



# DFC90 DIGITAL AUTOPILOT PILOT GUIDE





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# 1 System Overview

This manual assumes that the pilot is appropriately licensed, is proficient in operation of the aircraft and its equipment, and is in compliance with all Federal Aviation Regulations (FARs).

All images contained in this manual are for reference use only, and are subject to change.

Avidyne strongly recommends that pilots use the DFC90 system only under VFR conditions until completely familiar with its operation and use.

Boxed areas marked as **NOTE** within this manual identify certain situations or areas of operation having safety implications. While it is important for the operator to be familiar with all of the information in the manual, it is essential to the safe use of the DFC90 that pilots give careful attention to the material contained within these **NOTES**.

Boxed areas marked as **WARNING** within this manual identify certain situations or areas of operation having unique and heightened safety implications.

In order to avoid a diversion of attention from the task of safely taxiing, pilots should avoid performing the described cockpit tasks while the aircraft is in motion.

It remains the pilot's duty to monitor the autopilot for proper function upon activation and during use.

## *DFC 90 Digital Flight Control System*



## FUNCTIONAL OVERVIEW

The Avidyne DFC90 autopilot supports the following functions:

- Flight Director
- Heading Capture/Hold
- NAV Tracking
- GPSS Mode
- Approach Mode (includes LOC, ILS, VOR, BC)
- Altitude Hold
- Altitude Capture
- Vertical Speed Hold
- Indicated Airspeed Mode
- Straight and Level
- Speed-based Envelope Protection
- Pilot Selectable Intercept Angles

The Digital Flight Control (DFC) DFC90 autopilot has been designed to be a form-fit replacement for the STec System 55X. It requires an Avidyne attitude system (Release 8.0.2 or later PFD).

In a DFC-equipped airplane, the autopilot uses the output of the Avidyne Air Data and Attitude-Heading Reference System (ADAHRS) embedded in the PFD and is therefore an attitude-based autopilot. A digital, attitude-based autopilot will be noticeably more precise than the rate-based autopilot it is replacing.

Keeping in line with the desire for a replacement of the System 55X, the DFC-series of autopilots were designed to retain much of the familiar STec user interface. This minimizes re-training and takes advantage of existing habit patterns.

## **GENERAL AUTOPILOT OPERATIONS**

As a rule, the pilot should not attempt to provide “active assistance” to the autopilot by utilizing yoke controls, when engaging the autopilot or while the autopilot is engaged in AP mode.

### **ALWAYS A VERTICAL AND LATERAL MODE ENGAGED**

The DFC90 autopilot has been designed to always have both a lateral and vertical mode engaged. If a specific lateral mode has not been selected by the pilot, then the system defaults to Roll Hold mode. If a specific vertical mode has not been selected by the pilot, then the system defaults to Pitch Hold mode.

### **SINGLE PRESS TO HOLD, DUAL BUTTON PRESS TO CAPTURE**

A single button press is typically required to engage a desired mode, while a dual button press is typically required to capture a new target. For example, to engage altitude hold, press ALT; to engage heading hold, press HDG, to hold indicated airspeed, press IAS. Likewise, to engage a vertical mode that will result in capturing a new altitude, press both IAS and ALT or VS and ALT, to capture a course, press both HDG and NAV, etc.

### **PRIMARY LOCATION FOR BUG/TARGET SETTING**

The primary location for setting both the IAS and VS targets are via the dedicated knobs on the autopilot control head.

The primary location for setting the HDG and ALT targets are via line select keys and right-hand knob on the PFD.

VS target can optionally be set via a line select key on the PFD. The VS target stays synched between the two locations for setting targets.

## AURAL ALERTS

Aural alerting, through the aircraft intercom system, is provided for warnings from the autopilot. In the context of the bullets below, “coupled” describes the condition when the autopilot servos are flying the airplane and “non-coupled” describes the condition when the servos are not flying the airplane and instead, the pilot is expected to follow the flight director command bars. Specifically, aural alerts as defined in the parenthesis are provided under the following conditions:

- Autopilot Disengaged (5 Disconnect beeps)
- Underspeed during coupled operations (“Speed Protection Active”)
- Overspeed during coupled operations (“Speed Protection Active”)
- Underpeed during non-coupled Flight Director-only operations (“Caution, Underspeed”)
- Overspeed during non-coupled Flight Director-only operations (“Caution, Overspeed”)
- Attitude and Heading Reference System (AHRS) and Turn Coordinator Miscompare (“Gyro Miscompare”)

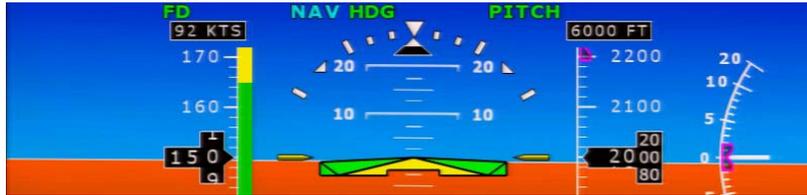
## ARMED VS ENGAGED MODES INDICATIONS

The DFC-series of autopilots has a more readily distinguishable armed vs. engaged modes in order to provide the user higher awareness of the current autopilot state and upcoming state transitions.

An armed mode is defined as a state that will be captured when and if the airplane crosses that target. Armed modes are indicated by a cyan (blue) color on both the autopilot control panel and on the PFD mode annunciator strip.

An engaged mode is defined as a state that the autopilot is holding. Engaged modes are indicated by a green color on both the autopilot control panel and on the PFD mode annunciator strip.

The images below demonstrate the armed and engaged coloring on both the display and the autopilot control head. In this example, Heading (HDG) and Pitch modes are engaged and Nav mode is armed.



#### MODE TRANSITION INDICATION

Automatic transition from armed (cyan) to engaged (green) states is indicated by the cyan armed button on the autopilot control panel and mode annunciation on the PFD changing to green and flashing for up to 10 seconds.

Note that the engaged (green) autopilot mode annunciators will also flash when in underspeed or overspeed conditions. This flashing is intended to gain the pilot's attention and to indicate that while the modes are still engaged (green), the underspeed or overspeed condition may be affecting the system's ability to hold the target value. As soon as the underspeed or overspeed condition is no longer true, the annunciators stop flashing and the system reacquires the target values as required.

#### MANUAL ELECTRIC TRIM IMPACT

Any attempt to engage manual electric trim (MET) via the cockpit controls will result in the autopilot disconnecting and then the trim running as commanded by the MET control.

**NOTE**

**Trim Behavior in Cirrus Aircraft**

For Cirrus aircraft, if the airplane is equipped with a pitch servo, actuating the trim switch will disconnect the AP. For Cirrus aircraft that are equipped only with pitch trim, actuating the trim switch will have no effect during autopilot operations (trim will not adjust and the AP will not disengage). For predictability of results, pilots of Cirrus aircraft should therefore determine whether the aircraft is equipped with a pitch servo or pitch trim before actuating the trim switch in IMC conditions.

**ENVELOPE PROTECTION**

The DFC90 system provides a speed-based form of Envelope Protection.

Envelope Protection, which provides underspeed and overspeed warnings and protection during these autopilot operations, is always operational whenever the autopilot is engaged in any mode. This is true even if the servos are disengaged and the system is conducting flight director (FD) only operations.

**NOTE**

**Aircraft Stall Possible with Envelope Protection**

Conditions can exist where an aircraft can be placed in an attitude and/or configuration that would exceed the capability of the Envelope Protection system to prevent a stall.

When the servos are engaged (AP mode), the likelihood that a command that can be made resulting in an autopilot induced stall

is significantly reduced over conventional autopilots. If for example, a positive rate of climb was commanded and a low power setting is being held, the autopilot will attempt to achieve the commanded state but as the energy of the airplane decays to approximately  $1.2 V_s$  (clean stall speed), the autopilot will adjust bank angle and then pitch angle as required to maintain no lower than  $1.2 V_s$ . Bank angle may be reduced before pitch is adjusted in an effort to avoid even entering envelope protection. As soon as bank angle is adjusted by the autopilot, the pilot is alerted through visual means on the PFD (“**UNDERSPEED**” text alert and any engaged (green) autopilot mode annunciator will flash) and as soon as pitch is adjusted, the pilot is alerted through the same visual means on the PFD, and aural alerting in the headsets. If the autopilot were not in AP mode but instead was in FD-only mode, envelope protection is still functioning. Using that same example of positive climb rate and low power settings, the flight director command bars will adjust as required in bank and pitch to keep the aircraft at  $1.2 V_s$ . As always with flight director only mode, it is up to the pilot to maneuver the aircraft to achieve the flight director guidance.

Similarly, on the high-speed end of the spectrum, envelope protection will provide protection and alerting near  $V_{ne}$ . In this case, as  $V_{ne}$  is approached in AP mode, the autopilot will adjust pitch as required to maintain an airspeed near  $V_{ne}$ . Aircraft bank angle is not adjusted by the autopilot during overspeed protection. Depending on conditions (e.g. rapidly changing airspeed, turbulence, etc.), it is possible for  $V_{ne}$  to be exceeded. An overspeed condition is annunciated to the pilot via an “**OVERSPEED**” text alert on the PFD, an aural alert in the headsets, and by a flashing of any engaged (green) autopilot mode annunciators. If the autopilot were not in AP mode but instead was in FD-only mode, overspeed protection is still functioning. In this case, the flight director command bars will adjust as required in pitch to keep the aircraft right at  $V_{ne}$  but it is up to the pilot to make the necessary flight control input in order to achieve the flight director guidance. Depending on conditions, precisely tracking the flight director can result in  $V_{ne}$  exceedences.

**NOTE**

**Envelope Protection During Icing Conditions**

The DFC90 autopilot is not to be used during icing conditions. The autopilot does not collect any kind of AOA or icing input and therefore does not register changing aircraft dynamics during icing conditions. Therefore, this means that Envelope Protection is not effective under icing conditions.

**BARO ADJUST**

Upon input of a new barometric altimeter setting, the autopilot automatically re-captures the previously set target altitude, without further action required from the pilot. In other words, if the autopilot was in Altitude Hold for example, changing the barometric pressure setting will result in the autopilot automatically correcting the appropriate amount to re-capture the previous MSL altitude hold target.

## ENGAGEMENT AND HOLD LIMITS

Engagement limits of the autopilot may be wider than the hold limits. The autopilot will not engage if an engagement was attempted outside of the published engagement limits. If the autopilot was engaged between the maximum engagement limits and the maximum hold limits, the autopilot will reduce the value to be within the published maximum hold limits.

The maximum engagement and hold limits are as follow:

<b>Autopilot Mode</b>	<b>Maximum Engagement Limits</b>	<b>Maximum Hold Limits</b>
Roll Hold	±60° bank	±22° bank
Heading	±60° bank	±22° bank (but typically holds 1 standard rate of turn)
Pitch Hold	±30° pitch	±10° pitch
IAS Hold	20 KIAS to $V_{ne}$	$1.2V_s$ ( $1.1V_s$ in APPR) to $V_{ne}$
VS Hold	±1600 fpm	±1600 fpm
Straight and Level	The demonstrated limits are the same as the autopilot engagement limits	Will stabilize in +2° pitch and zero bank angle
Localizer, VOR, GPS approach <b>Capture</b>	Not Applicable	±22° bank
Localizer, VOR, GPS approach <b>Track</b>	Not Applicable	±10° bank

## COMPARATORS

The DFC90 autopilot is always running comparators in the background. There are several types of comparators running during operation of the autopilot as noted in the chart below. If conflicting information is provided, the comparator identifying the conflict with the accompanying pilot indication and autopilot behavior is noted in the table below:

Type of Comparator	Indication to Pilot	Autopilot behavior
Internal kinematic comparator within the AHRS (compares AHRS state data with itself, eg. turn rate without accompanying heading change, etc)	"CROSSCHECK ATTITUDE" annunciation on PFD for minor issues and indicator removal and replacement by "Red-X" for major issues	No change for "Crosscheck Attitude" conditions and potential disconnect for Red-X conditions
AHRS-to-Turn Coordinator (TC) Comparator	Miscompare Alert message(s) presented to the pilot on the PFD ("AHRS MISCOMP") and in the headset ("GYRO MISCOMPARE")	Autopilot will disconnect but allow manual re-engagement by the pilot  (Note, if the AHRS-TC miscompare condition was present after initial ground power-up, the autopilot will be prevented from engaging in any modes.)

## AUTOPILOT ENGAGEMENT

From a standby state (autopilot has power, “AP READY” displayed but no modes are engaged and the airplane is within the engagement limits defined above), pressing any button on the autopilot (except GS and APPR) will engage the DFC autopilot. If a specific lateral and/or vertical mode is not pressed, the system will default to ROLL hold mode in the lateral channel and PITCH hold mode in the vertical channel.

From a standby state:

- Press “AP” → autopilot (servos coupled) engages in **ROLL** and **PITCH** and will hold whatever bank and pitch was present at time of pressing (assuming within command limits)
- Press “FD” → flight director (servos not coupled) engages in **ROLL** and **PITCH** and will command via the green flight director command bars whatever bank and pitch was present at time of pressing (assuming within command limits). It is still up to the pilot to maneuver the plane as required to follow those command bars.
- Press “STRAIGHT & LEVEL” → autopilot (servos coupled) engages and drives the airplane from whatever attitude it is in to zero bank and a small positive pitch that approximates level flight.
- Press any other button(s) (except GS or APPR) on the autopilot → autopilot (servos coupled) engages and will enter the modes as commanded.

## AUTOPILOT DISENGAGEMENT

The autopilot can be disengaged using any one of the following methods:

- Press the AP Disconnect switch on the control yoke;
- Activate the trim switch on the control yoke (this does not apply on pitch trim-only aircraft);
- Press the “AP” button on the autopilot control panel (servos will disconnect but the flight director will remain active);

- Pull the circuit breaker(s) controlling the power to the autopilot.

The autopilot will also disconnect if the stall warning alarm is present in the aircraft.

In most cases, the autopilot disconnect will be accompanied by a 5-beep disconnect aural alert. This tone can be muted by pressing the AP Disconnect switch on the control yoke.

#### FD vs. AP

The status of the reference bugs, autopilot annunciators, autopilot control head, and flight director steering command bars indicate when the PFD is coupled with the autopilot. A solid magenta heading, altitude, IAS or VS bug indicates that function is currently coupled to an active/engaged mode of the autopilot. A hollow magenta bug indicates that the function is not currently coupled to the autopilot in an active/engaged mode. In other words, a hollow bug indicates manual flight status.

The flight director command bars will indicate the required steering of the aircraft to achieve the commanded tracking of the autopilot. In full autopilot mode, both the “AP” and “FD” buttons will be lit on the autopilot control panel and “AP” will be displayed in the autopilot annunciation field on the display, the command bars will be visible and **magenta** and the aircraft should track those bars very precisely.

In Flight Director only mode, only the “FD” button (and not the “AP” button) will be lit on the autopilot control panel and “FD” will be displayed in the autopilot annunciation field on the display, the command bars will be visible and **green**, and the pilot is expected to use the flight controls as required to track those bars. In Flight Director only mode, the pilot is hand flying the airplane and is expected to guide the aircraft such that the yellow aircraft reference symbol is tucked into the steering command bars.

The flight director command bars in a DFC90 autopilot are designed for easy use and improved performance during uncoupled autopilot operations.

There are no instrument panel FD or AP switches in a DFC90 equipped airplane.

## PFD ANNUNCIATIONS

The top strip of the PFD is dedicated for autopilot mode annunciators. Active modes are depicted in green and armed modes are depicted in cyan. Alerts are depicted in yellow and are listed in order of priority. If multiple alerts are received, then the highest priority message is displayed.

Whenever “**UNDERSPEED**” or “**OVERSPEED**” are displayed, all engaged (green) autopilot mode annunciators will flash.

The tables below are a listing of all annunciators that are possible with the DFC90 system.

### DFC90 Annunciations

Normal Annunciations	AP	NAV	ROLL	PITCH	ALT	TRIMMING UP
	FD	NAV APPR	HDG	ALT	GS	TRIMMING DN
	AP READY	GPSS	NAV	IAS		GPSS INVALID
		GPSS APPR	NAV APPR	VS		NAV INVALID
			GPSS	GS		GS INVALID
			GPSS			TC FAIL
			GPSS APPR			AIRS MISCOMP
			GPSS APPR			NO PED COMM
			45° INT			MSR FAIL
Envelope Protection					OVERSPEED	
					UNDERSPEED	
Straight & Level		STRAIGHT AND LEVEL				
Autopilot Inop	AUTOPILOT INOP					
	AUTOPILOT INOP AIRS FAIL					
	AUTOPILOT INOP SELF TEST FAIL					
	AUTOPILOT INOP AIRS ALIGNING					
	AUTOPILOT INOP TURN COORDINATOR FAIL					
	AUTOPILOT INOP AIRS MISCOMPARE					
Disconnect	NO COMMUNICATION WITH AUTOPILOT					
	AUTOPILOT DISCONNECTED					

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## 2 Normal Startup Sequence

### **POWER CONSIDERATIONS**

The DFC90 consumes 0.25A when no servos are in operation and up to 0.9A with all servos operating at 100% duty cycle.

There is no on/off switch to the DFC-series of autopilots. As soon as the governing power bus is active through normal aircraft checklist steps, the autopilot will power up.

### **SELF-TEST/ALIGNMENT**

The DFC autopilot requires two events to be fully functional. The first is a successful completion of a self-test and the second is a successful alignment of the ADAHRS. To assure readiness of the autopilot for flight, it is also recommended that the pilot conduct the Pre-Flight Test described later in this chapter.

DFC self-test takes less than 5 seconds following power application. The normal self-test indications are a lighting of lights on the autopilot control panel, dwelling approximately 1-2 seconds on each color. The lighting color order is White-Cyan-Green-White. Self-test should be considered a success after the button lighting with no associated failure message along the top strip of the PFD.

The top strip of the PFD will display an annunciation that the autopilot is INOP (inoperative) while the ADAHRS is aligning. The message will explicitly state that the ADAHRS is aligning. Any other anomaly during alignment is displayed as a descriptive annunciation along that same top annunciator strip on the PFD.

### **BRIGHTNESS CONTROLS**

The autopilot control head button and knob lighting is controlled via the cockpit dimming controls/rheostats.

If the autopilot control panel appears “inoperative” or non-responsive from a lighting perspective, check the instrument lighting rheostat on the bolster to ensure it is not set to a night position.

## PRE-FLIGHT TEST

1. Ensure “AP READY” is displayed on PFD annunciator strip
2. Press AP button on autopilot control head
  - a. Ensure AP button is lit in green
  - b. Ensure “**AP**”, “**ROLL**”, “**PITCH**” annunciations are depicted in green on the PFD annunciator strip
3. Set the Heading Bug to be approximately 90 degrees off current aircraft heading
4. Press HDG button on autopilot control head
  - a. Ensure HDG button is lit in green
  - b. Ensure the ailerons are being driven in the proper direction by the servos
  - c. Ensure “**HDG**” annunciation has replaced ROLL annunciation and that it is depicted in green on the PFD annunciator strip (“**UNDERSPEED**” may also be displayed along the right edge and the green engaged autopilot modes will flash – this is normal)
5. Press the AP Disconnect switch on the control yoke
  - a. Ensure the aural autopilot disconnect tone is heard in the headset
  - b. Ensure “**AUTOPILOT DISCONNECTED**” annunciation is depicted in yellow on the PFD annunciator strip
  - c. Ensure “**AP READY**” annunciation is then depicted in green on the PFD annunciator strip
6. Trim the aircraft to the appropriate pre-takeoff position in accordance with normal aircraft checklist procedures.

#### NOTE

#### **Preflight Test Does Not Test Every Aspect of AP**

The Pre-Flight test of the DFC90 autopilot outlined above will check the functionality of such items as the ability of the autopilot to engage and disconnect, the ability of the autopilot to engage the roll axis control surfaces, and the communications between the autopilot and the PFD. However, the Pre-Flight test does not check the function of every item essential to the use of the autopilot. It remains the pilot's duty to monitor the autopilot for proper function upon activation and during use.

### **BEFORE TAKEOFF TECHNIQUES**

A normal technique is to set up the desired autopilot targets while still on the ground (e.g. IAS or VS, ALT and HDG bugs).

Neither the Flight Director or Autopilot should be engaged until in-flight and at a safe altitude, a minimum of 200' AGL.

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## 3 Climb-out/Enroute

This section covers normal modes of the autopilot during climb-out and enroute operations as well as procedures, mode control and display.

### **NORMAL OPERATING MODES**

Envelope Protection is active in all of the autopilot modes defined below.

#### **PITCH MODE**

In Pitch Hold mode, the autopilot will maintain a constant pitch from the moment of mode entry. If the mode was entered at a pitch that exceeds the maximum hold limit, the pitch will be reduced to the maximum hold limit value.

Pitch mode is the default vertical mode if no other vertical mode was selected at time of autopilot entry.

There is no specific Pitch Hold button on the autopilot control head and no way to alter the commanded pitch once in Pitch Hold mode.

The autopilot modes annunciator indication is green **"PITCH"**.

#### **ROLL MODE**

In Roll Hold mode, the autopilot will maintain a constant bank angle from the moment of mode entry. If the mode was entered at a bank angle that exceeds the maximum hold limit, the bank angle will be reduced to be the maximum hold limit value.

Roll mode is the default lateral mode if no other lateral mode was selected at time of autopilot entry.

There is no specific Roll Hold button on the autopilot control head and no way to alter the commanded bank once in Roll Hold mode.

The autopilot modes annunciator indication is green **"ROLL"**.

## HEADING (HDG) MODE

Heading mode is entered by pressing the “HDG” button on the autopilot control panel. The system will light up the control panel button in green and track the set heading bug value and the bug will become solid magenta. Select a new heading by moving the heading bug at any time while the autopilot is in heading mode and the autopilot will track the new bug value.

The aircraft will turn in the same direction that the heading bug knob was spun. If the knob was spun 300 degrees to the right, the airplane will turn to the right for 300 degrees.

Typical bank angles used in heading mode is 1 standard rate of turn, or roughly 22 degrees of bank at normal airspeeds.

Pressing the heading knob synchronizes the selected heading to the current heading.

The autopilot modes annunciator indication is green “**HDG**”.

## NAVIGATION (NAV) MODE

Nav mode is entered by pressing the “NAV” button on the autopilot control panel. The system will light up the control panel button in green and track the lateral profile provided by the navigation source that is selected in the Primary Nav line select key (LSK) of the PFD. This could be GPS or it could be VLOC.

The system will seek a 45-degree intercept angle to that nav course unless either the aircraft is sufficiently close to the commanded course (at which time it is in capture mode) or the pilot has set up a pilot-selectable intercept angle of something other than 45 degrees.

Typical bank angles used during Nav mode intercepts are 22 degrees and this may be reduced if in close proximity to the intended course or during VOR station passage.

The system will briefly transition to a coast mode during VOR station passage within the “cone-of-confusion” and any entered course changes while inside that area will result in a smooth turn to a wind-corrected heading until the station signal is re-acquired and signal tracking can resume.

For the condition when Nav mode is conducting its own 45 degree intercept, this is depicted by a cyan “NAV” autopilot mode annunciator indicating Nav mode is armed, followed by a green “45° INT” indicating the system is currently conducting a 45 degree intercept of the commanded Nav course. When the transition to captured course happens, the green “45° INT” extinguishes and in its place a green “NAV” is displayed.

**NOTE**

**Approaches with Curved Paths Must Use GPSS**

Certain GPS procedures involving curved paths can not be flown in NAV mode (e.g. holds, DME arcs, etc). GPSS mode must be used for those procedures.

### GPS ROLL STEERING (GPSS) MODE

GPSS mode is entered by pressing the “GPSS” button on the autopilot control head. The system will light up the control panel button in green and track the lateral profile provided by the navigation source to the active GPS waypoint.

In GPSS mode, the GNS-430 is driving the intercept angle and subsequent course tracking. It is generally a more accurate intercept and tracking mode to be in than Nav mode. Roll commands are generated by the GNS-430 system in GPSS mode.

If the Primary Nav LSK on the PFD is not set to a GPS source (GPS1 or GPS2), then the “GPSS” autopilot mode annunciator is lit in yellow indicating you have one source driving the CDI depiction and another source driving the autopilot.

If GPSS mode has been selected on the autopilot control head, and there is no active GPS waypoint, then “GPSS INVALID” is also depicted along the autopilot modes annunciator line of the PFD. The aircraft will continue in wings level, straight flight in this case.

## ALTITUDE HOLD (ALT) MODE

Altitude Hold mode is entered by pressing the “ALT” button on the autopilot control panel. The system will light up the control panel button in green, sync the altitude bug on the altimeter to the nearest 10 feet to current altitude and turn it solid, and hold the altitude at the time of mode entry.

If the barometric setting is subsequently adjusted, the airplane will automatically climb or descend as required to reacquire the selected altitude.

If the altitude bug is moved more than 50’ away from the holding altitude, it will turn hollow. The autopilot does not command an aircraft altitude change at this point and it provides a means for a new future altitude target to be preset.

The only place to set the Altitude bug is via a LSK on the PFD.

The autopilot modes annunciator indication is green “**ALT**”.

## INDICATED AIRSPEED (IAS) HOLD MODE

Indicated Airspeed Hold mode is entered by pressing the “IAS” button on the autopilot control panel. The system will light up the control panel button in green, and adjust the aircraft pitch as required to achieve the bugged indicated airspeed target and turn the IAS bug solid. If already in IAS mode, any subsequent adjustments to the IAS bug sets a new IAS target for the system and aircraft pitch is automatically adjusted to achieve that new IAS target.

In aircraft equipped with pitch trim only (no separate pitch servo), this mode is still functional but may feel less precise than those aircraft that also have a pitch servo. In these cases, the aircraft IAS may vary by as much as 5 knots around the target IAS as the trim system works to hold the target IAS.

The minimum settable IAS bug is  $V_{so}$  and the maximum settable IAS bug is  $V_{ne}$ .

The only location to set the IAS bug is via the dedicated IAS knob on the autopilot control panel. The knob has a push-to-sync capability that will sync the target IAS to the current aircraft IAS.

The autopilot modes annunciator indication is green “IAS”. There is no armed (cyan) IAS mode.

#### VERTICAL SPEED (VS) HOLD MODE

Vertical Speed Hold mode is entered by pressing the “VS” button on the autopilot control panel. The system will light up the control panel button in green, turn the VS bug solid and adjust the aircraft climb/descent rate as required to match the bug setting.

The range of settable VS targets is  $\pm 1600$  fpm.

The primary location to set the VS bug is via the dedicated VS knob on the autopilot control head. A secondary method is via a LSK on the PFD page. The knob has a push-to-sync capability that will sync the target VS to the closest 50 fpm to the current aircraft VS.

The autopilot modes annunciator indication is green “VS”. There is no armed (cyan) VS mode.

#### ALTITUDE CAPTURE MODE

Altitude captures can be performed using either IAS or VS.

To perform an indicated airspeed-based altitude capture, set both the IAS bug and the ALT bug to the desired values and press both the “IAS” and “ALT” buttons on the autopilot control panel at the same time. The system will light up the IAS button in green and turn the IAS bug solid and light up the ALT button in cyan and turn the ALT bug solid. Assuming a logical combination of speed and altitude were selected, the aircraft will immediately start a pitch change to seek the target indicated airspeed. A pilot throttle input may be required to sustain the target airspeed.

**NOTE**

**Logical Combination of Commanded Targets**

A logical combination of commanded autopilot targets means a combination of the altitude bug and either the vertical speed bug or indicated airspeed bug that can be achieved. For example, an altitude bug that is above current aircraft altitude and a positive vertical speed bug is a logical combination. In contrast, an altitude bug that is above current aircraft altitude and a negative vertical speed bug is NOT a logical combination.

To perform a vertical speed-based altitude capture, set both the VS bug and the ALT bug to the desired values and press both the “VS” and “ALT” buttons on the autopilot control panel at the same time. The system will light up the VS button in green and turn the VS bug solid and light up the ALT button in cyan and turn the ALT bug solid. Assuming a logical combination of vertical speed and altitude were selected, the aircraft will immediately start a pitch change to seek the target vertical speed. If a logical combination wasn't already preset, the VS bug will jump to +/- 500 fpm and then the aircraft will climb or descend as required. If, during a vertical speed-based altitude capture, either the target vertical speed or altitude are changed to become an illogical combination, the aircraft will fly the target vertical speed. A pilot throttle input may be required to sustain the target vertical speed.

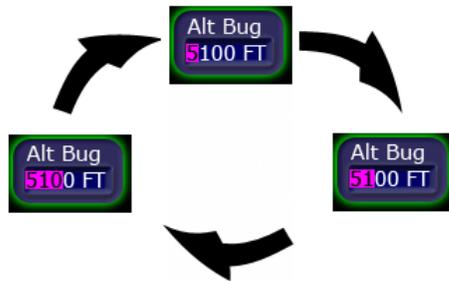
In the case of an indicated airspeed-based altitude capture, if a logical combination of speed and altitude were not selected, the aircraft will maintain its current state (will not initiate the climb or descent). For example, if a target altitude was selected above current aircraft altitude but an IAS target that was faster than current aircraft IAS was also selected, the airplane will NOT descend to pick up airspeed and then start the climb. Instead, it will hold position. The same is true if a descent were attempted at a speed slower than current aircraft speed.

The desired means of mode entry is via a simultaneous push of both the speed and altitude buttons on the autopilot control panel. However, an alternative technique is to press and hold one of the buttons, and while that button is still depressed, press the other

paired button. For example, for an IAS-based altitude capture, the IAS button can be pressed and held, and while that button is depressed, press the ALT button. When both are released, the speed mode will be active and the altitude mode armed just as intended.

The altitude bug control cycles through a 'thousands' mode, 'hundreds' mode, and 'tens' mode with each press of the adjacent line select key.

**Setting the Altitude Bug in DFC90**



There is also a 'black out' period where the autopilot will ignore the commanded target altitude if it is being edited as the original target altitude is approached. For example, if the system is currently performing an altitude capture on departure leg to an ATC assigned altitude, and as the aircraft is approaching that original assigned altitude, ATC issues a new assigned altitude that the pilot is in the process of entering into the system, the autopilot will ignore the original target and keep climbing to the new target. As soon as the edit mode is exited, as indicated by the altitude bug value or button no longer being reverse highlighted, the autopilot will honor whatever target altitude is active in the system.

The autopilot modes annunciator indication for altitude captures are a green "IAS" or "VS" and a cyan "ALT". As the target altitude is approached, the "IAS" or "VS" annunciators and buttons on the autopilot control panel extinguish and the "ALT" annunciator and button turns green and flashes for up to 10 seconds indicating the system is capturing the target altitude. At the end of the flashing period, both the modes annunciator and the control panel button are displayed in steady green.

## STRAIGHT AND LEVEL

### NOTE

#### **Straight and Level Definition**

Pressing the “STRAIGHT AND LEVEL” button on the autopilot will result in a zero bank, +2° pitch angle attitude. It is not an altitude hold mode or a zero vertical speed mode, nor does it hold a heading.

### NOTE

#### **Straight and Level Usable Envelope**

The Straight and Level button and functionality were demonstrated to the POH limits of the aircraft ( $\pm 60^\circ$  bank,  $\pm 30^\circ$  pitch). This mode is not to be relied upon to stabilize an aircraft under all conditions.

Activating this mode will result in the aircraft reaching a wings level, +2° pitch angle attitude. Depending on the power setting and aircraft configuration, this could produce a climb, steady altitude, or a descent

Straight and Level mode is entered by pressing the “STRAIGHT & LEVEL” button on the autopilot control panel. The system will light up the control panel button in green (blinking) and immediately change the bank and pitch as required to seek wings level, +2° pitch angle conditions. Once straight and level is achieved, the Straight & Level button on the control panel will be steady green until another mode is selected. Upset recovery will be a smooth, but depending on the entry attitude, aggressive maneuver designed to achieve those steady state conditions in an expedited manner. At sufficiently high power settings and aircraft configurations (e.g. no drag devices), a +2° pitch angle will result in a shallow climb. At low power settings and/or aircraft configurations, a +2° pitch angle may result in a descent.

Straight and Level mode can be entered from any autopilot state, including from the off position.

**NOTE**

**Limitation of Overspeed Protection in Straight and Level**

Overspeed protection is not ensured during initiation of Straight and Level mode. Depending on the dynamics of the airplane and the available torque in the servos, the recovery to straight and level conditions may exceed  $V_{ne}$ . For example, if the aircraft were in an extreme nose-low and/or high-speed condition at time of Straight and Level activation, it is possible for  $V_{ne}$  to be exceeded during the recovery to straight and level conditions.

The autopilot modes annunciator indication is a green “**STRAIGHT AND LEVEL**”. If the aircraft was not in a wings level, zero flight path condition at time of mode entry, then both the button and the mode annunciator will flash green while the aircraft is being maneuvered to achieve those conditions. At that time, both the control panel button and the mode annunciator stop flashing and turn steady green.

#### PILOT SELECTABLE INTERCEPTS

The autopilot can be commanded to perform a pilot selectable intercept angle in the lateral modes of GPSS and NAV. This can prove useful both enroute as well as in the terminal area and approaches.

To perform a pilot selectable intercept of a calculated nav course, set the heading bug to the desired value and press both the “HDG” and “NAV” (or “GPSS”) buttons on the autopilot control panel at the same time. The system will light up the HDG button in green and turn the heading bug solid and light up the NAV (or GPSS) button in cyan.

The heading knob can be adjusted at any time (before or after entering pilot selectable intercept mode) and the system will adjust the intercept angle accordingly.

The desired means of mode entry is via a simultaneous push of both the heading (HDG) and lateral nav (GPSS or NAV) buttons on the autopilot control panel. However, an alternative technique is to press and hold one of the buttons, and while that button is still depressed, press the other paired button. For example, for a 30-degree intercept of a Nav course, the HDG button can be pressed and held, and while that button is depressed, press the NAV button. When both are released, the heading mode will be active and NAV mode will be armed just as intended.

To disarm the intercept, press the "HDG" button. To re-arm the intercept, press "HDG" and either "NAV" or "GPSS" again.

The autopilot modes annunciator indication for pilot selectable intercepts are a green "HDG" and a cyan "NAV" or "GPSS". As the lateral nav course is approached, the "HDG" annunciators and buttons on the autopilot control panel extinguish and the "NAV" or "GPSS" annunciators and button turns green and flashes for up to 10 seconds indicating the system is capturing the lateral nav course. At the end of the flashing period, both the modes annunciator and the control panel button are displayed in steady green.



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# 4 Approach Procedures

## GENERAL BEHAVIOR

The integrated DFC90 and EXP5000 PFD system is designed to take full advantage of the auto transition capability of the GNS-430 units for flying a GPS flight plan ending in an ILS approach.

The CDI course is automatically set to the inbound localizer course resulting in a hands-free transition if the navigator has been set to autoslew (automatic ILS CDI output switch) and VLOC was not manually selected by the pilot on the PFD Pri Nav line select key. If the navigator hasn't been set up to auto slew, or VLOC was manually selected in the PFD Pri Nav field, it is recommended that the inbound course be set using the PFD course set knob to serve as a reference during the localizer intercept and tracking.

Note that "GS" mode as annunciated refers to a generic glideslope, encompassing both ILS glideslope and GPS WAAS approach vertical guidance.

## APPROACH MODES

### WAAS APPROACHES

When "GPS1" or "GPS2" has been selected as the source in the "Primary Nav" LSK, and one of the GPS approach types with vertical guidance (LPV, L/VNAV, LNAV+V) is the selected approach, the ADI will provide horizontal and vertical guidance by means of the HDI and VDI.

WAAS approaches are intended to flown in NAV APPR mode in the DFC90 system and thus the "Primary Nav" LSK must be set to GPS1/2. Roll commands are issued by the GNS-430 in GPSS mode instead of the DFC90 and proper vertical guidance can not be assured, hence the need to fly WAAS approaches in NAV APPR modes. Glide slope will not arm if the autopilot mode is GPSS.

If the autopilot were left in GPSS mode and the "Primary Nav" LSK is set to GPS1/2, then the autopilot will automatically switch

from GPSS to NAV mode if/when a valid glide slope signal is received.

If the autopilot were left in GPSS mode and the “Primary Nav” LSK is set to VLOC1/2, then the glide slope will not arm and the autopilot will not automatically switch from GPSS to NAV mode.

There are several types of WAAS approaches:

- **LNAV (Lateral Navigation):** Provides lateral (horizontal) guidance only, with standard GPS precision of 0.3 NM full-scale deflection. This is essentially the same as a non-WAAS GPS approach. It is flown as any other non-precision approach – descend to MDA, fly at MDA altitude to the MAP, and execute the missed approach procedure if appropriate.

For this approach type, a manual coupling to the autopilot is permitted. Prior to FAF the “NAV” (or “APPR”) button on AP must be pressed. There is no glide slope in a LNAV approach so a manual means to accomplish the vertical component of this approach needs to be enabled (VS and ALT). Then fly coupled to MDA.

- **LNAV+V (Lateral Navigation with Vertical Information)**  
This mode provides the same lateral navigation as LNAV, but presents an ILS GS-like presentation on the VDI. The GPS draws a 3-D picture of the approach based on crossing the FAF at the depicted altitude. Then it follows a glidepath from the published approach, which is typically a 3 degree angle to the touchdown zone. This type of approach remains a non-precision approach and does not consider any step-down limitations.

For this approach type, a manual coupling to the autopilot is permitted. Prior to FAF the “NAV” (or “APPR”) button on AP must be pressed. If it is not manually changed to NAV, then an automatic switch will occur when/if a GPS glide slope signal is received. In either the manual or automatic case, the AP switches to NAV APPR. Then fly coupled to MDA.

- **LNAV/VNAV (Lateral Navigation with Vertical Navigation)** In this mode, the GPS provides lateral navigation, providing more accurate guidance than regular LNAV but easier to follow indications than a localizer. The vertical navigation is driven by GPS signals. LNAV/VNAV approaches are operationally different from LNAV+V in that the glide path is protected from obstructions but attention still must be applied to step down fixes. Also, the minimum altitude presented is a decision altitude/height (DA/DH) – DA being what is on the altimeter, and DH being the height of the DA above the touchdown zone elevation. This is not a MDA, thus, fly it just as though it were a precision approach. Follow the glide slope needle just as though it were an ILS GS and continue all the way to DA before initiating a missed approach, if appropriate.

This type of approach is automatically coupled to the autopilot meaning that somewhere in the vicinity of the FAF, the system will automatically toggle the autopilot mode from GPSS to NAV APPR and GS will arm.

- **LPV (Localizer Precision with Vertical Guidance)** The lateral guidance is significantly more precise than LNAV, and equivalent to that of a localizer, except easier to fly. Vertical guidance is provided to minimums as low as 200' AGL above the touchdown zone. Lateral tolerance starts out at 0.3 NM full-scale (slightly tighter than a localizer at the FAF), transitioning to 350 feet either side at the runway threshold (slightly looser than a localizer). The steering remains linear all the way so you don't get the difficult to follow swings of a real localizer close in. The vertical guidance is precise and has a DA/DH (shown as "DA(H)" on Jepp charts) rather than a MDA.

This type of approach is also automatically coupled to your autopilot. This means, in the vicinity of the FAF, the system will automatically toggle the autopilot mode from GPSS to NAV APPR and GS will arm.

## GPS APPROACH (RNAV OR OVERLAY OR LNAV)

- Ensure the Primary Nav LSK is set to a GPS source and a GPS approach is loaded in the GNS430
- Press the “NAV” or “APPR” or “GPSS” buttons on the autopilot control panel
- Note that the “NAV” and “APPR” buttons on the autopilot control panel are lit in green or the “GPSS” and “APPR” buttons are lit in green if the autopilot is flying the bank commands
- Note that “**NAV APPR**” or “**GPSS APPR**” is displayed in the PFD mode annunciator section
- Execute a missed approach, if appropriate

## VOR APPROACH

- Ensure the Primary Nav LSK is set to a VHF source and tuned to a VOR
- Ensure the approach course is set in the Selected Course window
- Press “APPR” on the autopilot control panel, or “NAV” and then “APPR” (VOR approaches are the only types of approaches in which the “APPR” button must be pressed.)
- Note that both the “NAV” and “APPR” button on the autopilot control panel are lit in green
- Note that “**VOR APPR**” is displayed in the PFD mode annunciator section
- Execute a missed approach, if appropriate

## LOCALIZER APPROACH

When flying a Vectors-To-Final approach, use the Heading knob and the “HDG” button on the autopilot control panel when ATC is issuing vectors.

NAV APPR can be armed prior to capturing the localizer beam but it is highly recommended to wait until ATC clears you for the approach before trying to arm NAV and APPR. To arm NAV APPR while still in Heading mode, press the “HDG” and “NAV” (or “HDG” and “APPR”) buttons at the same time. Once armed, the system will automatically capture the localizer signal and transition out of Heading/Vectors mode on its own.

- Ensure the Primary Nav LSK is set to a VHF source and tuned to a localizer
- Ensure the front course is set in the Selected Course window
- When cleared for the approach or established on final, press the “NAV” or “APPR” buttons on the autopilot control panel (either will work)
- Note that the “NAV” and “APPR” buttons on the autopilot control panel are lit in green
- Note that “NAV APPR” is displayed in the PFD mode annunciator section
- If desired, a combination of VS and ALT or just VS modes can be used to control the vertical axis
- Execute a missed approach, if appropriate

## ILS APPROACH INCLUDING GLIDE SLOPE INTERCEPT

When flying a Vectors-To-Final approach, use the Heading knob and the “HDG” button on the autopilot control panel when ATC is issuing vectors.

NAV APPR can be armed prior to capturing the localizer beam but it is highly recommended to wait until ATC clears you for the

approach before arming NAV and APPR. To arm NAV APPR while still in Heading/Vectors mode, press the “HDG” and “NAV” (or “HDG” and “APPR”) buttons at the same time. Once armed, the system will automatically capture the localizer signal and transition out of Heading mode on its own.

- Ensure the Primary Nav LSK is set to a VHF source and tuned to a properly identified ILS
- Press “NAV” or “APPR” on the autopilot control panel (Approach mode will automatically arm if tuned to an ILS frequency)
- The autopilot will enter NAV and Approach lateral modes or arms them if off course
- The autopilot will automatically arm the GS vertical mode, retaining the existing vertical mode until capture
- At this point, “NAV” and “APPR” buttons along with the previous vertical buttons will be lit green on the autopilot control panel and the “GS” button will be lit in cyan
- PFD mode annunciator will display **NAV** and **APPR** along with the previous vertical mode in green and **GS** in cyan
- When the autopilot captures glideslope, the vertical mode button on the autopilot control panel and mode annunciator on the PFD will transition to a flashing green “**GS**” which will flash for approximately 10 seconds before going steady green
- Execute a missed approach, if appropriate

Glide slope is intended to be captured from below. If so desired, or required via NOTAM, GS mode can be toggled on/off through presses of the “GS” button on the autopilot control panel. There is no other required time to press the “GS” button.

In the event the pilot is attempting to capture the glide slope from above, glide slope will be captured as the aircraft passes through the glide slope signal, if GS mode was previously armed. If GS hadn't been armed, glide slope will be captured by manually pressing the “GS” button on the autopilot control panel when within 1 dot of glide slope centerline.

## PROCEDURE TURN ILS OR LOCALIZERS

The procedure for an ILS or Localizer with a procedure turn in a combined DFC90/430 system is the same as the straight-in procedures except that Heading mode should be used on the procedure turn. This is accomplished by pressing the “HDG” button on the autopilot control panel and then using the heading knob. Command the heading bug to the outbound procedure turn heading. Hold that heading until the point at which it is time to turn inbound. Use the heading knob to select the inbound procedure turn heading, being careful to turn the heading knob in the same direction you wish the aircraft to turn. When established on the front inbound procedure turn heading, arm the NAV APPR modes by simultaneously pressing the “HDG” button and the “NAV” or “APPR” button.

If equipped with a combined DFC90/GNS430W set of equipment and if the procedure turn is activated in the 430W, then the autopilot can be flown in GPSS mode by pressing the “GPSS” button on the autopilot control panel. In this case, the aircraft will automatically fly the outbound procedure turn heading, automatically make the turn inbound to the inbound procedure turn heading and then fly that inbound procedure turn heading. The pilot is still responsible for manually pressing the “APPR” (or “NAV”) button on the autopilot control panel when established on the front inbound localizer course. In this case, Primary Nav must be ensured/set to VLOC.

## BACK COURSE APPROACHES

Always ensure the front course is set in the Selected Course window. The system will recognize it is on a back course when the VHF receiver is locked onto a valid signal and there is a sufficient difference between aircraft heading and the selected course. There is no “REV” or similar button in a DFC90 autopilot. A “BC” annunciation will be added to the HDI, the HDI and CDI indicators will display correct sensing, and the autopilot will turn in the proper direction.

- Ensure the Primary Nav LSK is set to a VHF source and tuned to a LOC/ILS
- Ensure the front course is set in the Selected Course window
- Press either the “NAV” or “APPR” button on the autopilot control panel (either will work fine)
- Note that the “NAV” and “APPR” button are lit in green on the autopilot control panel
- Note that “NAV APPR” is displayed in green in the autopilot modes annunciator section of the display

## MISSED APPROACH

Prior to going missed approach, disconnect the autopilot, apply go-around power, ensure the aircraft is trimmed for the power setting, establish a climb attitude and use the autopilot to smoothly execute the assigned climb-out or published missed approach procedures. A recommended technique is as follows:

- Set the altitude bug to the desired altitude
- Press the “HDG” or “NAV” button on the autopilot control head, depending on missed approach instructions
- Press the “ALT” and “VS” buttons on the autopilot control head simultaneously to command an altitude capture
- Press the “OBS” button on the GNS430 to continue the coupled missed approach



<b>5</b>	<b>Abnormal Procedures .....</b>	<b>5-2</b>
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# 5 Abnormal Procedures

## **GENERAL FAILURE MODE INFORMATION**

The only failure modes that result in the loss of a DFC-series autopilot are when the system AHRS is unavailable (Red-Xs over the attitude display) or when the PFD has no power whatsoever.

Each autopilot contains an internal data recorder for use during service operations. The contents of the data logs remain the property of Avidyne. If an anomalous behavior is observed with the autopilot, pressing the "GS" button on the autopilot control panel multiple times will produce a series of events in the data log that will aid the Avidyne Service Center in finding and analyzing the data logs during troubleshooting operations.

Some failure modes identified in this section do not affect the functioning of the AHRS and therefore allow continued use of the autopilot.

In all cases, basic airmanship should be exercised and fundamentals utilized such as maintain aircraft control, analyze the situation, and take proper action.

### LOSS OF PFD DISPLAY (AHRS STILL OPERATIONAL)

#### **Failure Indication:**

A loss of PFD display condition is identified by a display being unreadable but PFD bezel button lights are still lit.

#### **Functionality Lost:**

Under these conditions, if there are no readable PFD displays left, there is a degradation in the ability to enter some autopilot commands/bug settings.

#### **Recommended Pilot Action:**

Use the autopilot sync capability and count clicks to accomplish the intended action. For example, to accomplish an altitude

capture, one technique is to press the “ALT” button on the autopilot control panel to achieve altitude hold mode. Then push to sync either the “VS” or “IAS” knobs on the autopilot control panel and twist the knob in the desired direction, counting each click of the knob (e.g. 5 counter clock-wise clicks of IAS results in 5 knots less than current IAS, each click of the VS knob results in 50 fpm). At this point, engage either “IAS” or “VS” to climb/descend and then press “ALT” again when the standby altimeter shows the desired altitude.

## LOSS OF PFD BEZEL BUTTONS

### **Failure Indication:**

A failure of the PFD bezel buttons is indicated by the display still being present and functional but the bezel buttons are inoperative.

### **Functionality Lost:**

The ability to enter altitude and heading autopilot commands and target bugs will be lost.

The ability to change which GNS430 navigator is driving the PFD nav solution will also be lost.

### **Recommended Pilot Action:**

Use the autopilot in the remaining usable modes (e.g. Alt Hold, NAV, GPSS, VS, IAS, Envelope Protection). Consider pulling both PFD circuit breakers for less than 20 seconds to conduct a warmstart.

## LOSS OF PFD DISPLAY AND BEZEL BUTTONS

### **Failure Indication:**

A failure of the PFD display and bezel buttons is indicated by the display being blank or a solid color such as green, and the bezel buttons are inoperative.

**Functionality Lost:**

The ability to enter some autopilot commands/target bugs will be degraded or lost. The rest of the PFD remains functional in this case (e.g. internal ADAHRS, automatic communication with MFD and 3<sup>rd</sup> party avionics, etc).

The ability to change which GNS430 navigator is driving the PFD nav solution will also be lost.

**Recommended Pilot Action:**

Use the autopilot in the remaining usable modes (e.g. Alt Hold, NAV, GPSS, VS, IAS, Envelope Protection). Consider pulling both PFD circuit breakers for less than 20 seconds to conduct a warmstart.

LOSS OF TURN COORDINATOR

**Failure Indication:**

A failure of the aircraft turn coordinator is indicated by an alert message (“TC FAIL”) displayed in the autopilot mode annunciator area of the PFD displays. The autopilot will also disconnect under these conditions if experienced in-flight the AP disconnect aural tones will be heard.

**Functionality Lost:**

One of the two attitude comparators (see Comparators segment in Section 1 of this manual) that is running in the background will be inoperative in this case.

If the turn coordinator is failed upon initial power-up, the autopilot will be prevented from engaging in any mode. This special case is indicated by a yellow “**AUTOPILOT INOP TURN COORDINATOR FAIL**” message in the center of the PFD autopilot mode annunciator area.

**Recommended Pilot Action:**

Apply extra attention to the normal instrument cross check and if the PFD display(s) are assessed to be accurate, manually re-engage the autopilot in the desired mode.

LOSS OF AHRS

**Failure Indication:**

A failure of an AHRS is identified by Red-Xs over the attitude and HSI compass card. Additionally, a yellow “**AUTOPILOT INOP AHRS FAIL**” message is displayed in the center of the autopilot mode annunciator area on the PFD.

**Functionality Lost:**

A loss of AHRS will result in a complete loss of autopilot functionality.

**Recommended Pilot Action:**

Immediately transition to hand-flying via the standby instruments and seek VMC as soon as feasible.

Consider attempting a single PFD warmstart by cycling both PFD circuit breakers for less than 20 seconds.

LOSS OF AIR DATA

**Failure Indication:**

A failure of the on-board air data system(s) is indicated by the airspeed, altimeter and vertical speed tapes being replaced by Red-Xs.

**Functionality Lost:**

The following autopilot modes will be lost:

- Altitude Hold
- Altitude Capture

- IAS Hold
- VS Hold
- Envelope Protection

**Recommended Pilot Action:**

Press the “STRAIGHT & LEVEL” button on the autopilot control panel, OR, manually disconnect the autopilot, maneuver the airplane to the desired attitude, and then re-engage the autopilot via the “AP” button which puts the system into Roll and Pitch Hold. All lateral modes are still fully functional including Heading mode as are Roll and Pitch, Straight and Level, and ILS including glide slope. In addition, you can use the VS knob on the control panel to control pitch.

#### LOSS OF PFD

**Failure Indication:**

A total failure of the PFD is indicated by both the display and bezel buttons all blank/unlit.

**Functionality Lost:**

A loss of the PFD will result in a complete loss of autopilot functionality.

**Recommended Pilot Action:**

Immediately transition to hand-flying via the standby instruments and seek VMC as soon as feasible.

Consider attempting a single PFD warmstart by cycling both PFD circuit breakers for less than 20 seconds. A successful warmstart will restore all PFD and autopilot functionality.

#### LOSS OF ENGINE

Loss of engine does not affect the DFC90 operation but the DFC90 autopilot can be useful during loss of engine situations. One technique is to set the IAS bug to best glide speed and

engage IAS mode in the event of engine-out conditions. The autopilot will adjust aircraft pitch as required to slow down, or speed up to achieve  $V_g$ , freeing up time to perform other cockpit duties during this emergency situation.

One minor variation of this technique is to set the IAS bug to  $V_g$  after climb-out so that it is already preset to  $V_g$ .

## OTHER ERROR MODES

Autopilot failures that prevent any operation are annunciated across the center of the PFD mode annunciator strip in amber (yellow) as shown in the example immediately below.

*PFD Autopilot Annunciator*



## GENERAL OR UNKNOWN FAILURES

### **Failure Indication:**

If the DFC-PFD system recognizes that the autopilot is invalid but can not decipher the reason, a yellow "AUTOPILOT INOP" message is displayed along middle of the PFD annunciator strip.

### **Functionality Lost:**

All autopilot functionality will be lost for the duration of this message display, meaning the autopilot would disconnect or prevent engagement. It is possible that the autopilot will conduct

an auto-reset which would kick off any engaged autopilot mode but following a successful reset, all functionality would be restored and a manual re-command of autopilot modes will be available.

**Recommended Pilot Action:**

Immediately transition to hand-flying via the PFD display.

If the autopilot does not conduct a successful automatic restart, consider attempting an autopilot restart by cycling the autopilot circuit breaker.

AHRS-TC MISCOMPARE DURING GROUND OPERATIONS

**Failure Indication:**

If the DFC-PFD system recognizes that the AHRS and the Turn Coordinator are experiencing a miscompare during ground operations before a successful engagement, a yellow “**AUTOPILOT INOP AHRS MISCOMPARE**” message is displayed along middle of the PFD annunciator strip.

**Functionality Lost:**

This message can only occur after system power application and if it does, the autopilot will not engage in any modes while this alert is active. This warning is designed to cover the condition where, after power up, the system is reading a difference between a valid TC signal and a valid AHRS signal. In this case, autopilot engagement is prevented.

**Recommended Pilot Action:**

Consider cycling power to the PFD and autopilot via the circuit breakers or using the Avionics Master. If that was not successful, plan your flight without autopilot.

## BUILT-IN TEST (BIT) FAILURE

### **Failure Indication:**

If the DFC-PFD system recognizes that the autopilot is invalid due to failing an internal self-test, a yellow “**AUTOPILOT INOP SELF TEST FAIL**” message is displayed along middle of the PFD annunciator strip.

### **Functionality Lost:**

All autopilot functionality will be lost for the duration of this message display. It is most likely experienced during initial power on of the autopilot during ground operations and therefore, would not allow autopilot engagement.

### **Recommended Pilot Action:**

If on the ground and the fault does not clear itself within 15 seconds, consider cycling power to the autopilot either via the circuit breaker or the overall avionics master.

If unsuccessful, recognize that all autopilot functionality will be lost so plan your flight accordingly.

## AHRS ALIGNING

### **Failure Indication:**

If the PFD AHRS has not finishing aligning, a yellow “**AUTOPILOT INOP AHRS ALIGNING**” message is displayed along the middle of the PFD annunciator strip. This message should be expected to be seen during all normal ground operations in the course of all standard alignments.

### **Functionality Lost:**

Since the DFC autopilot requires a fully aligned AHRS for its attitude source, the autopilot will remain non-functional until the AHRS is aligned and the message is removed.

### **Recommended Pilot Action:**

If on the ground, wait until the AHRS has finished aligning before taking off.

If in the air, follow the PFD Pilot Guide instructions for completing an in-air restart before attempting to use the autopilot. If the in-air restart was not successful, plan the rest of the flight without use of the autopilot.

## NO COMMUNICATION WITH AUTOPILOT

### **Failure Indication:**

If the PFD stops receiving data from the autopilot, a yellow “**NO COMMUNICATION WITH AUTOPILOT**” message is displayed in the center of the PFD annunciator strip.

### **Functionality Lost:**

All autopilot functionality will be lost for the duration of this message display. It is possible that the autopilot will conduct an auto-reset which would kick off any engaged autopilot mode but following a successful reset, all functionality would be restored and a manual re-command of autopilot modes will be available.

### **Recommended Pilot Action:**

Immediately transition to hand-flying via the PFD display.

If the autopilot does not conduct a successful automatic restart, consider attempting an autopilot restart by cycling the autopilot circuit breaker.

## **ALERTS**

In addition to recognized system failures as noted above, there are several alerts that may affect DFC autopilot and subsequent pilot operations.

## TRIMMING UP/DOWN

### **Failure Indication:**

If the DFC-PFD system recognizes that trim has been running for an excessive duration, a yellow “**TRIMMING UP**” or “**TRIMMING DN**” message is displayed along the right edge of the PFD annunciator strip.

### **Functionality Lost:**

No functionality has been lost. In all cases, the trim system can be manually overridden with pilot-controlled control stick/yoke inputs.

### **Recommended Pilot Action:**

Monitor the alert and if it is removed within a few seconds, no further action need be taken – the autopilot is operating normally.

If the alert is present for more than a few seconds, consider disconnecting the autopilot, manually trim the aircraft accordingly and if autopilot operations are still desired, re-engage the autopilot in the desired mode.

## GPSS INVALID

### **Failure Indication:**

If the DFC-PFD system recognizes that the autopilot mode is GPSS but the roll steering information from the GNS-430 is invalid, a yellow “**GPSS INVALID**” message is displayed along the right edge of the PFD annunciator strip.

### **Functionality Lost:**

Either a flight plan has not been entered in the governing GNS-430 and GPSS mode was selected on the autopilot control head in which case, there is no loss of functionality, or the system is unable to fly the flight plan in GPSS roll steering due to some anomalous GNS-430 situation or the ground speed is less than 40 knots.

**Recommended Pilot Action:**

Enter a flight plan into the navigator or select an autopilot mode that is not GPSS.

NAV INVALID

**Failure Indication:**

If the DFC-PFD system recognizes that the VHF lateral nav signal from the GNS-430 is invalid, a yellow “NAV INVALID” message is displayed along the right edge of the PFD annunciator strip. In addition, the Horizontal Deviation Indicator (HDI) along the bottom edge of the ADI will be Red-X'd.

The autopilot will command a wind corrected course hold and, if sufficient power is available, the flight path angle at the time the system displayed “NAV INVALID”.

**Functionality Lost:**

The ability to track a VHF lateral course (VOR or Localizer) from the selected GNS-430 navigator has been lost.

**Recommended Pilot Action:**

Consider switching the navigator that is driving the PFD CDI and autopilot.

If unable to select a usable alternative navigation source, take the proper action when a navigation source has been lost. If on a published approach that requires VHF-based lateral guidance, the approach must be terminated.

Consider switching to GPSS or Heading modes of the autopilot for lateral mode operations.

GLIDE SLOPE INVALID

**Failure Indication:**

If the DFC-PFD system recognizes that the VHF vertical nav signal (glide slope) from the GNS-430 is invalid, a yellow “GS

**INVALID**” message is displayed along the right edge of the PFD annunciator strip. In addition, the Vertical Deviation Indicator (VDI) along the right edge of the ADI will be Red-X'd.

**Functionality Lost:**

The ability to track a VHF vertical course (Glide Slope) from the selected GNS-430 navigator has been lost.

**Recommended Pilot Action:**

Consider switching the navigator that is driving the PFD VDI and autopilot.

If unable to select a usable alternative navigation source, take the proper action when the glide slope signal has been lost. If on a published ILS approach, transition to non-precision approach procedures and minimums or go missed approach.

TC FAIL

**Failure Indication:**

If the DFC-PFD system recognizes that the blind-mounted turn coordinator has failed, a yellow **“TC FAIL”** message is displayed along the right edge of the PFD annunciator strip. In addition, the autopilot, if it were engaged at the time, will automatically kick off and the AP disconnect aural tones will be heard.

**Functionality Lost:**

If on the ground, the autopilot will not allow engagement in any mode with this condition.

If the turn coordinator fails at any time after initially working during any given ground operation or flight, then the only autopilot functionality that has been lost is the automatic, behind-the-scenes comparator that is running between the Avidyne AHRS and the blind-mounted turn coordinator. The autopilot will automatically disengage but will allow manual re-engagement and will still function in all modes during this condition.

**Recommended Pilot Action:**

If on the ground during this condition, cycle power to the turn coordinator by cycling the avionics master. This also has the affect of cycling power to the autopilot itself which would clear any false reports of TC failure.

If the alert is presented at some time after initial autopilot engagement, consider re-engaging the autopilot and continue standard autopilot operations but be vigilant knowing that the AHRS-TC comparator is not running.

AHRS MISCOMP

**Failure Indication:**

If the DFC-PFD system recognizes that a miscompare condition is active between the Avidyne AHRS and the blind-mounted turn coordinator, a yellow “**AHRS MISCOMP**” message is displayed along the right edge of the PFD annunciator strip. This display alert is accompanied by a single aural alert “GYRO MISCOMPARE” that is audible in the headsets. In addition, the autopilot, if it were engaged at the time, will automatically disengage and the AP disconnect aural tones will be heard.

**Functionality Lost:**

If on the ground, the autopilot will not allow engagement in any mode with this condition.

If a miscompare condition is experienced at any time after initially engaging the autopilot in any mode, then the only autopilot functionality that has been lost is the automatic, behind-the-scenes comparator that is running between the Avidyne AHRS and the blind-mounted turn coordinator. The autopilot will automatically disengage but will allow manual re-engagement and will still function in all modes during this condition.

**Recommended Pilot Action:**

If on the ground during this condition, cycle power to the turn coordinator by cycling the avionics master. This also has the affect of cycling power to the autopilot itself which would clear any false reports of AHRS-TC miscompares. If that was not successful, plan your flight without autopilot.

If the alert is presented at some time after initial autopilot engagement, evaluate the accuracy of the PFD AHRS solution by comparing the PFD display to the backup gauges, and if in VMC conditions, the out-the-window view. If it can be concluded that the PFD is accurate, consider re-engaging the autopilot and continue standard autopilot operations but be vigilant knowing that the AHRS-TC comparator has noted a sensor miscompare.

NO PFD COMM

**Failure Indication:**

If the autopilot stops receiving data from the PFD, a yellow “**NO PFD COMM**” message is displayed along the right edge of the PFD annunciator strip.

**Functionality Lost:**

All autopilot functionality will be lost.

**Recommended Pilot Action:**

Immediately transition to hand-flying the aircraft.

Consider attempting a single PFD warmstart by cycling both PFD circuit breakers for less than 20 seconds.

MSR FAIL

**Failure Indication:**

If the autopilot computer determines that it can no longer read from, or write to the internal maintenance and safety recorder, a yellow “**MSR FAIL**” message is displayed along the right edge of the PFD annunciator strip. In addition, all aural associated with the autopilot (e.g. disconnect beeps, envelope protection alerts, autopilot command mismatch alerts), will be absent.

**Functionality Lost:**

The autopilot will still be fully functional in all pilot-usable modes but the on-board data logging has likely stopped and all autopilot aural alerts will be unavailable.

**Recommended Pilot Action:**

Apply extra vigilance to the autopilot annunciator status messages along the top of the PFD due to the absence of the associated aural alerts.

After the flight, notify an Avidyne Service Center or Avidyne Customer Support to coordinate for a repair action.

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# 6 Limitations and Performance

## LIMITATIONS

1. The DFC90 must not be used during icing conditions.
2. The DFC90 minimum use height is 200ft AGL. This means the autopilot must be disengaged for takeoff and landing and disengaged for missed approach or go around until climb and configuration are established above 200ft AGL.
3. DFC90 operations are prohibited in aircraft equipped with pitch trim-only when flaps are deployed more than 50% (no dedicated pitch servo).
4. Maximum flap retraction speed (50% to full retracted) with autopilot engaged is 110 KIAS in aircraft equipped with pitch trim-only.
5. DFC90 operation is prohibited above 185 KIAS
6. The Avidyne DFC90 Series of Digital Autopilots Pilot's Guide, P/N 600-00252-000, Revision 03, or later appropriate revision, must be available to the pilot during all flight operations.

## GENERAL PERFORMANCE – CIRRUS AIRCRAFT

The input forces required for roll-axis control surface actuation are demonstrably light and it is not difficult to force the servo (roll trim spring cartridge) to drive to its limit. By design, reaching the physical limit causes a micro-switch to be tripped which effectively decouples the autopilot commands from the flight control surfaces.

Pilot-induced inputs on the system including yoke input, rudder input, p-factor, fuel imbalance, airspeed and general aircraft trim alignment can all contribute to this condition.

### WARNING

#### Reaching Servo Limits Can Cause Uncommanded Rolls

If the roll servo limit is reached, the autopilot may stop following lateral commands. This could appear to the pilot as an uncommanded roll or a failure to follow the commanded lateral target.

As a result, it is highly recommended that a pilot avoid making flight control inputs while in coupled autopilot mode operations aside from minor rudder input to maintain coordinated flight. Moderate rudder or any roll input may result in an inability of the DFC90 autopilot to track the commanded targets.

## PERFORMANCE IN PITCH TRIM-ONLY AIRCRAFT

As noted earlier, all modes and behaviors described in this manual work both in aircraft with pitch servos and those without (pitch trim-only) with the exception of the reaction to manual electric trim inputs. However, aircraft equipped with pitch trim only (no pitch servo) should expect a less precise and, depending on the environmental and aircraft dynamic conditions, a slower reaction time in the vertical axis when experiencing vertical turbulence or other inputs like flap deployment/retraction, IAS mode tracking and unusual attitude recoveries using the Straight and Level button.

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**Website** There is a dedicated website that provides more information on this product at <http://www.dfc90.com>

### **FAQs**

<http://www.avidyne.com/downloads/products/dfc90/DFC90-DFC100-FAQs.pdf>

**Service Hotline** A hotline has been established to service questions or issues regarding Avidyne products. The U.S. Toll Free number is 1-888-723-7592. International toll free numbers are listed at <http://www.avidyne.com/contact/intphones.asp>

**Email** Customer/product support issues can be emailed as well

- Europe – [support@avidyneurope.com](mailto:support@avidyneurope.com)
- Australia & Asia – [support@avidyneaustralasia.com](mailto:support@avidyneaustralasia.com)
- Everywhere else should email [techsupport@avidyne.com](mailto:techsupport@avidyne.com)

When calling or emailing for product-related help, please have the following information available, if able:

- Customer Name/Account Information
- Aircraft tail number, DFC90 serial number, PFD serial number and software versions.
- A good description of the problem or question.

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