TECHSAVIATION
Training Center

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NAVIGATION - ATA 34-00

Navigation

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Air Data Reference System

The Air Data Reference System (ADRS) has these components:

- Three pitot Air Data Modules (ADM)
- Three static ADMs
- One Total Air Temperature (TAT) probe
- Two Angle-Of-Attack (AOA) sensors.

The Flight Control Electronics (FCE) cabinets have the Air Data Reference Functions (ADRF).

The pitot and static ADMs convert pitot and static air pressures to a digital signal and send them to the FCEs. Temperature data from the dual-element TAT probe and AOA data is also sent to the FCEs.

The Electronic Flight Instrument System/Display Select Panels (EFIS/DSP) allow the flight crew to select the barometric correction data that is sent to the FCEs.

Using this data, the ADRFs calculate these values:

- Altitude
- Computed airspeed
- Mach number
- Air temperatures
- Angle of attack
- True airspeed
- Altitude rate.

The ADRF data in the FCEs uses all three pitot/static inputs, both AOA inputs, and both TAT inputs to calculate voted air data. This data is used by other functions in each FCE.

The data is also sent to the Common Computing Resource (CCR) cabinets through the Common Data Network (CDN) for use by the Display Crew Alerting System (DCAS) and other systems.

Because the TAT probe is not aspirated, the ADRF functions in the FCEs use cabin air compressor inlet temperature data if the ground speed is less than 50 knots.

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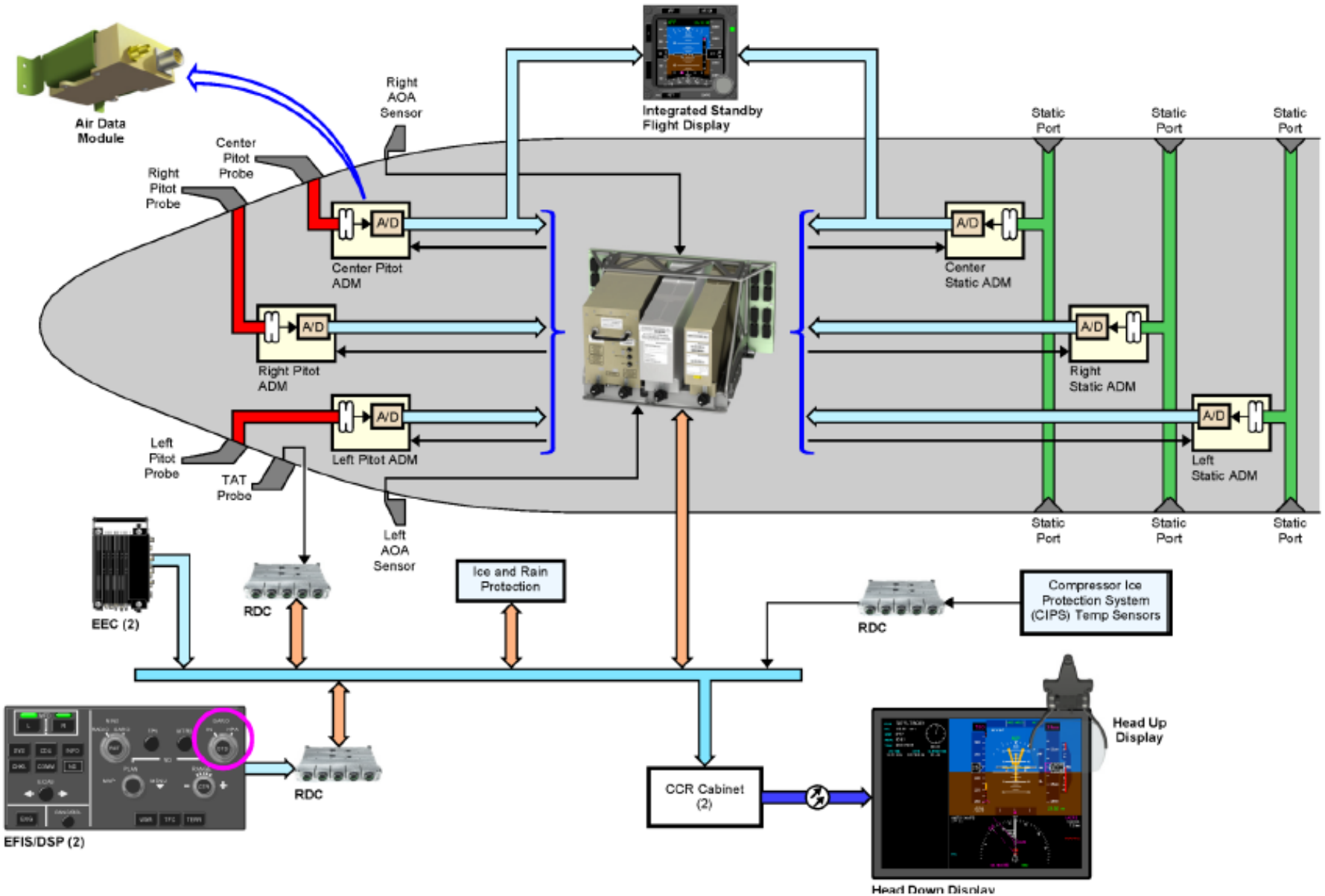

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Earth Reference System

The Earth Reference System (ERS) has these components:

- Two Inertial Reference Units (IRU)
- Two Attitude and Heading Reference Units (AHRU)
- Four Airplane Personality Modules (APM).

Each IRU and AHRU has three ring laser gyros and three linear accelerometers. Using these and air data from the Flight Control Electronics (FCE), the ERS calculates these values:

- Attitude (pitch, roll, and yaw)
- Position (latitude and longitude)
- True heading
- Magnetic heading
- Inertial velocity vectors
- Linear accelerations
- Angular rates
- Track angle
- Wind speed and direction
- Inertial altitude
- Vertical speed
- Ground speed
- Drift angle
- Flight path angle.

The IRUs and the AHRUs are mounted on trays in the aft electronic equipment bay. The APMs provide alignment correction data, which compensates for any misalignment between the mounting trays and the airplane axes.

The Integrated Navigation Radios (INR) send Global Positioning System (GPS) data to the IRUs and AHRUs.

The IRUs and AHRUs calculate hybrid inertial/GPS data and send it to the Common Data Network (CDN).

The Display Crew Alerting System (DCAS) uses the data for display on the Primary Flight Displays (PFD) and Navigation Displays (ND).

Before the ERS can operate in the navigation mode, the IRUs and AHRUs must be aligned. The alignment is started by selecting the IRS switches on the P5 overhead panel to the ON position.

If the ERS is on the ground and the ERS is operating on battery power, the ground crew call horn operates to alert the ground crew.

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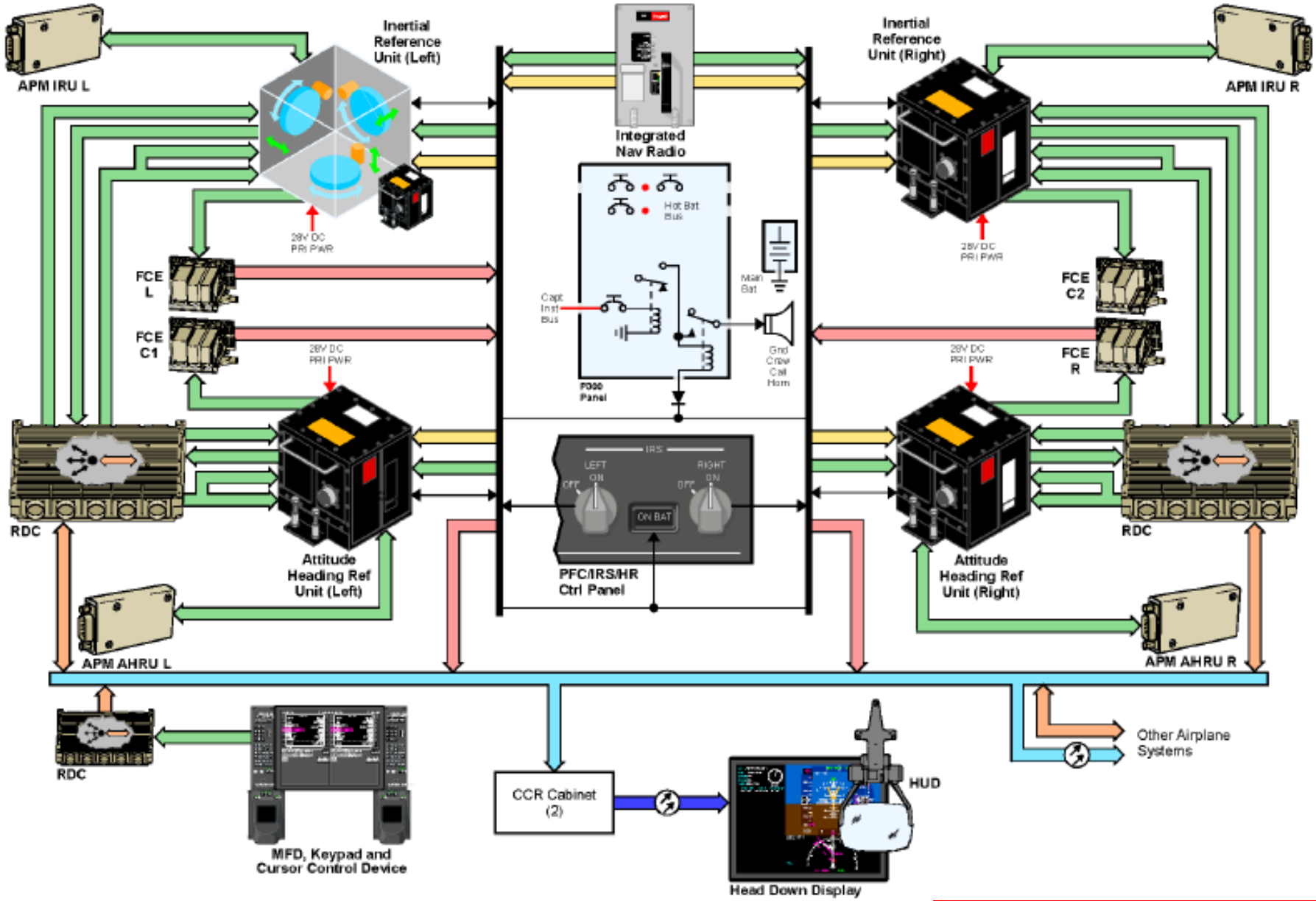

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Integrated Navigation System

Introduction

The Integrated Navigation Radios (INR) combine these systems in one Line Replaceable Unit (LRU):

- Instrument Landing System (ILS)
- VHF Omnidirectional Range (VOR) system
- Marker Beacon (MB) system
- Global Positioning System (GPS)
- GPS Landing System (GLS).

Instrument Landing System

The Instrument Landing System (ILS) supplies precision approach guidance during instrument approaches to the Display Crew Alerting System (DCAS) displays and the Auto-flight Function (AFF) in the Flight Control Electronics (FCE).

The ILS receiver is a module in each Integrated Navigation Radio (INR).

The ILS can be tuned automatically by the Flight Management Function (FMF) either as part of the flight plan or for position updating purposes.

The flight crew can also tune the ILS through the FMF using the Control Display Units (CDU) on a Multi-Function Display (MFD).

The DCAS displays show the ILS data. The localizer and glideslope deviation appear on scales on the Primary Flight Display (PFD).

The ILS uses the VOR antenna on the vertical stabilizer during the approach to capture the localizer. It then switches internally to the localizer radome antennas during the final phase of the approach.

The ILS audio is sent to the flight deck communication/warning speakers.

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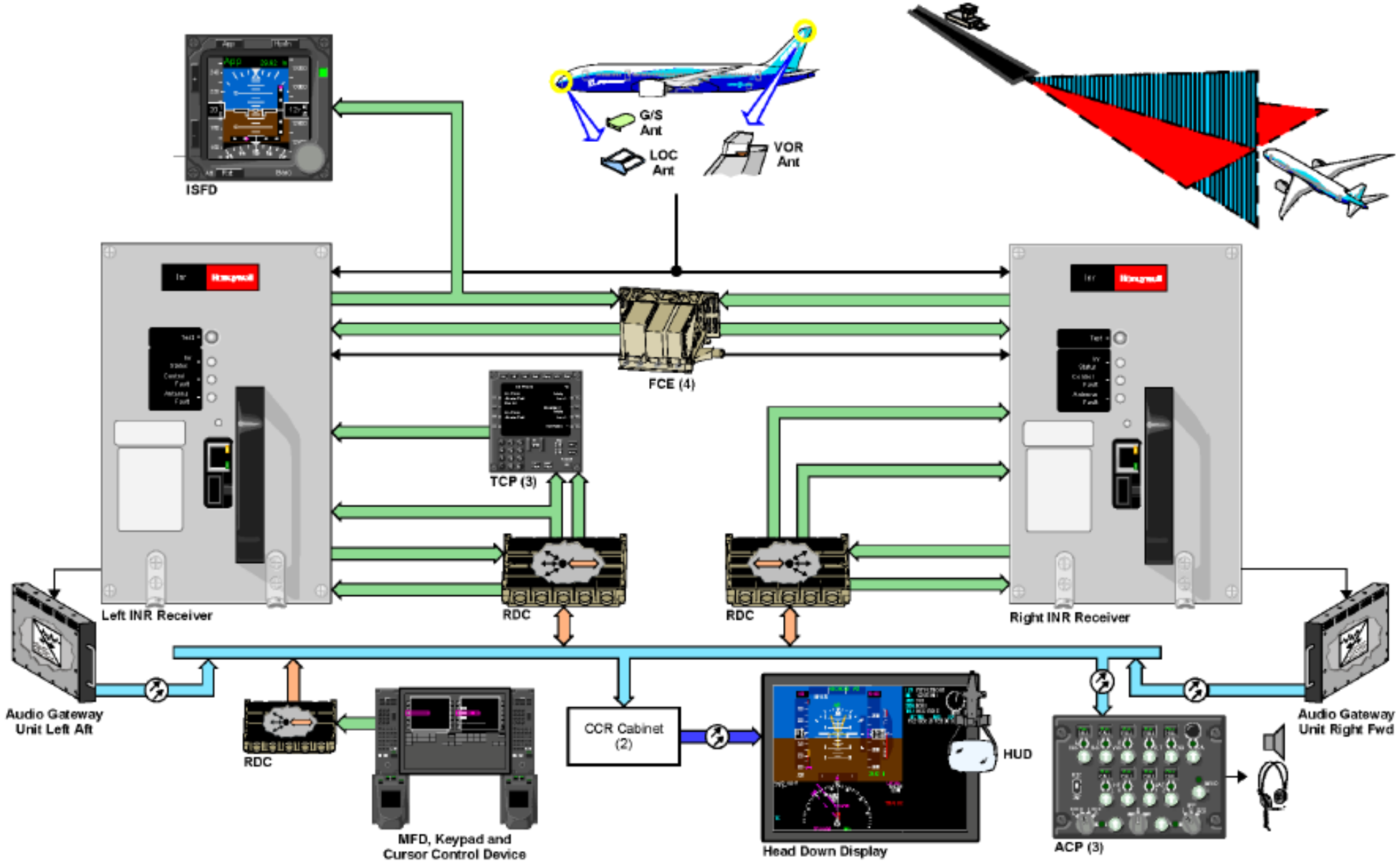

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INR System-VOR

The VHF Omnidirectional Range (VOR) system supplies bearing and deviation signals relative to ground stations to the Flight Management Function (FMF) and the Display Crew Alerting System (DCAS) displays.

The VOR receiver is a module in each Integrated Navigation Receiver (INR).

The VOR can be tuned automatically by the FMF as part of the flight plan.

The flight crew can also tune the VOR through the FMF using the Control Display Units (CDU) on a Multi-Function Display (MFD).

The FMF uses VOR data to update airplane position.

VOR bearing pointers appear on the navigation map display when selected by the flight crew.

The dual-element VOR antenna is on the top of the vertical stabilizer.

The VOR antenna also acts as the Instrument Landing System (ILS) localizer capture antenna during approach.

The VOR audio is sent to the flight deck communication/warning speakers.

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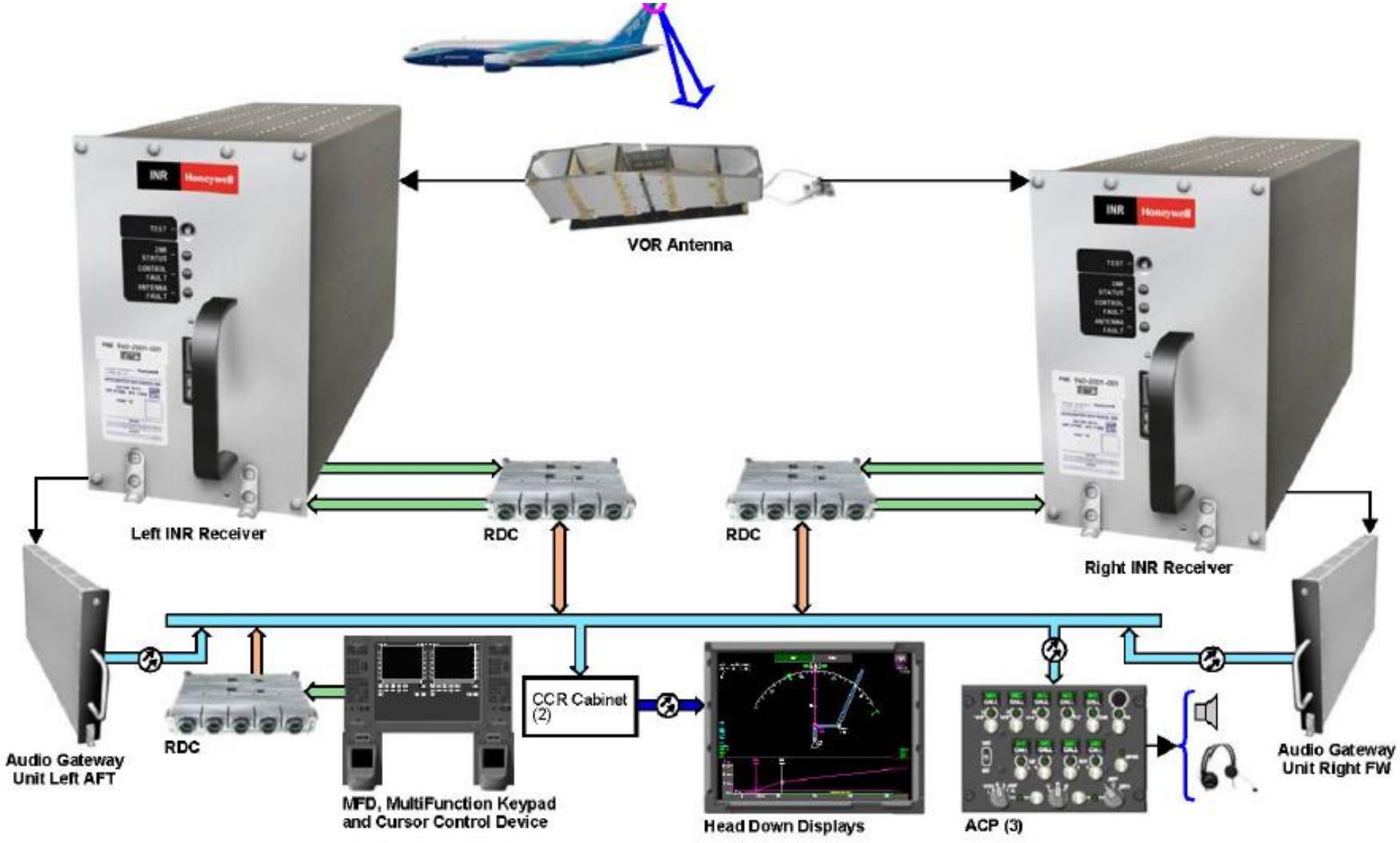

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INR System-Marker Beacon

The Marker Beacon (MB) system gives aural and visual indications when the airplane passes over a particular geographical location.

The visual indications appear on the Primary Flight Display (PFD) on the Display Crew Alerting System (DCAS) displays.

The MB aural tones are sent through the communication/warning speakers.

The MB receiver is a module in each Integrated Navigation Radio (INR). The MB function operates in the left INR only.

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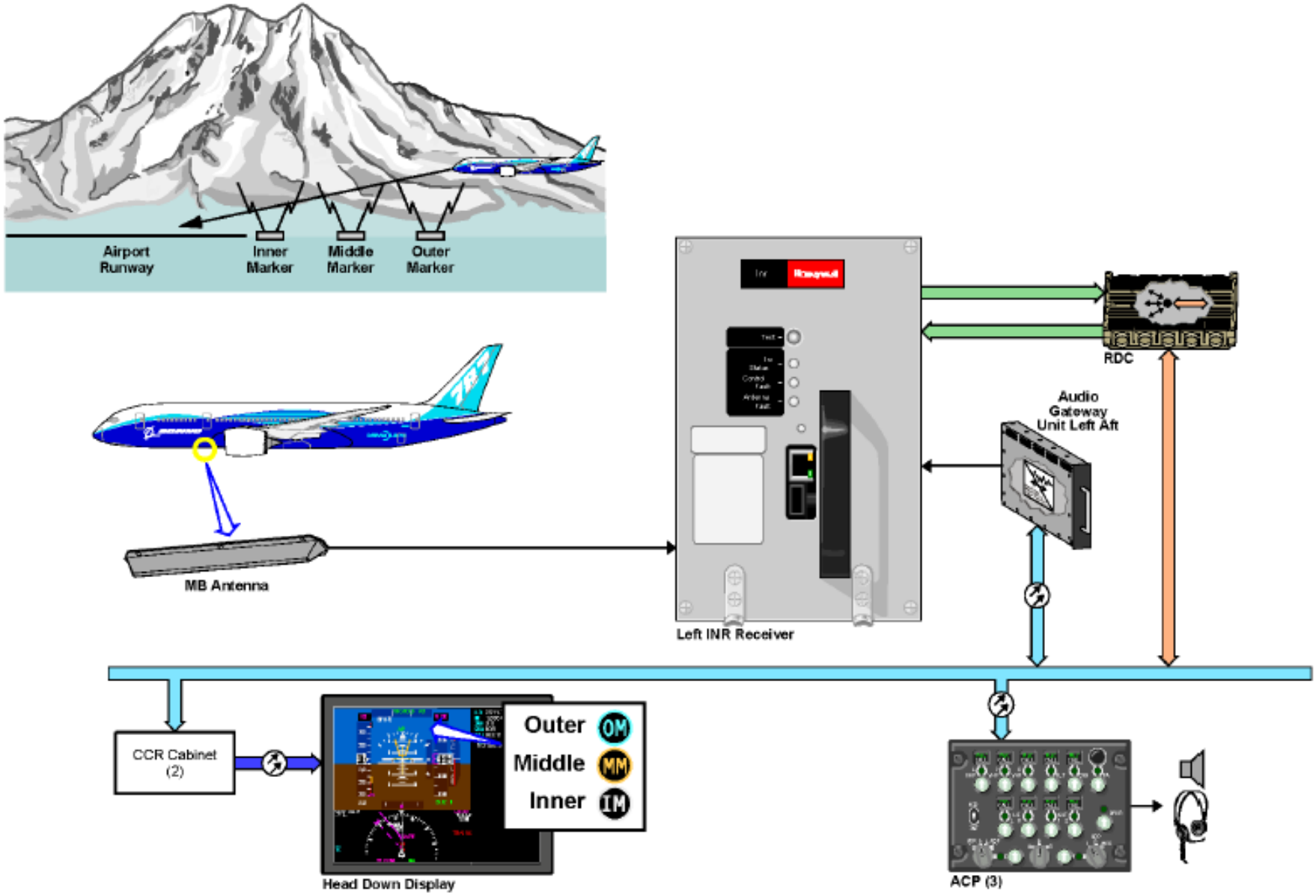

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INR System-GPS

The Global Positioning System (GPS) uses navigation satellites to supply accurate airplane position to the Flight Management Function (FMF), the Earth Reference System (ERS), and the flight crew.

The GPS calculates this data:

- Airplane latitude
- Airplane longitude
- Airplane altitude
- Time.

The GPS receiver modules are in the Integrated Navigation Radios (INR).

The GPS uses ERS position data to help in the satellite acquisition mode. The ERS then uses GPS data to calculate more accurate inertial data.

The FMF uses GPS position as the prime source for the calculation of airplane position. It is also the source for accurate time.

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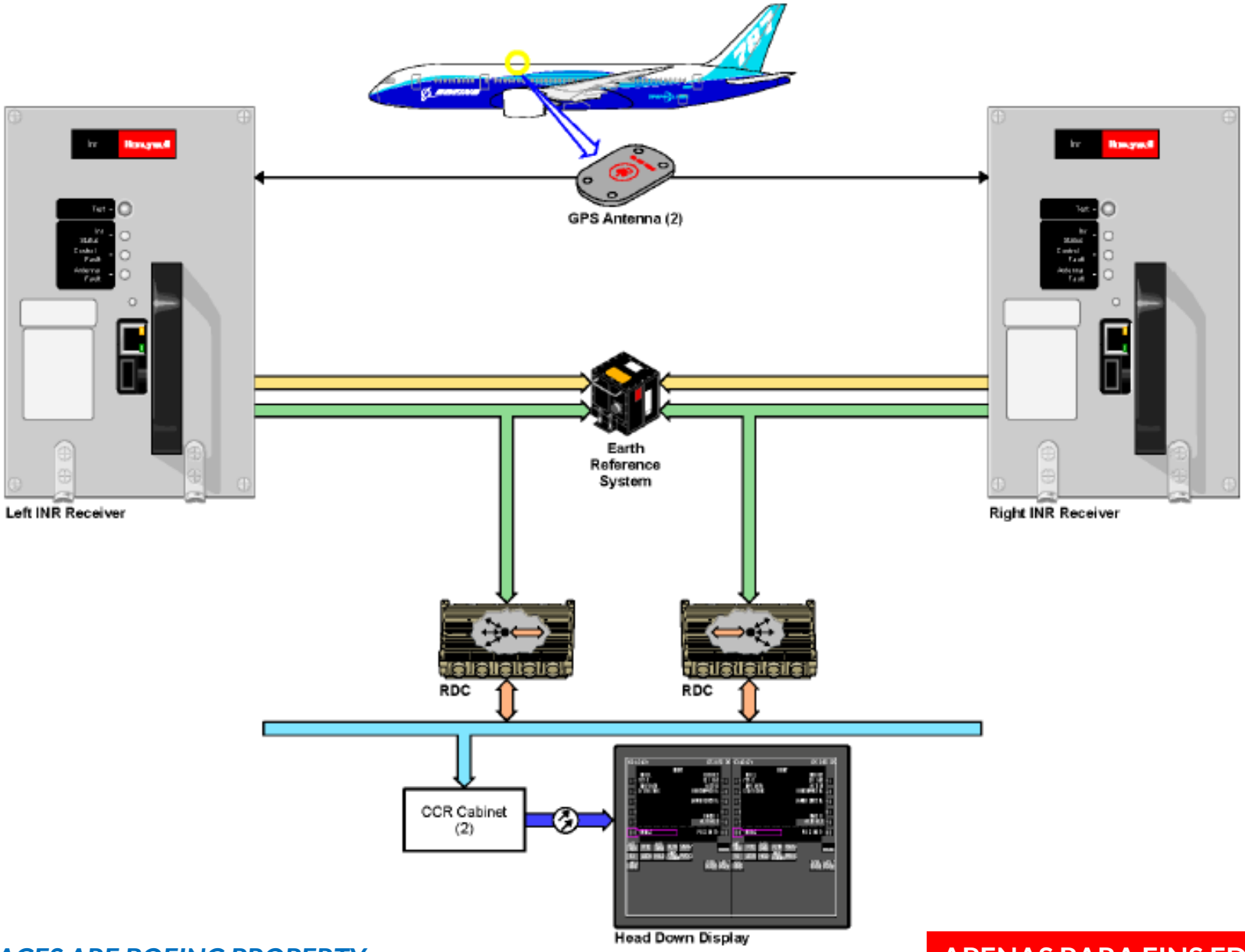

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INR System-GLS

The Global Navigation Satellite System (GNSS) Landing System (GLS) uses satellite and ground-based navigation stations to give lateral and vertical guidance during approach and landing.

These are the primary components of the GLS:

- Integrated Navigation Radio (INR)
- Tuning Control Panels (TCP)
- Dual element VHF
- Omnidirectional Range (VOR) antenna
- Global Positioning System (GPS) antennas.

The GLS is in each INR.

The GLS receives GPS signals through the GPS antennas. These give position, velocity, and time data for the GLS function.

The dual VOR antenna receives the VHF Data Broadcast (VDB) signals from the Ground Based Augmentation Station (GBAS). This gives differential corrections for the calculation of the GLS guidance commands.

The GBAS is near an airport and has a range of approximately 25 nautical miles (46 kilometers). GBAS has reference GPS receivers that compare the GPS position with the location of the GBAS facility. Corrections are calculated and transmitted to an airplane on the VDB datalink.

One GBAS can supply multiple landing approach data to different runways at different airports.

An airplane uses correct position data to make deviation displays on the Display Crew Alerting System (DCAS) displays.

The GLS can be tuned automatically by the Flight Management Function (FMF) as part of the flight plan.

The flight crew can also tune the GLS through the FMF using the Control Display Units (CDU) on a Multi-Function Display (MFD).

These systems use GLS data:

Autoflight Function (AFF) DCAS

Integrated Standby Flight Display (ISFD).

The GLS audio is sent to the flight deck communication/warning speakers.

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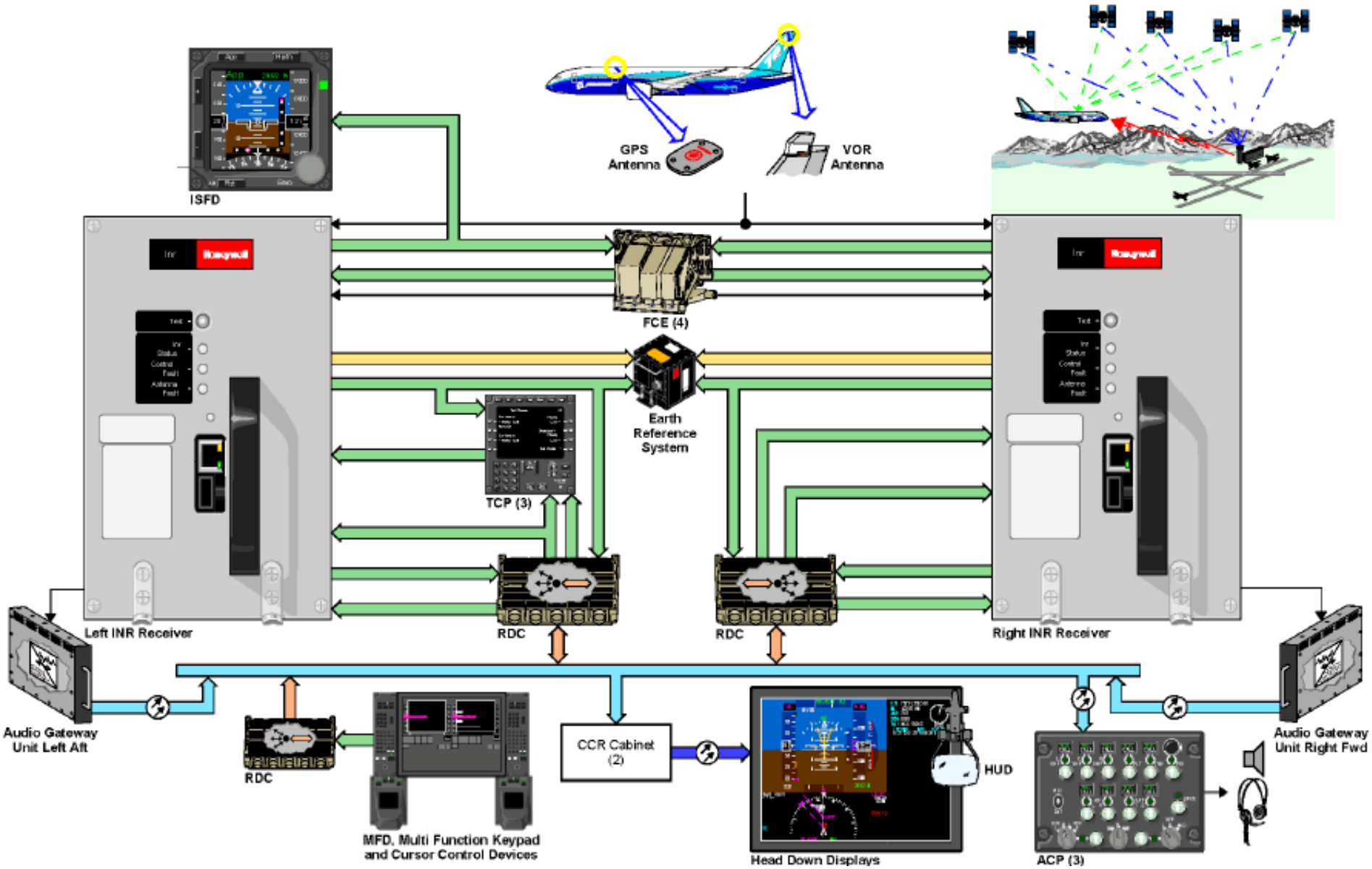

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Radio Altimeter System

The Radio Altimeter (RA) system supplies the pilots and airplane systems with altitude above the terrain. The system operates at low altitude (0 to 2,500 feet).

The system has two transceivers, each with its own transmit and receive antennas. The transceivers calculate the radio altitude, which appears on the Display Crew Alerting System (DCAS) displays.

Each pilot can select a radio minimums altitude on the onside Electronic Flight Instrument System/ Display Select Panel (EFIS/DSP).

The radio minimums are shown on the onside Primary Flight Display (PFD) next to the altitude tape display.

When the radio altitude is equal to or less than the radio minimums, the radio minimums display and the radio altitude change color from white to amber. The radio minimums also flashes momentarily.

The RA system data is also used by these systems:

- Autoflight Functions (AFF)
- Thrust Management Function (TMF)
- Terrain Awareness Warning System (TAWS)
- Traffic Alert and Collision Avoidance System (TCAS).

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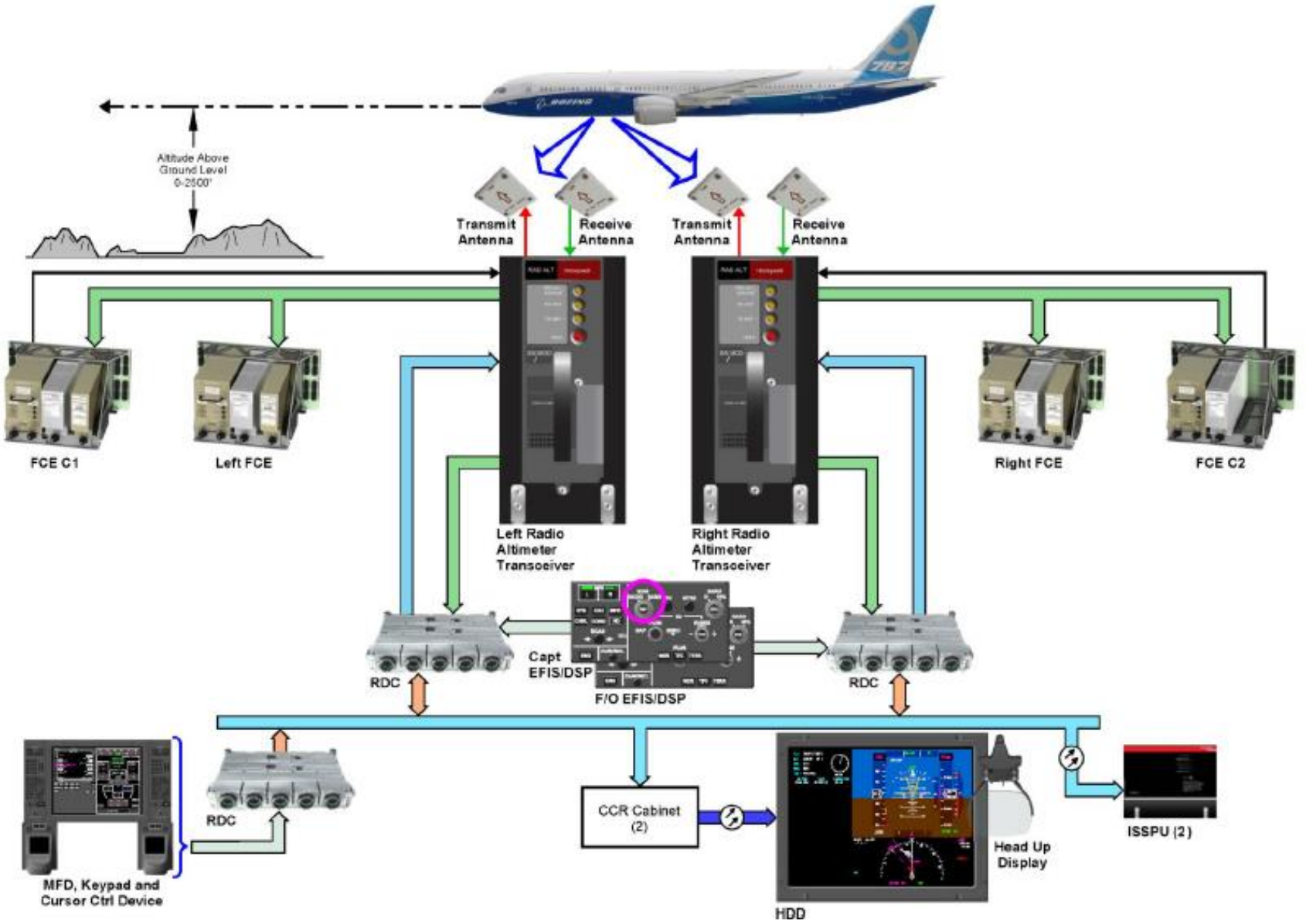

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Distance Measuring Equipment System

The Distance Measuring Equipment (DME) system supplies slant range distance between the airplane and a ground station to the Flight Management Function (FMF) and the Display Crew Alerting System (DCAS).

The FMF uses DME distance to update airplane position calculations.

The Primary Flight Display (PFD) and the navigation displays show the DME distances to either tuned Instrument Landing System (ILS) localizers or VHF Omnidirectional Range (VOR) stations.

The DME system supplies suppression pulses to the Air Traffic Control (ATC) function and the Traffic Alert and Collision Avoidance System (TCAS) in the Integrated Navigation Radios (INR). This is because DME frequencies are in the ATC and TCAS frequency range.

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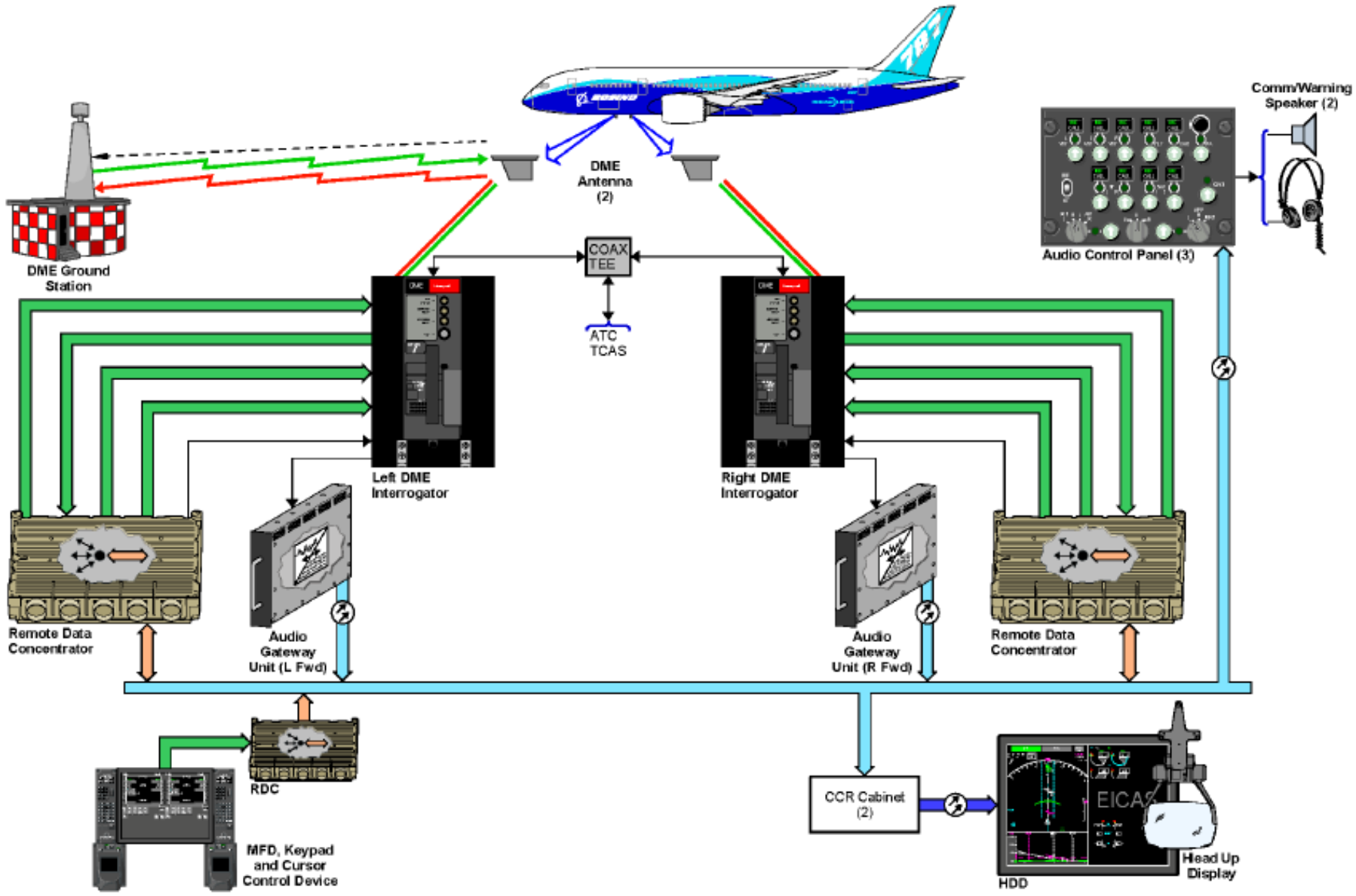

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Integrated Surveillance System

Introduction

The Integrated Surveillance System (ISS) combines these systems in one Line Replaceable Unit (LRU):

- Air Traffic Control (ATC) transponder function
- Traffic Alert and Collision Avoidance System (TCAS)
- Weather Radar (WXR) system
- Terrain Awareness Warning System (TAWS).

ISS-ATC System

The Air Traffic Control (ATC) function lets ground facilities monitor airplane movement through controlled airspace. The ATC ground stations monitor airplane location and altitude.

The ATC function is in each Integrated Surveillance System Processor Unit (ISSPU).

The ATC menu on the Tuning Control Panel (TCP) lets the flight crew select the:

- Left or right ATC function for operation
- Airplane ATC identification code
- Initiation of the identification pulse.

The flight crew uses the transponder mode selector on the alerting and transponder panel to select the ATC mode.

The ATC function gets altitude data from the Flight Control Electronics (FCE) and uses it for the altitude reporting function.

The ATC function supplies suppression pulses to the DME interrogators and TCAS.

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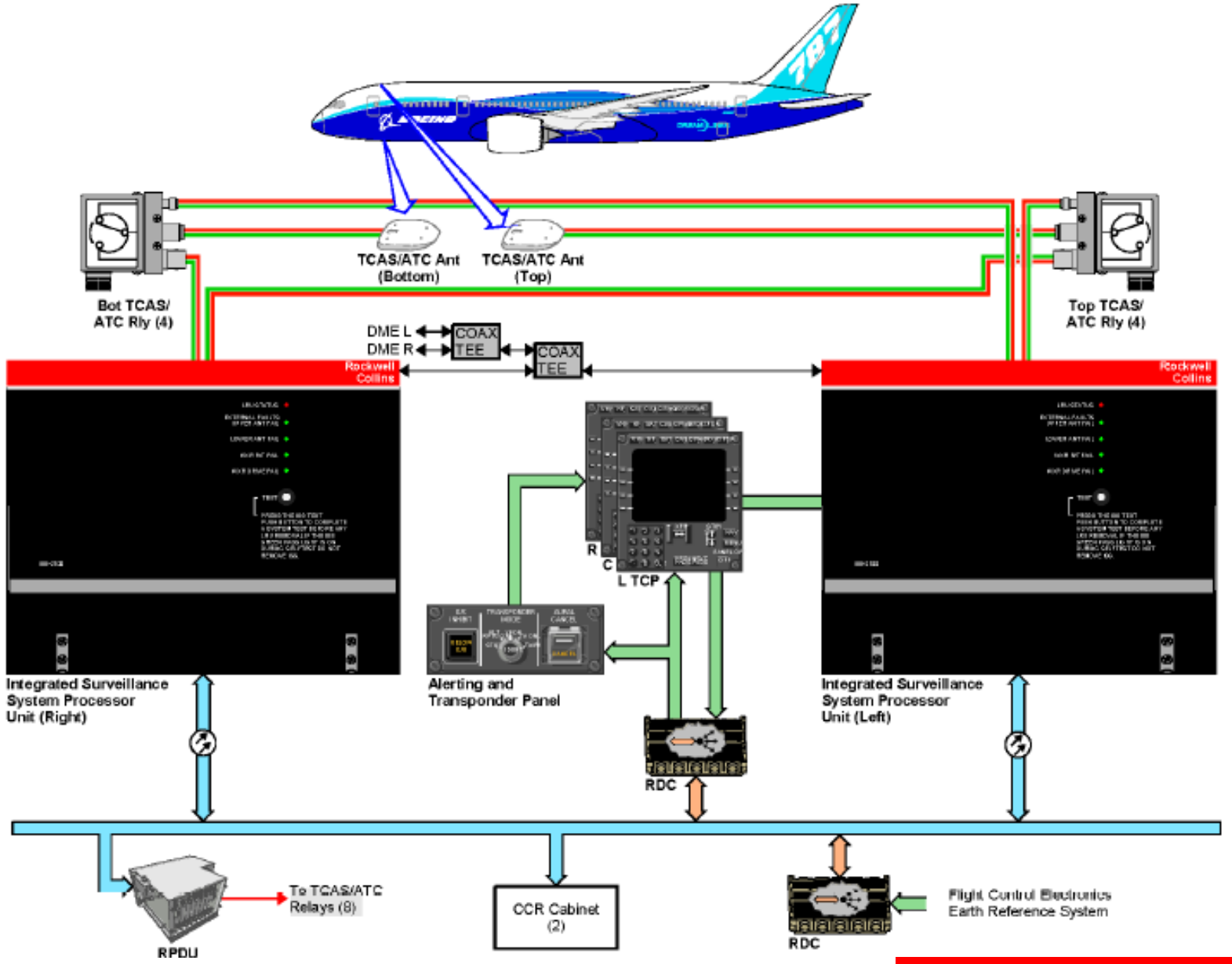

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ISS-TCAS

The Traffic Alert and Collision Avoidance System (TCAS) gives alerts to the flight crew of possible collisions with other airplanes.

The TCAS function is in each Integrated Surveillance System Processor Unit (ISSPU).

TCAS uses the ATC function to send TCAS data to other TCAS equipped airplanes. TCAS gives two types of advisories to the flight crew. One type of advisory is the Traffic Advisory (TA) that gives indication of other airplanes in the area.

The other type of advisory is the Resolution Advisory (RA). The RA gives an indication to the flight crew to change the vertical direction of the airplane or hold the present altitude to prevent a possible collision.

If an airplane is a collision threat, the TCAS function selects the best maneuver to prevent a collision. If the other airplane has TCAS, a maneuver coordination is done through the ATC data link.

The TCAS function sends data to the Display Crew Alerting System (DCAS) displays.

The traffic (TFC) button on the Electronic Flight Instrument System/ Display Select Panel (EFIS/DSP) causes the location and track of other airplanes to appear on the map displays.

The Primary Flight Displays (PFD) show the flight crew how to change or hold vertical speed. Aural alerts come on in the flight deck through the communication/warning speakers.

The ATC/TCAS antennas are on the top and bottom of the airplane. The antennas are directional.

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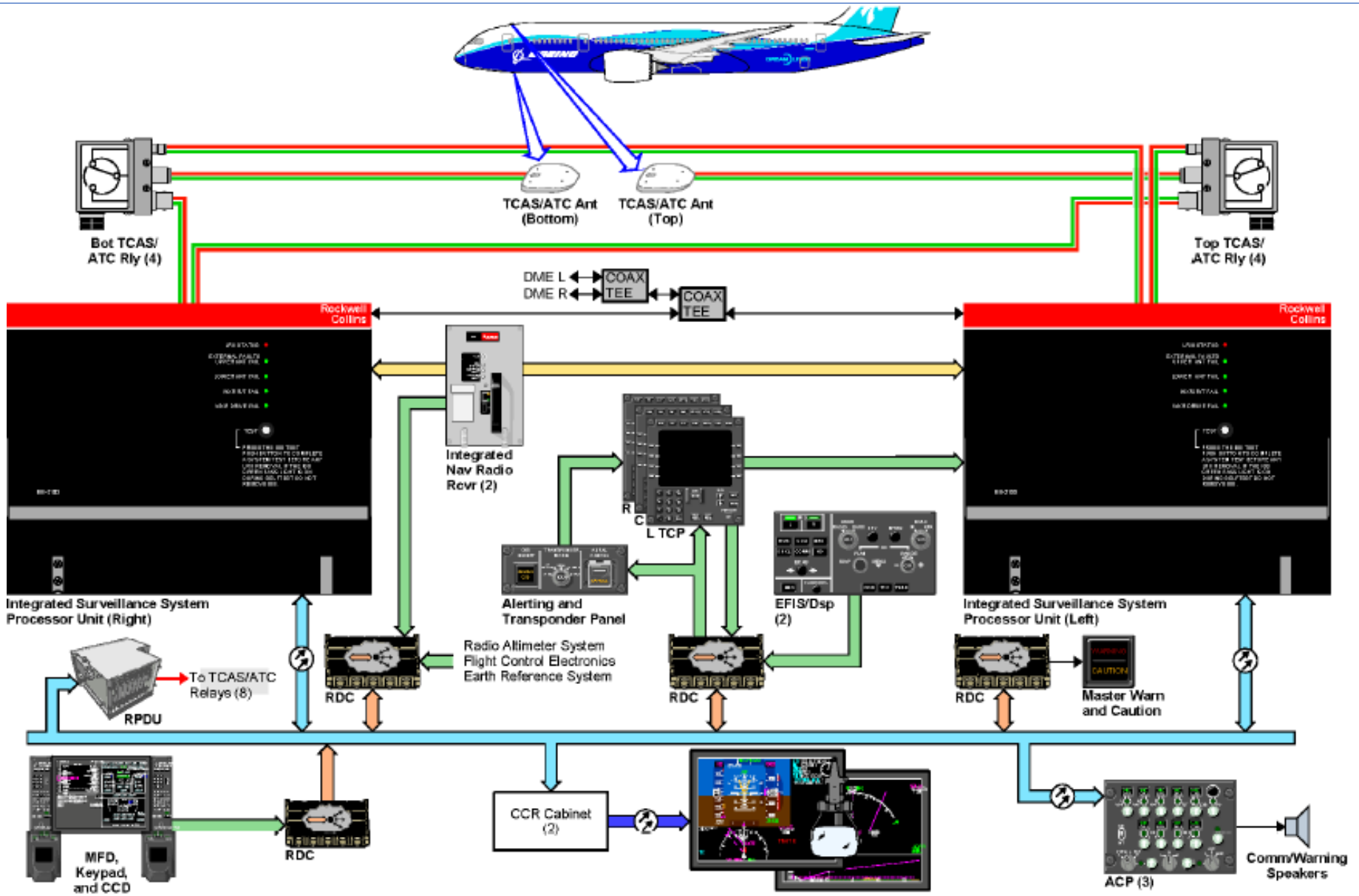

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ISS-WXR System

The Weather Radar (WXR) system shows the flight crew weather conditions along the flight path. This lets the crew change the flight path to go around bad weather conditions. The flight crew also uses the WXR system as a navigational aid.

The WXR function is in each Integrated Surveillance System Processor Unit (ISSPU).

These are the WXR components:

- Two Receiver/Transmitter Modules (RTM)
- Antenna flat plate
- Antenna drive unit.

The RTM sends weather display data to the ISSPU through a fiberoptic cable.

The ISSPU then sends the WXR data to the Display Crew Alerting System (DCAS). DCAS shows a four-color weather display on the navigation map display and the Primary Flight Display (PFD) mini map.

The onside Electronic Flight Instrument System/Display Select Panel (EFIS/DSP) selects weather returns to show on the displays and also controls the range for the weather display.

The flight crew selects the operation mode, receiver gain, and antenna tilt angle on the WXR menu on the Tuning Control Panels (TCP).

The map mode can show coastlines or large bodies of water.

The WXR has a predictive windshear mode that can find conditions that cause a windshear. If it finds these conditions, it makes an aural warning and shows a special windshear display on the displays.

Because a windshear is most dangerous when the airplane is at low altitude, the WXR comes on automatically on the ground during takeoff and when the airplane goes below 2,300 feet during approach.

Antenna attitude stabilization is done using data from the Earth Reference System (ERS).

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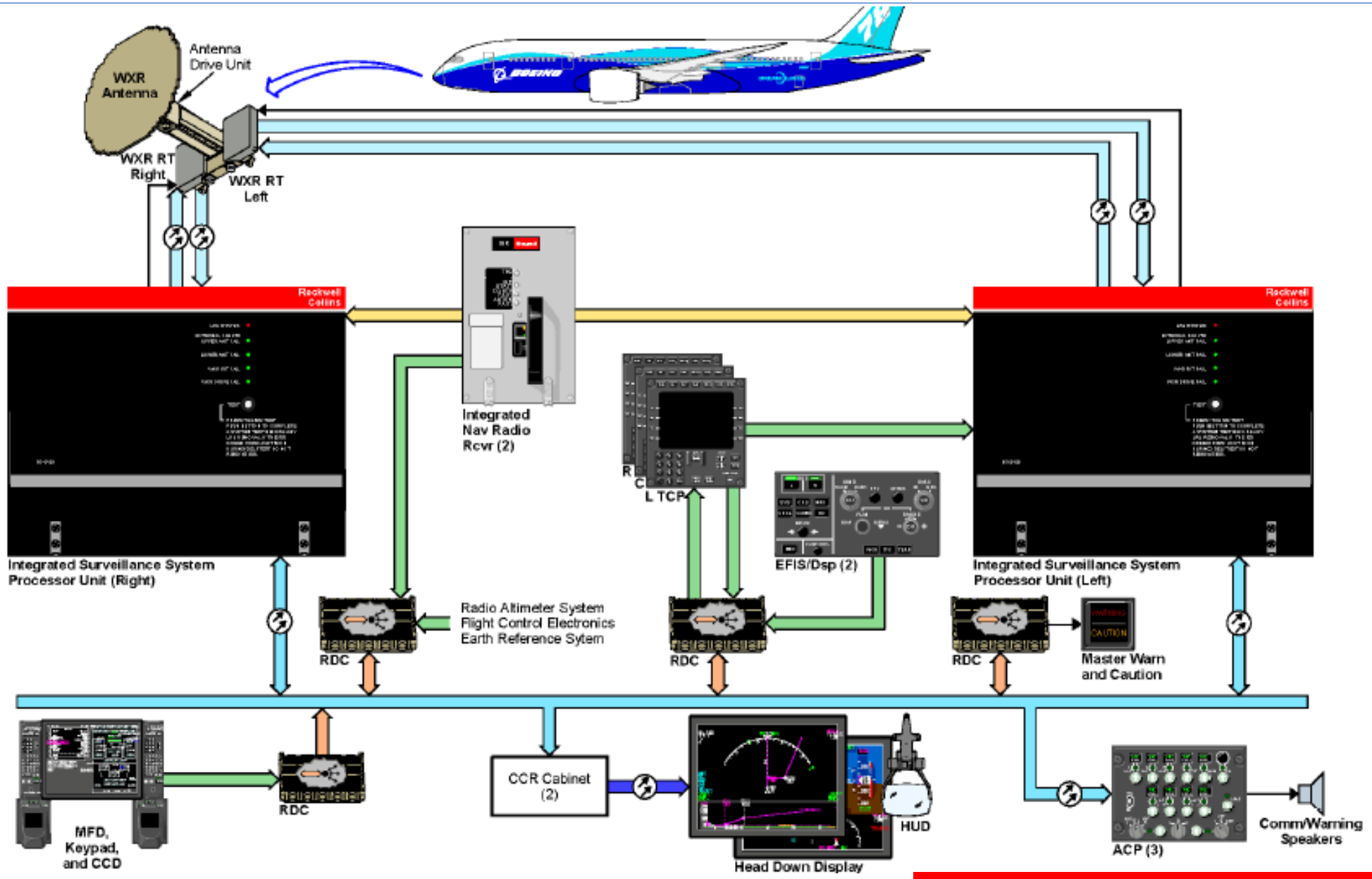

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ISS-TAWS

The Terrain Awareness Warning System (TAWS) gives alerts or warnings to the flight crew of unsafe terrain clearance. Alerts and warnings have aural and visual indications. These indications continue until the pilots correct the condition that started the warning or alert.

The TAWS function is in each Integrated Surveillance System Processor Unit (ISSPU).

The TAWS uses these inputs to calculate alerts and warnings:

- Common Data Network (CDN) – includes air data, inertial data, flight management data, flap position data, and landing gear position data
- Instrument landing system data
- Radio altimeter data.

TAWS alerts and warnings go to the Display Crew Alerting System (DCAS) and the communication/warning speakers.

The TAWS supplies these prioritized modes when the airplane is between 30 and 2,450 feet of radio altitude:

- Mode 1 – excessive descent rate
- Mode 2 – too much terrain closure rate
- Mode 3 – excessive descent after takeoff or go-around
- Mode 4 – insufficient terrain clearance when not in the landing configuration
- Mode 5 – excessive deviation below glideslope
- Mode 6 – altitude aural callouts
- Mode 7 – reactive windshear
- Terrain awareness mode
- Terrain Clearance Floor (TCF) mode
- Runway Field Clearance Floor (RFCF) mode.

The system supplies voice warnings to help the pilots identify the cause of the warning or alert.

The flight crew can use the TAWS menu on the Tuning Control Panels (TCP) to select the left or right TAWS function. They can also select these override functions:

- Trailing edge flaps
- Landing gear
- Terrain.

The TA mode uses a worldwide terrain database to give early warnings of terrain proximity.

The TCF mode uses data for the landing airport to provide early warnings of an unsafe approach.

The RFCF mode provides warnings for runways at higher elevations compared to the terrain below the approach path.

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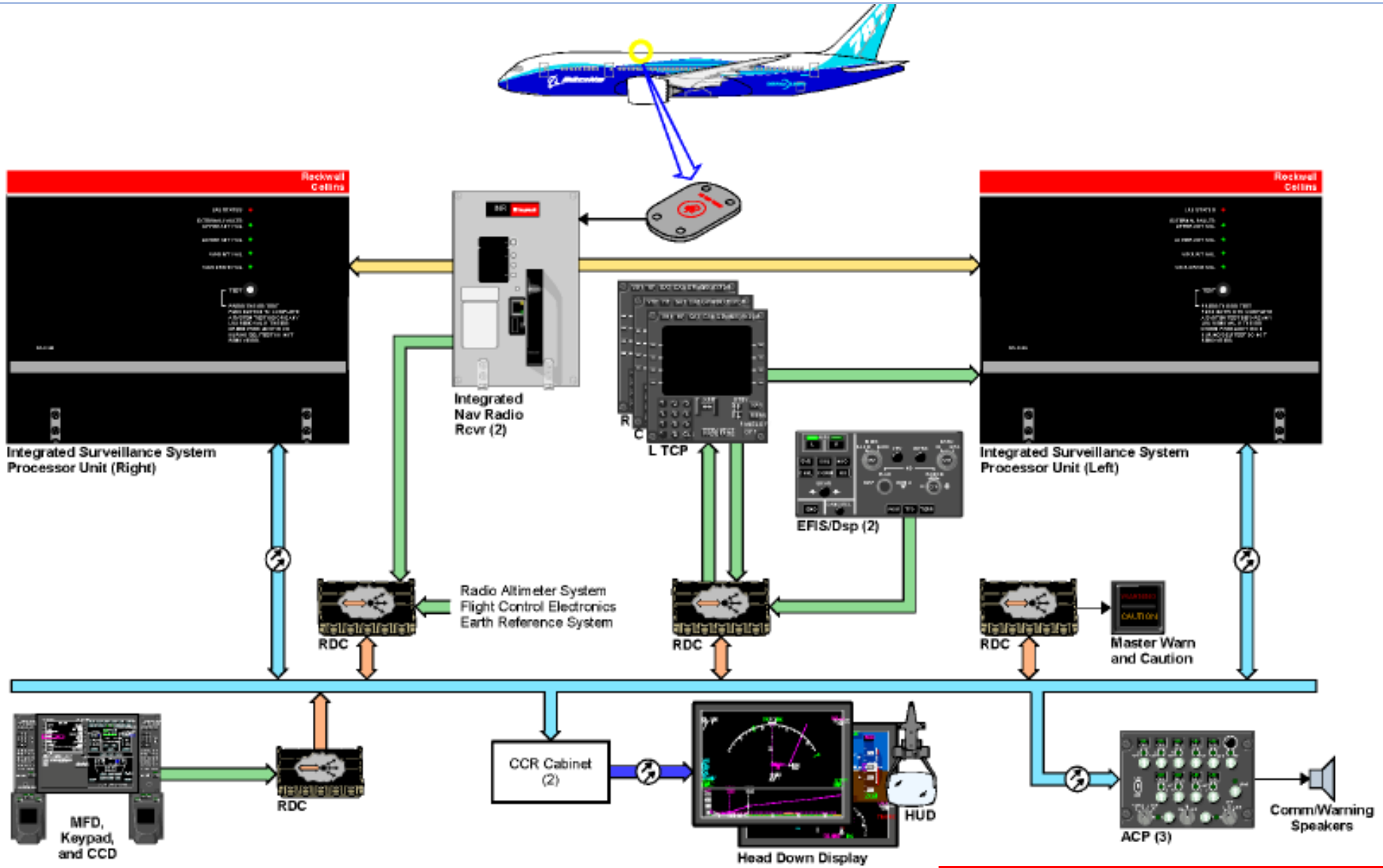

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ISS-Displays

The integrated surveillance system displays are:

- Traffic Alert and Collision Avoidance System (TCAS)
- Weather Radar (WXR)
- Terrain Awareness Warning System (TAWS).

These TCAS symbols can appear on the navigation map display and the Primary Flight Display (PFD) mini map display:

- Other traffic (white open diamond)
- Proximate traffic (solid white diamond)
- Traffic advisory (solid amber circle)
- Resolution advisory (solid red box).

WXR appears in these four colors on the map displays:

- Green (light moisture)
- Yellow (moderate moisture)
- Red (heavy moisture)
- Magenta (turbulence).

The WXR has a maximum range of 320 Nautical Miles (NM).

When a Predictive Wind Shear (PWS) warning or caution occurs, the windshear symbol will indicate where the microburst is in relation to the airplane heading.

The TAWS data appears on the navigation map display and the PFD mini map. It has a maximum range of 320 NM.

The terrain is shown using colored dot patterns to indicate the terrain altitude relative to the airplane altitude.

On the Vertical Situation Display (VSD), the terrain can be seen relative to the airplane flight path.

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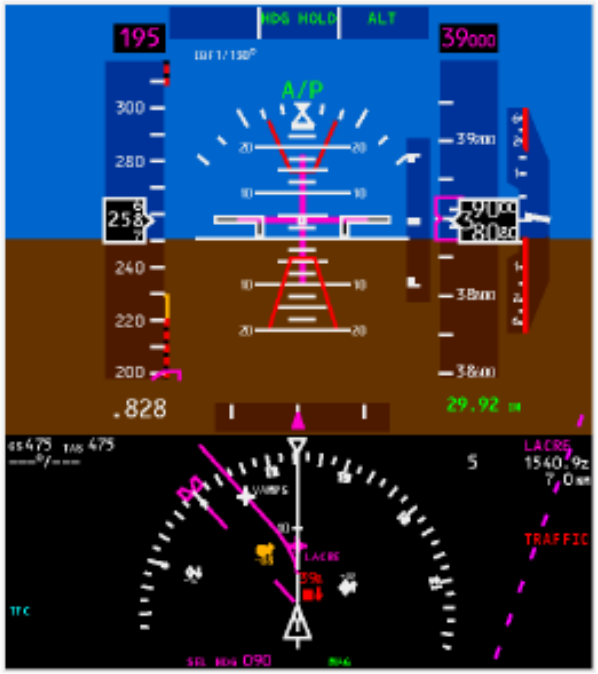
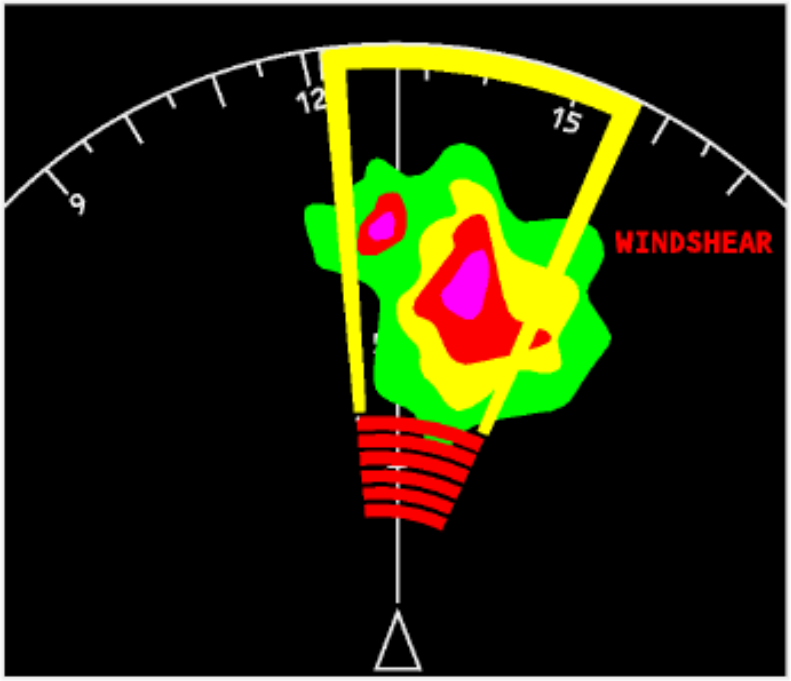
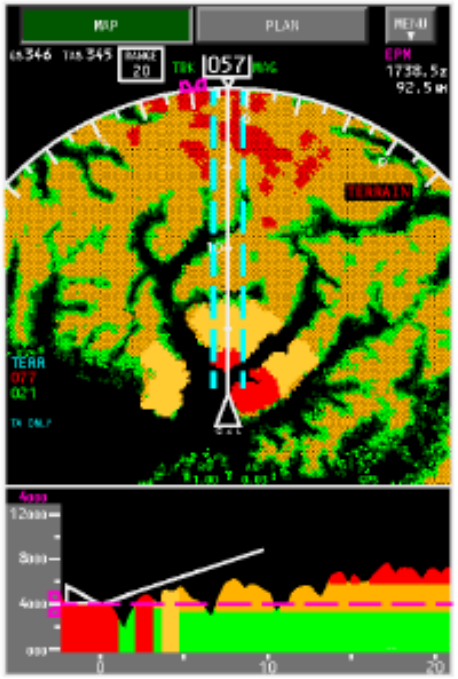


TCAS Display



Weather Radar Display



Terrain Display

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Integrated Standby Flight Display

The Integrated Standby Flight Display (ISFD) is a backup system that shows the flight crew this data:

- Pitch attitude
- Roll attitude
- Barometric altitude
- Magnetic heading
- Indicated Airspeed (IAS)
- Instrument Landing System (ILS) localizer and glideslope deviation.

The ISFD uses center pitot and static data from the air data modules to calculate IAS and barometric altitude.

Internal inertial sensors calculate pitch and roll data.

The left Integrated Navigation Radio (INR) sends ILS deviation data to the ISFD.

The center 1 Flight Control Electronics (FCE) provides 28V DC power for the ISFD. The FCE also sends magnetic heading and groundspeed data.

If all FCEs fail, the ISFD sends backup airspeed and altitude data to the Display Crew Alerting System (DCAS) through the Common Data Network (CDN).

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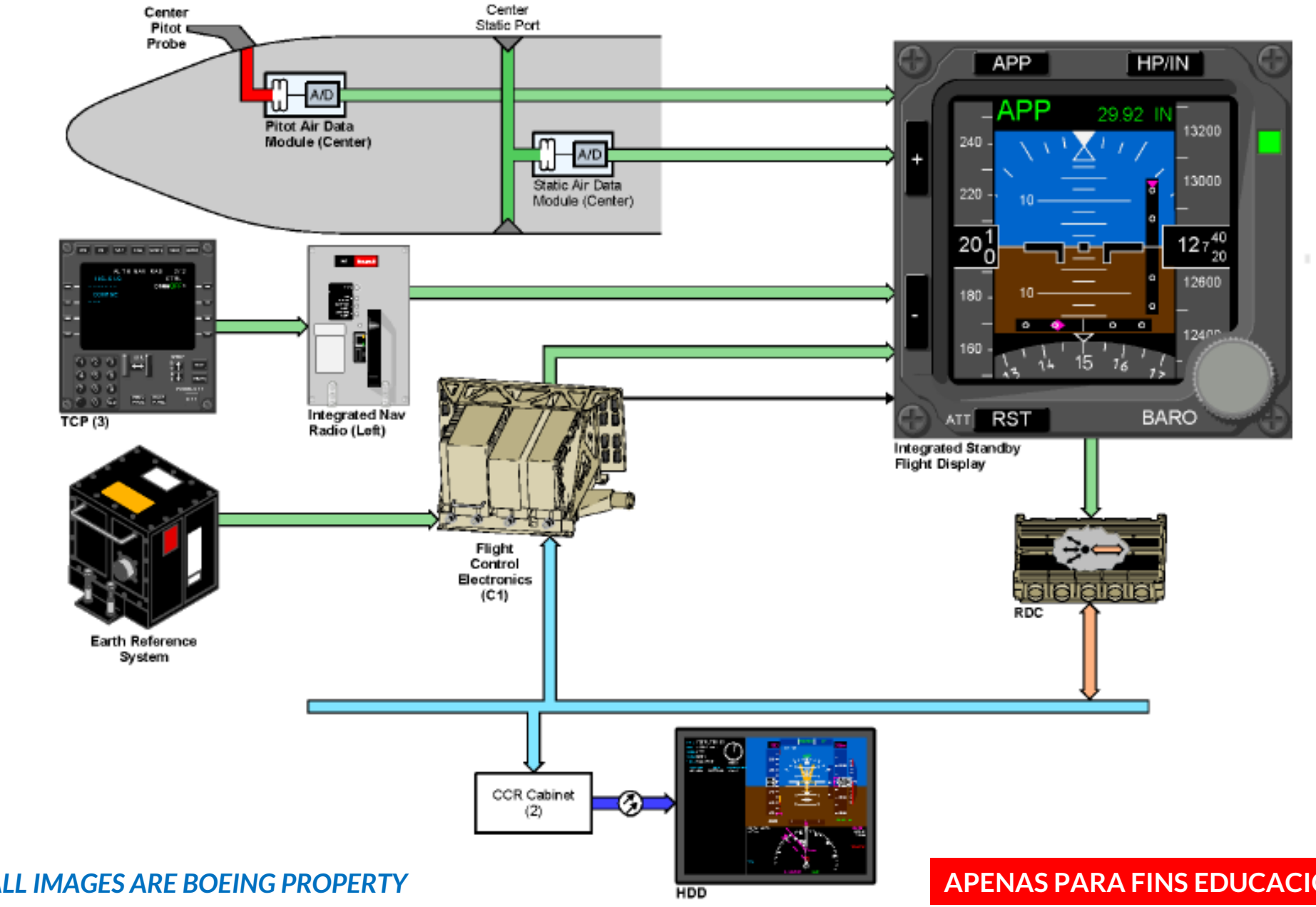

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