button located just below the FCC engage buttons.

Each FCC has an independent power source when activated will provide flight control input directly to the flight controls through three independent hydraulic systems. As such, each FCC can be allowed to have full independent control of all aircraft flight control surfaces, or multiple FCCs can be operated in tandem to provide full fail-safe operation for coupled approaches and autoland.

The pitch and roll cues used by the FCCs to control the aircraft can be displayed on the Primary Flight Display by selecting either the Captains or First Officer's Flight Director switch to ON.

(The F/D switches are located on both ends of the AFDS/MCP, one each for the captain and first officer.)

Selecting the Flight Director to ON will cause the AFDS to display it's pitch and roll cues directly on the Primary Flight Display. The F/D will provide pitch and roll cues that the crew can follow while flying the aircraft by hand, or these cues can be used to provide direct monitoring of autopilot commands to the flight controls.

The flight director steering cues can be displayed in two different formats, depending upon user preference.

The most intuitive format is the Pitch/Roll bar display because it provides and independent pitch bar, and an independent roll bar overlaid upon the Primary Flight Display.
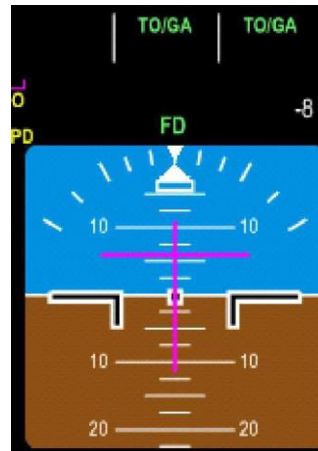
The second format that can be used is a single cue format known as a "Flying V" or "Flying Wing." While less intuitive for beginners this type of flight director is actually easier to use than the pitch/roll bars above.
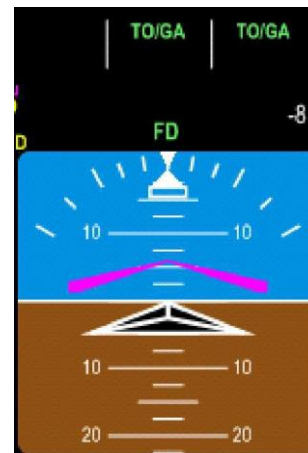
(*You can choose between your desired flight director format by using the PMDG/OPTIONS menu item within Microsoft Flight Simulator. See Chapter 00_Introduction for more information..*)

AFDS Mode Control Panel: The Flight Director is a wonderful tool for reducing pilot workload, but in order to function effectively, the crew must be skilled at instructing the flight director as to the desired flight path.

The Flight Director is controlled by the crew through Autopilot Flight Director System/Mode Control Panel (AFDS/MCP).

The AFDS/MCP is located on the glare shield, and provides direct control of all AFDS functions.

The AFDS/MCP has lighted function switches which allow the crew to control which modes are being used by the autopilot/flight director. There switches are grouped by function, primarily SPEED, ROLL and PITCH.

The AFDS/MCP can sometimes be confusing for pilots unaccustomed to fully integrated autopilots but it is simple to remember that the AFDS/MCP allows the crew to tell the flight director how to manage speed, pitch and roll in order to navigate the airplane along the desired flight path.

(Modes that can be used are described in detail later in this chapter.)

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

Any activated mode can be disengaged by selecting a different command mode on the MC, or by disengaging all operating autopilots and deselecting the flight director.

If VNAV, LNAV, LOC or APP modes are armed, the mode can be disengaged by pressing the associated switch a second time.

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. When fully coupled for an approach 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 through an individual hydraulic system. The three autopilot servo systems are powered using hydraulic systems 1, 2, and 3.

If only one autopilot is engaged, it is capable of controlling the pitch and roll axes of flight. In this mode, the yaw dampers provide for yaw control when the aircraft receives a roll command from the FCC, resulting in fully coordinated flight using just one autopilot. In the event of a failure affecting the engaged single autopilot, the failure will be announced on the PFD by an amber line drawn through the autopilot mode. An EICAS warning message and alert tones will also alert the crew to such a failure.

If multiple FCCs are engaged, (two or three) and the AFDS has entered approach mode, the FCCs combine to provide pitch, roll and yaw control. Full rudder control is maintained and will automatically provide runway alignment at touchdown, as well as yaw compensation input in the event of an engine failure during a precision approach.

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 all three FCCs occurs on approach, an autopilot disconnect will result. If a 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 autopilot control of the aircraft in three separate regimes:

- Autothrottle
- Roll Mode
- Pitch Mode

During flight, the status of each of these autopilot modes is displayed on the primary flight display at all times. The AFDS mode annunciator provides the crew with important information regarding the current and armed modes for the autothrottle, roll and pitch modes. The lower portion of the AFDS also displays the current command mode of the AFDS system.

AUTOTHROTTLE   ROLL   PITCH

AUTOPILOT FLIGHT DIRECTOR MODE ANNUNCIATOR
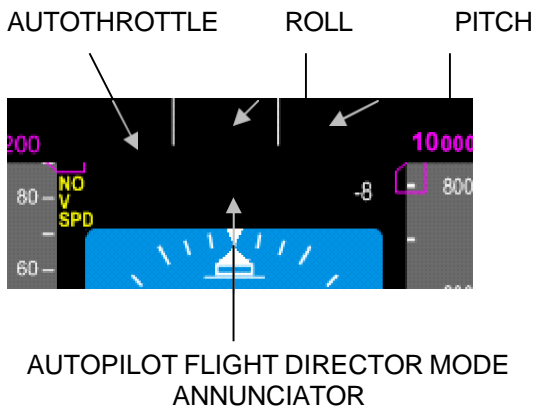
AUTOTHROTTLE Command Modes:
While thrust can be set manually by the crew at any time, the autothrottle is an efficient and precise method of maintaining accurate and efficient use of engine power throughout the flight envelope. Autothrottle modes which may be announced of the AFDS mode annunciator are:

THR: Thrust autothrottle mode. Thrust setting is based on FMC calculated thrust requirements to maintain a commanded vertical speed such as in a climb to altitude.

THR REF: Thrust is set to maintain current thrust limit setting as calculated/determined through FMC THRUST LIM page. Thrust

limit is displayed on upper EICAS display above engine indications.

IDLE: Throttles in transit to idle thrust position.

HOLD: Throttles set but disengaged from autothrottle servo in order to protect against uncommanded thrust setting changes, as in during takeoff roll.

SPD: Speed autothrottle mode. Thrust is set to maintain a commanded aircraft speed. Most often associated with VNAV managed climb or descent modes where pitch and power are modulated to target a particular aircraft speed, not a particular climb/descent performance. 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.

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 AFDS mode annunciator are:

TO/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 and behaviors selected via the options menu.

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.

HDG HOLD: Commands bank to hold present heading. If current bank angle is greater than 15⁰, will hold heading at time wings are level.

LOC: Commands bank to capture localizer when intercept track does not exceed +/- 60⁰. Once captured, will command bank to maintain localizer.

ROLLOUT: Mode will announce on passing 1500 feet AGL and engage at 5 feet AGL. Commands to follow runway centerline on touchdown.

ATT: Commands bank angle to maintain current bank at time first Flight Director switch is selected on if Flight Directors and Autopilots have been off.

PITCH Command Modes: Pitch mode commands aircraft pitch to maintain altitude, vertical speed, 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 becomes a powerful tool to manage climbs and descents to high degrees of accuracy and efficiency, as the autopilot will use both pitch and thrust to maintain commanded airspeed while navigating a vertical climb or descent path. Pitch modes which may be announced on the AFDS mode annunciator are:

TO/GA: Commands pitch angle required for takeoff or go around. On ground, mode is armed and will command for 8⁰ nose up pitch, followed by required flight director climb pitch after ground clearance.

VNAV: VNAV armed to engage on passing 400 feet AGL.

VNAV SPD: Commands pitch up/down to maintain selected airspeed.

VNAV PTH: Commands pitch up/down to maintain selected FMC altitude or FMC calculated VNAV descent path.

VNAV ALT: Commands pitch up/down to maintain MCP commanded altitude.

FLCH SPD: Commands pitch to maintain speed selected in MCP IAS/Mach window during an altitude change. Will change to ALT when MCP altitude is captured.

V/S: Maintains vertical speed selected in MCP V/S window. Will change to ALT when MCP commanded altitude is captured.

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

G/S: Commands pitch to maintain glideslope when intercept track does not exceed +/- 40⁰ of front course. Will follow glideslope once engaged.

FLARE: Announced below 1500 feet, will engage between 60-40 feet AGL. Commands pitch to reduce sink rate. Disengages at touchdown and lowers nosewheel slowly to runway.

AFDS Command Modes: The status of the entire AFDS system is also displayed on the AFDS 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.

CMD: Any autopilot is selected ON and is properly engaged.

LAND 2: Displayed below 1500 AGL to advise crew of autoland degradation due to 1 autopilot failure or being out of synch. Approach and landing is being managed by remaining two autopilots.

LAND 3: Displayed below 1500 AGL to advise crew that all three autopilots have engaged and are coupled for an autoland approach.

NO AUTOLAND: Advises crew of loss of autoland system due to system fault or autopilot failure. No FLARE or ROLLOUT modes are available.