

# Gulfstream G150

## AIRPLANE FLIGHT MANUAL

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### AUTOPILOT SYSTEM

#### DESCRIPTION

The Flight Control system is an integrated 3-axis autopilot and flight director, containing automatic elevator trim control. The system is configured for dual flight directors and is certified for ILS Category 2 operations.

The system consists of the following:

- Two FGC-3000 Flight Guidance Computer Module (2)
- One FGP-3000 Flight Guidance Panel (1)
- SVO-85C Primary Servo (2)
- SMT-86C Servo Mount (2)
- SVO-85B Primary Servo (1)
- SMT-86B Servo Mount (1)

#### FGS MODES

##### **Flight Guidance Mode Selection**

The primary means of selecting and deselecting flight guidance modes is by pressing the appropriate button on the FGP. Pressing an FGP button when the mode is not selected will select the mode. A subsequent press of the FGP button deselects the mode. The FGS defaults to the basic lateral and vertical flight guidance modes when no modes are selected by the FGP.

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#### LATERAL MODES

| Modes             | Activated by       | Control Functions             |
|-------------------|--------------------|-------------------------------|
| Roll Hold (Basic) | ----               | Heading Hold, Roll Hold       |
| Heading Select    | HDG                | Heading Select, Lateral       |
| Navigation        | NAV                | FMS, Localizer, VOR           |
| Approach          | APPR               | FMS, Localizer, VOR           |
| Back Course       | B/C                | Localizer Go Around           |
| Go Around         | GA (Control Wheel) | Heading Hold                  |
| Half Bank         | 1/2 BANK           | Bank Command limited to 12.5° |

#### **Roll Hold Mode (Basic Roll)**

The basic lateral mode of the FGS is roll hold. Roll hold consists of two submodes - roll and heading hold. If the roll attitude of the aircraft is less than 5° at mode activation, the system generates commands to maintain the existing aircraft heading (wings level). If the roll attitude is between 5° and 30° at mode activation, the system generates commands to hold the aircraft's existing roll angle. If the roll attitude is greater than 30° at mode activation, the system generates commands to hold the roll angle at 30°.

#### **Heading Select Mode (HDG)**

When in heading select mode, the system generates commands to capture and maintain the selected heading shown on the PFD and/or MFD. The selected heading is set by the HDG knob on the FGP. Heading mode is selected by pressing the HDG switch on the FGP.

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### **Navigation Mode (NAV)**

Navigation mode is selected by pressing the NAV button on the FGP. When in navigation mode, the system generates commands to capture and track the selected lateral navigation course (FMS, Localizer, and VOR).

### **Approach Mode (Lateral)**

Approach mode is selected by pressing the APPR button on the FGP. When in lateral approach mode, the system generates commands to capture and track the final approach course (FMS, localizer, and VOR).

### **Back Course Mode**

Back course mode is selected by pressing the B/C button on the FGP when a localizer is tuned. When in back course mode, the system generates commands to capture and track the back course approach (localizer).

### **Go Around Mode (Lateral)**

Go around mode is selected by pressing the GA button. When in lateral go around mode, the system generates commands in the lateral axis to hold the heading existing when the GA button is pressed. Activation of go around mode automatically disconnects the autopilot.

### **Half Bank**

Half Bank is selected by pressing the ½ BANK button. Half Bank is automatically selected when climbing through the half bank transition altitude (30,000 ft). Half Bank reduces the maximum commanded roll angle to 12.5°.

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#### VERTICAL MODES

| Modes               | Activated by       | Control Functions                  |
|---------------------|--------------------|------------------------------------|
| Pitch Hold (Basic)  | ----               | Pitch Hold                         |
| Altitude Hold       | ALT                | Altitude Hold (Pressure Altitude)  |
| Altitude Preselect  | ----               | Altitude Preselect (Baro Altitude) |
| Vertical Speed      | VS                 | Vertical Speed (fpm)               |
| Flight Level Change | FLC                | IAS, Mach                          |
| Approach            | APPR               | FMS, Glideslope                    |
| Vertical Navigation | VNAV               | FMS                                |
| Go Around           | GA (control wheel) | Go Around                          |
| Overspeed           | ----               | IAS, Mach                          |

#### **Pitch Hold Mode (Basic Pitch)**

The basic vertical mode of the system is pitch hold mode. When in pitch hold mode, the system generates commands to hold the pitch angle of the aircraft that exists when the mode is selected. When in pitch hold mode, the VS/pitch wheel (down/up) is used to change the pitch reference.

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### **Altitude Hold Mode (ALT)**

Altitude hold mode is selected by pressing the ALT button on the FGP. Additionally, altitude hold mode is automatically selected after altitude capture has occurred and the aircraft has stabilized at the preselected altitude. When in altitude hold mode, the system generates commands to capture and maintain the pressure altitude that exists when the mode is selected.

### **Preselect Altitude Mode**

There is no manual selection of preselect altitude (PSA) mode, it is armed continuously except in altitude hold, vertical approach capture/track states. When in preselect altitude mode, the system generates commands to capture the preselected (barometric) altitude.

### **Vertical Speed Mode (VS)**

Vertical speed mode is selected by pressing the VS switch on the FGP except in vertical approach capture/track and flight level change overspeed modes. When in vertical speed mode, the system generates commands to maintain the vertical speed that exists when the mode is selected. In vertical speed mode, the VS/Pitch wheel is used to slew the vertical speed reference.

### **Flight Level Change Mode (FLC)**

Flight level change mode is selected by pressing the FLC button on the FGP except when in vertical approach capture/track mode. Reference airspeed is synchronized to the aircraft's current speed (IAS/Mach) upon mode selection. The pilot controls the reference airspeed by using the SPEED knob. When FLC mode is selected, a climb or descend submode command is entered based on the difference between the aircraft present altitude and the preselected altitude. If the preselected altitude is higher than the current altitude, climb submode is entered and visa versa. In either submode, a vertical speed floor is implemented, forcing the aircraft toward the selected altitude if the selected speed reference is inadequate.

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#### **Approach Mode (Vertical)**

Approach mode is selected by pressing the APPR button on the FGP. The approach mode arms when selected and the system generates commands to capture and track vertical guidance for precision approaches (glideslope or GPS when approved) when the lateral approach mode is in the track state and the vertical capture requirements are met.

#### **Vertical Navigation (VNAV)**

The vertical navigation function enables the FMS to command various FGS vertical modes and provide references for these modes. VNAV is armed by pressing the VNAV button on the FGP except in ILS/MLS vertical approach capture/track or when FLC overspeed mode is active. Selection of VNAV does not automatically change the active guidance mode. When VNAV is armed, the FMS can automatically select the FGS vertical mode if required. The FGS generates commands to follow the pitch command signal from the FMS when coupled VNAV guidance is active in PATH and VGP modes. The pilot can manually change any of the FCS mode selections made by the FMS. Pilot action suspends the current FMS VNAV control of the FGS, but does not preclude automatic reassertion of control by the FMS.

#### **Go Around Mode (Vertical)**

Go around mode is selected by pressing the GA button on control wheel. When in vertical go around mode, the system generates a fixed 9° pitch up command.

#### **Overspeed Mode**

Overspeed mode is automatically selected when an overspeed occurs, unless altitude hold mode or preselect altitude capture or track states are active. When in overspeed mode, the system generates commands to reduce the airspeed at 0.865 - 0.87 M<sub>i</sub>. Airspeed bug moves to 0.84 M<sub>i</sub>. The system remains in overspeed mode until changed by the pilot or an automatic mode change occurs.

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### **Malfunction Protection**

The flight control system uses a multi-layered response to failures which may occur within the system and data from external sensors. Malfunction protection and response are provided by a dual channel main processor (Level II verified) and I/O processor (Level I verified) architecture. The main processor provides protection against flight guidance data failures and single channel attitude control failures. The I/O processor provides additional limiters and monitors including protection from possible generic software design errors in the main processor program.

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#### **Flight Guidance Data Failures**

When there is a failure detected in any sensor data used in the flight guidance computations, the system internally reverts to the basic mode for the affected axis, pitch attitude hold for vertical modes and roll attitude hold for lateral modes. If the failure condition remains for a period of time, typically four seconds, the flight director display removes the steering command and annunciate the failure by placing a red line through the active mode annunciation. The flight director returns to normal operation if the data returns to a valid condition or another operational mode is selected.

Response to flight guidance data is provided by pitch and roll attitude and attitude rate limiters. These limiters limit the aircraft response to those approaching normal maneuvering; 5 °/second of roll rate in the lateral axis, and 0.2g in the vertical axis.

Aircraft response to failures which result in main processor servo commands exceeding the maximum rate limit are limited by the I/O processor cutout function and servo torque limiting. If the aircraft exceeds predetermined attitudes, attitude rates, or accelerations, the I/O processor will zero the command going to the servo control loop. The servo drives the control surface toward the position it was in prior to the malfunction. The cutout switch is activated only if the command is in the opposite direction to arrest the malfunction.

In addition to the cutout function, servo torque is limited through direct electronic limiting of servo motor current. By limiting the maximum rate of change of the control surface, torque limiting limits the aircraft response prior to cutout operation.

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### **Servo Control Failures**

The dual channel analog servo control architecture provides fully fail passive response to failures occurring within the servo control function.

The pilot's flight director commands are computed in one FGC-3000 module and the copilot's flight director commands are computed in the other module. Using the CPL button on the FGP, the pilot selects which flight director steering commands are displayed on both PFD's with two exceptions. In approach or go-around modes, left flight director commands are displayed on the left PFD and right flight director commands are displayed on the right PFD. The autopilot, if engaged, is always coupled to the selected flight director. The selected flight director commands are sent to the attitude loops in both computers where identical computations are performed using redundant sensor data for command limiting and feedback. The resulting servo commands in each computer are fed to the analog servo loop where they are voted before being applied to the servo.

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#### AUTOPILOT CONTROLS

The FGP-3000 flight guidance panel ([Figure 7-22-1](#), [page VII-22-15](#)) is a single unit that controls two independent flight guidance systems using the following controls:

CRS knob (2) - Provides control of the pilot and copilot selected courses. The knobs are continuously turning with no mechanical or electrical stops. An integral button in center of the knob provides a direct-to function.

ALT knob - Controls the altitude preselect display on the PFD. The knob is continuously rotating with electrical stops at -1000 ft and 50,000 ft. Normally each “click” of this switch changes the preselected altitude by 1000 foot increments. The switch has a second position that is achieved by pulling the knob away from the panel. The increment size is changed to 100 ft per click. In either position, the full range (-1000 to 50,000) is available. Movement of the switch automatically arms altitude select, except when in approach mode.

HDG knob/selector - Consists of a lower two-position selector, an upper continuously turning knob, and an integral center button. The selector sets the reference for pilot selected angles - track or heading (track is only available when an IRS is installed). The knob is used to select the desired angle. The button provides a “sync” to current angle function.

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Vertical Speed/Pitch Wheel - Has two separate functions. If vertical speed mode is active, this wheel is used to change the vertical speed reference proportionally to the rotation angle. If vertical speed mode is not active, movement of this wheel deselects any vertical mode that may be active (except glideslope capture) and selects pitch mode. In pitch mode, rotation of the wheel changes the pitch reference proportionally to the rotation angle.

YD/AP DISC disconnect bar - Provides a positive means of disconnecting the autopilot and yaw damper by directly removing power from the servos. Once the autopilot and yaw damper are disconnected using this means, the bar must be restored to its normal position before reengagement is possible.

FD button (2) - Selects and removes the steering commands on the PFD. At power up, the steering commands are displayed on the PFD. Steering commands are selected on both PFD's by engaging the autopilot, selection of go around mode, automatic selection of overspeed mode, or by manual selection of a vertical or lateral mode, when steering commands are not displayed on either PFD and the autopilot is not engaged. Coupling to a flight director selects the steering commands on the coupled side, if steering commands are displayed on either side, or if the autopilot is engaged.

AP button - Engages or disengages the autopilot. Note that there is also an AP disconnect switch mounted on each pilot control wheel. Engagement of the autopilot automatically engages the yaw damper. Activating the pitch trim switch on either pilot or copilot control wheels disconnects the autopilot and leaves the yaw damper operational.

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YD button - Engages or disengages the yaw damper. Manual engagement/disengagement of the yaw damper is completely independent of autopilot engagement.

CPL button - Controls the routing of flight guidance commands to the autopilot and flight directors. The coupled side is indicated by illumination of the appropriate arrow on the PFD AP display. When the left arrow is on, the autopilot uses flight guidance commands from the pilot channel. When the right arrow is on, the autopilot uses guidance commands from the copilot channel. Except when in ILS approach submode or go-around modes, the CPL pushbutton controls which flight guidance commands drive the flight director command bars. In approach and go-around modes, the flight directors operate independently.

The following buttons are momentary buttons used to select/deselect modes. Unless the active mode is approach, selection of a lateral or vertical mode respectively, automatically deselects any other lateral or vertical mode. Unless the active mode is go-around, a second press deselects the mode. Go-around is cleared by autopilot engagement or selection of another mode:

HDG button - Automatically selects and clears either heading select mode or track select mode, based upon the setting of the HDG select knob. When in heading select mode, or track select mode, changing the position of the HDG select knob clears one mode and selects the other.

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1/2 BANK button - Allows the pilot to override the FCS automatic transitions to/from half bank mode. Half bank limits the maximum command bank angle to 12.5°. Half bank is indicated by a white 1/2 BNK annunciation on the PFD. Selection of half bank is inhibited when lateral go around is active by outside localizer/azimuth capture/track, or by outside FMS navigation capture/track.

NAV button - Selects/deselects the navigation mode. In NAV mode the autopilot uses the active navigation source selected on the display control panel (DCP).

APPR button - Selects/deselects approach mode.

B/C button - Selects/deselects back course mode. There is no automatic selection of back course mode.

ALT button - Selects/deselects altitude hold mode.

VNAV button - Selects/deselects vertical navigation mode. In VNAV mode, the autopilot follows pitch commands generated by the FMS.

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FLC button - Selects/deselects flight level change mode. In FLC mode, desired airspeed is synchronized to the aircraft's current speed at the time of mode selection. This speed can then be slewed up/down using the SPEED knob; turning the knob increases or decreased speed setting in FLC mode. Pressing the knob switches alternately between IAS and Mach for display of airspeed on PFD. Automatic changeover from IAS to Mach occurs at 35,000 ft in climb and from Mach to IAS at 29,270 ft in descent. When FLC mode is selected, a climb or descent submode is entered automatically based on the difference between the aircraft present altitude and the preselected altitude. If the preselected altitude is higher than the current altitude, the climb submode is entered. If the preselected altitude is lower than the current altitude, the descend submode is entered. In either case, a minimum vertical speed is implemented, which forces the aircraft toward the selected altitude with a certain minimum vertical speed.

VS button - Selects/deselects vertical speed mode.

There are two additional autopilot switches external to the panel. A momentary button on the control wheel serves as the primary means to disconnect the autopilot. Momentary button on the control wheel engages the go-around mode.

Yaw damper remains engaged unless landing gear is down or with flaps 40°

### Caution Messages

A/P NOSE DOWN / UP - Excessive autopilot pitch trim

A/P NOSE LEFT / RIGHT - Excessive trim forces in the yaw axis

A/P PITCH TRIM FAIL - Autopilot pitch trim failure

A/P WING DOWN (L/R) - Excessive trim forces in the roll axis

MACH TRIM FAIL - Autopilot Mach trim failure

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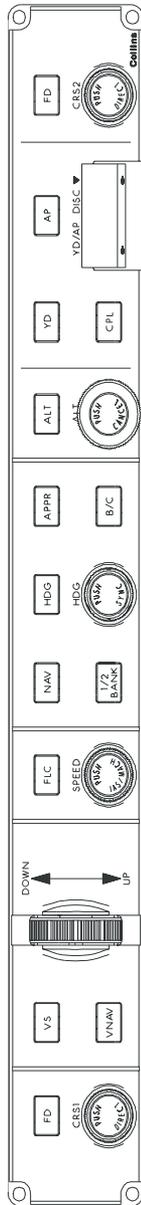


Figure 7-22-1. FGP-3000 Flight Control Panel

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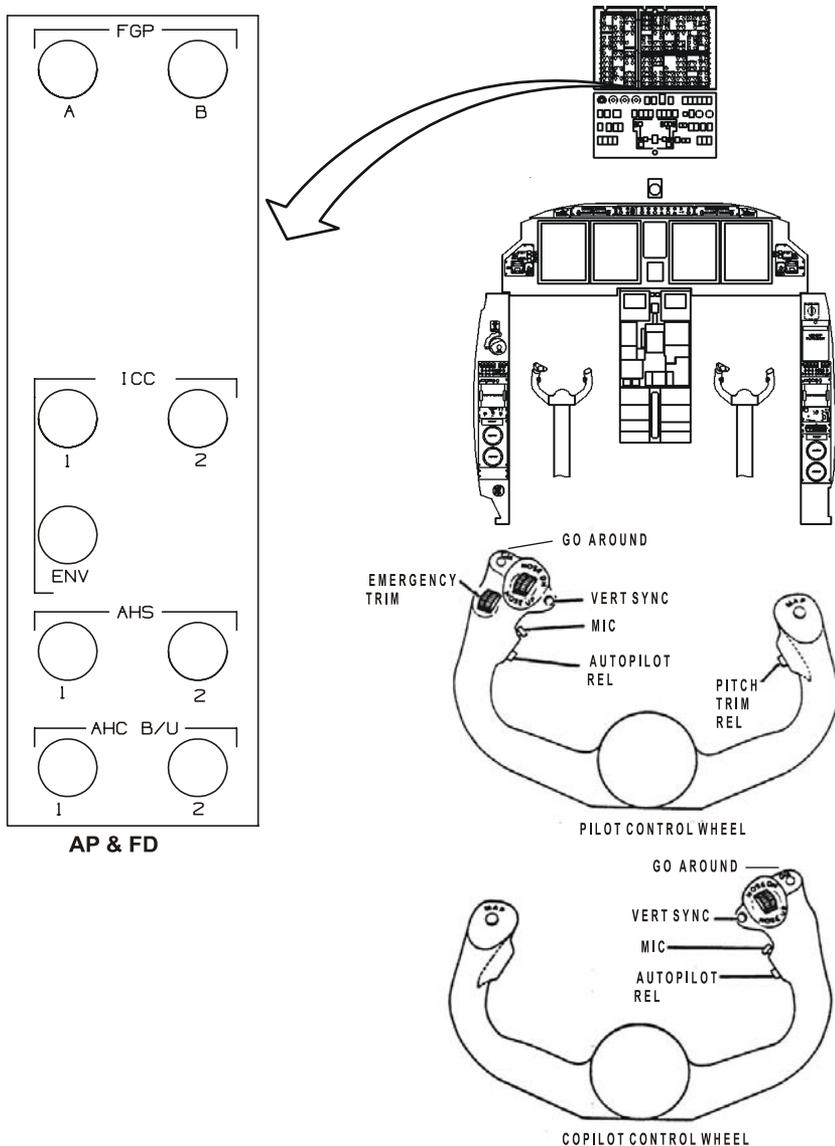


Figure 7-22-2. Autopilot Controls