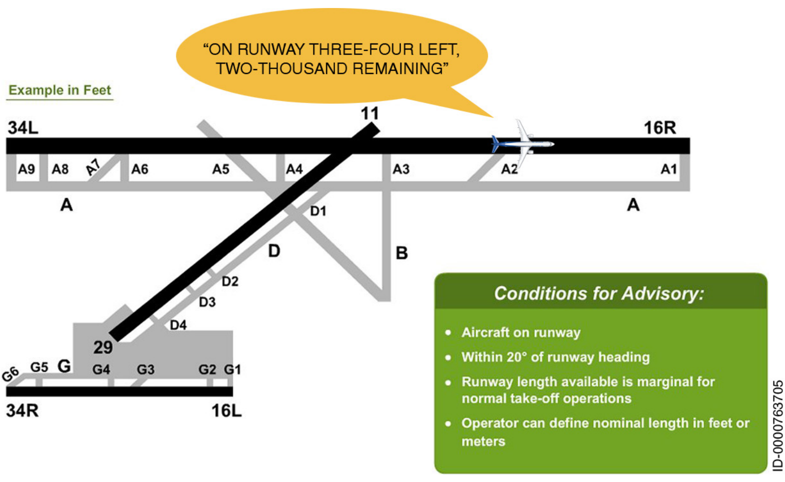

Figure 20-26
Insufficient Runway Length – On-Ground

The available runway length is determined by comparing the aircraft position on the runway with the distance available, as defined in the EGPWS runway database.

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The aural message **"ON RUNWAY XX, YY REMAINING"** (XX is the runway identifier, and YY is the distance in feet or meters) is announced when the aircraft is on the runway, within 20 degrees of the runway heading, and the nominal takeoff runway length is insufficient. The aural message is only annunciated once each time the aircraft enters a runway when the requirements that enable the logic are satisfied.

The insufficient runway length on-ground advisory does not take into account aircraft performance factors such as aircraft weight, wind, runway condition, slope, air temperature, and altitude of airport. The advisory is only comparing the available runway length of the aligned runway with the nominal runway length set in the APM parameter.

DISTANCE REMAINING – REJECTED TAKEOFF ADVISORY

The distance remaining during a rejected takeoff advisory provides the flight crew position awareness during a rejected takeoff (RTO), as shown in Figure 20-27.

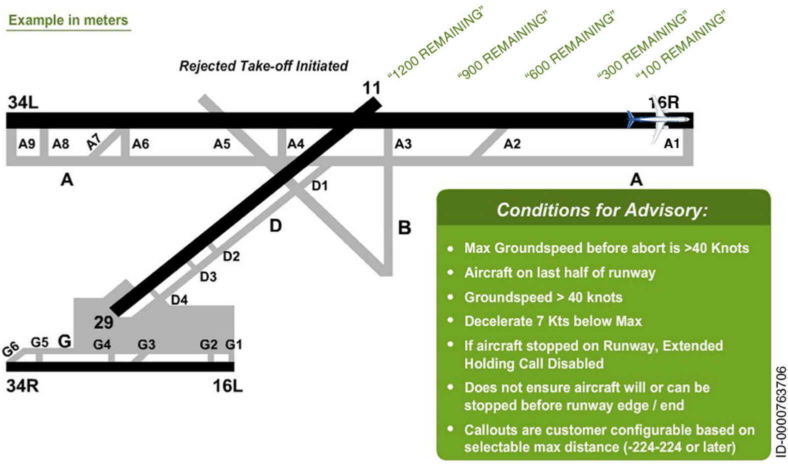

Figure 20-27
Distance Remaining – Rejected Takeoff

The distance remaining aural advisories are activated during the following conditions:

- The aircraft is on the last half of the runway or a specified distance from the runway end defined in the APM parameter
- Radio altitude is less than or equal to 100 feet

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- Groundspeed is greater than or equal to 40 knots
- Aircraft groundspeed during the takeoff roll decreases by 7 knots from the maximums.

An example of a distance remaining aural message is **"YY REMAINING"** (YY is the distance in feet or meters). The aural message is not sounded after the aircraft has taxied off the runway, crosstrack distance is greater than 200 feet, or the aircraft heading is not within 20 degrees of the runway heading.

When units are set to feet, the aural alerts are sounded in thousand-foot intervals, except the last possible advisory occurs at 500 feet. When units are set to meters, the aural alerts are sounded in 300-meter intervals, except the last possible advisory occurs at 100 meters.

TAXIWAY TAKEOFF ADVISORY

The taxiway takeoff advisory enhances crew awareness of excessive taxi speeds or an inadvertent takeoff on a taxiway, as shown in Figure 20-28.

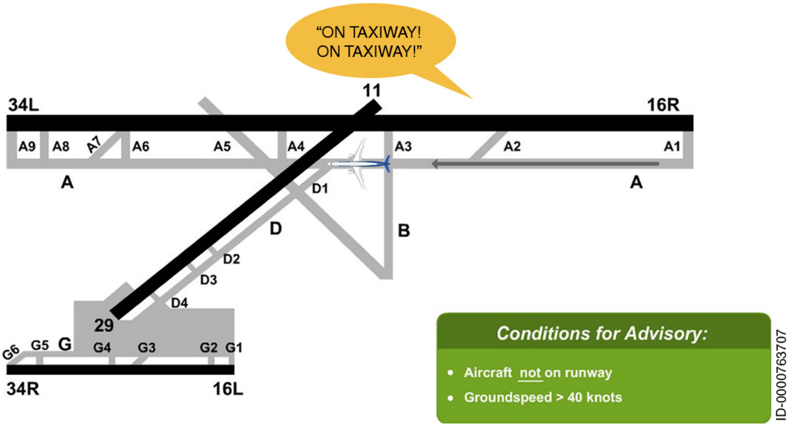

Figure 20-28
Taxiway Takeoff

The aural message **"ON TAXIWAY! ON TAXIWAY!"** is announced when the aircraft is not on the runway and is moving over 40 knots.

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APPROACHING SHORT RUNWAY – IN-AIR ADVISORY

The purpose of the approaching short runway in-air advisory is to provide the crew with awareness of which runway the aircraft is lined up with and that the available runway for landing is less than the defined nominal runway length, as shown in Figure 20-29.

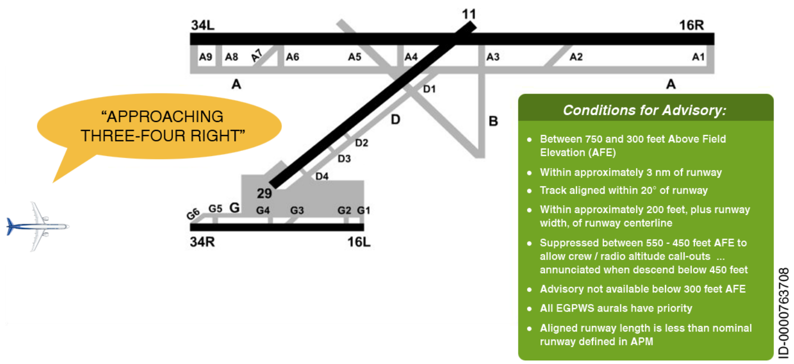

Figure 20-29
Approaching Short Runway – In-Air Advisory

The available runway length is determined by comparing the runway length, as defined in the EGPWS runway database, with the nominal runway length required for the aircraft, as defined in the APM.

The aural message **"APPROACHING XX, YY AVAILABLE"** (XX is the runway identifier and YY is the distance in feet or meters) is announced under the following conditions:

- All conditions for a routine approaching runway in-air advisory are met
- Aligned runway is shorter than the nominal runway length.

The aural message occurs once for each runway alignment when the requirements that enable the logic are satisfied. For example, if the aircraft aligns with a normal length runway followed by a side-step to a short runway while still meeting the requirements for approaching runway in-air advisory, two advisories would be heard. The first a routine **"APPROACHING XX"** (XX is the runway identifier) and a second non-routine **"APPROACHING XX, YY AVAILABLE"** (XX is the runway identifier and YY is the distance in feet or meters).

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The advisory suppression window is the same as the approaching runway in-air advisory.

The approaching short runway in-air advisory does not take into account aircraft performance factors such as aircraft weight, wind, runway condition, slope, air temperature, and altitude of airport. The advisory is only comparing the nominal runway length in the APM with the length of the runway the aircraft is aligned with.

If more than one runway meets the qualifying conditions (e.g., two runways within 20 degrees of heading of each other), then the message **“APPROACHING RUNWAYS”** is generated.

Stabilized Approach Monitor

The stabilized approach monitor is intended to inform the flight crew of awareness of unstabilized approaches and thus reduce landing risks and potential runway excursions.

Information contained herein or provided by a stabilized approach monitor annunciation does not supersede any standard operating procedure (SOP). Runway location data may have errors inherent in the source of such data. Such errors can delay an alert or may result in unwanted alerts.

The stabilized approach monitors may become unavailable at any time due to loss of accuracy of GPS signals.

Other EGPWS aural alerts may preempt stabilized approach monitor annunciations. Stabilized approach monitor annunciations may be issued during radio communications, flight crew/cockpit communications, or during other aural messages provided in the cockpit by other aircraft systems.

LANDING FLAP MONITOR

The landing flap annunciator gives the flight crew awareness of a possible unstable approach if the flaps are not set in a landing configuration. Although the existing EGPWS Mode 4 envelope already provides a landing flap annunciation **“TOO LOW FLAPS”** at 245 feet radio altitude, many operators prefer to be advised at a much higher altitude from a stabilized approach point of view. Therefore, the stabilized approach monitor is designed to provide a landing flaps annunciation independent from Mode 4.

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The first landing flap monitor aural message is **“FLAPS** (pause) **FLAPS.”** The first landing flap monitor is generated when:

- Flaps are not in the landing configuration
- Height above field elevation is less than or equal to APM parameter (typically 950 feet)
- Aircraft is descending
- TOGA has not been selected in the last 10 seconds.

The first landing flap monitor is shown in Figure 20-30.

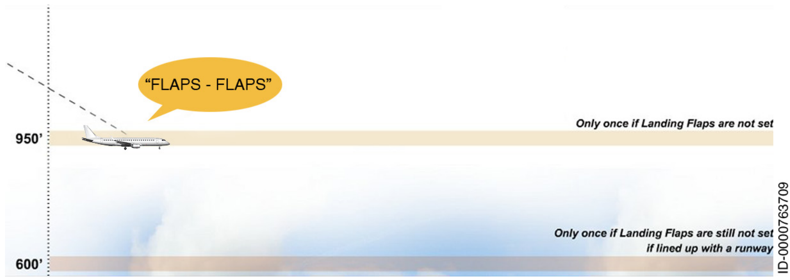

Figure 20-30
First Landing Flaps Monitor

The second landing flap monitor is **“FLAPS - FLAPS** (no pause).**”** The second landing flap monitor is generated when:

- Flaps are not in the landing configuration
- Height above field elevation is less than or equal to APM parameter for the lower flap gate (typically 600 feet)
- Aircraft is descending
- Aircraft is within 5 NM of the approach end of the runway
- Aircraft bearing deviation from the runway centerline is less than 20 degrees
- Aircraft track deviation from the runway centerline is less than 20 degrees
- TOGA has not been selected in the last 10 seconds.

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The second landing flap monitor is shown in Figure 20-31.

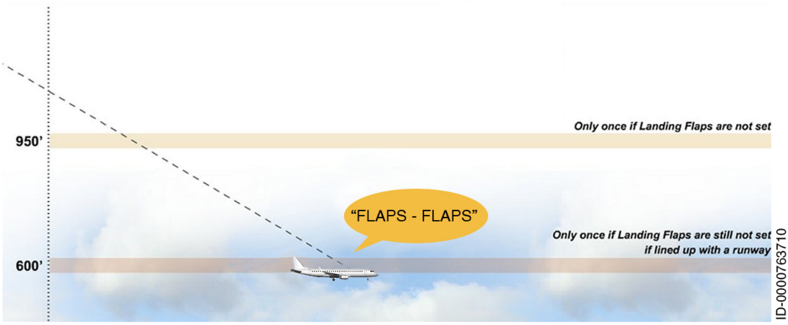

Figure 20-31
Second Flap Monitor at 600 Feet

The aural messages occur once when the requirements that enable the logic are satisfied.

EXCESSIVE APPROACH ANGLE MONITOR

The purpose of the excessive approach angle monitor shown in Figure 20-32, provides the flight crew with awareness of a possible unstabilized approach if the approach angle to the destination runway becomes too steep.

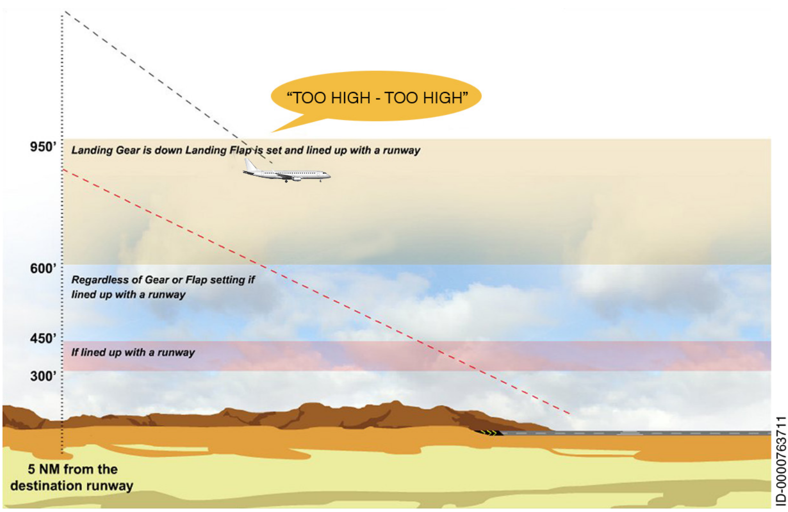

Figure 20-32
Excessive Approach Angle Monitor

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The aural message **“TOO HIGH - TOO HIGH”** is announced when the following conditions are met:

- The aircraft is below 950 feet AGL (default value) with gear and flaps in the landing configuration, or height AFE is less than or equal to 600 feet (default value), regardless of gear and flap configuration.
- The aircraft is within approximately 3 NM of the runway, and aircraft bearing and track deviation from the runway centerline is less than 20 degrees.
- The aircraft is descending.
- Position of uncertainty is less than 0.02 NM.
- Geometric altitude vertical figure-of-merit (VFOM) is less than 150 feet.
- Glideslope deviation is invalid or more than 2 dots above the beam, or localizer deviation is invalid or more than 1 dot left or right of beam.
- Distance to runway end and the current approach angle violate the excessive approach angle curve set by way of the APM parameter. The excessive approach angle curve uses the nominal glideslope angle to runway end from the runway database to accommodate airports with steeper than typical approach angles.
- The selected destination is not closely spaced parallel runways where the approach ends of the runways are not adjacent such that the distance from the aircraft to each runway threshold is significantly different.
- At least 60 seconds have passed since the last excessive approach angle alert condition has been sounded.
- TOGA has not been selected in the last 10 seconds.

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The aircraft must be lined up with the destination runway on final approach to enable this function. When a circling approach is flown, the aircraft can flyover the runway on downwind leg, making the computed angle to the runway very large. Therefore, the excessive approach angle monitor is not enabled until 600 feet AFE (minimum circling minima) unless the aircraft is fully configured to land.

NOTE: There is an effective 450-foot lower limit where unstable voice would take precedence.

Figure 20-33 shows a height-distance plot for a runway whose desired approach angle is 3 degrees.

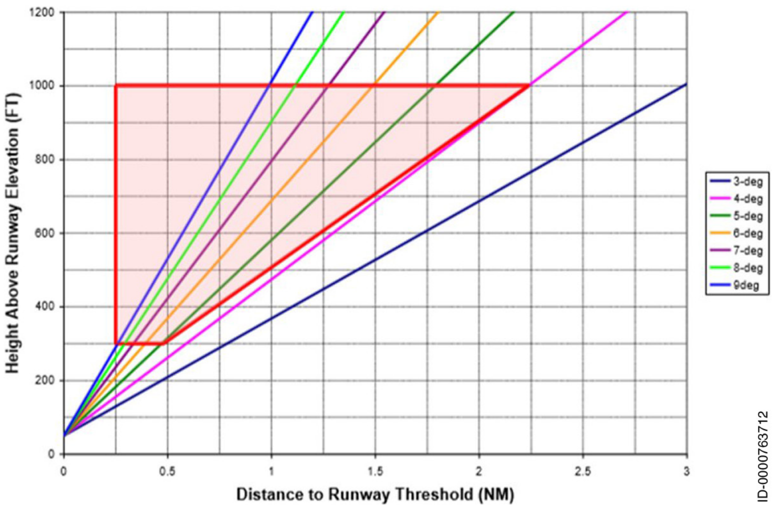

Figure 20-33
Excessive Approach Angle

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EXCESSIVE APPROACH SPEED MONITOR

The excessive approach speed monitor, shown in Figure 20-34, provides the crew with awareness of a possible unstable approach due to excessive approach speeds.

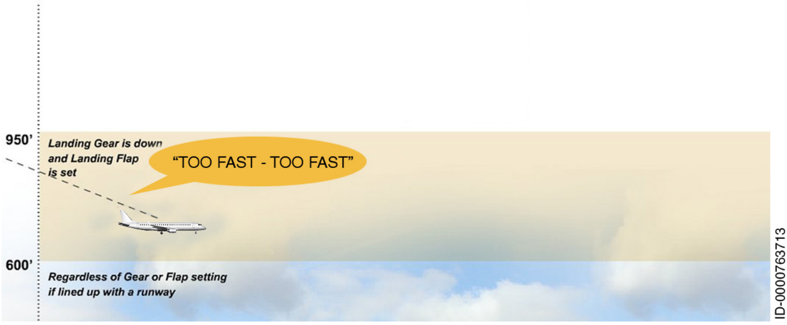

Figure 20-34
Too Fast Monitor

The excessive approach speed monitor provides an annunciation if the aircraft approach speed becomes too fast compared to the target approach speed (V_{REF}). Since pilots are often asked to maintain high speed during the final approach, the excessive speed envelope is designed to allow greater deviation from the target approach speed at higher altitude.

The aural message **"TOO FAST - TOO FAST"** is announced when the following conditions are met:

- Height AFE is less than or equal to 950 feet (default setting) with gear and flaps in the landing configuration, or height AFE is less than or equal to 600 feet (default setting), regardless of gear and flap configuration if the aircraft is lined up with a runway
- The aircraft is flying faster than the excessive speed monitor envelope
- The aircraft is descending
- At least 60 seconds have passed since the last time the excessive speed alert conditions were exited.

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Figure 20-35 shows an example of the excessive speed envelope.

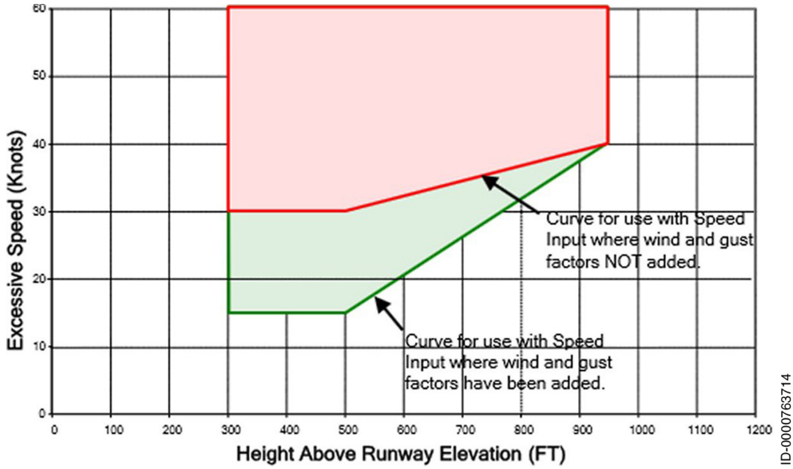

Figure 20-35
Excessive Speed Envelope

When a circling approach is flown, the aircraft speed remains high on the downwind leg. Therefore, the excessive speed monitor is not enabled until 600 feet AFE unless the aircraft is fully configured to land, which indicates the aircraft is committed to land.

NOTE: There is an effective 450-foot lower limit where the unstable voice if enabled, would take precedence.

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UNSTABLE APPROACH MONITOR

The purpose of the unstable approach monitor shown in Figure 20-36 provides the flight crew with awareness of a possible unstable approach.

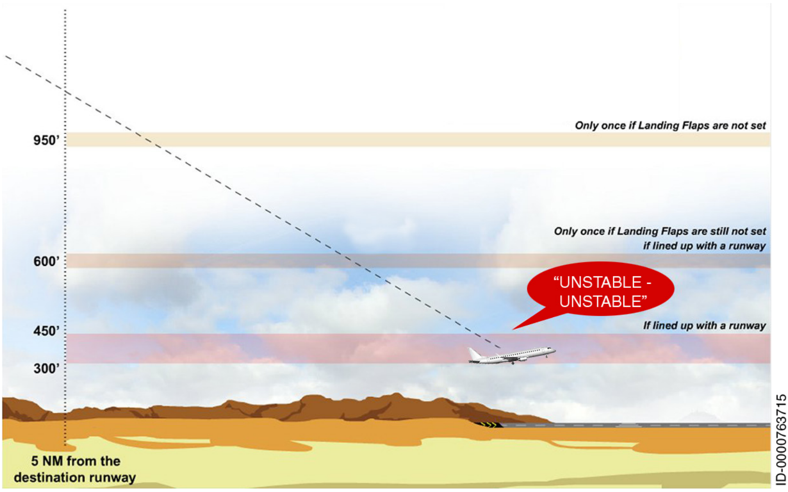

Figure 20-36
Unstable Approach Monitor

The aural message **"UNSTABLE - UNSTABLE"** is announced when the following conditions are met:

- Height AFE is less than or equal to 450 feet (default setting) and greater than 300 feet (default setting)
- One of the approach monitors has been annunciated (landing flap monitor, excessive approach angle monitor, or excessive approach speed monitor) and the trigger conditions still apply.

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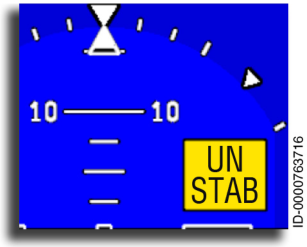

In addition to the aural message, a caution annunciation is displayed on the ADI to alert the pilot to the unstable approach condition. UNSTAB is displayed in the upper-right corner of the ADI. The annunciator toggles reverse video (UNSTAB / UNSTAB) for 5 seconds after becoming active and remains steady as long as the condition persists. EGPWS alerts are displayed in the same location and have a higher priority when conditions to display both at the same time occur.

TERRAIN LOOK AHEAD ALERTING

The internal terrain database provides the ability to look ahead of the aircraft and detect terrain or obstacle conflicts with greater alerting time.

The terrain awareness alerting algorithms continuously compute terrain clearance envelopes ahead of the aircraft. If the boundaries of these envelopes conflict with terrain elevation data in the terrain database, then alerts are issued. Two envelopes are computed, one corresponding to a terrain caution alert and the other to a terrain warning alert level.

The caution and warning envelopes use the terrain clearance floor as a baseline and look ahead of the aircraft in a volume that is calculated as a function of aircraft position, flight path angle, track, and speed relative to the terrain database image forward of the aircraft.

NOTE: Situational Awareness Terrain (SA Terrain) is displayed on the MFD. For more information, refer to Section 6, Multifunction Display - Navigation.

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Terrain/Obstacle Caution and Warning Envelopes

Caution and warning alerts are generated if terrain or obstacles conflict with ribbons projected forward of the aircraft, as shown in Figure 20-37 and Figure 20-38. These ribbons project down, forward, then up from the aircraft with a width starting 1/4 NM and extending out at ±3° laterally, more if turning. The look-down and up angles are a function of the aircraft flight path angle, and the look-down distance is a function of the aircraft altitude with respect to the nearest or destination runway. This relationship prevents undesired alerts when taking off or landing. The look-ahead distance is a function of the aircraft speed and distance to the nearest runway.

Figure 20-37 shows the terrain caution and warning envelope boundaries.

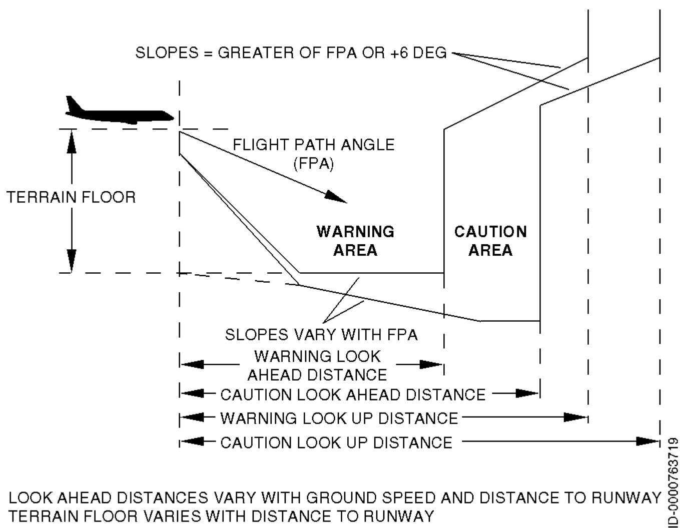

Figure 20-37
Terrain Caution and Warning Envelope Boundaries

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Figure 20-38 shows the terrain caution and warning envelope detection envelope perspective view.

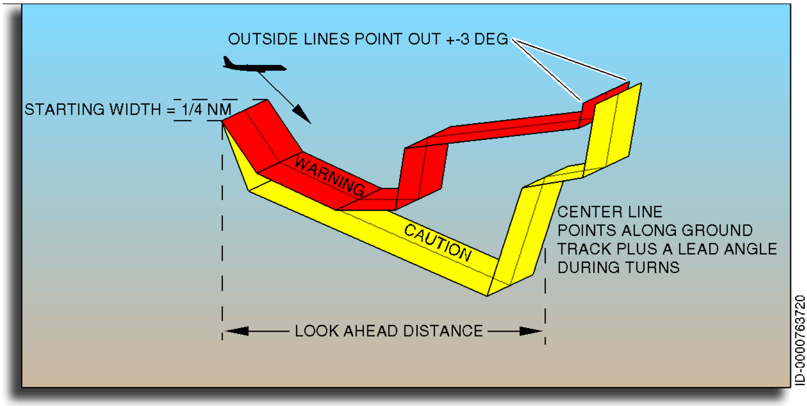

Figure 20-38
Terrain Detection Envelope – Perspective View

TERRAIN/OBSTACLES CAUTION ALERTS

If the aircraft penetrates the caution envelope boundary, the voice aural **"CAUTION TERRAIN, CAUTION TERRAIN"** is generated. The caution alert is roughly between 40 and 60 seconds of advance alerting, and the phrase is repeated every 10 seconds if still within the terrain caution envelope.

*NOTE: Through the APM voice menu option, this message can be set to **"TERRAIN AHEAD, TERRAIN AHEAD**."*

The terrain awareness function responds to an obstacle caution alert by triggering the obstacle caution voice aural **"CAUTION OBSTACLE, CAUTION OBSTACLE**." The phrase is also repeated every 10 seconds if still within the terrain caution envelope.

*NOTE: Through the APM voice menu option, this message can be set to **"OBSTACLE AHEAD, OBSTACLE AHEAD**."*

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In addition, alert discretes are provided for activation of visual annunciators. Simultaneously, terrain areas where terrain (or obstacles) violates the terrain caution envelope along the aircraft track and within ±90° of the aircraft track are shown in solid yellow color on the terrain display.

NOTE: Terrain caution alerts activate the GND PROX *annunciator. The actual display text is independent of the EGPWS.*

TERRAIN/OBSTACLE WARNING ALERTS

If the aircraft penetrates the warning envelope boundary, the voice aural **"TERRAIN TERRAIN, PULL UP"** is generated. The warning alert is roughly 30 seconds of advanced alerting, and the phrase **"PULL UP"** is repeated continuously while within the warning envelope.

*NOTE: Through the APM voice menu option, this message can be set to **"TERRAIN AHEAD PULL UP**."*

The terrain awareness function responds to an obstacle warning alert by triggering the obstacle warning voice aural **"OBSTACLE OBSTACLE, PULL UP**." The phrase **"PULL UP"** is repeated continuously while within the warning envelope.

*NOTE: Through the APM voice menu option, this message can be set to **"OBSTACLE AHEAD, PULL UP**."*

In addition, alert discretes are provided for activation of visual annunciators. Simultaneously, terrain areas where terrain (or obstacles) violates the terrain warning envelope along the aircraft track and within ±90° of the aircraft track are shown in solid red color on the terrain display.

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NOTES: 1. Terrain/obstacle warning alerts activate the PULL UP annunciator. The actual display text is independent of the EGPWS.

2. During takeoff, terrain/obstacle cautions and warnings are inhibited by the terrain takeoff guard.

The basic caution (yellow alert envelope) and warning envelope (red alert envelope) boundaries are described as follows:

- **Caution Altitude Floor** – The caution altitude (terrain floor) is computed as a function of aircraft altitude with respect to nearest runway altitude, range to the nearest runway threshold position, and descent rate. This parameter represents a distance below the aircraft. The relationship to the nearest runway threshold location prevents undesired alerts when the aircraft is taking off or landing at an airport. The descent rate is used to predict the altitude lost to initiate a constant g recovery maneuver. The system is compatible with terrain clearances that are permitted by regulatory approach and departure design criteria.
- **Caution Look Ahead Distance** – The caution look ahead distance is computed from aircraft groundspeed and turn rate to provide an advanced warning with adequate time for the crew to react safely. Depending on the situation, this distance roughly corresponds to between 40 and 60 seconds of advance alerting.
- **Warning Altitude Floor** – The warning altitude floor is set to a fraction of the caution altitude floor, as shown previously in the upper part of Figure 20-37. The warning altitude floor is computed as a function of aircraft altitude with respect to nearest runway altitude, range to the nearest runway threshold position, and descent rate. This parameter represents a distance below the aircraft. The relationship to the nearest runway threshold location prevents undesired alerts when the aircraft is taking off or landing at an airport. The descent rate is used to predict the altitude lost to initiate a constant g recovery maneuver.

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- **Warning Look Ahead Distance** – The warning look ahead distance is a fraction of the caution look ahead distance (computed from aircraft groundspeed and turn rate) to provide an advanced warning with adequate time for the crew to react safely.

Terrain Awareness Alerting Guard

Terrain awareness caution and warning voice alerts, lights, and threat display are inhibited below 30 feet of radio altitude within 1 mile of the runway or when groundspeed is 60 knots or lower.

TERRAIN AWARENESS MODE CONTROL AND REQUIRED NAVIGATION PERFORMANCE (RNP)

RNP values are determined as a function of flight mode. The flight mode logic is shown in Figure 20-39, along with the required EGPWS RNPs for each mode. If the accuracy of all the available position sources exceeds the maximum allowable value (the RNP), the terrain awareness functions are inhibited.

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As indicated in Figure 20-39, approach mode RNP can be variable. Some specific runways may require position accuracy better than 0.5 NM. The runway database supplies the RNPs for those runways. Table 20-2 and Figure 20-39 show how the various flight modes are determined.

Table 20-2
Flight Mode Definitions

Mode	RNP	Mode Requirements
Terrain Awareness Takeoff Mode	1.0 NM	On-ground (groundspeed <60 knots) Reset when Geometric altitude > (departure runway elevation +4,000 feet).
Terrain Awareness En Route Mode	2.0 NM	Terrain Awareness takeoff, approach, and terminal mode are not active. Reset when Terrain Awareness takeoff, approach, or terminal mode are active.
Terrain Awareness Terminal Mode	1.0 NM	Geometric altitude <15,500 feet, distance to destination runway is < 50 NM, both takeoff mode and Terrain Awareness approach modes are not active. Reset when Geometric altitude >16,000 feet, distance to destination runway >51 NM, or either Terrain Awareness takeoff mode or Terrain Awareness approach mode are active.
Terrain Awareness Approach Mode	≤0.5 NM (variable)	Geometric altitude <nearest runway elevation + 3,500 feet, distance to destination runway < 10 NM, and Terrain Awareness takeoff mode is not active. Reset when [Geometric altitude > nearest runway elevation + 3,500 feet], or distance to destination runway >11 NM, or Terrain Awareness takeoff mode is true.

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The RNP flight mode diagram is shown in Figure 20-39.

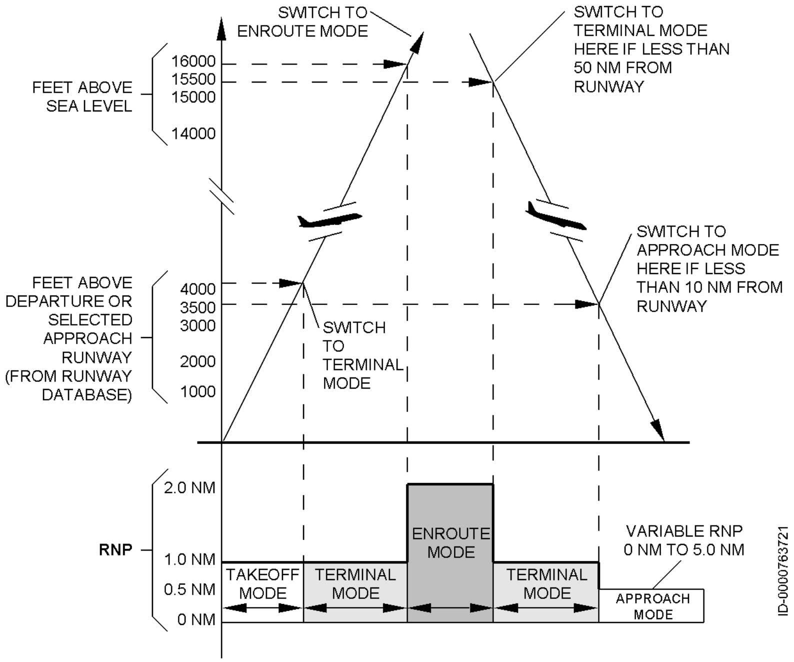

Figure 20-39
RNP – Flight Mode Diagram

EGPWS COCKPIT SWITCHES

The following are cockpit switches that can be configured as menu selections:

- Terrain inhibit
- Glideslope cancel
- Flap warning override (option)
- Self-test
- RAAS inhibit (option).

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OPERATIONAL PROCEDURES

> *CAUTION: The terrain display is to be used to enhance situational awareness only and is not to be used for navigation or escape guidance.*

System Activation

The EGPWS is fully active when the following systems are powered and functioning normally:

- EGPWS
- Radio altimeter
- Air data
- ILS or glideslope receiver
- IRS (attitude)
- GPS, FMS, or IRS (position)
- Landing gear
- Landing flaps
- Stall warning or AOA (windshear only).

In the event that required data for a particular function is not available, that function is automatically inhibited and annunciated (e.g., if position data is not available or determined unacceptable, TAD and TCF are inhibited, any active terrain display is removed, and TERR FAIL, TERR INOP, TERR UNAVAIL (or equivalent) is indicated).

Some installations use redundant systems, so if the primary source of data fails, the EGPWS continues on the secondary source.

EGPWS status annunciators are provided for GPWS inoperative (Mode 1-6 functions), terrain inoperative (TAD/TCF functions), and windshear inoperative are displayed on the CAS.

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EGPWS Self-Test

The EGPWS test is accessed by pushing LSK 3L on the TEST 1/2 page on the MCDU, as shown in Figure 20-40.

Figure 20-40
TEST Page

Pushing the EGPWS test button starts the test cycle and shows an EGPWS test screen. When the test is complete, the test display reverts to the original EGPWS screen. This test does not require crew intervention to exit. The cycle turns off automatically.

In addition to power-up and continuous BIT, user-activated tests by discrete test switches and/or maintenance system commands are supported.

The EGPWS provides a self-test capability for verifying and indicating intended functions. The self-test capability consists of one level to aid in testing and troubleshooting the EGPWS.

The Level 1 – Go/No Go test provides an overview of the current operational functions and an indication of their status.

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For this sequence, when the test switch is activated, the cockpit visuals are activated, and voices are issued to indicate what functions are correctly operating. For example, if no faults exist on an installation that uses the terrain awareness function in addition to basic GPWS and windshear, then the result of the self-test would typically be:

**"GLIDESLOPE, PULL UP, WINDSHEAR WINDSHEAR WINDSHEAR,
TERRAIN TERRAIN, PULL UP"**

However, if no valid glideslope input was present then the sequence would be:

**"GLIDESLOPE INOP, PULL UP, WINDSHEAR WINDSHEAR WINDSHEAR,
TERRAIN TERRAIN, PULL UP"**

The following phrases are used to report system status during the system self-test:

- GPWS INOP
- Glideslope INOP
- Terrain INOP
- Bank Angle INOP
- Callouts INOP
- Runway Awareness INOP
- Approach Monitor INOP
- Takeoff Flaps Monitor INOP
- Altimeter Monitor INOP
- GPWS Inhibited
- Terrain Inhibited
- Self Test Inhibited
- Runway Awareness Inhibited
- Approach Monitor Inhibited
- Takeoff Flaps Monitor Inhibited

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- Altimeter Monitor Inhibited
- Steep Approach Activated
- Runway Awareness OK, Feet (or Meters)
- Runway Awareness Not Available
- Approach Monitor Not Available
- Takeoff Flaps Monitor Not Available
- Altimeter Monitor Not Available.

During system self-test, all INOP annunciators are activated.

Level 1 self-test is used to verify proper operation of the EGPWS on the ground as follows:

1. Ensure that adequate aircraft power is available and the EGPWS and associated systems are powered.
2. Ensure that any EGPWS inhibiting switches are in the normal (non-inhibiting) position.
3. Verify that EGPWS inoperative annunciators are out. If an inoperative annunciation is indicated, perform the EGPWS self-test (as follows) and seek corrective action if the inoperative condition persists.
4. Momentarily push the EGPWS self-test switch.

   When a self-test is initiated, the EGPWS first checks for any configuration (installation or database) errors. If any are detected, it is audibly announced, and the test is terminated. If no errors are detected, the test continues through a sequence resulting in turning on and off all system annunciators and announcing specific audio messages. Any functions determined inoperative are also announced (e.g., **"GLIDESLOPE INOP"**). The self-test terminates automatically at the conclusion.

   The following is the self-test sequence:

   - **GND PROX FAIL**
   - **REACTIVE WSHEAR FAIL**
   - **TERRAIN FAIL**
   - All fail messages are turned off

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- GND PROX is displayed on the PFDs
- The aural **“GLIDESLOPE”** message is announced
- GND PROX is removed from display
- PULL UP is displayed on the PFDs
- The aural **“PULL UP”** message is announced
- PULL UP is removed from display
- WSHEAR is displayed on the PFDs
- The aural **“WINDSHEAR, WINDSHEAR”** message is announced
- WSHEAR is removed from display
- WSHEAR is displayed momentarily on the PFDs
- PULL UP is displayed on the PFDs
- The aural **“TERRAIN, TERRAIN, PULL UP”** message is announced
- PULL UP is removed from the display
- GND PROX is displayed on the PFDs
- The aural **“RUNWAY AWARENESS OK“** message is announced in one of the following methods based on APM selection:
  - **“RUNWAY AWARENESS OK”** feet (female voice)
  - **“RUNWAY AWARENESS OK”** feet (male voice)
  - **“RUNWAY AWARENESS OK”** meter (female voice)
  - **“RUNWAY AWARENESS OK”** meter (male voice).

5. Verify expected indications and enunciations during test, repeating as necessary, noting any erroneous conditions. A successful test is accomplished if all expected indications are observed, and no inoperative functions or display anomalies are indicated or observed.

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Normal Procedures

The EGPWS provides visual and/or audio alerts for detected:

- Potential dangerous terrain conditions (Modes 1-4, TCF, and TAD)
- Below glideslope conditions (Mode 5)
- Descent below predefined altitudes or excessive bank angle (Mode 6)
- Severe windshear conditions (Mode 7)
- SR/SL conditions.

These consist of warning, caution, and advisory alerts based on the detection alert threshold penetration. Table 20-3 lists the various alerts by mode and type.

Table 20-3
EGPWS Alerts by Mode and Type

Alert	Warning	Caution	Advisory
(Siren) **WINDSHEAR** (3X)	7		
Any **PULL UP**	1, 2, TA		
CAUTION WINDSHEAR		7	
TERRAIN TERRAIN		2, TA	
OBSTACLE OBSTACLE		TA	
TERRAIN		2	
APPROACHING MINIMUMS			6
MINIMUMS			6
CAUTION TERRAIN		TA	
CAUTION OBSTACLE		TA	
TOO LOW TERRAIN		4, TCF	
TOO LOW GEAR or **FLAPS**		4	
Altitude Callouts			6
SINK RATE		1	
DON'T SINK		3	
GLIDESLOPE		5	
BANK ANGLE			6
RAAS			6

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NOTE: For all EGPWS caution or warning alerts, follow the avoidance/escape procedures published in AFM/FOM or any company-provided publications.

Abnormal Procedures

Partial system deactivation or compensation can be accomplished for abnormal procedures as follows:

- **Mode 1 Excessive Descent Rates** – If steep approaches are to be performed (4° or better), this can be accomplished automatically by onboard systems, depending on the airport. When active, Mode 1 alerts are desensitized to compensate for normally higher descent rates for these types of operation, eliminating related unwanted alerts.
- **Mode 2 Excessive Closure Terrain** – When required to operate in close proximity to terrain (less than 2,500 feet above), Mode 2 alerts can be desensitized or overridden by selecting the GPWS Flap **Inhibit** button on the **Aural Inhibits** page to eliminate related unwanted alerts. This requires manual deactivation.
- **Mode 4 Unsafe Terrain Clearance** – Mode 4 alerts can be reduced by selecting the GPWS Flap **Inhibit** button on the **Aural Inhibits** page. This is generally recommended when performing approaches with less than landing flaps selected. This requires manual deactivation.
- **Mode 5 Descent Below Glideslope** – Mode 5 glideslope alerts can be manually canceled when below 2,000 feet radio altitude (standard G/S cancel) by pushing the **GS INHIBIT** button on the warning panel. This is typically selected when an unreliable glideslope is expected or when maneuvering is required during an ILS final approach. The G/S cancel is automatically reset following landing or if the aircraft climbs above 2,000 feet.
- **Terrain Alerting and Clearance Floor** – Pushing the **INHIBIT*** button inhibits TAD and TCF alerting and display, including obstacles when enabled. This is used when position accuracy is inadequate or when operating at airports not in the terrain database. Selecting **INHIBIT** results in the display of the **TERR INHIB** annunciator on the MFD. Terrain inhibit requires manual deactivation.

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Emergency Procedures

The EGPWS Flap **Inhibit** button or other inhibits (as installed) can be used as required for an emergency situation (e.g., flaps up).

For additional information, refer to an applicable Aircraft Flight Manual (AFM) or EGPWS Aircraft Flight Manual Supplement (AFMS).

EGPWS FAILURE CONSIDERATIONS

When the enhanced terrain features become inoperative, the EGPWS retains the standard GPWS operations. However, under this condition, when the aircraft is in the landing configuration, at normal descent rates, with no ILS glideslope signal present, no glideslope-associated warning annunciators are provided. If the runway awareness and advisory function becomes inoperative, the EGPWS retains the enhanced terrain awareness features and standard GPWS operations.

Audio and visual alert/advisory messages are not provided for a particular function if it is inoperative, inhibited, or unavailable.

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The EGPWS supplies the EICAS with a variety of status messages. These are listed in Table 20-4.

Table 20-4
EGPWS EICAS Status Messages

EICAS Message	Failure Mode
GND PROX FAIL	Modes 1-5 only are inoperative. (The inputs required for Modes 1, 2, 3, 4, or 5 are failed.)
REACTIVE WSHEAR FAIL	Mode 7 (windshear detection and alerting) is inoperative. (The inputs required for Mode 7 are failed.)
TERRAIN FAIL	Terrain/Obstacle Awareness Alerting is inoperative. (The inputs required for Terrain/Obstacle Awareness Alerting are failed, or the Terrain Threat database is corrupted or not loaded.)
RAAS 1-2 FAIL	SR/SL is inoperative. (The inputs required for RAAS are failed, the threat database is corrupted or not loaded, or the EGPWS outputs are invalid or stale.) Message is not shown if RAAS is inhibited.
RAAS INHIBITED	RAAS is inhibited by the crew by a cockpit selection.

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21. Digital Voice Data Recorder (DVDR)

INTRODUCTION

This section describes the operation and components of the digital voice data recorder (DVDR).

The DVDR system combines a flight data recorder (FDR), a cockpit voice recorder (CVR), and a datalink message recorder (DLR) into a single DVDR unit, as shown in Figure 21-1. Two DVDR units are installed in the aircraft. DVDR1 is located in the forward avionics bay, and DVDR2 is located in the aft avionics bay. DVDR1 includes the recorder independent power supply (RIPS), which provides 10 minutes of operation after the loss of aircraft power. Each DVDR unit is a solid-state recording device that receives, records, and preserves all required data parameters and voice recordings from the crew and area microphones.

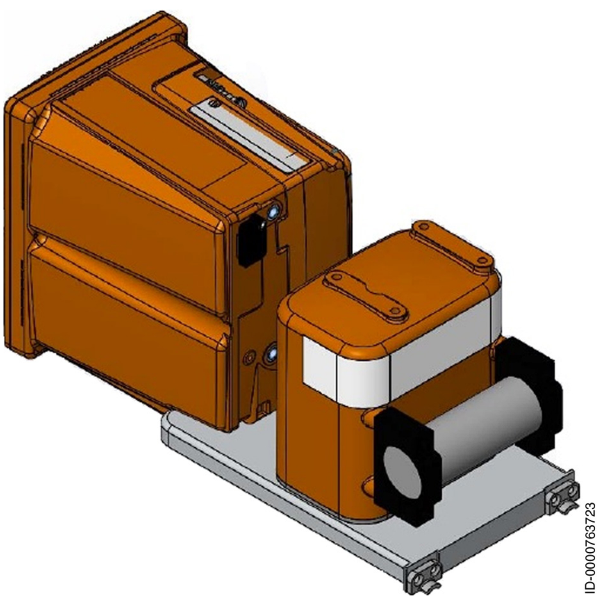

Figure 21-1
DVDR Unit

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The DVDR system has the following components:

- Two DVDR units with impact switches
- Cockpit overhead control panel (controls both DVDR units)
- Cockpit area microphone
- Tri-axial accelerometer (measures G forces).

DVDR OPERATION

The DVDR system block diagram is shown in Figure 21-2. A total of 120 minutes (2 hours) of audio information is recorded on four input channels, one from the cockpit area microphone and three from the primary crew microphones. Audio information includes:

- Voice communication transmitted from or received by the flight deck
- Attached radios
- Audio signals from each boom or mask microphone in use
- Voice communication of flight crewmembers using the interphone system
- Voice or NAV ident (navigation identifier) signals introduced into the headset or speaker
- Voice communication of flight crewmembers using the passenger address system.

Voice data is recorded for 2 hours before the oldest data is recorded over by new voice data. The DVDR contains the last 2 hours of audio information. The DVDR automatically starts recording audio data as soon as power is applied to the unit and continues until power is removed from the unit. Recorded voice data is erased by the crew only when the aircraft is on the ground.

Datalink message traffic is recorded for 2 hours before the oldest data is recorded over by new datalink messages. The DVDR automatically starts recording datalink messages once a connection is obtained and continues until power is removed from the unit or the connection is removed. Recorded message data cannot be erased or altered.

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A tri-axial accelerometer measures linear motion in three axes and sends this data to the DVDR.

Flight data is recorded for 25 hours before the oldest data is overwritten by new data. The DVDR contains the last 25 hours of flight data information. The unit automatically begins recording flight information when the first engine is started, or any time the aircraft is in the air. Time correlation is maintained between the flight data and voice recordings. Recorded flight data cannot be erased or altered.

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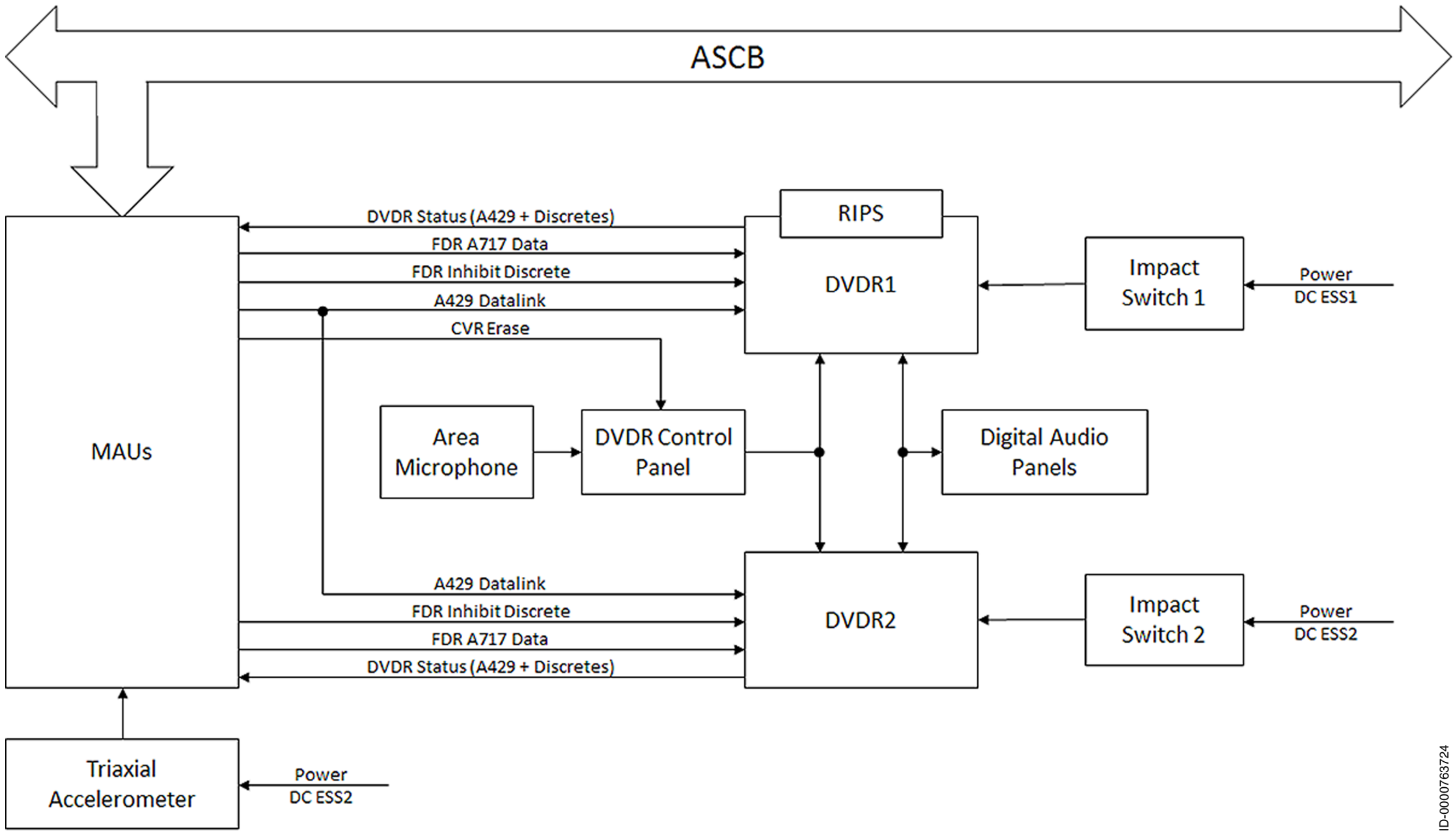

Figure 21-2
DVDR System Block Diagram

Control Panel

Pilot input to the DVDR is accomplished through the DVDR control panel, shown in Figure 21-3. The DVDR control panel is located on the cockpit overhead panel and the multifunction control and display unit (MCDU). The control panel has buttons to perform the DVDR test or CVR erase function. The panel also has a phone jack to connect a headset to monitor the audio going to or tones from the CVR units. An MCDU DVDR page can enable FDR recording on the ground for maintenance purposes.

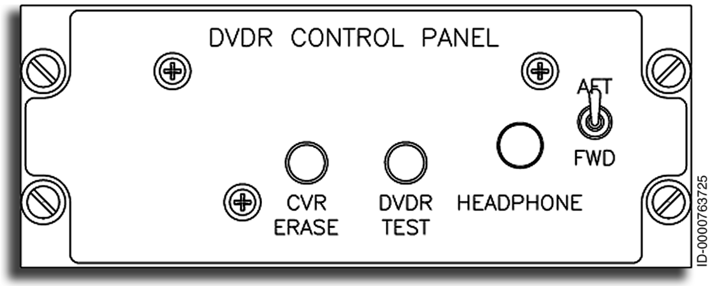

Figure 21-3
DVDR Control Panel

The control panel is located in the upper-left corner of the overhead panel. The controls are as follows:

- **FWD/AFT (Forward/Aft) Switch** – Selects the forward or aft DVDR for monitoring or audio response.
- **DVDR TEST Button** – Initiates the commanded internal self-test of the CVR function in both units. The test completes in less than 5 seconds. Four 1-second tones of 640 Hz from the selected DVDR indicate the test passed. No tone and a CAS message indicate a failure.
- **CVR ERASE Button** – This button erases all four audio channels in the DVDR. The button is pushed in and held for at least 2 seconds. The unit responds with an aural tone of 400 Hz for a duration of 4 seconds through the headphone jack when erasure is complete. The DVDR permits audio data to be erased only when the aircraft is on the ground, and the parking brake is set.

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- **Audio Jack** – The audio input going to the selected DVDR (FWD/AFT) is directed to the headphone jack to be monitored when a headset is connected. Also, any tone response is heard at this jack.

Microphones

The same four audio channels are recorded in both DVDRs. The acoustic environment cockpit area microphone is located in the front center of the cockpit area on the windshield divider post in front of both pilots. The other three channels are the primary crew microphones and audio channels as selected by the audio panels.

Accelerometers

The tri-axial accelerometer is located in the main landing gear area. Acceleration forces are measured along the longitudinal, lateral, and vertical axes of the airframe and sent to both DVDRs for recording.

Impact Switches

The impact switches remove power from both DVDR units when the aircraft experiences a severe impact. This preserves the recorded data by preventing the data from being overwritten.

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Recorder Independent Power Supply (RIPS)

DVDR1 includes the recorder independent power supply (RIPS), which provides 10 minutes of DVDR operational power after the loss of aircraft power. The location of the RIPS is shown in Figure 21-4. DVDR2 does not contain a RIPS and automatically shuts down if no power is detected for more than 200 milliseconds.

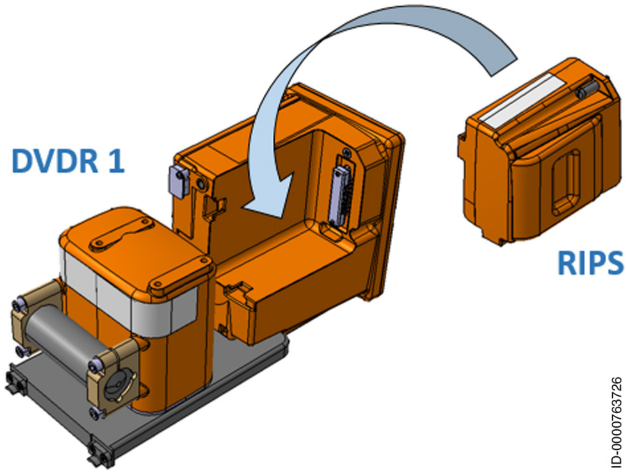

Figure 21-4
RIPS Installation on DVDR1

DVDR Testing

The DVDR is tested by three built-in tests (BITs). No visual test or fault indicators are on the DVDR control panel or DVDRs. Audio tones and crew alerting system (CAS) messages provide the DVDR status. The DVDR unit implements extensive BITs to detect errors within the unit using the following three methods:

- **Power-Up or Initialization Self-Test** – The power-on initialization function starts the DVDR and performs power BIT to determine the integrity of the system. When a failure is detected, the failure condition is stored in the DVDR crash-protected memory, and the proper CAS message is sent to the engine indication and crew alerting system (EICAS).
- **Commanded Self-Test** – To perform a commanded self-test of the CVR function, the DVDR test button is pushed and held in on the overhead control panel for longer than 2 seconds. This test is performed on the ground and in flight.

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NOTE: Flight data and voice recording are stopped on the two DVDRs during this test. Recording resumes after the tone is generated. The system performs the self-test and responds with an aural indication when the test is successful. The two DVDRs run the test at the same time. The completion tone is only heard from the one selected by the FWD/AFT switch. If a failure occurs, a CAS message is displayed, and no completion tone is generated for the failed DVDR.

- **Continuous Background Test** – The background BITs are performed continuously using spare processor time to verify the correct operation of the DVDR unit. When a failure is detected, a CAS message is generated.

DVDR Failure

When a failure is detected by any of the internal tests in either DVDR, the fault is reported by a CAS message on the EICAS window, and the fault or test failure is also reported to the Epic Onboard Maintenance System.

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CIRCUIT BREAKER CONTROL

The circuit breaker for the DVDR is on the MCDU CB BY SYS page. The page is displayed by selecting the ELEC SYS , CB BY SYS , and FDR/CVR pages. This sequence displays the page shown in Figure 21-5.

Figure 21-5
FDR/DVR Circuit Breaker Page

When IN is displayed, power is being supplied to the DVDR. When OUT is displayed, the circuit breaker has been pulled out, and the DVDR is not receiving power. IN and OUT are selected by toggling the 2R button for DVDR 1 and 3R for DVDR 2. When either DVDR power bus fails, the system automatically displays the OUT condition.

Abnormal Operation

When the DVDR power system fails, the system reports the condition to the aircraft Epic Onboard Maintenance System, and a CAS message is generated to indicate the failure. All DVDR CAS messages are advisory in nature, and some messages are inhibited in critical phases of flight, such as takeoff.

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22. Satellite Communications (SATCOM) (Option)

INTRODUCTION

This section describes the operation and components associated with the optional satellite communications (SATCOM).

The SATCOM system is an aeronautical mobile satellite communications system that supplies worldwide two-way communications between the aircraft and the ground. SATCOM provides voice and packet-mode data, such as Aircraft Communications Addressing and Reporting System (ACARS).

The SATCOM system is designed to be used with the IRIDIUM satellite network. This system offers multichannel functionality by integrating with the cockpit audio system to supply airline operational control services and future air traffic control (ATC) services and integrating with the communications management function (CMF) to supply ACARS/AFIS datalink services.

The SATCOM system provides a dual-channel voice system combined with a dedicated Iridium Transceiver.

SATCOM IRIDIUM is a long-range communication system provided by satellite link through the IRIDIUM satellite constellation, operating in the range of 1616 MHz to 1625.5 MHz.

SATCOM IRIDIUM provides long-range, beyond-line-of-sight (BLOS) voice communication capability to the flight deck by interfacing with the aircraft Digital Audio System. The calls are managed by the MCDU and downlink aircraft parameters (DAP), and the audio is routed by DAP to the aircrew headsets and/or speakers. SATCOM IRIDIUM is not approved for satellite voice communication with Air Traffic Services (ATS).

SATCOM IRIDIUM also provides long-range, beyond-line-of-sight (BLOS) datalink communication by providing a satellite subnetwork to the CMF, therefore enabling ACARS over Iridium. For aircraft with FANS 2 CPDLC datalink system enabled, FANS 1/A+ over Iridium is available.

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The aircraft earth station (AES) consists of the following:

- Multichannel SATCOM (MCS) LRUs (SDU and HPA)
- The antenna subsystem
- The avionics subsystems that supply cockpit voice and data systems and cabin communications system.

Standard interfaces between the MCS avionics and other aircraft avionics enable the AES to accept data and voice messages from various sources, encode that information on radio frequency (RF) carrier frequencies, and transmit those carriers to a ground earth station (GES). The AES also receives RF signals from a GES through the satellite segment and outputs the data or voice message to the pilot, copilot, or passengers.

Details on each of the AES components are described in the following paragraphs.

- **MCS Avionics** – The MCS avionics is made up of the satellite data unit (SDU). The SDU supplies the interface to all aircraft avionics and implements all functions associated with the two communication channels and transceiver. The SDU manages the RF link protocols on the satellite side and supplies the system interface with communications management avionics. The SDU interface to other aircraft avionics involves the exchange of the ARINC 429.

A cockpit audio system transfers cockpit voice to and from the SDU. Messages requiring cockpit action or initiation are displayed on the multifunction control and display unit (MCDU). The CMF routes packet data messages to and from the SDU. Cabin communications use a cabin communications system (CCS) to supply voice telephony communication.

- **Cockpit Voice Sources** – The SDU supports headset interfaces for cockpit use only. These interfaces include off-hook/on-hook signaling and dialing through the combination of an MCDU and audio control panel (ACP). When the SAT microphone button on the ACP is pushed, a discrete signal is sent to the SDU, and an MCDU preselected phone number is dialed.

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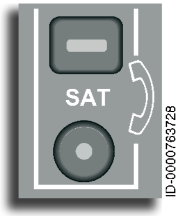
SATCOM SETUP, CONTROL, AND OPERATION

The operator uses various communication devices to select and control the type of information to be communicated.

Audio Control Panel (ACP)

The operation of telephony devices (SATCOM) selection through the audio panel is the same as the radio (VHF and HF) selection except for the following differences.



When a call is received at the SATCOM unit, a signal is relayed to the audio panel. The annunciators on the microphone button and the audio selector button for the SATCOM begin to flash. When installed, a chime or aural ringer is heard. When the microphone or selector buttons are selected, the annunciators stop flashing and remain lit, and a signal is output to the SATCOM unit to answer the call. The pilot then talks to the caller.

It is not necessary to enable push-to-talk (PTT) unless the hand microphone is used. The pilot can talk and listen. When another microphone button is selected while the call is in progress, the call is placed on hold and the microphone annunciator flashes. The selector annunciator goes off.

When the microphone button is selected again, both annunciators are lit, and the call is taken off hold.

When the microphone is deselected by pushing it again, the call is terminated, and both annunciators go off.

To initiate a call, the MCDU must be used to set up the call, and then the microphone button is selected.

When the call is terminated by something other than pushing the microphone button, the annunciators on the microphone selector button and the audio select button go off. The display goes back to the last active microphone.

More than one person can talk on a SATCOM channel. When possible, a priority system is used the same way as with radios.

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Multifunction Control and Display Unit (MCDU)

The SATCOM main menu, shown in Figure 22-1, is accessed by the MCDU main menu. This page gives access to the other SATCOM MCDU pages where telephone numbers are selected or entered, and the call is initiated. The pilot can select from up to 100 preprogrammed phone numbers stored in the owner requirements table (ORT) or manually enter a phone number using the MCDU keypad. This page shows the status of the SAT channel. When a channel is available, the page shows a <MAKE CALL option permitting the pilot to initiate a call. ANSWER CALL and REJECT are also options for an incoming call and an END CALL option to terminate a call.

Figure 22-1
SATCOM MAIN MENU Display

To make a call through the MCDU, do the following:

- When the number is stored in memory, push LSK 6R to access the directory and select the number from the directory. The number is displayed in the scratchpad. To dial a number, type the number into the scratchpad using the alphanumeric keys.
- Push LSK 2L (<MAKE CALL). The number transfers out of the scratchpad and is displayed below the <MAKE CALL prompt.
- The system automatically dials the number and connects the pilot to the person called.
- To end the call, push LSK 2L (END CALL).

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Regardless of where the calls are initiated, the two LRUs (ACP and MCDU) remain synchronized. A call initiated from the ACP is terminated from the MCDU. A call initiated from the MCDU is terminated from the ACP. Also, the MCDU and ACP reflect the call states, regardless of where the call was initiated.

BASIC PHONE OPERATION – VOICE

The Air-to-Ground and Ground-to-Air Voice operation is performed using the MCDU and the pilot headset. Refer to Section 14, Audio System, for more details.

Country Codes

Table 22-1 lists the country codes for air-to-ground communications.

Table 22-1
International Air-To-Ground Dialing Codes

Country	Code
Afghanistan	93
Albania	355
Algeria	213
Andorra	33628
Angola	244
Anguilla	1809
Antigua & Barbuda	1809
Antilles (Netherlands)	599
Argentina	54
Armenia	7
Aruba	297
Ascension Island	247
Australia	61
Austria	43
Azerbaijan	994
Azores	351
Bahamas	1809
Bahrain	973

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Bangladesh	880
Barbados	1809
Belarus	7
Belgium	32
Belize	501
Benin	229
Bermuda	1809
Bhutan	975
Bolivia	591
Bosnia-Herzegovina	387
Botswana	267
Brazil	55
Brunei Darussalam	673
Bulgaria	359
Burkina Faso	226
Burundi	257
Cambodia	855
Cameroon	237
Canada	1
Canary Islands	34
Cape Verde Islands	238
Cayman Islands	1809
Central African Republic	236
Chad	235
Chile	56
China	86
Christmas Island	672
Cocos Island	672
Colombia	57

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Comoros	269
Congo	242
Cook Islands	682
Costa Rica	506
Cote d'Ivoire	225
Croatia	385
Cuba	53
Cyprus	357
Czech Republic	42
Denmark	45
Diego Garcia (UK)	246
Djibouti	253
Dominica	1809
Dominican Republic	1809
Ecuador	593
Egypt	20
El Salvador	503
Equatorial Guinea	240
Estonia	372
Ethiopia	251
Falkland Islands	500
Faeroe Islands	298
Fiji	679
Finland	358
France	33
French Guiana	594
French Polynesia	689
Gabon	241
Gambia	220

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Georgia	7
Germany	49
Ghana	233
Gibraltar	350
Greece	30
Greenland	299
Grenada	1809
Guadeloupe	590
Guam	671
Guatemala	502
Guinea	224
Guinea-Bissau	245
Guyana	592
Haiti	509
Honduras	504
Hong Kong	852
Hungary	36
Ibiza	34
Iceland	354
India	91
Indonesia	62
Iran	98
Iraq	964
Irish Republic	353
Israel	972
Italy	39
Ivory Coast	225
Jamaica	1809
Japan	81

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Jordan	962
Kazakhstan	7
Kiribati	686
Korea (North)	850
Korea (South)	82
Kuwait	965
Laos	856
Latvia	371
Lebanon	961
Lesotho	266
Liberia	231
Liechtenstein	4175
Lithuania	370
Luxembourg	352
Macao	853
Macedonia	389
Madagascar	261
Madeira	35191
Malawi	265
Malaysia	60
Maldives	960
Mali	223
Malta	356
Marshall Islands	692
Martinique	596
Mauritania	222
Mauritius	230
Mayotte	269
Mexico	52

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Micronesia	691
Minorca	34
Moldova	373
Monaco	377
Mongolia	976
Montserrat	1809491
Morocco	212
Mozambique	258
Myanmar	95
Namibia	264
Nauru	674
Nepal	977
Netherlands	31
New Caledonia	687
New Zealand	64
Nicaragua	505
Niger	227
Nigeria	234
Niue	683
Norfolk Island	672
Northern Marianas	670
Norway	47
Oman	968
Pakistan	92
Palau	6809
Panama	507
Papua New Guinea	675
Paraguay	595
Peru	51

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Philippines	63
Poland	48
Portugal	351
Puerto Rico	1809
Qatar	974
Reunion	262
Rodriguez	230
Romania	40
Russian Federation	7
Rwanda	250
St. Helena	290
St. Kitts and Nevis	1809
St. Lucia	1809
St. Pierre and Miquelon	508
St. Vincent and The Grenadines	1809
Saipan	670
Samoa (U.S.A.)	684
Samoa (Western)	685
San Marino	378
Sao Tome and Principe	239
Saudi Arabia	966
Senegal	221
Seychelles	248
Sierra Leone	232
Singapore	65
Slovak Republic	42
Slovenia	386
Solomon Islands	677
Somalia	252

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
South Africa	27
Spain	34
Sri Lanka	94
Sudan	249
Suriname	597
Swaziland	268
Sweden	46
Switzerland	41
Syria	963
Tadzhikistan	7
Taiwan	886
Tanzania	255
Thailand	66
Togo	228
Tokelau Islands	690
Tonga	676
Trinidad & Tobago	1809
Tunisia	216
Turkey	90
Turkmenistan	7
Turks and Caicos Islands	1809
Tuvalu	688
Uganda	256
Ukraine	7
United Arab Emirates	971
United Kingdom	44
United States of America	1
Uzbekistan	7
Vanuatu	678

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Table 22-1 (cont)
International Air-To-Ground Dialing Codes

Country	Code
Vatican City	39
Venezuela	58
Vietnam	84
Virgin Islands (U.K.)	180949
Virgin Islands (U.S.A.)	1809
Yemen	96715
Yugoslavia	38(1)
Zaire	243
Zambia	260
Zimbabwe	263

Ground-To-Air Voice Communication

To establish ground-to-air communication, the caller must have the aircraft eight-digit SATCOM phone number and call: 011 + 8816 + the eight-digit transceiver telephone number.

This eight-digit number is assigned to the aircraft during installation. An aircraft can have more than one phone number, as defined by the installation agreement.

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Table 22-2 lists countries with ground-to-air SATCOM communications services.

Table 22-2
Ground-To-Air International Access Codes

Country	International Access Code
Anguila	001
Antigua and Baruda	011
Argentina	00
Australia (Telstar)	0011
Australia (Optus)	10011
Bahamas	001
Bahrain	0
Barbados	011
Belgium	00
Bermuda	1
Brazil	00
Brunei	00
Canada	011
Cayman Islands	0
Congo	00
Croatia	99
Denmark	009
Dominica	011
Dominican Republic	011
Finland	990
France	19
French Polynesia	00
Germany	00
Greece	00
Grenada	011
Iceland	90
Indonesia	00
Ireland	00

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Table 22-2 (cont)
Ground-To-Air International Access Codes

Country	International Access Code
Jamaica	011
Japan (KDD)	001
Japan (ITJ)	0041
Japan (IDC)	0061
Kuwait	00
Madagascar	16
Malaysia	00
Mexico	98
Monserrat	011
Netherlands	009
New Caledonia	00
Norway	00
Oman	00
Philippines	00
Puerto Rico	011
Qatar	0
Saudi Arabia	00
Senegal	012
Singapore	001
Sri Lanka	00
St. Kitts and Nevis	011
St. Lucia	0
St. Vincent/Grenadines	00
Sweden	009
Switzerland	00
Trinidad and Tobago	01
Turks and Caicos	0
United Arab Emirates	00
United Kingdom	00

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Table 22-2 (cont)
Ground-To-Air International Access Codes

Country	International Access Code
United States of America	011
Virgin Islands	011
Wallis and Fortuna	19
NOTES 1. Some countries have SATCOM communication service that is provided by more than one company. 2. Ground-to-air calling is not available for all countries. 3. In the countries listed here, ground-to-air calling cannot be available to all oceanic regions. 4. This table was issued by SKYPHONE.	

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23. Other Systems

INTRODUCTION

The following miscellaneous systems either supply or receive information from the Epic avionics system.

EMERGENCY LOCATION TRANSMITTER (ELT)

The emergency location transmitter (ELT) is used to locate the aircraft after it has gone missing. The ELT is monitored by the global positioning system (GPS). The ELT system contains an impact switch, as shown in Figure 23-1, and when armed, turns on the ELT transmitter after crash impact. The ELT operates on its own battery power until the battery is exhausted (three days or more). There is an ON/OFF switch on the ELT transmitter unit located in the rear avionics bay. The ELT cockpit control panel is located in the center of the cockpit instrument panel to the left of the auto brake selector.

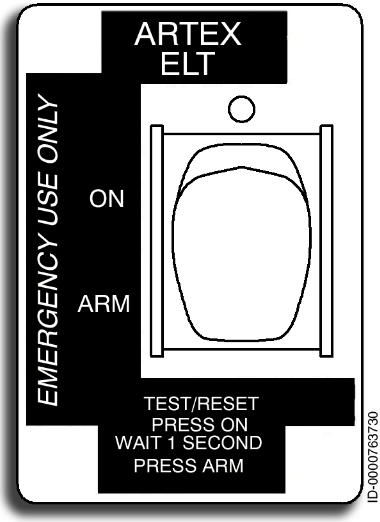

Figure 23-1
ELT Remote Switch

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The ELT automatically transmits the following when there is a crash:

- The standard emergency swept tone on the 121.5/243 MHz frequencies until the battery is dead
- The aircraft identification code or serial number of the ELT transmitter on the 406 MHz frequency
- The country code and ID code on the 406 MHz frequency
- Position information from the aircraft GPS navigational system on the 406 MHz frequency (option).

The status of the ELT, active or inactive, is indicated on the cockpit switch panel. When the ELT is active (transmitting), a light continuously flashes on the cockpit switch panel. When a problem is detected, the light gives a coded signal following the initial 1-second pulse.

The coded signals and related problems are as follows:

- One flash indicates a G-switch failure
- Three flashes indicate a 406.025-MHz transmitter problem
- Seven flashes indicate a battery problem.

Under normal conditions, the cockpit panel switch is in the ARM position, and the ELT switch is in the OFF position. On impact (changes in velocity of 4.5 feet per second (fps) or when subjected to 30 G forces of cross-axis forces), the G-switch automatically activates the ELT. The cockpit ELT panel light continuously flashes. To manually activate the ELT, set the cockpit panel switch to ON or set the ELT unit switch to ON.

When the ELT is accidentally activated by the ELT unit switch, cockpit panel switch, or the G-switch, the ELT must be reset. The two ways to reset the ELT are as follows:

- Set the cockpit panel switch to ON for at least 1 second, and then set the switch to ARM.
- Set ELT switch to ON and then turn to OFF.

NOTE: When the cockpit panel switch and the ELT unit switch are ON, the ELT is active and cannot be reset.

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INTEGRATED ELECTRONIC STANDBY (IES)

The IES, as shown in Figure 23-2, is located in the cockpit instrument panel between the inboard display units just above the landing gear panel. The IES shows artificial horizon, altimeter, and airspeed information on a single active matrix, liquid crystal, flat panel screen.

Figure 23-2
Integrated Electronic Standby (IES)

The IES uses the avionics system air data to execute air data related functions. The IES has internal gyros and accelerometers that execute inertial data functions.

The IES shows the following standby information:

- Attitude
- Slip/skid information
- Altitude (BARO corrected)
- Airspeed
- Mach number
- Vertical speed
- V_{MO}/M_{MO}.

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The IES also shows external information:

- Localizer and glideslope (from aircraft radio system ILS1)
- Heading (from aircraft inertial system IRU1).

The unit has five buttons and a knob. Altitude units (feet or meters) are set to the same as used by the primary flight display (PFD).

IES controls are described in the following paragraph:

- **CAGE** – When the **CAGE** button is pushed, the standby executes a CAGE of the internal gyros to cancel the accumulated drift.
- **ILS (Instrument Landing System) Button** – Pushing the **ILS** button shows glideslope and localizer deviations from aircraft radio system (ILS1). Heading is displayed from an external source (IRS1).
- **STD (Standard) Button** – Pushing the **STD** button sets the BARO correction to standard.
- **+ and - Buttons** – Pushing the **+** and **-** buttons control display brightness. A light cell is also used to automatically adjust the screen brightness for changing cockpit lighting conditions.
- **BARO Knob** – The BARO knob is used to adjust the barometric correction when STD is off.

The IES enters the ERROR state when a failure is detected (one or several functions), and a corresponding flag is displayed. When there is a loss of data, the IES enters the FAIL state, and an OUT OF ORDER page is displayed.

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STANDBY COMPASS

The lit magnetic compass, shown in Figure 23-3, has a rotating compass card, liquid damped with silicone fluid, and is enclosed in a transparent, molded bowl. The card is marked with white legends on a black background. The cardinal points are marked **N**, **S**, **E**, and **W**. Each 30-degree line, except the cardinal points, is identified by numerals representing degrees. Headings are read against a vertical lubber line.

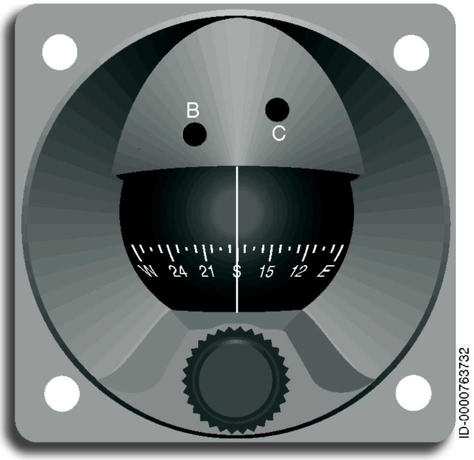

Figure 23-3
Standby Compass

The magnetic compass is compensated for aircraft magnetic interference, and a placard shows the deviations. The compass dimming is controlled by the same control that adjusts the clock display brightness and standby bezel lighting.

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Chronometer and Clock

The chronometer display is a digital readout of an elapsed timer based on pilot selection. The chronometer is displayed on the right side of the HSI, below the Baro setting readout on the PFD, as shown in Figure 23-4.

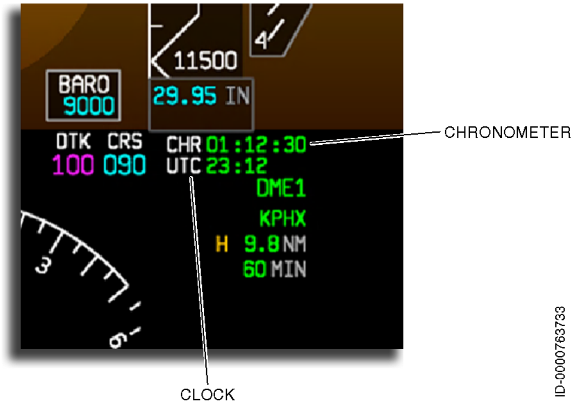

Figure 23-4
Chronometer and Clock

The chronometer is controlled by the chronometer button on the control wheels. When the chronometer is not displayed, the first push of the button displays the CHR label and readout with the readout counting up from 00:00. The next push pauses the readout. The next push resets the readout back to 00:00. The next push restarts the count, and the cycle begins again. The chronometer display converts to HH:MM:SS when the readout reaches 59:59. If the chronometer reaches 23:59:59 in this format, it rolls over to 00:00 as MM:SS and continues. The chronometer display is removed when the elapsed time has not changed for 30 seconds (the display is paused or reset).

The clock, shown in Figure 23-4, is displayed on the PFD, one line below the chronometer, with format UTC label in white, followed by HH:MM in green with leading zeros. The clock display is provided by the Epic system clock.

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PFD Auxiliary Window

The PFD Auxiliary window consists of the Flight Information window and the controller pilot datalink communications (CPDLC) inbox window.

FLIGHT INFORMATION WINDOW

As shown in Figure 23-5, the flight information consists of the Flight ID, tail number, transponder code (XPDR), UTC date, and elapsed time (ET). The flight information is displayed in the PFD Auxiliary window. A gray horizontal divider line is displayed between the Flight Information section and the CPDLC Inbox section of the PFD auxiliary window. A gray vertical divider line is displayed between the PFD display window and the PFD auxiliary window.

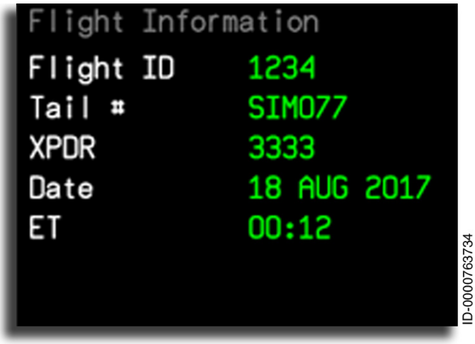

Figure 23-5
Flight Information Window

The Flight ID is displayed in the Flight Information window and is the same as on the XPDR page or the FMS Route page. The Flight ID is entered by the pilot on the FMS RTE 1 or TCAS/XPDR 1/2 page, which are automatically synchronized. When it is changed in the FMS page or XPDR page, the Flight ID in the Flight Information window is also changed.

The tail number is displayed in the Flight Information window and is the same as on the ATC/Logon Status page. The tail number is also known as the aircraft registration number.

The active transponder (XPDR) code is displayed in the Flight Information window and is the same as on the TCAS/XPDR 1/2 page. When it is changed on the XPDR page, the Flight Information window displays the changes.

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The date from the Epic system clock is displayed in the Flight Information window in (DD MMM YYYY) format.

The elapsed timer (ET) (count up) starts to count time from 00:00 when the aircraft takes off and stops when the aircraft touches down. After touchdown, the elapsed time stops counting time, and the flight time remains on the display. The elapsed time can be manually reset on the ground only. The word **Reset** is displayed in cyan to the right of the Elapsed time numerical value when the aircraft is on the ground. Using the CCD, the pilot highlights or selects the elapsed time field with the cursor. The elapsed time readout and the word **Reset** are highlighted by a cyan-colored box when the aircraft is on the ground. When **ENTER** is pushed on the CCD, the elapsed time is set to 00:00. When the pilot does not select **Reset** on the ground after the previous flight, the elapsed time is automatically reset to 00:00 at transition to the next takeoff and starts counting up again. The reset option is always displayed on the ground.

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The PFD Auxiliary window supports the display of CPDLC uplink messages without crew action in the CPDLC inbox. The purpose of this feature is to help keep the pilot's head up by displaying ATC uplink messages in the forward field of view. Information such as Title, Active Center Identifier, ATC Center Type, time stamp, status and the message body of the uplink message is displayed, as shown in Figure 23-6. The single latest uplink message is displayed in the PFD CPDLC inbox.

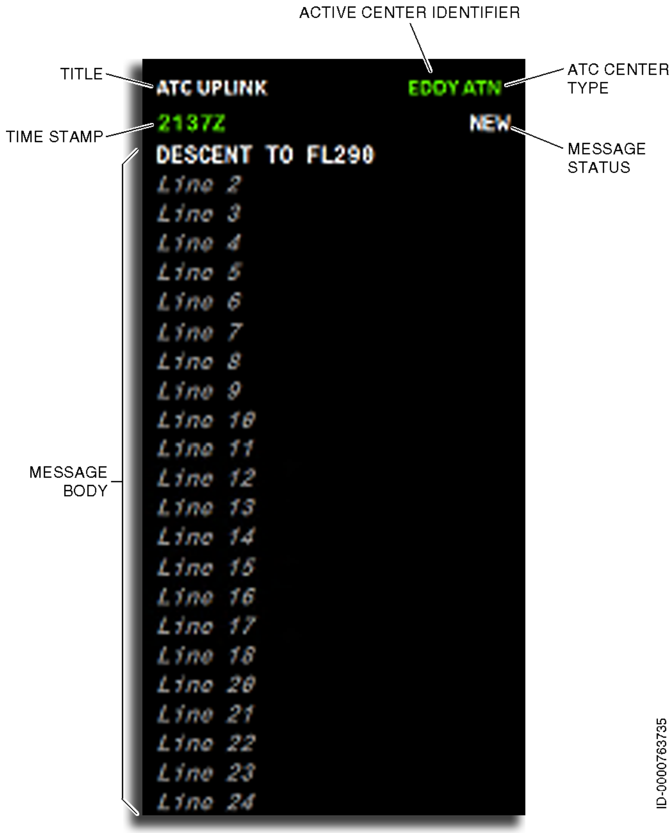

Figure 23-6
CPDLC Inbox

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When Message 1 is uplinked, it is displayed when the status is NEW. If a second message is uplinked, it will not be displayed until the pilot responds to the first message in the MCDU and the status is not NEW. The display provides 26 lines to display the uplink message. If a message goes over line 26 of the CPDLC inbox, line 26 is replaced with **MORE DATA – CHECK MCDU**, in large cyan font.

External Video/Camera Display

The external video/camera window format displays images from an external camera surveillance system (CSS). When the external video/camera display page is activated, the portion of the display between the upper and lower menus displays the video stream, as shown in Figure 23-7.

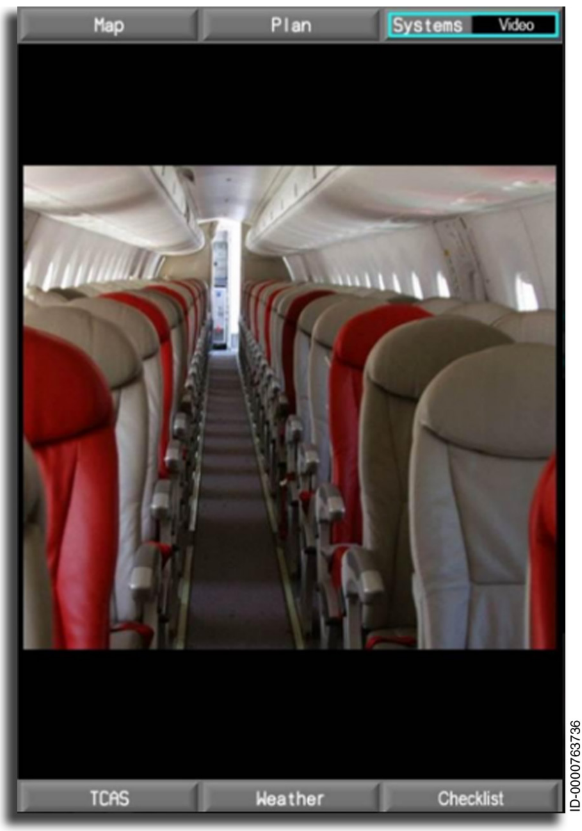

Figure 23-7
Video/Camera Display

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The video page can be enabled from the system title menu on the multifunction display, as shown in Figure 23-8

Figure 23-8
System Title Menu

Uplink Weather (Option)

The uplink weather displays graphical weather information on a moving map. Uplink Wx is available when the interactive navigation (INAV) option is selected.

The display system interfaces through the CMF to request data through VHF or SATCOM. Products that are currently supported include RADAR, winds aloft, and satellite data.

The WX can be selected from the Map → **Uplink Wx** / Plan → **Uplink Wx** dropdown menus on the MFD, as shown in Figure 23-9.

Figure 23-9
Uplink Wx Dropdown Menu

When the optional uplink weather is not selected, the Map and Plan dropdowns do not have the **Uplink Wx** radio button.

The uplink weather function shows graphical displays of weather information overlaid on the INAV map. Graphical weather is received from a ground station over datalink by way of VHF, HF, or SATCOM data transmissions.

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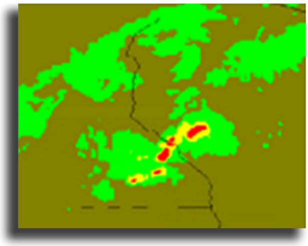
The uplink weather dropdown menu is used to select different types of graphical weather products displayed on the uplink weather map, turn the legends ON or OFF, and open the uplink weather dialog box. This menu, shown in Figure 23-9, contains the following selections:

- NEXRAD
- Satellite
- Winds
- Time
- Legend
- Request WX.

Buttons available for selection are highlighted in blue when the cursor is pointing within the interactive region of the button. A checkmark is displayed when buttons have a checkbox selected. The checkmark is removed when the button has been deselected.

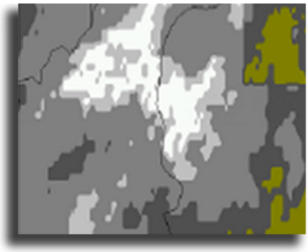
NEXRAD



ID-0000763739

The selection of the **NEXRAD** button displays a checkmark in the checkbox. This permits the display of uplinked radar weather on the uplink weather map.

SATELLITE



ID-0000763740

The selection of the **Satellite** button displays a checkmark in the checkbox. This permits the display of uplinked satellite weather on the uplink weather map.

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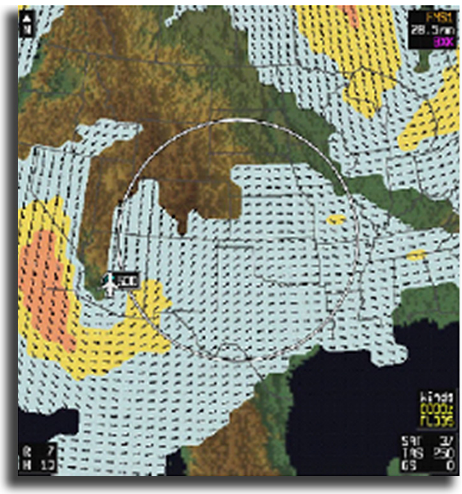
WINDS

The selection of the **Winds** button displays a checkmark in the checkbox. This permits the display of uplinked winds aloft on the INAV, as shown in Figure 23-10. Displaying the winds aloft at a specific altitude is accomplished by rotating the inner knob of the CCD to select the altitude on the altitude range display. The altitude in the range display is shown in flight levels.



ID-0000763741

Figure 23-10
Uplink Weather on INAV Display

TIME

The **Time** button is active when a weather product is selected for display. The **Time** button window displays the time the current weather product on the map was received into the aircraft. The pilot can toggle through previously-selected graphical weather data, then re-display the data on the map. Toggling through the previously-selected weather is done by moving the cursor over the **Time** button to highlight and select. The time displayed in the window is the most current weather data. Rotating the inner knob on the CCD scrolls through the previously-selected weather time slots.

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LEGEND

The uplink weather data legends, as shown in Figure 23-11, permit the pilot to see the color codes associated with the weather data selected for display. The selection of the **Legend** button displays a checkmark in the checkbox. The legends are located at the bottom-right corner of the uplink weather map display. When the **Legend** button is not available for selection, the button is highlighted in gray.

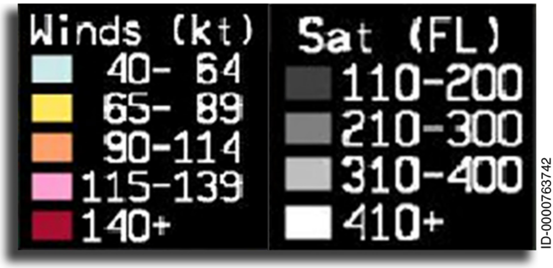

Figure 23-11
Legends

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REQUEST WX

When the **Request Wx...** button is selected, the uplink weather dropdown menu is removed, and the Uplink Wx dialog box, shown in Figure 23-12, opens with the Request Wx page displayed.

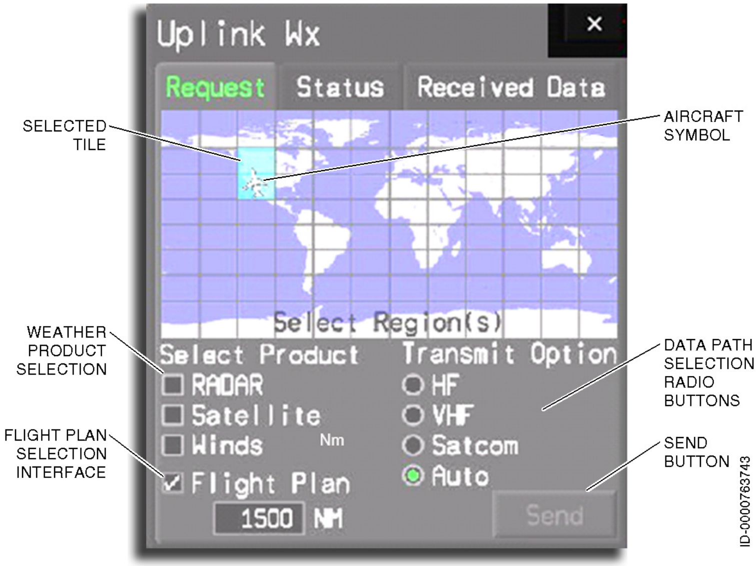

Figure 23-12
Uplink Wx Dialog Box

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UPLINK WEATHER DIALOG BOX

The Uplink Wx dialog box, shown in Figure 23-13, permits the pilot to request graphical weather products, review the status of the uplink files, and select different regions to display the graphical weather.

The uplink weather dialog box automatically closes when the CCD cursor and knob are inactive for more than 20 seconds. Three different pages can be selected from the dialog box. They are as follows:

1. Request tab
2. Status tab
3. Received Data tab.

The uplink weather data availability annunciator label NO COMM , shown in Figure 23-13, is displayed in amber when communication to the CMF is not available.

ID-0000763744

Figure 23-13
Wx Req NO COMM

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UPLINK WEATHER REQUEST TAB

The Request tab is used to select the region of the weather request, the type of weather products desired, and the transmit option used for transmitting the desired graphical weather to the display map. The Request tab is shown in Figure 23-13.

SELECT REGION MAP

The Request tab has a map used to select the regions for the displayed weather. The map is segmented into 96 geographic tiles, as shown in Figure 23-13. The Selection areas (tiles) are either geographical or based on the flight plan. The selection of geographic tiles is made with the CCD. When the cursor is placed on the Select Region(s) map, a magnification window is displayed to show the location of the cursor on the map. When the Flight Plan checkbox is selected, the selection of tiles is determined based on the tiles that coincide with the closed flight plan route. In the example shown in Figure 23-14, a red flight plan swath line is displayed to help illustrate the closed flight plan route. However, the red line is not displayed on the actual region map. Moving the cursor over the geographic tiles does not show the magnifier selector box until the Flight Plan checkbox is deselected.

Figure 23-14
Flight Plan

When the cursor is placed over the desired tile, the tile is selected by pushing either **ENTER** button on the CCD. Deselecting the tile is accomplished in the same way. A maximum of four tiles can be selected per weather request. When the fourth tile is selected, the rest of the tiles are shaded, and additional selections of tiles are disabled until one of the four selected tiles has been deselected.

When the Satellite and Winds checkboxes are selected individually, the bottom row of grid tiles is shaded and unavailable for selection.

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When the RADAR checkbox is selected prior to selecting any tiles, only the four tiles surrounding the current position of the aircraft are highlighted but not selected. All other tiles are shaded, and only those tiles highlighted can be selected for displaying radar. When the RADAR checkbox is selected after a grid tile has already been selected, normal selection of the grid tiles is permitted.

An aircraft symbol is displayed on the Select Region(s) map at the current aircraft position. The aircraft symbol is oriented on the Select Region(s) map to match the orientation of the aircraft on the uplink weather map. The aircraft symbol is removed when the FMS is no longer providing valid information.

SELECT PRODUCT

Under the **Select Product** label are four checkboxes:

1. RADAR
2. Satellite
3. Winds
4. Flight Plan.

These boxes are used to select the desired weather products being requested.

TRANSMIT OPTION

Requesting and receiving weather can be done by way of four transmission options. Choosing the type of transmission is done by selecting the desired option under the **Transmit Option** label. The **Transmit Option** label has four checkboxes:

1. HF
2. VHF
3. SATCOM
4. Auto.

On the initial selection of the Request tab, the transmit option defaults to Auto. The options available for selection are displayed in white reverse video (**VHF**). The options not available for selection are displayed in gray reverse video (**VHF**).

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ACTION BUTTONS

The **Clear** button is active when tiles have been selected on the Select Region(s) map. Pushing the **Clear** button deselects the selected graphic tiles.

The **Send** button is active when weather products have been selected, tiles have been selected on the map, and the uplink weather server is available. Pushing the **Send** button sends the requested weather to Flight Services and the dialog box changes to the Status tab.

NOTE: Requesting more than one weather product or region at a time results in an unusually long delay in receiving the requested data.

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UPLINK WEATHER STATUS TAB

The uplink weather Status tab, shown in Figure 23-15, displays the status of the files being uplinked to the aircraft. The Status tab displays the same grid map as the Request tab map, along with an aircraft symbol. The tiles selected from the Request tab are highlighted on this map.

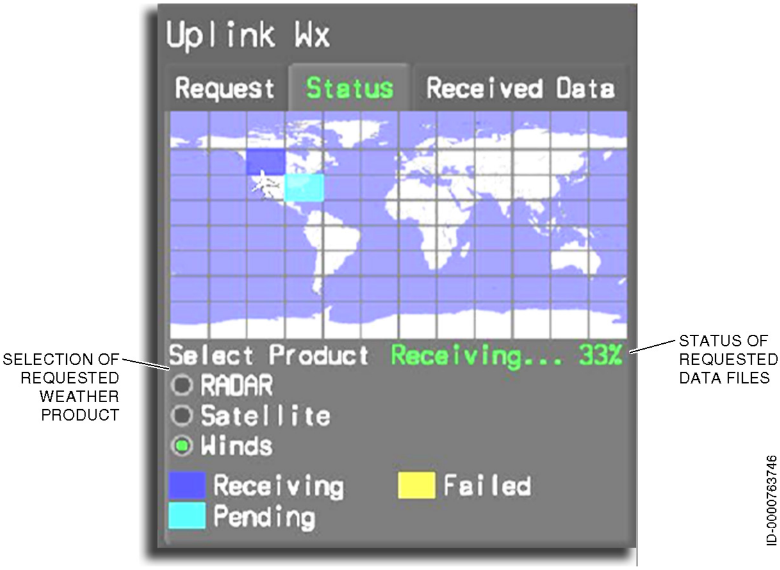

Figure 23-15
Uplink Wx Status Tab

The Status tab has a Select Product label on the left side of the display and directly below the map. The three radio buttons displayed for selection are as follows:

1. RADAR
2. Satellite
3. Winds.

When the uplink weather dialog box opens to the Status tab, the selected button defaults to the **RADAR** button. The desired weather product displayed for the selected map grid tiles is selected by highlighting the desired button under the Select Product label. Pushing either **ENTER** button on the CCD sets the uplink weather product for the selected tiles to the weather product.

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When weather is being received for a highlighted tile on the map, the tile flashes blue. A Receiving... label is displayed on the right side of the display directly below the map. The percentage complete is displayed next to the Receiving... label (e.g., Receiving...33%).

The bottom of the Status tab has a legend describing the status of the uplinked weather for each tile selected for displaying weather. Three labels are on the legend:

1. Receiving – Blue
2. Pending – Cyan
3. Failed – Yellow.

UPLINK WEATHER RECEIVED DATA PAGE

The uplink weather **Received Data** page, shown in Figure 23-16, permits the pilot to select a specified timestamp of the uplinked weather data. The **Received Data** page displays the same grid map as the **Request** tab map along with an aircraft symbol.

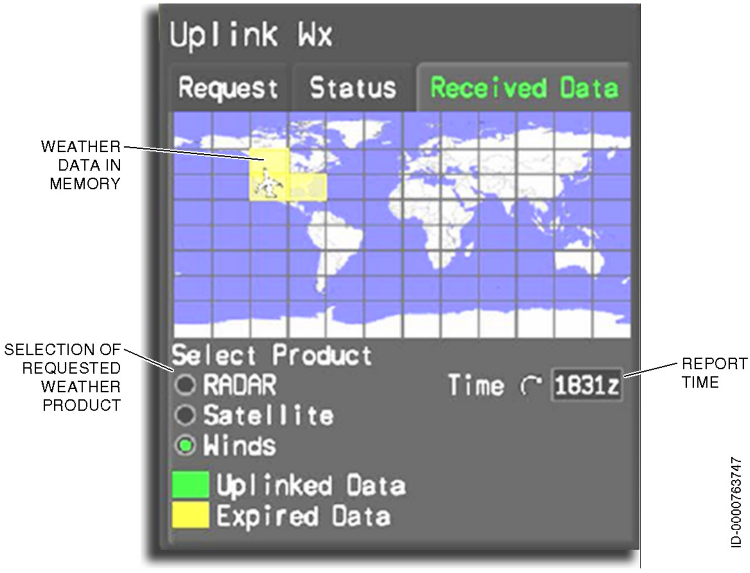

Figure 23-16
Received Data Tab (Winds Selected)

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The Received Data page has a Select Product label on the left side of the display and directly below the map. Three radio buttons displayed for selection are below this label:

1. RADAR
2. Satellite
3. Winds.

When the uplink weather dialog box opens to the Received Data page, the selected button defaults to the **RADAR** button. When the **RADAR** button is selected, the tiles containing previously uplinked radar data are highlighted.

When the **Satellite** button is selected, the tiles containing previously uplinked satellite data are highlighted.

When the **Winds** button is selected, the tiles containing previously uplinked winds aloft data are highlighted.

ID-763748

A white label (Time) is displayed on the right side of the display directly below the map. The timestamp is located to the right of the Time label. The timestamp displays the time the currently selected weather product was received. When the uplink weather dialog box opens to the Received Data page, or when a new weather product is selected, the displayed time defaults to the newest received weather for the weather product selected. Scrolling through the timestamps is accomplished by highlighting the time with the cursor and turning the inner knob on the CCD until the desired timestamp for the received weather product is located.

The bottom of the Received Data page has a legend displaying the status of the uplinked weather. Two labels are on the legend:

1. Uplinked Data – Green
2. Expired Data – Yellow.

Uplinked data is considered current data and is displayed on the map as a highlighted green grid. The received weather for RADAR and satellite is considered expired when the weather is more than 45 minutes old (for winds, 3 hours old).

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UPLINK WX ANNUNCIATORS

The following are additional uplink weather annunciators that can be found on the uplink weather map display.

TIMESTAMP ANNUNCIATOR

The uplink weather timestamp annunciator, as shown in Figure 23-17, is located at the bottom right side above the TCAS annunciation. This annunciator identifies the graphical weather products selected for display on the map and the timestamp of each product displayed. The winds aloft also has the altitude of the winds displayed.

The annunciator is displayed when a weather product has been selected for display, and the map half-range is 50 NM or greater. The name of the weather product is displayed in white (RADAR / Sat / Winds). The time and altitude annunciators are green when the weather products displayed have current weather. The annunciators are yellow when the weather products displayed are expired weather.

Figure 23-17
Timestamps

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RECEIVED DATA ANNUNCIATOR

The received data annunciator **UP WX** is located on the upper right side of the uplink weather map and displays below the active waypoint identifier. This annunciator is displayed when requested weather has been received, and the map half-range is 100 NM or greater. When activated, the **UP WX** annunciator flashes reverse video for 5 seconds and then remains steady.

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24. Multifunction Control and Display Unit (MCDU) Menu Pages

INTRODUCTION

The MENU page, shown in Figure 24-1, can be used to select various options, backup radios, setup, and maintenance information pages. The MENU page is displayed by pushing the MENU function key on the MCDU.

Figure 24-1
MENU Page

- **1L** – Displays the MISC MENU page
- **4L** – Displays the BKUP RADIO page (prompt only displayed on copilots MCDU)
- **3R** – Displays the DISPLAY SETUP page
- **5R** – Displays the MCDU MAINTENANCE MENU page
- **6R** – Displays the MCDU STATUS MENU page.

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MISC MENU

The MISC MENU page, shown in Figure 24-2, is displayed by selecting the MISC prompt (1L) on the MENU page.

Figure 24-2
MISC MENU Page

- **1L** – Displays the THRUST MANAGEMENT (MGT) page (described on page 11-4)
- **2L** – Displays the SETUP page
- **4L** – Displays the OPERATOR CONFIGURATION (OPR CONFIG) page
- **6L** – Displays the AURAL page
- **1R** – Displays the ACARS MAIN MENU page, described in detail in Section 13, Datalink, of the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide, Pub. No. D202012001536.
- **4R** – Displays the TEST 1/2 page.

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SETUP Page

The SETUP page, shown in Figure 24-3, is displayed by selecting the SETUP prompt (2L) on the MISC MENU page.

Figure 24-3
SETUP Page

- **1L** – Toggles the wind display on the PFD and MFD between XY and VECTOR formats on the pilot-side display. The current selection is displayed in large green font.
- **6L** – Displays the PFD Radio Setup page (described on page 13-53).
- **1R** – Toggles the wind display on the PFD and MFD between XY and VECTOR formats on the copilot-side display. The current selection is displayed in large green font.
- **2R** (not shown in Figure 24-3) – When a mismatch in the number of CAS messages computed by the monitor warning function (MWF) 1 and 2 occurs, CAS1, CAS2, and AUTO prompts are displayed in this field. Selecting CAS1 or CAS2 displays the CAS messages computed by MWF 1 or 2. Selecting AUTO will automatically select the more conservative monitor warning system. The current selection is displayed in large green font.
- **3R to 5R** – Used to select priority channels for the autoflight system and is described in detail on page 11-1.
- **6R** – Displays the MISC MENU page.

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Operator Configuration (OPR CONFIG)

The OPR CONFIG page, shown in Figure 24-4, is displayed by selecting the OPR CONFIG prompt (4L) on the MISC MENU page. The OPR CONFIG page enables interface for pilot selection of autoland, ETOPS, and E2TS functions. The current selection is displayed in large green font.

Figure 24-4
OPR CONFIG Page

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AURAL Page

The AURAL page, shown in Figure 24-5, is displayed by selecting the AURAL prompt (6L) on the MISC MENU page. The AURAL page enables the flight crew to turn the aural warnings on or off. The current selection is displayed in large green font.

Figure 24-5
AURAL Page

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TEST 1/2 Page

The TEST 1/2 page, shown in Figure 24-6, is displayed by selecting the TEST prompt (4R) on the MISC MENU page. The TEST 1/2 page allows selection on the weather radar pilot-test as well as testing of both aural warning channels A and B.

Figure 24-6
TEST 1/2 Page

- **4L** – Toggles the weather radar self-test between ON and OFF. The active mode is displayed in large green font. The weather radar pilot-activated test is described in detail in Section 18. Weather Radar Systems.
- **4R and 5R** – Selecting AURAL WARN A or B plays the aural warning test **"AURAL WARNING CHANNEL A (or B) TEST**."
- **6R** – Returns to the MISC MENU page.

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TEST 2/2 Page

The TEST 2/2 page, shown in Figure 24-7, is selected by pushing the NEXT or PREV function keys on the MCDU while the TEST 1/2 page is displayed. The TEST 2/2 page is used to initiate tests for the TCAS, EGPWS, radar altimeter, display, and stall systems.

Figure 24-7
TEST 2/2 Page

- **1L** – Initiates the TCAS test
- **2L** – Initiates the EGWPS test
- **3L** – Initiates the radar altimeter test and is available only when autoland is not engaged
- **5L** – Initiates a display test. When triggered, it will populate the PFD with all warning flags.
- **1R** – Initiates a test on the stall warning system. Test is available only on-ground with CAS less than 40 knots, and it will trigger activation of both shaker motors for 5 seconds.

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BKUP (BACKUP) RADIO

The BKUP RADIO page, shown in Figure 24-8, is displayed by selecting the BKUP RADIO prompt (4L) on the MENU page. The BKUP RADIO page provides access and the ability to tune and preset backup COM and NAV radios and access the transponder.

NOTE: The BKUP RADIO prompt is only selectable on the copilots MCDU.

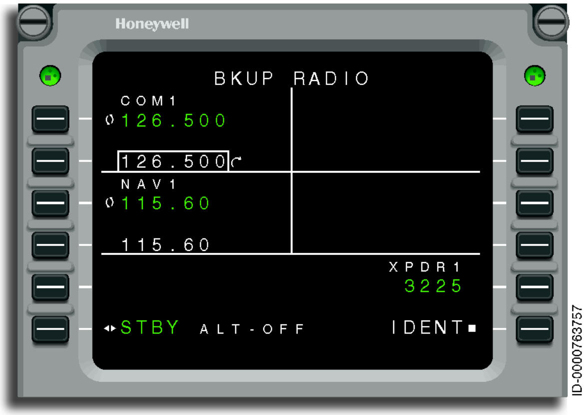

Figure 24-8
BKUP RADIO Page

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DISPLAY SETUP

The DISPLAY SETUP page, shown in Figure 24-9, is displayed by selecting the DISP SETUP prompt (3R) on the MENU page.

Figure 24-9
DISPLAY SETUP Page

- **5L** – Selecting the SVS BRT prompt and rotating the tuning knob changes the synthetic vision system (SVS) brightness on the PFD.
- **6L** – SVS is displayed or removed from the PFD by toggling the SVS prompt between ON and OFF. The active selection is displayed in large green font. SVS is described in detail in Section 5, Primary Flight Display (PFD).
- **5R** – This prompt is used to adjust the brightness of terrain topography on the INAV display. The value is adjusted by selecting LSK 5R and turning the knob on the CCD.

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MCDU MAINTENANCE MENU

The MCDU MAINTENANCE MENU page, shown in Figure 24-10, is displayed by selecting the MCDU MAINT prompt (5R) on the MENU page. The MCDU MAINTENANCE MENU page allows the selection of various maintenance pages.

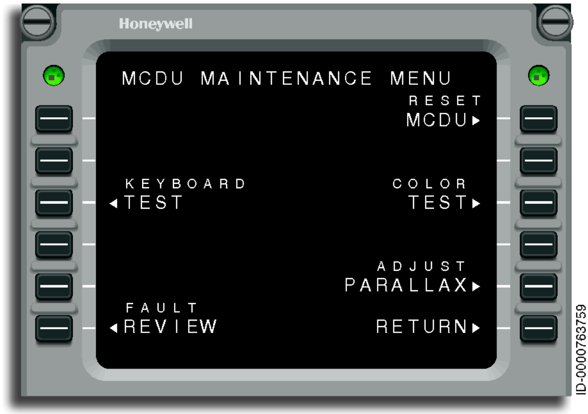

Figure 24-10
MCDU MAINTENANCE MENU Page

- **3L** – Displays the MCDU KEY TEST page
- **6L** – Displays the MCDU BITE HISTORY page
- **1R** – Displays the RESET MCDU page
- **3R** – Displays the MCDU COLOR TEST page
- **5R** – Displays the PARALLAX ADJUST page, described in detail in Section 17, Maintenance, of the Flight Management System (FMS) for the Embraer E-Jet E2 E190/E195-E2 Pilot's Guide, Pub. No. D202012001536.
- **6R** – Displays the MENU page.

NOTE: The maintenance pages are described in detail in the maintenance manual.

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Acronyms and Abbreviations

Acronyms and abbreviations used in this guide are defined as follows:

TERMS	DEFINITION
A	amps
A/C	air condition
A/I	anti-ice
A/T	autothrottle
AB	above
ABM	autobrake module
Abnorm	abnormal
ABS	absolute
AC	aircraft-centered, alternating current
ACARS	aircraft communications addressing and reporting system
ACAS	airborne collision avoidance system
ACC	air control center
ACCU	accumulator
ACP	audio control panel
ACT	altitude compensated tilt
ADA	advisory area, air data application
ADC	air data computer
ADF	automatic direction finder
ADI	attitude director indicator
ADIZ	air defense identification zone
ADLP	airborne datalink processor
ADM	air data module
ADMS	aircraft diagnostic and maintenance system
ADS	air data system
ADS-B	automatic dependent surveillance - broadcast
ADSP	air data smart probe

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TERMS	DEFINITION
ADT	automatic distress tracking
AES	aircraft earth station
AFCS	automatic flight control system
AFD	Airport Facility Directory
AFE	above field elevation
AFIS	automatic flight information system
AFM	Aircraft Flight Manual
AFMS	Aircraft Flight Manual Supplement
AFT	after
AGL	above ground level
AGM	advanced graphics module
AHRS	attitude and heading reference system
AIL	aileron
AIM	align in motion
AIS	airport information services
ALT	altitude
ALTN, Altn	alternate
AM	amplitude modulation
AMLCD	active-matrix liquid crystal display
Annun	annunciated
ANT	antenna
AOA	angle-of-attack
AOC	airline operational control
AOG	aircraft-on-ground
AP	autopilot
AP/FD	autopilot/flight director
API	antenna position indicator
APM	aircraft personality module, airline personality module
APP, APPR, Appr	approach
APU	auxiliary power unit

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TERMS	DEFINITION
AR	authorization required
ARINC	Aeronautical Radio Incorporated
ARTCC	air route traffic control center
ASA	aircraft surveillance applications
ASCB	avionics standard communications bus
ASEL	altitude select
ASSAP	airborne surveillance and separation assurance processing
AT	autothrottle
ATC	air traffic control
ATIS	automated terminal information service
ATS	Aerospace Technical Support
ATTCS	automatic takeoff thrust control system
AUTO, Auto	automatic
AVAIL	available
AVNX	avionics
AVOID	avoidance
AZM	azimuth mode
BARO	barometric
BATT	battery
BC	back course
BCM	brake control module
BCN	beacon
BFO	beat frequency oscillator
BIT	built-in test
BITE	built-in test equipment
BKUP	backup
BL	below
BLOS	beyond-line-of-sight
BOD	bottom-of-descent
BOSC	bottom-of-step climb

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TERMS	DEFINITION
BRG	bearing
BRK	brake
BRT	bright
BTMS	brake temperature monitoring system
BZ	buffer zone
C	centigrade
C/A	commercial access
CAB	cabin
CAS	calibrated airspeed, crew alerting system
CAT	category
CB	circuit breaker
CCA	circuit card assembly
CCD	cursor control device
CCS	cabin communications system
CCW	counterclockwise
CD	compact disk
CDI	course deviation indicator
CDTI	cockpit display of traffic information
CFIT	controlled flight into terrain
CHAN	channel
Chkl	checklist
CHR	chronometer
CIOCALS	control I/O control abstraction layer
CLB	climb
CLX	clearance
CM	configuration module
CMC	central maintenance computer
CMCF	central maintenance computer function
CMF	communications management function
CMS	code management system

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TERMS	DEFINITION
COM	communication
CON	continuous
CONFIG, Config	configuration
COTS	commercial off-the-shelf
CPA	closest point of approach
CPDLC	controller pilot datalink communications
CRG	cargo
CRS	course
CRZ	cruise
CSS	camera surveillance system
CTA	control area
Ctl, Ctrl	control
CTLZ	control zone
CTRL	controller
CVR	cockpit voice recorder
CW	clockwise, continuous wave
D-ATIS	digital automatic terminal information service
D-ROT	derotation
D/LNA	diplexer/low-noise amplifier
DA	decision altitude
DAP	downlink aircraft parameters
DC, dc	direct current, display contoller
DCL	departure clearance
DCLRST	deceleration speed restriction
DD	driftdown
DEM	digital elevation model
DEOS	digital engine operating system
Dest	destination
DET	detector

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TERMS	DEFINITION
DGRAD	degrade
DIFF	differential
Dir	direction
DISAG	disagreement
DISC	disconnect
DISCH	discharge
DIST	distance
DLR	datalink recorder
DME	distance measuring equipment
DN	down
DR	dead reckoning
DTK	desired track
DT	distress tracking
DU	display unit
DVDR	digital voice data recorder
DVR	digital voice recorder
EADI	electronic attitude director indicator
eAPIS	electronic advance passenger information system
eASCB-D	enhanced avionics standard communications bus, version d
EBAY	electronic bay
ECL	electronic checklist
ECS	environmental control system
EDP	engine driven pump
EDS	electronic display system
EED	early event detection
EFIS	electronic flight instrument system
EGNOS	European Geostationary Navigation Overlay System
EGPWF	enhanced ground proximity warning function
EGPWS	enhanced ground proximity warning system

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TERMS	DEFINITION
EGT	exhaust gas temperature
EHSI	electronic horizontal situation indicator
EICAS	engine indication and crew alerting system
ELEC, Elec	electric, electrical
ELEV	elevator
ELT	emergency locator transmitter
EM	emission mode
EMER, Emer	emergency
ENG	engine
EO	engine out
EOSID	engine out standard instrument departure
EPF	enhanced protection function
EPU	estimated position uncertainty
Equip	equipment
ESCAPE	essential system configuration and architecture for Primus Epic
ESS	essential
ET	elapsed timer
ETA	estimated time of arrival
ETE	estimated time en route
ETOPS	extended operations
ETP	equal time point
ETTS	electronic thrust trim system
EX	expanded
F	Fahrenheit, flap
FAA	Federal Aviation Administration
FADEC	full authority digital engine control
FAF	final approach fix
FAS	final approach segment
FAX	facsimile

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TERMS	DEFINITION
FBW	fly-by-wire
FCC	flight control computer
FCM	flight control modules
FCS	flight control system
FCU	flight control unit
FD	flight director
FDR	flight data recorder
FF	fuel flow
FGCS	flight guidance control system
FIFO	first in/first out
FIR	flight information region
FIREX	fire extinguisher
FL	flight level
FLCH	flight level change
FLT, Flt	flight
FMA	flight mode annunciator
FMS	flight management system
FOM	figure-of-merit
FOV	field of view
FP	flight plan
FPA	flight path angle
FPCP	flight path control point
fpm	feet per minute
FPR	flight path reference
FPS	flight path symbol
fps	feet per second
FREQ	frequency
FSBY, FSTBY	forced standby
ft	feet
FTM	feet to meters
FTS	Flight Technical Services
Funct	function

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TERMS	DEFINITION
FWC	fault warning computer
FWD	forward
FWSOV	firewall shut-off valves
G.W.	gross weight
G/S	glideslope
GA	go-around
GAGAN	GPS Aided Geo Augmented Navigation
GBAS	ground-based augmentation system
GEN	generator
GES	ground earth station
GFP	graphical flight planning
GHz	gigahertz
GLS	GBAS landing system
GMAP	ground mapping
GND	ground
GP	glide path, guidance panel
GPS	global positioning system
GPU	ground power unit
GS	glideslope
GSPD	groundspeed
H	hold, hour
HA	high altitude
HAL	horizontal alert limit
HDG	heading
HDPH	headphone
HF	high frequency
HFOM	horizontal figure-of-merit
HH	hours

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TERMS	DEFINITION
HI	high
HIL, HINT	horizontal integrity limit
HP	high pressure
HPA	high power amplifier
hPa	hectopascals
HS-ACE	horizontal stabilizer actuation control electronics
HSI	horizontal situation indicator
HTR	heater
HUD	head-up display
HYD, Hyd	hydraulic
Hz	hertz
I	inner
I/O	input/output
IAP	instrument approach procedure
IAS	indicated airspeed
IB	inboard
IBIT	initiated built-in test
ICAO	International Civil Aviation Organization
ID	ident, identification
IDENT, ident	identifier
IES	integrated electronic standby
IGN	ignition, ignitor
IHBT	inhibit
ILS	instrument landing system
IMP	impending
INAV	interactive navigation
inHg	inches of mercury
INIT	initialization
INMARSAT	International Maritime Satellite Organization

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TERMS	DEFINITION
INOP, Inop	inoperative
INPH	interphone
IR	inertial reference
IRS	inertial reference system
IRU	inertial reference unit
ISA	International Standard Atmosphere
ITT	interturbine temperature
ITU	International Telecommunications Union
IVS	inertial vertical speed
KG, kg	kilogram(s)
kHz	kilohertz
KPH	kilograms per hour
KTS	knots
kVA	kilovolt-ampere
kW	kilowatt
L	left
LA	low altitude
LAN	local area network
lat	latitude
LAV	lavatory
LB, lb, LB(S), lbs	pound(s)
LCD	liquid crystal display
LD	lower sideband data
LED	light emitting diode
LFE	landing field elevation
LG	landing gear
LH	left-hand
LIM	limit, limited

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TERMS	DEFINITION
LNAV	lateral navigation, long-range navigation
LO	low
LOC	localizer
lon	longitude
LP	low pressure
LPV	localizer performance with vertical guidance
LRM	line replaceable module
LRRA	low range radio altitude
LRU	line replaceable unit
LSA	low speed awareness
LSK	line select key
LT	light
LV	lower sideband voice
LVDT	linear variable differential transformer
M	Mach, magnetic, middle
MAG	magnetic
MAGVAR	magnetic variation
MAN	manual
MAP	missed approach point
MATZ	military air traffic zone
MAU	modular avionics unit
MB	marker beacon
MCDU	multifunction control and display unit
MCS	multichannel SATCOM
MCT	maximum continuous thrust
MED	medium
MEM	memory
MF	multifunction
MFD	multifunction display

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TERMS	DEFINITION
MGT	management
MHz	megahertz
MIC	microphone
MICST	stuck microphone
MIN	minimum
MKR	marker
MM	middle marker, minutes
MOA	military operations area
MPEL	maximum permissible exposure level
MRC	modular radio cabinet
MSAS	Multifunction Transportation Satellite-Based Augmentation System
MSG	message
MSL	mean sea level
MT	Mach trim
MTC	minimum terrain clearance
MTCA	military terminal control area
mW	Milliwatts
MWF	monitor warning function
MWS	monitoring warning system
N	noncolocated, North
N/A	not applicable
NAI	nacelle anti-ice
NAV	navigation
NAVAID	navigation aid
NCD	no computed data
NDB	navigation database, non-directional beacon
NG-NIC	next generation network interface controller
NIC	network interface card

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TERMS	DEFINITION
NIM	network interface module
NM	nautical miles
NML, NRM	normal
NO	number
NOAA	National Oceanic and Atmospheric Administration
NOTAM	notice to airmen
O	outer
OB	outboard
OCA	ocean control area
ODS	output data set
OEM	original equipment manufacturer
OFV	outflow valve
OMS	onboard maintenance system
OP	operational
OPR	operator
Orig	origin
ORT	owner requirements table
OVERPRESS	overpressure
OVRD	override
OVSP	overspeed
OXY	oxygen
P-ACE	primary actuator control electronics
PA	passenger address, public address
PACIS	passenger address and cabin interphone system
PAX	passenger
PBIT	power-up built-in test
PC	personal computer
PFD	primary flight display

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TERMS	DEFINITION
PFPA	potential flight path acceleration
PLI	pitch limit indicator
PNS	primary navigation source
POF	phase of flight
POS	position
PPH	pound per hour
PRAIM	predictive receiver autonomous integrity monitoring
PRESN	precision
PRESS	pressure
PREV	previous
PRKG	parking
Proc	processor
PROT	protector
PROX	proximity
PSEM	proximity sensor evaluation module
PSI, psi	pounds per square inch
psid	pounds per square inch differential
psig	pounds per square inch gauge
PTH	path
PTT	push-to-talk
PTU	power transfer unit
PWR	power
PWS	predictive windshear
QT	quart
QTY	quantity
R	right
RA, RALT	radar altimeter, radio altitude, resolution advisory
RAAS	runway awareness and advisory system

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TERMS	DEFINITION
RAD	radio
RAIM	receiver autonomous integrity monitoring
RAT	ram air turbine
RC	reduced carrier
RCB	radio control bus
RCLS	runway centerline light system
RCT, REACT	rain echo attenuation compensation technique
RECIRC	recirculate
REIL	runway end identifier light
REQ	request
RETD	retard
REV	reverser
RF	radio frequency
RFCF	runway field clearance floor
RH	right-hand
RIB	remote image bus
RIPS	recorder independent power supply
RLOUT	rollout
RNP	required navigation performance
RPM	revolutions per minute
RSTCAS	speed restriction CAS
RSV	reserve
RTA	receiver/transmitter/antenna
RTE	route
RTO	rejected takeoff
RUD	rudder
RVR	runway visual range
RWY	runway
RX	receiving

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TERMS	DEFINITION
S	slats, slaved, South, squelch
S/F	slat/flap
SA	selectively availability, situational awareness
SAT	satellite, static air temperature
SATCOM	satellite communications
SBAS	satellite-based augmentation system
SBH	audio frequency syllabic content to noise squelch
SBL	audio frequency syllabic content squelch
SDU	satellite data unit
SEC	secondary
sec, SS	second(s)
SECT	sector
SEL	select
SELCAL	selective calling
SENS	sensor
SERV	service
SID	standard instrument departure
SLV	slave
SMK	smoke
SMP	simplex
SOP	standard operating procedure
SOV	shut off valve
SPD	speed
SPDA	secondary power distribution assemblies
SPDBRK	speedbrake
SPDE	speed control mode (elevators)
SPDT, SPDt	speed control mode (throttles)

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TERMS	DEFINITION
SPEX	spares exchange
SPKR	speaker
SPLR	spoiler
SPLT	split
SPS	stall protection system
SQ	squelch
SQH	squelch high
SQL	squelch low
SR/SL	SmartRunway/SmartLanding
SRA	special rules area
SRC	source
SRN	short-range navigation
SRZ	special rules zone
SSM	sign status matrix
SSR	secondary surveillance radar
STAB	stabilization
STAR	standard terminal arrival route
STBY	standby
STD	standard
SUA	special use airspace
SVS	synthetic vision system
SW	switch
SWPS	stall warning protection system
SYNC	synchronize
SYS, Sys	system
T	terminal, true
T/O	take off, takeoff
TA	traffic advisories
TACAN	tactical air navigation

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TERMS	DEFINITION
TAD	terrain awareness display
TAS	true airspeed
TAT	total air temperature
TAWS	terrain awareness and warning system
TCA	terminal control area
TCAS	traffic alert and collision avoidance system
TCF	terrain clearance floor
TCH	threshold crossing height
TCQ	thrust control quadrant
TCS	touch control steering
TDS	takeoff data set, takeoff dataset selection
TDZ	touch down zone
TEMP	temperature
TERM	terminal
TERR	terrain
TGT	target
THR	thrust
TLA	throttle lever angle, thrust lever actuator
TMA	terminal maneuvering area
TMS	thrust management system
TO	takeoff
TOC	top-of-climb
TOD	top-of-descent
TOGA	takeoff/go-around
TOLD	takeoff and landing data
TRA	temporary reserved airspace
TRS	thrust rating selection, thrust rating system
TRU	transformer rectifier unit, true
TTFF	time-to-first-fix

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TERMS	DEFINITION
TTG	time-to-go
TTS	time-to-station
TURB	turbulence
TX	transmit
UD	upper sideband data
UDA	user defined area
UIR	upper flight information region
UR	unrestricted
UTC	universal time coordinated
UV	upper sideband voice
V	volts
V AC	volts alternating current
V DC	volts direct current
VALT	vertical altitude hold
VAR	variable
VASEL	VNAV altitude select
VDB	VHF data broadcast
VDR	VHF data radio, voice/data recorder
VENT	ventilation
VERT	vertical
VF	flap retraction speed
VFLC	vertical flight level change
VFLCH	VNAV flight level change
VFOM	vertical figure-of-merit
VFR	visual flight rules
VFS	final segment speed
VHF	very high frequency
VIB	vibration
VIDL	VOR/ILS datalink

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TERMS	DEFINITION
VINT	vertical integrity limit
VLV	valve
VNAV	vertical navigation
VoIP	voice over internet protocol
VOL	volume
VOR	very high frequency omnibearing range
VOR/LOC	very high frequency omni-directional radio range/localizer
VORTAC	combined VOR and TACAN station
VR	takeoff rotation speed
VREF	reference speed
VS	vertical speed
VSD	vertical situational display
VSI	vertical speed indicator
VSTALL	stall speed
VTA	vertical track alert
W	west
W/M	windmill, windmilling
WAAS	Wide Area Augmentation System
WAI	wing anti-ice
WC	waypoint-centered
WOW	weight-on-wheels
WPT	waypoint
WRN	warning
WSHEAR, WSHR	windshear
WSU	wireless server unit
WX	weather radar
WX/T	weather with turbulence
XBLD	cross-bleed

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TERMS	DEFINITION
XFEED	crossfeed
XFR	transfer
XPDR	transponder
ZPRL	zero pitch reference line

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