AUTOMATIC FLIGHT MANAGEMENT SYSTEMS

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FLIGHT MANAGEMENT SYSTEMS

Overview: The Flight Management System (FMS) on the 737 is designed to provide full control of the aircraft in all phases of flight. The Flight Management system is made up of the Autopilot Flight Director System, FMC/CDU, Flight Controls and onboard computers.

While it is common to think of these systems as being separate, it is helpful for the purpose of understanding how to interact with the airplane to consider the Flight Controls, FMC/CDU and Autopilot Mode Control as an integrated system for managing the flight path of the aircraft.

As a complete system, the Flight Management System (FMS) provides for automated vertical and lateral navigation of the aircraft. The system is designed so that the crew can interact with the FMS through the Flight Controls, the Autopilot Flight Director Mode Control Panel or the FMC/CDU.

Although the 737 FMS is capable of managing all phases of flight from takeoff to touchdown, the crew is under no obligation to use any of the systems provided. If desired the airplane can be flown by hand without using reference to any of the automated systems. Additionally, the AFDS Mode Control Panel can be used to provide Flight Director guidance while hand flying the airplane, or the FMC/CDU and AFDS MCP can be used in concert with the autopilot to provide fully automated flight control.

Use of the FMS will result in greater precision, significantly reduced overall operating expense, reduced wear and tear on the airframe and significantly reduced pilot workload during critical phases of flight.

Flight Management System Outlined: The 737 FMS is made up of the following systems:

- Radio Navigation Systems (VOR/ADF, etc)
- Inertial Reference System
- GPS
- Air Data Computers
- Electronic Flight Instrumentation System (EFIS)
- Engine Instrumentation and Crew Alerting System. (EICAS)
- Flight Management Computer (FMC)
- Autopilot Flight Director System Mode Control Panel (AFDS-MCP)

All of these systems function independently, but are integrated to control the pitch axis, roll axis, yaw axis and acceleration with precision in all phases of flight.

AUTOPILOT FLIGHT DIRECTOR SYSTEM

Overview: The AFDS integrates functions of the autopilot system, the flight director system, and the automatic stabilizer trim system in order to provide complete flight regime control. The AFDS is comprised of three Flight Control Computers (FCCs) that operate in parallel with each other to provide highly precise command and control capabilities.

The FCCs, Left and Right, have independent power sources and provide flight control input directly to the flight controls through two independent hydraulic systems. As such, each FCC can be allowed to have full independent control of all aircraft flight control surfaces, or both FCCs can be operated in tandem to provide full fail-safe operation for coupled approaches and autoland.

The AFDS takes data from various sensors on the aircraft (AoA, Airspeed, TAT probes, GPS, IRS, etc) and uses the information to provide pitch and roll cues to the flight director system. The flight director system is then able to display these pitch and roll commands graphically on the cockpit displays.

The crew can follow the flight director cues when flying by hand, or can engage the autopilot to follow the pitch/roll cues provided by the flight director.

When an autopilot is not active, the crew can follow the displayed pitch/roll cues by manipulating the flight controls to match the steering cues provided by the Flight Director.

When an autopilot is activated, it issues commands to the flight controls so as to maintain control of vertical speed, airspeed, altitude and heading as commanded by the flight director.

AFDS Mode Control Panel: The Flight Director has many modes for managing pitch, roll and thrust. The crew is able to select the desired modes for the Flight Director through the use of the Autopilot Flight Director System Mode Control Panel (AFDS MCP or simply the MCP.) The MCP is the primary method for directly controlling the Flight Director.

The MCP is located on the glare shield, and provides direct control of all Flight Director functions. A common misconception is to thing of this rectangular section of the panel as “The Autopilot.” Indeed this is not the case, as the autopilot is itself a computerized system of control logic and actuators that provide commands to the flight controls. The MCP, on the other hand, does exactly what it’s name suggests: It allows the crew to select the MODES that are used by the FLIGHT DIRECTOR.

Thus: Autopilot Flight Director System Mode Control Panel!

The MCP has lighted function switches which allow the crew to select the modes under which the AFDS operates. Remember at all times that the Flight Director provides commands for the Autopilot to control the airplane in *three* ways:

- Pitch
- Roll
- Thrust

For each of these areas, there is more than a single method that may be specified.

Pitch Modes:
Vertical Speed (V/S)
Vertical Navigation (VNAV)
Speed (SPD)
Flight Level Change (FLCH)
Altitude Hold (ALT)

Roll Modes:
Heading (HDG)
Lateral Navigation (LNAV)
VOR/Localizer (VOR/LOC)

Thrust Modes:
Thrust (N1)
Speed (SPD)

LNAV, VNAV, FLCH, V/S, N1 and SPD mode are all available for crew selection, as well as heading, airspeed, altitude and vertical speed.

In some cases, modes such as FLCH, APP (approach) and SPD will use a combination of engine power, roll and pitch to achieve the desired results, but it is often easiest to remember that effective use of the MCP means the crew will have a mode selected to manage pitch, roll and thrust individually.

Any active pitch/roll/thrust mode can be disengaged by selecting a different pitch/roll/thrust mode on the MCP.

Modes may also be disconnected by disengaging all operating autopilots and deselecting the flight director.

If the aircraft is on an approach and LOC and G/S capture has already occurred, then selecting a different command mode will not disengage the autopilot. In this situation, the only method available to disengage the AFDS is to disengage the autopilot and deselect the flight directors. Pressing the

TO/GA switch will also disengage the approach after LOC and G/S capture.

Flight Control Computers (FCCs): The function of the FCCs is to integrate the functions of the flight director and the autopilot systems. Each individual FCC provides control commands directly to its associated autopilot control servo. This servo operates the flight controls directly. Both autopilot servo systems are powered using the left and right hydraulic systems.

If only one autopilot is engaged, it is capable of controlling the pitch and roll axes of flight. In this mode, the yaw damper provides for yaw control when the aircraft receives a roll command from the FCC, resulting in fully coordinated flight.

If both autopilots are engaged and the AFDS has entered approach mode, the FCCs combine to provide redundant pitch, roll and yaw control. Full rudder control is maintained and will automatically provide runway alignment until touchdown.

In a multiple autopilot approach with a crosswind, the FCCs will use rudder input and bank angle to slip the aircraft for runway alignment. The bank angle available is limited and in stronger crosswind conditions the FCCs may use a combination of slip and crab to maintain runway alignment.

If a failure affecting both FCCs occurs during an approach, an autopilot disconnect will result. If any failure results in loss of either pitch or roll modes, the associated flight director command bar will be removed from the PFD. In cases where both pitch and roll mode are affected, the flight director will be removed entirely and replaced with a fault flag.

AFDS Systems: The AFDS, in conjunction with the FCC's, is capable of providing full regime, three-dimensional control of the aircraft in all phases of flight. This is accomplished by issuing commands to the Flight Control Computers that in turn provide control commands to the autopilot servos.

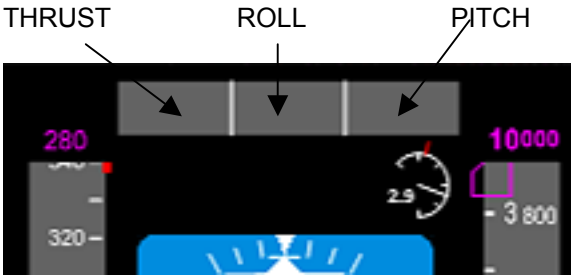
The autopilot controls the aircraft in three separate regimes:

- Thrust Mode
- Roll Mode
  - Pitch Mode

The status of each of these autopilot modes is displayed on the MCP, and on the primary flight display.

The area directly above the attitude indicator is called the "Flight Mode Annunciator" (FMA) and this provides the crew with important information regarding the current and armed modes for thrust, roll and pitch modes.

The lower portion of the FMA also displays the current status of the AFDS system. The AFDS status will be blank, indicating that the autopilot is not controlling the aircraft, or it will say CMD to indicate that the autopilot is controlling the airplane in accordance with flight director commands.



AUTOPILOT FLIGHT DIRECTOR MODE ANNUNCIATOR

THRUST Command Modes: The autothrottle has primary control for all automated thrust settings. While thrust can be set manually by the crew, the autothrottle is an efficient and precise method to set engine power.

Thrust modes that may be announced by the FMA mode annunciator are:

FMC SPD: This indicates that the autothrottle is maintaining speeds as commanded by the FMC while in VNAV pitch mode. The speed display on the MCP will be blank but the airspeed cursor on the flight instruments will show the commanded speed. The Autothrottle will maintain this speed by modulating thrust as required

within engine and aircraft performance limits.

N1: Thrust setting is based on FMC selected N1 values.

MCP SPD: Speed autothrottle mode. Thrust is set to maintain the speed set in the MCP Speed window. Rate of climb or descent will be a result of maintaining desired aircraft target speed through the adjustment of aircraft pitch. Autothrottle will not violate thrust limits or aircraft speed limits.

RETARD: Indicates that the autothrottles are reducing power after LVL CHG or VNAV is engaged for a descent at idle power.

ARM: this mode is displayed on the FMA when the Autothrottle has been armed, but no thrust mode was selected to provide the control logic.

HOLD: Indicates that autothrottle control of the thrust levers has been released in order to prevent thrust lever movement in the event of an Autothrottle failure. Will be annunciated at 84knots to indicate that the autothrottle has set takeoff power.

GA: Go around thrust mode. Thrust is modulated to provide a 2000 fpm climb rate. This mode can be terminated by selecting any other pitch mode.

ROLL Command Modes: The Roll mode commands bank angles so as to result in specific turn rates or velocity vectors. The autopilot will attempt to maintain the desired flight path, which can be dictated by a simple heading bug command setting, or by a complex series of waypoint programmed into the FMC. At no time will any autopilot roll mode exceed the bank limit selector or maneuvering speed limits in order to maintain course. Roll modes which may be displayed on the FMA are:

GA: Commands bank angle in order to maintain ground track during takeoff or go around maneuver. Ground track will be maintained based on track disposition at time of engagement. Alternatively, if the TO/GA Heading mode has been activated in the PMDG Styles menu, GA will command the aircraft to steer in accordance with the selected heading.

LNAV: Commands bank to follow active FMC route as displayed on the navigation display. If on ground, LNAV mode will arm to engage when passing through 50 feet AGL.

HDG SEL: Commands bank angle to maintain heading selected in MCP heading window.

VOR/LOC: Commands bank to capture localizer when intercept track does not exceed +/- 60º. Once captured, will command bank to maintain localizer.

PITCH Command Modes: Pitch mode commands aircraft pitch angles to maintain a particular altitude, vertical speed, forward airspeed or climb/descent path. Pitch mode is nearly always directly linked to actions in the Thrust mode. Pitch mode inputs can come from the MCP altitude command knob, the MCP vertical speed knob or the FMC directly. When used in conjunction with a Thrust mode, Pitch mode is a powerful tool to manage climbs and descents to a high degree of accuracy. The autopilot will use both pitch and thrust to maintain commanded airspeed while navigating a vertical climb or descent path. Pitch modes that may be announced on the FMA are:

TO/GA**:** Commands pitch angle required for takeoff or go around. On ground, mode is armed and will command for 8º nose up pitch, followed by required flight director climb pitch after ground clearance. Of TO/GA is pressed during approach, will provide climb attitude guidance for best climb rate.

V/S: Maintains vertical speed selected in MCP V/S window.

ALT ACQ: Indicates that the autopilot is changing aircraft pitch in order to acquire the MCP or FMC set altitude when transitioning from a climb or descent.

ALT HOLD: Commands pitch to maintain altitude set in MCP altitude window, FMC or when ALT HOLD switch is pushed on MCP.

VNAV PTH: Commands pitch up/down to maintain selected FMC altitude or FMC calculated VNAV descent path. The climb/descent path is calculated based upon desired altitudes entered into the FMC flight plan. The FMC attempts to use the most efficient climb and descent angles and will moderate pitch as necessary in conjunction with aircraft speed in order to maintain those calculated paths.

VNAV SPD: Commands pitch up/down to maintain selected airspeed. During descents, VNAV SPD will maintain airspeed based upon an idle power descent.

VNAV ALT: Displayed if VNAV is commanding pitch to maintain an intermediate altitude during a climb or descent. For example if final cruise altitude is FL350 and during a VNAV climb a restriction to FL290 is received, setting 29000 in the MCP altitude window will cause the aircraft to level at FL290 and enter VNAV ALT mode. VNAV ALT will be displayed only if level off occurred at an intermediate altitude, but VNAV is still the primary pitch mode for climb/descent.

MCP SPD: A combination of pitch and thrust is used to maintain MCP commanded speed.

G/S: Commands pitch to maintain glideslope when intercept track does not exceed +/- 40º of front course. Will follow glideslope once engaged.

FLARE: Will engage between 60-40 feet AGL. Commands pitch to reduce sink rate. Disengages at touchdown and lowers nose wheel slowly to runway.

AFDS Command Modes: The status of the entire AFDS system is also displayed on the FMA mode annunciator. This display provides the crew with immediate feedback on the current operating mode of the AFDS system. Displayed modes may be any of the following:

FD: Any flight director is selected ON while autopilots are disengaged. Pilot must manually follow Flight Director steering queues. All modes are available on the FMC, but the pilot is responsible for using control inputs to maintain pitch, roll and thrust (if the autothrottle is not engaged.)

CMD: Any autopilot is selected ON and is properly engaged. The Autopilot is controlling pitch and roll modes in accordance with flight director commands.

CWS P: Pitch is being maintained according to Control Wheel Steering logic.

CWS R: Roll is being maintained according to Control Wheel Steering logic.

What is Control Wheel Steering?:*CWS can be used to control pitch and or roll of the aircraft. CWS provides full control authority to the pilot and pitch and roll can be changed by applying pressure to the yoke. When pressure is released, the autopilot will maintain the pitch and roll attitude established by the control inputs.*

CWS Mode can be entered in three ways:

1) *Pressing a CWS autopilot engage button on the MCP.*
2) Application of sustained pressure on the controls while the autopilot is engaged in CMD mode.
3) Engage the autopilot with no previously selected pitch/roll modes.

When the AFDS enters CWS mode, CWS P and/or CWS R will be displayed on the FMC and the current pitch and roll attitude will be maintained until changed by control pressures, or selecting an alternate pitch/roll mode on the MCP.

Approach Modes: The autopilot is capable of flying a fully coupled ILS approach to landing if desired.

At a minimum, to fly a coupled autopilot approach, the appropriate ILS frequency must be entered in the navigation radio and the proper course selected for the approach. The APP switch on the MCP must be pressed and will initially illuminate.

The aircraft is capable of conducting a full Autoland with only a single autopilot engaged but this is not considered to be adequate for a safe Autoland.

To engage the second autopilot for a fully coupled Dual Channel Autoland, the ILS frequency and course should be set up for the second navigation radio and the CMD B autopilot switch should be pressed prior to reaching 800' AGL on the approach.

1CH or SINGLE CH: Will be displayed to indicate localizer capture by one autopilot. If only one navigation radio is tuned to the ILS frequency, this annunciation will remain for the entire approach.

In SINGLE CH mode, the aircraft will use roll and yaw to maintain the localizer course for the approach.

When 2/5 dots below the Glideslope, the APP switch on the MCP will extinguishes after localizer and Glideslope are captured.

Once the approach is fully captured, APP mode can be disengaged by:

- Pushing the TO/GA switch (click on upper left screw on MCP in the PMDG airplane. In the actual airplane the TOGA switch is located on the throttle under your thumb but that could not be modeled here.)
- Disengage the autopilots and turn off both Flight Director Switches.
- Tune the VHF Navigation receivers to a new frequency.

Autothrottle: The autothrottle system uses the FMCs to directly control throttle input for maximum fuel conservation. The autothrottle is capable of providing for full flight throttle management from takeoff to rollout.

Whenever engaged, the autothrottle system will provide speed limit protection by modulating thrust to prevent exceeding limits related to flap settings, angle of attack (alpha floor) and maximum structural speeds.

The FMC will display the thrust limit for the current regime of flight on the EICAS display, and provides commands directly to the autothrottle so as not to exceed these thrust limits in any mode of flight.

The autothrottle can accept automatic input directly from the FMC flight plan whenever VNAV is selected, or manually from the crew via the MCP.

MCP modes available to the crew for selection include, N1 Thrust (N1), speed (SPD), flight level change (FLCH) and VNAV. The autothrottle will provide speed protection in all of these modes.

The autothrottle sets thrust by moving both throttles together simultaneously. The autothrottle will maintain the relative position of the throttles, and stop throttle movement at the moment the first throttle reaches the desired thrust setting. The autothrottle then adjusts each engine individually to equalize thrust within 8% of N1.

Any throttle can be moved while the autothrottle is engaged, however the autothrottle will return the throttle to its commanded position once it is released.

When the autothrottle mode HOLD is announced on the PFD, the autothrottle servo is disconnected to prevent uncommanded movement of the autothrottle. The HOLD mode engages automatically when the aircraft accelerates above 65 knots during the takeoff. HOLD can also engage in flight in VNAV and FLCH modes if autothrottle movement is overridden or stopped manually.

The autothrottle will disconnect in any situation where a fault is detected in the engaged autothrottle mode, or if any reverse

thrust lever is raised to reverse idle. The autothrottle should be disengaged if one engine fails in flight, or if both FMCs fail.

If the autothrottle is armed in flight, but disengaged, it will automatically re-engage if any pitch or autothrottle mode is selected on the MCP.

Flap limit speeds, angle of attack, and airplane configuration limit speeds are monitored by the AFDS and the FMCs in all pitch and autothrottle modes **except V/S** mode. If an overspeed is anticipated, either the FMC will adjust pitch or the autothrottle will adjust thrust to prevent exceeding a speed limitation. The FMC may announce DRAG REQUIRED if it is determined that pitch adjustment is the only method to prevent an overspeed condition.

FLIGHT MANAGEMENT COMPUTER

Overview: The 737 carries two independent FMCs which run in parallel to each other in order to maximize accuracy, and eliminate errors.

The FMCs contain a database of navigation aids, waypoints, airports, airways, runways, SIDS, STARS, company route information and aircraft performance data.

The FMCs are loaded by ground personnel, and the databases are updated every twenty eight days.

During flight, the FMC will monitor the database for a combination of VOR and VOR/DME stations at high angles of intercept to the route of intended flight. During the flight, the FMC will autotune the VHF navigation equipment to provide update and verification of current aircraft position, and to provide position, radial and DME data to the crew for navigation purposes.

The FMCs will use this method of monitoring current aircraft positioning as well as GPS position data and IRS computed position data.

In the absence of reliable VOR tuning and GPS signal, the system will obtain an average position as computed by the Inertial Reference System. (IRS Not modeled in this PMDG version.)

The FMCs use the navigation database and aircraft performance information stored in non-volatile memory to provide complete lateral and vertical navigation. This is accomplished by interfacing with and providing commands to the AFDS and autothrottle systems.

The FMCs will use route, weather and aircraft performance data to operate the aircraft in the most economical fashion for any given flight regime based upon crew instructions.

FMC/CDU: The FMC/CDU is the tool the crew uses to interface with the FMC. The CDU also provides a means for the FMC to display information for crew use.

The FMC will display information related to the flight on the EFIS monitors, as well as through a series of FMC/CDU menus known as pages.

A CDU line containing small boxes is a signal to the crew that information must be entered for proper FMC operation. A line containing dashes indicates information that is optional for entry, but which will provide for more accurate FMC operation.

The FMC/CDUs are very specific about allowing correct data entry into the data fields. The FMC/CDU will not accept illogical references, or references which are not usable given the capabilities of the FMC.

The FMC/CDU provides a MENU key which allows the crew to select either the FMC functions of the FMC/CDU, or access to the ACARS capabilities of the FMC.

AFDS MODE CONTROL PANEL

AFDS MCP: The AFDS Mode Control Panel is located on the glare shield. This is one of the principle means used by the crew to communicate with and control the AFDS during most phases of flight. The MCP contains switches to select and arm the autopilots as well as various pitch, roll and axis modes of the AFDS. In addition, the MCP allows the crew to override an FMC commanded mode, or manually select heading, speed, altitude and vertical speed as desired.

MCP Layout: The MCP layout is designed to allow for an intuitive interface between the crew and the AFDS. Similar functions on the MCP are clustered together in order to separate dissimilar functions.

Flight Director Switches: Located on either end of the MCP, the Flight Director switches enable or disable the display of flight director command bars on the PFD.

The flight directors display information as reported by the left or right Flight Control Computer respectively. The autopilot will only accept commands from one Flight Director at a time. The current MASTER Flight Director is identified by an illuminated MA above the flight director switch.

Thrust/Speed Modes: All of the AFDS modes which use speed intervention and speed protection are clustered around the IAS/Mach speed selector knob.

Autothrottle Arm Switch: When selected ON, this switch arms the autothrottle for mode engagement. The autothrottle will engage when any of the following speed intervention/vertical navigation modes are engaged:

- FLCH
- VNAV
- TO/GA
- N1
- SPD

If the flight director is selected OFF and the autothrottle is armed, the autothrottle will revert to the SPD mode until flight directors are rearmed, or unless N1 mode is manually selected.

If VNAV is already engaged at the time the A/T ARM switch is selected ON, the autothrottle will engage in the appropriate mode for the regime of flight.

N1 Switch: If current mode is FLCH, SPD, VNAV SPD, VNAV PTH, VNAV ALT or TO/GA, pressing the N1 switch changes the thrust limit to the CLB thrust setting. This setting will be displayed on the EICAS. This does not affect the autothrottle mode, but changes the thrust limit allowed.

If any other mode is currently selected, pressing N1 will advance thrust to the currently displayed thrust limit.

SPD Switch: If pressed, the autothrottle is engaged in speed mode. SPD will be annunciated on the FMA and the throttle will control thrust to maintain the IAS/Mach displayed in the IAS/Mach MCP window. SPD mode will not exceed minimum or maximum speed limits.

Selector Knob: Changes the value displayed in the IAS/Mach window and updates the command speed bug on the PFD.

Left click will change single digits. Right click will change tens unit.

If VNAV mode is engaged, the window will usually be blanked because the speed input and control commands are being managed by the FMC. If VNAV mode is active and the SPD INTV (Speed Intervention) knob is pushed then the MCP Speed window will display the FMC commanded speed so that adjustments can be made.

Pressing SPD INTV will return speed control to the FMC as described in the flight plan.

If the autothrottle is operating in FLCH, SPD or TO/GA mode, the display will not be blanked.

SPD is inactive if in FLCH, VNAV or TO/GA mode.

C/O Switch: The Change Over switch allows the crew to manually select an reading in Knots or Mach.

IAS/Mach Window: Indicates current or selected VNAV speed unless VNAV is already engaged. PFD command airspeed bug is manipulated using this setting. Indicator will be blank when VNAV mode is engaged. When VNAV is engaged, speed and speed bugs are placed under control of the FMC.

LVL CHG Switch: Pressing the LVL CHG switch will disengage any other active pitch mode. Level Change integrates AFDS pitch control and autothrottle thrust control to effect an altitude change.

If the IAS/Mach indicator is blank: Indicator will un-blank and display the FMC target speed. If the FMC target speed is invalid, then LVL CHG will use the existing airspeed.

If the IAS/Mach indicator is not blank: Command speed for the climb will remain as displayed.

The Autothrottle will advance the throttles to the selected thrust for climbing, or reduces to idle if a descent is being effected.

AFDS will use pitch control to control speed after climb/descent thrust is set by the Autothrottle, resulting in the best rate of climb or descent.

When MCP altitude is reached, the pitch mode changes to altitude hold and ALT is displayed on the PFD. The autothrottle holds the commanded speed and SPD mode is engaged.

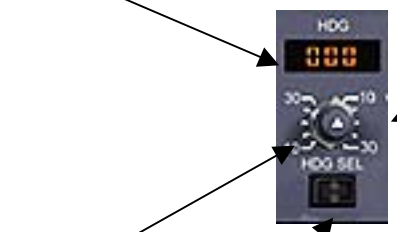
Bank Limit Selector: Allows the crew to manually set a bank limit for the aircraft. This switch is normally left at 30 degrees but may be selected lower as desired.

Within Microsoft Flight Simulator, the click area for the bank angle selector is located around the click area for the heading bug. If you accidentally alter the bank limit mode when attempting to change heading, simply move the mouse to the opposite side of the heading bug and click again. This will bring the bank limit switch back to 30 degrees.

If you notice during flight that your airplane is only turning slightly, this might be a culprit area to examine!

HDG Selector Knob: Allows magnetic heading to be selected in the HDG window. Heading mode will disarm if the aircraft captures an ILS on LOC mode.

HDG Window: Indicates magnetic heading selected using heading selector knob.



HDG SEL Switch: Engages heading hold manually. When pressed, AFDS will maintain current heading. If bank angle exceeds 15 degrees, AFDS will maintain heading at time the wings roll level.

VNAV Switch: Pressing the VNAV switch arms or engages the vertical navigation mode of the AFDS, and transfers pitch and speed modes of the AFDS and autothrottle to the FMC.

VNAV mode gives control of the pitch mode to the FMC and causes the AFDS to fly a vertical profile as it is described in the FMC flightplan and updated or modified by the crew.

If VNAV is engaged, VNAV mode appears in green on the PFD.

VNAV mode will not engage (but will arm) if the FMC Performance Initialization page is incomplete.

VNAV mode is disengaged by any of the following:

Engaging TO/GA, LVL CHG, SPD, V/S, ALT, or G/S pitch modes. Or if VNAV switch is pushed a second time before VNAV engagement.

LNAV Switch: Pressing LNAV switch arms or engages the lateral navigation mode of the AFDS, and transfers roll and yaw (heading) control to the FMC.

LNAV will engage as long as the aircraft is above 50 AGL and within 2.5 miles of the planned track. If the aircraft is outside of these parameters, LNAV mode will arm and engage when the aircraft moves within these parameters (e.g.- after takeoff).

LNAV mode will be displayed in greed on the PFD if LNAV mode is engaged.

If LNAV arms, but the aircraft is not on an intercept heading to planned track, the FMC scratch pad will show the text NOT ON INTERCEPT HEADING, and the previously armed roll mode will remain active.

LNAV mode is disengaged by any of the following:

Selecting HDG SEL modes.
At localizer capture.
If LNAV switch is pushed a second time before LNAV engagement.

VERT SPD Window: Displays current vertical speed at time V/S speed is pushed. Displays selected vertical speed as selected using V/S knob. Range is –6000 fpm to +6000 fpm.

V/S Switch: engages V/S mode. AFDS will maintain V/S set in V/S window. V/S does not provide speed protection in the climb or descent.

ALT Window: Displays altitude as selected using the altitude selector knob. Displayed altitude is target altitude for all AFDS, FMS and altitude alert functions. AFDS and FMC will not allow a climb or descent through the displayed altitude. If altitude has been captured, AFDS and FMC will not allow the aircraft to depart from displayed altitude unless a pitch mode has been selected.

Altitude Selector Knob: Allows selection of altitude in the ALT window.

If at cruise, and within 50nm of the Top Of Descent point, selecting a lower altitude in the MCP altitude window, then pressing the MCP ALT knob causes the DES NOW feature to become active, and the AFDS will initiate a 1,250 ft/min descent rate until intercepting the VNAV calculated descent path, at which point it will enter the VNAV descent path.

Altitude Intervention Switch: The ALT INTV button can be pressed to the following effect:

During a climb or descent, pushing the ALT INTV button will delete the next waypoint altitude constraint between the airplane and the altitude displayed in the ALT window. (For example: during a step descent, pressing the altitude selection knob will delete the next level off point in the FMC flight plan, provided it is above the MCP altitude displayed in the ALT window.)

If climbing, and no waypoint related altitude restrictions exist, pressing the ALT INTV button will transfer the MCP ALT value to the FMC and overwrite the FMC altitude. The aircraft will level at the MCP altitude.

When pushed during cruise, the ALT window value will be transferred to the FMC flightplan and the new altitude becomes the cruise altitude. If in VNAV ALT or VNAV PTH modes, VNAV will automatically initiate the required climb or descent.

ALT HOLD Switch: Manually engages altitude hold mode. AFDS will capture and hold the altitude as indicated at the time the switch is pushed.

Autopilot FCC Engage CMD Switches: Pressing switch engages associated FCC and places it in CMD mode. If both flight director switches are off, autopilot will engage in CWS Roll and CWS Pitch mode.

FCC DISENGAGE Bar: Pulling down forces all autopilots to disengage, or prevents them from being activated.

APP Switch: Arms or engages the AFDS to capture and track the localizer and glide slope. LOC and G/S are armed (displayed in white on PFD) only prior to actual capture of localizer and glideslope. AFDS can capture localizer or glideslope in any order, and upon capture each will display in green to show that LOC and G/S modes are both active.

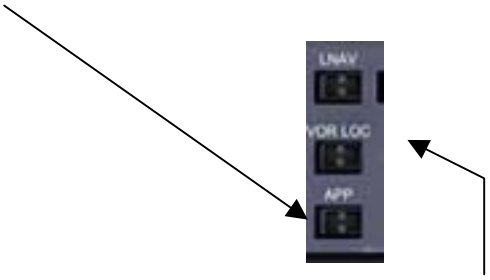
LOC capture can occur when aircraft track is within 120 degrees of the front course, G/S capture can occur when the intercept track angle is within 80 degrees of the localizer course.

Once LOC and G/S are captured, the APP switch will extinguish, indicating that the only way to disengage the APP mode is to follow the steps outlined earlier in this chapter.

APP mode can be terminated prior to localizer or glide slope capture by pushing the APP switch a second time, or by selecting LOC, LNAV or VNAV modes to override APP mode.

APP mode will also disengage if localizer is captured and different roll mode is selected. If the glideslope only has been captured, selection of a different pitch mode will disengage the APP mode.

If TO/GA is selected, or the flight directors are selected OFF at any time, APP mode will disengage.



VOR/LOC Switch: Arms or engages the AFDS to capture and track the localizer. LOC is armed only (displayed in white on PFD) prior to actual localizer capture. The current AFDS roll mode will remain active until localizer capture. LOC display will change to green when LOC mode becomes active upon localizer capture.

LOC mode can be disengaged by pressing the LOC switch a second time prior to LOC capture, or by selecting the flight directors OFF, or engaging the TO/GA mode.

It is generally important not to set the airplane up to violate your clearance limit while being vectored for an approach. When ATC instructs you to “Intercept the Localizer for Runway X” pressing VOR/LOC will intercept the localizer.

When cleared for the approach, pressing APP will allow the aircraft to intercept and descend via the Glideslope.

TCAS II Version 7

Overview: PMDG has partnered with Lee Hetherington, a veteran PMDG Beta tester, to bring you a TCAS II Version 7 logic engine that provides real world TCAS position and resolution advisory information precisely as displayed to airline pilots flying the 737NG.

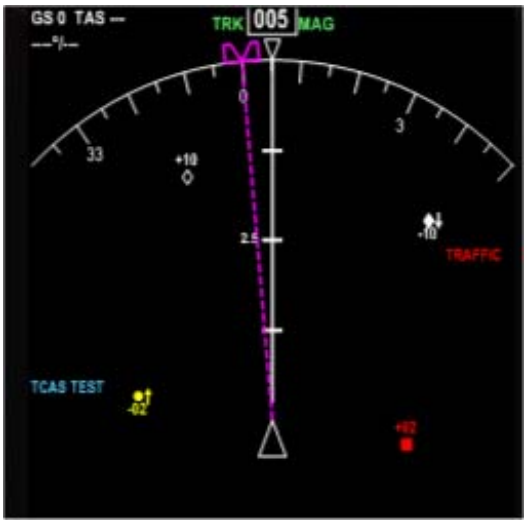
Written by Lee, the TCAS II Version 7 logic engine will be made available by him for many other applications, but we are proud to present his work integrated into the existing PMDG airplane to provide a TCAS simulation truly worthy of the phrase, "As Real as it Gets!"

TCAS is a vital aviation safety tool, and while traditional MSFS based TCAS simulations have served primarily as "aircraft position radar," Lee has teamed with PMDG to bring a TCAS II simulation that will provide Conflict Resolution Advisory information precisely as is done on the aircraft.

What TCAS II Does: TCAS II uses transponder encoded information to predict the closest point of contact for aircraft operating in the surrounding area. If it is apparent that the flight path of two aircraft will conflict, advisory information is provided to the crew in order to direct aircraft away from each other.

By integrating Lee's behavior model, we have been able to provide realistic real time TCAS information to the navigation display in the PMDG 737 cockpit. Resolution advisories are displayed in the format of avoidance boxes and vertical speed commands on the PFD and the VSI. Additionally we have provided aural callouts that are given to crews in order to maximize the effectiveness of escape procedures during a resolution advisory.

TCAS Display: Traffic information is displayed on the navigation display of the PMDG 737. To ensure TCAS is working, you can select TEST on the Transponder mode switch, and a test format will be shown on the navigation display, along with the advisory information, TCAS System Test OKAY."



TCAS range can be adjusted using the ND Range knob on the EFIS MCP. Maximum range for TCAS information is 40nm.

Traffic information displayed on the ND will be displayed using one of four graphic icons to identify the threat level of displayed traffic.

General Traffic not considered to be a conflict.

Proximate traffic within 6nm and +/- 1200ft vertically but not conflicting.

Traffic Advisory:Potential Threat Traffic. "Traffic Traffic" aural warning.

Resolution Advisory: Accompanied by pitch guidance to resolve traffic conflict.

TCAS Operation: TCAS is marvelous in it's simplicity. To receive the collision protection of TCAS, simply test the system prior to takeoff, and place the Transponder Mode selector in the TA/RA switch position to receive Traffic Advisories and Resolution Advisories.

Above/Normal/Below: For effective traffic detection, it is important to manage the TCAS bias. There are three bias modes. Above, Normal and Below. The switch position should reflect the current area of interest. If you are climbing, select ABOVE. During level flight select NORMAL. During descent select BELOW.

ABS/REL: There are two ways that TCAS can provide you with altitude information on displayed traffic. Absolute altitude and Relative altitude. Setting this switch to ABS will show you the current Mode S reported altitude encode for each detected target. REL will display the approximate vertical separation between your current altitude and the target aircraft altitude. REL is generally considered a better setting as the REL information makes it easier to determine whether traffic is above or below and by what distance.

Altitude information is displayed along with each traffic symbol, along with an arrow to indicate whether the conflicting traffic is climbing or descending.

General Traffic: On the 737NG, TCAS is configured to suppress the display of all traffic except for TA and RA qualifying traffic. (Yellow or Red). In principle, this would mean that you should never see conflicting traffic on TCAS.

Not all TCAS installations offer General Traffic Suppression, however and General Traffic information can be useful for maintaining good situational awareness. We have defaulted the TCAS setup to display General Traffic. For perfect realism, you can uncheck the “Show All Non-Threatening Traffic” box under TCAS on the VARIOUS page of the PMDG Styles menu.

Traffic Advisory (TA): A Traffic Advisory should be taken seriously, as it will be the first indication of a potential resolution advisory. A Traffic Advisory will be accompanied by the aural warning “Traffic! Traffic!” The Navigation Display will show the conflict traffic in yellow. This will help to quickly identify the correct relative location and altitude to begin searching.

Resolution Advisory (RA): A resolution advisory is considered to be an aircraft emergency. A resolution advisory will be displayed on TCAS in red, along with an aural command to climb or descend. Resolution advisories are designed to provide maximum vertical spacing between two aircraft that are in conflict with one another. The success of an RA depends upon immediate and decisive action by the crew in accordance with the instructions provided by the RA.

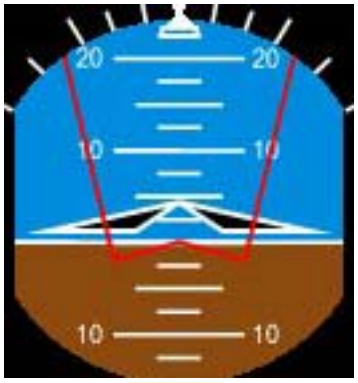
RA instructions are based upon an expectation that within 2.5 seconds of an RA, the crew will perform a +/-0.25G maneuver in accordance with the RA instructions.

On the Vertical Speed indicator, an RA will trigger two color bands

Red: Conflict Area
Green: Target Pitch Zone

The aural warning will give initial instructions for the RA, and the crew should adjust pitch to enter the green band on the VSI. Note that as the RA develops, it may change the location of the green band in order to increase or decrease the needed vertical speed to reflect greater or lower separation of conflicting traffic.

A similar “Conflict Box” is displayed on the attitude indicator to provide unambiguous guidance to the crew during an RA.



This “Conflict Box” is displayed in red and matches safe green band displayed on the Vertical Speed Indicator.

When TCAS has determined that both aircraft are clear of one another, the Conflict Box and colored pitch bands on the Vertical Speed will be removed, along with the aural advisory, “Clear of Conflict.”