B737 NG CBT - FMS - NAVIGATION MANAGEMENT AND MONITORING

COURSE OUTLINES

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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.

2-This part is intended to provide you with information on FMS navigation function. This is the outline -

INTRODUCTION

3-INTRODUCTION One of the FMC's functions is the automatic control of the airplane navigation. The navigation data used by the FMC are provided by permanent navigation database or flight crew data stored in either a supplemental or a temporary navigation database.

4-As you may recall, the permanent navigation database is periodically updated.

5-The data in the supplemental navigation database is stored until cleared by the flight crew. The data stored in the temporary database is automatically erased at flight completion.

6-The navigation database contains all the data necessary for the airplane operation over a defined route network. Here we will focus on waypoints.

WAYPOINTS

7-WAYPOINTS Waypoints are a predetermined navigation fixes which are used to define the flight route.

8-The waypoints are stored in the navigation database under four categories: waypoints, navaids, airports and runways. Note that flight crew cannot create waypoints in the runway category as they are only stored in the permanent navigation database.

9-In general, there are two types of waypoints: geographically fixed waypoints and conditional waypoints

Geographically fixed waypoints

10-GEOGRAPHICALLY FIXED WAYPOINTS A geographically fixed waypoint is a waypoint whose geographical position does not change.

11-For compatibility with the navigation database, waypoint identifiers are assigned to all waypoints in accordance with certain ground rules. Waypoint identifiers are limited to a maximum of five characters.

12-Application of these rules may result in more than one waypoint having the same identifier.

13-When you attempt to enter such a duplicated identifier, the CDU page changes to SELECT DESIRED to let you select proper waypoint.

14-The page lists the latitude and longitude of waypoints with the same identifier.

15-The waypoint category or type of navaid is displayed here. In this example duplicated identifiers belong to navaids. The line shows APT for airport and WPT for waypoint.

16-This is the frequency of the navaid. The name of the waypoint is also displayed, if it is a navaid,

17-With the selection of the proper waypoint, the page automatically changes to original page.

Conditional waypoints

18-CONDITIONAL WAYPOINTS Waypoints which are not geographically fixed are called conditional waypoints. Their location changes with flight conditions that include wind, true airspeed, thrust available and airplane pitch.

19-The conditional waypoints are displayed on the CDU in parenthesis and cannot be entered manually.

20-When you select a procedure on a DEPARTURES or ARRIVALS page, conditional waypoints are automatically entered into the route.

21-There are four types of conditional waypoints: passing through an altitude, flying a heading to a VOR radial or DME distance, intercepting a course and heading vector to a course or fix.

22-This is a conditional waypoint related to altitude passing constraint. It requires that a heading of 344 degrees should be held until the airplane is at or above 812 feet.

23-However, its location is not fixed. As the flight conditions change, location of waypoint also changes.

24-This conditional waypoint requires holding a heading of 312 degrees until VOR radial 042 is intercepted.

25-The condition of this waypoint is to maintain a heading of 312 degrees until 10 DME is passed.

26-This example shows a conditional waypoint for course intercept. You should keep a heading of 041 degrees until you intercept the course to the next waypoint.

27-A vector type conditional waypoint requires you to maintain the heading indefinitely.

28-When VECTOR is the active leg and LNAV is not engaged, the FMC automatically sequence to the next waypoint when within 3 nautical miles of the next leg.

29-If LNAV is engaged, the next waypoint becomes active only upon execution of the procedures for Proceeding Direct to a Waypoint or Intercepting a Leg to a Waypoint

30-The CDU provides you with various pages to review navigation data or create flight crew data. We start with the REFERENCE NAVIGATION DATA page.

REFERENCE NAVIGATION DATA PAGE

31-REFERENCE NAVIGATION DATA PAGE The reference navigation data page supplies information about waypoints, navaids, airports, and runways individually.

32-The identifier data lines display dashes initially. When an identifier already stored in permanent, supplemental or temporary database is entered, the relevant data shows in the display. Let's start with the waypoint reference data.

Waypoint data display

33-WAYPOINT DATA DISPLAY Put the identifier on the scratchpad in the waypoint line. The waypoint latitude and longitude are displayed here. This line shows the waypoint magnetic variation that is automatically computed based on latitude and longitude.

34-Now, let's enter another identifier in the waypoint line. You may see additional data on the page, if the waypoint has been created by the crew.

35-The reference identifier shows the identifier of the point where the created waypoint is referenced to. The radial/distance line shows the bearing and distance for the waypoint from the reference point.

Navaid data display

36-NAVAID DATA DISPLAY When you put in a navaid identifier, the page shows the latitude, longitude and magnetic variation associated with the navaid.

37-The displayed data also includes the frequency, classification and elevation of the entered navaid.

Airport data display

38-AIRPORT DATA DISPLAY The entry of an airport identifier enables a display of related airport definition data on the page. The data includes latitude, longitude, magnetic variation and elevation of the entered airport.

Runway data display

39-RUNWAY DATA DISPLAY The runway ident line on the airport data display lets you enter runway identifier to show the data for the related runway.

40-The page now shows runway threshold elevation in feet and runway length in feet and meters. Note that runways cannot be defined by the flight crew as they are stored in the permanent navigation database.

41-If an entered identifier is not in the permanent, temporary, or supplemental database, the reference navigation data page shows box prompts in related data fields needing entry. This allows you to create new data.

42-The SUMMARY prompt on the REFERENCE NAVIGATION DATA display selects the pages that show the data contained in temporary and supplemental database. If there is no temporary or supplemental data, this data field is blank.

43-The NAVIGATION OPTIONS prompt will be discussed later.

Supplemental navigation data

44-SUPPLEMENTAL NAVIGATION DATA The supplemental navigation database provides long term storage of navigation data that is not in the permanent database.

45-To show the supplemental navigation database, type SUPP in the scratchpad on the INITIALIZATION/REFERENCE INDEX page and then select NAVIGATION DATA prompt. You can access this page only on the ground.

46-This line displays the effectivity date of the supplemental database. The date also shows on the IDENT page.

47-Box prompts are displayed in the same line, if no valid date has been entered. For this database to be valid, you must enter an effectivity date.

48-When you enter an identifier as you did before, the page displays data for the entered identifier provided it is in the supplemental database.

Deleting created data

49-DELETING CREATED DATA Data may be deleted from the supplemental database either individually or entirely.

50-To remove individual data from the supplemental database, enter its identifier in appropriate Ident line. Select the DELETE key and then push the line select key next to the entered identifier. Data previously entered is deleted.

51-To delete entire data in the supplemental database, you use DELETE ALL SUPPLEMENTAL DATA prompt.

FLIGHT CREW CREATED NAVIGATION DATA

52-FLIGHT CREW CREATED NAVIGATION DATA If the permanent navigation database does not contain the desired waypoints, you can manually define created waypoints.

53-Created waypoints are defined as any of these four types.

54-You can enter all four types of created waypoints on the ROUTE or ROUTE LEGS pages. This will be discussed in ROUTE MANAGEMENT section.

55-These are the types of created waypoints that can also be defined on navigation data pages. This is what we are going to discuss in this section.

56-Entries defined on the REFERENCE NAVIGATION DATA pages are automatically stored in the temporary navigation database for one flight only.

57-On the other hand, entries defined on the SUPPLEMENTAL NAVIGATION DATA pages are automatically stored in the supplemental navigation database until deleted by the crew as described earlier.

58-In this example, we will create a waypoint defined as latitude and longitude on the reference navigation data page for a single flight. The entries in the navaid and airport category are the same however, the navaid category is used only for stations with DME.

59-With the crew-assigned identifier typed on the scratchpad, put it in the waypoint IDENT line.

60-Observe these rules for entering latitude and longitude. Do not insert a space or slash between the latitude and longitude. Do not omit leading zeroes. Enter all digits and decimal points unless the latitude and longitude are full degrees.

61-Key-in the latitude on the scratchpad and put it in the corresponding line.

62-Now enter the waypoint's longitude in the same way.

63-With the latitude and longitude data entered, execute the entry. You can repeat the same steps to define additional created waypoints as desired.

64-Another waypoint type that can be defined on the navigation data pages is Place Bearing/Distance waypoints.

65-The PLACE is any waypoint whose identifier must already be stored in either the permanent, supplemental or temporary database. Bearing and distance are defined with respect to this reference identifier.

66-These type of waypoints are named by the first three characters of the reference identifier followed by a two-digit sequence number.

67-Let's enter this waypoint in the temporary database. Type the waypoint identifier on the scratchpad and put it in the waypoint Ident line.

68-Enter the reference identifier. The CDU guides you to SELECT DESIRED page if there are more than one references with the same identifier. Select the appropriate reference.

69-Enter the bearing and distance in the related data line. Execute the entry. The waypoint is now stored in temporary database and will be erased at flight completion.

NAVIGATION POSITION

70-NAVIGATION POSITION To perform its navigation and guidance functions, the FMC continually computes the airplane's present position during flight.

71-The FMC determines the present position from the IRS, GPS, and navigation radios. The position data from these sensors are blended into a single position by using a special mathematical filtering method. This computed position is called FMC position.

72-Each FMC sends its FMC position to the other FMC with a confidence factor. In each FMC, the final FMC position is calculated from a combination of these two positions weighted from their respective confidence factors.

73-The navigation sensors are used in the following priority order to calculate and update the FMC position: IRS and GPS, IRS and two or more DMEs, IRS and a DME collocated with VOR, IRS and a DME collocated with localizer, IRS and a localizer and only IRS.

74-The first priority for FMC position updating is GPS data.

75-The next priority is to use distance from a pair of DME stations to determine the position. The FMC continuously tunes different DME pairs to re-calculate its position.

76-The FMC automatically tunes the DME radios. The primary FMC selects the DME stations to be tuned by both FMCs. It selects the DME stations that have the best range and geometry to give the most accurate estimate of position.

77-If there are not two DME stations within range or that do not have the necessary geometry, the FMC uses DME distance and VOR bearing from a collocated VOR/DME station. Note that with all radio updates, the FMC will correct the DME slant range distance for the airplane altitude.

78-If GPS data and radio data are not available or become invalid, the FMC uses IRS data to compute present position. In this case, the scratchpad message IRS NAVIGATION ONLY appears on the CDU.

79-In an airport terminal area, when the airplane is on a localizer approach, the FMC uses localizer deviation and DME distance to update the FMC position.

80-On the ground, the FMC uses GPS data to calculate the current position. This provides accurate FMC position during extended ground operations.

81-If GPS data is not available, the FMC calculates present position based on IRS data. The radio position is not used on the ground.

Actual navigation performance

82-ACTUAL NAVIGATION PERFORMANCE As we have seen earlier, the FMC position is calculated from a mathematical combination of the positions determined by the GPS, IRS and radio systems.

83-The estimated error in the FMC computed position is called actual navigation performance or ANP. It is calculated in nautical miles by the FMC itself during all phases of the flight.

84-For instance, ANP 4.00 means the FMC is 95% sure that the airplane's actual position lies within a circle with a radius of 4 nautical miles around the calculated position. Thus, the lower ANP value represents higher accuracy of FMC position estimate.

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Required navigation performance

85-REQUIRED NAVIGATION PERFORMANCE The required navigation performance, RNP, can be visualized as the maximum allowable error of FMC position estimate within a defined airspace. Thus actual navigation performance should not exceed the RNP value.

86-RNP is also expressed in nautical miles. For instance, an RNP 5 requires an FMC navigation performance that can keep the actual airplane position within a circle with a radius of 5 nautical miles for a given percentage of the time.

87-RNP for the active route segment and the current navigation performance or ANP are displayed on the navigation displays and ROUTE LEGS, POSITION SHIFT and RNP PROGRESS pages on the CDU.

88-The FMC uses one of the following as the displayed RNP: default RNP, navigation database RNP values and manually entered RNP

89-If there is no RNP value from the navigation database or an RNP has not been manually entered, the FMC sets these default RNP values for oceanic, en route, terminal, and approach environments.

90-Navigation database RNP values, if available, are assigned for certain segments or terminal procedures. You may need to make a manual RNP entry if the displayed RNP for the route or procedure is incorrect.

91-When ANP exceeds RNP, an UNABLE REQUIRED NAVIGATION PERFORMANCE RNP message is displayed to the flight crew. This indicates that the FMC position does not meet the required accuracy, so the procedure must be aborted

92-You may refer to these CDU pages to monitor, verify and control FMC navigation function. Let's start with position reference page.

POSITION REFERENCE PAGE

93-POSITION REFERENCE PAGE The position reference page is the second page of three position pages.

94-This page shows each IRS calculated airplane position, the GPS position, the navigation radio position and the FMC calculated position. Note that radio position is always blank when the airplane is on the ground.

95-The page also displays the ground speed calculated by the FMC and each ADIRU.

POSITION SHIFT PAGE

96-POSITION SHIFT PAGE The position shift page is the third page of the position pages.

97-This page shows the bearing and distance of the individual FMCs, GPSs, IRSs and radio system positions relative to the FMC combined position.

98-The data with parentheses in the center of the page shows active position references used in FMC position calculation.

99-The letter L or R indicates left or right GPS or IRS is being used in the FMC position calculation. The number 2 shows a dual system with both IRSs or GPSs are used in the FMC position calculation.

100-The RNP and ANP values are displayed here. Manual entry is allowed.

101-In flight, the POSITION SHIFT page lets you update the FMC calculated position to one of the positions shown in the page

102-In this example, we will update FMC position to left IRS position.

103-Select the left IRS prompt. The selected line is highlighted and the associated caret is removed. The execute light illuminates. The CANCEL prompt is displayed.

104-Execute the position shift. The FMC position shifts to the left IRS position. The page shows UPDATE COMPLETE at small font.

105-Now, let's move to the NAVIGATION STATUS page.

NAVIGATION STATUS PAGE

106-NAVIGATION STATUS PAGE The NAVIGATION STATUS page shows the status of the navaids tuned or in use by the FMC.

107-The first lines on the left and right show data related to VOR or ILS currently tuned on the navigation control panels.

108-The data includes VOR or ILS identifier, frequency and method used to tune the frequency. The M indicates manual tuning and P indicates procedural tuning.

109-The DME data fields show up to five DME identifiers and frequencies that are tuned by the FMC through the corresponding DME interrogator.

110-If the DME station is being used for navigation, data is displayed in large font and the identifier has a highlight.

111-If the DME station is being received but not used for navigation, data shows in large font with the identifier not highlighted.

112-When a tuned DME station is not received, the identifier and frequency are displayed in small font

113-These data lines show the currently selected GPS and IRS used in the FMC navigation calculation.

114-Now, push the NEXT PAGE key to show the NAVIGATION OPTIONS page.

NAVIGATION OPTIONS PAGE

115-NAVIGATION OPTIONS PAGE The NAVIGATION OPTIONS page lets you inhibit the use of specific navaids for the FMC position update.

116-Although FMC does not use navaids that are not suitable for navigation, it may not be aware of unreliable navaids declared by NOTAM or ATC. In this case, you should manually exclude these navaids from the FMC navigation solution. This is achieved through the NAVIGATION OPTIONS page.

117-The DME INHIBIT lines let you enter the identifier of up to two DME navaids that must not be used for FMC position updating. Likewise, you can inhibit the use of up to two VOR navaids.

118-Once an entry is made, you can useThe DELETE key to remove the related navaid from inhibit status or the entry is automatically erased at flight completion.

119-These prompts are used to select DME, VOR, GPS and LOCALIZER modes for updating the FMC position. The default mode is ON.

120-If the OFF mode is selected, the corresponding navigation sensor is excluded from FMC position updates. The current active mode is highlighted. The selection is automatically reset to ON at flight completion.

121-Notice that when the DME UPDATE is selected OFF, the VOR-DME and LOCALIZER-DME updates are also inhibited even if the VOR and LOCALIZER UPDATES are ON.

ENTRY OF POSITION SHIFT ON RUNWAY

122-ENTRY OF POSITION SHIFT ON RUNWAY When the GPS update is off, there may be a position shift when you are at the departure runway.

123-However, when the TO/GA switch is pushed, FMC automatically updates to runway threshold to make sure that flight starts with an accurate FMC position.

124-With the GPS update off, if published full runway length will not be used for takeoff then you must manually enter position shift.

125-To accomplish this, select the TAKEOFF REFERENCE page.

126-Enter runway remain distance which is distance between original threshold and start of takeoff.

127-When TO/GA switch is pushed, FMC will update to the runway remaining distance.

128-If you must remove the position shift, select the ROUTE page. Reenter the runway number. You must check and reenter other performance data as required.

COURSE END

129-End of course.