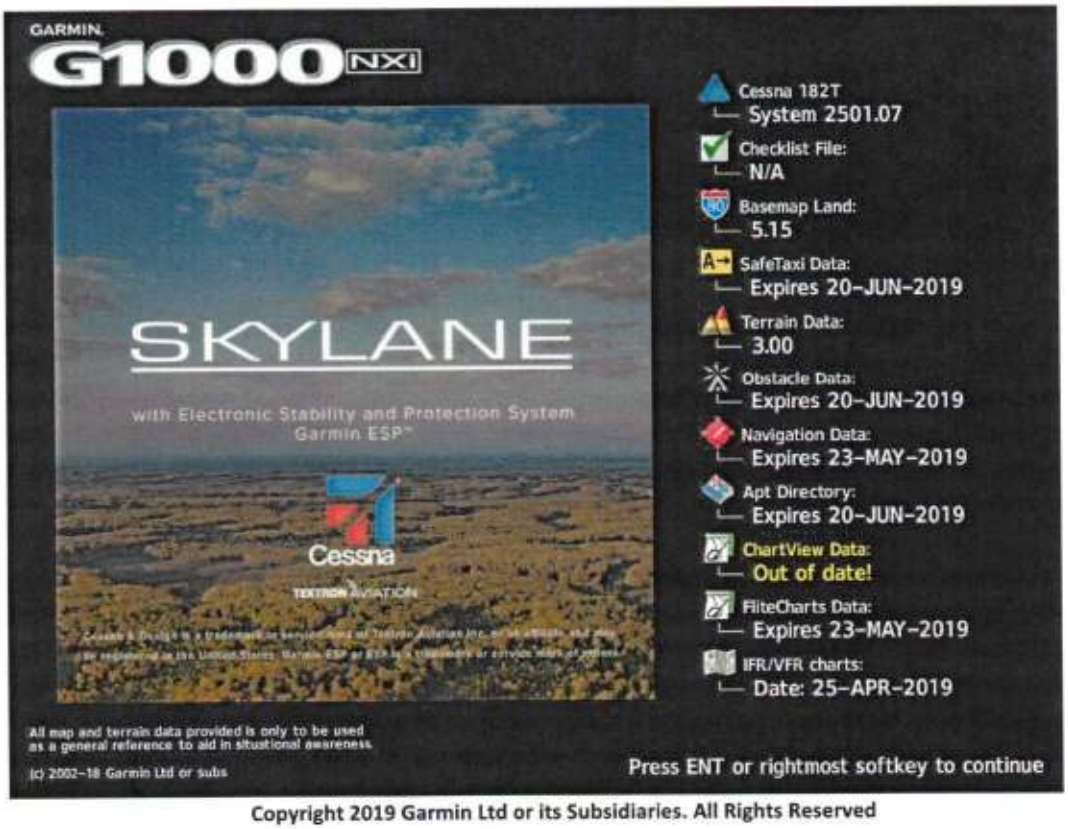
Garmin ESP™ in Textron Aviation Piston Aircraft

Electronic Stability and Protection (ESP™) is a built-in feature that is intended to discourage the exceedance of established attitude and airspeed parameters. All 2019 Textron Aviation Piston Aircraft with the GFC 700 autopilot have Garmin ESP™. ESP™ is trade marked by Garmin and will be referred to as ESP for readability of this guide. The pilot may verify the installation of ESP by viewing the text underneath the aircraft model identification on the background image of the "Splash Screen"at system startup. This text will read "with Electronic Stability and Protection System Garmin ESP". ESP is automatically enabled upon power up. ESP can be manually disabled and enabled before or during flight via the Aux Page Group / System Setup Page as described on page 4 of this guide.

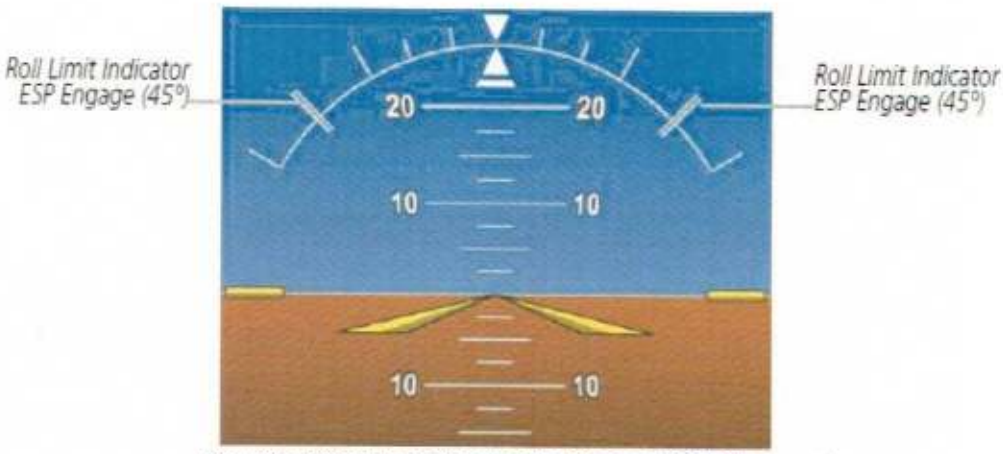


NOTE: The pilot should review ESP envelope limits, ESP system function, and the expected autopilot and aircraft reactions applicable to the specific aircraft model prior to flight.

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

1. 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 ESP believes the aircraft is in flight.
2. The aircraft is above 200 feet AGL (GPS Altitude), if GPS altitude is available.
3. The autopilot is not engaged, meaning the pilot is "hand flying."
4. The aircraft is within the maximum engagement limit range defined as Pitch (+/-50°) and Bank (+/-75°).

The pilot may quickly and easily recognize the ESP system is enabled and actively monitoring flight parameters by the presence of the double lines at the 45° point of the roll scale on the top of the PFD. If the double lines are present, ESP is enabled and the parameters for system function are met. If the double lines are missing from the roll scale, ESP is either disabled, or the parameters that allow ESP to function have not been met.



ESP engages when the aircraft exceeds one or more conditions beyond the normal flight envelope (pitch, roll, V_{NE}, 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.

As the aircraft deviates further from the normal envelope, the resistive force increases (up to an established maximum per aircraft model) to encourage control movement in the direction necessary to return to the normal envelope range. During bank or pitch excursions when maximum force is reached, force remains constant up to the maximum engagement limit. Above the maximum engagement limit, forces are no longer applied. High speed V_{NE} protection, as well as slow speed/impending stall protection have no maximum engagement limits and will stay at maximum force application until the specific speed condition is corrected.

The pilot can interrupt ESP by pressing 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 exceed their respective engagement limits. ESP can also be overridden by overpowering the servo's mechanical torque limit.

As an additional protective feature, ESP is designed to automatically turn on the autopilot after a specified period of normal flight envelope excursion. The autopilot automatic engagement feature of ESP could be especially helpful during situations such as, a pilot experiencing spatial disorientation, or possibly a pilot incapacitation scenario. In the Textron Aviation piston aircraft that are equipped with Garmin ESP (172, 182, 206, G36, and G58) when ESP has been engaged for more than 10 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. Level (LVL) mode in the bank axis returns the aircraft to zero degrees bank or "wings level." Level (LVL) mode in the pitch axis returns the aircraft to a vertical speed of 0 ft/min. The level modes will not seek any selected parameters such as heading (HDG) or the altitude selector (ALTS). To return the aircraft to desired autopilot mode, the pilot must make appropriate mode selections on the AFCS control panel.

ESP will automatically engage the autopilot after passing the 10 seconds in 20 seconds time period. Any time the pilot hears the "Engaging Autopilot" aural alert, the pilot must either relinquish flight controls to the autopilot, press the red AP DISC switch to disconnect the autopilot, or disengage the AP via another method. Pilots should make themselves familiar with all ways to disengage the Autopilot. 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. Physically overpowering the autopilot (especially in the pitch axis) will result in the autopilot commanding pitch trim opposing the pilot's force. Disconnecting autopilot after trying to physically overpower it could result in a significant nose up or nose down trim condition.

ESP is designed for discouraging normal flight envelope exceedances only. The ESP system is not designed for nor is it capable of upset recovery procedures such as significant turbulence, wake turbulence encounters, stalls, spins, etc. If an inflight upset is encountered, the pilot should press the red AP DISC switch to disable any automation and execute appropriate recovery procedures per the situation. Three key points to remember about ESP and inflight upset situations:

1. The ESP system does not have upset recovery strategy or procedure logic built in. ESP was intended to discourage operations outside of the normal flight envelope to assist the pilot in situational awareness.
2. The autopilot servos that the ESP system utilizes are designed to be smooth and have limited force available for correction. They were never intended to apply the rapid, full control movements that may be involved in significant inflight upset situations.

3. Due to the lack of upset recovery logic and the limitations of the autopilot servos, the ESP system has maximum bank limits (75°) and pitch limits (50°). Upon passing either of these parameters, any corrective ESP forces are removed, and the system will stop assisting so as not to impede any upset recovery procedures the pilot may be applying.

Note: ESP is enabled above 200 ft AGL from GPS altitude. The ESP system will default enabled if GPS Altitude is unavailable (GPS Loss of Integrity (LOI)), but the low speed ESP functions will be disabled. During GPS Loss of Integrity (LOI) situations, Textron Aviation recommends disabling ESP via the Aux-System Setup Page during takeoff and landing conditions. The steps for disabling ESP are illustrated below.

Note: Textron Aviation recommends disabling ESP prior to performing intentional flight maneuvers such as steep turns, slow flight, stalls, and any other intentional maneuver that may exceed the normal flight envelope. The steps for disabling ESP are illustrated below.

ESP can be enabled or disabled on the 'Aux-System Setup' Page on the MFD.

Enabling/Disabling ESP:

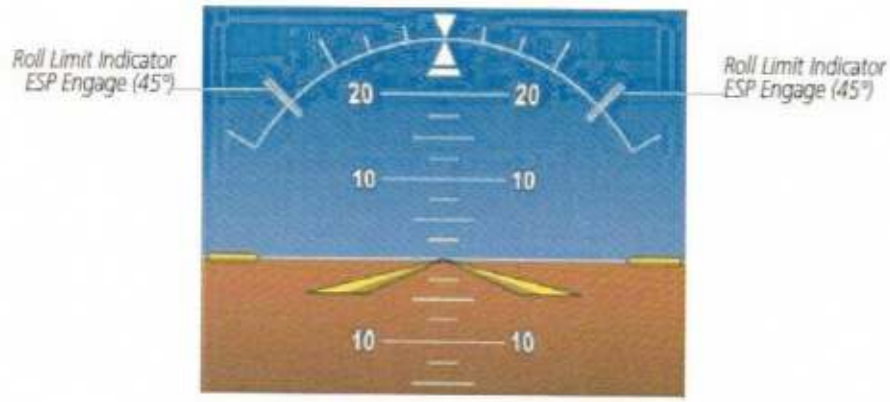
1) Turn the large **FMS** Knob to select the Aux Page Group.
2) Turn the small **FMS** Knob to select the System Setup Page.
3) If necessary, press the **SETUP 2** Softkey to display the 'Aux-System Setup 2' Page. If the 'Aux-System Setup 2' is already displayed, proceed to step 4.
4) Press the **FMS** 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) Press the **FMS** Knob to remove the cursor.

ESP is automatically enabled on system power up.

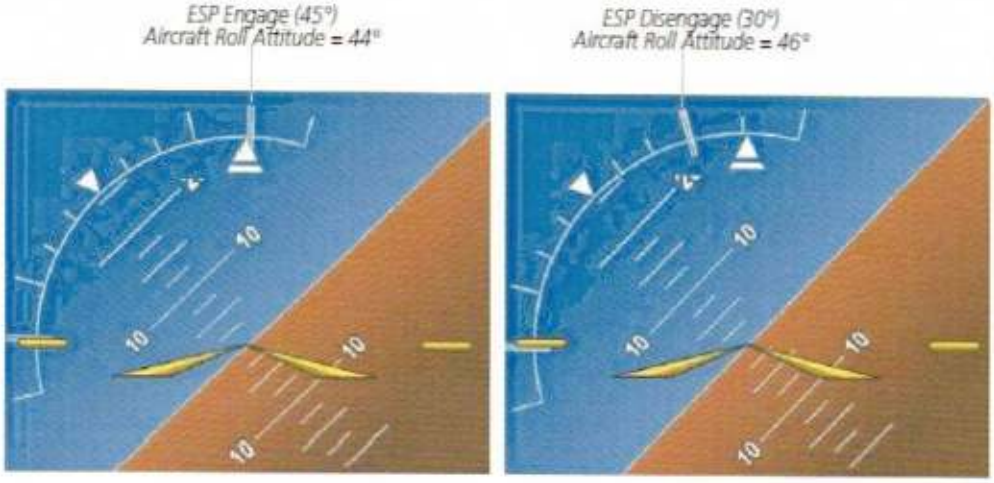
Excerpt taken from: Garmin G1000 NXi Pilot's Guide for NAV III, G36, and G58 aircraft

ROLL ENGAGEMENT (All Models)

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.



ESP Roll Engagement Indication (ESP NOT Engaged)



Before ESP Engage

After ESP Engage

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 normal flight envelope. As roll attitude decreases, ESP will disengage at 30°.

ESP Roll Operating Range, and Limits

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

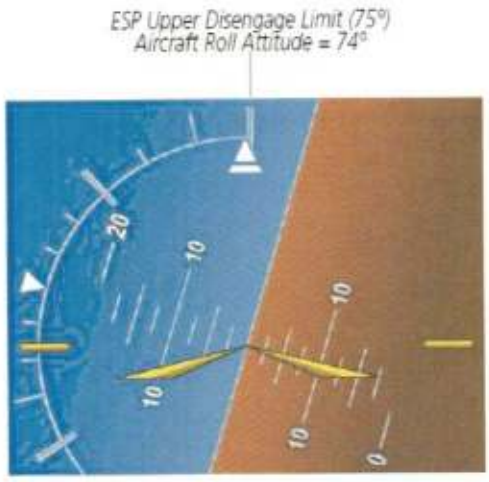
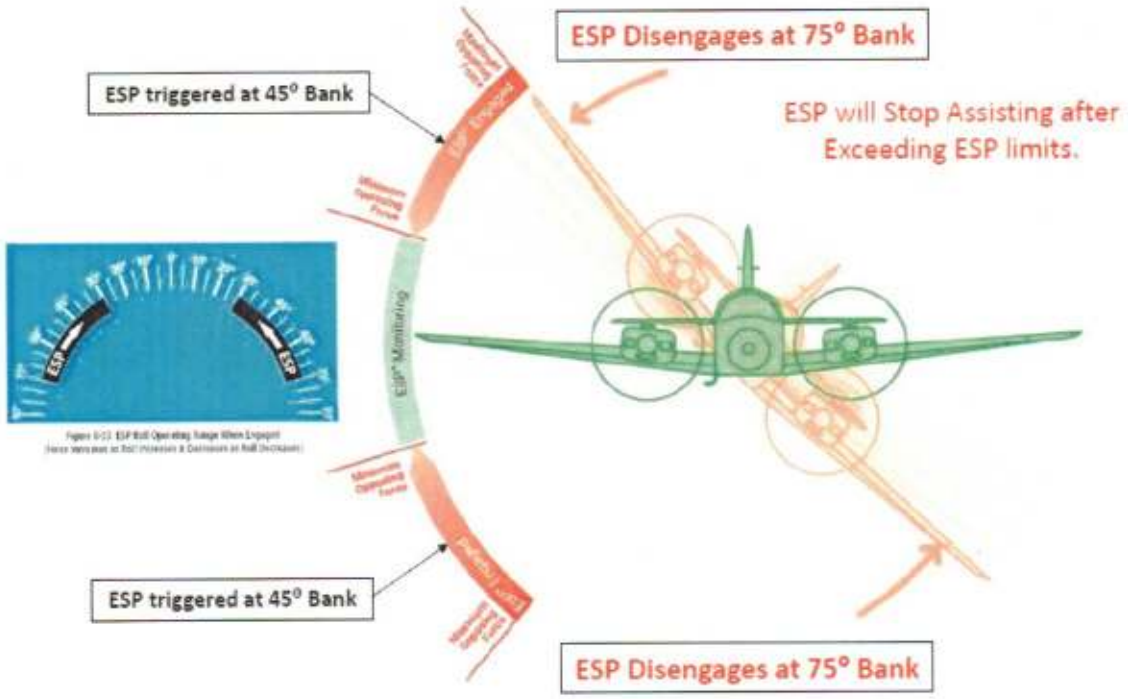


Figure 8-54 Roll Attitude Autopilot Engagement Limit (ESP Engaged)

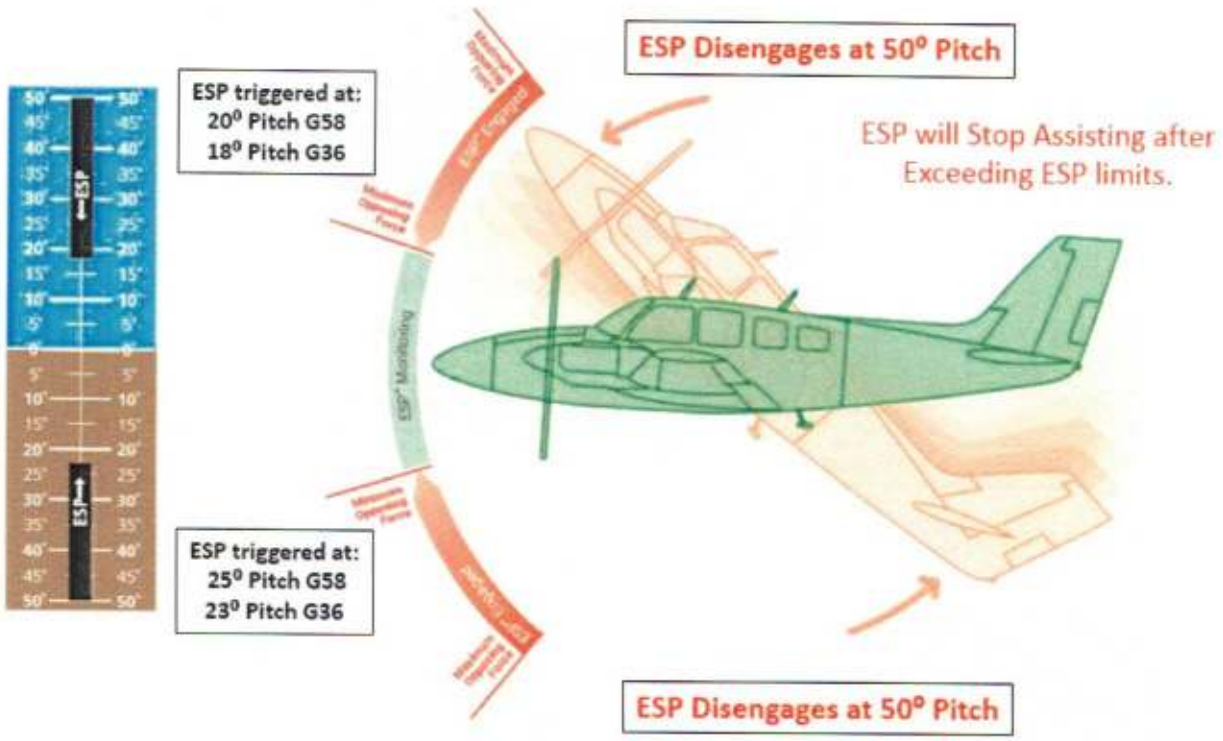


PITCH ENGAGEMENT

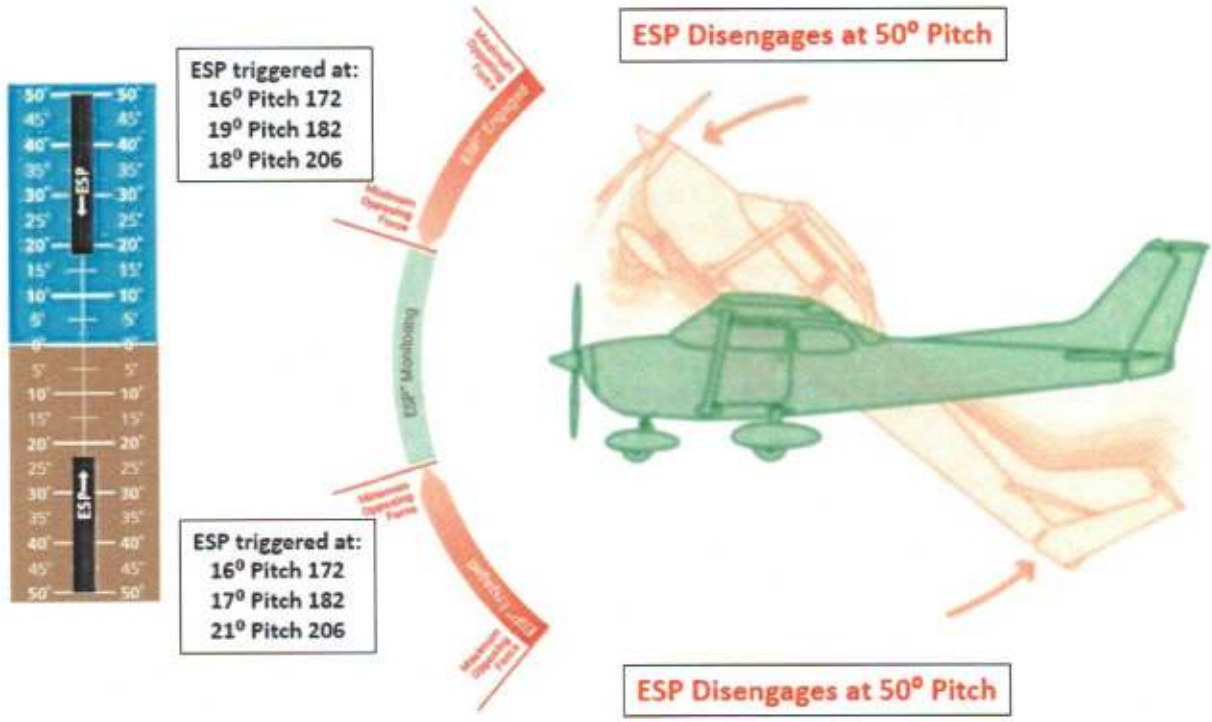
Once ESP is engaged, it will apply opposing force between engagement attitude and maximum engagement limit (50°). The opposing force increases or decreases depending on the pitch angle and the direction of pitch travel. This force is intended to encourage movement in the pitch axis in the direction of the normal pitch envelope for the aircraft. There are no indications marking the pitch ESP engage and disengage limits in these nose-up/nose-down conditions.

Aircraft models nose-up and nose-down limits vary and are listed in the pictures below.

Beechcraft ESP Pitch Limits:



Cessna NAV III ESP Pitch limits:



HIGH AIRSPEED PROTECTION (All Models)

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 engage. ESP will begin applying a nose down force to encourage the pilot to lower the nose of the aircraft thus returning to normal operating speeds.

LOW AIRSPEED PROTECTION (Model 182, 206, G36, G58)

When the stall warning has been active for at least one half second, ESP will engage. ESP will begin applying a nose down force to encourage the pilot to lower the nose of the aircraft thus returning to normal operating speeds. ESP will disengage when the stall warning has deactivated.

Note: ESP Low Airspeed Protection was designed to discourage pilots from inadvertent stalls and flight outside the normal operating envelope. It can not prevent all stalls from occurring in all conditions. The ESP Low Airspeed is not designed to recover the aircraft from a stalled condition.

Study the specific aircraft model autopilot malfunction checklists in the appropriate POH. The ESP system utilizes autopilot servos, and has the ability to automatically engage the autopilot, which can utilize the electric pitch trim system. The trim system abnormal, and autopilot abnormal procedures may be utilized if the ESP system exhibits a failure causing any unwanted ESP forces, or automatic autopilot engagements.

The procedure outlined below is an excerpt from the Cessna Caravan 208 Garmin G1000 NXi Pilot's Guide. Although this procedure is not specifically listed in any of the Textron Aviation Piston Aircraft model specific Pilot's Guides, it is the recommended method for handling a suspected autopilot malfunction.

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** Switch. 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** Switch.

Also listed below is an excerpt from the Cessna Caravan 208 Garmin G1000 NXi Pilot's Guide, providing guidance regarding not physically overpowering autopilot servos.

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 are required after the autopilot is disengaged.

Overall lessons learned from operating the system:

- ESP is only available when the aircraft is being "hand flown" with the autopilot not engaged.
- The pilot can determine if ESP is installed on an aircraft by looking at the G1000 NXi Avionics startup Splash page and the MFD Aux - System Setup Page 2 (Stability & Protection Option will be available).
- The presence of double lines at the 45° marking in the roll scale and the absence of any ESP CAS messages (ESP FAIL, ESP OFF) when the autopilot is disconnected provide the quickest visual indication that ESP is enabled and available.
- ESP will automatically be enabled prior to every flight and should be turned off prior to attempting training maneuvers that exceed ESP envelope limits (i.e., steep turns, slow flight, stalls, etc.) to prevent unwanted ESP activation and/or autopilot engagement. ESP may be re-enabled in flight after training maneuvers are complete.
- If the autopilot automatically engages following ESP activation (indicated by the green AP in the AFCS status bar at the top of the PFD), **DO NOT FIGHT THE AUTOPILOT**. Overpowering the pitch servo can lead to an out of trim condition.
- AFM/POH abnormal and emergency procedures should be used to handle any trim, autopilot, or ESP system abnormality.

Our goal is to assist pilots in clearly identifying the presence of potentially lifesaving ESP features, provide information about the system functions, and identify appropriate procedures to allow for effective use of the system in different flight environments.