

SECTION 3 AUTOMATIC FLIGHT CONTROL SYSTEM (OPTIONAL)



NOTE: The approved Pilot's Operating Handbook (POH) always supersedes the information in this Pilot's Guide.



NOTE: Refer to the approved Pilot's Operating Handbook (POH) for emergency procedures.



NOTE: A GMC 507 controller is required for GFC 500 AFCS functionality.

3.1 AFCS SYSTEM ARCHITECTURE

An Automatic Flight Control System (AFCS) is typically comprised of two major components: A Flight Director (FD) and Autopilot servos. The Flight Director provides pitch and roll commands to the autopilot servos. These pitch and roll commands are displayed on the PFD Page as Command Bars. When the Flight Director is active the pitch and roll commands can be hand-flown by the pilot or when coupled with the autopilot, the autopilot servos drive the flight controls to follow the commands issued by the Flight Director. The Flight Director operates independently of the autopilot servos, but in most cases the autopilot servos can not operate independent of the Flight Director.

3.1.1 AUTOPILOT AND YAW DAMPER OPERATION

The autopilot and optional yaw damper operate the flight control surface servos to provide automatic flight control. The autopilot controls the aircraft pitch and roll attitudes following commands received from the flight director. Pitch, Roll, and Yaw (if installed) autotrim provides trim commands to each servo to relieve any sustained effort required by the servo(s). Autopilot operation is independent of the optional yaw damper.

The optional yaw damper reduces Dutch roll tendencies, coordinates turns, and provides a steady force to maintain directional trim. It can operate independently of the autopilot and may be used during normal hand-flight maneuvers. Yaw rate commands are limited to 6 deg/sec by the yaw damper.

3.1.2 FLIGHT CONTROL

Pitch and roll commands are provided to the servos based on the active flight director modes. Yaw commands are provided by the yaw servo. Servo motor control limits the maximum servo speed and torque. This allows the servos to be overridden in case of an emergency.

3.1.3 PITCH AXIS AND TRIM

The autopilot pitch axis uses pitch rate to stabilize the aircraft pitch attitude during flight director maneuvers. Flight director pitch commands are rate and attitude-limited, combined with pitch damper control, and sent to the pitch servo motor. The pitch servo measures the output effort (torque) and optionally provides this signal to the pitch trim motor. The pitch servo commands the pitch trim motor to reduce the average pitch servo effort.

3.1.4 ROLL AXIS

The autopilot roll axis uses roll rate to stabilize aircraft roll attitude during flight director maneuvers. The flight director roll commands are rate- and attitude-limited, combined with roll damper control, and sent to the roll servo motor.

3.1.5 YAW AXIS

The yaw damper uses yaw rate and roll attitude to dampen the aircraft's natural Dutch roll response. It also uses lateral acceleration to coordinate turns and reduce or eliminate the need for the pilot to use rudder pedal force to maintain coordinated flight during climbs and descents.

3.1.6 G5 AFCS STATUS BOX

The AFCS status box displays Autopilot (AP) and Flight Director (FD) mode annunciations on the PFD Page.

Autopilot (AP) status is displayed middle of the G5 Autopilot Status Box. Lateral modes are displayed on the left, and vertical modes are displayed on the right. Armed modes are displayed in white and active in green.



Figure 3-1 Autopilot Status Box

3.2 GFC 500 AFCS CONFIGURATION

The following figure provides an overview of the GFC 500 system:



Figure 3-2 Core GFC 500 System

In addition to the core autopilot functions, the GFC 500 incorporates an independent monitor that uses independent inertial sensors to determine what is happening to the aircraft. By monitoring aircraft attitude, attitude rate and accelerations using these independent sensors, the monitor can shut down the autopilot if it determines the aircraft has exceeded predetermined limits.

The minimum configuration for the G500 system is a G5 configured as an Attitude Indicator and two GSA 28 servos (in the pitch and roll positions). This will provide Pitch, Roll, Track, and Air Data modes only.

If navigation modes are desired, a G5 connected to a compatible navigation source (e.g., a GTN 6XX/7XX) is an option.

The basic GFC 500 system is comprised of the following equipment:

System Overview

Flight Instruments

AFCS

Additional Features

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3.2.1 GMC 507 MODE CONTROLLER

The panel-mounted GMC 507 serves as the primary user interface for the GFC 500. The GMC 507 provides autopilot and Flight Director mode selection buttons and a wheel for convenient adjustment of the pitch, airspeed, and vertical speed references. The G5 PFD Page displays active and armed modes and reference values.

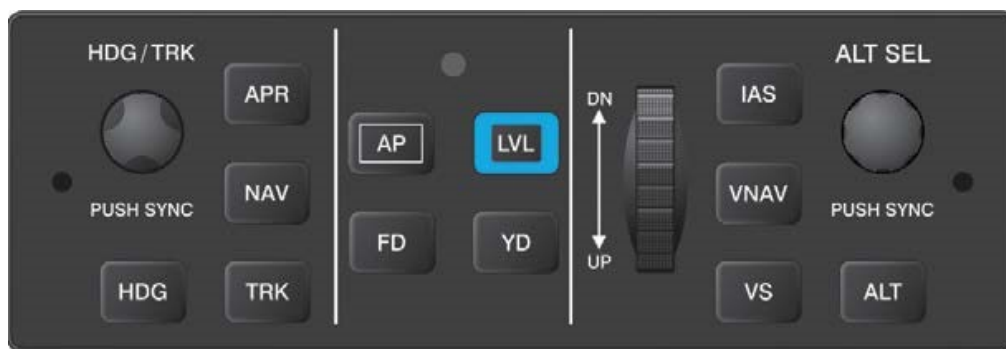


Figure 3-3 GMC 507

3.2.2 GSA 28 SERVO

The GSA 28 servos provide control surface actuation as part of the autopilot, yaw damper, electric trim, and ESP functions. The GSA 28 is a 'smart' servo which performs most of the autopilot processing functions and offers many inherent safety features. The brushless motor and electronic torque and speed sensing capabilities provide smooth, reliable operation. The GSA 28 design incorporates an internal engagement solenoid and a gear train that allows the motor to be backdriven by the pilot in case the solenoid fails to disengage. This eliminates the need for a mechanical slip clutch along with the associated performance limitations and maintenance requirements.



Figure 3-4 GSA 28



NOTE: Refer to the G5 Installation Manual for information on installing and configuring the G5 Integrated Autopilot Interface.

3.2.3 GFC 500 MESSAGES AND ANNUNCIATIONS

Table 3-1 GFC 500 Messages and Annunciations

Autopilot Messages	
AFCS Controller Key Stuck	The system has sensed a key input on the GMC 507 for 30 seconds or longer.
AFCS Controller Audio Database Missing	The audio database is missing from the GMC 507. The aural voice alerts will not be heard.
Servo Clutch Fault	One or more autopilot servos has a stuck clutch. The servo needs service.
Servo Trim Input Fault	The inputs to the trim system are invalid. The trim system needs service.
Autopilot Annunciations	
AFCS	Autopilot has failed. Autopilot and trim are inoperative and flight director is not available.
AP	Autopilot normal disconnect.
AP	Autopilot abnormal disconnect.
AP	Autopilot has failed. The autopilot is inoperative. FD modes may still be available.
MAXSPD	Autopilot Overspeed Protection mode is active. Autopilot will raise the nose to limit the aircraft's speed.
MINSPD	Autopilot Underspeed Protection mode is active. Autopilot will lower the nose to prevent the aircraft's speed from decreasing.
PFT	Autopilot preflight test is in progress.
PTRIM	Pitch Trim Fail – Manual Electric Pitch Trim is inoperative.
TRIM DOWN	Elevator Trim Down – Autopilot is holding elevator nose down force. The pitch trim needs to be adjusted nose down.
TRIM UP	Elevator Trim Up – Autopilot is holding elevator nose up force. The pitch trim needs to be adjusted nose up.

3.3 AFCS OPERATION

The AFCS provides the following main operating functions:

- **Flight Director (FD)** — The Flight Director function provides pitch and roll commands needed to guide the aircraft toward the active reference selected by the pilot. These pitch and rolls commands are displayed on the G5 PFD Page as Command Bars. When the Flight Director is active the pitch and roll commands can be hand-flown by the pilot. When the Autopilot is engaged the autopilot servos drive the flight controls to follow the commands issued by the Flight Director.
- **Autopilot (AP)** — The Autopilot function is provided by servo actuators which move the flight control surfaces in response to Flight Director steering commands, aircraft attitude, and airspeed. The optional pitch auto-trim function serves to relieve any sustained effort required by the pitch servo to keep the aircraft in trim.
- **Yaw Damper (YD)** — The optional Yaw Damper function provides Dutch Roll damping, assists in turn coordination, and provides a steady force to help maintain directional trim. If installed the YD comes on when the autopilot is engaged. It can be turned on/off independent of the autopilot and may be used during normal hand-flying maneuvers.
- **Manual Electric Trim (MET)** — The optional Manual Electric Trim uses the same servo as the auto-trim function and allows the pilot to command trim via a trim switch when the autopilot is not engaged. The MET function does not preclude the use of the aircraft's basic mechanical trim system.
- **Electronic Stability & Protection (ESP) (GFC 500)** — The ESP function provides a soft barrier to keep the aircraft within the desired operating envelope when the autopilot is not engaged. When the AFCS senses that the aircraft is near the defined operating limit in pitch attitude, roll attitude, high airspeed, or low airspeed, the ESP function will automatically engage one or more servos to nudge it back to the nominal operating envelope. While ESP utilizes the same sensors, processors, and actuators as the AFCS autopilot it is a separate mutually exclusive function. ESP can be easily overpowered by the pilot and can be disabled using the **AP DISC / TRIM INT** button.

3.3.1 GMC 507 CONTROLS

Table 3-2 AFCS Controls

① HDG Key	Selects/deselects Heading Select Mode. (Used for TRK Mode in installations without a magnetometer)
② NAV Key	Selects/deselects Navigation Mode. Cancels GS Mode if LOC Mode is either active or armed. Cancels GP Mode if GPS Mode is either active or armed. Cancels LOC Mode if GPS Mode is active and LOC Mode is armed.
③ AP Key	Engages/disengages the autopilot
④ LVL (Level) Key	Engages the autopilot (if the autopilot is disengaged) in level vertical and lateral modes
⑤ NOSE UP/DN Wheel	Adjusts the vertical mode reference in Pitch Hold, Vertical Speed, Indicated Airspeed, and Altitude Hold modes
⑥ IAS Key	Selects/deselects Indicated Airspeed Mode
⑦ ALT Key	Selects/deselects Altitude Hold Mode
⑧ VNAV Key	Selects/deselects Vertical Path Tracking Mode for Vertical Navigation flight control
⑨ VS Key	Selects/deselects Vertical Speed Mode
⑩ YD Key	Engages/disengages the yaw damper
⑪ FD Key	Activates/deactivates the flight director only Pressing once turns on the director in the default vertical and lateral modes. Pressing again deactivates the flight director and removes the Command Bars. If the autopilot is engaged, the key is disabled.
⑫ APR Key	Selects/deselects Approach Mode (GP or GS mode only)
⑬ HDG/TRK Knob	Selects the desired Heading/Track
⑭ ALT SEL Knob	Selects the desired Altitude setting
⑮ TRK Key	Selects/deselects Track (TRK) Mode.

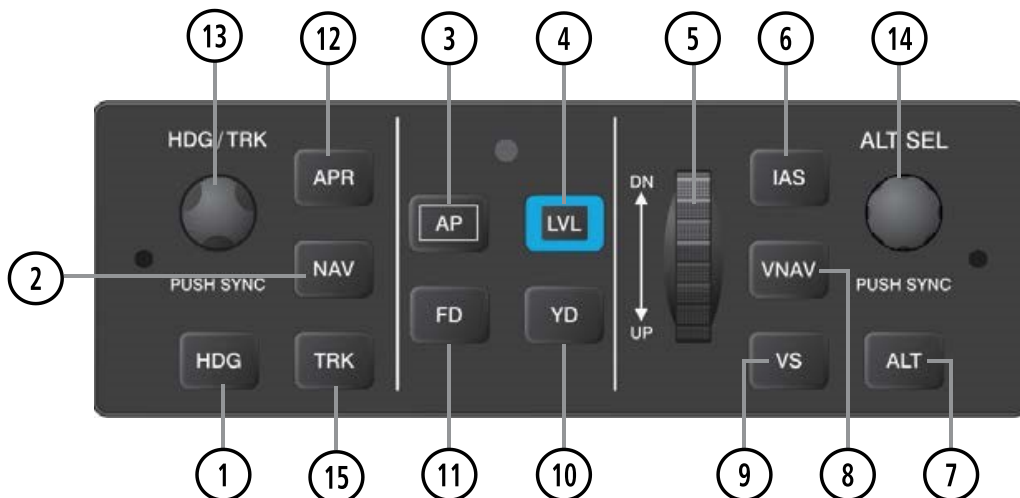


Figure 3-5 GMC 507 AFCS Control Unit

The following AFCS controls are located separately from the G5 and GMC 507 AFCS Control Unit:

Table 3-3 Other AFCS Controls

Control	Action
AP DISC / TRIM INT (Autopilot Disconnect)	An AP DISC / TRIM INT Button is located on the pilot's control stick. Press and release the AP DISC / TRIM INT Button to disengage the autopilot.
Go Around Button (Takeoff/Go Around)	Selects flight director Takeoff or Go Around Mode.
MET Switch (Optional) (Manual Electric Trim)	Used to command manual electric pitch trim.

3.3.1.1 ENGAGING THE AUTOPILOT

ENGAGING THE AUTOPILOT (GMC 507):

An initial press of the **AP** Key on the GMC 507 will activate the Flight Director and engage the autopilot in the default PIT and ROL modes.

3.3.1.2 DISENGAGING THE AUTOPILOT

The Autopilot is manually disengaged by pressing the autopilot disconnect button on the control stick or yoke or by pressing the **AP** Key on the GMC 507. Manual disengagement is indicated by a five-second flashing yellow 'AP' annunciation. Cancel the aural alert by pressing and releasing the **AP** Button again.

In addition, the optional **MET** trim switch will disengage the autopilot.

Automatic disengagement is indicated by a flashing red 'AP' annunciation. Automatic disengagement occurs due to:

- System failure
- Invalid sensor data
- Inability to compute default autopilot modes
- Autopilot internal monitoring detects abnormal behavior

3.3.1.3 OVERPOWERING AUTOPILOT SERVOS

In the context of this discussion, "overpowering" refers to any pressure or force applied to the pitch controls when the autopilot is engaged. A small amount of pressure or force on the pitch controls can cause the autopilot automatic trim to run to an out-of-trim condition. Therefore, any application of pressure or force to the controls should be avoided when the autopilot is engaged.

Overpowering the autopilot during flight will cause the autopilot's automatic trim to run, resulting in an out-of-trim condition or cause the trim to hit the stop if the action is prolonged. In this case, larger than anticipated control forces may be required after the autopilot is disengaged.

The following steps should be added to the preflight check:

- 1) Check for proper autopilot operation and ensure the autopilot can be overpowered.
- 2) Note the forces required to overpower the autopilot servo clutches.

3.3.2 FLIGHT DIRECTOR OPERATION



NOTE: Refer to the Installation Manual for AFCS setup information.

The flight director function provides pitch and roll commands to the pilot and autopilot, which are displayed on the PFD Page. With the flight director active, the aircraft can be hand-flown to follow the path shown by the Command Bars. The Flight Director has the following maximum commands: pitch (-15°, +20°) and roll (30°) angles.

3.3.2.1 ACTIVATING THE FLIGHT DIRECTOR

An initial press of a key listed in the table below (when the flight director is not active) activates the flight director in the listed modes. The flight director may be turned off and the Command Bars removed from the display by pressing the **FD** Key again. The **FD** Key is disabled when the autopilot is engaged.

Table 3-4 Flight Director Activation (GMC 507)

Control Pressed	Modes Selected			
	Lateral		Vertical	
FD Key	Roll Hold (default)	ROL	Pitch Hold (default)	PIT
AP Key	Roll Hold (default)	ROL	Pitch Hold (default)	PIT
GA Button	Takeoff (on-ground)	TO	Takeoff (on-ground)	TO
	Go Around (in-air)	GA	Go Around (in-air)	GA
ALT Key	Roll Hold (default)	ROL	Altitude Hold	ALT
VS Key	Roll Hold (default)	ROL	Vertical Speed	VS
VNAV Key	Roll Hold (default)	ROL	Vertical Navigation*	VNAV
IAS Key	Roll Hold (default)	ROL	Indicated Airspeed	IAS
APR Key	Approach**	GPS/VOR/ LOC/ILS	Pitch Hold (default)	PIT
NAV Key	Navigation**	GPS/VOR/ LOC	Pitch Hold (default)	PIT

Table 3-4 Flight Director Activation (GMC 507)

Control Pressed	Modes Selected			
	Lateral		Vertical	
HDG Key	Heading Select	HDG	Pitch Hold (default)	PIT
TRK Key	Track Select	TRK	Pitch Hold (default)	PIT
LVL Key	Level Hold	LVL	Level Hold	LVL

*Must be receiving VNAV data from a GPS navigator.

**The selected navigation receiver must have an active GPS course before NAV or APR Key press activates flight director.

3.3.2.2 FLIGHT DIRECTOR MODES

Flight director modes are normally selected independently for the pitch and roll axes. Unless otherwise specified, all mode keys are alternate action (i.e., press on, press off). In the absence of specific mode selection, the flight director reverts to the default pitch and/or roll modes.

Armed modes are annunciated in white and active in green in the AFCS Status Box. Under normal operation, when the control for the active flight director mode is pressed, the flight director reverts to the default mode(s) for the axis(es). Automatic transition from armed to active mode is indicated by the white armed mode annunciation moving to the green active mode field and flashing for 10 seconds.

If the information required to compute a flight director mode becomes invalid or unavailable, the flight director automatically reverts to the default mode for that axis. A flashing yellow mode annunciation and annunciator light indicate loss of sensor or navigation data required to compute commands. When such a loss occurs, the system automatically begins to roll the wings level (enters Roll Hold Mode) or maintain the pitch angle (enters Pitch Hold Mode), depending on the affected axis. The flashing annunciation stops when the affected mode key is pressed or another mode for the axis is selected. If after 10 seconds no action is taken, the flashing annunciation stops.

The flight director is automatically disabled if the attitude information required to compute the default flight director modes becomes invalid or unavailable.

3.3.2.3 COMMAND BARS

Upon activation of the flight director, Command Bars are displayed in magenta on the PFD Page. If the aircraft is being flown by hand, the command bars are displayed hollow. The Command Bars do not override the Aircraft Symbol. The Command Bars move together vertically to indicate pitch commands and bank left or right to indicate roll commands.

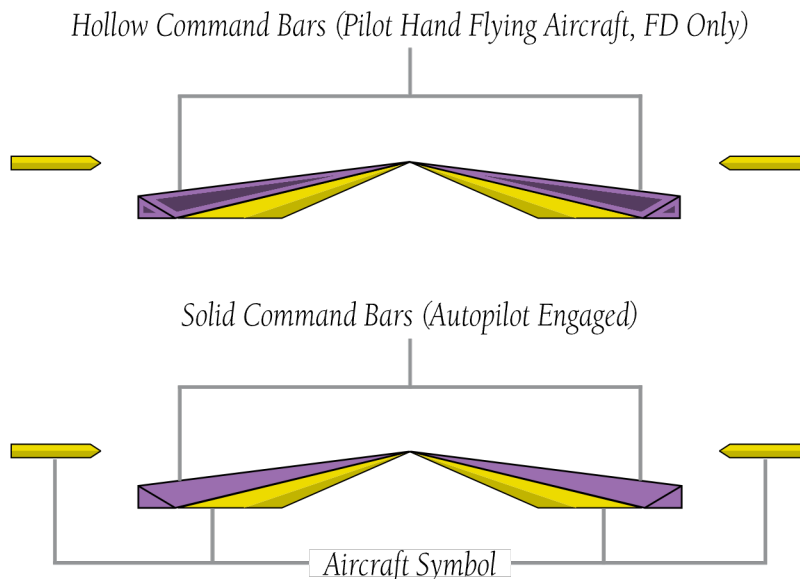


Figure 3-6 Command Bars (Single Cue Flight Director)

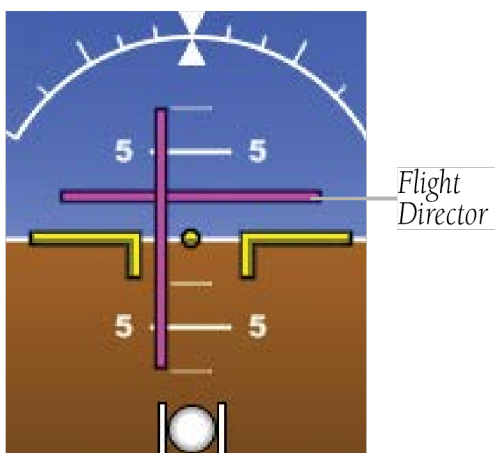


Figure 3-7 Flight Director (Dual Cue)

If the attitude information being sent to the flight director becomes invalid or unavailable, the Command Bars are removed from the display.

3.3.3 VERTICAL MODES

The table lists the vertical modes with their corresponding controls and annunciations. The mode reference is displayed next to the active mode annunciation for Altitude Hold, Vertical Speed, and Indicated Airspeed modes. The **NOSE UP/DN** Wheel can be used to change the vertical mode reference while operating under Pitch Hold, Vertical Speed, Indicated Airspeed, or Altitude Hold modes. Increments of change of values for each of these references using the **NOSE UP/DN** Wheel, are also listed in the table.

Table 3-5 Flight Director Vertical Modes

Vertical Mode	Description	Control	Annunciation	Reference Change Increment
Pitch Hold	Holds the current aircraft pitch attitude; may be used to climb/descend to the Selected Altitude	(default)	PIT	0.5°
Selected Altitude Capture	Captures the Selected Altitude	*	ALTS	10 ft
Altitude Hold	Holds the current Altitude	ALT Key	ALT	
Vertical Speed	Maintains the current aircraft vertical speed; may be used to climb/descend to the Selected Altitude	VS Key	VS	100 fpm
Indicated Airspeed (IAS)	Maintains the current aircraft airspeed in IAS while the aircraft is climbing/descending to the Selected Altitude	IAS Key	IAS	1 kt

Table 3-5 Flight Director Vertical Modes

Vertical Mode	Description	Control	Annunciation	Reference Change Increment
Vertical Navigation	Captures and tracks descent legs of an active vertical profile	VNAV Key	VNAV	
Glidepath	Captures and tracks the GPS WAAS glidepath on approach	APR Key	GP	
Glideslope	Captures and tracks the ILS glideslope on approach		GS	
Takeoff	Commands a constant pitch angle and wings level on-ground in preparation for takeoff	GA Button	TO	
Go Around	Commands a constant pitch angle and wings level in the air		GA	

* *ALTS armed automatically when PIT, VS, IAS, TO, or GA active, and under VNAV when Selected Altitude is to be captured instead of VNAV Target Altitude*

PITCH HOLD MODE (PIT)

When the flight director is activated (**FD** key pressed) or when the Autopilot is activated, Pitch Hold Mode is selected by default. Pitch Hold Mode is indicated as the active vertical mode by the green 'PIT' annunciation. This mode may be used for climb or descent to the Selected Altitude (shown above the Altimeter), since Selected Altitude Capture Mode is automatically armed when Pitch Hold Mode is activated.

In Pitch Hold Mode, the flight director maintains a constant pitch attitude. The pitch reference is set to the aircraft pitch attitude at the moment of mode selection. If the aircraft pitch attitude exceeds the flight director pitch command limitations, the flight director commands a pitch angle equal to the nose-up/down limit.

Changing the pitch reference:

When operating in Pitch Hold Mode, the pitch reference can be adjusted by using the **NOSE UP/DN** Wheel.

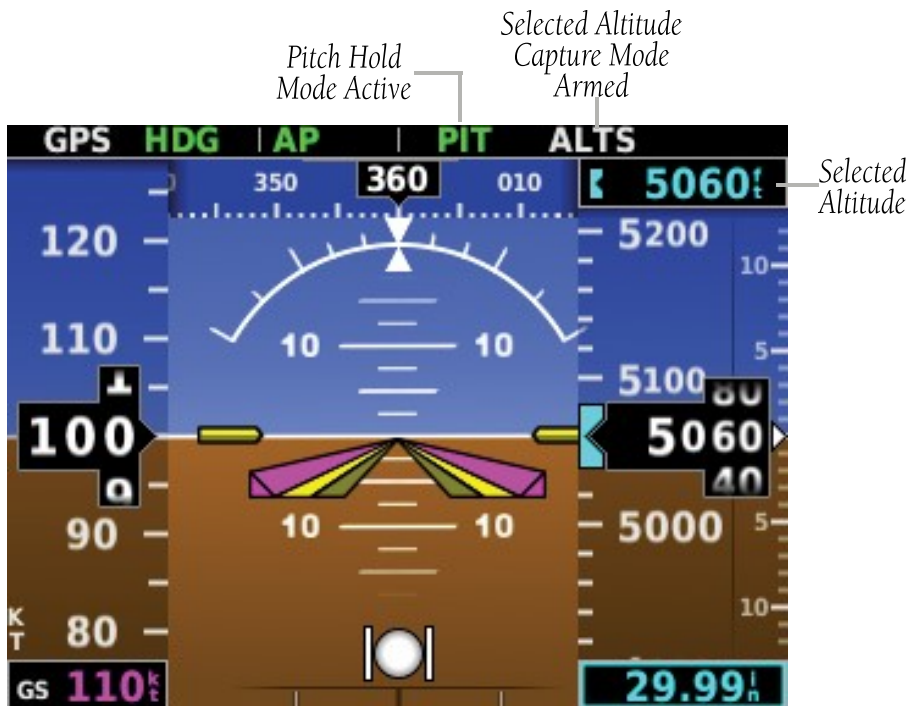


Figure 3-8 Pitch Hold & Selected Altitude Capture Modes

3.3.3.1 SELECTED ALTITUDE CAPTURE MODE (ALTS)

Selected Altitude Capture Mode is automatically armed with activation of the following modes:

- Pitch Hold
- Vertical Speed
- Indicated Airspeed
- TO/Go Around
- Vertical Path Tracking

The white 'ALTS' annunciation indicates Selected Altitude Capture Mode is armed.



Figure 3-9 Selected Altitude Capture Mode (Armed)

As the aircraft nears the Selected Altitude, the flight director automatically transitions to Selected Altitude Capture Mode with Altitude Hold Mode armed. This automatic transition is indicated by the green 'ALTS' annunciation flashing for up to 10 seconds and the appearance of the white 'ALTS' annunciation.

At 50 feet from the Selected Altitude, the flight director automatically transitions from Selected Altitude Capture to Altitude Hold Mode and holds the reference altitude. As Altitude Hold Mode becomes active, the white 'ALTS' annunciation moves to the active vertical mode field and flashes green for 10 seconds to indicate the automatic transition.

Setting the selected altitude:

Use the **ALT SEL Knob** on the GMC 507 to adjust the selected altitude.

Or

- 1) Press the Knob to display the Menu.
- 2) Select **Altitude** and use the Knob to change the Selected Altitude.

Syncing to the current altitude:

Press the Knob on the GMC 507.

Or

- 1) Press the Knob to display the Menu.
- 2) Select **Altitude** and press and hold the Knob to sync the Selected Altitude to the current altitude

Changing the Selected Altitude while Selected Altitude Capture Mode is active causes the autopilot to revert to Pitch Hold Mode with Selected Altitude Capture Mode armed for the new Selected Altitude.

3.3.3.2 ALTITUDE HOLD MODE (ALT)

Altitude Hold Mode can be activated by pressing the **ALT** Key; the AFCS maintains the current aircraft altitude (to the nearest 10 feet) as the Altitude Reference. Altitude Hold Mode active is indicated by a green 'ALT' annunciation in the G5 Autopilot Status Box.

Altitude Hold Mode is automatically armed when in Selected Altitude Capture Mode. Selected Altitude Capture Mode automatically transitions to Altitude Hold Mode when within 50 feet of the Selected Altitude. In this case, the Selected Altitude becomes the Altitude Reference.

3.3.3.2.1 CHANGING THE ALTITUDE REFERENCE

When operating in Altitude Hold Mode, the Altitude Reference can be adjusted in the following ways:

- The Altitude Reference can be adjusted up or down in 10-foot increments by rolling the **NOSE UP/DN** Wheel. Using this method, up to 200 feet of altitude change can be commanded. To change the Altitude Reference by more the 200 feet, use another vertical mode (PIT, VS) to capture the desired Selected Altitude.



Figure 3-10 Altitude Hold Mode

3.3.3.3 VERTICAL SPEED MODE (VS)

In Vertical Speed Mode, the flight director acquires and maintains a Vertical Speed Reference. Current aircraft vertical speed (to the nearest 100 fpm) becomes the Vertical Speed Reference at the moment of Vertical Speed Mode activation. This mode may be used for climb or descent to the Selected Altitude (shown above the Altimeter) since Selected Altitude Capture Mode is automatically armed when Vertical Speed Mode is selected.

When Vertical Speed Mode is activated by pressing the **VS** Key, 'VS' is annunciated in green in the Autopilot Status Box. The Vertical Speed Reference is also displayed below the Vertical Speed Indicator. A Vertical Speed Reference Bug corresponding to the Vertical Speed Reference is shown on the indicator.



Figure 3-11 Vertical Speed Reference on PFD Page

3.3.3.3.1 CHANGING THE VERTICAL SPEED REFERENCE

Use the **NOSE UP/DN** Wheel to adjust the Vertical Speed Reference in increments of 100 fpm.

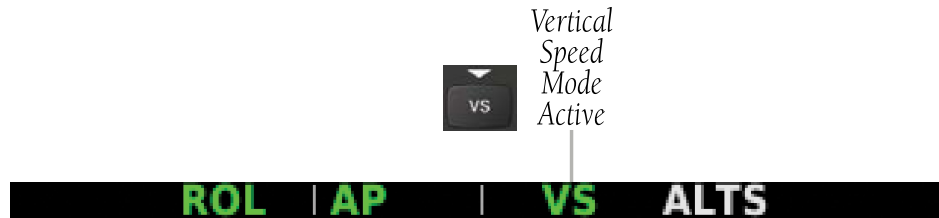


Figure 3-12 Vertical Speed Mode

3.3.3.4 INDICATED AIRSPEED MODE (IAS)

Indicated Airspeed Mode is selected by pressing the **IAS** Key on the GMC. This mode acquires and maintains the Airspeed Reference (IAS) while climbing or descending. When Indicated Airspeed Mode is active, the flight director continuously monitors Selected Altitude, airspeed and altitude.

The Airspeed Reference is set to the current airspeed upon mode activation. Indicated Airspeed Mode is indicated by a green 'IAS' annunciation in the Autopilot Status Box. The Airspeed Reference is also displayed as a light blue bug corresponding to the Airspeed Reference along the airspeed tape.

Engine power must be adjusted to allow the autopilot to fly the aircraft at a pitch attitude corresponding to the desired flight profile (climb or descent) while maintaining the Airspeed Reference.

3.3.3.4.1 CHANGING THE AIRSPEED REFERENCE

The Airspeed Reference (shown in both the Autopilot Status Box and above the Airspeed Indicator) may be adjusted by using the **NOSE UP/DN** Wheel.



Figure 3-13 Indicated Airspeed Reference on PFD Page

3.3.3.5 VERTICAL NAVIGATION MODE (VNAV)

Vertical Navigator Mode (VNAV) is not available for the certified instrument.

3.3.3.6 GLIDEPATH MODE (GP) (WITH EXTERNAL WAAS ENABLED IFR NAVIGATOR ONLY)

Glidepath Mode is used to track a WAAS or other satellite-based augmentation system WAAS generated glidepath. When Glidepath Mode is armed, 'GP' is annunciated in white in the Autopilot Status Box.

Selecting glidepath mode:

- 1) **EXTERNAL NAVIGATOR:** Ensure a GPS approach with vertical guidance (LPV, LNAV/VNAV, LNAV +V) is loaded into the active flight plan. The active waypoint must be part of the flight plan (cannot be a direct-to a waypoint not in the flight plan).
- 2) Ensure that GPS is the selected navigation source.
- 3) Press the **APR** Key on the GMC.



NOTE: Some RNAV (GPS) approaches provide a vertical descent angle as an aid in flying a stabilized approach. These approaches are NOT considered Approaches with Vertical Guidance (APV). Approaches that are annunciated on the HSI as LNAV or LNAV+V are considered Non-precision Approaches (NPA) and are flown to an MDA even though vertical glidepath (GP) information may be provided.



WARNING: When flying an LNAV approach (with vertical descent angle) with the autopilot coupled, the aircraft will not level off at the MDA even if the MDA is set in the altitude preselect.

Upon reaching the glidepath, the flight director transitions to Glidepath Mode and begins to capture and track the glidepath.

Once the following conditions have been met, the glidepath can be captured:

- The active waypoint is at or after the final approach fix (FAF).
- Vertical deviation is valid.
- The CDI is at less than full-scale deviation.
- Automatic sequencing of waypoints has not been suspended.



Figure 3-14 Glidepath Mode

3.3.3.7 GLIDESLOPE MODE (GS)

Glideslope Mode is available for LOC/ILS approaches to capture and track the glideslope. When Glideslope Mode is armed (annunciated as 'GS' in white), LOC Approach Mode is armed as the lateral flight director mode.



NOTE: Glideslope Mode requires a valid GPS position.

Selecting Glideslope Mode:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired localizer frequency.
- 2) EXTERNAL NAVIGATOR: Ensure that LOC is the selected navigation source.
- 3) Press the **APR** Key on the GMC.

Or:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired localizer frequency.
- 2) EXTERNAL NAVIGATOR: Load the approach (LOC, ILS, LDA, SDF, etc) into the flight plan.
- 3) Press the **APR** Key on the GMC.

Once LOC is the navigation source, the localizer and glideslope can be captured. Upon reaching the glideslope, the flight director transitions to Glideslope Mode and begins to capture and track the glideslope.



Figure 3-15 Glideslope Mode

3.3.3.8 GO AROUND (GA) AND TAKEOFF (TO) MODES

Go Around and Takeoff modes are coupled pitch and roll modes and are annunciated as both the vertical and lateral modes when active. In these modes, the flight director commands a constant set pitch attitude and keeps the wings level. The GA Switch is used to activate both modes. The mode entered by the flight director depends on whether the aircraft is on the ground or in the air.

Takeoff Mode provides an attitude reference during rotation and takeoff. This mode can be selected only while on the ground by pushing the **Go Around** Button. The flight director Command Bars assume a wings-level, pitch-up attitude.

Pressing the **Go Around** Button while in the air activates the flight director in a wings-level, pitch-up attitude, allowing the execution of a missed approach or a go around. Go Around Mode arms Selected Altitude Capture Mode automatically when the altitude preselect bug is set at least 100 ft above the current altitude, and attempts to modify the aircraft attitude (i.e., with the **NOSE UP/DN** Wheel) will result in reversion to Pitch and Roll Hold modes.

3.3.4 LATERAL MODES

The following table lists the lateral modes and respective control(s) and annunciation. Refer to the vertical modes section for information regarding Takeoff and Go Around Modes.

Table 3-6 Flight Director Lateral Modes

Lateral Mode	Description	Control	Annunciation
Roll Hold	Holds the current aircraft roll attitude or rolls the wings level, depending on the commanded bank angle	(default)	ROL
Heading	Captures and tracks the Selected Heading	HDG Key	HDG
Track	Captures and tracks the Selected Ground Track	TRK Key	TRK
Navigation, GPS	Captures and tracks the selected navigation source (GPS, VOR, LOC)	NAV Key	GPS
Navigation, VOR Enroute Capture/ Track			VOR
Navigation, LOC Capture/Track (No Glideslope)			LOC
Approach, GPS	Captures and tracks the selected navigation source (GPS, VOR, LOC, BC)	NAV Key	GPS
Approach, VOR Capture/Track			
Approach, LOC Capture/Track (Glideslope Mode automatically armed)			LOC
Approach, BC Capture/Track			BC
Takeoff	Commands a constant pitch angle and wings level on-ground in preparation for takeoff	Go Around Button	TO
Go Around	Commands a constant pitch angle and wings level in the air		GA

3.3.4.1 ROLL HOLD MODE (ROL)



NOTE: If Roll Hold Mode is activated as a result of a mode reversion, the flight director rolls the wings level.

When the flight director is activated or switched, Roll Hold Mode is selected by default. This mode is annunciated as 'ROL' in the Autopilot Status Box. The current aircraft bank angle is held, subject to the bank angle condition.



Figure 3-16 Roll Hold Mode Annunciation

Table 3-7 Roll Hold Mode Responses

Bank Angle	Flight Director Response
< 6°	Rolls wings level
6 to 20°	Maintains current aircraft roll attitude
> 20°	Limits bank to 20°

3.3.4.2 HEADING SELECT MODE (HDG)



NOTE: A magnetometer is required for Heading Select Mode (HDG).

Heading Select Mode is activated by pressing the **HDG** Key. Heading Select Mode acquires and maintains the Selected Heading. The Selected Heading is shown by a light blue bug on the HSI and in the box on the bottom right of the HSI.

Changing the selected heading:

- 1) Press the Knob to display the Menu.
- 2) Select **Heading** and use the Knob to change the Selected Heading.

Or

Rotate the **HDG/TRK** Knob.

Activating heading mode:

Press the **HDG** Key on the GMC.

Turns are commanded in the same direction as Selected Heading Bug movement, even if the bug is turned more than 180° from the present heading (e.g., a 270° turn to the right). However, Selected Heading changes of more than 330° at a time result in turn reversals.



Figure 3-17 Heading Mode Annunciation

3.3.4.3 TRACK MODE (TRK)

Track Mode is activated by pressing the **HDG** Key or **TRK** Key on the GMC. Track Mode acquires and maintains the Selected Ground Track. The Selected Ground Track is displayed as a magenta bug on the HSI and in the box on the bottom right of the HSI.

Changing the selected ground track:

- 1) Press the Knob to display the Menu.
- 2) Select **Track** and use the Knob to change the Selected Ground Track.

Or

Rotate the **HDG/TRK** Knob.

Activating track mode:

Press the **TRK** Key on the GMC.

Turns are commanded in the same direction as Selected Ground Track Bug movement, even if the bug is turned more than 180° from the present heading (e.g., a 270° turn to the right). However, Selected Ground Track changes of more than 330° at a time result in turn reversals.



Figure 3-18 Track Mode Annunciation



TRK | AP | ALT 6000!

Figure 3-19 Track Mode Annunciation

3.3.4.4 NAVIGATION MODE (GPS, VOR, LOC)



NOTE: The G5 must have a valid GPS position for VOR and LOC Modes.



NOTE: When intercepting a flight plan leg, the flight director gives commands to capture the active leg at approximately a 45° angle to the track between the waypoints defining the active leg. The flight director does not give commands fly to the starting waypoint of the active leg.

Pressing the **NAV** Key selects Navigation Mode. Navigation Mode acquires and tracks the navigation source. The flight director follows GPS roll steering commands when GPS is the navigation source. Navigation Mode can also be used to fly non-precision GPS, VOR, and LOC approaches where vertical guidance is not required.

If the Course Deviation Indicator (CDI) shows greater than one dot when the **NAV** Key is pressed, the selected mode is armed. If the CDI is less than one dot, Navigation Mode is automatically captured when the **NAV** Key is pressed. The armed annunciation appears in white to the left of the active roll mode.



GPS | AP | ALT 6500!

Figure 3-20 Navigation Mode Annunciation

If Navigation Mode is active and either of the following occur, the AFCS reverts to Roll Hold Mode (wings rolled level):

- Active navigation source manually switched
- Navigation input is lost
- GPS reception is lost

3.3.4.5 APPROACHES WITHOUT VERTICAL GUIDANCE



NOTE: The selected navigation receiver must have an active GPS course for the flight director to enter Approach Mode.

Press the **NAV** Key to arm/activate GPS (LNAV only) lateral mode. The lateral mode acquires and tracks the selected navigation source, depending on the loaded approach. Press **NAV** when the CDI is greater than one dot to arm the selected mode (annunciated in white). Press **NAV** when the CDI deviation is less than one dot to activate, capture and track the selected navigation source.

Table 3-8 Approach without Vertical Guidance

Example	Control	Lateral Mode	Annunciation	Description
LNAV	NAV Key	Approach, GPS	GPS	Captures and tracks the selected navigation source (GPS, VOR, LOC, BC)
VOR		VOR Approach Capture/Track	VOR	
LOC		LOC Approach Capture/Track	LOC	
BC		BC Approach Capture/Track	BC	

3.3.4.5.1 GPS APPROACH WITHOUT VERTICAL GUIDANCE

A GPS approach without vertical guidance (LNAV) is flown using GPS NAV Mode.

Selecting a GPS Approach without vertical guidance:

- 1) EXTERNAL NAVIGATOR: Ensure a GPS approach without vertical guidance (LNAV) is loaded into the active flight plan.
- 2) EXTERNAL NAVIGATOR: Ensure the 'GPS' indication is showing in the lower-left corner. If not, press the CDI Key on the navigator.
- 3) EXTERNAL NAVIGATOR: Select and activate the GPS approach using the PROC Key.
- 4) Press the **NAV** Key.
- 5) Adjust the aircraft's pitch axis as required.

3.3.4.5.2 VOR APPROACH

A VOR approach is flown using VOR Mode.

Selecting a VOR Approach:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired VOR frequency.
- 2) EXTERNAL NAVIGATOR: Ensure the 'VLOC' indication is showing in the lower-left corner. If not, press the CDI Key on the navigator.
- 3) Ensure that VOR1 or VOR2 is the selected navigation source on the HSI Page. It should say 'VOR1' or 'VOR2' on the HSI and the needle should be green.
- 4) From the HSI Page, press the Knob to display the Menu.
- 5) Set the inbound approach course. Select **Course** and use the Knob to adjust the course.
- 6) Press or the **NAV** Key on the GMC.

If there is less than half-scale deviation when the **NAV** Key is pressed, VOR Mode will activate (green text), intercept, and track the selected radial. If there is more than half-scale deviation when the **NAV** Key is pressed, VOR Mode will arm (white text) first, then activate when closer to the radial.

- 7) Adjust the aircraft's pitch axis as required.

3.3.4.5.3 LOCALIZER APPROACH (No GS)

LOC Mode is used to fly a localizer only approach (no glideslope).

Selecting LOC Mode for a localizer only approach:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired LOC frequency,
- 2) Ensure the 'LOC1' indication is showing in the lower-left corner. If not, press the CDI Key on the navigator. The HSI should automatically slew the needle to the correct course.
- 3) Press or the **NAV** Key on the GMC.

If the localizer deviation is less than half-scale when the **NAV** Key is pressed, the autopilot will activate LOC Mode and track the localizer, otherwise LOC Mode is armed and the pilot is responsible for intercepting the localizer. In some cases it may be necessary to use HDG Mode with LOC Mode armed to follow a vector to the localizer.

3.3.4.6 GPS APPROACHES WITH LATERAL + VERTICAL GUIDANCE

Press the **APR** Key to arm/activate both lateral and vertical modes for approach. When Glidepath (GP) Mode is armed for a GPS approach with vertical guidance, GPS Mode is automatically armed. Press the **APR** Key when the CDI is greater than one dot to arm the selected modes (annunciated in white). Press the **APR** Key when the CDI deviation is less than one dot to activate, capture and track the selected navigation source.

Table 3-9 Lateral + Vertical Approaches

Example	Control	Modes	Annunciation	Description
LPV, LNAV/VNAV, LNAV+V	APR Key	Lateral: GPS	GPS	Captures and tracks the lateral portion of a GPS approach
		Vertical: Glidepath	GP	Captures and tracks a WAAS approach glidepath
LOC, ILS	APR Key	Lateral: Localizer	LOC	Captures and track the localizer
		Vertical: Glideslope	GS	Captures and tracks the glideslope

3.3.4.7 GPS APPROACH WITH VERTICAL GUIDANCE



NOTE: To cancel Glidepath (GP) Mode without cancelling GPS Mode, **NAV** once. Pressing it a second time cancels GPS Mode.

When Glidepath (GP) Mode is armed for a GPS approach with vertical guidance, GPS Mode is automatically armed.

Selecting a GPS approach with vertical guidance:

- 1) **EXTERNAL NAVIGATOR:** Ensure a GPS approach with vertical guidance (LPV, LNAV/VNAV, LNAV+V) is loaded into the active flight plan.
- 2) **EXTERNAL NAVIGATOR:** Ensure the 'GPS' indication is showing in the lower-left corner. If not, press the CDI Key.

- 3) EXTERNAL NAVIGATOR: Select and activate the GPS approach using the PROC Key.
- 4) Press the **APR** Key.

3.3.4.8 LOCALIZER WITH GLIDESLOPE

LOC Mode (lateral) and GS Mode (vertical) are both armed by pressing the **APR** Key on the GMC. LOC/ILS approach captures are inhibited if the difference between aircraft heading and localizer course exceeds 105°.



NOTE: To cancel Glideslope (GS) Mode without cancelling LOC Mode, press **NAV** once. Pressing it a second time cancels LOC Mode.

Selecting LOC Mode with GS Mode:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired LOC frequency.
- 2) EXTERNAL NAVIGATOR: Ensure the 'LOC1' indication is showing in the lower-left corner. If not, press the CDI Key. The HSI should automatically slew the needle to the correct course.
- 3) Press the **APR** Key on the GMC.

This simultaneously selects LOC Mode and GS (Glideslope) Mode. If the localizer deviation is less than half-scale when the APR Key is pressed, the autopilot will activate LOC Mode and track the localizer, otherwise LOC Mode is armed and the pilot is responsible for intercepting the localizer.

If the following occurs, the autopilot reverts to Roll Hold Mode (wings rolled level):

- Approach Mode is active and the Navigation source is manually switched
- The localizer signal is lost

If the Glideslope signal is lost, GS Mode will revert to Pitch Hold Mode and hold the last pitch attitude.

3.3.4.9 BACKCOURSE APPROACH



NOTE: When making a backcourse approach, set the Selected Course to the localizer front course.

Backcourse Mode captures and tracks a localizer signal in the backcourse direction. Backcourse is indicated by 'BC' in the autopilot status box.

If GS and LOC Mode are armed, the autopilot can only capture the localizer front course, indicated by 'LOC' in the autopilot status box. If only LOC Mode is armed (not GS Mode), the autopilot will capture either the front course or the backcourse based on the angle at which the aircraft intercepts the localizer.

Selecting BC Mode:

- 1) EXTERNAL NAVIGATOR: Tune and activate the desired LOC frequency.
- 2) EXTERNAL NAVIGATOR: Ensure the 'LOC1' indication is showing in the lower-left corner. If not, press the CDI Key.
- 3) EXTERNAL NAVIGATOR: Select the front course on the CDI.
- 4) Press the **NAV** Key on the GMC.

If the aircraft heading is within 75° of the localizer backcourse then BC Mode will be armed. If the aircraft heading is within 105° of the localizer front course, LOC Mode will be armed.

3.3.4.10 LEVEL MODE

Level Mode is coupled in pitch and roll modes and is annunciated as both the vertical and lateral modes when active. Pressing the **LVL** Key engages the autopilot in Level vertical and lateral modes. Level Mode does not track altitude or heading. When the **LVL** Key is pressed all armed and active modes are cancelled and the autopilot and flight director revert to LVL mode for pitch and roll. While in level mode, all other modes are available by pressing the corresponding button.

3.4 GFC 500 AFCS ALERTS

3.4.1 TRIM ALERTS

If the commanded operation cannot be achieved due to the limitations configured, the following messages can be displayed over the pitch ladder. The annunciation is removed once the condition is resolved.



Figure 3-21 TRIM UP Alert



Figure 3-22 TRIM DOWN Alert

Alert Condition	Annunciation	Description
Up-elevator Trim Required	TRIM UP	The autopilot does not have the required elevator authority to reach the desired flight condition.
Down-elevator Trim Required	TRIM DOWN	

Table 3-10 Status Alerts

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3.4.2 SPEED ALERTS

If the remote autopilot unit supports speed alerts and the airspeed limitations configured have been reached, the following messages can be displayed the airspeed tape. The annunciation is removed once the condition is resolved.



Figure 3-23 MAXSPD Alert



Figure 3-24 MINSPD Alert

Alert Condition	Annunciation	Description
High speed Protection	MAXSPD	Autopilot unit will raise the nose to limit the aircraft's speed.
Low speed Protection	MINSPD	Autopilot unit will lower the nose to prevent the aircraft's speed from decreasing.

Table 3-11 Speed Alerts

3.5 ELECTRONIC STABILITY & PROTECTION (ESP) (GFC 500)

System Overview



WARNING: Do not assume ESP will provide stability protection in all circumstances. There are in-flight situations that can exceed the capabilities of ESP technology.



WARNING: A GPS navigator that can provide AGL height data is required for low-air-speed protection.



WARNING: The autopilot (or ESP) will disengage if the roll attitude exceeds 75° or the pitch attitude exceeds 50°.

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Electronic Stability and Protection (ESP) is a feature that is intended to monitor the aircraft and provide control input feedback when necessary to discourage operating the aircraft at potentially unsafe attitudes and/or airspeeds. If enabled, this feature will automatically arm when the aircraft is above 500 feet AGL and the autopilot is not engaged, and disarm when below 200 feet AGL (if AGL height data is unavailable, ESP can be armed on the ground, but low-air-speed protection will not be available).

When selected, ESP engages automatically when the aircraft approaches or exceeds one or more predetermined airspeed or attitude limitations. Stability protection for each flight axis is provided by the autopilot servos, which apply force to the appropriate control surface(s) to discourage pilot control inputs that would cause the aircraft to exceed the normal or "protected" flight envelope. This is perceived by the pilot as resistance to control movement in the undesired direction when the aircraft approaches a steep attitude, and/or the airspeed is below the minimum or above the maximum configured airspeed.

As the aircraft deviates further from the normal attitude and/or airspeed, the force increases proportionally (up to an established maximum) to encourage control movement in the direction necessary to return to the normal attitude and/or airspeed range.

When ESP has been engaged for more than 10 seconds (cumulative; not necessarily consecutive seconds) of a 20-second interval, the autopilot can be configured to engage with the flight director in Level Mode, bringing the aircraft into level flight. An aural "Engaging Autopilot" alert is played and the flight director mode annunciation will indicate 'LVL' for vertical and lateral modes.

Level mode as activated by ESP is limited by altitude. ESP will not be able to activate Level mode until the aircraft climbs above 2000 feet AGL. ESP will be locked out of automatically activating Level mode after the aircraft descends below 1500 feet AGL as well. Also note that Level mode as activated by ESP is different than manually selected Level mode. Manually selected Level mode is not limited by altitude at all.



NOTE: If AGL height data is unavailable automatic engagement of Level mode is not supported.

ESP is enabled or disabled from the PFD Page Menu.

Enabling/Disabling ESP using the G5 Menu:

- 1) From the PFD Page, press the **Knob** to display the Menu.
- 2) Turn the **Knob** to highlight **ESP**.
- 3) Press the **Knob** to enable or disable ESP.



Figure 3-25 AFCS (ESP Enabled)

3.5.1 ROLL ENGAGEMENT

System Overview

Roll Limit Indicators displayed on the roll scale are configurable between 45° and 60° right and left, indicating where ESP will engage. As roll attitude exceeds the configured limit, ESP will engage and the Roll Limit Indicators will move to 15° less than the configured ESP bank limit. The Roll Limit Indicator now indicates where ESP will disengage as roll attitude decreases.

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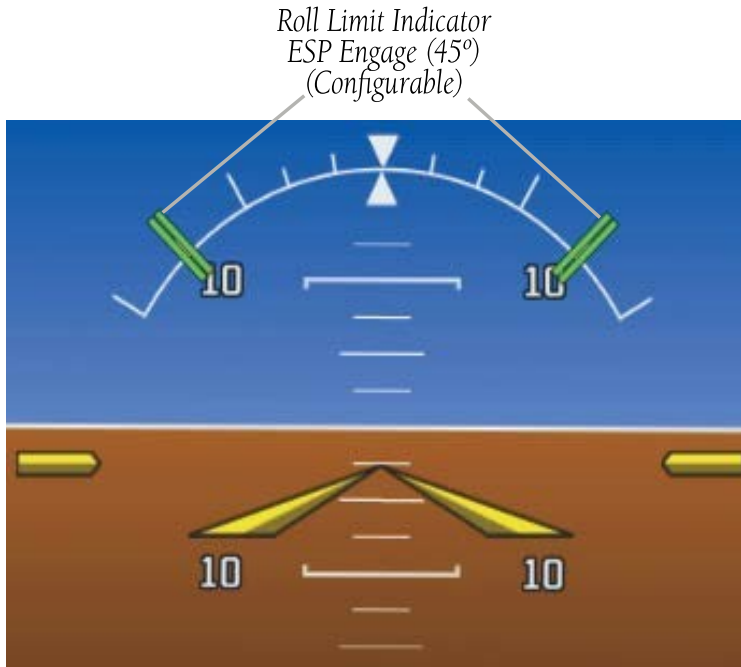


Figure 3-26 ESP Roll Engagement Indication (ESP Enabled but NOT Engaged)

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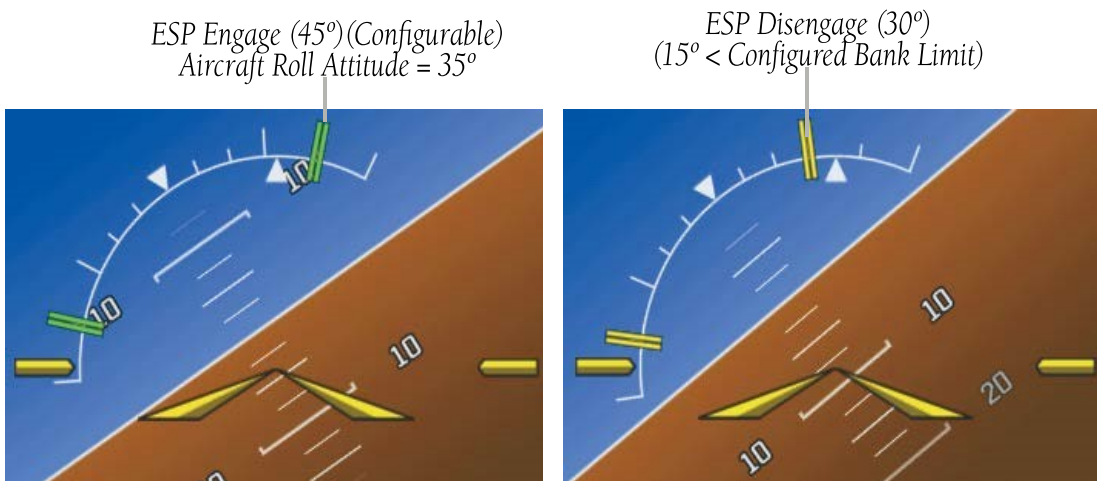


Figure 3-27 Roll Increasing to ESP Engagement

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Once engaged, the torque applied by ESP is at its maximum when bank angle is 15° more than the configured bank limit, and tapers to the minimum applied torque when the bank angle is 15° less than the configured bank limit. The force increases as roll attitude increases and decreases as roll attitude decreases. The applied force is intended to encourage pilot input to return the airplane to a more normal roll attitude. When beyond 15° of the configured bank limit, the maximum torque is held until the aircraft returns inside the protected envelope.

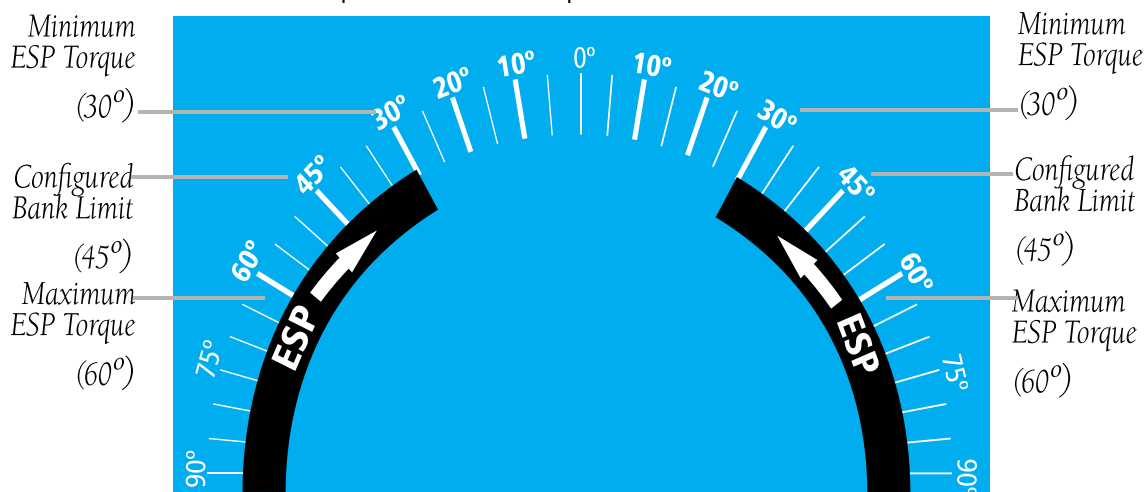


Figure 3-28 ESP Roll Operating Range When Engaged
(Force Increases as Roll Increases & Decreases as Roll Decreases)

3.5.2 PITCH ENGAGEMENT

ESP pitch engagement is configurable between 10° and 25° nose-up and between 5° and 25° nose-down. Once engaged, the torque applied by ESP is at its maximum when pitch is 5° more than the configured nose-up and nose-down pitch limits, and tapers to the minimum applied torque when pitch is 5° less than the configured nose-up and nose-down pitch limits. When beyond 5° of the configured pitch limit, the maximum torque is held until the aircraft returns inside the protected envelope.

The opposing force increases or decreases depending on the pitch angle and the direction of pitch travel. This force is intended to encourage movement in the pitch axis in the direction of the normal pitch attitude range for the aircraft.

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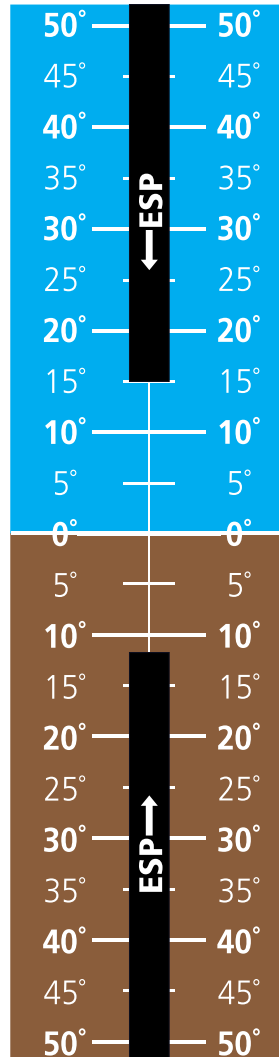


Figure 3-29 ESP Pitch Operating Range When Engaged
(Force Increases as Pitch Increases & Decreases as Pitch Decreases)

3.5.3 AIRSPEED PROTECTION (GFC 500 ONLY)



NOTE: If AGL height data is unavailable low-airspeed protection is not supported.

An airspeed below the minimum configured airspeed or above maximum configured airspeed will result in ESP applying force to raise or lower the nose of the aircraft. When the high or low airspeed condition is remedied, ESP force is no longer applied.

SECTION 4 ADDITIONAL FEATURES

4.1 GPS STEERING (GPSS)



NOTE: This section is only applicable to non-Garmin autopilots.

When installed with the appropriate interfaces, the G5 can interface to some third-party autopilot systems.

4.1.1 GAD 29B (OPTIONAL)

The GAD 29B (optional) is an adapter that converts digital heading and course data into analog signals used by analog autopilot systems. The GAD 29B is installed remotely between the G5 and an existing autopilot. The analog signals from the GAD 29B mimic those of spinning-mass heading gyros that provide data to the autopilot and allow the gyro to be replaced by the G5 and GAD 29B combination. The GAD 29B is also used to interface certain Garmin IFR navigators with the G5.

The GAD 29B sends analog information about the G5's heading bug to a third-party analog autopilot, allowing it to operate in HDG mode and follow the G5 heading bug. The navigation course selected on the G5 is also sent to the analog autopilot, enabling proper operation of the autopilot's NAV mode.



NOTE: If multiple navigators are configured, course data is sent by the GAD 29B for navigator #1 only.



Figure 4-1 GAD 29B (Optional)

GPS Steering (GPSS) provides roll command signals calculated by the GPS navigator to the autopilot in order to allow the aircraft to anticipate turns, make smooth transitions when passing waypoints, and fly leg types such as procedure turns and holding patterns.

Some autopilots have built-in support for GPS Steering (GPSS) commands from a GPS navigator. These autopilots receive digital GPSS commands directly from the navigator. Refer to the Airplane Flight Manual and autopilot system documentation for instructions on how to use the autopilot's GPSS function.

For older autopilots that do not have built-in support for digital GPSS signals, GPSS functionality may be emulated using the analog heading bug output of the G5 and GAD 29B, by operating the autopilot in HDG mode and selecting GPSS from the G5 menu.



NOTE: If multiple navigators are configured, GPSS emulation is supported for navigator #1 only.



NOTE: GPSS commands are not sent to the autopilot when a VLOC source is displayed on the HSI.

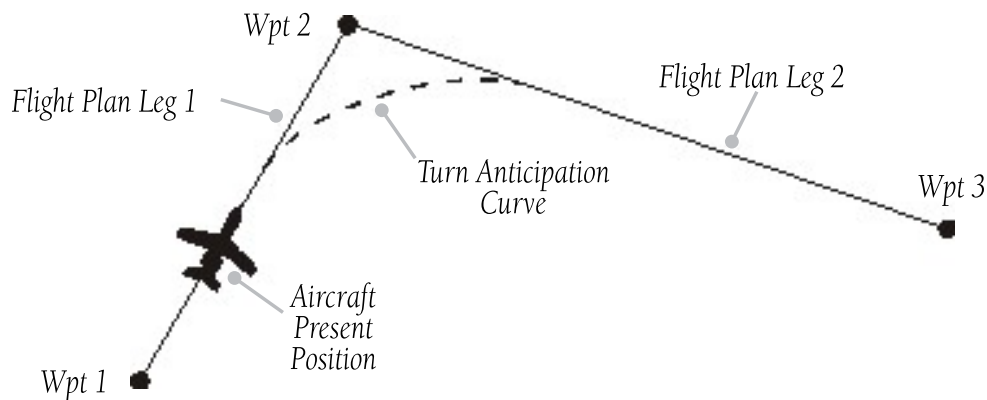


Figure 4-2 GPSS Turn Anticipation

Enabling/Disabling GPSS Mode:

- 1) Press the Knob to display the Menu.
- 2) Turn the Knob to select **GPSS**.
- 3) Press the Knob to enable/disable **GPSS** Mode.

When GPSS is selected on the G5, the heading bug will change to a hollow outline, and a crossed-out heading bug symbol appears on the G5 indicating that the autopilot is not coupled to the heading bug. The heading bug is still controllable and may still be used for reference.

When the G5 and GAD 29B are providing analog GPSS emulation, GPSS turn commands from the navigator are converted into a heading error signal to the autopilot. When the autopilot is operated in HDG mode, the autopilot will fly the turn commands from the GPS navigator. If the GPSS data is invalid (for example, if there is not active GPS leg) or the selected HSI source on the G5 is not GPS, the annunciated "GPSS" text will turn amber and a zero turn command will be sent to the autopilot.



Figure 4-3 GPSS Enabled (PFD Page)



Figure 4-4 GPSS Enabled (HSI Page)

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