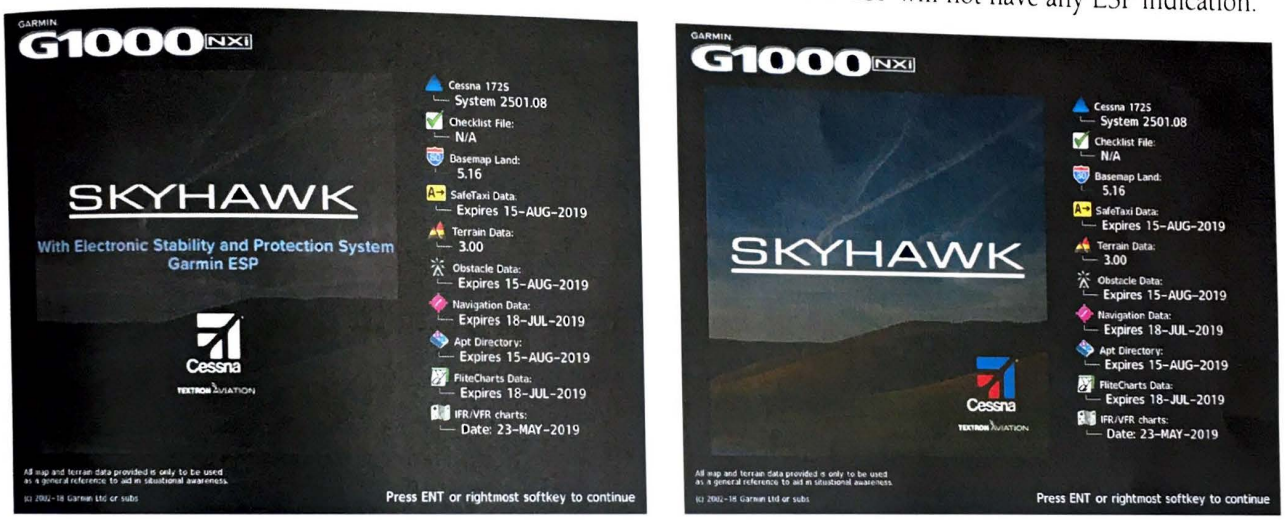
8.11 ELECTRONIC STABILITY & PROTECTION (ESP™)

NOTE: *ESP is designed to be a safety enhancement feature. ESP is not a full authority, envelope protection system.*

NOTE: *ESP is designed to discourage exceeding the normal flight envelope. It is not designed or capable of performing the necessary recovery procedures required due to encounters with adverse flight conditions and environments.*

Electronic Stability and Protection (ESP™) is an optional feature that is intended to discourage the exceedance of attitude and established airspeed parameters. This feature will only function when the aircraft is above 200 feet AGL and the autopilot is not engaged.

Aircraft equipped with Garmin Electronic Stability and Protection (ESP) will display "Electronic Stability and Protection System; Garmin ESP" on the power-up page. Aircraft without ESP will not have any ESP indication.



With ESP (reference) Without ESP (reference)

Figure 8-53 ESP MFD Power-up Page Examples

ESP engages when the aircraft exceeds one or more conditions beyond the normal flight envelope (pitch, roll, VNE, or impending stall). Enhanced stability for each condition is provided by applying a force to the appropriate control surface to return the aircraft to the normal flight envelope. This is perceived by the pilot as resistance to control movement in the undesired direction when the aircraft approaches a steep attitude, high speed, or impending stall condition.

The ESP feature will only function when the aircraft meets the following conditions:

- The aircraft is in flight. The system infers this by speed. If the aircraft GPS ground speed is over 30 knots, or True Airspeed is over 50 Knots.
- The aircraft is above 200 feet AGL (GPS Altitude), if GPS altitude is available.
- The autopilot is not engaged, meaning the pilot is "hand flying."
- The Aircraft is within the maximum engagement limit range defined as Pitch (±50°) and Bank (±75°).

ESP is automatically enabled above 200 ft AGL using GPS altitude. If a Loss of GPS Integrity (LOI) occurs ESP will default to enabled, however low speed ESP functions will be disabled.

As the aircraft deviates further from the normal attitude and/or airspeed, the force increases (up to an established maximum) to encourage control movement in the direction necessary to return to the normal attitude and/or airspeed range. For all conditions except for high airspeed, once maximum force is reached, force remains constant up to the maximum engagement limit. Above the maximum engagement limit, forces are no longer applied. There is no maximum engagement limit associated with high airspeed.

When ESP has been engaged for more than ten seconds (cumulative; not necessarily consecutive seconds) of a 20-second interval, the autopilot is automatically engaged 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.

In the event of unexpected autopilot behavior, the pilot can interrupt ESP by pushing and holding either the Control Wheel Steering (**CWS**) or Autopilot Disconnect (**AP DISC**) switch. Upon releasing the **CWS** or **AP DISC** switch, ESP force will again be applied, provided aircraft attitude and/or airspeed are within their respective engagement limits. ESP can also be overridden by overpowering the servo's mechanical torque limit. Although the pilot may physically overpower the ESP forces prior to the 'Engaging Autopilot' message, the pilot must recognize when the autopilot is engaged and not attempt to physically override the autopilot.

If flight maneuvers exceeding the normal ESP envelope are intended, the feature can be disabled. ESP can be enabled or disabled on the 'Aux - System Setup' Page on the MFD.

Enabling/Disabling ESP:

1) Turn the large **FMS** Knob to select the Aux Page Group.
2) Turn the small **FMS** Knob to select the 'Aux - System Setup' Page.
3) If necessary, press the **SETUP 2** Softkey to display the 'Aux-System Setup 2' Page. If the 'Aux - System Setup 2' is already displayed, proceed to step 4.
4) Push the **FMS** Knob to activate the cursor.
5) Turn the large **FMS** Knob to place the cursor in the Stability & Protection field.
6) Turn the small **FMS** Knob to select 'Enabled' or 'Disabled'.
7) Push the **FMS** Knob to remove the cursor.

ESP is automatically enabled on system power up.

ROLL ENGAGEMENT

Roll Limit Indicators are displayed on the roll scale at 45° right and left, indicating where ESP will engage (see following figure). As roll attitude exceeds 45°, ESP will engage and the on-side Roll Limit Indicator will move to 30°, as shown in the following figure. The Roll Limit Indicator is now showing where ESP will disengage as roll attitude decreases.

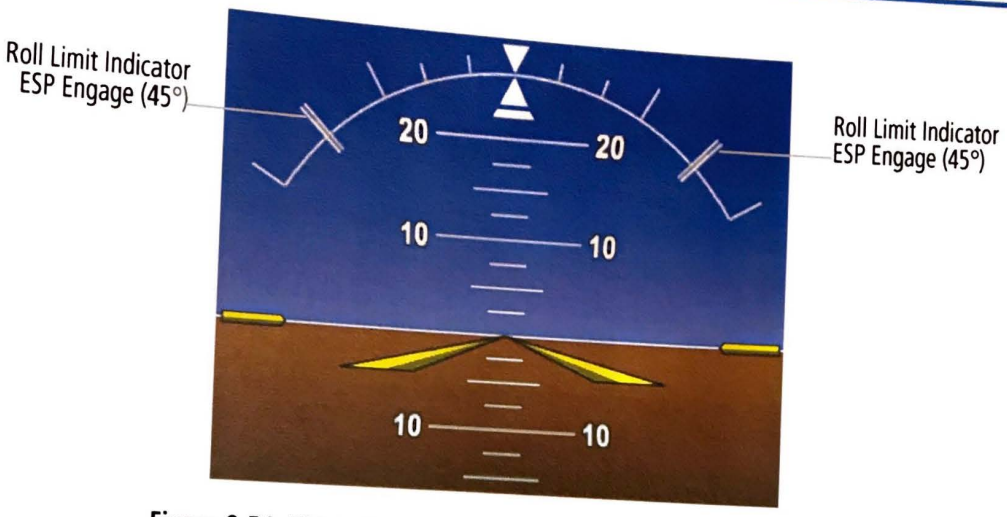
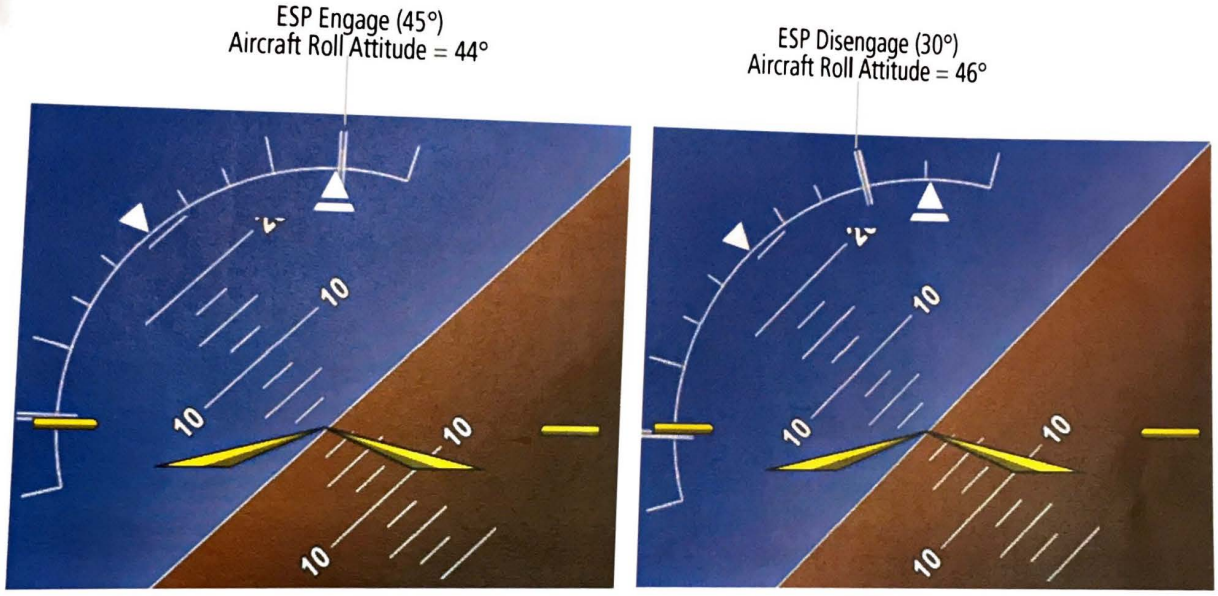


Figure 8-54 ESP Roll Engagement Indication (ESP NOT Engaged)



Before ESP Engage **After ESP Engage**

Figure 8-55 Roll Increasing to ESP Engagement

Once engaged, ESP force will be applied between 30° and 75°, as illustrated in the following figure. The force increases as roll attitude increases and decreases as roll attitude decreases. The applied force is intended to encourage pilot input that returns the airplane to a more normal roll attitude. As roll attitude decreases, ESP will disengage at 30°.

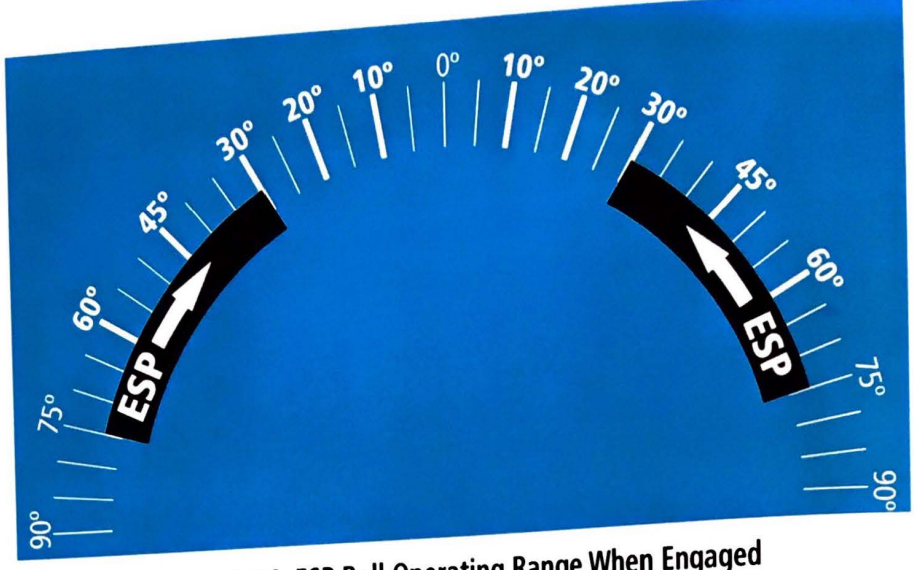


Figure 8-56 ESP Roll Operating Range When Engaged (Force Increases as Roll Increases & Decreases as Roll Decreases)

ESP is automatically disengaged if the aircraft reaches the autopilot roll engagement attitude limit of 75° (following figure).

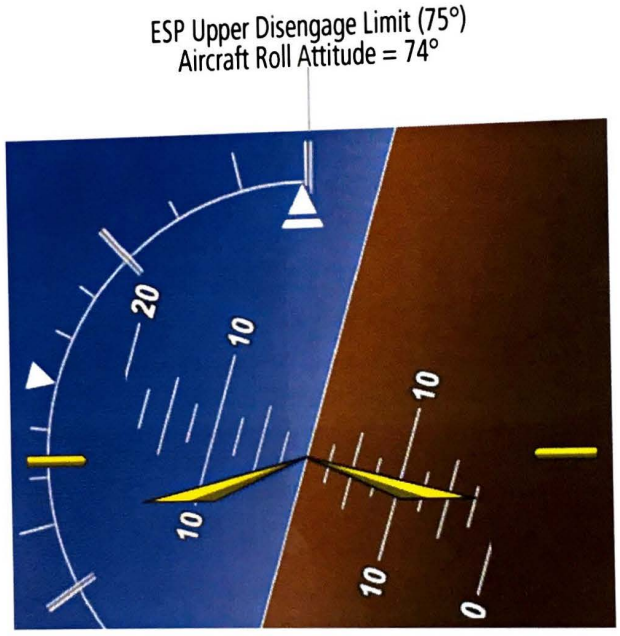


Figure 8-57 Roll Attitude Autopilot Engagement Limit (ESP Engaged)

PITCH ENGAGEMENT

ESP pitch engagement parameters are set specifically for each aircraft model. The following tables shows specific engagement angles, maximum opposing force angles and disengagement limits. Once ESP is engaged, it will apply opposing force between approximately 15° and 50° nose-up and between approximately 12° and 50° nose-down, as indicated in the following figure. Maximum opposing force is applied between approximately 25° and 50° nose-up and between approximately 22° and 50° nose-down. ESP pitch engagement parameters are set specifically for each aircraft model. Table 8-5 shows specific ESP engagement angles, maximum opposing force angles, and disengagement limits.

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.

There are no indications marking the pitch ESP engage and disengage limits in these nose-up/nose-down conditions.

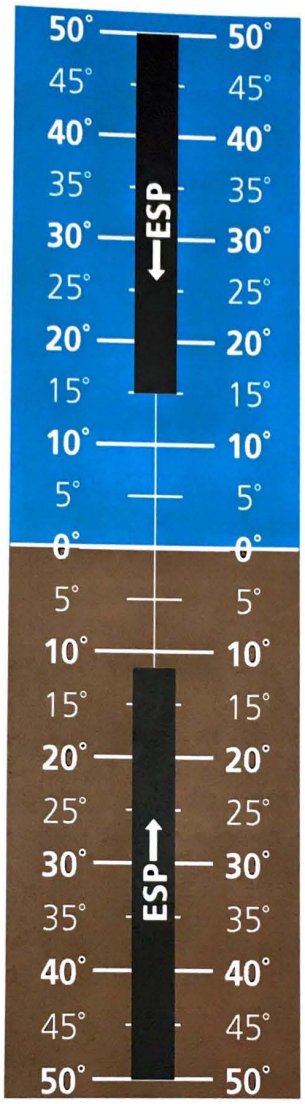


Figure 8-58 ESP Pitch Operating Range for the Cessna 172 When Engaged (Force Increases as Pitch Increases & Decreases as Pitch Decreases)

ESP High Pitch Protection Limits			
	C-172	C-182	C-206
Angle Opposing Force Begins	16°	19°	18°
Max Opposing Force Angle	20°	24°	23°
ESP Disengagement Angle	14°	14°	14°

Table 8-5 ESP Pitch Protection by Aircraft Model

ESP Low Pitch Protection Limits			
	C-172	C-182	C-206
Angle Opposing Force Begins	-16°	-17°	-21°
Max Opposing Force Angle	-20°	-22°	-26°
ESP Disengagement Angle	-14°	-12°	-17°

Table 8-6 ESP Pitch Protection by Aircraft Model

HIGH AIRSPEED PROTECTION

Exceeding Vne will result in ESP applying force to raise the nose of the aircraft. When the high airspeed condition is remedied, ESP force is no longer applied.

LOW AIRSPEED PROTECTION

(Model 172) When the aircraft decelerates below 55 KIAS and remains below 55 KIAS for 1 second, ESP will activate and begin applying nose down force. ESP will stop applying the nose down force once airspeed has increased above 55 KIAS.

(Models 182 and 206) When the stall warning has been active for at least one half second, ESP will activate and begin applying a nose down force. ESP will stop applying the nose down force once the angle of attack has been reduced sufficiently to deactivate the stall warning.

OVERSPEED PROTECTION

***NOTE:** Overspeed protection is not active in ALT, GS or GP modes.*

While Pitch Hold, Vertical Speed, Flight Level Change, Vertical Path Tracking, or an altitude capture mode is active, airspeed is monitored by the flight director. Overspeed protection is provided to limit the flight director's pitch command in situations where the flight director cannot acquire and maintain the mode reference for the selected vertical mode without exceeding Vne.

When Overspeed Protection is active, the Airspeed Reference appears in a box above the Airspeed Indicator, flashing a amber 'MAXSPD' annunciation. Engine power should be reduced and/or the pitch reference adjusted to slow the aircraft. The annunciation disappears when the overspeed condition is resolved.

Figure 7-30 Overspeed Annunciation

UNDERSPEED PROTECTION

Underspeed Protection is available when the optional Electronic Stability and Protection (ESP) system is installed and the autopilot is on. It is designed to protect the airplane from stalls. When the aircraft reaches a predetermined airspeed, a yellow MINSPD annunciation will appear above the airspeed indicator.

For airplanes that have ESP installed, the AFCS can detect and protect against underspeed situations while the autopilot is engaged. It is designed to discourage aircraft operation below minimum commandable airspeeds.

Figure 7-31 Underspeed Annunciation

ALTITUDE-CRITICAL MODES (ALT, GS, GP, GA, FLC)

As the aircraft slows, within 5 to 10 seconds from reaching stall warning, an aural "AIRSPEED" alert will sound. If the aircraft decelerates to stall warning, the lateral and vertical flight director modes will change from active to armed, and the autopilot will provide input causing the aircraft to pitch down and the wings to level.

An aural "AIRSPEED" alert will sound every five seconds and a red "UNDERSPEED PROTECT ACTIVE" annunciation will appear to the right of the vertical speed indicator. The pitch down force will continue until the aircraft reaches a pitch attitude at which IAS equals the IAS at which stall warning turns off, plus two knots.

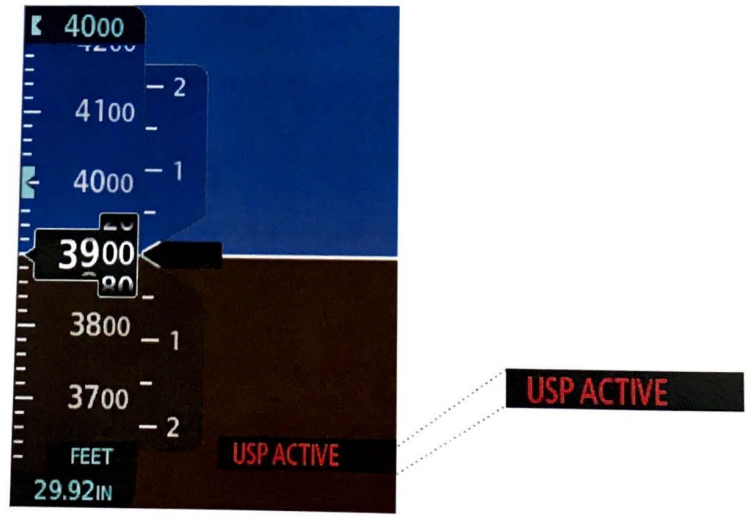


Figure 7-32 Underspeed Protect Active Annunciation

When airspeed increases (as a result of adding power/thrust) to above the IAS at which stall warning turns off, plus two knots, the autopilot will cause the aircraft to pitch up until recapturing the vertical reference. The vertical and lateral flight director modes will change from armed to active. The pitch attitude may be very high as the aircraft climbs back to the desired altitude. This high pitch angle and rate of climb is intended to minimize time spent below the desired altitude.

USP Airspeeds - Altitude Critical Modes	172 KIAS All Flap	182 KIAS All Flap	206 KIAS All Flap
MINSPD Alert Appears	60	61	61
Altitude Critical USP Activation	60	Stall Warning	Stall Warning

Table 7-7 USP Activation - Altitude Critical Modes

NON-ALTITUDE CRITICAL MODES (VS, VNAV, PIT, LVL)

When the airspeed trend vector reaches a predetermined airspeed, a single aural "AIRSPEED" will sound, alerting the pilot to the impending underspeed condition. If the aircraft decelerates to an IAS below the minimum commandable autopilot airspeed, a red "UNDERSPEED PROTECT ACTIVE" annunciation will appear to the right of the vertical speed indicator. The vertical flight director mode will change from active to armed, and the autopilot will cause the aircraft to pitch down until reaching a pitch attitude at which IAS equals the minimum commandable autopilot airspeed.

When airspeed increases (as a result of adding power/thrust) to an IAS above the minimum commandable autopilot airspeed, the autopilot will cause the aircraft to pitch up until recapturing the vertical reference. The vertical flight director mode will change from armed to active.

USP Airspeeds - Non Altitude Critical Modes	172 KIAS All Flap	182 KIAS All Flap	206 KIAS All Flap
MINSPD Alert Appears	60	61	61
Non-Altitude Critical USP Activation	60	61	61

Table 7-8 USP Activation - Non Altitude Critical Modes

7.6 ABNORMAL OPERATION

SUSPECTED AUTOPILOT MALFUNCTION

***NOTE:** Consult the aircraft documentation for the location of circuit breakers as well as specifics that may supplement or amplify this procedure.*

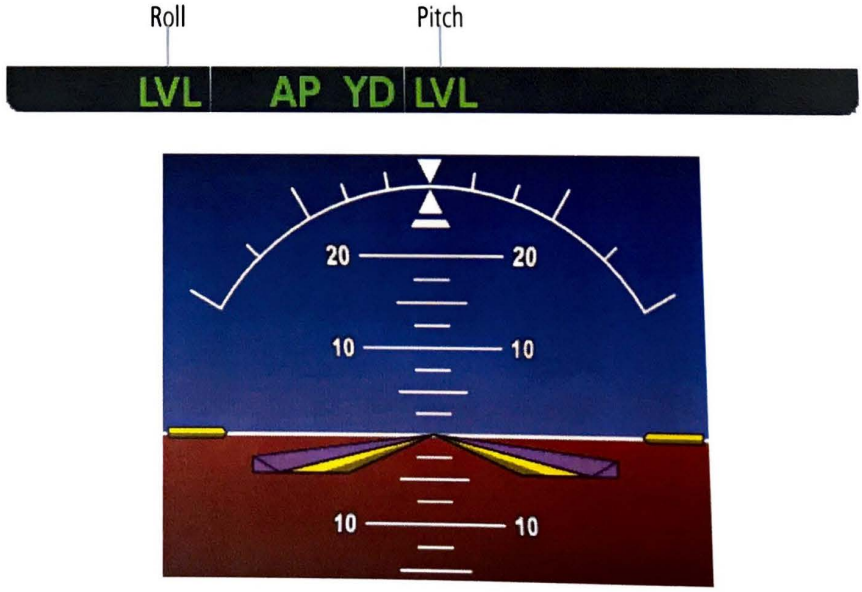
If an autopilot failure or trim failure is suspected to have occurred, perform the following steps:

1) Firmly grasp the control wheel.
2) Press and hold the **AP DISC** Button. The autopilot will disconnect and power is removed from the trim motor. Power is also removed from all primary servo motors and engaged solenoids. Note the visual and aural alerting indicating autopilot disconnect.
3) Retrim the aircraft as needed. Substantial trim adjustment may be needed.
4) Pull the appropriate circuit breaker(s) to electrically isolate the servo and solenoid components.
5) Release the **AP DISC** Button.

LEVEL MODE

Level (LVL) mode also becomes active as a function of Electronic Stability and Protection (ESP). Refer to the Additional Features section for a detailed discussion of the optional ESP feature.

When the normal flight envelope thresholds have been exceeded for more than 50% of the last 20 seconds, Level mode is activated. The autopilot will engage and provide input to bring the aircraft back into straight and level flight based on zero degrees roll angle and zero feet per minute vertical speed. An aural engaging autopilot alert sounds and the lateral and vertical flight director annunciations will display "LVL". The AFCS will remain in Level mode until the pilot selects another mode.



Command Bars Indicate Level with the Horizon

Figure 7-33 Level Mode Annunciation

INTERCEPTING AND FLYING A DME ARC

The AFCS will intercept and track a DME arc that is part of the active flight plan provided that GPS Navigation Mode is engaged, GPS is the active navigation source on the CDI, and the DME arc segment is the active flight plan leg. It is important to note that automatic navigation of DME arcs is based on GPS. Thus, even if the APR key is pressed and LOC or VOR Approach Mode is armed prior to reaching the Initial Approach Fix (IAF), Approach Mode will not activate until the arc segment is completed.

If the pilot decides to intercept the arc at a location other than the published IAF (i.e. ATC provides vectors to intercept the arc) and subsequently selects Heading Mode or Roll Mode, the AFCS will not automatically intercept or track the arc unless the pilot activates the arc leg of the flight plan and arms GPS Navigation Mode. The AFCS will not intercept and fly a DME arc before reaching an IAF that defines the beginning of the arc segment. Likewise, if at any point while established on the DME arc the pilot deselects GPS Navigation Mode, the AFCS will no longer track the arc.

GO AROUND (GA) MODE

Pressing the **GA** 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. Attempts to modify the aircraft attitude (i.e., with the **NOSE UP/NOSE DN** Keys or **CWS** Button) result in reversion to Pitch and Roll Hold modes.

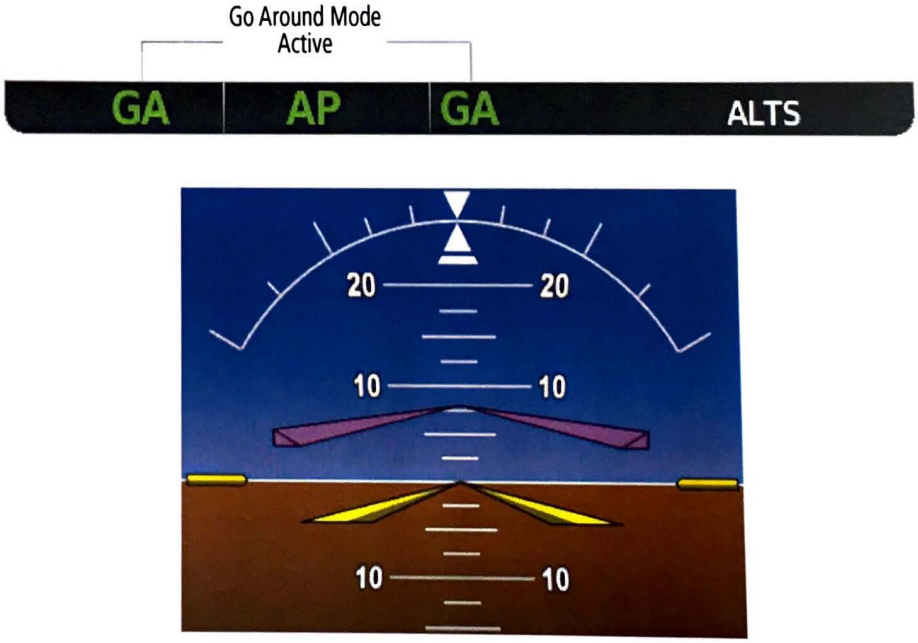


Figure 7-25 Go Around Mode