



# **B737 NG CBT - AUTOMATIC FLIGHT**

## **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 lesson consists of four parts: Part 1-Autoflight system in general, Part 2- Autoflight pitch and roll modes, Part 3-Autoflight takeoff, approach and landing and Part 4- Autoflight system non-normal operation.

## AUTOMATIC FLIGHT - PART 1

3-AUTOMATIC FLIGHT - PART 1 This first part of automatic flight system is intended to introduce you to the system architecture and its organization. Here is the chapter outline: \* Introduction \* Autopilot Flight Director System \* Mode Control Panel \* Autothrottle system \* Flight mode annunciation \* Autoflight mode annunciation \* Autopilot operation \* Autothrottle operation \* Flight director operation.

## INTRODUCTION

4-INTRODUCTION The purpose of Automatic Flight System (AFS) is to reduce the crew workload and enhance the control of flight.

5-The automatic flight system is a collective term which covers a number of systems including the autopilot flight director system (AFDS) and the auto throttle (A/T) system.

6-The mode control panel (MCP) on the glareshield panel allows the flight crew to communicate with the automatic flight system.

7-The FMC CDU lets you select thrust limits, target airspeeds and flight routes for the automatic flight system to follow.

8-The automatic flight system mode status is displayed on the flight mode annunciation which is located on the upper strip of the each pilot's primary flight display. The system also incorporates warning annunciation.

## AUTOPILOT FLIGHT DIRECTOR SYSTEM (AFDS)

9-AUTOPILOT FLIGHT DIRECTOR SYSTEM (AFDS) The autopilot flight director system consists of two individual flight control computers (FCCs) which are identified as FCC "A" and FCC "B". One of the FCCs is specified as master and the other as slave.

### Flight control computer

10-FLIGHT CONTROL COMPUTER The FCCs mainly control two systems: the autopilot and the flight director. Each FCC also provides Mach trim, altitude alert and speed trim functions.

### Autopilot functions

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11-AUTOPILOT FUNCTIONS For autopilot functions, the FCCs get crew inputs from the mode control panel and data from various airplane systems. Next, FCCs calculate pitch and roll commands based on Control Laws.

12-FCCs then send the commands to their respective aileron and elevator servo actuators. These actuators control the movement of the ailerons and elevators, which control the flight path of the airplane.

13-For autopilot functions, the FCC controls autopilot “A” and FCC “B” controls autopilot “B”. When the crew engages one autopilot, that autopilot is the master and the other autopilot is the slave.

14-When the crew engages both autopilots (dual mode), the first autopilot engaged is the master and the second engaged is the slave.

15-The master autopilot controls the mode displays on the flight mode annunciator (FMA) and the data that goes to the auto throttle and flight management computer.

### Flight director functions

16-FLIGHT DIRECTOR FUNCTIONS For the flight director functions, the FCC uses almost the same inputs to calculate the flight director pitch and roll commands as it uses to calculate the autopilot pitch and roll commands.

17-As the flight director function does not move the control surfaces, the flight director commands do not go to the autopilot actuators; instead, the commands go to the respective attitude indicator to position the flight director command bars.

18-When the MCP flight director switches are on, the flight director commands show on the attitude indicator provided that an operation mode is engaged. The flight crew can use the flight director commands to control the attitude of the airplane.

19-Normally, FCC “A” drives the Captain’s command bars and FCC “B” drives the First Officer’s command bars.

### Mach trim

20-MACH TRIM The FCC also has a Mach trim function. As the airplane speed gets very fast, the center of lift moves rearward and the airplane nose starts to drop. This is called “tuck under”.

21-The FCC Mach trim function prevents tuck under. When the airplane airspeed is more than mach 0.615, the FCC automatically moves the elevator up to keep the nose of the airplane level. Note that the Mach trim function operates with or without the autopilot engaged or the flight director on.

### Altitude warning

22-ALTITUDE WARNING FCC also supplies an altitude warning when one of these conditions occurs: the airplane is approaching a preselected altitude or the airplane is deviating above or below from a selected altitude.

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23-Let's see how the system alerts the crew upon approaching a preselected altitude of, say, 20000 feet. When the aircraft is about 900 ft. above (or below) the selected altitude, a momentary aural tone sounds. A white box appears around the selected altitude and the white box around the current altitude becomes bold. At 300 feet from the selected altitude, the box around the selected altitude disappears.

24-If the airplane now deviates more than 300 feet above or below the selected altitude, a momentary aural warning occurs and the current altitude box changes color to amber and begins to flash.

25-When the airplane is at 300 feet from the selected altitude, the box around the selected altitude disappears.

26-The visual warning stops for these conditions: \* The airplane returns to within 300 feet of the selected altitude.

27-The airplane is more than 900 feet from the selected altitude.

28-You set a new altitude on the MCP.

### Speed trim

29-SPEED TRIM The FCC's speed trim function keeps the speed set by the pilots with commands to the horizontal stabilizer when the engine thrust is high and the airspeed is low. This primarily occurs during takeoff.

30-Note that speed trim function only operates when the autopilots are disengaged. The flight directors may be on or off.

### MODE CONTROL PANEL (MCP)

31-MODE CONTROL PANEL (MCP) The mode control panel (MCP) lets the crew control the automatic flight system. The panel incorporates toggle switches, selectors, and push-buttons switches that you use to control the flight control computer. There are also displays to show selected parameter values. Let's see the functions of those switches and displays.

32-The course selectors select the VHF omnidirectional range (VOR) course or the instrument landing system (ILS) course.

33-The course selectors also provide selected course information to the respective flight control computer, VHF navigation receiver and display unit.

34-The two course displays indicate the VOR or ILS course you select. The display range is from 0 to 359 degrees.

35-Two flight director switches turn on and turn off the flight director function in the FCCs.

36-When the left flight director switch is set to on, the flight director command bars appear on the Captain's attitude indicator. With the right flight director switch selected on, the command bars on the First Officer's attitude indicator appear. When flight director switch is set to OFF, command bars retract from related pilot's attitude indicator.

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37-The master lights on the MCP indicates which FCC controls the flight director mode selection.

38-The autothrottle arm switch is used to arm or disconnect the auto throttle. When the switch is in the off position, the autothrottle disengages and autothrottle activation is disabled. When you set the autothrottle arm switch to the arm position, the autothrottle system arms for engagement. The autothrottle arm light illuminates green when the autothrottle arm switch is in the arm position.

39-There are four A/P engage switches on the MCP. Two switches are for FCC "A" and other two are for FCC "B".

40-The switches engage an autopilot to the command (CMD) mode or the control wheel steering (CWS) mode. These modes will be described later.

41-When you push the A/P engage switch and if the engagement criteria are met, the related autopilot engages and the switch light comes on. If you push the switch again, the autopilot disengages. Only one autopilot can be engaged at a given time unless the approach (APP) mode is engaged.

42-The autopilot disengage bar lets you disconnect the autopilot. When you push the autopilot disengage bar down, yellow stripe is exposed, both autopilot disengage and autopilot engagement is disabled. The bar must be in the up position before you engage the autopilot again.

43-The mode selector switches allow you to select autoflight modes. These are the automatic flight system modes: autothrottle modes: N1, and speed. Modes controlled by the autopilot are: the roll channel: heading select, lateral navigation (LNAV), VOR localizer (VOR LOC). The modes controlled by autopilot pitch channels are: vertical navigation (VNAV), level change, altitude hold and vertical speed. The mode controlled by both roll and pitch channels is approach. These modes are described in Part 2 and Part 3.

44-To select a mode you push the related switch. The switch light illuminates to indicate the mode selection. The mode can be turn off by pushing the switch again. While a mode is active, deselection can be automatically inhibited and is indicated by the switch being extinguished.

45-Any mode, operating either on the pitch or roll channel, disengages when another mode is selected in the same channel. All modes can be disengaged by de-selecting the autopilot and turning the flight directors off.

46-The indicated airspeed/mach selector is used to set the target airspeed or mach in the indicated airspeed/mach display and on both primary flight displays. The selector is inoperative when indicated airspeed/machdisplay is blank.

47-The indicated airspeed/Mach display shows the speed selected by indicated airspeed/Mach selector.

48-The indicated airspeed is displayed from 100 to 399 knots in one knot increments. The Mach shows from 0.60 to 0.89 mach in 0.01 mach increments.

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49-When initial power is applied, indicated airspeed/Mach display and PFD speeds set to 100 knots.

50-The speed displays blank when the VNAV mode is active, the autothrottle is engaged in FMC speed mode or during two engine go-around executed by the autopilot flight director system.

51-The speed display also features a warning function which activates in the event of under-speed and over-speed conditions.

52-In the case of under speed condition, which occurs when the airspeed drops to the alpha floor limit, a flashing character “A” appears in the left position of the window.

53-In the event of an over-speed condition, which occurs when at the Vmo or Mmo limit, the gear limit or flap limit is reached, the flashing character “8” displays in the same position.

54-The speed display usually indicates the speed in knots below Flight Level 260 and in Mach above Flight Level 260. The changeover switch lets you change indicated airspeed/Mach display from indicated airspeed to Mach or vice versa. This changeover occurs automatically at approximately Flight Level 260.

55-The heading selector sets heading in the heading display and the selected heading on the primary flight displays and navigation displays.

56-The heading display shows the heading selected by the flight crew.

57-The bank angle selector lets the flight crew set the maximum allowable bank angle. The bank angle can be selected from 10 to 30 degrees with in between selections of 15, 20 and 25 degrees. Note that bank angle selection is effective only in heading select or VOR mode.

58-The altitude selector sets altitude on the altitude display in 100 foot increments. It also sets the selected altitude on primary flight displays.

59-The altitude display shows the altitude selected by the flight crew. The altitude range is from 0 to 50,000 feet. Note that displayed altitude is reference for altitude alerting and automatic level-offs.

60-The vertical speed thumbwheel sets vertical speed on the vertical speed display and the selected vertical speed bug on the primary flight displays.

61-To set the vertical speed, rotate the thumbwheel toward the up position to make a nose up change in vertical speed. Turn the thumbwheel toward the down position to make a nose down change in the value.

62-The vertical speed display shows the vertical speed selected by the flight crew. The vertical speed range is from -7,900 feet per minute to +6,000 feet per minute. The display has increments of 50 feet per minute from 0 to 1000 feet per



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minute and 100 feet per minute for more than 1000 feet per minute.

63-The speed intervention switch is used only in the VNAV mode. When you push the switch, the indicated airspeed/MACH display shows the FMC target speed. Now, you may turn the indicated airspeed/MACH selector to change the FMC target speed.

64-The altitude intervention switch lets you change the FMC target altitude and delete altitude constraints in the flight plan.

65-Note that speed intervention and altitude intervention switches are not available in some configurations.

### **AUTOTHROTTLE (A/T) SYSTEM**

66-AUTOTHROTTLE (A/T) SYSTEM Autothrottle (A/T) system is computer controlled electromechanical system that controls engine thrust within engine design parameters.

67-The autothrottle system is able to provide automatic thrust control from the start of takeoff through climb, cruise, descent, approach and go-around or landing.

68-The autothrottle system incorporates an autothrottle computer which does the calculations for automatic control of engine thrust. The computer then sends the commands to the autothrottle servo motors to move the thrust levers.

69-During autothrottle operation, it is recommended that both electronic engine controls be ON or both be in alternate. This minimizes thrust lever separation.

70-The autothrottle has two primary modes of operation: speed mode and thrust mode. In speed mode, the autothrottle controls engine thrust to control airplane speed. In thrust mode, the autothrottle controls thrust to maintain FMC N1 target.

71-The autothrottle can also enter other modes such as arm, throttle hold, retard and go-around depending on the flight phase and mode selected. Let's first see the A/T modes that are selectable on the MCP.

72-Autothrottle arm, speed and N1 modes can be selected on the MCP.

73-The autothrottle arm switch lets your arm or disconnect the auto throttle. When the switch is in the off position, the autothrottle disengages and the autothrottle activation is disabled.

74-When you set autothrottle arm switch to arm position, autothrottle system arms for engagement and the autothrottle arm light illuminates green.

75-The A/T system is now ready to receive commands, but no mode is selected. You can set thrust levers manually and minimum speed protection is available.

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76-The N1 switch lets you manually engage the autothrottle in thrust mode when it is compatible with the autopilot flight director system modes already engaged.

77-When you push the N1 switch, the autothrottle engages to maintain thrust at the N1 limit selected from FMC CDU. The switch light illuminates. Note that when vertical navigation climb or level change climb is engaged, the N1 mode automatically engages.

78-If you push the N1 switch when its light is illuminated, thrust mode deactivates and the switch light extinguishes. The autothrottle goes back to the ARM mode.

79-The speed switch lets you manually engage the autothrottle in MCP speed mode when it is compatible with existing autopilot flight director system modes.

80-When you push the SPEED switch, the autothrottle engages to control engine thrust to maintain the speed selected on the MCP. The switch light illuminates.

81-If you push the switch when its light is illuminated, the SPEED mode deactivates and the switch light extinguishes. The autothrottle goes back to ARM mode.

82-The autothrottle system also has a FMC SPEED mode which has no switch on the MCP. In the FMC SPEED mode, the autothrottle controls thrust to control airplane speed to the FMC flight plan target speed.

83-There are other autothrottle modes that are also not selectable on the MCP.

84-The throttle hold mode is automatic and the autothrottle goes into this mode during the takeoff ground roll. The pilot can set the thrust levers manually. This mode is used to prevent the autothrottle from accidentally retarding the thrust levers and to allow an aborted takeoff.

85-After takeoff is complete, the A/T changes from throttle hold to arm mode.

86-In the RETARD mode, the autothrottle moves the thrust levers to the aft stops. The RETARD mode is followed by the ARM mode.

87-During approach, when you push a TO/GA switch once, the autothrottle commands a reduced thrust go-around.

88-During go-around, if you push a TO/GA switch a second time, the autothrottle commands maximum thrust go-around to the FMC go around N1 limit.

### Thrust mode annunciation

89-THRUST MODE ANNUNCIATION The thrust mode annunciator at the top of the engine display shows the FMC calculated N1 limits and the thrust modes for each flight phase.

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90-Here are the thrust mode display annunciations. In some configurations, you see these thrust mode display annunciations.

91-When the FMC is not providing the autothrottle system with N1 limit values, the autothrottle computer calculates a single N1 limit for both engines. The message AUTOTHROTTLE LIMIT shows in white on the engine display. In this mode, the autothrottle computer does not calculate an engine N1 limit for takeoff.

### FLIGHT MODE ANNUNCIATION

92-FLIGHT MODE ANNUNCIATION The automatic flight system modes of operation show on the flight mode annunciation (FMA) at the top of the primary flight display above the attitude indicator.

93-The top strip indicates autothrottle and autopilot flight director system modes. Engaged or captured modes are shown in large green letters. The armed modes are shown in smaller white letters at the bottom.

94-The left window shows data about the autothrottle. When the autothrottle is armed, the word ARM appears in white in the window. The autothrottle engaged mode shows in green in the same window.

95-The window at the right shows the autopilot flight director system pitch modes. These are the pitch armed modes which appear in white. These are the pitch engaged modes which appear in green.

96-The window at the middle shows autopilot flight director system roll modes. These are the roll armed modes which appear in white. These are the roll engaged modes which appear in green. In some airplanes, you see these additional roll armed and roll engaged mode.

97-When there is a mode change, a box shows around the new mode on the FMA display for 10 seconds.

98-The autopilot status shows above the attitude indicator.

99-The green flight director annunciator indicates that the flight director is on. When an autopilot is engaged, the flight director annunciator is replaced with a green COMMAND annunciation.

100-In some airplanes, the autopilot status is indicated on the top strip.

101-When the autopilot is engaged in control wheel steering mode, then the amber control wheel steering roll and control wheel steering pitch replace the command annunciation. The flight director annunciation will also display if the flight director is on.

102-In some airplanes, you also see these autopilot modes.

### AUTOFLIGHT STATUS ANNUNCIATION

103-AUTOFLIGHT STATUS ANNUNCIATION The autoflight status or warning annunciation located on the left and right

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forward panels provide warnings in relation to status of the automatic flight system.

104-The autoflight status annunciation incorporates an autopilot disengage light, an autothrottle disengage light, an FMC light and a test switch.

105-The three position disengage light test switch lets you do a test of the lights. When you push the test switch to the number 1 position, all three annunciator lights come on steady amber. When you push the test switch to the number 2 position, the A/P and A/T annunciations come on steady red. The FMC annunciation comes on amber.

106-The color of an autopilot disengage light can be red or amber. When an autopilot disconnects, the red autopilot annunciator flashes and a horn sounds. The horn and flashing lights can be reset by pushing either Captain's or First Officer's autopilot disengage light or either captain's or first officer's autopilot disengage switch.

107-The red autopilot annunciation comes on steady when any of these conditions occurs: the stabilizer out of trim warning is set below 800 feet radio altitude on dual channel approach, altitude acquire mode is inhibited during autopilot go-around because single autopilot operation is not available, the power up test fails on the ground, or the disengage light test switch is held in position 2.

108-When an autopilot changes automatically from command to control wheel steering roll or pitch, the autopilot disengage light flashes amber. The light continues to flash until the crew pushes the light to reset the warning or selects a valid command mode.

109-The amber autopilot disengage light appears steady, when the disengage light test switch is held in position 1. In some airplanes, although the disengage light test switch is not held in position 1, the light comes on to indicate a downgrade in auto land capability.

110-The color of the autothrottle disengage light can also be red or amber. When the autothrottle disengages, the red autothrottle annunciation flashes.

111-The red autothrottle annunciation illuminates steady when the disengage light test switch is held in position 2.

112-The autothrottle disengage light flashes amber to indicate an auto throttle airspeed warning.

113-The autothrottle light starts to flash, if the true airspeed is not within limits compared to the FMC or the MCP selected airspeed, when the flaps are greater than 0.5 degrees, the true airspeed is 10 kts faster than target airspeed or the true airspeed is less than target airspeed minus 5 kts and the airplane is not accelerating to the target airspeed.

114-The amber autothrottle annunciation illuminates steady when the disengage light test switch is held in position 1.

## AUTOPILOT OPERATION

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115-AUTOPILOT OPERATION There are two autopilot engage switches on the MCP for each autopilot system. These switches let the flight crew engage the autopilot in the command (CMD) or control wheel steering (CWS) mode.

116-When you push one of the autopilot engage switches, the interlock circuits in the FCC make sure that a number of conditions are satisfied before engagement of the autopilot. Some of these conditions are pilot-controlled.

117-Ensure that no force is being applied on the control wheel, the stabilizer trim cutout switch is in the normal position and the stabilizer trim switch is not pushed. If all conditions are satisfied, the switch light comes on indicating that autopilot has engaged.

118-You can normally engage only one autopilot at a given time. If autopilot “A” is engaged and you choose to engage autopilot “B”, autopilot “A” will disengage after “B” has engaged. However, in approach mode you can engage both autopilots at the same time.

### Command mode

119-COMMAND MODE When you engage an autopilot in the command mode, the command annunciation displays on the flight mode annunciation. In the command (CMD) mode, the autopilot controls the airplane automatically using the related FCC commands with no control wheel inputs from the pilots.

### Control wheel steering mode

120-CONTROL WHEEL STEERING MODE When the autopilot is engaged in the control wheel steering (CWS) mode, CWS roll and CWS pitch replace the command annunciation. In control wheel steering mode, autopilot controls the airplane using control wheel inputs from the pilots.

121-With the control wheel steering engaged, when the pilot moves the control wheel, the airplane takes up the new attitude, and on releasing the wheel, the autopilot goes to the attitude hold sub modes and holds the airplane attitude obtained at that moment.

122-If you release the control wheel when the bank angle is less than 6 degrees, the autopilot goes to the heading hold sub mode. The autopilot decreases the bank angle to 0 degrees within 3 seconds and then maintains the airplane heading.

123-If you release the control wheel when the bank angle is more than 30 degrees, it decreases to 30 degrees.

124-In some cases, one autopilot axis engages in command mode while the other autopilot axis engages in control wheel steering mode.

125-With the autopilot selected in command mode, the roll control wheel steering engages under two conditions: you do not select a roll mode or you deselect a roll mode.

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126-Or although a roll mode has been selected, you apply a control wheel force of more than 10 pounds. The control wheel steering roll is annunciated on the FMA while this mode is engaged.

127-Similarly, with the autopilot selected in command, the pitch control wheel steering engages if you don't select a pitch mode or you deselect a pitch mode.

128-Or although a pitch mode has been selected, you apply a control column force of more than 21 pounds. The control wheel steering pitch is annunciated on the FMA while this mode is engaged.

129-When the autopilot is in the altitude hold mode, at the selected altitude, and if you engage the control wheel steering pitch by applying control wheel force, the control wheel steering pitch replaces altitude hold annunciation. You must keep force on the control wheel until the airplane is more than 250 feet from the MCP altitude. Otherwise, the control wheel steering pitch changes to ALTITUDE ACQUIRE, the airplane returns to the selected altitude and the ALTITUDE HOLD mode engages.

130-The autopilot can be disengaged in three ways: you normally push the autopilot disengage switch on the outboard handgrip of the control wheel, you can also disengage the autopilot by pushing an illuminated autopilot engage switch; or pushing down the autopilot disengage bar on the MCP.

131-The autopilot also automatically disengages when certain events occurs. Some of them are: activating either pilot's control wheel trim switch, moving the STAB TRIM AUTOPILOT cutout switch to CUTOFF, pushing either TO/GA switch after touchdown with both autopilots engaged in command, either left or right IRS system FAULT light is illuminated, loss of electrical power, respective hydraulic system pressure or a sensor input which prevents proper operation of engaged autopilot and mode also causes the autopilot to disengage.

132-These are the indications of autopilot disengagement: the autopilot engage light extinguishes, the autopilot status annunciation changes, the autopilot disengage light flashes red and warning horn sounds.

### AUTOTHROTTLE OPERATION

133-AUTOTHROTTLE OPERATION As we have seen earlier, the auto throttle arm switch must be set to ARM position to engage the auto throttle. The green autothrottle arm lights illuminates on the MCP and the white ARM annunciation appears on the FMA to show the autothrottle status. For each flight phase, the autothrottle N1 or MCP speed modes may be selected from the MCP. The N1 or speed mode select switch light comes on to show the mode is active. The autothrottle modes of operation show on the FMA at the top of the primary flight display.

134-The autothrottle engages automatically when following AFDS modes are engaged: TO/GA, level change, altitude acquire, vertical speed, vertical navigation, altitude hold and glide slope capture.

135-You can disengage the autothrottle in two ways: you may move the autothrottle ARM switch to the OFF position, or

you can also disengage the autothrottle by pushing either autothrottle disengage switch on the thrust levers.

136-These are the indications of autothrottle disengagement: the autothrottle ARM switch moves to the OFF position, the autothrottle indicator light extinguishes, the autothrottle mode switch light extinguishes, the autopilot status annunciation changes, and the autopilot disengage light flashes red. Note that the autothrottle disengage lights do not illuminate when the autothrottle automatically disengages after landing touchdown.

## FLIGHT DIRECTOR OPERATION

137-FLIGHT DIRECTOR OPERATION The flight directors can be operated with or without the autopilot and autothrottle.

138-The flight director commands operate in the same command modes as the autopilot except two modes.

139-The takeoff mode is a flight director only mode. You cannot use the autopilot for takeoff.

140-The flight director has no landing flare capability. The flight director command bars retract out of view at approximately 50 feet radio altitude on an ILS approach.

141-You activate the flight director by moving the flight director switch to the F/D position. The respective autopilot status indicates FD on the FMA. However, the command bars do not appear if the command roll and pitch modes are not selected. Upon selection of the roll and pitch modes, the flight director bars show as magenta bars on the attitude indicator.

142-You can remove the flight director command bars, by moving the respective flight director switch to OFF.

143-There is a master flight director indicator light above each flight director switch. This light shows which FCC is the master FCC.

144-This is how the master FCC is determined. When one or both autopilots are engaged in command, the FCC for the first autopilot in command is the master FCC, regardless of which flight director is turned on first.

145-When no autopilot is engaged in command, the FCC for the first flight director turned on is the master.

146-Both FCCs are the master and operate independently when: the flight directors are on and neither autopilot is engaged in command mode, and if the approach mode is engaged with glide slope and localizer captured, or go-around mode is engaged with radio altitude less than 400 feet, or takeoff mode is engaged with radio altitude less than 400 feet. Independent flight director operation is indicated by illumination of both master lights.

## AUTOMATIC FLIGHT- PART 2

147-AUTOMATIC FLIGHT- PART 2 This part deals with the operation of autoflight system pitch and roll modes during climb, cruise and descent. Here is the outline: \* Autoflight roll modes \* Autoflight pitch modes \* Altitude and speed intervention.

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## AUTOFLIGHT ROLL MODES

148-AUTOFLIGHT ROLL MODES The autoflight roll modes control the airplane heading and the lateral path.

149-For roll modes, the FCCs calculate the aileron commands that go to the roll autopilot actuators and flight director roll commands that go to the attitude indicators.

150-These are the roll modes that are selectable from the MCP: Heading select, lateral navigation and VOR/Localiser.

151-The Flight mode annunciation displays the roll engaged and armed modes.

152-FCCs also calculate the roll commands for Go-around (G/A) and Takeoff (T/O) modes which are discussed in part 3.

153-You can also engage the autopilot with the control wheel steering roll by engaging an autopilot in the command mode without selecting a roll mode. This allows you to control the roll attitude of the airplane as if the autopilots are disengaged. This is indicated with amber CWS R label on the FMA.

### Heading select (hdg sel) mode

154-HEADING SELECT (HDG SEL) MODE Heading select mode lets you change the airplane heading.

155-The heading that the airplane will turn is the heading value set in the MCP heading display. The maximum bank angle in the turn is the bank angle limit set on the MCP.

156-These are the two ways to use the heading select mode: first engage the heading select mode and set a heading or select a new heading when the heading select mode is already engaged. The difference between these two cases is the autopilot's logic for selecting the direction to execute the turn.

157-For first engagement of the heading mode, you need to set the heading before selecting the mode. First, rotate the heading selector to set the desired heading in the heading display and then push the heading select switch. The heading select shows as the active roll mode on the FMA. The green box around the letters indicates that this is a new mode and disappears in 10 seconds. The airplane turns in the shortest direction toward selected heading regardless the direction as you turn heading selector. When the turn is completed, the airplane maintains the selected heading.

158-If the heading select mode is already engaged, rotate the heading selector to set a new heading. When you turn the selector counterclockwise, the airplane turns to the left. When you turn the selector clockwise, the airplane turns to the right. In other words, the airplane turns in same direction as rotation of heading selector. The airplane then holds the heading set on the MCP.

159-If heading select is used to intercept a radio course, it automatically disengages upon capture of selected radio course in VOR/LOC and approach modes.

### Vor/loc mode



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160-VOR/LOC MODE The VOR / localizer mode is used to capture and track a VOR radial or localizer course for cruise and approach control.

161-In order to use the VOR/localizer mode, the VHF navigation receiver must be set to the VOR or the localizer frequency.

162-You use one of the course selectors on the MCP to select the desired course. The course shows on the course display. The bank angle limit is also set on the MCP.

163-If autopilot "A" is engaged, the Captain's course selector and number 1 VHF navigation receiver send VOR or localizer data to FCC "A". The FCC then calculates the roll command to capture and follow the selected course.

164-If autopilot "B" is engaged, the First Officer's course selector and the number 2 VHF navigation receiver send VOR or localizer data to the FCC B. The FCC then calculates the roll command to capture and follow the selected course.

165-Let's see the sequence of operation of autopilot from heading select mode to VOR capture. Starting in the heading select mode and it is annunciated in the roll mode window.

166-Set the VOR station radio frequency into the VHF navigation radio receiver and identify the station.

167-Then, turn the course selector to set the desired VOR course. Usually the two course selectors are set to the same course. Push the VOR LOC switch. The mode is now in the VOR arm submode.

168-When the VOR is in the arm submode, VOR/LOC shows in white letters on the second line of the roll window of the FMA. The autopilot stays in this submode until the airplane reaches the capture point.

169-When the airplane reaches the capture point, the VOR mode changes to the capture submode. The capture point is not fixed and depends on the intercept angle and closure rate. Course capture is indicated when VOR/LOC annunciation changes from armed to engaged in large green letters. After the course capture, the airplane turns to track the course and VOR mode shifts to on-course submode.

170-Directly overhead a VOR station, there is a region where the radio signals are not usable. This region is called "cone of confusion". When the VOR radio beam is lost as the airplane enters the cone of confusion, the VOR mode shifts to over-station submode and autopilot temporarily maintains the airplane heading. When the VOR radio beam is acquired again, it reverts to on-course mode and continues to track the selected course.

171-The flight crew can also use the VOR LOC mode to perform a localizer only approach.

172-To use the localizer mode, set the ILS frequency into VHF navigation radio receiver and identify the ILS.

173-Then turn the course selector to set the ILS course. Push the VOR LOC mode selector switch. This arms the localizer

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mode.

174-When the localizer mode arms, the FMA shows VOR/LOC in small white letters. Upon capture of localizer course, the active roll mode changes to VOR/LOC and the FMA shows VOR/LOC in green letters. The airplane turns to track the localizer course.

175-With the localizer frequency selected, when the VOR/Localizer is annunciated in the armed or engaged mode, VHF navigation receivers automatically switch from tail antenna to nose antenna. If the antenna switching does not occur, the localizer mode is inhibited.

### **Lateral navigation (Lnav) mode**

176-LATERAL NAVIGATION (LNAV) MODE In the lateral navigation mode (LNAV), the autopilot flight director system uses the FMC roll commands to capture and follow the lateral flight route programmed into FMC. The flight route is entered through FMC CDUs and can include standard instrument departures, standard terminal arrival routes and instrument approaches.

177-You use the lateral navigation switch on the MCP to activate the lateral navigation mode. When the autopilot flight director system is in the lateral navigation mode, the LNAV annunciation shows on the FMA.

178-In some airplanes it is possible to arm the lateral navigation mode before the flight. To arm the lateral navigation mode on the ground, both flight directors must be ON.

179-In addition, these conditions must be valid: the original runway is in the flight plan, the active route is programmed into the FMC and the track of first leg is within 5 degrees of runway heading.

180-With all these conditions satisfied, if you activate lateral navigation before selecting TO/GA, the lateral navigation mode arms.

181-After you push a TO/GA switch, although the flight mode annunciation still shows lateral navigation armed in the roll mode, the light on the lateral navigation switch goes off.

182-At 50 feet above ground level lateral navigation engages automatically.

183-To engage the lateral navigation in flight, you have to consider two factors: cross-track distance and intercept angle.

184-If the airplane is within 3 nautical miles of the active route, you can engage lateral navigation from any airplane heading.

185-If the airplane is more than 3 nautical miles of the active route, lateral navigation engages when these conditions are valid: the airplane is on a heading that intercepts the active route at an angle of 90 degrees or less, and before the active

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waypoint. With these conditions satisfied, when you push lateral navigation switch, the autoflight system intercepts and tracks the active route.

186-Lateral navigation automatically disconnects when another roll mode is activated.

187-Or when the airplane reaches final waypoint.

188-Or when the airplane did not capture the localizer course.

## AUTOFLIGHT PITCH MODES

189-AUTOFLIGHT PITCH MODES The autoflight system pitch modes control the airplane in climb, cruise and descent. These modes also provide vertical guidance and commands for approach and automatic landing. When an autoflight pitch mode is activated, an autothrottle mode automatically engages if it is armed.

190-For pitch modes, the FCCs calculate the elevator commands that go to the elevator autopilot actuators and flight director pitch commands that go to attitude indicators.

191-These are the pitch modes selectable from the MCP: Level Change (LVL CHG), Vertical Speed (V/S), Altitude Hold (ALT HOLD) and Vertical Navigation (VNAV). The FCC also automatically selects these pitch modes: Altitude Acquire (ALT ACQ) and MCP speed (MCP SPD). There are no mode selector switches to select these modes. The FMA displays the pitch modes.

192-You can also engage the autopilot in control wheel steering pitch by activating an autopilot in the command mode without selecting a pitch mode. This lets you control the airplane pitch as if the autopilots are disengaged. This is indicated with amber CWS P label on the FMA.

193-When the autopilot controls elevator to hold MCP selected speed, MCP SPEED shows in the pitch window of the flight mode annunciator.

194-If MCP speed annunciation shows in the autothrottle window, this means that the autothrottle is controlling the thrust to hold the MCP selected speed.

195-In a climb and descent, you can use vertical navigation, level change, and vertical speed or pitch control wheel steering modes. During cruise vertical navigation, altitude hold or control wheel steering pitch modes are normally used. Now let's take a closer look at the pitch modes.

### Level change (lvl chg)

196-LEVEL CHANGE (LVL CHG) The level change (LVL CHG) mode lets the pilot make automatic climb or descent to change flight level.

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197-Those are some features of level change mode: the level change mode always commands the airplane to the MCP selected altitude.

198-If the airplane is at the MCP selected altitude, level change does not activate.

199-During level change, the autothrottle controls thrust. The autopilot flight director system controls airspeed with the elevator. The speed reference is the MCP selected speed.

200-Now let's see how the autothrottle controls thrust in level change mode. In a level change climb, the autothrottle uses active N1 to limit thrust.

201-In a level change descents, the autothrottle uses idle thrust.

202-Because it uses either maximum N1 limit or idle thrust, the level change mode is most suitable for large altitude change.

203-To initiate a level change climb or descent; first select a new altitude, then push the level change switch. With the level change mode active, the light on the level change switch comes on. Then you may set the airspeed.

204-If you push the level change switch when in vertical navigation, the MCP speed indicator shows the FMC target speed. Level change mode uses this speed until you set a new speed in the window.

205-For a level change climb, the pitch mode window on the FMA shows MCP speed and autothrottle mode window annunciates N1.

206-For a level change descent, the pitch mode window on the FMA shows MCP speed and autothrottle mode window annunciates RETARD followed by ARM.

207-When approaching the MCP selected altitude, the autopilot pitch channel controls the elevator to level off the airplane. FMA pitch mode changes from MCP speed to Altitude acquire. The autothrottle mode changes over from the N1 to the MCP speed. When the level off is complete autopilot pitch mode changes to altitude hold.

208-You cannot use level change mode after glideslope capture.

### **Vertical speed (v/s) mode**

209-VERTICAL SPEED (V/S) MODE You can also use the V/S mode to climb or descend to the altitude set in the MCP. You usually prefer this mode when small altitude changes are required, because it causes small variations in airplane's pitch attitude and thrust.

210-The vertical speed thumbwheel lets you set the desired vertical speed. Note that whenever the vertical speed mode is activated, autothrottle automatically engages in speed mode to hold the MCP speed.

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211-Let's take a look at use of the vertical speed mode when you are already in climb or descent to the selected MCP altitude and when you are flying at selected MCP altitude with altitude hold engaged.

212-When you are already in climb or descent to the selected MCP altitude, push the V/S switch to engage vertical speed mode. The switch light illuminates. The FMA displays vertical speed as the pitch mode and the MCP speed as autothrottle mode. Vertical speed display on the MCP shows the current vertical speed.

213-You can set the desired vertical speed with the vertical speed thumbwheel. The short magenta line on the vertical speed indicator shows the selected vertical speed. The climb continues at the vertical speed that you set.

214-The airplane starts to level off before the MCP altitude. Altitude acquire replaces vertical speed as the pitch mode annunciation and the vertical speed switch light goes out. When the level off is complete, autoflight pitch mode changes to altitude hold.

215-Now consider that you are flying at MCP selected altitude and pitch mode is altitude hold. To use the vertical speed mode, first you must select a new MCP altitude which should be at least 100 feet different than the current MCP altitude. This cause's the altitude hold switch light to illuminate and the vertical speed mode to arm. V/S appears on the FMA in smaller white letters.

216-To engage the vertical speed mode, you must turn the V/S thumbwheel to set the climb or descent rate. The light on the altitude hold switch extinguishes. Vertical speed switch light illuminates. Vertical speed is annunciated as the pitch mode on the FMA. Now the airplane climbs or descends to new MCP altitude with selected vertical speed.

217-You cannot use vertical speed mode after glideslope capture.

218-The vertical speed mode is also inhibited, when altitude hold mode is active at selected MCP altitude.

### Altitude acquire (alt acq)

219-ALTITUDE ACQUIRE (ALT ACQ) The FCC automatically selects the altitude acquire mode when the airplane approaches the MCP selected altitude. The FMA shows altitude acquire as the pitch mode.

### Altitude hold (alt hold)

220-ALTITUDE HOLD (ALT HOLD) Engagement of the altitude hold mode occurs in two ways: automatic engagement and manual engagement.

221-Altitude hold mode automatically engages when the airplane reaches the MCP altitude after level change, vertical speed or vertical navigation climb or descent. The airplane maintains the altitude set on the MCP. The FMA shows altitude hold as the pitch mode. The altitude hold switch light extinguishes.

222-When FCC "A" is the master FCC, the selected MCP altitude is referenced to the Captain's barometric altimeter

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setting.

223-When FCC “B” is the master, the First Officer’s barometric altimeter setting is used.

224-You can also engage altitude hold mode manually to stop a climb and a descent. If you push the altitude hold switch when the airplane is not at the MCP selected altitude, the switch light comes on and the airplane holds the uncorrected barometric altitude when altitude hold switch was pushed.

225-However, leveloff does not occur immediately. The airplane overshoots the altitude, but comes back to it. The FMA shows altitude hold as a pitch mode.

226-After altitude hold engages, changes in altimeter barometric setting do not change the selected altitude reference.

227-You cannot use altitude hold mode after glideslope capture.

### Vertical navigation (vnav)

228-VERTICAL NAVIGATION (VNAV) In the vertical navigation (VNAV) mode, the autoflight system uses pitch and autothrottle commands from the FMC to fly the vertical navigation profile selected on the CDU.

229-The profile includes climb, cruise, descent and speeds. It can also include waypoint altitude constraints.

230-You use the vertical navigation switch on the MCP to activate the vertical navigation mode.

231-Vertical navigation has two active modes: vertical navigation speed and vertical navigation path.

232-In the vertical navigation speed mode, the autopilot flight director system controls the elevator to hold the FMC target speed. The autothrottle controls thrust to hold the FMC thrust limit. The FMA displays VNAV SPD as pitch mode and N1 as autothrottle mode.

233-In the vertical navigation path mode, the autopilot flight director system controls elevator to hold the FMC altitude or descent path. The autothrottle controls thrust to maintain the FMC target speed. The FMA displays VNAV PTH as the pitch mode and FMC SPD as the autothrottle mode.

234-When the vertical navigation mode is active, the target speed is determined by the FMC; thus, the speed display on the MCP is blank.

235-In operation of vertical navigation mode, selected MCP altitude plays an important role. If the airplane is between the manually selected MCP target altitude and FMC target altitude for the active waypoint, vertical navigation will not engage. Thus you must adjust the FMC or MCP target altitude as necessary.

236-In addition, if the selected MCP altitude is between the airplane and the FMC target altitude, the airplane levels off at

the MCP selected altitude, not at the FMC target altitude.

### Vertical navigation

237-VERTICAL NAVIGATION In some airplanes, it is possible to arm vertical navigation before the flight. To arm the vertical navigation mode on the ground, both flight directors must be ON.

238-In addition, a valid flight plan must be programmed into FMC and performance data to calculate the vertical guidance command must be entered and executed.

239-With all these conditions satisfied, if you activate vertical navigation before selecting TO/GA, vertical navigation mode arms.

240-After takeoff, when the airplane is at 400 feet above ground level, the vertical navigation automatically engages.

241-Now, let's examine the operation of the VNAV in climb, cruise and descent.

### Vnav climb

242-VNAV CLIMB Suppose that FMC flight plan has a cruise altitude of FL 330. With the VNAV engaged, while the airplane is climbing to the FMC altitude, the autopilot flight director system operates in VNAV speed mode and holds FMC target speed with the elevator. The autothrottle holds the FMC thrust limit. Accordingly, the FMA shows VNAV SPD as a pitch mode and N1 as an autothrottle mode. When airplane reaches FL330, it automatically levels off. The VNAV speed mode changes to VNAV path mode. The autothrottle changes from N1 to FMC speed.

243-During VNAV climb if you set a MCP altitude which is lower than FMC altitude, but not lower than your current altitude, the airplane automatically levels off when it reaches MCP selected altitude and VNAV disengages.

244-You can re-engage the VNAV by selecting a new MCP altitude which is equal to or greater than the FMC altitude. The airplane again starts to climb in VNAV speed mode. At FMC altitude, the airplane automatically levels off and the VNAV speed mode changes to VNAV path mode.

### Vnav cruise

245-VNAV CRUISE During VNAV cruise at FMC altitude, the autopilot flight director system operates in VNAV path mode and holds FMC altitude with elevator. The autothrottle holds FMC target speed. Accordingly, FMA shows the VNAV path as pitch mode and FMC speed as autothrottle mode.

246-While cruising at FMC altitude with VNAV engaged, if you select a lower MCP altitude, the FMC automatically arms to start descent upon arrival at FMC top of descent point.

247-If you haven't selected a lower MCP altitude when the airplane is within 5 nautical miles of the top-of - descent point, the CDU alerting message RESET MCP ALTITUDE is displayed.

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## Vnav descent

248-VNAV DESCENT VNAV descent starts at the top -of - descent point. The VNAV descent complies with waypoint altitude restrictions by following the calculated vertical path.

249-VNAV can perform a descent in either of two modes: speed descent and path descent.

250-In VNAV speed descent mode, the FMC controls thrust and pitch to hold the target descent speed; then the autothrottle set the trust to idle at the top of descent point. The FMA shows RETARD then ARM as an autothrottle mode. The autopilot flight director system maintains the FMC target speed and the FMA pitch mode displays VNAV speed.

251-In VNAV path descent the FMC controls thrust and pitch to hold a descent path. The autopilot flight director system maintains the FMC descent path. The autothrottle normally retards the thrust to idle. However if the wind causes the ground speed to become too slow to maintain the descent path, the autothrottle increases the thrust to hold the FMC target speed and the mode changes from ARM to FMC speed mode.

252-During VNAV descent, if there is a strong tailwind, the autopilot flight director system pitches down to hold the descent path. However, if the tailwind results in an increase in airspeed by 10 knots or more above FMC target speed, the CDU advisory message DRAG REQUIRED is displayed. Use the speed brakes, trim or reduced thrust, as required, to reduce the airspeed within 5 knots of FMC target speed.

253-The airplane automatically levels off at MCP selected altitude or VNAV altitude, whichever is reached first. The autothrottle changes from ARM to FMC speed mode, if it is not already in this mode. The autopilot flight director system operates in VNAV path mode and holds the altitude with elevator.

## Vnav disengagement

254-VNAV DISENGAGEMENT Vertical navigation automatically disconnects: \* When another pitch mode is selected.

255-Or when the end of lateral navigation route is reached.

256-Or when the glideslope is captured.

257-Or when transition of glideslope intercept waypoint is made with glideslope mode armed.

258-When cross track error exceeds twice the RNP value while active leg has a navigation data base vertical angle and lateral navigation is not engaged.

## SPEED AND ALTITUDE INTERVENTION

259-SPEED AND ALTITUDE INTERVENTION Speed and altitude intervention functions, if installed, are used to change the FMC target speed and FMC target altitude. Note that these functions are available only when vertical navigation is engaged.



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### Speed intervention

260-SPEED INTERVENTION The speed intervention switch lets you change the FMC target speed with the MCP speed selector and stay in the VNAV mode. Let's see how the speed intervention operates.

261-As you remember, when VNAV is active, the MCP indicated air speed/MACH display window is blank. Thus you cannot change the speed with the MCP speed selector.

262-When you push the speed intervention switch, the current FMC target speed appears in the indicated air speed/MACH display. MCP shows after the speed on the CDU to indicate that MCP controls the speed. Now you can change the speed with the speed selector.

263-Turn the speed selector to set a new FMC speed. The new speed shows in the MCP indicated airspeed/MACH display and on the CDU.

264-Push the speed intervention pushbutton again, if you want to return to the original FMC target speed. The IAS/MACH display blanks and the speed on the CDU returns to the original FMC target speed.

### Altitude intervention

265-ALTITUDE INTERVENTION The altitude intervention switch lets you change the FMC target altitude and remove the altitude constraints in the flight plan with the MCP altitude selector while staying in VNAV.

266-There is no indication on the MCP to show that you selected the altitude intervention. The only indication is on the FMC LEGS page on the CDU. You can use altitude intervention function in VNAV climb, cruise and descent. Let's start with the use of altitude intervention in VNAV climb.

#### Altitude intervention in vnav climb

267-ALTITUDE INTERVENTION IN VNAV CLIMB In VNAV climb, the altitude intervention is used for three purposes: to remove altitude constraints, to resume VNAV climb and to change the FMC cruise altitude.

268-To understand how altitude intervention is used to remove altitude constraints, consider a typical climb profile with altitude constraints. The MCP altitude window displays the altitude constraint for the first waypoint. You are informed that the altitude constraints for NHN01 and GURSS are deleted.

269-To remove altitude constraints, set the MCP altitude to the next higher altitude constraint which is at 18000 feet in this example and then push the altitude intervention switch. The lowest FMC altitude constraint below selected MCP altitude is removed. Now push the altitude intervention switch again. The other FMC altitude constraints below the selected MCP altitude is removed. You can push the switch up to eight times to remove eight altitude restrictions.

270-The airplane levels off at 18000 ft. to follow the FMC altitude constraint. When the airplane is at the FMC constraint,

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you can use altitude intervention to continue the VNAV climb. ATC now clears you to your planned cruise altitude; set 33000 in the MCP altitude window. Push the altitude intervention switch. The airplane resumes the VNAV climb to the cruise altitude of FL330.

271-When in VNAV climb, the altitude intervention function also lets you to set a new cruise altitude. Suppose that ATC clears you to a new cruise altitude of FL370. Set 37000 in the MCP altitude window; and push the altitude intervention switch. If the MCP altitude is above the current FMC cruise altitude, the FMC cruise altitude resets to MCP altitude. Note that FMC cruise altitude cannot be reduced using the altitude intervention switch.

### **Altitude intervention in vnav cruise**

272-ALTITUDE INTERVENTION IN VNAV CRUISE In VNAV cruise, altitude intervention is used for two purposes: to change the cruise altitude and to start an early descent.

273-When in VNAV cruise mode, altitude intervention lets you change the cruise altitude. In this example, ATC clears you to a new cruise altitude of FL400; set 40000 in the MCP altitude window and then push the altitude intervention switch. If the MCP altitude is above the current FMC cruise altitude, The FMC cruise altitude changes to MCP altitude and the airplane starts a cruise climb.

274-When in the VNAV cruise mode, you cannot set a lower cruise altitude with altitude intervention. However, you can use altitude intervention to start an early descent. If you set the MCP altitude below the current FMC cruise altitude and push the altitude intervention switch, the airplane starts an early descent.

### **Altitude intervention in vnav descent**

275-ALTITUDE INTERVENTION IN VNAV DESCENT In VNAV descent, altitude intervention is used for two purposes: to remove altitude constraints and to resume VNAV descent.

276-Consider a typical VNAV path descent profile with altitude constraints. In the descent to AHTEM, the MCP altitude window displays an altitude constraint at this waypoint. You are told that altitude constraint at AHTEM is deleted.

277-To delete the altitude restriction, set the MCP altitude to the next lower altitude constraint which is 11000 feet in this example, and push the altitude intervention switch. The highest FMC altitude constraint above selected MCP altitude is removed.

278-The airplane levels off at 11000 ft. to follow the FMC altitude constraint. When the airplane is at the FMC constraint, you can use altitude intervention to continue the VNAV descend. When you are cleared for the next waypoint, set 10000 in the MCP altitude window and push the altitude intervention switch. The airplane resumes the VNAV path descent to 10000 feet. Note that this function works only when the MCP altitude is set below current altitude.

279-If all FMC altitude constraints are removed during VNAV path descent, the FMC automatically shifts to VNAV speed

descent.

280-In this example, to delete all altitude constraints you need to set the MCP altitude to 7000 feet which is the lowest altitude constraint, then push the altitude intervention switch. Each time you push the altitude intervention switch, an altitude constraint is removed.

### AUTOMATIC FLIGHT- PART 3

281-AUTOMATIC FLIGHT- PART 3 This part deals with the operation of autoflight system during takeoff, approach and go-around. Here is the chapter outline: \* Automatic flight takeoff \* Automatic flight, approach and landing \* Automatic flight go-around \* Automatic flight system operation in windshear.

### AUTOMATIC FLIGHT TAKEOFF

282-AUTOMATIC FLIGHT TAKEOFF Takeoff is a flight director only mode of the autopilot flight director system. You cannot use the autopilot for takeoff. You may engage the autopilot after takeoff. The autothrottle provides thrust control and maintains thrust at FMC selected takeoff N1 limit.

283-This is the typical takeoff sequence: before takeoff, takeoff start, takeoff roll, lift-off and climb out.

284-You must set all of these conditions before starting the takeoff: move both flight director switches to the ON position. The master flight director indicator light next to the flight director switch that was turned on first illuminates.

285-Select the runway heading with the heading selector and the bank angle limit with the bank angle limit control.

286-Set the initial altitude with the altitude selector.

287-Put the autothrottle arm switch to the ARM position.

288-Select V2 speed with the MCP speed selector.

289-Note that you can also arm LNAV and VNAV as needed before the takeoff.

290-With the all settings completed, these annunciations must be observed on the Captain and First Officer primary flight displays: the FD displays as the autopilot status. ARM displays as the autothrottle status. There are no pitch and roll mode annunciations. The flight director roll and pitch command bars are out of view and the selected target speed shows the V2 speed.

291-In addition, you must ensure that the thrust mode display indicates TO (takeoff) to show that the autothrottle limit is takeoff thrust, and N1 reference cursors are at FMC takeoff N1 limit.

292-To engage the takeoff mode, advance the thrust levers to about 40% N1. Then let the engines stabilize. This ensures that thrust increases symmetrically to the takeoff N1 limit. Then push a TOGA switch.

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293-When you push a TO/GA switch, these events take place. The autothrottle engages in the takeoff thrust mode and moves the thrust levers forward until the engines reach takeoff thrust.

294-On the MCP, both master lights come on to show that the flight directors are independent.

295-The FMA shows TO/GA as the pitch mode. The autothrottle annunciation changes from ARM to N1. No roll mode is annunciated on the FMA.

296-The flight director command bars appear on the primary flight display. The pitch command shows a pitch down attitude of 10 degrees. The roll command shows a wings level attitude.

297-Note that in some configurations, the FMA annunciates heading select as roll mode and flight director roll command is heading select.

298-During takeoff roll, when the airspeed is 60 knots, the flight director shows a pitch up command of 15 degrees.

299-If an engine fails during takeoff roll, the flight directors will then show a pitch up command of 12.5 degrees due to a change in the FCC in command.

300-When the airspeed is 84 knots, the autothrottle temporarily disengages and autothrottle mode changes from N1 to throttle hold. In the throttle hold mode, the autothrottle does not command thrust. You can set the thrust manually if desired or initiate an aborted takeoff if necessary.

301-In takeoff mode, the F/D can also be engaged with the F/D switches off. This is the pop-up mode.

302-When both flight director switches are in the OFF position, if a TO/GA switch is pushed after 80 knots below 2000 feet above ground level, flight director command bars automatically show for both pilots. The flight directors stay in the pop-up mode for 150 seconds after the airspeed reaches 80 knots.

303-At lift-off, the flight director continues at a 15-degree nose up pitch command. However, as the climb rate increases, flight director pitch goes from a 15-degree nose up command to speed target command to hold a target speed of V2 plus 20 knots.

304-An engine failure during takeoff causes the pitch command target airspeed to change.

305-If failure occurs when the airspeed is less than V2, V2 is the flight director target airspeed.

306-An engine failure between V2 and V2 plus 20 knots causes the target airspeed to change to the current indicated air speed.

307-If failure occurs when the airspeed is more than V2 plus 20 knots, there is no change to the target airspeed.

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308-At lift off, the flight director roll command maintains wings level.

309-As you recall, in some configurations, the flight director roll command maintains heading select. Bank angle is limited to 8 degrees below 400 feet radio altitude. When the airplane is above 400 feet radio altitude, a bank angle between 10 and 30 degrees can be selected.

310-During climb out, a radio altitude of 400 feet is an important milestone. It sets the lowest limit for changing the flight director pitch and roll modes and engaging the autopilot. The radio altitude of 800 feet is another milestone which sets the limit for thrust reduction. Now let's review operation of autoflight system during climb out.

311-At 400 feet radio altitude, the master flight director indicator light, extinguishes. It was the second one turned on.

312-The roll command continues to hold the wings level and the roll annunciation is blank. The pitch annunciation is still shows TO/GA. The flight director stays as the active autopilot status until the pilot engages the autopilot.

313-When the radio altitude is more than 400 feet, you can engage a roll mode without a change in the pitch mode.

314-Above 800 ft. AGL, the autothrottle mode changes from throttle hold to ARM.

315-You can now push the N1 switch to reduce the thrust. The FMA annunciates N1 as autothrottle mode. The thrust mode display indicates CLB and N1 reference cursors show FMC climb N1 limit.

316-In some airplanes, thrust reduction to climb power occurs automatically upon engagement of vertical navigation, altitude acquire or altitude hold mode.

317-In other airplanes, automatic reduction to climb thrust occurs when the airplane reaches thrust the reduction altitude which is selected on the FMC CDU TAKEOFF REF page 2/2 during preflight, or when the airplane levels off in altitude hold or vertical navigation path.

318-When the radio altitude is more than 400 feet, you can also engage the autopilot in command mode.

319-When you engage the autopilot in command, CMD annunciation replaces FD in the autopilot status display.

320-The pitch mode changes to level change, if another pitch mode has not been selected. The FMA shows MCP speed as the pitch mode.

321-The MCP indicated airspeed/Mach window and the airspeed cursor changes to  $V_2 + 20$  knots.

322-The roll mode changes to heading select if another roll mode has not been selected.

323-A radio altitude of 400 ft. also sets a boundary for the methods used to terminate the takeoff mode.

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324-Below 400 feet radio altitude, the takeoff mode is terminated by turning off both flight director switches.

325-Above 400 feet RA, the selection of another pitch mode or engaging an autopilot will terminate the takeoff mode.

### **AUTOMATIC FLIGHT TAKEOFF WITH LNAV SELECTED**

326-AUTOMATIC FLIGHT TAKEOFF WITH LNAV SELECTED You can select lateral navigation as the flight director roll mode during takeoff. With both flight directors on, push the lateral navigation switch to arm the lateral navigation mode before pushing the TO/GA switch. Lateral navigation switch light illuminates and the LNAV armed annunciation shows in the FMA roll mode.

327-When you push a TO/GA switch, the light on the lateral navigation switch goes out. This means that you cannot deselect the lateral navigation mode. The FMA pitch mode shows TO/GA. The autothrottle annunciation changes from ARM to N1. The roll mode still shows LNAV as armed.

328-The roll mode keeps the wings level until the airplane reaches 50 feet above ground level. At 50 feet above ground level, lateral navigation engages automatically.

329-When the airplane reaches 400 feet above ground level, the light on the lateral navigation switch comes back on. You can now deselect lateral navigation if needed.

330-If you engage the autopilot in the command mode, the pitch mode shifts to level change. The FMA shows MCP speed as a pitch mode. The roll mode stays in lateral navigation.

### **AUTOMATIC FLIGHT APPROACH AND LANDING**

331-AUTOMATIC FLIGHT APPROACH AND LANDING Let's review a few basics before discussing the automatic flight approach and landing, to have a better understanding on the subject.

332-Automatic flight systems can be divided into two groups: fail-passive autoflight systems and fail- operational autoflight systems.

333-An automatic flight system is fail-passive if in the event of a failure, there is no significant deviation of airplane flight path or attitude; but the landing is not completed automatically. After failure, the pilot must assume control of airplane and either manually fly the landing or go around. A fail- passive autoflight system requires two autopilots for operation.

334-An automatic flight system is fail-operational if in the event of a failure below alert height, the approach, flare and landing, can still be completed automatically. After failure, the automatic flight system downgrades to fail-passive system.

335-A typical fail-operational autoflight system consists of three autopilots. However, in Boeing airplanes, fail-operational capability is provided by two autopilots and an Integrated Standby Flight Display (ISFD). The ISFD sends inertial data to flight control computers and provides the redundancy that a 3rd autopilot would normally provide.

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336-There are B737 models which are fitted with a fail-passive autoflight system. Some other models are equipped with fail-operational autoflight system. They are usually called autoland systems. There are slight differences between two configurations in execution of the rollout and indications in the cockpit.

337-In airplanes with fail-passive capability, the automatic flight system provides fail-passive operation through landing flare and touchdown or an automatic go-around.

338-In airplanes with fail-operational capability, an automatic flight system provides either fail-operational or fail-passive operation through landing flare, touchdown and rollout, or through an automatic go-around.

339-The FMA annunciates LAND3 when the system is at the fail-operational level and operating normally for an automatic landing and rollout. You will see LAND 2 annunciation when the system is downgraded to fail-passive operation due to a failure which has occurred above alert height; however, the autoland system is still capable of performing an automatic landing and rollout. NO AUTOLAND in amber appears when the system is unable to make an automatic landing.

340-When the system is downgraded to fail-passive operation, a NO LAND 3 advisory message is displayed on the Upper Engine Display. The display shows a NO AUTOLAND message when the system is not capable of making an automatic landing. Now let's go back to the operation of autoflight approach mode.

341-The approach mode is the only mode where both autopilots can be engaged at the same time.

342-The approach mode is activated via the approach switch on the MCP. The switch lets you arm the autopilot flight director system to capture and track localizer and glideslope.

343-In the approach sequence, the autopilot first captures the localizer and then the glideslope. The localizer can be intercepted in heading select, lateral navigation or control wheel steering roll mode.

344-The approach mode can be engaged for dual or single autopilot operation, which are usually known as single channel autopilot approach and dual channel autopilot approach. The autoflight system also provides guidance for a go-around and controls automatic landings.

345-Some airplanes also have an Integrated Approach Navigation (IAN) capability which allows the use of ILS-like pilot procedures and display features. Let's start with dual channel autopilot approach.

## Dual channel a/p approach

346-DUAL CHANNEL A/P APPROACH The dual channel autopilot approach, or dual autopilot approach, is a must for fail-operational and/or fail-passive operation.

347-For a dual autopilot approach there are two ground rules: both VHF navigation receivers must be tuned to the ILS frequency and both autopilots must be selected in command before 800 feet RA.

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348-To execute a dual autopilot approach, first, tune both VHF NAV receivers to the ILS frequency and then set the inbound course on the MCP.

349-When the airplane is on a localizer intercept heading, push the approach switch. The switch light illuminates. The FMA annunciates VOR/LOC armed in the roll window and G/S armed in pitch window.

350-Then push the command switch on the second autopilot before 800 feet above ground level. This arms the second autopilot for automatic engagement after localizer and glideslope are captured, and when a descent below 1500 radio altitude takes place.

351-When the airplane captures the localizer course, the FMA active roll mode changes to VOR/LOC. SINGLE CHANNEL or 1 CHANNEL is annunciated in amber for the autopilot status, which means that only one autopilot is engaged. The airplane turns to follow the localizer track. Now you set the heading to match the localizer course.

352-The glideslope can be captured from above or below. When the airplane captures the glide slope, the previous pitch mode disengages and the FMA shows G/S in green letters as active pitch mode. The approach switch light goes out, provided that the localizer has also been captured. This means that you cannot deselect the approach mode by pushing the approach switch. The airplane pitch tracks the glideslope and the thrust mode display shows go-around as the active N1 thrust limit.

353-We will discuss the rest of the approach sequence for fail-passive and fail-operational airplanes separately. In fail-passive B737-800 models, with the localizer and glideslope captured, the second autopilot engages when the airplane is below 1500 feet radio altitude. After pitch monitor confidence test is successfully completed, the SINGLE CHANNEL or 1 CHANNEL annunciation is removed. FLARE armed is annunciated in the pitch window of the FMA. The autopilot go-around mode arms but is not annunciated.

354-At 800 feet radio altitude, make sure that the second autopilot has been selected for dual autopilot approach. You cannot engage the second autopilot in command below 800 feet radio altitude.

355-At 400 feet radio altitude, autopilots automatically increase the amount of stabilizer nose up trim. If the autopilots subsequently disengage, you must hold forward control wheel force to maintain the desired pitch attitude.

356-If the FLARE indication does not show armed before the airplane reaches a radio altitude of 350 feet, both autopilots will automatically disengage.

357-The flare mode controls the airplane to a smooth touchdown at a point past the glideslope antenna. At approximately 50 feet radio altitude, the autopilots start the flare maneuver to touchdown. The FMA annunciates FLARE as the active pitch mode and flight director command bars are removed.

358-During the flare, at approximately 27 feet radio altitude, the autothrottle begins retarding thrust to idle for



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touchdown. On the FMA, the autothrottle mode changes from MCP speed to RETARD and autothrottle mode light on the MCP extinguishes.

359-The autothrottle automatically disengages two seconds after touchdown. There are no visual or aural warnings when the autothrottle disengages during a normal landing.

360-The autopilot must be manually disengaged after touchdown. The landing rollout is carried out manually after disengaging the autopilot.

361-In fail-operational airplanes, with the localizer and glideslope captured, the second autopilot engages when the airplane is below 1500 feet radio altitude. After the pitch monitor confidence test is successfully completed, the SINGLE CHANNEL or 1 CHANNEL annunciation changes to LAND 3. The FLARE armed is annunciated in the pitch window and the ROLLOUT armed is annunciated in the roll window of the FMA. The autopilot go-around mode arms but is not annunciated.

362-At 800 feet radio altitude, make sure that the second autopilot has been selected for dual autopilot approach. You cannot engage the second autopilot in command mode below 800 feet radio altitude.

363-At 500 feet radio altitude, check for the presence of LAND 3 or LAND 2 annunciation to ensure that you can continue the autoland. If the second autopilot, in CMD mode, remains armed and does not engage, instead of LAND 2 or LAND 3, the amber NO AUTOLAND annunciation will appear to alert you that dual autopilot control has not been established and the autoland is to be terminated.

364-At 450 feet radio altitude, the autoland system goes into the alignment mode. This mode is not annunciated and provides rudder compensation for two purposes. First, to reduce large crab angles that result from crosswinds, and second, to control the adverse moments caused by an engine failure.

365-At 400 feet radio altitude, autopilots automatically increase the amount of stabilizer nose up trim. If the autopilots subsequently disengage, you must hold forward control wheel force to maintain the desired pitch attitude.

366-If FLARE does not show armed before the airplane reaches a radio altitude of 350 feet, both autopilots automatically disengage.

367-At approximately 50 feet radio altitude, the autopilots start the flare maneuver to touchdown. The FMA annunciates FLARE as the active pitch mode and flight director command bars are centered.

368-During flare, at approximately 27 feet radio altitude, the autothrottle begins retarding thrust to idle at touchdown. On the FMA, the autothrottle mode changes from MCP speed to RETARD and autothrottle mode light on the MCP extinguishes.

369-The autothrottle automatically disengages two seconds after touchdown. There are no visual or aural warnings when

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the autothrottle disengages during a normal landing.

370-At approximately two feet radio altitude, rollout mode activates. The FMA displays ROLLOUT as the active roll mode. The autopilots control the rudder and nose wheel steering to keep the airplane on the localizer centerline.

371-Rollout guidance ends when the airplane comes to a full stop or when the autopilots are disengaged.

### Single channel a/p approach

372-SINGLE CHANNEL A/P APPROACH The single channel autopilot approach is executed with only one autopilot engaged in command. Single autopilot approach operation is the same as dual, with a few exceptions.

373-The second autopilot is not engaged after approach mode is selected.

374-The FMA shows SINGLE CHANNEL or 1 CHANNEL as the autopilot status mode for the entire approach after localizer is captured.

375-The FLARE indication is not annunciated and the full automatic flare and touchdown capability is not available.

376-An autopilot go-around is not available.

### Integrated approach navigation (ian)

377-INTEGRATED APPROACH NAVIGATION (IAN) IAN (Integrated Approach Navigation) is a Cat I only approach system and allows the pilot to fly the approach like an ILS.

378-IAN approaches may be flown with or without the autopilot. At or above minimums, you are expected to disengage the autopilot and manually complete the flare and touchdown.

379-If the autopilot remains engaged below 100 feet radio altitude with either roll or pitch mode engaged, an aural alert is annunciated over the flight deck speaker and an amber AUTOPILOT flashes on the FMA.

380-You can activate IAN by pushing the approach switch on the MCP, but to initiate a FMC IAN approach, you must select the type of the approach on the FMC CDU, before you push the approach switch.

381-When the approach switch is selected, the final approach course (FAC) armed is annunciated in the roll window and the glidepath armed is annunciated in the pitch window.

382-Upon capture of the final approach course, the FMA active roll mode changes to FAC. SINGLE CHANNEL in green is annunciated for autoflight status. The airplane turns to track the final approach course. Now you set the heading to match the final approach course.

383-When the airplane captures the glide path, previous pitch mode disengages and the FMA shows G/P in green letters

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as the active pitch mode. The airplane pitch tracks the glide path and thrust mode display shows go-around as the active N1 thrust limit.

384-Below 2000 feet radio altitude, the autopilot go-around mode arms but is not annunciated.

385-At minimum descent altitude or decision altitude, you must disengage autopilot and autothrottle. The autothrottle status window blanks and autopilot annunciation changes to FD.

386-At 50 feet radio altitude, the flight director command bars are removed. The flare and touchdown are executed manually.

387-Other types of IAN approaches are also available. Depending on the type of approach, the FMA will display different annunciations.

388-If you are executing an ILS approach, the FMA will annunciate VOR/LOC and G/S for roll and pitch modes respectively.

389-For an ILS approach with glide slope selected off or a localizer only approach, you will see VOR/LOC and G/P annunciations as the roll and pitch modes respectively.

390-For a back course localizer approach, the FMA shows B/CRS as the roll mode and G/P as the pitch mode.

### ABNORMAL CONDITIONS DURING APPROACH

391-ABNORMAL CONDITIONS DURING APPROACH Here, we will discuss how autoflight system behaves in two abnormal conditions during the approach: beam anomaly or ground station failure, and single engine failure.

392-BEAM ANOMALY/GROUND STATION FAILURE During a single channel or flight director only approach, if a persistent ILS beam anomaly or ground station failure is detected, the autopilot will disconnect and/or the flight director bars will be removed.

393-In airplanes with fail-operational system, while in a dual channel approach, if a beam anomaly is detected prior to annunciation of LAND 3 or LAND 2, the autopilots will disconnect and/or the flight director bars will be removed.

394-If a beam anomaly or ground station failure is detected after annunciation of LAND 3 or LAND 2, the appropriate localizer or glideslope deviation scale turns amber and flashes, the respective deviation pointer flashes, and a horizontal amber line is drawn through the appropriate roll (VOR/LOC) or pitch (G/S) mode on the FMA. The autopilots remain engaged until manually disconnected.

### Single engine failure

395-SINGLE ENGINE FAILURE In case an engine failure during approach, if the APU is not used to supply a second electrical source, NO AUTOLAND is annunciated and autoland with rollout is not available.

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396-In the event of an engine failure, if the APU is used to provide a second electrical source before the engagement of the second autopilot, LAND 3 will be annunciated but you may fly a fail-passive autoland with rollout, observing the fail-passive minimums.

### AUTOMATIC FLIGHT GO-AROUND

397-AUTOMATIC FLIGHT GO-AROUND You can use go-around mode to cancel an approach.

398-When descending below 2000 ft. radio altitude, the autothrottle arms for go-around regardless of autopilot flight director system engagement.

399-In some models, the autothrottle arms for go-around above 2000 ft. radio altitude when the flaps are not up or when glide slope is captured.

400-With the autothrottle armed for go-around, if you push a TO/GA switch the go-around mode engages.

401-Go-around can be executed either with autopilots or manually with flight director. Let's start with the autopilot go-around.

#### A/p go-around

402-A/P GO-AROUND For an autopilot go-around there are two pre-conditions: both autopilots must be engaged in command mode and the FLARE mode must be armed or active.

403-With your first push of a TO/GA switch the following take place in the thrust side: the autothrottle moves the thrust levers forward and the engine thrust increases for reduced thrust go-around N1 which produces 1000 to 2000 fpm rate of climb, the speed switch light goes off on the MCP and the FMA autothrottle mode annunciates go-around.

404-The pitch mode engages in TO/GA and TO/GA shows on the FMA as the active mode for the pitch mode. The flight director pitch command shows initially 15 degrees nose up until reaching the programmed rate of climb. Then it changes to hold mode, a target speed that is referenced to the flap settings.

405-The flight director roll commands hold the current ground track. The roll mode annunciation is blank.

406-The indicated air speed/Mach display is blank. The airspeed cursor indicates the maneuvering speed for the existing flap position. As you retract the flaps, the airspeed cursor move to the maneuvering speed for the new flap position and the airplane accelerates to the new target speed as the flaps are retracted.

407-In airplanes equipped with the fail-operational system, and with LAND 3 or LAND 2 annunciated, pushing the TO/GA switch after touchdown or activating the manual electric trim will be ignored by both autopilots, both flight directors, and the autothrottle system. This makes sure that an inadvertent push of the TO/GA switch does not affect rollout.

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408-After the autothrottle reaches reduced go-around thrust, you can push the TO/GA switch again. The autothrottle moves the thrust levers to the full go-around N1 limit. The autothrottle mode changes from go-around to N1 on the FMA. Now let's see how you can exit from an autopilot go-around.

409-Below 400 feet RA, both autopilots and flight directors must be disengaged to exit from an autopilot go-around.

410-Above 400 feet RA, you can select a different pitch or roll mode to exit from the go around; or you can fly with go-around up to the missed approach altitude, then exit from a go-around.

411-If you select a roll mode, say heading select, above 400 ft. radio altitude, the selected mode engages in single channel autopilot roll operation and is controlled only by the first autopilot which was turned on. However, pitch is still controlled by both autopilots in TO/GA.

412-Exiting from a go-around by selecting a pitch mode is difficult. First, you cannot select control wheel steering pitch to exit from go-around.

413-Second, the selected pitch mode does not engage until the trim conditions change so that the single A/P can supply enough elevator control for required nose-down trim.

414-With the trim conditions satisfied, the selected pitch mode engages in single autopilot operation and is controlled by the first autopilot which was turned on; the second autopilot disengages, the roll mode engages in control wheel steering roll, and the autothrottle mode changes to MCP speed.

415-If you keep the autoflight system in go-around close to the missed approach altitude selected on the MCP, the altitude acquire mode engages when approaching the selected altitude. The autothrottle now starts to control speed and changes to MCP speed mode.

416-When the airplane levels off at the MCP altitude, the second autopilot that was turned on disengages. The MCP indicated airspeed/MACH display shows the present speed. The pitch mode changes to ALTITUDE HOLD and the control wheel steering roll shows as the roll mode on the FMA. The autopilot stays in control wheel steering roll mode until you select another roll mode.

417-Note that, if the single autopilot does not have enough elevator control, the altitude acquire mode is inhibited. The red autopilot warning light comes on steady red. To extinguish autopilot warning lights, disengage autopilots or select higher altitude on MCP.

### **F/d go-around**

418-F/D GO-AROUND You can execute a manual flight director go-around when both autopilots are not operating.

419-Or when the airplane enters windshear conditions while landing.

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420-You can use the flight director go-around when you are below 2000 ft. radio altitude.

421-In some airplanes, the flight director go-around mode can be engaged above 2000 feet of radio altitude if the flaps are down or if the glide slope is captured.

422-To engage the flight director go-around, you push a TO/GA switch. The autopilot, if engaged, disengages. Then the flight director go-around operation is the same as an A/P go-around except that you must control pitch and roll by following the flight director command bars that show target pitch and roll attitudes to maintain track and flap maneuvering speed.

423-Note that if you start a flight director go-around below 2000 feet radio altitude, the flight director command bars automatically appear on the attitude indicators even if the flight director switches are off. As you remember, this is called the pop up mode.

424-To exit from a flight director go-around below 400 feet RA, both flight directors switches must be turned off.

425-Above 400 feet RA, you can select another pitch or roll mode to exit from the flight director go-around.

426-If you change the roll mode first, the flight director roll engages in the selected mode and the pitch mode remains in TO/GA.

427-If you change the pitch mode first, the flight director pitch engages in the selected mode and the roll mode will engage in heading select.

428-If you engage an autopilot during a flight director go-around, the pitch mode engages in level change and the roll mode engages in heading select if another roll mode was not engaged first.

429-If you need to execute a single engine flight director go-around, push either TO/GA switch.

430-The flight director roll command holds the current ground track. The roll mode annunciation is blank.

431-The pitch mode engages in TO/GA and TO/GA shows on the FMA as the active mode for the pitch mode. The flight director pitch command is initially 13 degrees nose up. As the climb rate increases it changes to hold a target speed.

432-The flight director target speed is displayed on indicated air speed/Mach display and on the airspeed cursor.

433-If engine failure occurs prior to the go-around engagement, the flight director target speed is the selected MCP speed.

434-If engine failure occurs after go-around engagement, then the flight director target speed is calculated based on time elapsed since go-around engagement.

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**Go-around roll mode with LNAV**

435-GO-AROUND ROLL MODE WITH LNAV While in an autoland operation with FLARE arm or FLARE engage displayed and LNAV arm annunciated on the FMA, when you push a TO/GA switch above 400 feet radio altitude, lateral navigation will engage as the roll mode.

436-If you push a TO/GA switch below 400 feet radio altitude, lateral navigation does not engage. The roll mode will be track hold.

437-Now you are executing a flight director approach and FLARE is not armed or engaged and LNAV arm is annunciated on the FMA, if you push a TO/GA switch above 50 feet radio altitude, the flight director lateral navigation will engage as the roll mode.

438-If you push a TO/GA switch below 50 feet radio altitude, lateral navigation does not engage. The roll mode will be track hold.

439-In fail-operational airplanes, during an autoland operation with LAND 2 or LAND 3 displayed and LNAV arm annunciated on the FMA, when you push a TO/GA switch above 400 feet radio altitude with both engines operating, lateral navigation will engage as the roll mode.

440-If you push a TO/GA switch below 400 feet radio altitude, lateral navigation does not engage. The roll mode will be track hold.

441-Now you are executing a flight director approach. LAND2 or LAND3 is not displayed and LNAV arm is annunciated on the FMA. If you push a TO/GA switch above 50 feet radio altitude, the flight director lateral navigation will engage as the roll mode.

442-If you push a TO/GA switch below 50 feet radio altitude, lateral navigation does not engage. The roll mode will be track hold.

**AUTOMATIC FLIGHT SYSTEM OPERATION IN WINDSHEAR**

443-AUTOMATIC FLIGHT SYSTEM OPERATION IN WINDSHEAR Windshear is a sudden change of wind speed and/or direction along the flight path.

444-The autopilot counteracts most wind shears. The flight director system provides windshear recovery guidance. The autothrottle system also helps in windshear recovery by providing quick response to any change in speed.

445-When windshear is encountered during flight director takeoff or go-around, the flight director pitch command provides you with guidance for windshear recovery.

446-Initial flight director pitch command is aimed to maintain the target speed. When the vertical speed decreases to

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approximately +600 fpm, the flight director pitch bar shows a 15-degree nose-up pitch attitude.

447-If vertical speed continues to decrease, the flight director pitch command stays at a 15-degree pitch attitude until the speed drops to approximately stick shaker limit.

448-The flight director then commands pitch attitudes which result in intermittent activation of the stick shaker.

449-As the airplane transits the windshear condition, the flight director operates in reverse. As the vertical speed increases above + 600 fpm, the flight director commands pitch attitudes to accelerate the airplane back to the target speed.

450-If windshear is encountered during an ILS approach, both the F/D and A/P attempt to keep the airplane on altitude, or on glideslope after glideslope capture, regardless of angle of attack or stick shaker limitations. You should take control by pushing the TO/GA switch or disconnecting the autopilot and flying manually, before airspeed decreases below stick shaker and into a stall.

451-Severe windshear may exceed the performance capability of the autoflight system and/or the airplane. In this situation, you must, if necessary to avoid ground contact, be prepared to disconnect the autothrottle, advance the thrust levers to the forward stop, disconnect the autopilot and manually fly the airplane.

#### **PART 4-AUTOFLIGHT NON-NORMAL OPERATION**

452-PART 4-AUTOFLIGHT NON-NORMAL OPERATION These are the autoflight non-normal conditions: Autopilot disengage autothrottle disconnect autoland unavailable and autoland degradation.

453-When all autopilots are disengaged, the red autopilot light flashes and the aural tone sounds. You should fly the airplane manually or re-engage an autopilot.

454-When the autothrottle is disconnected, the red autothrottle light flashes. You should control thrust manually or re-engage the autothrottle.

455-If autoland system is not available due to multiple faults, NO AUTOLAND annunciation appears on primary flight display. In addition, NO AUTOLAND advisory message is displayed on the upper display unit.

456-When a fault causes the autoland system to downgrade from LAND 3 to LAND 2 status LAND 2 annunciation appears on primary flight display. In addition, NO LAND 3 advisory message is displayed on the upper display unit.

#### **COURSE END**

457-End of course.