

## AUTOMATIC FLIGHT

### 1. GENERAL

- ✈ The Automatic Flight System (AFS) consists of the Autopilot Flight Director System (AFDS) and the Autothrottle (A/T).
- ✈ The Flight Management Computer (FMC) provides N1 limits and target N1 for the A/T and command airspeeds for the A/T and AFDS.
- ✈ The AFDS and A/T are operated from the AFDS Mode Control Panel (MCP) and the FMC from the Control Display Unit (CDU) or Multi-function Control Display Unit (MCDU).
- ✈ The AFDS MCP provides coordinated control of the autopilot (A/P), Flight Director (F/D), A/T and altitude alert functions.
- ✈ AFS mode status is displayed on the Flight Mode Annunciators on each pilot's 737-Classics ADI or 737 NGs Primary Flight Display (PFD).
- ✈ Normally, the AFDS and A/T are used to maintain airspeed and/or thrust setting calculated by the FMC.

### 2. AUTOPILOT FLIGHT DIRECTOR SYSTEM (AFDS)

#### General

- ✈ The AFDS is a dual system consisting of two individual Flight Control Computers (FCCs) and a single Mode Control Panel (MCP).
- ✈ The 2 FCCs are identified as A and B. For autopilot (A/P) operation, they send control commands to their respective pitch and roll hydraulic servos, which operate the flight controls through 2 separate hydraulic systems.
- ✈ For F/D operation, each FCC positions the F/D command bars on the respective ADI or PFD.

#### MCP Mode Selector P/Bs

- ✈ The Mode Selector Push Buttons (P/Bs) are pressed to select desired command modes for the AFDS and A/T.
- ✈ The letters ON, or two green lights, illuminate to indicate mode selection and that the mode can be deselected by pressing the P/B again. While a mode is active, deselection can be automatically inhibited and is indicated by the P/B light being extinguished (e.g. ALT HOLD at the MCP altitude).
- ✈ When engagement of a mode would conflict with current AFS operation, pressing the Mode Selector P/B has no effect. All AFDS modes can be disengaged by selecting another command mode or by disengaging the A/P and turning the F/D switches OFF.

### MCP Parameter Selections

- ✈ The following information is in addition to that contained in the controls and indicators section of this chapter.
- ✈ Parameter selections common to both FCCs for speed, heading, altitude and vertical speed are made from the MCP.
- ✈ Two course selectors and course displays are located on the MCP. The Captain's Course Selector provides selected course information to the A FCC, the no. 1 VHF NAV receiver and to the Captain's HSI or Navigation Display (ND) Course Pointer and course deviation bar. The First Officer's Course Selector provides selected course information to the B FCC, the no. 2 VHF NAV receiver and to the First Officer's HSI, or ND, course pointer and deviation bar.
- ✈ While in the VOR LOC or APP mode, the A FCC (A A/P and Captain's F/D), uses the selected course and NAV data from the no. 1 VHF NAV receiver. The B FCC (B A/P and First Officer's F/D), uses the selected course and VHF NAV frequency set on the no. 2 VHF NAV receiver.
- ✈ Different courses and frequencies can be selected for the two VHF NAV receivers at any given time. This can cause disagreement between the Captain's and First Officer's F/D Command Bar displays and affect A/P operation.

### Unselected MCP Altitude Change

- ✈ The FCCs issue a warning when the MCP displayed altitude changes without altitude selector movement or when the MCP altitude disagrees with the active altitude stored in the FCCs.
- ✈ The warning consists of the following three items:
  - Intermittent altitude alert tone.
  - Flashing altitude alert lights.
  - MCP displays 50 000 ft.
- ✈ The warning continues until reset by rotating the MCP altitude selector or on ground with airspeed less than 60 kt.
- ✈ During the warning with 50 000 ft displayed on the MCP, the FCCs reference their last stored altitude, not the displayed 50 000 ft.
- ✈ When the warning is reset by rotating the altitude selector, the direction of rotation and number of detents are applied to the FCC stored altitude. This altitude value then replaces the 50 000 ft displayed on the MCP and becomes the new active altitude.

## 3. AFS ELECTRICAL POWER & RADIO ALTITUDE LOSS

### AFS Power interruption Loss

- ✈ Power interruption or loss may cause disengagement of the AFDS and/or the A/T. Re-engagement is possible after power is restored.
- ✈ Dual channel A/P operation is possible only when 2 generators are powering the busses.

### AFS Radio Altitude Loss

- ✈ Two independent radio altimeters provide radio altitude to the respective FCC. The Captain's radio altimeter provides radio altitude to the A/T.

## 4. AUTOPILOT ENGAGEMENT CRITERIA

- ✈ Each A/P is engaged with a separate engage paddle or P/B, depending on the type of MCP installed. Either A/P can be in one of three states :
  - OFF: paddle in OFF, or lights in CWS and CMD P/B extinguished.
  - CWS : paddle in CWS, or lights in CWS P/B illuminated.
  - CMD : paddle in CMD, or lights in CMD P/B illuminated.
- ✈ The A/P cannot be engaged unless both of the following conditions are met :
  - No force is applied to the control wheel or column.
  - The Stabilizer Trim Autopilot Cutout Switch is at NORMAL.
- ✈ Once these engage criteria are satisfied and no system failures exist, either A/P can be engaged to CWS or CMD. Control pressure applied now, with the A/P engaged in CMD overrides pitch and/or roll into CWS while the A/P remains in CMD.
- ✈ The F/D Command Bars may retract from view upon initial A/P engagement in CMD. This occurs when the F/D pitch or roll commands are not approximately centered at the time of engagement. Additionally, the engaged A/P changes modes to CWS for pitch and/or roll.
- ✈ Engaging a second A/P in either CWS or CMD during single channel A/P operation, disengages the first A/P. However, both A/Ps remain engaged in CMD if the first and second A/P are engaged after the approach (APP) mode has been selected and both VHF receivers are tuned to a valid ILS frequency.
- ✈ The A/P automatically disengages when any of the following occur :
  - Pressing either A/P Disengage P/B.
  - Pressing either Take-off/Go-around P/B with a single A/P engaged in CWS or CMD < 2000 ft RA.
  - Pressing either Take-off/Go-around P/B after touchdown with both A/Ps engaged in CMD.
  - Moving the A/P Engage Paddle to OFF, pressing illuminated CMD P/B or moving the A/P disengage bar to disengage.
  - Activating either pilot's control wheel Trim Switch.
  - Moving the Stabilizer Trim Autopilot Cutout Switch to CUTOOUT.
  - Loss of respective hydraulic system pressure.
  - Either Left or Right IRS system failure or FAULT Light illuminated.
  - Loss of electrical power or power change or a sensor input which prevents proper operation of the engaged A/P and mode.

## 5. AUTOPILOT CONTROL WHEEL STEERING

### Engage Paddle in CWS or CWS P/B illuminated

- ✈ Placing an engage paddle in the CWS position, or pressing the CWS P/B, engages the A/P pitch and roll axes in the CWS mode and displays CWS P and CWS R on the FMAs.
- ✈ With CWS engaged, the A/P maneuvers the aircraft in response to control pressures applied to the control wheel or column. The control pressure is similar to that required for manual flight. When control pressure is released, the A/P holds existing attitude.

- ✈ If column pressure is released with bank angle 6 degrees or less, the A/P rolls the wings level and holds existing heading. This feature is inhibited when any of the following conditions exist:
  - Below 150 ft RA with the landing gear down.
  - After F/D VOR capture with TAS 250 kt or less.
  - After F/D LOC capture in the APP mode.

#### **Pitch CWS with Engage Paddle in CMD, or CMD P/B illuminated**

- ✈ The pitch axis engages in CWS while the roll axis is in CMD when:
  - A command pitch mode has not been selected or was deselected.
  - A/P pitch has been manually overridden with control column force. The force required for override is greater than normal CWS control column force. This manual pitch override is inhibited in the APP mode with both A/Ps engaged.
- ✈ CWS P is annunciated on the Flight Mode Annunciators while this mode is engaged. Command pitch modes can then be selected.
- ✈ When approaching a selected altitude in CWS P with the A/P in CMD, CWS P changes to ALT ACQ and, when at the selected altitude, ALT HOLD engages.
- ✈ If pitch is manually overridden while in ALT HOLD at the selected altitude, ALT HOLD changes to CWS R. If control force is released within 250 ft of the selected altitude, CWS P changes to ALT ACQ and the A/P returns to the selected altitude and ALT HOLD engages. If the elevator force is held until more than 250 ft from the selected altitude, pitch remains in CWS PITCH.

#### **Roll CWS with Engage Paddle in CMD or CMD P/B illuminated**

- ✈ The roll axis engages in CWS while the pitch axis is in CMD when:
  - A command roll mode has not been selected or was deselected.
  - A/P roll has been manually overridden with control wheel force. The force required for override is greater than the normal CWS control wheel force.
- ✈ CWS R is annunciated on the Flight Mode Annunciators while this mode is engaged. Command roll modes can then be selected.
- ✈ CWS R with an A/P engaged in CMD can be used to capture a selected radio course while the VOR/LOC or APP mode is armed. Upon intercepting the radial or localizer, the F/D and A/P annunciation changes from CWS R to VOR/LOC engaged and the A/P tracks the selected course.

## **6. AUTOPILOT FLIGHT DIRECTOR SYSTEM (AFDS) COMMAND MODES**

- ✈ Command modes can be armed or engaged when an A/P is engaged in CMD and/or one or both F/D switches are ON.
- ✈ The Take-off mode is a F/D only mode. The automatic flare during the APP mode is a dual A/P only maneuver.

**Altitude Acquire Mode (ALT ACQ)**

- ✈ The ALT ACQ mode is the transition mode entered automatically from a V/S, LVL CHG or VNAV (intermediate level-off) mode to the ALT HOLD mode. The altitude acquire mode is also armed while climbing or descending in CWS P with an A/P Engage Paddle at CMD or CMD P/B illuminated.
- ✈ Altitude acquire engagement is annunciated ALT ACQ for pitch when leveling off in either V/S, LVL CHG or VNAV (intermediate level-off at the MCP altitude). However, VNAV remains annunciated throughout the altitude acquire mode when leveling off in VNAV at the FMC cruise altitude.
- ✈ ALT ACQ engagement is inhibited when the ALT HOLD switch is pressed or while the glide slope is captured.

**Altitude Hold Mode (ALT HOLD)**

- ✈ The ALT HOLD mode gives pitch commands to hold the MCP selected altitude or the altitude at which the ALT HOLD P/B was pressed. ALT HOLD engages in either of two conditions :
  - maintaining altitude at the MCP selected altitude. This is indicated by annunciation of ALT HOLD and the ALT HOLD P/B extinguished.
  - maintaining altitude not at the MCP selected altitude. This is indicated by the annunciation of ALT HOLD and the ALT HOLD P/B illuminated.
- ✈ ALT HOLD mode engagement, not at the MCP selected altitude, occurs with either of the following :
  - Pushing the ALT HOLD P/B while not at the selected altitude.
  - Selecting a new MCP altitude while in ALT HOLD at the selected altitude.
- ✈ ALT HOLD is inhibited after G/S capture.
- ✈ The altitude selected on the MCP is referenced to the Captain's barometric setting for the A/P A and F/D, and to the First Officer's barometric setting for the A/P B and F/D. After ALT HOLD engages, changes in barometric settings do not change the selected altitude reference.

**Vertical Speed Mode (V/S)**

- ✈ The V/S mode gives pitch commands to hold the selected vertical speed.
- ✈ The V/S mode has an armed and an engaged state.
- ✈ Pressing the V/S P/B engages the V/S mode, except when engaged in ALT HOLD at the MCP altitude or after glide slope capture. When WS mode is engaged, the Vertical Speed Display changes from blank to present vertical speed and desired vertical speeds can be selected with the VERT SPEED wheel.
- ✈ The V/S mode is armed when the ALT HOLD mode is engaged and a new MCP altitude is selected. When V/S armed is annunciated, the V/S mode can be engaged by moving the VERT SPEED wheel.
- ✈ The V/S mode automatically engages when the ALT ACQ mode is engaged and a new altitude is selected. The V/S mode engages and existing vertical speed appears in the Vertical Speed Display. When engaged in WS the commanded vertical speed can be changed with the VERT SPEED wheel. Vertical speeds can be selected which command flight toward or away from the selected altitude.

### Level Change Mode (LVL CHG)

- ✈ The LVL CHG mode co-ordinates pitch and thrust commands to make an automatic climb or descent to preselected altitude at selected airspeed. A LVL CHG climb or descent is initiated by selecting a new altitude and pressing the LVL CHG P/B.
- ✈ During a LVL CHG climb, the annunciations are MCP SPD for pitch and N1 for the A/T. During a LVL CHG descent, the annunciations are MCP SPD for pitch and RETARD for the A/T while reducing thrust toward idle. When at idle thrust, ARM is annunciated for the A/T.
- ✈ If a speed mode had been active prior to engaging LVL CHG, the selected speed is retained as the target speed for the LVL CHG mode. If LVL CHG is engaged with no active speed mode, the IAS/MACH Display and airspeed cursors synchronize to existing speed, which becomes the LVL CHG target speed. After LVL CHG mode engagement, the target speed can be changed with the MCP Speed Selector.

### Vertical Navigation Mode (VNAV)

- ✈ With the VNAV mode engaged, the FMC commands AFDS pitch and A/T modes to fly the vertical profile selected on the FMC Cuds. The profile includes preselected climb, cruise altitude, speed, descent and can also include altitude constraints at specified waypoints. The profile may end with an ILS approach to the destination airport.
- ✈ Pressing the VNAV switch selects the VNAV mode, provided FMC performance initialization is complete and other VNAV criteria are satisfied. The mode P/B illuminates, the MCP IAS/Mach Display becomes blank and the airspeed cursors are positioned at the FMC commanded airspeed. The FMA displays are VNAV SPD or VNAV PTH for the AFDS pitch mode and FMC SPD, N1, RETARD or ARM for the A/T mode.
- ✈ VNAV climb and descent are constrained by the selected MCP altitude. VNAV commanded speed can be changed via the CDUs.
- ✈ During VNAV cruise flight, selecting a lower MCP altitude arms the FMC to begin the descent automatically upon arrival at the FMC calculated top of descent point.
- ✈ During a VNAV path descent, VNAV remains engaged until :
  - Glide slope capture, or
  - Another pitch mode is selected, or
  - LNAV is disengaged outside RNP range without localizer capture.

### Lateral Navigation Mode (LNAV)

- ✈ In the LNAV mode, the FMC controls AFDS roll to intercept and track the active FMC route. The desired route is activated and modified through the CDUs. In addition to enroute guidance, the active route can include terminal procedures such as SIDS, STARs and instrument approaches.
- ✈ Engagement criteria must be met to use LNAV. There must be an active route in the FMC, capture criteria must be satisfied and the LNAV P/B pressed.
- ✈ LNAV capture criteria is divided into two categories. First, any heading satisfies capture criteria when within 3 NM of the active route segment. Second, outside of 3 NM, the aircraft must be on an intercept course of 90 degrees or less and intercept the route segment before the active waypoint.

- ✈ LNAV will automatically disconnect for several reasons. It will disconnect upon reaching the end of the active route or upon entering a route discontinuity. Additionally, it will disconnect upon either intercepting an approach path inbound. Finally, either loss of capture criteria (e.g. due to route modification), or selecting HDG SEL will disconnect LNAV.

### **Glide Slope Capture (GS)**

- ✈ Glide slope capture cannot occur prior to localizer capture.
- ✈ The G/S can be captured from above or below. Capture occurs at 2/5 dot. G/S annunciates captured, the previous pitch mode disengages, the APP P/B extinguishes, and the thrust mode annunciates GA.

### **After LOC and G/S Capture**

- ✈ After LOC and G/S capture, the APP mode can only be exited by pressing a TO/GA P/B or by disengaging the A/P and turning both F/D switches OFF or retuning a VHF NAV receiver.
- ✈ The A/P will not disengage for an invalid ILS signal when above 1500 ft RA. However, the F/D command bars retract to indicate the invalid signal.
- ✈ Shortly after capturing both LOC and G/S and below 1500 ft RA, the second A/P engages to the flight controls, FLARE armed is annunciates and the A/P go-around mode arms but is not annunciates.
- ✈ The pitch and roll axes cannot be manually overridden into CWS. Manual override of the autopilots will result in autopilot disengagement.

### **800 Feet Radio Altitude**

- ✈ The second A/P must be engaged in CMD prior to 800 ft RA to execute a dual channel A/P approach. Otherwise, CMD engagement of the second A/P is inhibited.

### **400 Feet Radio Altitude**

- ✈ During autoland at 400 ft RA the stabilizer is automatically trimmed aircraft nose up. If the A/Ps subsequently disengage, forward control column force may be required to hold the desired pitch attitude.
- ✈ If FLARE is not armed by approximately 350 ft RA, both A/Ps automatically disengage.

### **Flare**

- ✈ The A/P flare maneuver starts at approximately 50 ft RA and is completed at touchdown. FLARE engaged is annunciates and the F/D command bars retract.
- ✈ 737-400/NGs: The stabilizer is again automatically trimmed an additional amount nose up at 50 ft RA.
- ✈ The A/T begins retarding thrust at approximately 27 ft RA so as to reach idle at touchdown. The A/T automatically disengages approximately 2 seconds after touchdown.
- ✈ The A/P must be manually disengaged after touchdown. There is no automatic roll out mode available.

### A/P Go-Around Mode

- ✈ The A/P go-around (GA) mode requires dual A/P operation and becomes armed when FLARE armed is annunciated. The A/P GA mode cannot be engaged before flare arm is annunciated or after touchdown.

*WARNING : If the GA mode is selected after touchdown and prior to A/T disengagement the A/Ps disengage and the A/T may command GA thrust*

- ✈ Pressing either TO/GA P/B engages the GA mode and GA engaged is annunciated for the AFDS. The MCP IAS/Mach Display becomes blank and the airspeed cursors are positioned at the AFDS commanded speed. Command airspeed is flap maneuvering speed.

### A/P Go-Around Pitch Control

- ✈ Upon GA engagement, the thrust levers advance toward the reduced go-around N1 (calculated by the A/T computer). Pressing either TO/GA P/B after reduced go-around N1 is attained advances the thrust levers further to full go-around N1 (calculated by the FMC).
- ✈ The A/P initially commands a 15 degree nose-up pitch attitude, and the airspeed cursors display maneuvering speed for the flap setting. When a programmed rate of climb is established, the A/P controls pitch to hold airspeed based on the normal flap maneuvering speed.

### A/P Go-Around Roll Control

- ✈ With the GA mode engaged, the A/Ps maintain the aircraft ground track existing at GA engagement.

### Leaving the GA Mode

- ✈ Below 400 ft RA, the A/Ps must be disengaged to change either pitch or roll modes from GA. Above 400 ft RA, other pitch and roll modes can be selected.
- ✈ If the roll mode is changed before the pitch mode, the selected mode engages in single A/P roll operation and is controlled by the A/P which was first in CMD. Pitch control remains in the dual A/P GA mode.
- ✈ If the pitch mode is changed before the roll mode, the selected pitch mode engages in single A/P operation and is controlled by the A/P which was first in CMD. The second A/P disengages, the roll mode changes to CWS R and both the A/T and thrust mode engage in compatible modes.
- ✈ The pitch mode cannot be changed from GA until sufficient nose-down trim has been input to allow single channel A/P operation. This nose-down trim is automatically added to reset the trim input at 400 ft, and 50 ft (737-400/-800/-900), radio altitude on the approach.
- ✈ With pitch engaged in GA, ALT ACQ engages when approaching the selected altitude and ALT HOLD engages at the selected altitude if the stabilizer position is satisfactory for single A/P operation.
- ✈ The transition from GA to ALT ACQ is normally successful if the selected altitude is at least 1000 ft above the GA engagement altitude. A higher selected altitude may be required if full GA thrust is used.



- ✈ If stabilizer trim is not satisfactory for single A/P operation, ALT ACQ is inhibited and the A/P disengage lights illuminate steady red and pitch remains in GA. To extinguish the A/P disengage lights, a higher altitude can be selected or the A/Ps disengaged.

### Approach Mode Single A/P (APP)

- ✈ A single A/P ILS approach can be executed by not engaging the second A/P in CMD after pressing the APP mode select switch. Single A/P approach operation is the same as dual, with the following exceptions :
  - A/P status of 1 CH is annunciated for the entire approach after localizer capture.
  - Full automatic flare and touchdown capability is not available. FLARE is not annunciated and stabilizer trim bias is not applied.
  - An A/P go-around is not available.

### Level Change Mode (LVL CHG)

- ✈ The LVL CHG mode co-ordinates pitch and thrust commands to make an automatic climb or descent to preselected altitude at selected airspeed. A LVL CHG climb or descent is initiated by selecting a new altitude and pressing the LVL CHG P/B.
- ✈ During a LVL CHG climb, the annunciations are MCP SPD for pitch and N1 for the A/T. During a LVL CHG descent, the annunciations are MCP SPD for pitch and RETARD for the A/T while reducing thrust toward idle. When at idle thrust, ARM is annunciated for the A/T.
- ✈ If a speed mode had been active prior to engaging LVL CHG, the selected speed is retained as the target speed for the LVL CHG mode. If LVL CHG is engaged with no active speed mode, the IAS/MACH Display and airspeed cursors synchronize to existing speed, which becomes the LVL CHG target speed. After LVL CHG mode engagement, the target speed can be changed with the MCP Speed Selector.

### Vertical Navigation Mode (VNAV)

- ✈ With the VNAV mode engaged, the FMC commands AFDS pitch and A/T modes to fly the vertical profile selected on the FMC CDUs. The profile includes preselected climb, cruise altitude, speed, descent and can also include altitude constraints at specified waypoints. The profile may end with an ILS approach to the destination airport.
- ✈ Pressing the VNAV switch selects the VNAV mode, provided FMC performance initialization is complete and other VNAV criteria are satisfied. The mode P/B illuminates, the MCP IAS/Mach Display becomes blank and the airspeed cursors are positioned at the FMC commanded airspeed. The FMA displays are VNAV SPD or VNAV PTH for the AFDS pitch mode and FMC SPD, N1, RETARD or ARM for the A/T mode.
- ✈ VNAV climb and descent are constrained by the selected MCP altitude. VNAV commanded speed can be changed via the CDUs.
- ✈ During VNAV cruise flight, selecting a lower MCP altitude arms the FMC to begin the descent automatically upon arrival at the FMC calculated top of descent point.
- ✈ During a VNAV path descent, VNAV remains engaged until :
  - Glide slope capture, or
  - Another pitch mode is selected, or
  - LNAV is disengaged outside RNP range without localizer capture.

### Lateral Navigation Mode (LNAV)

- ✈ In the LNAV mode, the FMC controls AFDS roll to intercept and track the active FMC route. The desired route is activated and modified through the CDUs. In addition to enroute guidance, the active route can include terminal procedures such as SIDs, STARs and instrument approaches.
- ✈ Engagement criteria must be met to use LNAV. There must be an active route in the FMC, capture criteria must be satisfied and the LNAV P/B pressed.
- ✈ LNAV capture criteria is divided into two categories. First, any heading satisfies capture criteria when within 3 NM of the active route segment. Second, outside of 3 NM, the aircraft must be on an intercept course of 90 degrees or less and intercept the route segment before the active waypoint.
- ✈ LNAV will automatically disconnect for several reasons. It will disconnect upon reaching the end of the active route or upon entering a route discontinuity. Additionally, it will disconnect upon either intercepting an approach path inbound. Finally, either loss of capture criteria (e.g. due to route modification), or selecting HDG SEL will disconnect LNAV.

### Heading Select Mode (HDG SEL)

- ✈ Pressing the HDG SEL P/B engages the heading select mode. HDG SEL is annunciated for the AFDS.
- ✈ The heading select mode sends roll commands to turn to and maintain the heading shown in the MCP Heading Display. When HDG SEL is engaged, roll commands are given to turn in the nearest direction to the selected heading. After HDG SEL engagement, roll commands are given to turn in the same direction as the rotation of the heading selector only.
- ✈ The bank angle limit is established by the Bank Angle Limit Selector on the MCP
- ✈ The HDG SEL mode automatically disengages upon capture of the selected radio course in the VOR LOC and APP modes.

### VOR/LOC Mode (VOR/LOC)

- ✈ The VOR mode gives roll commands to capture and track the selected VOR course. The bank angle limit is established by the Bank Angle Limit selector on the MCP.
- ✈ The LOC mode gives roll commands to capture and track the selected localizer along the inbound front course bearing. Back course tracking is not available.
- ✈ Pressing the VOR/LOC P/B selects the VOR mode if a VOR frequency is tuned or selects the LOC mode if a localizer frequency is tuned. The VOR/LOC P/B illuminates and VOR/LOC armed is annunciated. The selected course can be intercepted while engaged in L NAV, HDG SEL or CWS R with an A/P engaged in CMD. The capture point is variable and depends on intercept angle and closure rate. Localizer capture occurs not later than 1/2 dot deviation. When within the course capture area, the VOR/LOC annunciation changes from armed to captured and roll commands track the VOR or localizer course.
- ✈ When a localizer frequency is selected, the navigation radios automatically switch from the antenna in the tail to the antenna in the nose when VOR/LOC is annunciated (armed or engaged). If antenna switching does not occur, the localizer and approach modes are inhibited.

### Approach Mode Dual A/Ps (APP)

- ✈ The approach mode arms the AFDS to capture and track the localizer and glide slope. It can be engaged for dual or single A/P operation.
- ✈ Approach mode allows both A/Ps to be engaged at the same time. Dual A/P operation provides fail passive control through landing flare and touchdown or an automatic go-around. During fail passive operation, the flight controls respond to the A/P commanding the lesser control movement.
- ✈ The NAV receiver associated with the master FCC must be tuned to an ILS frequency before the approach mode can be selected. For a dual A/P approach, the second NAV receiver must be tuned to the ILS frequency and the corresponding A/P engaged in CMD prior to 800 ft RA.

### Localizer and Glide slope Armed

- ✈ After selecting the localizer frequency, course and pressing the APP P/B selects the APP mode. The APP P/B illuminates and VOR LOC and GS annunciate armed. The APP mode permits selecting the second A/P to CMD, which arms the second A/P for automatic engagement after LOC and GS capture and when descent below 1500 ft RA occurs.
- ✈ The localizer can be intercepted in the HDG SEL, CWS R or LNAV mode.

### Localizer Capture (LOC)

- ✈ The localizer capture point is variable and depends on intercept angle and rate of closure, but does not occur at less than 1/2 dot. Upon localizer capture, VOR LOC annunciates capture, 1 CH is annunciated for A/P status, the previous roll mode disengages and the aircraft turns to track the localizer.

## 7. FLIGHT DIRECTOR

- ✈ F/D commands operate in the same command modes as the A/P except :
  - The Take-off mode is a F/D only mode.
  - Dual F/D guidance is available for single engine operation.
  - The F/D has no landing flare capability.
  - F/D command bars retract from view at approximately 50 ft RA on an ILS approach.
- ✈ The two F/D switches on the MCP turn the F/Ds ON and OFF for each pilot. Turning a switch ON, displays command bars on the respective pilots ADI or PFD if command pitch and roll modes are engaged. If command pitch and roll modes are not engaged, the F/D command bars do not appear. The F/Ds can be operated with or without the A/P and A/T. F/D command modes can be used with an A/P engaged in CWS.
- ✈ The master FCC is indicated by illumination of the respective Master (MA) F/D Indicator Light. The master FCC is determined as follows :
  - With neither A/P engaged in CMD, the FCC for the first F/D turned on is the master.
  - With one or both A/Ps engaged in CMD, the FCC for the first A/P in CMD is the master FCC, regardless of which F/D is turned on first.

- ✈ Normally, FCC A drives the Captain's command bars and FCC B drives the First Officer's command bars. With both F/D switches ON, the logic for both pilot's F/D modes are controlled by the master FCC and both ADIs or PFDs show the same mode status. If both pilot's VHF NAV frequencies and/or courses have not been set the same, their F/D commands may not agree.
- ✈ F/D modes are controlled directly from the respective FCC under certain conditions. This independent F/D operation occurs when neither A/P is engaged in CMD, both F/D switches are ON and one of the following mode conditions exist :
  - APP mode engaged with LOC and G/S captured.
  - GA mode engaged and below 400 ft RA.
  - TO mode engaged and below 400 ft RA.
- ✈ Independent F/D operation is indicated by illumination of both MA lights. Capt and F/O pitch commands may differ by 2 to 3 degrees. When independent operation terminates, the MA light extinguishes on the slaved side.
- ✈ If an engine generator is lost during a F/D TO or GA, the FCC on the unaffected side positions the F/D command bars on both ADIs or PFDs. If the F/D MA light on the affected side had been illuminated, it extinguishes upon electrical bus transfer.

### **Flight Director Take-off Mode**

- ✈ The F/D take-off mode is engaged by pressing the TO/GA P/B on either thrust lever. The AFDS annunciation is TO/GA and HDG SEL.
- ✈ Initial F/D commands are 10 degrees nose-down pitch and HDG SEL for roll. At 60 kt IAS, the F/D pitch command changes to 15 degrees nose-up and roll remains HDG SEL mode.
- ✈ The F/D provides pitch commands after liftoff. It continues to command 15 degrees pitch until a sufficient climb rate is acquired. It then commands pitch to maintain the MCP speed plus 20 kt IAS; this speed is set during preflight. Next, when either A/P is engaged in CMD or when the MCP selector is rotated, 20 kt IAS is automatically added to the MCP display. Higher speeds may then be selected.
- ✈ The F/D roll mode is HDG SEL from take-off mode engagement through the take-off climb-out.
- ✈ To terminate the take-off mode below 400 ft RA, both F/D switches must be turned OFF.
- ✈ Above 400 ft RA, the take-off mode can be terminated by selecting other F/D pitch modes or by engaging an A/P in CMD.
- ✈ Engaging an A/P in CMD after a F/D take-off, automatically engages the A/P and F/Ds in LVL CHG for pitch and HDG SEL for roll. If the F/D roll mode had been previously changed from HDG SEL to LNAV or VOR LOC, the A/P initially engages in the same roll mode as the F/Ds. When LVL CHG engages, the MCP IAS/Mach Display and airspeed cursors change to  $V_2 + 20$  kt.
- ✈ If an engine fails during take-off before reaching  $V_2$  speed, F/D pitch commands are referenced to  $V_2$ . If engine failure occurs after reaching  $V_2$ , but less than  $V_2+20$ , the reference speed is the speed at engine failure. If engine failure occurs at or above  $V_2+20$ ,  $V_2+20$  is the commanded speed. Reference speed is never less than  $V_2$  for the current flap setting. Roll control remains the same as for two engines operating.

### Flight Director Go-Around Mode

- ✈ Several criteria must be met before the F/D can engage in the go-around mode.
  - In flight below 2000 ft RA and not in the take-off mode.
  - F/D switches ON or OFF.
  - One or neither AP engaged in CMD.
  - TO/GA P/B pressed.
- ✈ After engaging in GA, Command bars appear for both pilots, TO/GA is annunciated for the F/D pitch mode, the IAS/Mach Display blanks and the airspeed cursors display maneuvering speed for the existing flap setting.
- ✈ Below 400 ft RA, both F/D switches must be turned from ON to OFF to exit the F/D GA mode. Above 400 ft RA, other pitch and roll modes can be selected. If the roll mode is changed first, the F/D pitch mode remains in the GA mode. If the pitch mode is changed first, F/D roll mode automatically changes to HDG SEL.
- ✈ Engaging an A/P in CMD following a F/D go-around automatically engages the A/P and F/Ds in LVL CHG and HDG SEL for pitch and roll, respectively.

### Two Engine F/D Go-Around

- ✈ The F/Ds command 15 degrees nose-up pitch and roll to hold the approach ground track at the time of GA engagement. After reaching a programmed rate of climb, pitch commands hold the maneuvering speed for each flap setting.

### Single Engine F/D Go-Around

- ✈ During a single engine go-around, the F/D pitch command is initially 13 degrees nose-up but, as climb rate increases, F/D pitch commands maintain a target airspeed. Roll commands are the same as for two engine go-around.
- ✈ If engine failure occurs prior to GA engagement, MCP selected speed becomes the target speed.
- ✈ If engine failure occurs after GA engagement, F/D target speed depends on whether 10 seconds have elapsed since GA engagement :
  - If prior to 10 seconds, the MCP selected approach speed becomes the target speed.
  - If after 10 seconds and the airspeed at engine failure is within 5 kt of the GA engagement speed, the airspeed that existed at GA engagement becomes the target speed.
  - If after 10 seconds and the airspeed at engine failure is more than 5 kt above GA engagement speed, then the current airspeed becomes the target speed.
- ✈ The G/A target speed is not less than V2 speed based on flap position unless in windshear conditions.
- ✈ The F/D target speed is displayed on the MCP and by the airspeed cursors. No commanded acceleration can occur until a higher speed is selected on the MCP.  
*With both F/D switches ON Capt and F/O pitch commands may differ by 2 to 3 degrees.*

## 8. ALTITUDE ALERTING SYSTEM

- ✈ Altitude alerting references the altitude selected on the MCP. Alerting occurs when approaching or departing the selected altitude. Altitude alerting is inhibited when wing flaps are extended to 25 or greater, or while the G/S is captured.

### 737 Classics

- ✈ Alerting consists of an amber ALTITUDE ALERT light, located adjacent to each pilot's primary altimeter and, for deviation alerting, a momentary tone.
- ✈ When approaching within 750 ft of selected altitude both ALTITUDE ALERT lights illuminate steady (acquisition alerting). When at 250 ft from selected altitude, the lights extinguish.
- ✈ Upon deviating from the selected altitude by more than 250 ft, a momentary tone sounds and the ALTITUDE ALERT lights flash (deviation alerting). Flashing continues until one of the following occurs :
  - altitude deviation becomes less than 250 ft.
  - a new altitude is selected.

### 737NG

- ✈ Alerting consists of white or amber boxes on the PFD altitude displays and, for deviation alerting a momentary tone.
- ✈ When approaching within 750 ft of selected altitude, a white box is displayed around the selected altitude display and the box around the current altitude becomes bold (acquisition alerting). When at 200 ft from the selected altitude, the selected altitude box is removed.
- ✈ Upon deviating from the selected altitude by more than 200 ft, a momentary tone sounds and the box around the current altitude becomes amber and flashes (deviation alerting). Flashing continues until one of the following occurs :
  - altitude deviation becomes less than 200 ft.
  - a new altitude is selected.

## 9. AUTOTHROTTLE

- ✈ The A/T system provides automatic thrust control from the start of take-off through climb, cruise, descent, approach and go-around or landing. In normal operation, the FMC provides the A/T system with N1 limit values.
- ✈ The A/T moves the thrust levers with a separate servo motor on each thrust lever. Manually positioning the thrust levers does not cause A/T disengagement unless 10 degrees of thrust lever separation is exceeded during a dual channel approach after FLARE armed is annunciated. Following manual positioning, the A/T may reposition the thrust levers to comply with computed thrust requirements except while in the THR HOLD and ARM modes.

### PMC / FADEC Operation

- ✈ The A/T system operates properly with PMCs ON or OFF (737 NG : EECs ON or ALTN). In either case, the A/T computer will not exceed the FMC N1 limits.

### Engagement and Disengagement

- ✈ Moving the A/T Arm Switch to ARM, arms the A/T for engagement in the N1, MCP SPD or FMC SPD mode. The A/T Arm Switch is magnetically held at ARM and releases to OFF when the A/T becomes disengaged.
- ✈ Any of the following conditions or actions disengages the A/T :
  - Moving the A/T Arm Switch to OFF.
  - Pressing either A/T Disengage P/B.
  - An A/T system fault is detected.
  - 2 seconds have elapsed since landing touchdown.
  - Thrust lever split becomes more than 10 degrees during a dual channel approach after FLARE armed is annunciated.
- ✈ A/T disengagement is followed by A/T Arm Switch releasing to OFF and flashing red A/T Disengage Lights.
- ✈ The A/T Disengage Lights can be extinguished by any of the following actions :
  - Returning the A/T Arm Switch to ARM.
  - Pressing either A/T Disengage Light.
  - Pressing either A/T Disengage P/B.
- ✈ The A/T Disengage Lights do not illuminate when the A/T automatically disengages after landing touchdown.

### Take-off Mode

- ✈ The take-off mode is engaged by pressing either TO/GA P/B with the aircraft on ground, the A/T armed and the desired take-off N1 thrust limit selected from a CDU. The A/T annunciation changes from ARM to N1 and the thrust levers advance toward take-off thrust.
- ✈ The A/T sets take-off thrust. THR HOLD annunciates at 64 kt or 84 kt depending on the type of A/T computer installed to indicate the A/T cannot change thrust lever position, but thrust levers can be repositioned manually.
- ✈ After liftoff, the A/T remains in THR HOLD until 400 ft RA is reached and approximately 18 seconds have elapsed since liftoff, 737 NG : the A/T remains in THR HOLD until 800 ft RA is reached. A/T annunciation then changes from THR HOLD to ARM. Reduction to climb thrust can now be made by pressing the N1 P/B.
- ✈ Until 2 min 30 sec after liftoff, automatic reduction to climb thrust is inhibited when engaging LVL CHG or WS mode. If VNAV, ALT ACQ or ALT HOLD is engaged during this 2 min 30 sec period, automatic thrust reduction occurs normally.

### N1 Mode

- ✈ The A/T maintains thrust at the N1 limit selected from a CDU. N1 is annunciated for the A/T and the N1 P/B illuminates. Pressing the N1 P/B changes the A/T mode from N1 to ARM.
- ✈ If an engine fails while the A/T is in the N1 mode, the thrust lever of the failed engine will advance forward a few degrees and return to or below the other thrust lever position.

**A/T Speed Mode**

- ✈ The A/T speed mode is available throughout the flight once the take-off phase is completed. Pressing the MCP SPEED P/B selects the speed mode if compatible with the engaged AFDS pitch mode. MCP SPD is annunciated for the A/T and the SPEED P/B illuminates. The speed or Mach shown in the MCP IAS/MACH Display is the target speed. The A/T will not set power above the displayed N1 thrust limit, however, the A/T can exceed an N1 value that has been manually set by the N1 Manual Set Knob.
- ✈ If an engine fails while the A/T is in a speed mode, both thrust levers advance together to maintain the target speed.
- ✈ When on final approach in landing configuration the A/T corrects for normal wind gusts through airspeed and acceleration sensing.
- ✈ Below 400 ft RA, A/T thrust lever response rates and engine power levels are sufficient to place the engines in the rapid acceleration range.

**FMC Speed Mode**

- ✈ The FMC SPD mode is an A/T mode which is commanded by the FMC during VNAV operation. When engaged, the MCP IAS/Mach Display is blank, the airspeed cursors are positioned at the FMC commanded airspeed and the A/T maintains this commanded speed.
- ✈ The A/T is limited to the N1 value displayed.

**N1 Equalization**

- ✈ The A/T attempts to equalize N1 through the dual servo individual thrust lever control. Equalization control is limited to 8 degrees of thrust lever split.

**ARM Mode**

- ✈ The A/T annunciates ARM when the A/T Arm Switch is at ARM and no A/T mode is engaged.
- ✈ The thrust levers can be manually positioned without interference from the A/T system while ARM is annunciated.
- ✈ The A/T automatically transfers from THR HOLD to ARM during T/O.
- ✈ The A/T automatically transfers to ARM from the SPEED or N1 mode when the mode is deselected by pressing the respective P/B while the light is illuminated.

**Descent Retard Mode**

- ✈ The A/T engages and annunciates RETARD during LVL CHG and VNAV descent (except during VNAV cruise descent). RETARD changes to ARM when the thrust levers reach the aft stop or when they are manually prevented from reaching the aft stop.

**Landing Flare Retard Mode**

- ✈ During landing, the RETARD mode engages, reduces thrust and annunciates RETARD 2.5 seconds after FLARE mode engagement or at 27 ft radio altitude, whichever occurs first.



- ✈ During a non-precision or visual approach with flaps extended to 15 or greater and the AFDS not in ALT ACQ or ALT HOLD, the A/T RETARD mode engages at 27 ft radio altitude. The A/T automatically disengages approximately 2 seconds after landing touchdown.

### Go-Around Mode

- ✈ With the A/T Arm Switch at ARM, the A/T go-around mode is armed when descending below 2000 ft RA, with or without the AFDS engaged, or upon G/S capture. Once armed, the A/T go-around mode can be engaged until 2 seconds have elapsed after landing touchdown.
- ✈ Pressing either TO/GA P/B engages the A/T go-around mode. GA is annunciated for the A/T and the thrust levers advance to the reduced go-around thrust setting (calculated by the A/T computer). After reaching reduced go-around thrust, pressing either TO/GA P/B, signals the A/T to advance thrust to the full go-around N1 limit (calculated by the FMC).
- ✈ After reaching reduced or full go-around thrust, the A/T GA mode can be terminated by selecting another AFDS pitch mode or when ALT ACQ annunciates engaged.
- ✈ During a single engine F/D go-around, the A/T will increase thrust to the full N1 limit.

### A/T Mode Engagement and Transfer

- ✈ A general summary of A/T mode engagement and transfer is as follows :
  - A/T SPEED or N1 modes are automatically engaged when AFDS command pitch modes become engaged.
  - A/T SPEED or N1 modes can be manually selected or deselected by pressing the SPEED or N1 P/B if action is compatible with other engaged AFDS modes.
  - Engaging LVL CHG or VNAV climb modes automatically engages the A/T N1 mode.
  - Engaging LVL CHG or VNAV descent modes (except VNAV cruise descent) automatically engages the A/T in RETARD and when thrust is at idle, then ARM.
  - Engagement of ALT HOLD or G/S capture automatically engages the A/T in the MCP SPD mode, or during intermediate VNAV level-off, in FMC SPD mode.

## 10. COMMAND SPEED LIMITING AND REVERSION MODES

- ✈ AFS command limiting and reversion operation is independent of the stall warning and Mach airspeed warning systems.

### Command Speed Limiting

- ✈ The AFS provides speed, pitch & thrust commands to avoid exceeding the following limit speeds :
  - Vmo/Mmo
  - Flap placards.
  - Landing gear placard.
  - Minimum speed.
- ✈ Speeds greater than Vmo/Mmo cannot be selected from the MCP. Speeds can be selected which exceed flap and gear placards or are less than minimum speed.
- ✈ Minimum speed is based on angle of attack and is approximately 1.3 Vs for the current flap configuration. It is sensed by the angle of attack vanes, one on either side of the forward fuselage. Speed brake extension is not taken into account.

- ✈ If a speed greater than a placard speed, or less than minimum speed is selected, the AFS allows acceleration or deceleration to slightly short of the limit, then commands the limit speed.
- ✈ The overspeed or underspeed limiting symbol appears in the MCP IAS/Mach Display when the commanded speed cannot be reached.
- ✈ Either pitch or thrust, whichever is engaged in a speed mode, attempts to hold the limit speed. The commanded limit speed and MCP Speed Condition Symbol remain until another speed is selected which does not exceed the limit. A speed 15 kt greater than the minimum speed must be selected to remove the underspeed limiting symbol.

### **N1 Mode**

- ✈ The A/T maintains thrust at the N1 limit selected from a CDU. N1 is annunciated for the A/T and the N1 P/B illuminates. Pressing the N1 P/B changes the A/T mode from N1 to ARM.
- ✈ If an engine fails while the A/T is in the N1 mode, the thrust lever of the failed engine will advance forward a few degrees and return to or below the other thrust lever position.

### **A/T Speed Mode**

- ✈ The A/T speed mode is available throughout the flight once the take-off phase is completed. Pressing the MCP SPEED P/B selects the speed mode if compatible with the engaged AFDS pitch mode. MCP SPD is annunciated for the A/T and the SPEED P/B illuminates. The speed or Mach shown in the MCP IAS/MACH Display is the target speed. The A/T will not set power above the displayed N1 thrust limit, however, the A/T can exceed an N1 value that has been manually set by the N1 Manual Set Knob.
- ✈ If an engine fails while the A/T is in a speed mode, both thrust levers advance together to maintain the target speed.
- ✈ When on final approach in landing configuration the A/T corrects for normal wind gusts through airspeed and acceleration sensing.
- ✈ Below 400 ft RA, A/T thrust lever response rates and engine power levels are sufficient to place the engines in the rapid acceleration range.

### **FMC Speed Mode**

- ✈ The FMC SPD mode is an A/T mode which is commanded by the FMC during VNAV operation. When engaged, the MCP IAS/Mach Display is blank, the airspeed cursors are positioned at the FMC commanded airspeed and the A/T maintains this commanded speed. The A/T is limited to the N1 value displayed.

### **N1 Equalization**

- ✈ The A/T attempts to equalize N1 through the dual servo individual thrust lever control. Equalization control is limited to 8 degrees of thrust lever split.

### **ARM Mode**

- ✈ The A/T annunciates ARM when the A/T Arm Switch is at ARM and no A/T mode is engaged. The thrust levers can be manually positioned without interference from the A/T system while ARM is annunciated.

- ✈ The A/T automatically transfers from THR HOLD to ARM during T/O.
- ✈ The A/T automatically transfers to ARM from the SPEED or N 1 mode when the mode is deselected by pressing the respective P/B while the light is illuminated.

### Descent Retard Mode

- ✈ The A/T engages and annunciates RETARD during LVL CHG and VNAV descent (except during VNAV cruise descent). RETARD changes to ARM when the thrust levers reach the aft stop or when they are manually prevented from reaching the aft stop.

### Landing Flare Retard Mode

- ✈ During landing, the RETARD mode engages, reduces thrust and annunciates RETARD 2.5 seconds after FLARE mode engagement or at 27 ft radio altitude, whichever occurs first.
- ✈ During a non-precision or visual approach with flaps extended to 15 or greater and the AFDS not in ALT ACQ or ALT HOLD, the A/T RETARD mode engages at 27 ft radio altitude. The A/T automatically disengages approximately 2 seconds after landing touchdown.

### Go-Around Mode

- ✈ With the A/T Arm Switch at ARM, the A/T go-around mode is armed when descending below 2000 ft RA, with or without the AFDS engaged, or upon G/S capture. Once armed, the A/T go-around mode can be engaged until 2 seconds have elapsed after landing touchdown.
- ✈ Pressing either TO/GA P/B engages the A/T go-around mode. GA is annunciates for the A/T and the thrust levers advance to the reduced go-around thrust setting (calculated by the A/T computer). After reaching reduced go-around thrust, pressing either TO/GA P/B, signals the A/T to advance thrust to the full go-around N1 limit (calculated by the FMC).
- ✈ After reaching reduced or full go-around thrust, the A/T GA mode can be terminated by selecting another AFDS pitch mode or when ALT ACQ annunciates engaged.
- ✈ During a single engine F/D go-around, the A/T will increase thrust to the full N1 limit.

### A/T Mode Engagement and Transfer

- ✈ A general summary of A/T mode engagement and transfer is as follows :
  - A/T SPEED or N1 modes are automatically engaged when AFDS command pitch modes become engaged.
  - A/T SPEED or N1 modes can be manually selected or deselected by pressing the SPEED or N1 P/B if action is compatible with other engaged AFDS modes.
  - Engaging LVL CHG or VNAV climb modes automatically engages the A/T N1 mode.
  - Engaging LVL CHG or VNAV descent modes (except VNAV cruise descent) automatically engages the A/T in RETARD and when thrust is at idle, then ARM.
  - Engagement of ALT HOLD or G/S capture automatically engages the A/T in the MCP SPD mode, or during intermediate VNAV level-off, in FMC SPD mode.

## 10. COMMAND SPEED LIMITING AND REVERSION MODES

- ✈ AFS command limiting and reversion operation is independent of the stall warning and Mach airspeed warning systems.

### Command Speed Limiting

- ✈ The AFS provides speed, pitch and thrust commands to avoid exceeding the following limit speeds :
  - Vmo/Mmo.
  - Flap placards.
  - Landing gear placard.
  - Minimum speed.
- ✈ Speeds greater than Vmo/Mmo cannot be selected from the MCP. Speeds can be selected which exceed flap and gear placards or are less than minimum speed.
- ✈ Minimum speed is based on angle of attack and is approximately 1.3 Vs for the current flap configuration. It is sensed by the angle of attack vanes, one on either side of the forward fuselage. Speed brake extension is not taken into account.
- ✈ If a speed greater than a placard speed, or less than minimum speed is selected, the AFS allows acceleration or deceleration to slightly short of the limit, then commands the limit speed.
- ✈ The overspeed or underspeed limiting symbol appears in the MCP IAS/Mach Display when the commanded speed cannot be reached.
- ✈ Either pitch or thrust, whichever is engaged in a speed mode, attempts to hold the limit speed. The commanded limit speed and MCP Speed Condition Symbol remain until another speed is selected which does not exceed the limit. A speed 15 kt greater than the minimum speed must be selected to remove the underspeed limiting symbol.

### Reversion Modes

- ✈ During some flight situations, speed control by the AFDS or A/T alone could be insufficient to prevent exceeding a limit speed. If this occurs, AFDS and/or A/T modes automatically revert to a more effective combination. The reversion modes are :
  - Placard limit reversion.
  - Performance limit reversion.
  - Minimum airspeed reversion.
- ✈ Mode reversion occurs slightly before reaching the limit speed. Both the AFDS and the A/T have reversion modes which activate according to the condition causing the reversion.

### Placard Limit Reversion

- ✈ When one of the placard limits (gear, flap or Vmo / Mmo) is reached, the overspeed limiting symbol appears in the MCP IAS/Mach Display and the following occurs:
  - If not in AFDS or A/T speed control and the A/T is armed, the A/T reverts to SPEED and controls speed to the placard limit.
  - If in AFDS or A/T speed control, no reversion is necessary. The AFDS or A/T, whichever is controlling speed, holds speed slightly below the placard limit.
  - If the A/T is not available, no reversion response to gear or flap placard speeds is available. The AFDS reverts to speed control for Vmo / Mmo speed limiting.

### Performance Limit Reversion

- ✈ This function occurs only while operating in the WS mode when the selected vertical speed and airspeed combination exceeds the thrust capability to maintain the selected airspeed. If airspeed becomes more than 5 kt below the MCP selected airspeed and is not increasing, the AFS reverts to LVL CHG and the underspeed limiting symbol appears in the MCP IAS/Mach Display.
- ✈ The underspeed limiting symbol remains displayed until a different speed or a different pitch mode is selected.
- ✈ Performance limit reversion also occurs with the A/T OFF and the autopilot engaged.

### Minimum Speed Reversion

- ✈ The AFDS and A/T do not control to a speed which is less than minimum speed for the current flap configuration. This speed is approximately 1.3 Vs. Speed brake extension is not taken into account. Minimum speed, FMC speed or selected speed, whichever is higher, becomes the AFS commanded speed. If actual speed becomes equal to or slightly less than the minimum speed, the underspeed limiting symbol appears in the MCP IAS/Mach Display and if operating in the V/S mode, the AFDS reverts to LVL CHG.
- ✈ The AFS commands a speed 5 kt greater than minimum speed. Selecting a speed 15 kt greater than minimum speed reactivates normal MCP speed selection control. The AFDS commands nose down pitch to increase airspeed if the thrust levers are not advanced. When actual speed becomes 15 kt greater than minimum speed, the underspeed limiting symbol disappears.
- ✈ The A/P disengages and the F/D command bars retract when in a LVL CHG climb with a command speed equal to minimum speed and a minimum rate of climb cannot be maintained without decelerating.
- ✈ Minimum speed reversion is not available when the A/T is OFF and the AFDS is in ALT HOLD, ALT ACQ (737-300/-400/-500 only) or after G/S capture.

## 11. AFS OPERATION IN WINDSHEAR

### General

- ✈ The autopilot and flight director provide positive corrective action to counteract most Windshears.
- ✈ The autothrottle system also aids in windshear recovery by providing quick response to any increase or decrease in speed. The commanded levels of power may be beyond what the average pilot might consider necessary but, in fact, are required by the situation.

### Take-off or Go-Around

- ✈ If windshear is encountered during F/D take-off or go-around, the F/D pitch command bar will provide commands to maintain  $V_2 + 20$  kt until vertical speed decreases to approximately + 600 fpm. At this point, the F/D pitch bar commands a 15 degree nose-up pitch attitude. If vertical speed continues to decrease, F/D continues to command a 15 degree pitch attitude until a speed of approximately stick shaker is reached. It then commands pitch attitudes which result in intermittent activation of the stick shaker. As the aircraft transits the windshear condition, the F/D programming will be reversed. As climb rate increases above approximately + 600 fpm, the F/D commands pitch attitudes which result in acceleration back to  $V_2 + 20$  kt. The A/P and F/D both operate in a similar manner during A/P or F/D go-around.

### Approach and Landing

- ✈ If windshear is encountered during an ILS approach, both the F/D and A/P attempt to hold the aircraft on altitude, or on glide slope after glide slope capture, without regard to angle of attack or stick shaker limitations. Airspeed could decrease below stick shaker and into a stall if the pilot does not intervene by pressing the TO/GA P/B or disconnecting the A/P and flying manually.

## 12. THRUST MODE ANNUNCIATION

- ✈ The thrust mode annunciation is located on the center instrument panel above the N1 RPM indications. It displays the active N1 limit reference mode for autothrottle and manual thrust control. N1 limits are also displayed on the N1 RPM indicator cursors 737 Classics with the reference knobs pushed in, 737 NGs 800 with N1 SET outer knob in AUTO.
- ✈ N1 limits are normally calculated by the FMC. When FMC N1 limit calculations become invalid, or if either engine N1 is less than 18%, A/T LIM is annunciated. The autothrottle computer then calculates a single N1 limit for the affected engine(s).

(R)TO - (Reduced) Take-off.

(R)CLB - (Reduced) Climb.

CRZ - Cruise.




G/A - Go-around.

CON - Continuous.

- - - - FMC is not computing thrust limits.

A/T LIM - Autothrottle limit Indicates that A/T computer is calculating a degraded N1 limit for the affected engine or engines.

## 13. FAULTS &amp; INDICATIONS

LIGHT	INDICATION	VALID FOR					
		300	400	500	600	700	800 900
	<p><b>AUTOPILOT DISENGAGE LIGHT</b> (red/amber) (2x)</p> <ul style="list-style-type: none"> <li>- Flashes red and tone sounds when autopilot has disengaged. Can be reset by pressing either disengage light or either A/P Disengage Switch.</li> <li>- Steady red if :               <ol style="list-style-type: none"> <li>1) Stabilizer is out of trim below 800 ft on a dual channel approach.</li> <li>2) Altitude acquire mode is inhibited during an A/P go-around. (Stabilizer not trimmed for a single A/P operation.)</li> <li>3) Disengage Light Test Switch is held in position 2.</li> </ol> </li> <li>- Failure of automatic ground system tests.</li> <li>- Steady amber when the Disengage Light Test Switch is held in position 1.</li> <li>- Flashes amber if A/P automatically reverts to CWS pitch or roll while in CMD. Resets when either light is pressed or another mode engaged.</li> </ul>	X	X	X	X	X	X
	<p><b>STABILIZER OUT OF TRIM</b> (amber)</p> <p>Operates only when A/P is engaged Remains extinguished with neither A/P engaged When illuminated, means A/P is not trimming Properly.</p>	X	X	X	X	X	X
	<p><b>AUTOTHROTTLE DISENGAGEMENT LIGHT</b> (red/amber) (2x)</p> <ul style="list-style-type: none"> <li>- <u>Flashing red</u> : F/D and A/T have disengaged.</li> <li>- <u>Steady red</u> : When the Disengage Light Test Switch is held in position 2.</li> <li>- <u>Steady amber</u>: When the Disengage Light Test Switch is held in position 1.</li> <li>- <u>Flashing amber</u>: Indicates A/T airspeed error if speed not held within +10 or -5 kt of commanded speed when all of the following conditions exist :               <ol style="list-style-type: none"> <li>1) In flight.</li> <li>2) Flaps not up.</li> <li>3) A/T engaged in MCP SPD, or FMC SPD mode.</li> </ol> </li> </ul> <p>An automatic test of the A/T flashing amber function is performed if the A/T is engaged and the following conditions exist :</p> <ul style="list-style-type: none"> <li>- MCP SPD or FMC SPD is A/T active mode.</li> <li>- More than 2 min 30 sec after liftoff.</li> <li>- Flaps extended.</li> </ul> <p>A/T amber flight flashes for 2 seconds, remains extinguished for 2 seconds and then flashes for 2 seconds again.</p>	X	X	X	X	X	X