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## **INTRODUCTION**

The Primus 2000XP includes an Automatic Flight Control System (AFCS) that provides dual channel autopilots, dual yaw dampers, dual flight directors and automatic pitch trim. The autopilot and yaw damper functions operate in an active standby mode, with only one channel active at a time. All computations are performed by two Flight Guidance Computers (FGC), located in the Integrated Avionics Computer (IAC). The FGC receives inputs from the Electronic Flight Instrument System (EFIS), the Air Data Computers (ADC), the Inertial Reference System (IRS), the Flight Management System (FMS), the Fault Warning Computer (FWC) and the Data Acquisition Unit (DAU).

## **DESCRIPTION**

All computations are performed by the FGCs which are located in IAC1 and IAC2. The FGCs receive inputs from the following through the Avionics Standard Communications Bus:

- Flight Management System
- Electronic Flight Instrument System
- Inertial Reference System
- Fault Warning Computer
- Data Acquisition Units
- Micro Air Data Computers

## **GUIDANCE PANEL**

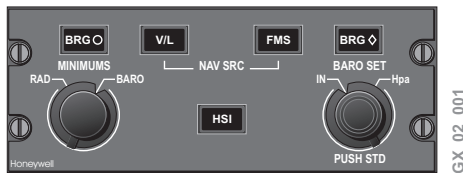
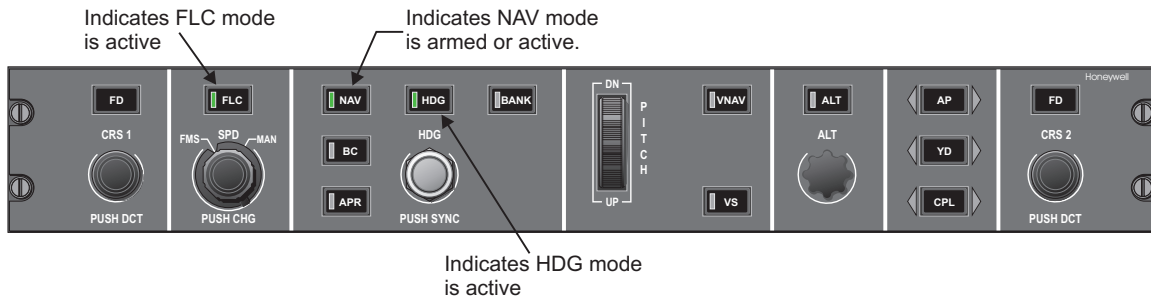
The AFCS functions controlled by the FGC include:

- Flight director modes
- Pitch wheel references
- Engagement of the autopilot and yaw damper functions
- Selection of left or right Primary Flight Display (PFD) data to be used by FGC

Through the flight computer, the AFCS will provide flight guidance outputs for display on the Primary Flight Display (PFD). The flight director functions are as follows:

- Mode selection
- Computation of guidance
- Data management and source selection
- Command bar output for display

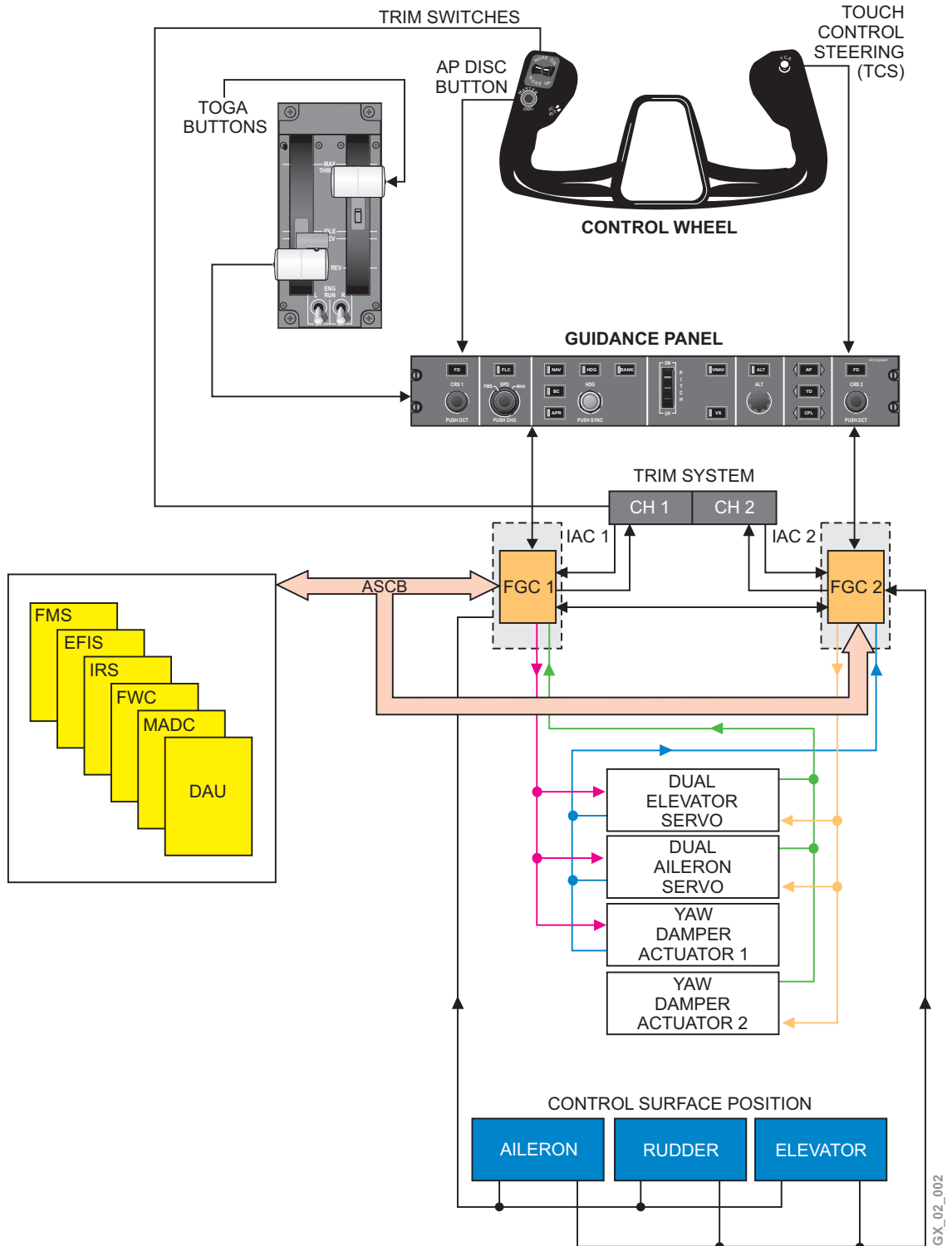
If an autopilot or flight director mode is armed or active, the annunciator on the appropriate button is illuminated.



(The PFD control panels are located on each side of the guidance panel)

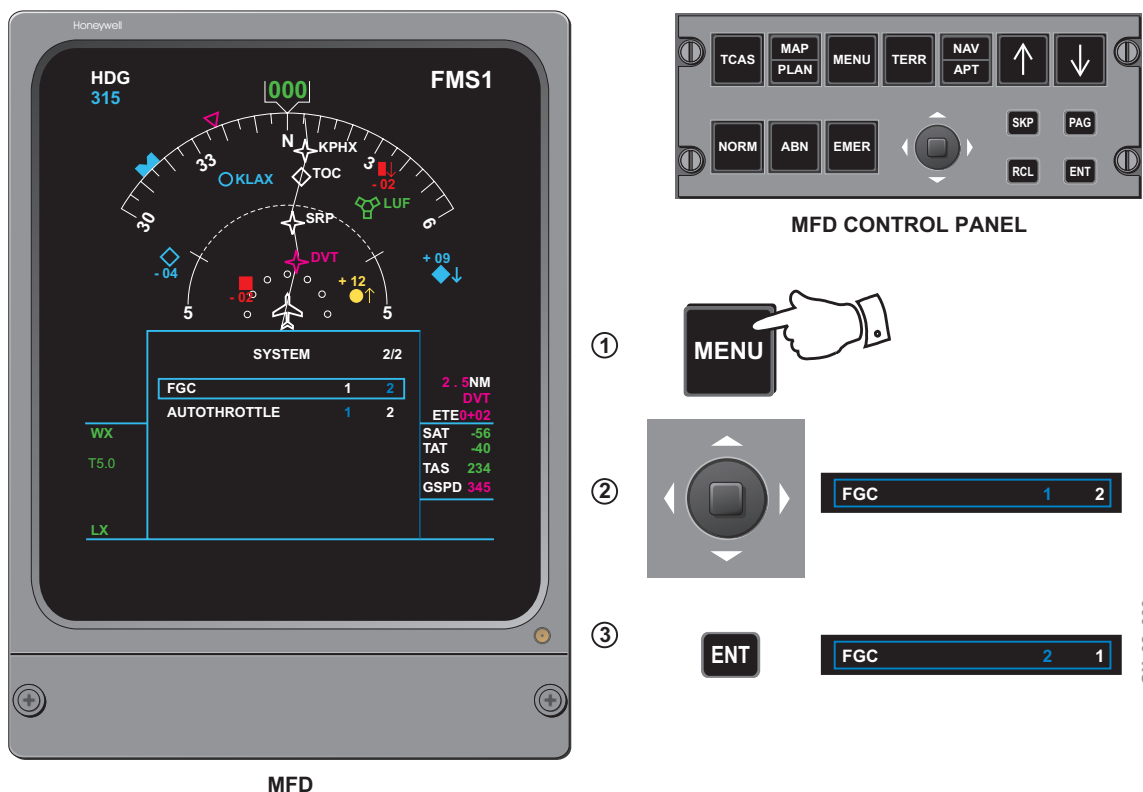
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**AFCS SCHEMATIC**



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Manual selection of the master AFCS channel is accomplished via the pop-up menu on either multifunctional display (MFD), in conjunction with the MFD control panel located on the pedestal.



## AUTOPILOT

The autopilot (AP) system automatically controls the airplane in pitch and roll attitude via servo control of ailerons, elevator and aircraft pitch trim system. The two autopilot computer channels operate in a high priority/low priority (active/standby) configuration.

Assignment of priority channel is alternated on power-up. The high priority channel provides control functions, while the low priority channel operates in a back-up mode. The autopilot/yaw damper actuators and pitch trim interface can only be driven by the priority channel.

In the event of a channel failure, the priority will automatically switch to the other channel.

Each FGC shall determine which symbol generator is driving the selected PFD, as selected on the reversion control panel located on the pedestal. The following guidance data is received via the Avionics Standard Communications Bus (ASCB), for use in the FGC:

Air data source identification	Lateral and vertical path deviations
Attitude source identification	Distance to station
NAV source identification	Tuned-to-NAV and To/From status
Course error	Inner, middle and outer marker data
Heading error	Radio altitude and flags

The source of other guidance information is selected via the source identifier received from selected PFD symbol generator. The data received includes:

**IRS:**

Roll angle	Normal acceleration
Pitch angle	Ground speed
Roll rate	True track angle
Pitch rate	Flight path angle
Yaw rate	Magnetic heading
Longitudinal acceleration	True heading
Lateral acceleration	Inertial vertical speed

**ADC:**

Baro-corrected altitude	True airspeed
Pressure altitude	Dynamic pressure
Vertical speed	VMO
Mach	MMO
Calibrated airspeed	

**FMS:**

Lateral steering command and flags	VNAV submode selection flags
VNAV targets	

**FWC:**

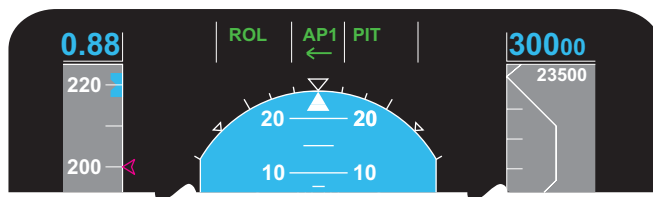
Preselected altitude

**Display Controller (DC):**

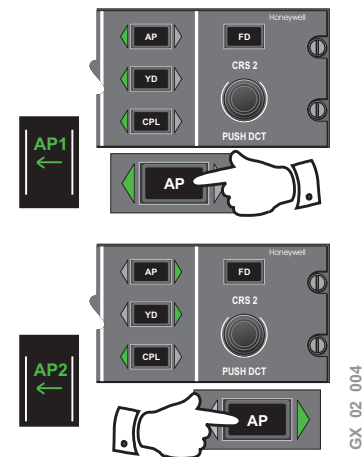
Speed references

## AUTOPILOT ENGAGEMENT

Autopilot is engaged via the AP button on the guidance panel. When there are no vertical or lateral mode active, the autopilot will engage in (PIT) and (ROL) FD modes.



When selected, AP1 or AP2 will flash for approximately 5 seconds, then steady.



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Autopilot control authority:

- Roll rate is limited to  $\pm 7.5^\circ/\text{sec}$ .
- Pitch rate
  - $\pm 0.3$  g's in straight and level flight
  - maximum  $0.7$  g's pitch up in a turn

The autopilot can engage throughout the range:

- Pitch =  $\pm 50^\circ$
- Roll =  $\pm 75^\circ$ 
  - Once engaged, the autopilot will reduce the pitch and roll angles below control limits

Autopilot control limits:

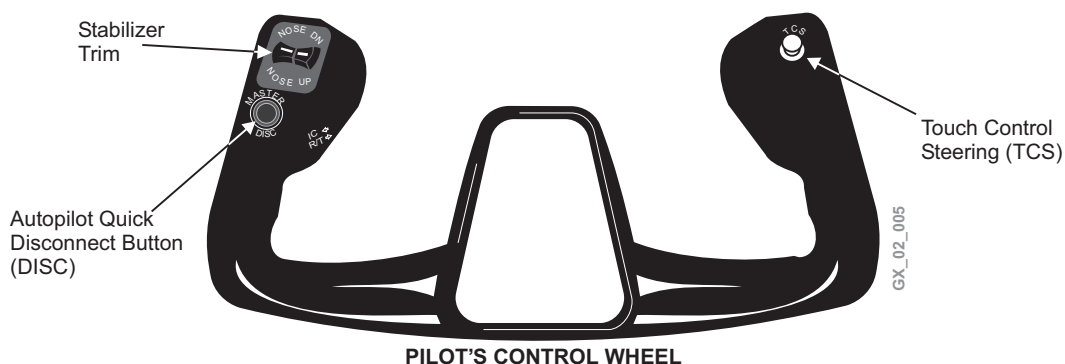
- Roll =  $\pm 35^\circ$  except in Approach (APP) mode. When in APP mode, the roll limits are reduced linearly from  $\pm 25^\circ$ , above 200 feet radio altitude, to  $\pm 5^\circ$  at zero feet radio altitude
- Pitch =  $\pm 20^\circ$ . In APP mode, the nose-down pitch limit is reduced below 300 feet, programmed by vertical rate and radio altitude



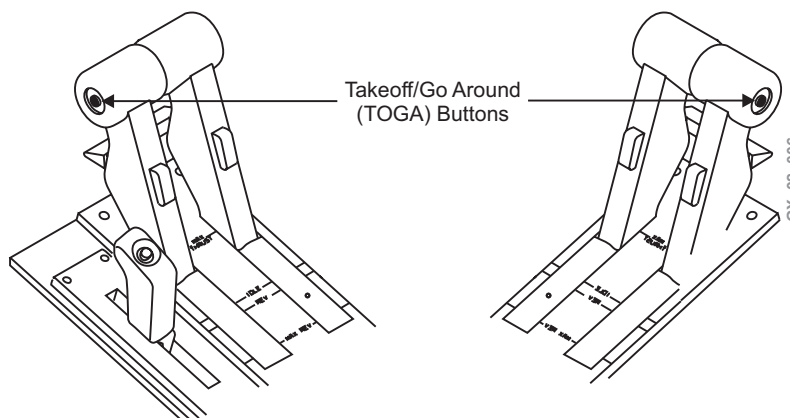
### AUTOPILOT DISENGAGEMENT

Autopilot disengagement is accomplished by activating any of the following:

- AP button on guidance panel
- Autopilot quick-disconnect (DISC) button on either control wheel
- Manual stabilizer trim when touch control steering (TCS) not active
- YD button on FGC panel
- TCS button on either control wheel (while depressed). When the TCS button on either control wheel is activated, the aileron and elevator servo clutches are released, the autopilot is disengaged and the flight director is resynchronized. Releasing the TCS button reengages the servo clutches and autopilot is engaged, if within normal pitch and roll limits. Where applicable, the flight director modes will react as if the autopilot had just been engaged



- Takeoff/Go Around (TOGA) buttons on thrust levers
- Motor trip/failure or AFCS failure
- Stick shaker acuation



The AP1 or AP2 annunciator will flash red continually and an aural “cavalry charge” will sound repeatedly. The annunciation and aural can only be canceled by depressing DISC on either control wheel.

## **YAW DAMPER**

The yaw damper provides stability augmentation and turn coordination for the airplane yaw axis via two linear actuators, in series with the rudder control system.

The yaw damper function will automatically engage on the ground, within 3 seconds after successful completion of AFCS power-up test. As with the autopilot, the yaw damper operates in an active/standby configuration. When engaged, the active yaw damper will center both linear actuators.

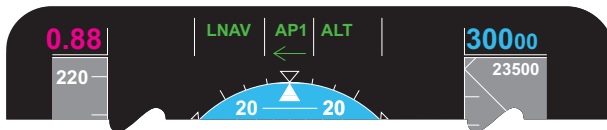
The YD will not automatically engage once the airplane is airborne. The YD button, located on the guidance panel, may be used to reengage the YD. When YD is engaged, the associated arrow on the guidance panel is illuminated.

One yaw damper must be engaged for autopilot operation. Autopilot engagement without YD will occur only when both YDs have failed in flight.



For more information on yaw damper, please refer to Chapter 10, FLIGHT CONTROLS.

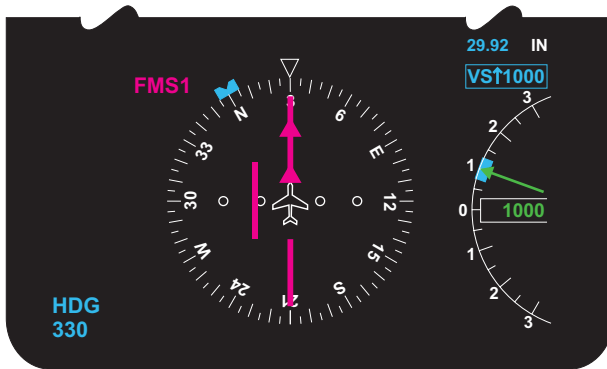
PFD ANNUNCIATION



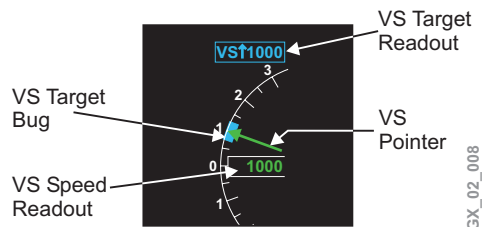
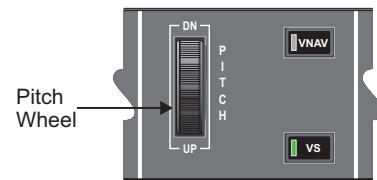
AP ENGAGE STATUS



TOUCH CONTROL STEERING (TCS) STATUS



VERTICAL SPEED REFERENCE

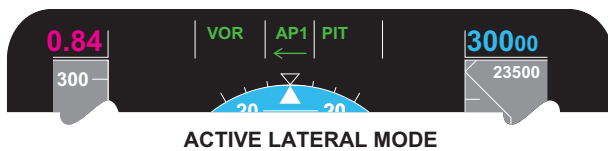
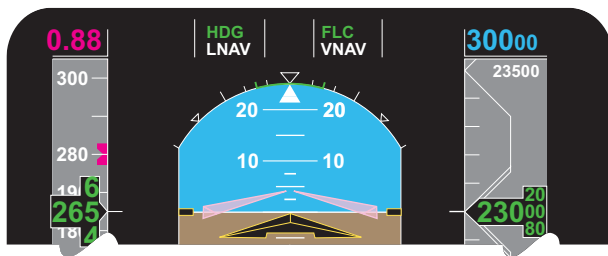


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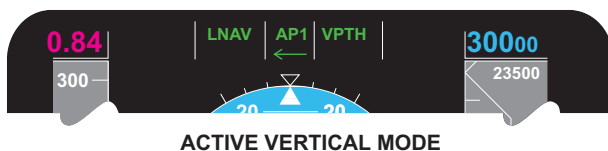
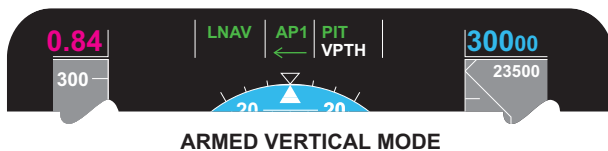
### FLIGHT DIRECTOR (FD)

The Flight Director modes of operation can be divided into two major subgroups, the Lateral modes and the Vertical modes. Only one lateral mode and one vertical mode may be active (green) at any time; however, one lateral arm (white) mode and up to two vertical arm (white) modes may be selected.

The armed and active modes are annunciated on both PFDs. Armed modes are displayed in white below active modes, which are displayed in green. The lateral modes are annunciated on the left side of the displays and the vertical modes on the right side, above the attitude sphere. Low bank mode is annunciated via green eyebrow on top of the attitude sphere.



Active mode flashes for 5 seconds upon automatic mode capture.



Active mode flashes for 5 seconds upon automatic mode capture.

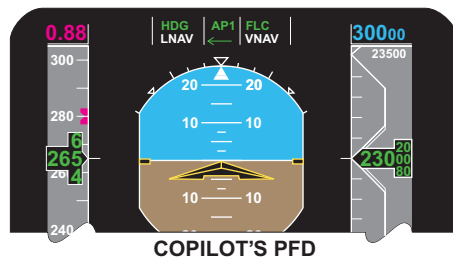
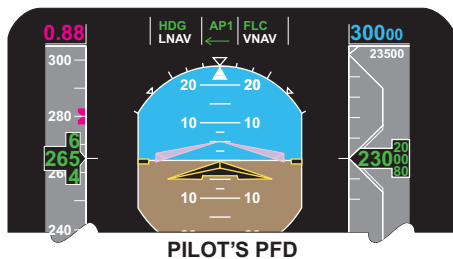
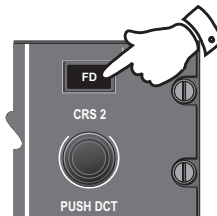


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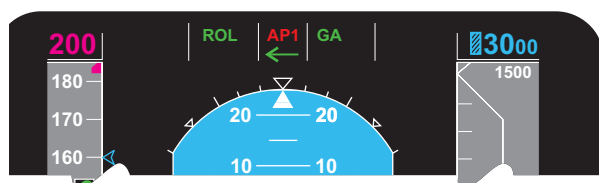
Flight director command bars appear on the PFD whenever a lateral mode is selected. The FD switch is used to remove flight director command bars. If the AP is on, the off-side button will remove the off-side flight director bar(s) only. If the AP is on, the on-side button is not functional. Flight director command bars are always present on both PFDs when Go Around (GA), Takeoff (TO) or Windshear Guidance (WS) modes are active.



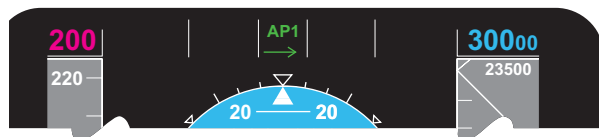
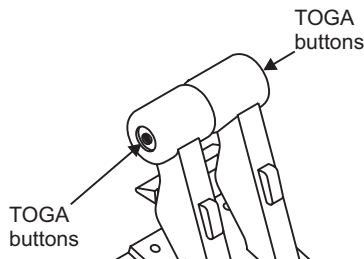
**FD Switch:**  
Used to remove flight director command bars from the non-coupled PFD.



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FLIGHT DIRECTOR COMMANDS AND STATUS



FLIGHT DIRECTOR DATA SOURCE (CPL)



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**GUIDANCE PANEL**

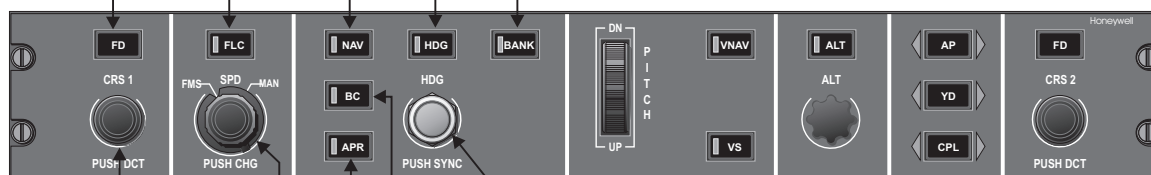
**Flight Director (FD) Switch**  
Used to remove flight director command bars.  
**AP ON** – Onside button not functional  
offside button removes offside FD.  
**AP OFF** – Onside button removes both FD  
offside button removes offside FD.

**Navigation (NAV) Switch**  
Used to arm lateral guidance  
for capture of selected  
navigation course or desired  
track. NAV sources can be  
FMS, LOC (only), VOR.

**Bank (BANK) Switch**  
Used to manually select  
bank angle limit in HDG,  
or VOR modes.

**Flight Level Change (FLC) Switch**  
Used to climb or descend to a  
new altitude reference, while  
maintaining an airspeed or mach  
reference.

**Heading (HDG) Switch**  
Used to activate the lateral  
guidance to compute  
steering commands, based  
on selected heading.



**Course 1 (CRS 1) Button**  
Used to move the  
course pointer on  
selected PFD.  
**Push Direct (PUSH  
DCT) Button**  
When pushed,  
causes course  
pointer to indicate  
direct course to  
tuned VOR.


**Speed (SPD) Button**  
Used to set speed on PFD  
(manually or by use of FMS).  
**MAN** - Airspeed reference set  
by turning inner knob. When  
inner knob pushed, changes  
IAS to Mach or Mach to IAS.  
**FMS** - Airspeed reference set  
by FMS.

**Approach (APP) Switch**  
Used to arm the lateral guidance  
for localizer capture. When  
localizer capture, vertical  
guidance is armed for glideslope  
capture. Also used to arm the  
lateral guidance for VOR  
approaches when VOR is NAV  
source.

**Back Course (BC) Switch**  
Used to select approach  
mode guidance for capture  
and tracking of back course  
data.

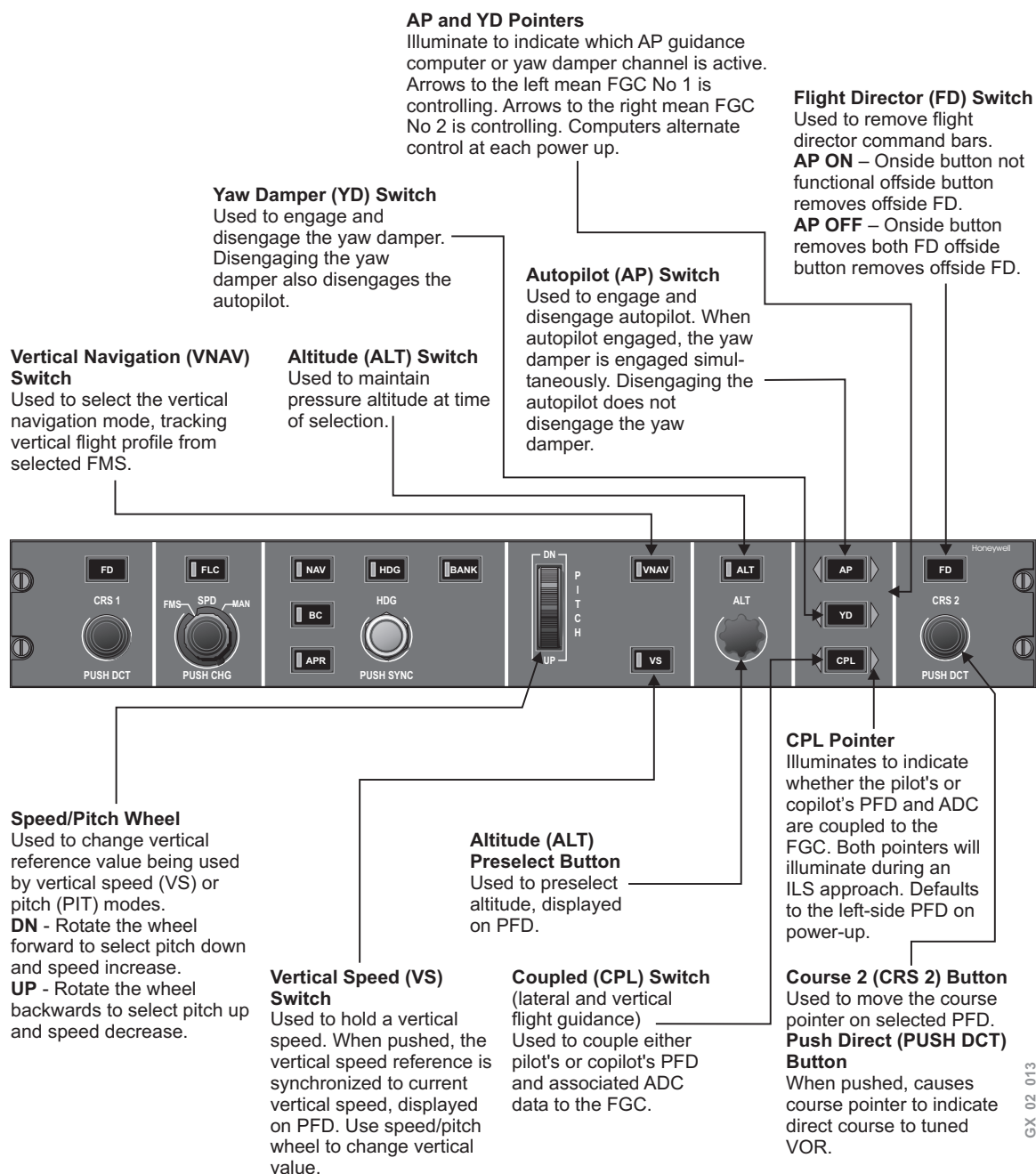
**Heading (HDG) Button**  
Used to move the heading  
bug on PFD.  
**Push Synchronize (PUSH  
SYNC) Button**  
When pushed, causes  
heading bug to synchronize  
to airplane heading.

**NOTE:**  
Annunciator, (on all flight  
director mode switches),  
illuminates when selected  
mode is armed or active.

Annunciator  
Light 

GX\_02\_012

GUIDANCE PANEL (Cont)



GX\_02\_013

**FLIGHT DIRECTOR MODES**

LATERAL MODES		
SWITCH (GUIDANCE PANEL)	MODE	ANNUNCIATION
HDG	Heading Select	HDG
NAV	Based on displayed navigation source (VOR, FMS, or localizer)	VOR / LNAV / LOC
APR	Based on VOR navigation source	VAPP
BC	Back Course	BC
BANK	High/Low Bank (HDG or VOR mode only)	Eyebrow on attitude sphere (low bank only)

VERTICAL MODES		
SWITCH (GUIDANCE PANEL)	MODE	ANNUNCIATION
VS	Vertical Speed Hold	VS
None	Automatic Altitude Capture	ASEL
ALT	Altitude Hold	ALT
FLC	Flight Level Change	FLC
VNAV	Vertical Navigation Modes requested by FMS	VFLC VASEL VALT VPTH

MULTI-AXIS MODES			
SWITCH (GUIDANCE PANEL)	MODE	ANNUNCIATION	
		Lateral Field	Vertical Field
APR	Based on localizer navigation source	LOC	GS
<b>Switch (Throttles)</b>			
TOGA	Go Around	ROL	GA
TOGA	Takeoff	ROL	TO
TOGA	Windshear Guidance	ROL	WSHR



BASIC MODES		
SWITCH (GUIDANCE PANEL)	MODE	ANNUNCIATION
None	Roll Hold	ROL
None	Roll Hold Submode (wings level)	ROL
	Roll Hold Submode (heading hold)	ROL
None	Pitch Hold	PIT

## LATERAL MODES

### Roll (ROL) Mode

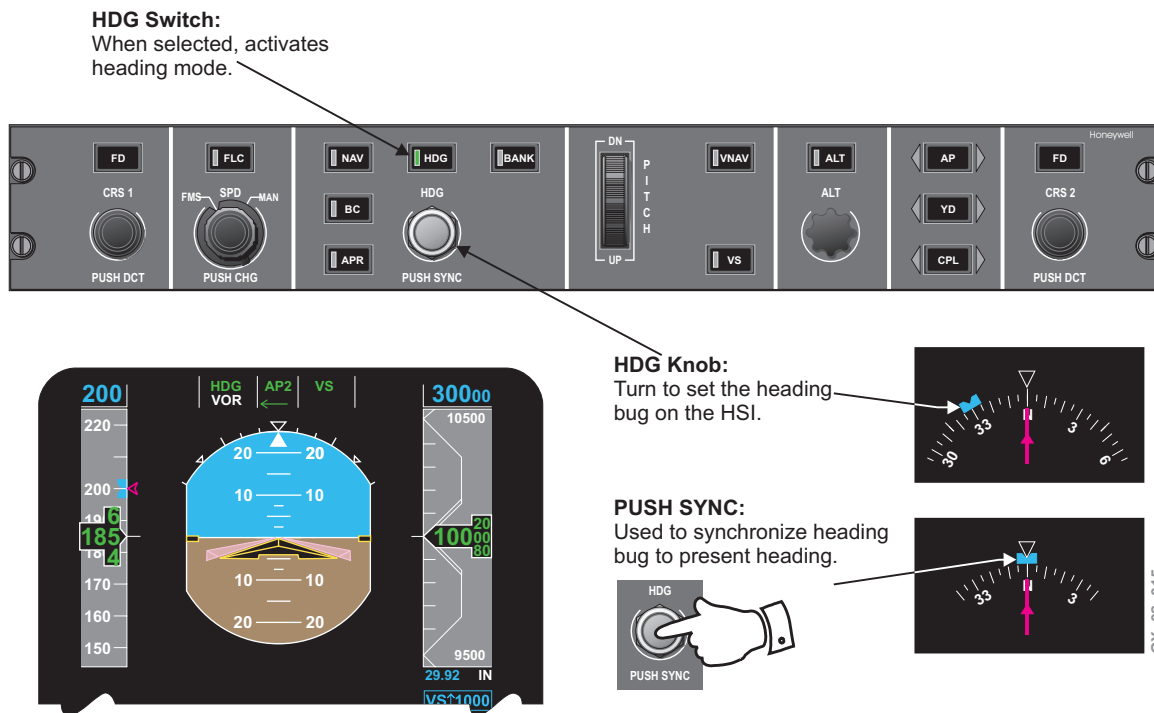
Roll mode is automatically selected, when no other lateral mode is active, and the autopilot is engaged. Roll mode generates commands to hold the heading that exists when the mode is initiated, unless the bank angle upon initiation is over 6° (commands are then generated to hold the bank angle). The roll mode reference is reset to the current heading, or current roll angle, upon AP engagement.

Roll mode is annunciated in the lateral capture field on the PFD. Roll mode is cleared by selecting another lateral mode. ROL will flash for approximately 5 seconds, when active.



## Heading Select (HDG) Mode

The heading select mode is activated via the HDG switch on the guidance panel.



If the heading bug is turned through more than 180° but less than 360° (airborne), the FGC will follow the bug all the way around to the target and not turn in the shortest arc. The FGC provides guidance to the selected target using the shortest arc when on the ground. The on-ground logic will prevent the airplane from turning in the wrong direction following takeoff, due to maneuvering the airplane may have done on the ground.

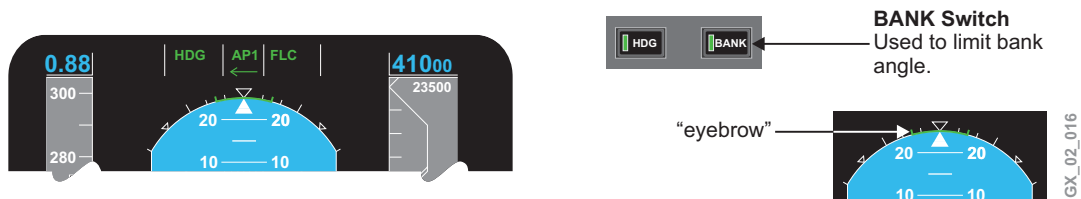
## Bank Mode

While in BANK mode, the roll rate commanded by the heading or VOR modes is limited to 4°/sec. If the roll angle is less than or equal to 6° when ascending through an altitude of 35,050 feet, the FGC automatically transitions to the low bank limit of 17°. If the roll angle is greater than 6°, an automatic bank limit transition will not occur until the roll angle is reduced to less than or equal to 6°.

When descending through 34,950 feet, the bank limit shall revert to the high bank limit of 27°, if the roll angle is less than or equal to 6°. If the roll angle is greater than 6°, high bank limit reversion will not occur until the roll angle is reduced to less than or equal to 6°.

The bank angle can also be toggled between high and low bank limits by means of the BANK switch on the guidance panel.

When heading or VOR mode are active with the low bank limit, an “eyebrow” is displayed between  $\pm 17^\circ$  on top of the attitude sphere on the PFD.



### Lateral Navigation Modes

Lateral navigation mode is activated by selecting the NAV button on the guidance panel. The following navigation sources may be activated:

- Very high frequency Omnidirectional Range (VOR)
- Localizer (LOC)
- FMS Lateral Navigation (LNAV)

If in (ROL) mode when (NAV) is selected, heading select mode is automatically activated. A capture of any armed lateral navigation mode will cancel the heading mode.

Lateral navigation guidance and automatic transitions are computed based on the following data, received from the selected PFD:

- Lateral path deviation (VOR and LOC)
- Course or heading error
- NAV source identification (VOR, LOC, FMS)
- VOR radio frequency retuned flag
- To-From flag
- Distance to station (DME) and tuned -to-NAV flag
- Radio altitude

## **VOR Mode**

VOR mode provides for automatic intercept, capture and tracking of a selected VOR radial. This mode is used to navigate on an airway between two VOR stations. This mode is NOT to be used to intercept and track a VOR radial for a VOR approach. Approach mode must be used for that purpose.

If Distance Measuring Equipment (DME) information is not available, the FGC uses FMS range to the VOR station. If FMS range is not available, the FGC estimates a distance of 30 NM.

Capture and tracking will occur, provided that:

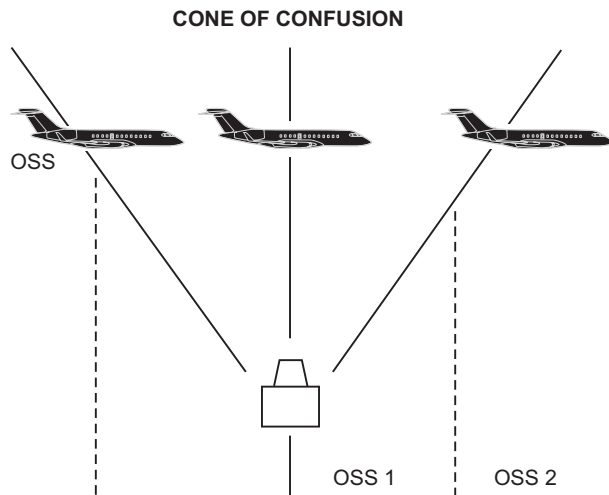
- The intercept angle is less than 60°. The optimum intercept angle should be less than 45°. If greater than 45°, course cut limiting may occur to limit steering commands to 45° which forces flight path to get to radial sooner to prevent overshooting beam center
- The bank angles required do not exceed the roll limits

FD roll commands are limited to  $\pm 24^\circ$  when in VOR capture and roll rate commands are 5.5°/sec. When VOR track is active, FD roll commands are  $\pm 14^\circ$  and roll rate commands 4°/sec.

If selected VOR is retuned to another VOR frequency, while in VOR capture, track or overstation, VOR mode cancels and rearms automatically.

When the airplane is passing over the VOR transmitter (cone of confusion), VOR mode will fly towards selected course reference (overstation passage). If selected course is unchanged prior to entry into cone of confusion, previously computed wind correction is applied and VOR mode will not command a turn towards selected course pointer. Changes of course pointer setting when overstation will cause a change in course hold reference.

If DME is available, the cone of confusion entry boundary is estimated based on distance to transmitter and altitude, or VOR TO/FROM transition. When over the VOR station, VOR will follow a course change of up to 120°. The cone of confusion exit boundary is based on altitude, airspeed and time. If DME information is not available, the cone of confusion boundaries are determined by level of beam noise or VOR TO/FROM transition. When in VOR overstation, the flight director roll commands are limited to  $\pm 24^\circ$  and roll rate commands are 7°/sec. The overstation sensor (OSS) monitors entry into zone of confusion and removes radio deviation from the roll command.



**OSS** - is used to detect erratic radio signals encountered in the area above VOR transmitter.

**OSS1** monitors beam deviation and will occur when:

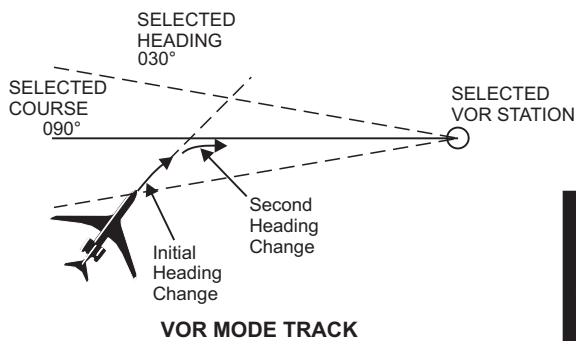
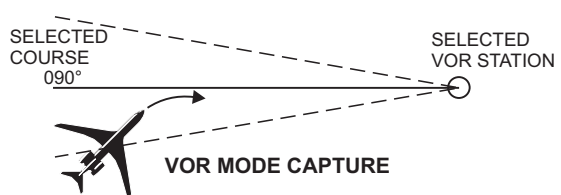
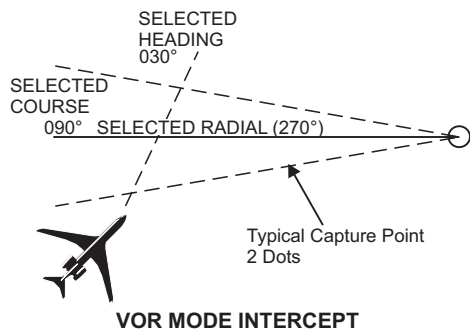
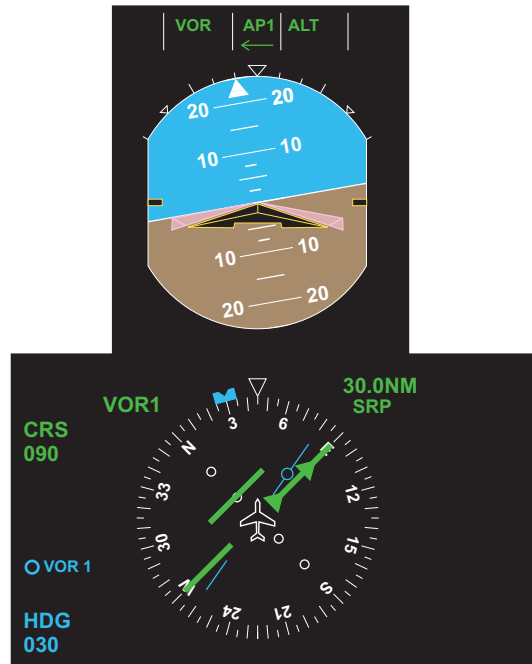
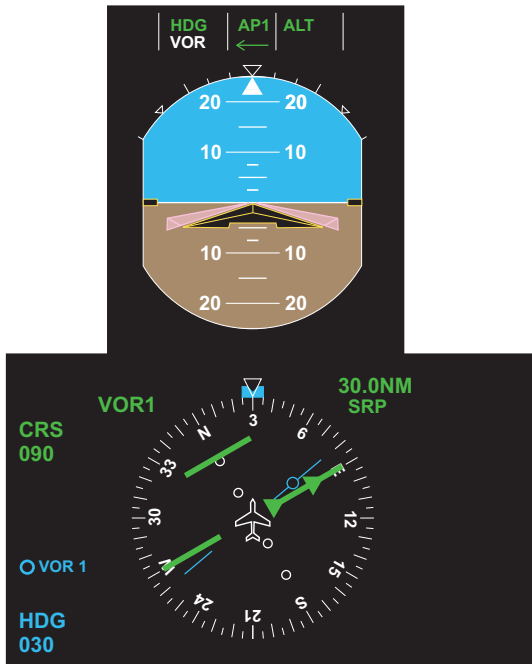
- OSS has occurred.
- A calculated period of time has elapsed since last TO/FROM transition.
  - The period of time elapsed is calculated using true airspeed and altitude.
  - The higher the altitude, the longer it takes to get through cone of confusion.
  - The higher the airspeed, the faster the airplane will be through the cone.
- VOR track has occurred, plus 3 seconds of elapsed time.
- Distance to station is less than 1/4 of the altitude and DME present, or
- Lateral deviation is greater than 1 dot and rate of deviation is greater than 25 feet/sec and DME is not present.

**OSS2** - ensures beam deviation is useable and will occur when:

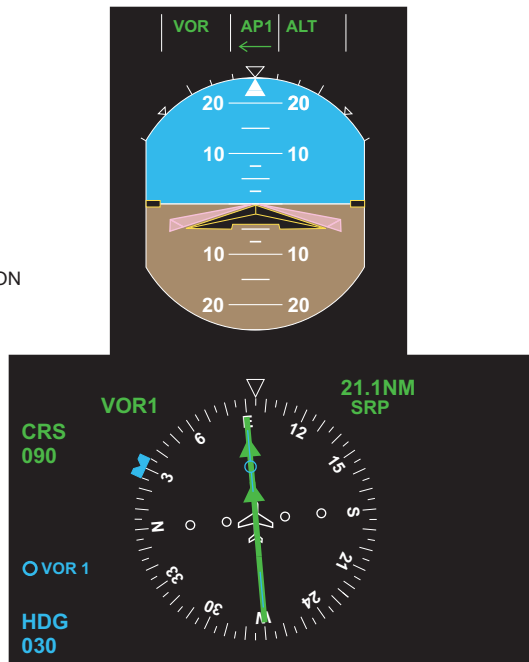
- OSS1 has occurred, plus 3 seconds.
- Beam deviation is less than 1 dot.
- Beam rate is less than 25 feet/sec.

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As VOR moves from ARMED to ACTIVE, the VOR will flash for approximately 5 seconds, when active.



**NOTE:**  
During course cut limiting, typically the roll command will make an initial heading change, level out and fly towards the beam, then make a second heading change to line up on the center of the radial.



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### Localizer (LOC) Mode

Localizer mode provides for automatic intercept, capture and tracking of the front course localizer beam, to line up on the centerline of the runway in use.

Localizer capture and tracking commands are based on the distance-to-transmitter. The FMS will output distance to tuned navaid or distance to destination, based on the following conditions:

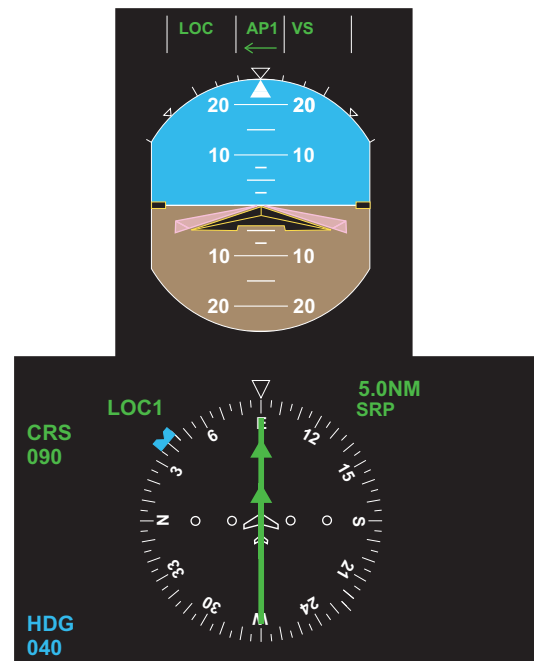
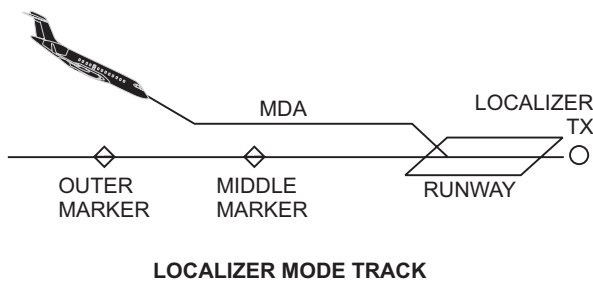
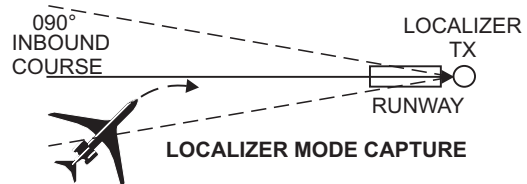
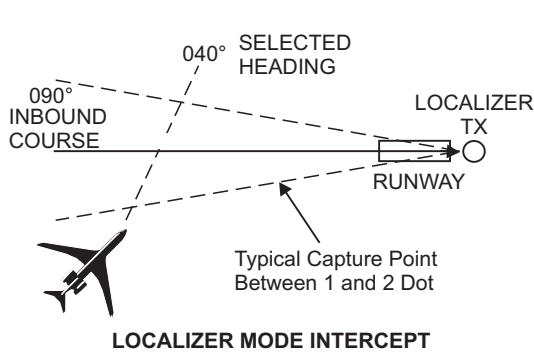
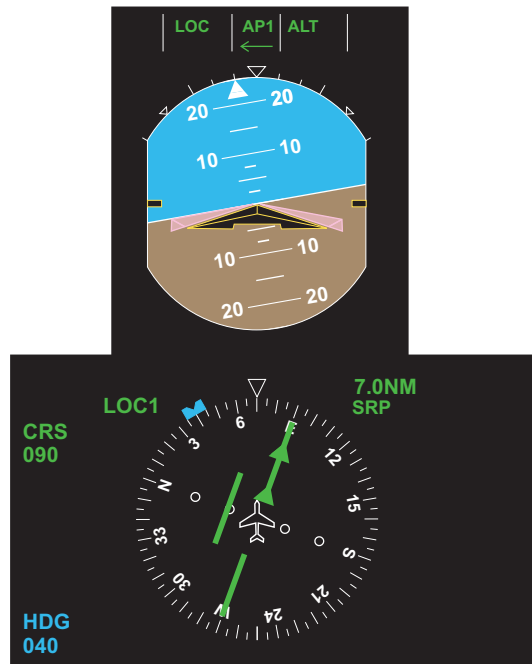
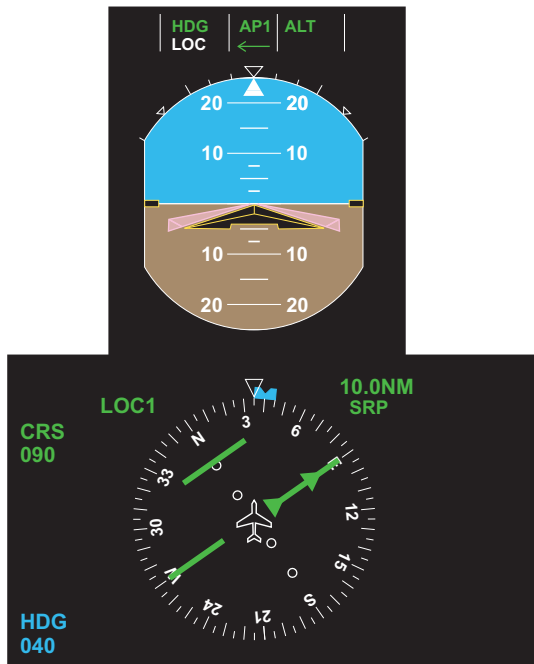
- If the FMS is used to autotune the LOC, the FMS will output the distance to the tuned LOC transmitter
- If the FMS is tuned manually by LOC-ident on the CDU, the FMS will output the distance to the tuned LOC transmitter, regardless of approach or flightplan
- If the LOC frequency is manually tuned with a LOC-frequency on the CDU, or if tuned on the RMU, and the FMS will output distance to destination selected in the flight plan
- If the LOC frequency is manually tuned with a LOC-frequency on the CDU, or if tuned on the RMU, and the FMS does not have a destination selected, no distance information will be output by the FMS. In this case, the AFCS will use estimated distance

The AFCS priority for determining distance to LOC transmitter is:

- Distance-to-station (DME) information, if the DME is valid and co-located with the localizer transmitter
- If DME information is not available, or not co-located, the distance to localizer is based on radio altitude, true airspeed, glideslope deviation and an assumed flight path angle of 3°
- If, in addition to invalid DME, the radio altitude is invalid, the AFCS will use FMS distance information
- If the FMS is also unavailable, then AFCS will use a default value of 10 nm

If a destination other than the one designated in the FMS flight plan is used and the LOC-frequency is manually tuned with a LOC-frequency on the CDU, or tuned on the RMU, and DME and RAD ALT are not available, the FMS will output erroneous distance to destination data. To prevent potential problems in this circumstance, a limit was placed on the value the AFCS will accept from the FMS for distance (30 nm). Testing showed that when performing a close-in capture (7 - 10 nm) using the maximum value for distance (30 nm), the LOC overshoots on initial capture were within acceptable limits and were damped out within 2 oscillations.

FD roll commands are  $\pm 30^\circ$  when capturing localizer. During localizer track mode, the roll commands are  $\pm 24^\circ$ . Roll rate commands are  $7^\circ/\text{sec}$ . during capture and  $5.5^\circ/\text{sec}$ . during track modes. The optimum intercept angle is  $45^\circ$ . If intercept angle is greater than  $45^\circ$ , course cut limiting may occur. As LOC moves from ARMED to ACTIVE, the LOC will flash for approximately 5 seconds, when active.



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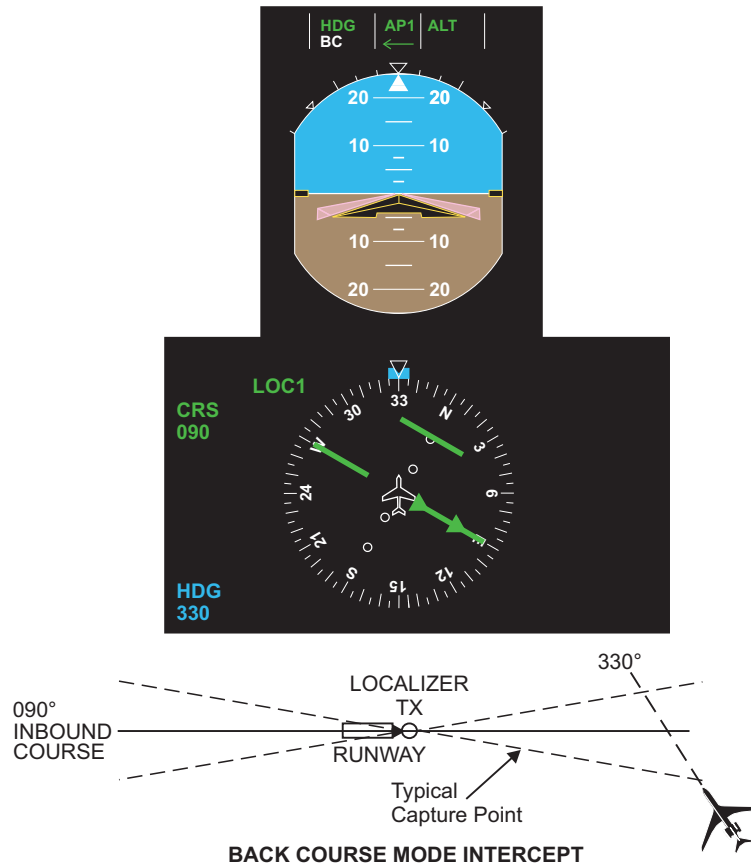


### **Back Course (BC) Mode**

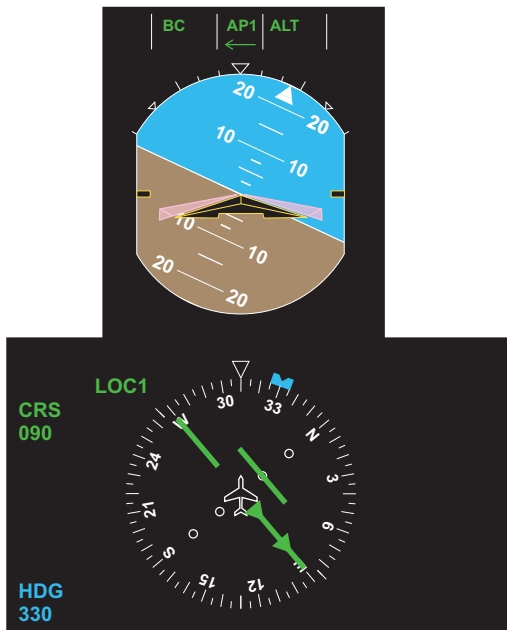
Back course mode provides for automatic intercept, capture, and tracking of the back course localizer signal.

BC mode is identical to LOC mode except that the transmitter is located 2000 feet in front of the touch-down point. The course arrow must be set to the front course runway heading. The FGC will invert the course and radio deviation signals to provide correct back course steering commands.

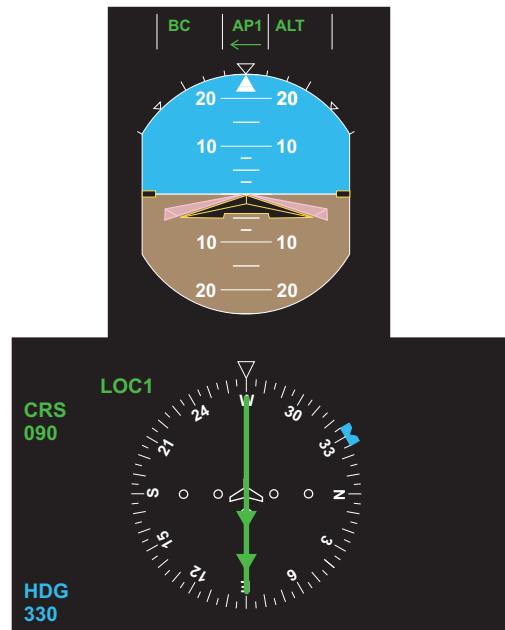
As BC moves from ARMED to ACTIVE, the BC will flash for approximately 5 seconds, when active.



**BACK COURSE MODE INTERCEPT**



**BACK COURSE MODE CAPTURE**



**BACK COURSE MODE TRACK**

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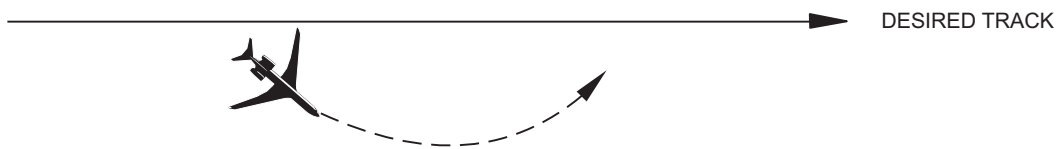
### FMS Lateral Navigation (LNAV) Mode

The FMS lateral steering command is a roll command which aligns the airplane with the flight plan in the FMS. The FGC limits the FMS roll commands to 30° and roll rate to 5.5°/sec.

As LNAV moves from ARMED to ACTIVE, the LNAV will flash for approximately 5 seconds, when active.

LNAV capture will also occur when the airplane is within 2.5 miles of the desired track, and moving away from it.

LNAV capture will occur when the airplane is within 2.5 miles of the desired track, and moving away from it.



LNAV capture will occur when the airplane is at a calculated point, as a function of track error and groundspeed, if the airplane is flying towards the desired track.

LNAV capture will occur when the airplane is at a calculated point, as a function of track error and groundspeed, if the airplane is flying towards the desired track.



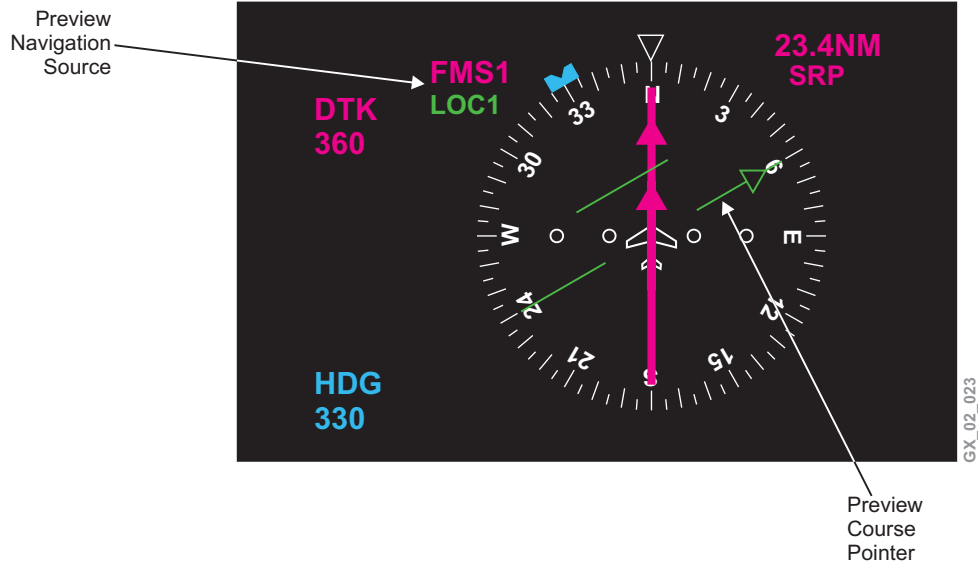
The FD will transition automatically (NAV to NAV transfer) from FMS navigation to a LOC or VOR approach via the APR, or BC button. The selected NAV source **must be FMS**, NAV radio must be tuned to the approach frequency and preview mode selected, to allow a NAV transfer to occur.

The previewed approach is armed by pushing the APR or BC switch on guidance panel. When LOC or BC captures, it replaces LNAV.

If the active vertical mode was not VNAV prior to capture, the vertical mode remains unchanged. If the active vertical mode was VNAV prior to capture, then ALT mode will replace the vertical mode.

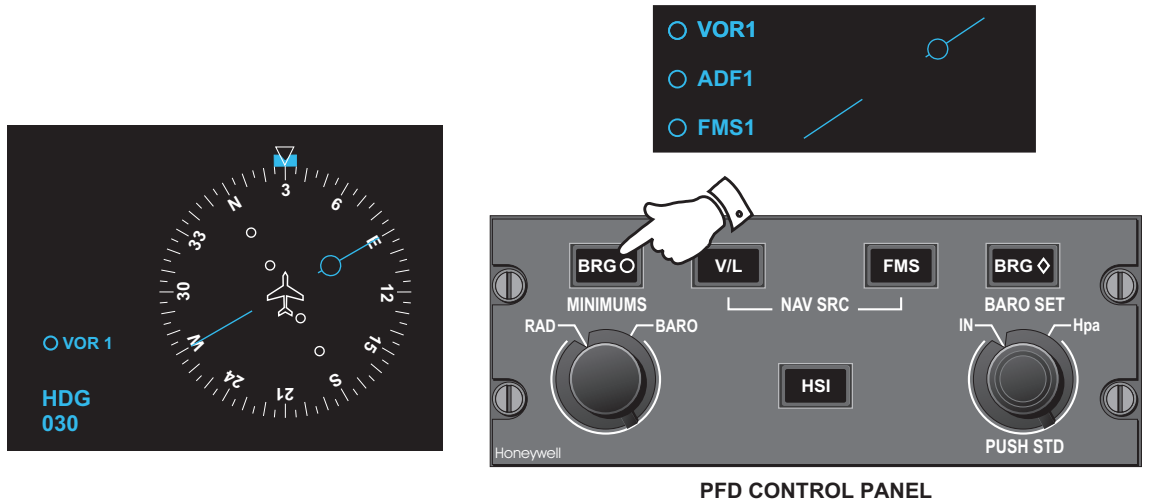
If armed approach mode was APR (ILS), then GS is armed with LOC capture and GS will capture when GS criteria is met.

**Previewed Approach**



### BEARING (BRG) SOURCE

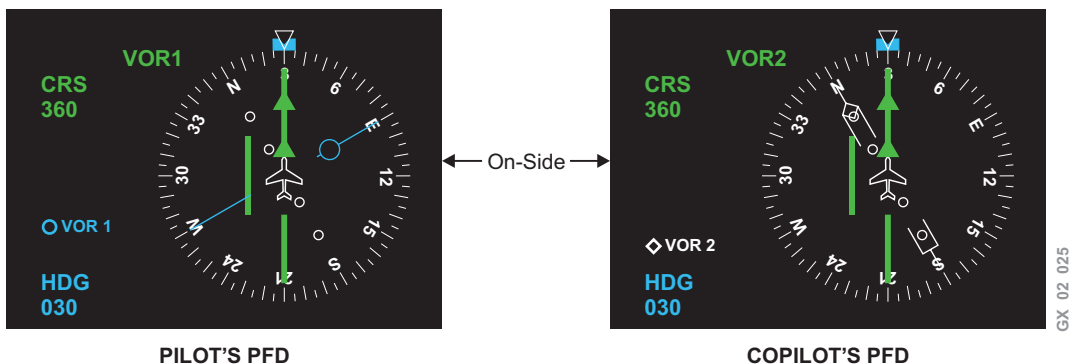
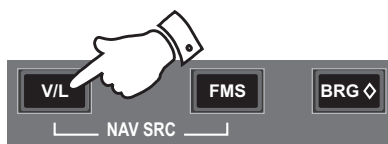
Bearing information VOR1, ADF1 or FMS1 and bearing information VOR2, ADF2 or FMS2 is selected on either the pilot's and/or the copilot's PFD control panel, located on the glareshield.



**NOTE:**  
Pushing BRG button(s) will toggle the following in sequence:  
- VOR  
- ADF  
- FMS  
- Blank

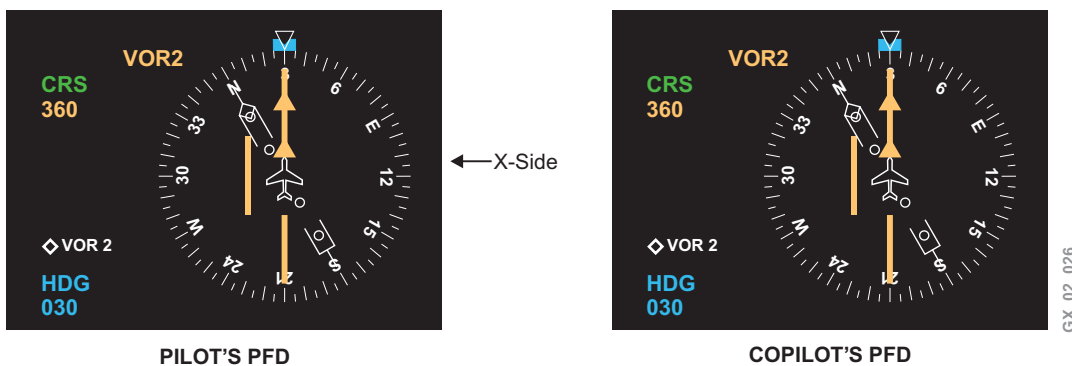
### VOR/LOC NAV SOURCE

NAV source, VOR/LOC, is selectable on either the pilot's and/or the copilot's PFD control panel.



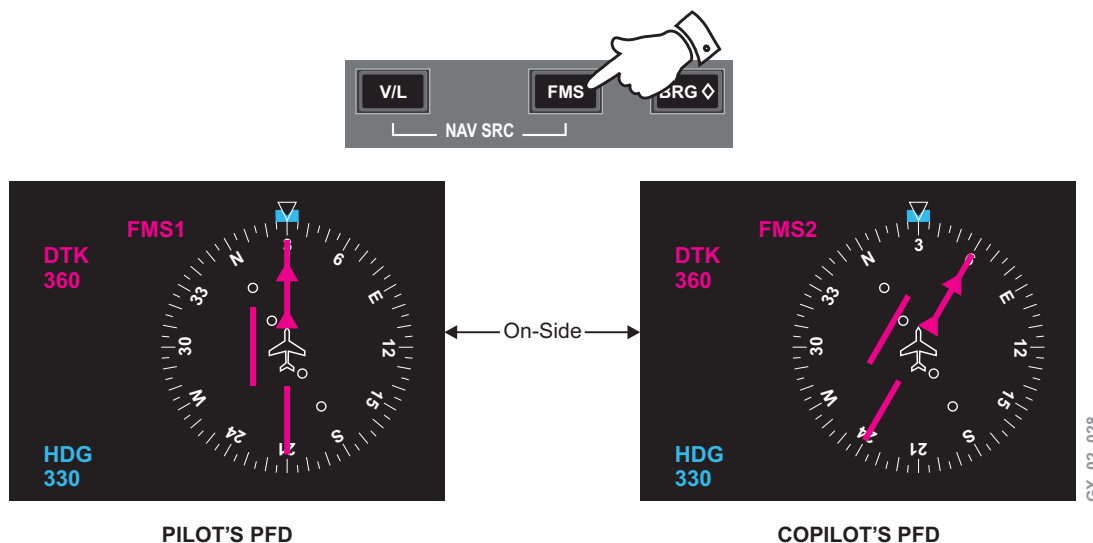
### NOTE

Pushing V/L button will toggle the NAV source in the following sequence:  
on-side VOR/LOC — X-side VOR/LOC — on-side VOR/LOC.



### FMS NAV SOURCE

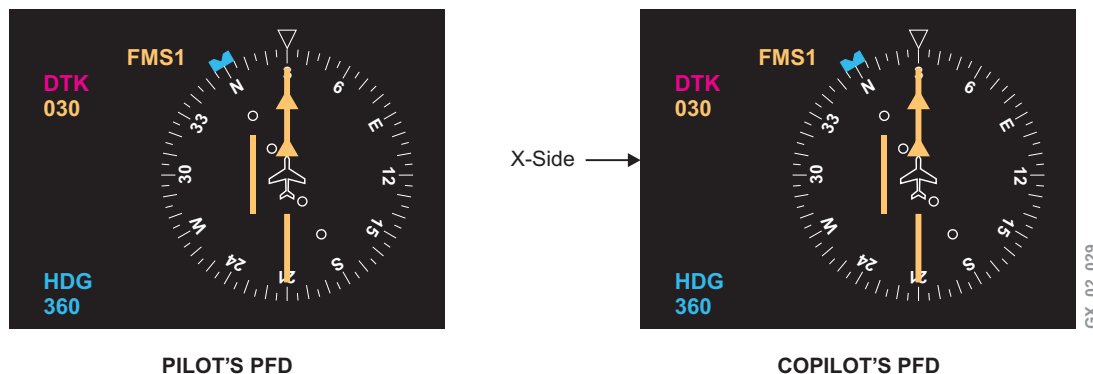
FMS source, FMS1, FMS2, FMS3 (if installed) or Navigation Display Unit (NDU), also referred to as Lasertrack (LTRK) (if installed) is selectable on either the pilot's and/or the copilot's PFD control panel.

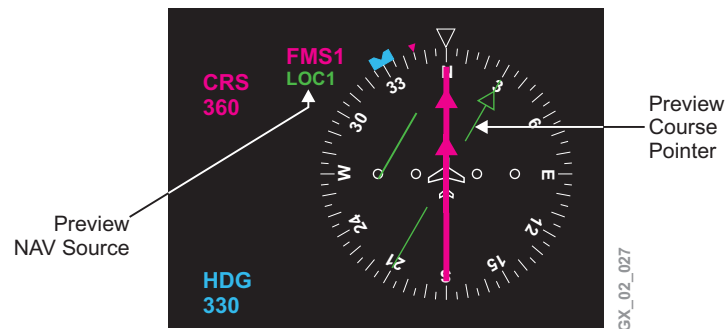


### NOTE

If V/L is the primary NAV source, pushing the FMS button will cancel V/L as primary NAV source and will set on-side FMS as primary NAV source.

Pushing FMS button will toggle the NAV source in the following sequence:  
on-side FMS — X-side FMS — LTRK (if installed) — on-side FMS or on-side FMS — FMS3 (if installed) — X-side FMS — on-side FMS





### NOTE

If FMS is the primary NAV source, the first push of the V/L button will set preview NAV source. The second push of V/L button will cancel FMS as primary NAV source and set VOR/LOC as primary NAV source. Pushing FMS button while V/L preview NAV source is displayed, will cancel preview NAV source.

## VERTICAL MODES

### Flight Level Change (FLC) Mode

FLC mode is used to climb or descend to a new altitude reference, while maintaining a calibrated airspeed, or mach reference. FLC mode is selected via the flight level change switch on the guidance panel and is automatically active. FLC is cleared when another armed vertical mode is captured.

FGC will generate pitch commands to capture and track the speed reference displayed on the selected PFD.

If preselect altitude is above the airplane's present altitude and there is adequate thrust, FLC mode will climb at the speed reference until preselected altitude is captured. If thrust is inadequate, FLC mode will hold present airplane altitude until adequate thrust is applied.

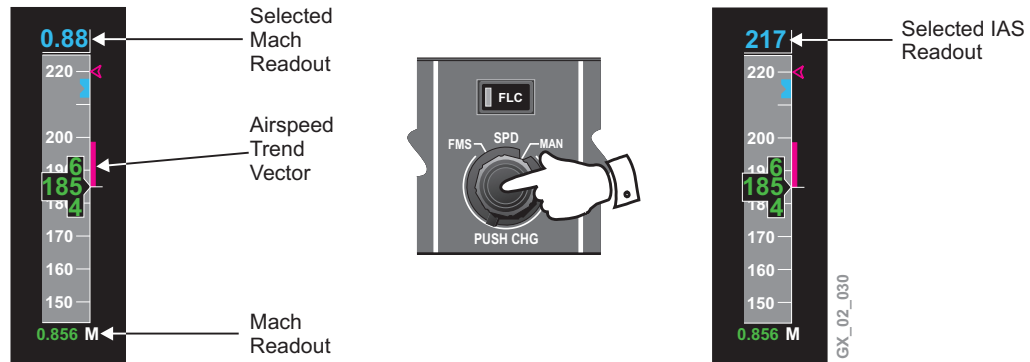
If preselect altitude is below the airplane's present altitude and thrust is appropriate, FLC mode will descend at the speed reference until preselected altitude is captured. If thrust is excessive, FLC mode will decelerate the airplane at its present altitude.

FGC pitch guidance will not generate commands to exceed V<sub>mo</sub> or M<sub>mo</sub>. When a potential overspeed condition exists, FLC will command a pitch maneuver to maintain a speed reference 3 knots less than V<sub>mo</sub> or M<sub>mo</sub>.

Pushing the SPD PUSH CHG button (inner knob) on the guidance panel while in FLC mode will toggle the speed reference from Indicated Airspeed (IAS) to Mach or vice versa. To obtain Mach readout, Mach must be greater or equal to 0.40 M.

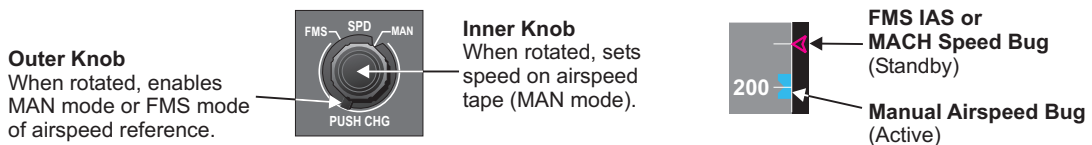


FLC will command a proportional thrust increase/decrease during small climbs and descents. In large climbs or descents, FLC will command climb thrust or idle thrust as required.

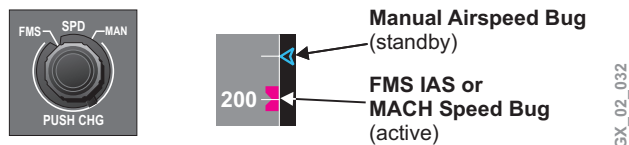


Automatic transfer from IAS to Mach speed reference will occur in the climb, above 32,400 feet. Automatic transfer from Mach to IAS speed reference will occur in descent, below 31,900 feet. Manual transfer can override the automatic transfer by pushing the SPD PUSH CHG button. There is no auto transfer between IAS and Mach in MAN speed.

MAN speed selection is accomplished by selecting MAN on the outer knob, and turning the inner knob on the SPD button. An airspeed bug will follow the commands from the inner knob, and is located on the airspeed tape of the selected PFD. The MAN speed bug is cyan and can be in either kts or MACH.



FMS speed selection is programmed in the active flight plan in the FMS. A Mach speed bug will appear on the airspeed tape of the selected PFD. The FMS speed bug is magenta and can be in either kts or MACH.



**NOTE**

For aircraft not equipped with IAC Batch 2 software, FLC climbs in Mach are prohibited.

For aircraft equipped with IAC Batch 2 software, FLC climbs above Mach 0.86 are prohibited.

### Pitch Hold (PIT) Mode

PIT mode is automatically selected when no other vertical mode is active, and the autopilot is engaged. Note that the lateral mode automatically engaged is the ROL mode. If the pitch angle is greater than 20°, pitch hold mode will reduce the airplane pitch angle to ± 20°. PIT reference is modifiable (within pitch limits), via pilot inputs to the pitch thumb-wheel, or by TCS. The FGC will not prevent exceedances of VMO or MMO in PIT mode.

PIT mode is annunciated in the vertical capture field on the PFD. Pitch mode is cleared by selecting another vertical mode. PIT will flash for 5 seconds, when active.

The pitch hold mode holds a flight path angle rather than a fixed pitch angle. The selected flight director pitch angle will change with altitude, configuration and/or airspeed changes, while climbing, descending or in level flight.

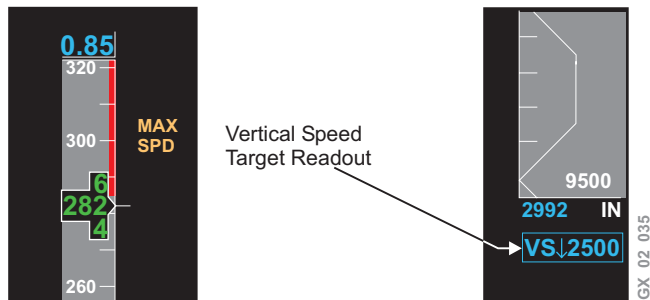


### Vertical Speed (VS) Select Mode

VS mode is used to maintain a pilot selected vertical speed reference. FGC will generate pitch commands to align the airplane vertical rate displayed on the PFD. The airplane vertical rate is adjustable via the pitch wheel. The pilot may select another vertical speed reference without canceling VS mode by depressing the TCS button, and maneuvering the airplane to another vertical speed.



FGC will not generate commands to exceed Vmo or Mmo when in VS mode. When a potential overspeed condition is detected, VS flight director pitch commands will be limited to 3 knots less than Vmo or Mmo and MAX SPD annunciation is displayed on the PFD.



When VS mode is active, the pitch angle is limited to  $\pm 20^\circ$ . The vertical speed commands are from - 8000 feet/minute to + 6000 feet/minute.

VS mode is activated by selecting VS on guidance panel. VS mode is annunciated in the vertical capture field on the PFD. VS mode is cleared by selecting another vertical mode. VS will flash for 5 seconds, when active.

### Altitude Select (ASEL) Mode

ASEL mode provides for automatic capture, flare and level off onto a preselected altitude.

ASEL is armed automatically when the airplane is flying at a continuous vertical rate of greater than 1 foot/second towards preselected altitude displayed on PFD for 1 second. The preselected altitude is adjusted via the altitude preselect knob on the guidance panel.



ASEL will capture when ascending toward the preselect altitude and the preselected altitude is within 2000 feet of current altitude and the altitude rate required to fly a constant 0.05g capture curve is less than the current airplane inertial climb rate.

ASEL will capture when descending toward the preselect altitude and the preselected altitude is within 10,000 feet of current altitude and the altitude rate required to fly a constant 0.05g capture curve is less than the current airplane inertial descent rate.

FGC will generate pitch commands to capture the preselect altitude displayed on the selected PFD. Pitch angle is limited to  $\pm 20^\circ$ . Once the reference altitude is reached, the altitude hold mode is activated.

### NOTE

When ASEL is the active (green) vertical mode, and the ALT preselector has not been changed, selection of any other vertical modes other than GS is inhibited.

Attempting to select any vertical mode on the guidance panel while ASEL is active, the ASEL annunciation on the PFDs shall flash for five seconds to indicate acknowledgement of the button press.

While ASEL is active, preselecting the next altitude will enable all vertical modes.

### Altitude Hold (ALT) Mode

ALT mode is used to maintain a barometric altitude reference.

ALT mode is activated automatically following preselect altitude capture (ASEL), or can be activated manually via the altitude switch (ALT) on the guidance panel to maintain a pressure altitude at time of selection.

If the ALT mode is selected when the airplane is in a climb or descent, FGC will generate pitch commands to zero the vertical speed and capture the selected altitude.

The pilot may select another altitude reference without canceling ALT mode by depressing the TCS button, and maneuvering the airplane to a new altitude.

The ALT mode will use a baro-corrected altitude and respond to baro knob changes to airplane pitch angle up to  $\pm 20^\circ$  limit.

ALT mode is annunciated in the vertical capture field on the PFD. ALT will flash for 5 seconds, when active.

### Vertical Navigation (VNAV) Modes

VNAV mode contains 4 vertical submodes that can be flown using speed and altitude targets, that are programmed in the active flight plan of the FMS.

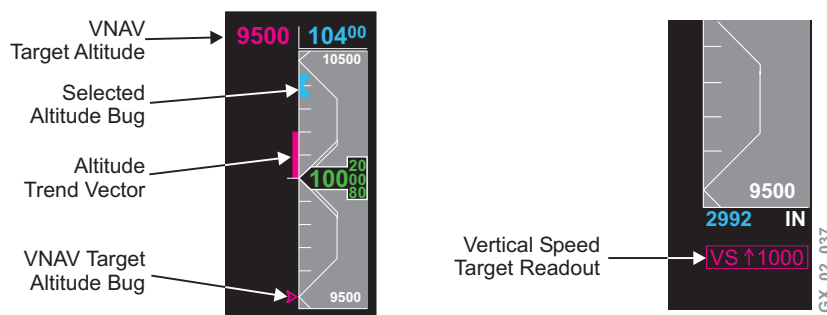
A double C-chord (aural) is activated for VNAV vertical track alerts.

VNAV mode is activated by selecting VNAV on the guidance panel. The vertical mode active at the time shall remain engaged.

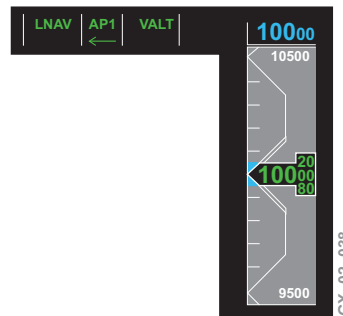
FMS submode selections when in VNAV mode are as follows:

- VFCL - Operates identical to FLC mode, except that the target airspeed and altitude from the FMS are used for climb or descent. If VALT or VPTH is engaged and FLC is selected on the guidance panel, VFCL will become active
- VPTH - Used to fly a fixed flightpath angle to a vertical waypoint during descent. VPTH will engage whenever FMS initiates a path descent which may occur while in VFCL or VALT modes. LNAV must be the lateral navigation mode for VPTH to capture

A VNAV target altitude bug will appear on the altitude tape of selected PFD



- VASEL - Operates identical to ASEL mode. VASEL submode will arm as soon as VFCL or VPTH is engaged  
VASEL mode is canceled whenever VALT mode engages
- VALT - Operates identical to ALT mode. VALT submode will engage automatically when VASEL has captured the target altitude. VALT will also engage whenever VNAV is activated via the VNAV switch on the guidance panel and airplane is within 250 feet of VNAV target altitude



## MULTI-AXIS MODES

### Approach (LOC/GS, VAPP) Modes

The approach mode provides for automatic intercept, capture and tracking of the front course localizer and glideslope signals which enables the pilot to fly a fully coupled ILS approach. APR modes are based on vertical path deviation and valid glideslope on the selected PFD. Review the Localizer section for further details.

When APR mode is armed and no FD is present at the time or in lateral ROL mode, HDG is automatically active until localizer capture.

### ILS

When the aircraft is within 75 nm flight plan distance or 30 nm direct distance, the ILS will be automatically tuned. Additionally, the LOC preview mode will be automatically set and the LOC preview course will be set to the localizer bearing. These settings can still be overwritten by the crew.

ILS lateral/vertical capture and tracking is established, based on data from selected PFD.

The lateral beam must be captured before the vertical beam in order to prevent inadvertent descent.

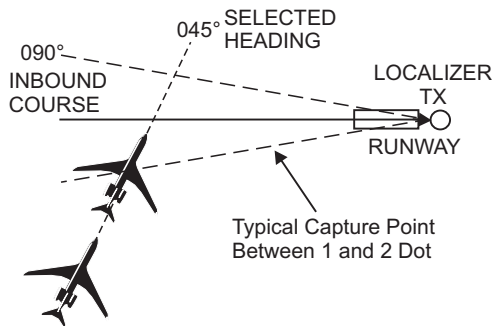
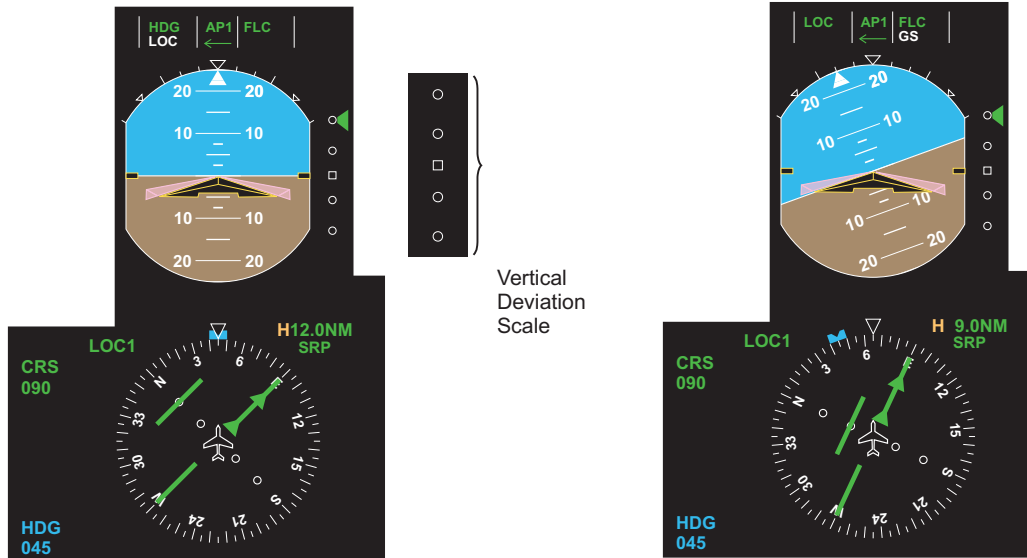
Tracking performance for glideslope mode is within  $\pm 1$  dot from 700 to 100 feet (radio altimeter).

ASEL is inhibited during glideslope capture.

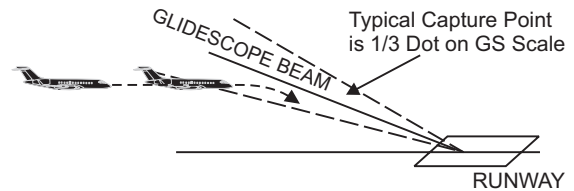
During a CAT 2 approach, EFIS will monitor for excessive deviation from the beam and will provide appropriate annunciation. The outputs provided by AFCS (used by EFIS) in the determination of CAT 2 status are glideslope arm or capture and dual couple status. A valid CAT 2 status is indicated on the PFD. A CAT 2 window also appears to display deviation from the beam. The fully coupled (dual arrow) ILS approach becomes active when the aircraft is below 1200 feet AGL.

### **VOR Approach (VAPP) Mode**

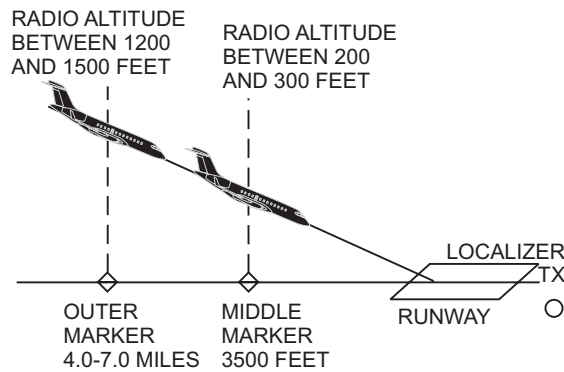
The APR button must be selected in order to get VAPP mode. With flaps other than zero, the FGC sets bank limits and rate limits to ensure proper gain control and performance from VOR capture through the approach profile, to landing. FD roll commands are  $\pm 30^\circ$  during VOR approach capture and roll rate commands  $7^\circ/\text{sec}$ . When track phase is active, FD commands are  $\pm 14^\circ$  and roll rate commands  $4^\circ/\text{sec}$ .



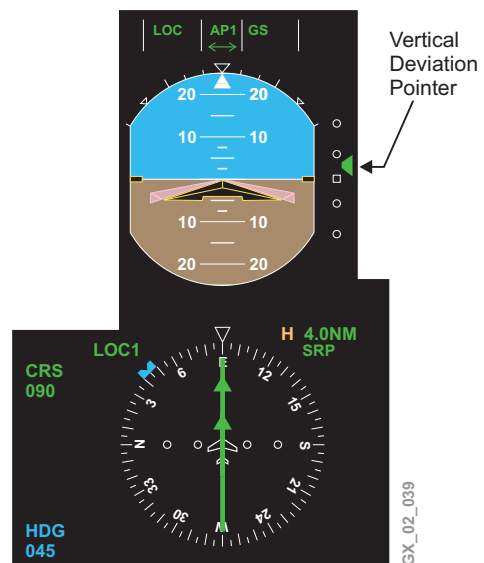
**APPROACH MODE INTERCEPT**



**APPROACH MODE CAPTURE**



**APPROACH MODE TRACK**

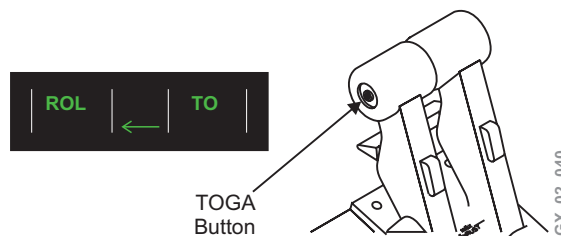
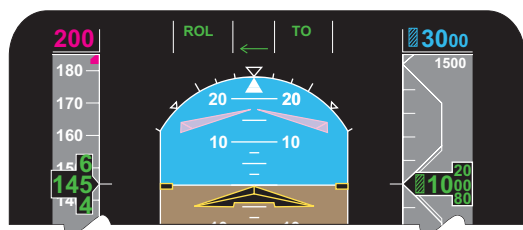


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## TAKEOFF (TO) MODE

TO mode provides pitch and lateral commands during the takeoff phase of flight.

TO mode is activated by pushing one of the throttle-mounted TOGA buttons, while on the ground. When TO mode is selected, all other lateral and vertical modes are cleared.



Lateral TO mode generates a wings level command. The wings level command will remain active following automatic altitude capture. TO mode captures the current heading at 80 kts during takeoff roll.

TO mode will capture the preselected altitude.

Vertical TO mode generates a fixed pitch attitude of 17.5°, based on power being developed by the engines. In the event of a loss of an engine, (N1 < 70% on either engine), the pitch command will be reduced to 13°.

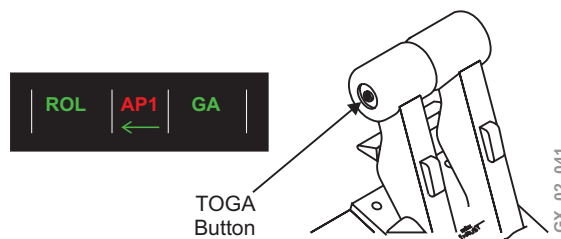
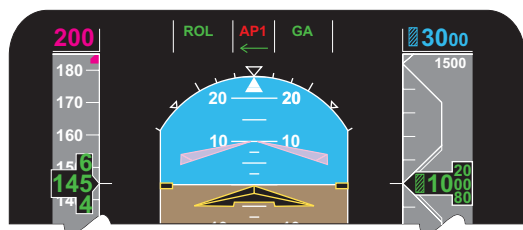
The autothrottles will provide full takeoff thrust until TO mode is cleared.

TO mode can be cleared by selecting the AP on (PIT), or by selecting another vertical mode.

## GO AROUND (GA) MODE

GA mode provides pitch and lateral commands for a transition from an approach to climb out condition, when a missed approach has occurred.

GA mode is activated by pushing one of the throttle-mounted TOGA buttons, while airborne. When GA mode is selected, autopilot is disengaged and all other lateral and vertical modes are cleared. The resultant AP disengage warning may be canceled by pressing the AP DISC switch.



Lateral GA mode generates a wings level command and the heading flown at GA selection will be captured. GA will capture the preselected altitude as long it is set to a minimum of 500 feet above TOGA initiation altitude.



Vertical GA mode generates a fixed pitch attitude of 10°, based on power being developed by the engines.

The autothrottle will provide full takeoff thrust until GA mode is cleared.

GA mode can be cleared by selecting the AP on (PIT), or by selecting another vertical mode.

### **WINDSHEAR GUIDANCE (WSHR) MODE**

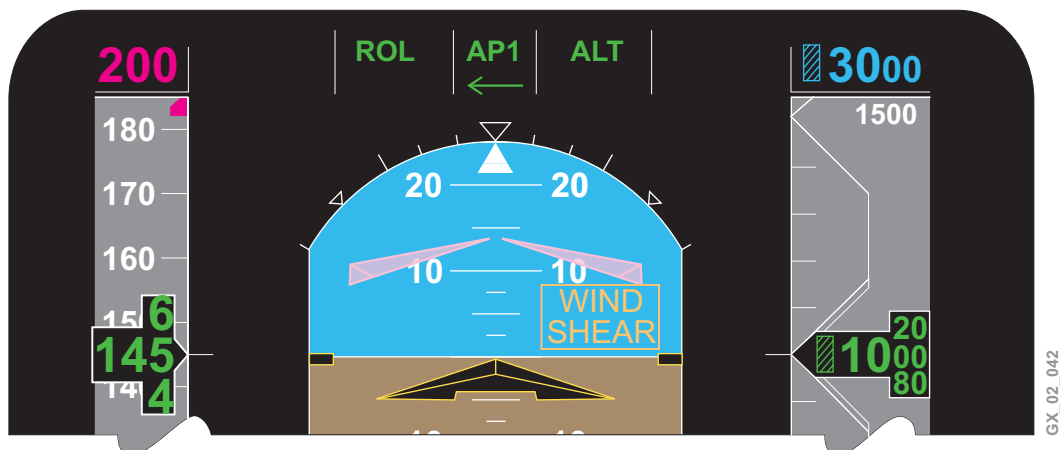
Windshear provides for detection of windshear conditions and escape guidance during approach and takeoff phases of flight.

WSHR mode can be activated by either depressing the throttle-mounted TOGA button, or advancing the thrust levers towards takeoff, when a windshear warning has been displayed on EFIS.

WSHR mode will provide vertical guidance in accordance with optimal windshear escape profile. The airplane will not be commanded to descend unless the airplane is encroaching on the stall speed safety margin.

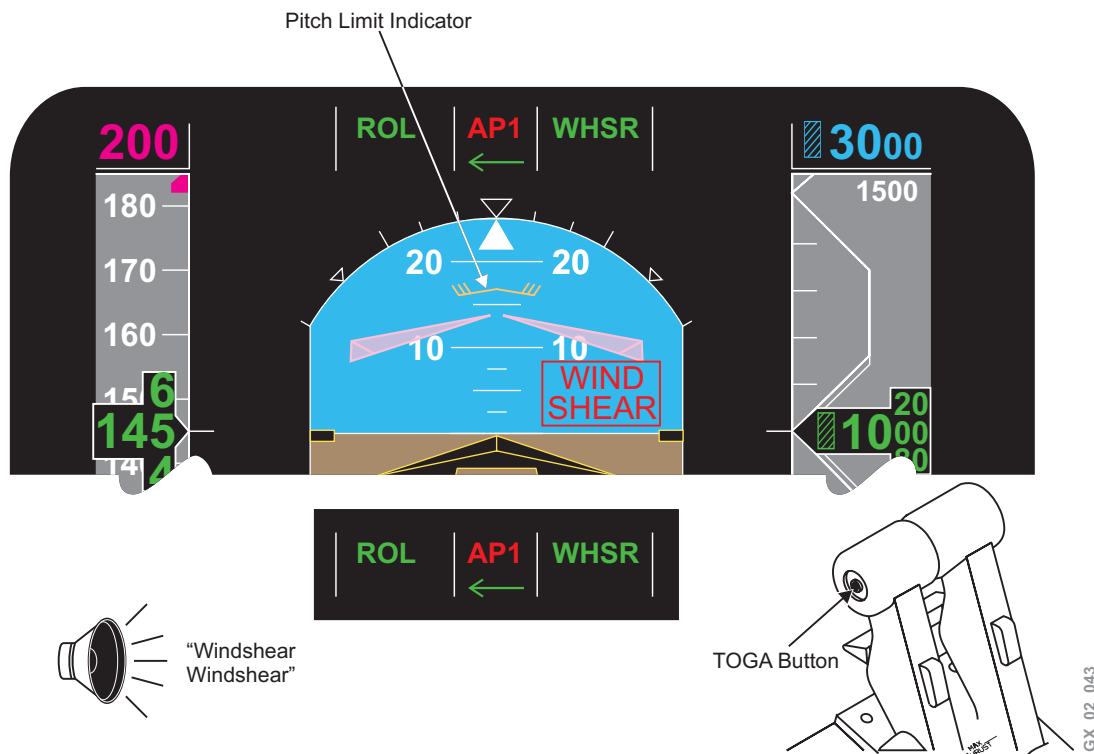
Lateral guidance will maintain wings level.

For an increasing performance shear (updraft/headwind), an amber “WINDSHEAR” caution message will be displayed on the PFD. The WSHR guidance mode cannot be activated when the caution message is displayed.



For a decreasing performance shear (downdraft/tailwind), a red “WINDSHEAR” warning message will be displayed on the PFD. When WSHR mode is active, the flight director lateral and vertical modes will be deactivated and replaced by the “ROL” lateral mode and the “WSHR” vertical mode. The WSHR guidance mode will be accompanied by an aural warning and will automatically disconnect the autopilot. WSHR mode cannot be canceled when a Windshear Warning is present.

When the WSHR mode is activated, the attitude at which the aircraft will reach stall speed is indicated on both PFDs by the Pitch Limit Indicator (PLI). The PLI is removed from each PFD when the WSHR FD mode is disengaged.



**NOTE**

Windshear mode is currently disabled via an IAC configuration module strap. Demonstration to FAA, Transport Canada and JAA need to occur prior to certification.

**AUTOMATIC EMERGENCY DESCENT MODE**

The “Cabin Altitude” aural warning is enunciated when cabin altitude exceeds 9000 feet. The EDM mode is automatically entered anytime the following criteria is met:

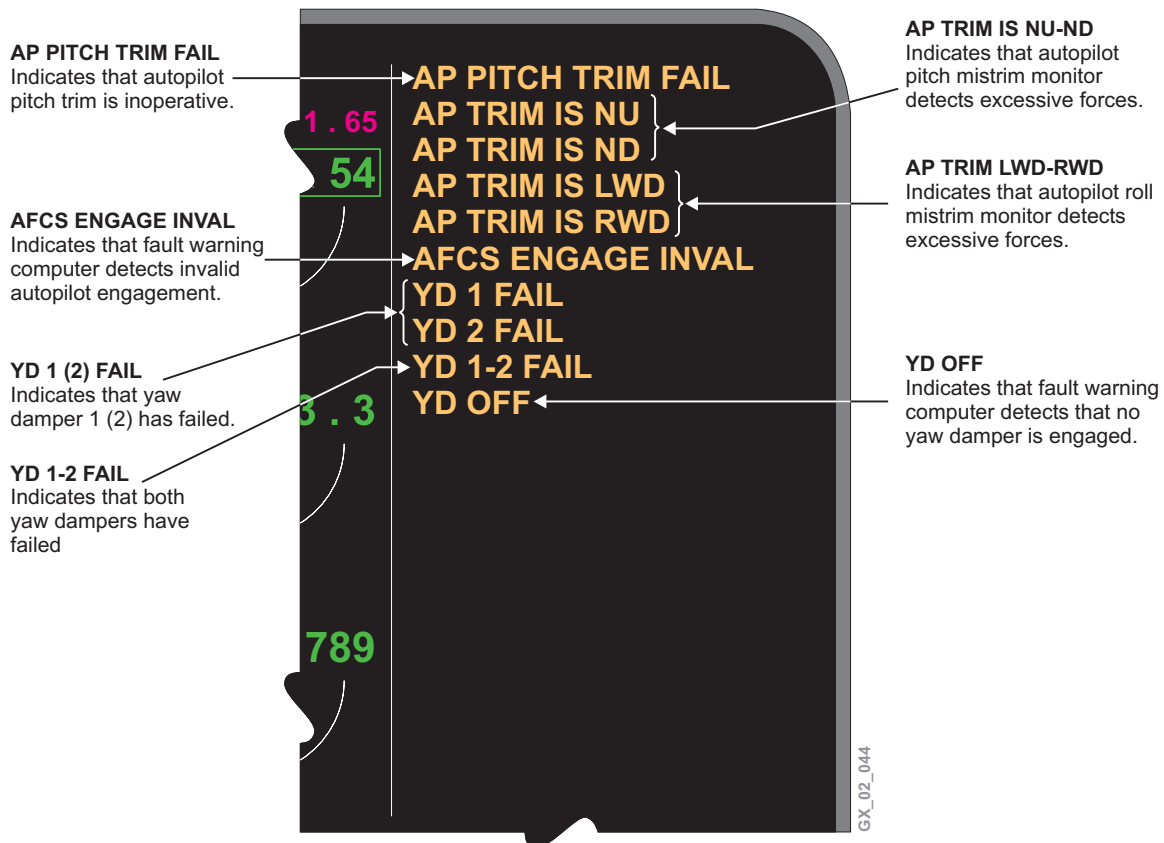
- The autopilot is engaged
- The airplane pressure altitude is above 25,000 feet
- The cabin altitude exceeds 14,500 feet

Once the above conditions are met, then:

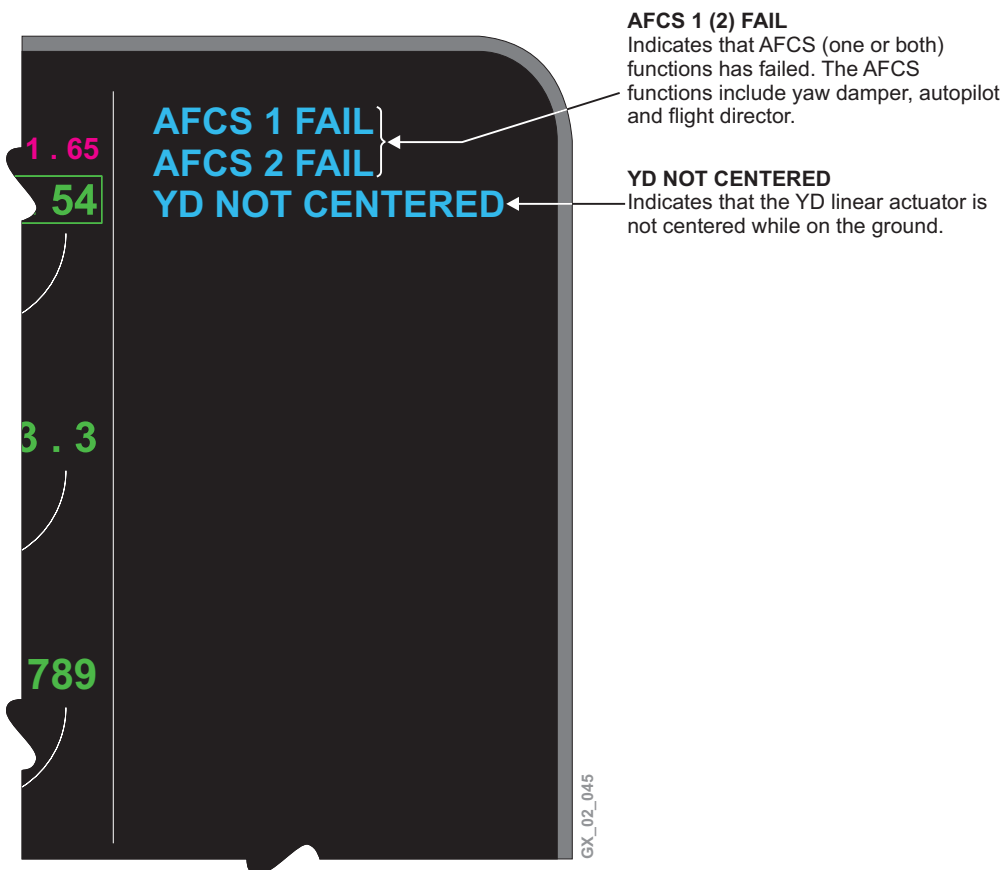
- The aural warning “Emergency Descent” is enunciated
- An EMERGENCY DESCENT red CAS message is annunciated
- EDM is displayed in red in the PFDs vertical flight director mode area. HDG is displayed in green as the lateral flight director mode
- The ALT preselector is automatically set to 15,000 feet or 4500 meters
- The HDG bug is automatically set to 90 degrees left of current heading
- The IAS/Mach digital readout displayed on the PFDs is displayed in red
- The selected airspeed bug is the manual speed bug
- The manual speed bug is placed at a position corresponding to the airspeed target and displayed in red while EDM is active
- The speed target is not manually selectable through the speed knob on the guidance panel while EDM is active. Changing the FMS/MAN switch position of the speed knob on the guidance panel has no effect while EDM is active. The FMS speed bug is indicated by a magenta, triangular symbol, displayed on the outside of the airspeed tape
- The HDG bug and ALT preselector are changeable by the flight crew while in the emergency descent mode
- The airspeed target continuously synchronizes to  $V_{mo} - 10$ . The selected IAS/Mach digital readout displayed on the PFDs remains the selected airspeed type. If Mach is the selected airspeed type, the display automatically transitions from Mach to IAS when descending through 32,400 feet
- The speed target is set to 250 kts upon ASEL becoming the active FD mode
- Selection of any lateral or vertical FD mode while in EDM results in the EDM annunciation flashing for five seconds
- The FD flies a HDG/FLC descent to 15,000 ft. The FD performs a normal transition to ASEL and then ALT mode upon leveling at 15,000 ft. The EDM annunciation flashes for five seconds upon transitioning between modes. The FD vertical mode annunciation remains EDM until the mode is exited
- The FD system remains in EDM until the autopilot is disengaged. This is the only way to cancel the emergency descent mode

- Activation of TCS for greater than 1 second is considered an autopilot disengagement
- The autopilot is disengaged at anytime while in EDM
- When the autopilot is disengaged, the FD modes remain the lateral and vertical modes active at the time. The FD mode is HGD/FLC if the autopilot is disengaged while in the descent and ASEL is not active, HDG/ASEL if the autopilot is disengaged while transitioning from descent to level flight or HDG/ALT if the autopilot is disengaged after capturing the selected altitude target
- Autothrottle is automatically engaged upon initiation of the emergency descent mode
- Cancellation of the emergency descent mode does not disengage the autothrottles
- Autothrottles are manually disengaged and reengaged while in EDM. The autothrottles are not automatically reengaged if disengaged. Auto engagement occurs only upon initiation of the emergency descent mode
- The EMERGENCY DESCENT CAS message is recorded by the FDR when posted

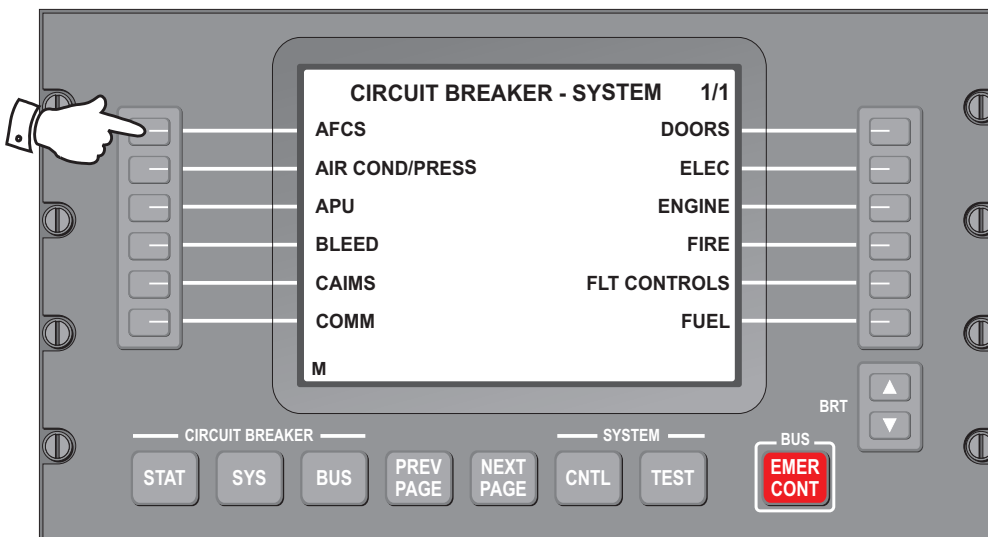
**AUTOPILOT – FLIGHT DIRECTOR EICAS MESSAGES**



AUTOPILOT – FLIGHT DIRECTOR EICAS MESSAGES (Cont)



EMS CIRCUIT PROTECTION



CB - AFCS SYSTEM 1/3			
A/T CTLR	AC 1	CCBP	IN
A/T SERVOS	DC 1		IN
AP 1 SERVOS	DC1		IN
AP 2 SERVOS	DC 2		IN
GUID PANEL CH 1	BATT		IN
GUID PANEL CH 2	DC ESS		IN
CB - AFCS SYSTEM 2/3			
IAC 1	BATT		IN
IAC 2	DC ESS		IN
IAC 3	BATT		IN
YD 1	BATT		IN
YD 2	DC ESS		IN
YD HEAT 1	DC 1		IN
CB - AFCS SYSTEM 3/3			
YD HEAT 2	DC 2		IN

M

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