B737 NG CBT - NAVIGATION

COURSE OUTLINES

TABLE OF CONTENT

TABLE OF CONTENT

TABLE OF CONTENT

COURSE START

1-LEGAL CAUTION The material contained in this training program is based on the information obtained from current state, local and company regulations and it is to be used for training purposes only. At the time of designing this program contained then current information. In the event of conflict between data provided herein and that in publications issued by the authority, the authority shall take precedence.

NAVIGATION

2-NAVIGATION This chapter deals with the navigation. It is organized in five major sections •

AIR DATA INERTIAL REFERENCE SYSTEM

3-AIR DATA INERTIAL REFERENCE SYSTEM First, we will review the Air data inertial reference system. Here is the outline: •

INTRODUCTION

4-INTRODUCTION The air data inertial reference system (ADIRS) supplies flight data such as speed, altitude, position, heading and attitude.

5-The ADIRS data is used for the display units, flight management computers, autoflight system and all other airplane systems requiring inertial and air data.

6-The ADIRS mainly consists of two air data inertial reference units (ADIRU), four air data modules (ADM), an inertial system display unit (ISDU), an IRS mode select unit (MSU) and an IRS transfer switch.

7-The ADIRU combines the functions of the air data computer and inertial reference system in the same unit.

8-Therefore, each ADIRU is has two parts, either of which can work separately in case of failure in the other. The Air Data Reference (ADR) part supplies barometric altitude, airspeed and Mach, angle of attack, temperature and overspeed warnings. The Inertial Reference part, or IRS, supplies attitude, heading, accelerations, track, ground speed and position.

9-The air data modules receive total air pressure and static air pressure from the primary pitot probes and the primary static ports respectively. Then, they convert pneumatic pressure to electrical signals and send this data to the ADIRUs. The air data part of the system is discussed in the section which deals with flight instruments.

Inertıal system dısplay unıt (ısdu)

10-INERTIAL SYSTEM DISPLAY UNIT (ISDU) The inertial system display unit, or ISDU, is on the aft overhead panel.

11-You use the ISDU to enter or show the IRS data. The ISDU will be discussed later.

Mode select unit (msu)

12-MODE SELECT UNIT (MSU) The mode select unit, or MSU, is also on the aft overhead panel.

13-The MSU gives the mode selection data to the IRSs. It also shows system operational and fault status to the flight crew.

14-The mode selectors have four positions: OFF, ALIGN, NAVIGATION and ATTITUDE.

15-The mode selectors have a feature to reduce the risk of accidental position change to a mode which may disable its operation.

16-When the selector is in the NAVIGATION position, you must pull the knob to put it in the ATTITUDE mode.

17-When the selector is in the ALIGN position, you must pull the knob to put it in the OFF mode.

18-All other position changes do not need you to pull the knob.

19-The MSU also incorporates: ALIGN, FAULT, ON DC and DC FAIL annunciators.

Irs transfer switch

20-IRS TRANSFER SWITCH The IRS transfer switch is on the forward overhead panel.

21-The IRS transfer switch is used to select the IRS to supply inertial reference data to the components and systems. The switch does not affect air data reference signals.

22-The IRS transfer switch has three positions: Normal, Both on Left and Both on Right

23-With the switch in normal position, the related airplane systems use their default IRS for inertial data.

24-If right IRS fails, you select the BOTH ON LEFT position to make the airplane systems use inertial data from only the left IRS.

25-Similarly, if the left IRS fails, you select the BOTH ON RIGHT position to make airplane systems use inertial data from only the right IRS.

26-Whenever the IRS transfer switch is in the BOTH ON LEFT or BOTH ON RIGHT position, the INSTRUMENT SWITCH messages show on the primary flight displays.

Irs power

27-IRS POWER The inertial reference systems can operate on either AC or DC power.

28-The left IRS is normally powered from the AC standby bus, and the right IRS from the AC transfer bus 2.

29-If AC power is not available, either or both systems automatically switch to backup DC power from the airplane battery.

30-If AC power is not restored within five minutes, the backup DC power to the right IRS is automatically terminated.

BASIC PRINCIPLES

31-BASIC PRINCIPLES The inertial reference system in each ADIRU is a self-contained system which provides worldwide navigation information independent of external radio aids.

32-In normal navigation mode, the inertial reference systems provide attitude, true and magnetic heading, acceleration, vertical speed, ground speed, track, present position, and wind data to appropriate airplane systems.

33-The inertial reference systems are the airplane's single source of attitude and heading information, except for the standby attitude indicator and standby magnetic compass.

34-Each inertial reference system has three accelerometers and three ring laser gyros.

35-The accelerometers and gyros are in strap-down configuration. This means that they are fixed to the airplane and oriented on the airplane principal axes, and move with the airplane when it moves around or along the axes.

36-Acceleration is the rate of change of the speed along a particular axis. It indicates how fast the speed of airplane is changing along this axis.

37-The accelerometers, in each inertial reference system, sense accelerations along the airplane's pitch, roll and yaw axis. This lets the ground speed and position of the airplane be calculated at any instant provided that the initial speed and position are known.

38-A ring laser gyro is a device which measures angular motion about its sensitive axis. The operation principle is based on the measurement of frequency difference between two laser beams rotating in opposite direction.

39-When the gyro is at rest, the two beams travel the same path lengths to complete their loop so they have the same frequency. When the gyro turns, the beams travel different path lengths, causing a difference in their frequency which is proportional to the angular rate.

40-Each inertial reference system uses three ring laser gyros with their sensitive axis aligned to the airplane roll, pitch and yaw axis. They sense airplane rotation around these axis.

IRS ALIGNMENT

41-IRS ALIGNMENT Before the flight, it is necessary to do an alignment of the IRS and initialize the system with airplane current position, so that it can enter the navigation mode.

42-The IRS uses accelerometers and gyros for alignment.

43-The accelerometers sense the earth gravity. This enables the IRS to calculate the airplane initial altitude.

44-The gyros sense the earth rotation rate, along with the gravity data. This enables the IRS to calculate the true north and the airplane's current position latitude.

45-Although the IRS can calculate current position latitude, it is not capable of finding the current positon longitude. Thus, the current airplane's position in latitude and longitude must be entered to complete the alignment of IRS.

46-Inserting the current airplane position enables the IRS to know the longitude. It also lets the IRS compare the latitude it finds with the value you put in to make sure its calculation of latitude is correct.

47-To ensure that the earth rotation is the only movement sensed by the IRS, the airplane must remain stationary during alignment

48-The IRS alignment time varies between a minimum of 5 minutes at the equator to 17 minutes maximum at 78.25 degrees, north or south latitudes.

49-If the airplane is at a latitude of between 60.0 degrees north and south, the alignment time will vary between 5 and 10 minutes.

50-Between latitudes of 60.0 and 70.2 degrees north or south, the alignment time is fixed at 10 minutes.

51-Between latitudes of 70.2 and 78.25 degrees north or south, the alignment time is fixed at 17 minutes.

52-The IRS does not align at a latitude more than 78.25 degrees.

53-You use the mode selectors on the MSU to start the IRS alignment. The left selector controls the left IRS and the right selector controls the right IRS.

54-Move the selectors to NAV. This lets the IRSs go o navigation mode when the alignment is complete.

55-The ON DC lights come on for 5 seconds. During this time, the IRSs do a DC power test.

56-After 5 seconds, the ON DC lights go off and the ALIGN lights illuminate. The IRSs are now in the alignment mode

57-Airplane present position must be entered at this time.

58-You usually use the FMC CDU to put in present position data. You can also use the inertial system display unit for the same purpose. The CDU preflight operations will be discussed in another lesson.

59-When the alignment ends, the ALIGN lights extinguish. The IRSs now go to the navigation mode.

Irs alignment abnormals

60-IRS ALIGNMENT ABNORMALS There are three abnormal conditions which can occur during the IRS alignment. No present position entry, discrepancy between entered position, and the IRS stored position or the IRS computed position and airplane motion detection

No present position entry

61-NO PRESENT POSITION ENTRY If present position is not entered before the alignment period ends, the ALIGN lights flash and an ENTER IRS POSITION message shows on CDU.

62-When the present position is entered, the ALIGN lights go off. The ENTER IRS POSITION message disappears.

Discrepancy in present position

63-DISCREPANCY IN PRESENT POSITION The IRS uses two types of comparison tests to prevent an error in the system initialization: comparison of the entered position with the last stored position, and comparison of the entered latitude with the computed latitude.

64-Each IRS keeps a record of its last position when it was shut down.

65-During alignment, if the position you enter is more than 1 degree different in latitude or longitude than the last stored IRS position, the ALIGN lights flash and the ENTER IRS POSITION message shows on the CDU.

66-If you enter the same position again, the IRS will accept the position and continue the alignment process. The ALIGN lights stop flashing and the ENTER IRS POSITION CDU message disappears.

67-Before shifting to the navigation mode, the IRS also compares the entered latitude with its computed latitude.

68-The difference in latitude happens either when an IRS makes an error in latitude computation or when you make a mistake in latitude entry.

69-If there is a difference between the IRS computed latitude and pilot entered latitude, the ALIGN lights will again flash and the ENTER IRS POSITION message shows on the CDU.

70-If you enter the same latitude again, the ALIGN lights stop blinking, the FAULT light or lights illuminate and the ENTER IRS POSITION message goes out of view.

71-If a single FAULT light has illuminated, the difference in latitude is usually caused by the related IRS computed latitude error.

72-In this case, you should move the mode selector to OFF. After the ALIGN light extinguishes, move the selector to NAV and initiate a new alignment. If the FAULT light illuminates again, notify maintenance.

73-If both FAULT lights have illuminated, the difference in latitude is due to wrong latitude entry. In this case, you can enter correct position without starting a new alignment.

74-Move the mode selector on the MSU to ALIGN and enter the correct latitude and longitude.

75-The FAULT light goes off when the correct latitude is entered. Move the mode selector to the NAV position. The ALIGN lights go out and the IRSs enter navigation mode.

Airplane motion detection

76-AIRPLANE MOTION DETECTION With the IRSs in the alignment mode, if the airplane moves the alignment mode stops. The IRS MOTION message shows on the CDU scratchpad.

77-If the airplane motion stops within 30 seconds, the IRSs automatically restart the alignments. You push the CLEAR key on the CDU to remove the IRS MOTION message from the scratchpad.

IRS IN-FLIGHT OPERATION

78-IRS IN-FLIGHT OPERATION During flight, each IRS computes its position. However, error in the IRS computed position increases with the flight time. Navigation accuracy may be less than required, when it is the sole source of position reference,

79-Magnetic variation between 82 degrees north and 82 degrees south is stored in each IRS memory.

80-The IRS combines the data corresponding to the present position with the true heading to determine magnetic heading.

81-Special procedures are necessary for flight at latitudes higher than 82 degrees north or south and some other areas near the poles, as the IRS cannot provide magnetic heading in this areas. However, the IRS continues to supply true heading.

Irs shutdown

82-IRS SHUT DOWN After the flight, you turn the mode selectors to OFF to shut down the IRSs.

83-The ALIGN lights illuminate and the IRSs start a 30 seconds shut down cycle.

84-When the shut down cycle is complete and the ALIGN lights go off.

85-During through flight stops, you’d better shut down the IRSs completely and then do a new alignment.

RS FAST REALIGNMENT

86-IRS FAST REALIGNMENT When there is not enough time to do a full alignment, you can perform a fast realignment.

87-The airplane must not be moved during the fast realignment.

88-To initiate a fast realignment set the mode selectors to ALIGN position.

89-The ALIGN lights illuminate and the IRSs are now in fast realignment mode

90-Enter a new position if necessary.

91-Then turn the mode selectors to NAV position.

92-The alignment completes within 30 seconds and the ALIGN lights extinguish.

93-Note that if time permits it is preferable to do a full alignment of the IRS as it results in a more precise alignment.

INERTIAL SYSTEM DISPLAY UNIT (ISDU)

94-INERTIAL SYSTEM DISPLAY UNIT (ISDU) The inertial system display unit, or ISDU, is used to send digital data to the IRSs and show digital information from the IRSs.

95-The SYSTEM DISPLAY switch lets you select left or right IRS data to show on the IRS display.

96-The IRS display has two windows to show data selected with the display selector.

97-You use the DISPLAY SELECTOR to select the data to show from the IRS

98-The display selector has five positions: TEST, TRACK/GROUND SPEED, PRESENT POSITION, WIND and HEADING/STATUS.

99-The TEST position can only be used during an alignment to do a system self-test. It is spring–loaded to the TRACK/GROUND SPEED position. When you select the TEST position, all lights on the inertial system display unit and mode selector unit momentarily illuminate.

100-Other selector positions are used after the IRSs are aligned.

101-If the TRACK/GROUND SPEED position is selected, the left window shows the true track and the right window indicates ground speed in knots.

102-You move the selector to PPOS to see the present position of the airplane. The left window displays present latitude and right window displays present longitude of the airplane.

103-When you set the selector to the WIND position, the left window displays present true wind direction and right window displays present wind speed in knots.

104-If you move the selector to the HEADING/STATUS position, the left window displays present true heading. The right window displays applicable maintenance status code.

105-During alignment, you can use the heading/status position to see the time remaining until alignment is complete on the right IRS window.

106-For the 17 minute alignments, the window shows 15 until the time remaining reaches 14 minutes. The display then counts down to zero in one minute intervals

107-A brightness control on the center of the display selector lets you adjust the brightness of the IRS display and back

lights.

108-You can use the ISDU keyboard to enter present position data for the IRSs. Let’s see how you can enter the airplane present position through ISDU.

109-Move the IRS mode selectors to the NAV position to start alignment.

110-Turn the ISDU display selector to present position.

111-You can enter the latitude or longitude first. Let’s start with latitude.

112-Push the N2 key to enter latitude. The letter N shows in the left IRS DISPLAY and the light on the ENT key comes on.

113-Push the keys to enter the latitude data. When you push each key, the number appears at the far right of the left IRS DISPLAY. Numbers entered before will shift one space to the left

114-Now push the ENT key to send the data to both IRSs. The light on the ENT key goes off when data is accepted by IRSs.

115-The longitude entry is similar to the latitude entry. You start with pushing the E6 or W4 key and then enter longitude data.

116-Now push the enter key. The IRSs can complete the alignment.

117-If you make a mistake, use clear key to clear the entry and start again.

118-Note that if you enter a latitude greater than 90 degrees, or a longitude greater than 180 degrees or a minute value greater than 59.9, when you push the enter key, the clear key illuminates.

119-You must push the CLR key to clear the invalid position entry and start again.

IRS ABNORMALS

120-IRS ABNORMALS Now, we will discuss three abnormal conditions in relation to the IRS operation: loss of alignment, loss of AC power and anomaly in backup DC power.

Loss of alignment

121-LOSS OF ALIGNMENT An IRS may lose alignment if it loses both AC and DC power or if the MSU switch is moved out of the NAV position.

122-When an IRS loses alignment, the FAULT light illuminates on the MSU, the MASTER CAUTION lights and the IRS system annunciator illuminate and the primary flight display shows the ATTITUDE flag.

123-If alignment is lost in flight, it is not possible to realign the IRS until back on the ground and the navigation function, including track, ground speed, present position, and wind is not available for the rest of the flight.

124-In this case, you can select the attitude mode to restore the attitude information. Note that once the attitude mode is selected, it cannot be changed back to navigation mode.

125-To select the attitude mode, move the related mode selector to ATTITUDE. Keep the airplane straight and level, and do not accelerate for at least 30 seconds as the IRS aligns in the attitude mode.

126-When attitude alignment is complete, the FAULT light extinguishes and attitude information is available again. However you should not engage either autopilot.

127-If the FAULT light does not extinguish, move the IRS transfer switch to BOTH ON RIGHT or BOTH ON LEFT. Do not engage the autopilots.

128-The attitude mode can also provide heading information.

129-To display heading data you must manually enter current magnetic heading on the CDU POSITION INITIALIZATION page or on the overhead IRS display unit.

130-On the CDU, enter the three digit heading value in the scratchpad. Use the related line select key 5R to enter the heading in the IRS.

131-To enter the heading through the ISDU, push the H5 key and enter the heading value. Then push the ENTER key to enter the heading in the IRS.

132-Due to drift in the IRS heading, you must periodically cross–check and update magnetic heading entered in the IRS, as necessary.

Loss of ac power

133-LOSS OF AC POWER When an IRS AC power fails and the IRS is on DC power, the respective ON DC light illuminates. The MASTER CAUTION light and the IRS system annunciator also illuminate.

134-If the right ON DC light illuminates, the right IRS operates for 5 minutes on DC power.

135-If AC power is not restored within five minutes, the right IRS automatically shuts down.

136-If the left ON DC light illuminates, the left IRS operates as long as the DC power is available

137-If an ON DC light illuminates when the airplane is on the ground, a ground call horn in the nose wheel well sounds to alert of a battery drain condition.

Anomaly in DC backup power

138-ANOMALY IN DC BACKUP POWER A DC FAIL light comes on when the backup DC power for the related IRS is not normal. The MASTER CAUTION lights and the IRS system annunciator also illuminate. If the other lights are extinguished, continue normal operation. The IRS is operating normally on AC power

GLOBAL POSITIONING SYSTEM

139-GLOBAL POSITIONING SYSTEM Now, we will review Global Positioning System. Here is the outline: Overview Basic principles GPS Abnormals

OVERVIEW

140-OVERVIEW The global positioning system (GPS) uses navigation satellites to supply 3- dimensional airplane position, precise time and ground speed data to the FMC and other airplane systems.

141-There are two independent GPS systems on the airplane. Each system consists of an antenna and a receiver.

142-The antennas are on the top of the fuselage. They collect navigation satellite signals and send them to the receiver.

143-The GPS receiver in the multi-mode receiver uses the satellite signals to calculate GPS data.

144-The GPS position is indicated on various CDU pages. POSITION REFERANCE page 2 of 3 shows the left and right GPS latitude and longitude position.

145-The POSITION SHIFT page 3 of 3 displays the left and right GPS position with respect to the FMC position.

146-The NAVIGATION STATUS page 1 of 2 shows the GPS currently in use by the FMC for position calculation.

147-Operation of the GPS is completely automatic. Therefore, there is no GPS control except that you can manually inhibit GPS input for the FMC position updating on the NAVIGATION OPTIONS page 2 of 2.

GPS- BASIC PRINCIPLES

148-GPS- BASIC PRINCIPLES The Global Positioning System is comprised of three segments: Space Segment, Control Segment, and User Segment.

149-The space segment consists of a constellation of 24 satellites.

150-The satellites orbit 10,900 nautical miles above the earth.

151-Each GPS satellite completes its orbit in approximately 12 hours.

152-An atomic clock keeps the precise time reference in each satellite.

153-The satellites continuously transmit radio signals in the UHF band with navigation data, range code, and the exact time.

154-The control segment incorporates a master control station and monitoring stations on Earth. The control segment continuously monitors and tracks the satellites, corrects satellite orbits and clocks, and updates the satellite navigation message regularly.

155-The user segment is the GPS receiver unit on the airplane. It receives the satellite signals and calculate the airplane position, time and ground speed.

156-The operating principle of GPS is based on the measurement of the time taken by the satellite signal to reach the airplane GPS receiver. Since the radio signal travels at the speed of light, the receiver can calculate the distance to the satellite.

157-In order to let the receiver measure signal time of travel, each satellite transmits its signal with the information of exact time when the signal is sent.

158-Upon receipt of satellite signal, the receiver compares the satellite signal to a signal that it makes at the same time as the satellite. The difference between the two signals is the time the satellite signal took to get to the receiver.

159-However, since the receiver's internal clock is not as accurate as the satellite atomic clock, there is an unknown clock bias which causes an error in measurement of signal time of travel and thus, the range.

160-Therefore, to calculate the airplane position in latitude, longitude, and altitude, and the time bias, the receiver must know the position of and receive signals from at least four satellites.

161-The receiver then measures the ranges to all satellites at the same time and computes position and time bias with four range equations.

162-The GPS also has a receiver autonomous integrity monitoring function, or RAIM. The RAIM monitors the status of the satellites that the GPS receiver uses for calculations, and provides an estimate of the GPS position error. The FMC uses the autonomous integrity monitor to determine if it can use GPS data for navigation.

GPS ABNORMALS

163-GPS ABNORMALS If both GPS systems have a failure, the GPS light on the IRS mode select unit comes on. The MASTER CAUTION lights and the IRS system annunciator also illuminate.

164-When both GPS units fail, the FMC only uses IRS or radio inputs for position update.

165-In addition, look-ahead terrain alerting and display are not available due to position uncertainty.

166-In the event of both GPS units failing, you can continue normal operation as long as actual navigation performance meets the requirements for the phase of flight.

167-If one GPS unit fails, there is no annunciation.

168-However, when you push the system annunciator panel for recall, the MASTER CAUTION lights and the IRS system annunciator come on and the GPS light on IRS mode select unit illuminates.

RADIO NAVIGATION SYSTEMS

169-RADIO NAVIGATION SYSTEMS This part covers radio navigation systems. Here is the outline: •

AUTOMATIC DIRECTION FINDING (ADF)

170-AUTOMATIC DIRECTION FINDING (ADF) The automatic direction finding or ADF, system uses radio signals from ground non-directional beacons, or NDBs, to determine the relative bearing to the station being received.

Overview

171-OVERVIEW There may be one or two ADF systems installed in the airplane. Each ADF system incorporates an antenna assembly and a receiver.

172-The ADF antennas are on the top of the fuselage. They receive radio signals from NDBs.

173-The antenna assembly is also capable of receiving commercial AM broadcasts.

174-The receiver uses inputs from the antenna to calculate bearing to the received station

175-You use the respective ADF receiver control on the audio control panel to listen to NDB station audio or the Morse code identifier.

Adf control panel

176-ADF CONTROL PANEL Captain’s and First Officer’s ADF control panels are located on the aft electronic panel.

177-The panel has two frequency display windows. The windows show the frequency that you set with the frequency selectors.

178-The display windows also incorporate indicators that show if the system is in the ADF mode or the antenna mode.

179-The tone selector has three positions: a position for receiver 1, receiver 2, and off.

180-There are some NDB stations that transmit their Morse code identifier by turning transmission on and off to produce dots and dashes. The identifier transmitted in this way is not audible because its frequency is well above the scope of human hearing.

181-You must select TONE position to hear the Morse code identifier transmitted from this type of NDB. When the TONE position is selected, the ADF receiver imposes a tone onto signal coming from the NDB to make the identifier audible.

182-There are two frequency selectors. Each frequency selector sets the frequency for the display window that is directly above it. The selectors have three knobs. The inner knob sets the tenths and ones numbers. The middle knob sets the tens numbers. The outer knob sets the hundreds numbers.

183-The mode selectors select the OFF, ANTENNA or ADF modes.

184-With the switch in OFF position, power is removed from the respective ADF receiver.

185-The ANTENNA position is used to optimize the audio, which allows easier identification of the NDB station tuned. With the selector in ANTENNA position, no bearing information is available.

186-When the selector is placed to the ADF position, the ADF light comes on in the respective display window. This is the normal navigation position.

187-With the selector in the ADF position, the ADF bearing data is sent to the display units and the standby radio magnetic indicator where ADF bearing pointers show the direction to the station relative to the airplane heading. In ADF mode, audio reception is also possible

188-The TEST push buttons on top of the ADF mode selectors let you test related ADF bearing pointers and warning flags on the display units and the standby radio magnetic indicator.

189-To start a system test, momentarily push the TEST button. You will observe the following ADF indications on the display units and standby radio magnetic indicator: The ADF pointer goes out of view and the ADF fail shows. Two seconds later, ADF fail flag disappears and ADF bearing pointer remains out of view. Next, the ADF pointer goes to a test position of 135 degrees relative bearing until the end of test.

190-In some B737 models, the ADF control panel is configured like this. This panel has a transfer switch which lets you select ADF for display.

Adf indicating

191-ADF INDICATING The ADF data shows on the Captain’s and First Officer’s NAVIGATION displays and standby radio magnetic indicator.

192-You use the VOR/ADF switches on the EFIS control panel to show the ADF data on the navigation displays.

193-With a valid in-range NDB station tuned, you must set the respective VOR/ADF to the ADF position switch on the EFIS control panel to show the ADF bearing pointers on the display units. The bearing pointers show on the expanded displays if the ADF bearing is in the compass rose display limit.

194-If heading or track information is lost or invalid, the ADF bearing pointers on the display units will be removed. The ADF bearing pointer on the standby radio magnetic indicator will not display the correct magnetic bearing. However, the

pointer may continue to indicate correct relative bearing as long as the ADF receiver is operating.

195-When there is a failure of the ADF receivers, the amber ADF fail flags show in the lower corners of the display units and fail flag comes into view on the standby radio magnetic indicator.

VHF OMNIDIRECTIONAL RANGING (VOR)

196-VHF OMNIDIRECTIONAL RANGING (VOR) The VHF omnidirectional ranging or VOR system supplies magnetic bearing data from a VOR ground station to the airplane.

Overview

197-OVERVIEW The VOR ground stations transmit signals that produce magnetic tracks, or radials, numbered from 000 to 359. The radial 000 is always referenced to magnetic north

198-The VOR system has an antenna and two receivers with VOR/marker beacons function.

199-The VOR antenna is at the top of the vertical stabilizer.

200-The signals from the antenna go to the VOR receivers which calculate station bearing and decode the Morse code station identifier signal and station audio. The receivers also have marker beacon functions.

201-The receivers send VOR bearing to the display units, the standby radio magnetic indicator and the flight control computers

Vor flight deck controls

202-VOR FLIGHT DECK CONTROLS The Captain’s and First Officer’s VHF navigation control panels are on the aft electronic panel. The panel supply frequency inputs and test commands not only to the VOR but also to the DME and ILS radios. The VHF navigation panel will be discussed later.

203-You must manually tune the VOR on the VHF navigation control panel to display the VOR information on the display units and the standby radio magnetic indicator.

204-You use the respective navigation receiver control and voice/range selector on the audio control panel to listen to the VOR station voice audio, or the Morse code identifier, or both voice audio and Morse code identifier.

205-A VHF navigation transfer switch is located on the forward overhead panel.

206-When either VOR receiver fails, the VHF NAVIGATION transfer switch lets you select the other VHF NAV receiver as the source for the Captain’s and First Officer’s display. This action transfers not only VOR data, but also DME, ILS and MCP course data.

Vor indicating

207-VOR INDICATING The VOR data shows on the Captain's and First Officer's navigation displays and standby radio magnetic indicator.

208-With a valid VOR station entered, you must set the mode selector on the respective EFIS control panel to VOR the position to show VOR data on the navigation display.

209-When you move the VOR/ADF switch to the VOR position, the VOR bearing pointers show on the display. The VOR bearing pointers can also show in the APPROACH and MAP modes.

210-The tuned VOR frequencies are shown at the bottom left and right corners of the display for bearing pointers 1 or 2. The reference VOR frequency shows in the upper right corner of the display.

211-If the VOR receiver gets a valid station identifier from the VOR station, the station identifier replaces the VOR frequency.

212-When there is a failure of the VOR receivers, the display electronics units remove the VOR deviation bar and scale, the TO/FROM pointer and the indicator, the VOR frequency and NAV data source, and the VOR bearing pointers on the displays.

213-The amber VOR flags show on both the centered and expanded VOR displays.

214-For VOR receiver failures, the fail flag comes into view on the standby radio magnetic indicator

DISTANCE MEASURING EQUIPMENT (DME)

215-DISTANCE MEASURING EQUIPMENT (DME) The Distance Measuring Equipment, or DME provides slant range information from a ground station in nautical miles.

Overview

216-OVERVIEW The airplane DME unit transmits interrogation signal to ground stations. Upon receipt of this signal, the station retransmits the signal back to the aircraft after a 50 microsecond delay. The DME unit measures the time interval between the start of interrogation and reception of the reply from the station. Since the speed of the radio signal is a known factor, the DME unit converts this time measurement to the slant range between the airplane and the station.

217-During normal operations, two different DME signals or a signal from a collocated VOR/DME pair provides an accurate radio geographical position to the FMC.

218-The radio position is displayed on the POSITION REFERENCE page 2 of 3 in latitude and longitude.

219-The B737 has two DME systems each consists of an antenna and a DME interrogator.

220-When you put a paired VOR or ILS frequency into the VHF navigation control panel, the associated DME frequency is

automatically selected.

221-The interrogators get manual tune frequency inputs and flight management computer auto-tune frequency inputs from the VHF navigation control panel. If the VHF navigation control panel tune inputs fail, the interrogators get an auto-tune input directly from the FMC.

222-You can inhibit DME station tuning for FMC position updating on the NAVIGATION OPTIONS page 2 of 2.

223-You use the respective NAVIGATION receiver control and voice/range selector on the audio control panel to listen to the DME identification signal. You will hear the DME audio when the voice/range selector is in the Range or Both position.

224-The NAVIGATION STATUS page 1 of 2 shows the identifiers of DMEs currently providing update data to the FMC

Dme indicating

225-DME INDICATING You must manually tune the DME on the VHF navigation control panel and set the respective VOR/ADF switch to the VOR position on the EFIS control panel to show the DME distance on the display units.

226-DME distance is also displayed on the display units when the ILS receivers are tuned to a collocated DME and localizer facility.

227-When the DME distance is not computed data, white dashes replace the numbers

228-If the DME has a failure, an amber DME flag replaces the DME distance.

INSTRUMENT LANDING SYSTEM (ILS)

229-INSTRUMENT LANDING SYSTEM (ILS) The instrument landing system, or ILS, provides lateral and vertical guidance data necessary to carry out an instrument approach to a runway.

Overview

230-OVERVIEW ILS consists of two main components: the localizer and glideslope.

231-The localizer ground station transmits signals to provide the airplane with lateral guidance to the extended runway centerline.

232-The glideslope ground station transmits signals to provide the airplane with a descent path to the touchdown point on the runway

233-The localizer and glideslope antennas in the nose radome and a VOR/localizer antenna on the vertical stabilizer receive radio signals from the ground stations.

234-The ILS has two multi-mode receivers or MMRs that contain the ILS function. The multi-mode receivers get radio inputs from the antennas and supply localizer and glideslope deviation to various airplane systems.

235-The ILS receivers are tuned manually on the VHF navigation control panel.

236-You use the respective NAV receiver control and voice/range selector on the audio control panel to listen to ILS station audio, or the Morse code station identifier, or both.

Ils indicating

237-ILS INDICATING The ILS data shows on the Captain's and First Officer's display units and standby attitude indicator.

238-To show the ILS data on the standby attitude indicator, you need to set the approach selector on the standby attitude indicator to the APPROACH position. The standby attitude indicator is discussed in a different lesson.

239-Similarly, you must set the mode selector on the EFIS control panel to the APPROACH position to show the ILS data on the Captain's and First Officer's NDs. PFD also indicates ILS data when an ILS is manually tuned. The tuned ILS frequency or identifier is also indicated on the displays.

240-When the localizer function fails, the LOC flag replaces the localizer deviation pointer and scale.

241-When the glideslope receiver function has a failure, the G/S flag replaces the glideslope deviation pointer and scale

242-As we have seen, the Morse code identifier of a tuned VOR, ILS, or ADF can be converted to alpha characters to show on the primary flight display and navigation display. You should monitor this identifier for correct navigation radio reception.

243-You should verify the identity of the tuned navigation station from the audio Morse code when the tuned frequency remains shown or an incorrect identifier is shown.

MARKER BEACON SYSTEM

244-MARKER BEACON SYSTEM The marker beacon system supplies visual and aural indications when the airplane flies over airport runway marker beacon transmitters.

Overview

245-OVERVIEW The marker beacon system has an antenna on the bottom of the fuselage. It receives the marker beacon signals.

246-A marker beacon receiver integrated with the VOR 1 receiver provides marker beacon audio to the remote electronics unit and marker beacon data to the display electronics unit.

Marker beacon system displays

247-MARKER BEACON SYSTEM DISPLAYS The marker beacon data is shown on the upper right corner of attitude display on the primary flight display units.

248-When the airplane goes above the outer marker, the cyan OM letters show on the display.

249-When the airplane is over the middle marker, the amber MM letters show on the display.

250-When the airplane goes above the inner marker, back course marker, or an airways marker, the white IM letters show.

251-If marker beacon data fails the display does not show.

Marker beacon audio outputs

252-MARKER BEACON AUDIO OUTPUTS If you want to hear marker beacon audio, you select the marker beacon audio on the audio control panel

253-When the airplane goes above the outer marker, a low-pitch aural tone keyed two dashes per second will continuously be heard

254-When the airplane is over the middle marker, a medium-pitch continuous aural tone keyed in alternate dots and dashes will be heard

255-Over the inner marker, a high-pitch continuous aural tone keyed 6 dots per second will be heard.

VHF NAVIGATION CONTROL PANEL

256-VHF NAVIGATION CONTROL PANEL The VHF navigation control panel supplies frequency inputs and test commands to the VOR, DME and ILS navigation radios.

257-The VHF navigation control panel has two frequency display windows. The active frequency display window shows the frequency that the navigation radios use for operation. The standby frequency display window shows the next frequency you want to use.

258-The transfer switch, when momentarily pushed, transfers the standby frequency to the active frequency display window and active frequency to standby frequency display window.

259-The frequency selector lets you manually select the standby frequency.

260-The test switch is used to do a test of the VOR receiver, the ILS receiver, and the DME interrogator and marker beacon system

Multi-mode navigation control panel

261-MULTI-MODE NAVIGATION CONTROL PANEL Some B737 models are equipped with multi-mode navigation control panel.

262-The panel incorporates two display windows. The upper display window indicates the active mode and frequency. The

lower display window indicates the standby mode and frequency.

263-The transfer switch transfers the standby mode and frequency to the active display window and active mode and frequency to standby display window.

264-The Frequency Selection Keypad lets you manually select the standby frequency. You can use the CLEAR key to clear the standby frequency.

265-You use the mode switches to manually insert ILS or VOR into the standby display window. In some B737 models, the global navigation satellite landing system (GLS) mode is also available for selection.

266-The test switch is used to do a test of the VOR, ILS, DME, marker beacon and GLS systems

RADIO NAVIGATION SYSTEMS TEST

267-RADIO NAVIGATION SYSTEMS TEST VOR TEST To do a test of the VOR receivers, enter a valid VOR frequency into the active frequency display window.

268-Set a selected course of 000 on the autoflight system mode control panel.

269-Set the mode selector on the EFIS control panel to the VOR position.

270-Push the test switch on the VHF navigation control panel.

271-The VOR display shows a VOR fail flag, the deviation bar goes out of view and then returns to the centered position.

Ils test

272-ILS TEST To do an ILS test, you must enter a valid ILS frequency into the active frequency display window.

273-Set a course on the mode control panel that is within 90 degrees of the airplane heading.

274-Set the mode selector on the EFIS control panel to the APPROACH position.

275-Push the test switch on the VHF navigation control panel

276-On the primary flight display and navigation display the localizer and glideslope pointers disappear and the LOCALIZER and the GLIDESLOPE flags appear momentarily, the pointers come into view and the display shows one dot left and one dot up, and then the display shows one dot right and one dot down. At last, the pointers return to normal display

Dme test

277-DME TEST If there is a DME frequency that is paired with the VOR or ILS frequency, a test command also goes to the DME interrogator.

278-DME first displays the DME fail flag, then dashes for two seconds, and then normal the DME distance.

Marker beacon test

279-MARKER BEACON TEST When you do a test of the marker beacon system, you do a test of the VOR receiver 1 at the same time. To do a marker beacon system test, select a valid VOR frequency and push the test switch on the navigation control panel.

280-FT shows on the primary flight display.

281-With the marker beacon audio selected on the audio control panel, you continuously hear the outer, middle, and inner marker audio at the same time.

Gls test

282-GLS TEST With a valid frequency tuned, the GLS test is the same as the ILS test. However, the DME is not tested with GLS and no indications will be displayed.

VHF NAVIGATION TRANSFER SWITCH

283-VHF NAVIGATION TRANSFER SWITCH A VHF navigation transfer switch selects the source of the data that the display electronics units use for the navigation displays.

284-The VHF NAV switch has three positions: Normal, Both on 1 and Both on 2

285-With the switch in normal position, the multimode receiver 1 supplies data for the Captain’s displays and multimode receiver 2 supplies data for the First Officer’s displays.

286-If the multimode receiver 2 fails, you select BOTH ON 1 position to make the display electronics units use multimode receiver 1 as the source for the Captain’s and First Officer’s displays.

287-Similarly, if the multimode receiver 1 fails, you select BOTH ON 2 position to make the display electronics units use multimode receiver 2 as the source for the Captain’s and First Officer’s displays.

RADIO NAVIGATION ABNORMALS

288-RADIO NAVIGATION ABNORMALS If the display mode selected on the EFIS control panel does not agree with the tuned VOR/ILS frequency, a source annunciation shows on the display units.

289-If you select VOR mode with an ILS frequency tuned or APPROACH mode with a VOR frequency tuned, the EFIS MODE/NAV FREQUENCY DISAGREE annunciation shows on the display. The DME display and ILS/VOR frequency at the upper right corner displays dashes.

290-In some B737s, the IRS mode select unit has both ILS and GLS lights. If an ILS or GLS failure occurs, the respective light comes on. The MASTER CAUTION lights and the IRS system annunciator also illuminate. Do not fly an ILS or GLS

approach when the related light illuminates.

ATC TRANSPONDER

291-ATC TRANSPONDER This part deals with the ATC transponder. Here is the outline: Overview ATC transponder panel ATC transponder test.

Overview

292-OVERVIEW The airplane transponder replies to the interrogations from the air traffic control, or ATC, ground stations.

293-The ATC transponder also replies to Mode S interrogations from the traffic alert and collision avoidance systems of other airplanes or ground stations.

294-The airplane has two ATC transponders which are controlled by a single control panel.

ATC TRANSPONDER PANEL

295-ATC TRANSPONDER PANEL The ATC transponder panel is on the aft electronic panel. The panel also incorporates traffic alert and collision avoidance or TCAS, functions which are discussed in different lesson

296-The transponder Selector lets you select transponder Number 1 or transponder Number 2 as the active transponder. The active transponder is shown on the code display window.

297-You use the code selectors to set the four- digit transponder code. The four-digit code shows on the code display window.

298-The transponder mode selector has several positions the TEST position is spring loaded and starts an ATC transponder functional test.

299-With the mode selector in the standby position, the transponder does not transmit.

300-If you set the altitude reporting function to the off position, the transponder responds to ATC interrogations without altitude reporting.

301-When the selector is moved to altitude reporting on position, the transponder operates with altitude reporting.

302-The TA and TA/RA positions are related to TCAS function and discussed in different lesson.

303-The altitude source switch is used to select the left ADIRU or right ADIRU as the source of altitude data for the ATC transponder.

304-When the ATC controller requests the airplane identifier, you push the IDENT switch to make the transponder transmit an identification signal.

305-The FAIL light illuminates steady when there is a transponder malfunction

306-In some B737 models, you find an ATC transponder panel like this. These are the ATC code selector and code display window

307-You use the altitude source selector to select an ADIRU for altitude data.

308-The transponder selector selects a transponder to use. The transponder in use shows in the code display window.

309-The reply selector has three positions. In the STANDBY mode, the transponder does not transmit.

310-When the selector is ON, the selected transponder transmits signal.

311-With the selector in AUTO, the transponder transmits in flight and does not transmit on the ground

312-The FAIL light illuminates to show a transponder failure.

313-When requested by ATC controller, push IDENT switch to transmit an identification signal

314-The mode selector have two modes in relation to ATC operation. When the selector is in the altitude reporting off position, the transponder operates without altitude reporting.

315-With the mode selector in the transponder position, the transponder responses ATC interrogations with altitude reporting

316-When TEST is selected, ATC transponder functional test starts.

Atc transponder test

317-ATC TRANSPONDER TEST To start The ATC function test of the transponder set the transponder mode selector to the TEST position and hold it. If the transponder panel is this type, the reply selector must be in the ON or AUTO position. The FAIL light comes on. If the FAIL light goes off after three seconds, the test is successful.

WEATHER RADAR

318-WEATHER RADAR Now we discuss the weather radar. Here is the outline: •

Overview

319-OVERVIEW The weather radar has two main tasks: to detect adverse weather conditions possibly with turbulence ahead of the airplane and to map the terrain ahead and below the airplane

320-The weather radar operation is based on the echo principle. The radar transmits radio signals forward of the airplane and collects signals reflected from precipitation droplets or other objects. The return signals are then processed to show weather, terrain, and windshear events.

321-The radar antenna is behind the nose radome. The antenna can swing 90 degrees on one side to the other from the airplane centerline.

322-The antenna may also be tilted up and down between plus/minus 15 degrees.

323-The ADIRUs supply pitch and roll data for antenna stabilization which keeps the antenna azimuth scan parallel to the earth horizontal plane regardless of the airplane attitude.

324-The weather radar transmitter/receiver processes the return signals and supplies weather radar display data.

325-The weather radar data shows in four different colors on the navigation displays. The colors show the intensity of return signals from the weather or the terrain.

326-Green is used for the areas with light precipitation.

327-Yellow shows the areas with medium precipitation.

328-Red shows the areas with heavy precipitation.

329-Magenta shows the areas with turbulence.

330-The radar detects turbulence when there is horizontal movement of precipitation toward or away from the radar antenna. Thus it cannot detect clear air turbulence.

331-The weather radar system detects and shows turbulence only up to 40 nautical miles, regardless of selected range

332-In the map mode, radar shows terrain features. Green is used for areas with weak returns such as flat lands, calm sea. Areas with moderate returns are yellow. Areas with strong returns such as mountains and cities are red.

333-You use the map mode to identify coastlines, mountainous regions, cities, or large structures. This mode can be useful in areas where ground–based navigation aids are limited.

334-You use weather radar map switch on the EFIS control panel to turn the weather radar on and off. However, certain conditions cause the predictive windshear function to turn the weather radar system on automatically. The predictive windshear is discussed in different lesson.

335-The weather radar returns show in the: MAP, center MAP, expanded VOR and expanded APPROACH modes.

336-When 640 nautical mile range is selected, weather radar only shows weather displays out to a maximum range of 320 nautical miles.

337-If a range more than 40 nautical miles is set on the EFIS control panel, the navigation displays show weather and turbulence data up to a range of 40 nautical miles and only weather data beyond 40 nautical miles.

Weather radar panel

338-WEATHER RADAR PANEL The weather radar panel is located on the aft electronic panel.

339-The weather radar control panel provides mode selection, tilt control and gain control.

340-The mode selector has four positions: test, weather, weather/turbulence and map. The selected mode is shown in the bottom left of the navigation display

341-The TEST position is used to test the weather radar operation. Weather radar test will be discussed in a different section.

342-With the mode selector in the weather position, weather data shows on the navigation displays. Turbulence does not show.

343-When you select weather/turbulence position, weather and turbulence data show on the navigation displays. The turbulence is displayed up to a maximum range of 40 nautical miles.

344-When the selector is set to the MAP position, ground and terrain features show on the navigation displays.

345-The tilt control adjusts the antenna tilt angle from +15 degrees to -15 degrees. The tilt angle is displayed on the navigation displays.

346-The gain switch is used to adjust the sensitivity of the radar receiver. The AUTO position maintains optimum receiver sensitivity. The MAXIMUM position sets the receiver to maximum sensitivity allowing lesser intensity precipitation levels to show on display

347-Whenever the gain switch is moved out of AUTO position, the cyan VAR indication appears on navigation displays.

Multiscan weather radar

348-MULTI-SCAN WEATHER RADAR In B737s with Multi-scan weather radars, the weather radar control panel is organized differently.

349-The Multi-scan weather radar performs multiple scans at different tilt angles by automatically adjusting tilt and gain for short, medium and long range weather. The computer merges the weather data from multiple scans, eliminates ground clutter and stores optimized weather picture in its memory. The flight crew simply selects the portion of the optimized picture by adjusting desired range.

350-The Multi-scan weather radar detects weather in front of the airplane out to 320 nautical miles, and from ground level up to 60,000 feet above mean sea level.

351-The radar computer designates weather along the flight path as primary weather. All other weather is designated as

secondary weather, and is displayed with black stripes through it. You can use secondary weather data in making changes to your flight plan to avoid primary weather on the flight path.

352-This is one type of control panel which is associated with the Multi-scan weather radar. The mode selectors have three positions: AUTO, MAP and MANUAL.

353-The auto position activates weather radar in the Multi-scan mode which provides display of turbulence out to 40 nautical miles, weather out to 320 nautical miles, and windshear out to 5 nautical miles.

354-The MAP position displays major geographical features such as cities, lakes, mountains and coast lines

355-You select the MANUAL position to use the manual altitude control for weather analysis.

356-With the MANUAL mode selected, you rotate the MANUAL ALTITUDE CONTROL to select an altitude from 0 to 60,000 ft. mean sea level in increments of 1000 ft. to do a weather analysis.

357-The GAIN CONTROL knob is normally in the CALIBRATED position where the radar automatically adjusts the receiver sensitivity. Rotating the knob out of CALIBRATED varies gain between MINIMUM and MAXIMUM.

358-The SYSTEM CONTROL selector is used to put the weather radar system in the normal operation mode or to do a system operation test.

359-Another panel used with the Multi-scan weather radar provides the Captain and First Officer with independent controls. Left controls are for the Captain’s display, the right for the First Officer’s display.

360-The transfer switch transfers other map display selections to related map.

361-With the weather position selected, weather data shows on the navigation displays. Turbulence does not show.

362-When you select weather/turbulence position, the weather and turbulence data show on the related navigation display. The turbulence is displayed up to a maximum range of 40 nautical miles.

363-When you select the MAP position, both ground and weather returns without turbulence information show on the navigation display.

364-You use the ground clutter switch to temporarily display ground clutter when the radar is in auto mode.

365-The AUTO switch lets you select full automatic weather radar operation. With AUTO selected the flight crew’s displays update simultaneously, even when different ranges and modes are selected. The tilt and gain inputs are not required as they are automatically adjusted.

366-The GAIN Control is normally in the calibrated gain position which is selected when the triangle is at the 12 o’clock

position. You rotate the knob clockwise to increase the gain and counterclockwise to decrease the gain. The navigation display will show the letters VAR when gain is moved above or below the CAL gain position.

367-The tilt control lets you manually adjust the antenna tilt angle which is shown on the navigation display.

Weather radar test

368-WEATHER RADAR TEST To do a test of weather radar system, you select the TEST mode on weather radar panel. Then push the WXR switch on the EFIS control panel with MAP, center MAP, VOR, or APP mode selected. Verify the test pattern shows on the navigation display. Then, the test is successful. Select another mode or push the TEST switch again to go back to normal operation

Weather radar abnormals

369-WEATHER RADAR ABNORMALS Now we look at the weather radar failure displays and range disagreement conditions.

Failure displays

370-FAILURE DISPLAYS When the radar receiver/transmitter processes unsatisfactory data, an alert messages shows on the navigation display.

371-You see letter WXR in amber on the display. These are the alert messages and priority from the highest to lowest. WEAK- calibration fault ATT - attitude input fault and STAB – stabilization off. The weather display will continue to show with an alert message.

372-The failure of the radar transmitter/receiver or antenna or weather panel causes weather radar to fail. The weather display goes out of view. The WXR message and the FAIL message shows on the navigation display.

373-If a weather radar system test fails, the test pattern does not show, amber WXR alert and FAIL alert show the display. The cause of failure is indicated below the FAIL alert.

374-These are the possible radar fault messages: ANT - antenna fault R/T - receiver/transmitter fault, CONT-control panel fault, ATT-attitude input fault, WEAK-calibration fault and STAB-stabilization off.

375-The display electronics units compare the navigation display ranges from the EFIS control panel, the weather radar receiver/transmitter and the flight management computer (FMC). A difference between any of these ranges causes an amber range disagreement annunciation.

Range disagreement

376-RANGE DISAGREEMENT If the selected range on the EFIS control panel is different than the weather radar range, the WXR RANGE DISAGREE annunciation shows on the navigation display.

377-When the selected range on the EFIS control panel is different than the FMC MAP display range, the MAP RANGE

DISAGREE annunciation shows on the navigation display.

378-When the selected range on the EFIS control panel is different than the FMC MAP display range and the weather radar range MAP/WXR RANGE DISAGREE annunciation shows on the navigation display.

COURSE END

379-End of course.