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AVIATION TRAINING

DPE and CFI Avionics Guide

Retrofit

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AVIATION TRAINING

Garmin International, Inc.

1200 East 151st Street

Olathe, Kansas 66062, U.S.A.

Garmin (Europe) Ltd.

Liberty House, Hounsdown Business Park

Southampton, Hampshire SO40 9LR U.K.

Garmin AT, Inc.

2345 Turner Road SE

Salem, OR 97302, U.S.A.

Garmin Corporation

No. 68, Zhangshu 2nd Road

Xizhi District, New Taipei City, Taiwan

Contact Garmin Product Support or view warranty information at flygarmin.com™.

Table of Contents

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INTRODUCTION

Garmin has a broad portfolio of retrofit product offerings that provide options and capabilities for aircraft in many different aviation sectors. There are many different retrofit avionics configurations in aircraft today. This manual will discuss two common setup styles to understand general principles of system design and the interface of a variety of Line Replaceable Units (LRU). The use of a LRUs allows a more robust system with no single points of failure as well as faster return to service when repair is needed. For example, if an air data computer failed it is faster and less expensive to replace a single air data computer, than it would be if all the avionics were in one single box together.

This guide will address potential LRU failure modes in a broad sense to help develop functional understanding. Installation specific training can be developed for enhanced operations as well as proficiency. However, the Garmin Pilot's Guide (PG), Pilot's Operating Handbook (POH), and Aircraft Flight Manual Supplement (AFMS) remain the authoritative documents for aircraft. Not every aircraft will have all the equipment referenced in this document. This document provides avionics system familiarization and an overview of potential failure modes and sample system operation/failure mode scenarios that correspond to flight training requirements. This guide will reference functional generalities so that Designated Pilot Examiners (DPE) and Certified Flight Instructors (CFI) may create and train a logic flow of how to deal with failures in electronic flight decks.

This guide references LRUs by functionality such as flight instruments, navigation, and audio control. This allows a pilot to think of LRU functions and capabilities and what to expect and do when a function or capability is lost. This document does not include all functions or features such as wireless connectivity. Each "Failure Mode Section" will have two options that can be correlated the two common setup styles. These setup configurations will be discussed in more detail in the System Overview Options section.

System Overview Options

Aircraft that have Garmin retrofit avionics installed can have many configurations and have a variety of interfaced equipment. For the purposes of this manual, it is assumed that the panel is certified for IFR operations and will conform to one of two major setup styles that are shown in the figures below.

Figure 1 is an outline of a Flight Display centric panel. This may be the use of up to two TXi/G500/G3X flight displays and up to two navigators. This setup style will be referenced in each "Failure Mode" section as "*Flight Displays.*" With this type of configuration there will always be at least one electronic instrument or various analogue instruments that serve as backups.

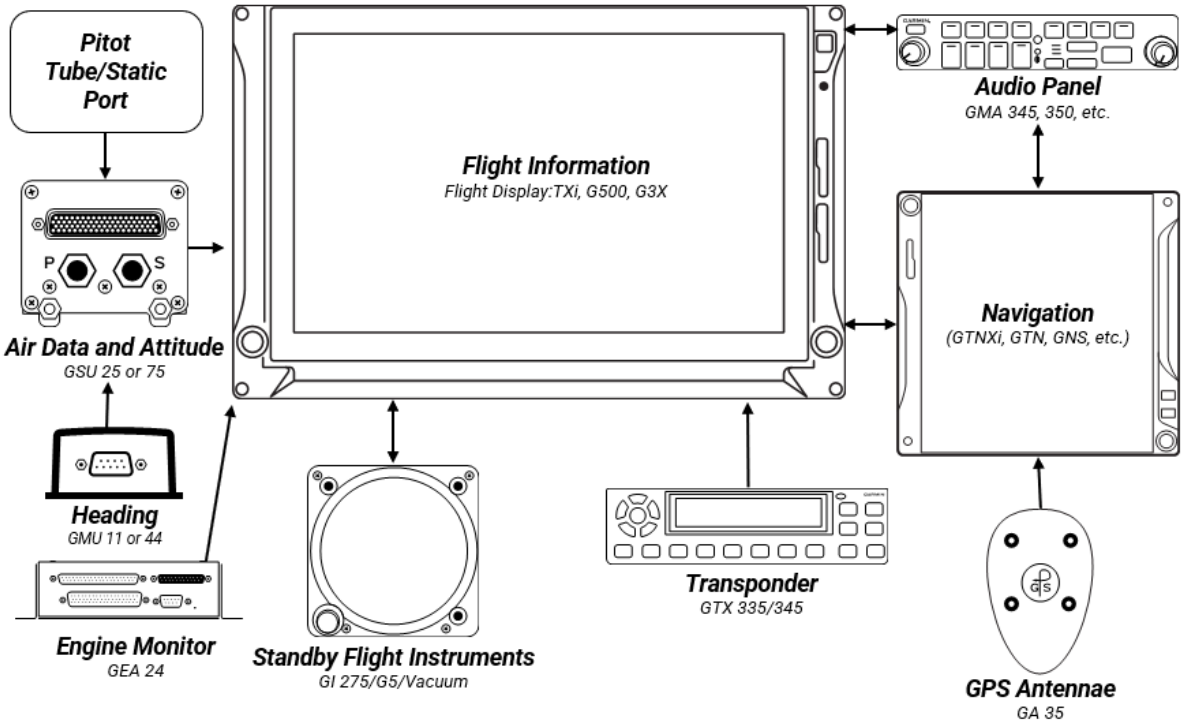

Figure 1: Flight Display Configuration

Note: This diagram is used to illustrate the data feed sources. Data routing varies depending on the flight display as well as the specific images of the LRUs. For example, the image shown for heading is a GMU 11 which would be used with the G3X. For specific configuration questions, please reference the installation documentation and/or consult a Garmin Dealer.

Figure 2 is an outline of an Electronic Instrument centric panel. This configuration may include multiple stand alone GI 275s or up to two G5s with the use of analogue gauges and up to two navigators. This will be referenced in each "Failure Mode" section as "*Electronic Instrument.*" With this type of configuration there will always be at least one electronic instrument or other analogue instruments which serve as primary/backup.

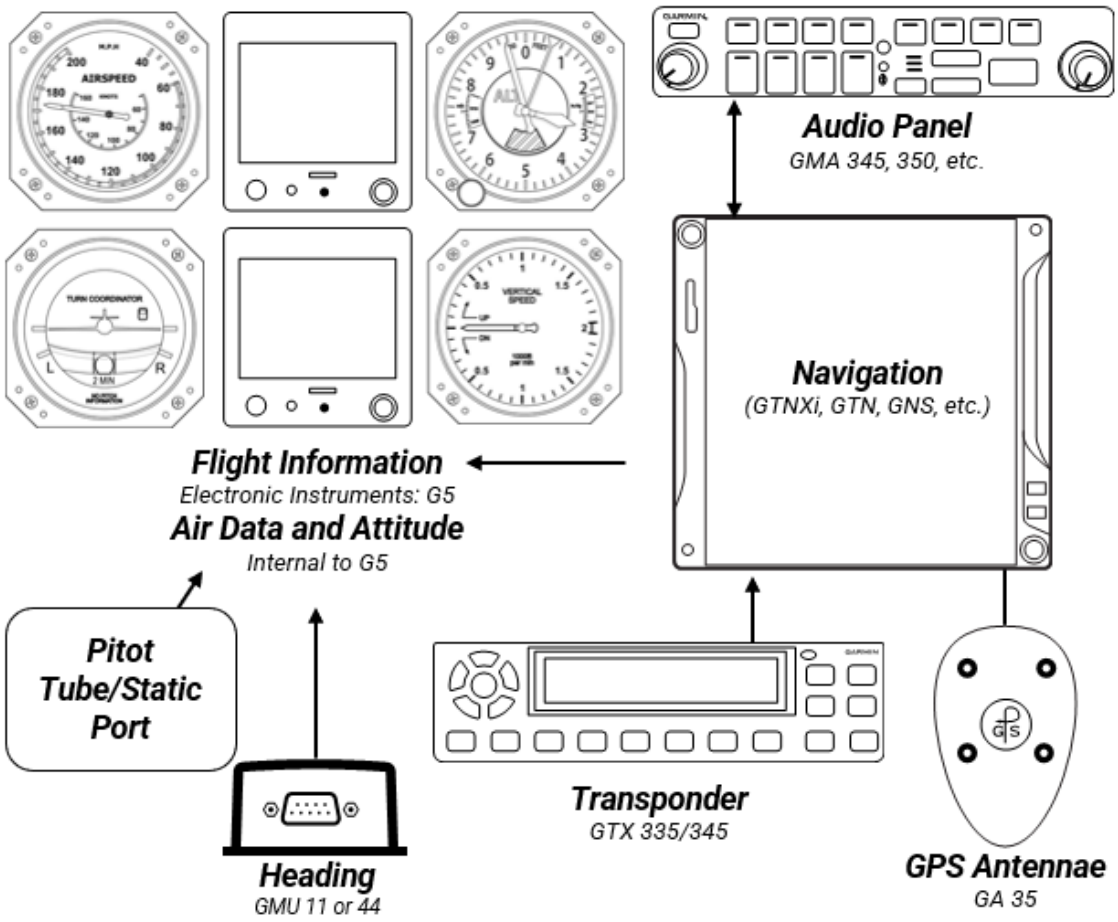

Figure 2. Electronic Instrument Configuration

Note: This diagram is used to illustrate the data feed sources. Data routing varies depending on the flight display as well as the specific images of the LRUs. For specific configuration questions, please reference the installation documentation and/or consult a Garmin Dealer.

FLIGHT INFORMATION (TXI, G500, G3X, GI 275, G5)

The flight instruments can be displayed in several ways. The critical flight data in this system are attitude, heading, course guidance, airspeed, altitude, turn and bank, and vertical speed. This is the information from the traditional "six pack." For the purposes of this manual the focus is on the critical display information for VFR and IFR minimum requirements. If this system fails, the pilot should land as soon as practical for service.

Failure Modes

Flight Display: In the unlikely event of a total screen failure the pilot should shift focus to the back up instrumentation. For either the TXi, legacy G500, or G3X systems there will be at least a GI 275, G5, or analogue flight instruments to provide the critical attitude, heading, airspeed, and altitude. These indicators will be installed in the pilot's primary field of view providing a quick transition to this new reference data.

Electronic Instruments: For a single Attitude Indicator (AI) failure the electronic instrument in the HSI position will revert to become an Attitude Indicator. You can also manually select this through the menu. Navigation information that was displayed on the HSI may be viewed through the reverted AI or from the electronic CDI on the map page/default nav page of the navigator.

Note: The GI 275 and G5 standby instruments can be equipped with a back up battery that allows the instrument to function for an additional 4 hours after an electrical source failure. Not all GI 275 configurations will be equipped with a back up battery. Consult your AFMS for configuration details and system limitations.

ATTITUDE (GSU 75, GSU 25, GI 275, and G5)

Attitude information (pitch, roll, yaw, turn and bank) are all synthesized inside of the GSU (for flight displays) or internal to the electronic instruments (for GI 275 and G5). These devices use solid state sensors and accelerometers to produce the same data that was once provided using a traditional gyroscope. The use of these digital devices allows for greater accuracy, redundancy, and reliability than legacy methods. If this system fails, the pilot should land as soon as possible for service.

Failure Modes

Flight Display: The failure of attitude information will result in a red "X" over the aircraft symbol. The pilot should immediately adjust their instrument scan to the backup instrumentation for this data.

Electronic Instruments: The failure of attitude information will result in a red "X" annunciated over the aircraft symbol with "ATTITUDE FAIL" text above. The pilot should immediately turn the HSI into "PFD mode" and resume their instrument scan excluding the failed AI. Navigation guidance can be received from reverted AI screen or CDI display on a GTN map/default nav page.

AIR DATA (GSU 75, GSU 25, GI 275, and G5)

Air data (airspeed, altitude, vertical speed) uses solid state sensors to compute the air data in a similar way as legacy technologies. Airspeed is still computed by ram air pressure as compared to static air pressure. Altitude is computed by barometric sensor based off static air pressure. Vertical speed is computed by barometric rate of change based off static air pressure. So, all airspeed related failures in regard to pitot icing/blockage and static blockage remain the same as traditional training. The following failure modes are based on a failure of hardware that computes this data. If this system fails, the pilot should land as soon as possible for service.

Failure Modes

Flight Display: If the Garmin Sensor Unit (GSU) fails this will result in a red "X" annunciation over the indicated airspeed, altimeter, and vertical speed tapes. Standby GI 275 or G5 systems have their own pneumatic lines plumbed directly to the device and there are sensors internal to the instrument that generate this data. The pilot should immediately adjust their instrument scan to the backup instruments to derive this data.

Electronic Instruments: If there are failures with these sensors, then the applicable data will be red "X" annunciated over the information fields. Applicable air data can be interpreted from the standby instrumentation. In some cases, it may be best to focus your scan on the standby instrumentation similar to that of a full display failure. For panels with G5s continue your scan with the analogue air instruments.

Note: In the event of a pitot static blockage the symptoms will be the same as for analogue gauges. Loss of pitot ram air pressure will not cause a red "X" but will display as diminished or zero airspeed as applicable. IAS mode and ESP may not be available due to this loss in air data. Respond accordingly with pitot heat and supplement other instrumentation to compensate for the inaccuracy.

HEADING (GMU 44/GMU 11)

Independent heading is derived using a magnetometer that senses the earths magnetic field to determine the direction the nose of the aircraft is pointing. This device is what makes it possible to replace the gyroscope previously used in conventional Directional Gyro indicators without the indication being based off GPS track. If this system fails, the pilot should land as soon as practical for service.

Failure Modes

Flight Display: If the GMU 44 fails entirely the heading indication above the HSI will turn magenta and be displaying GPS track and not heading.

Electronic Instruments: If the GMU 11 fails entirely the heading indication above the HSI will turn magenta and be displaying GPS track and not heading.

Note: Most GMU failures are partial failures as a result of electromagnetic interference. This can be due to inappropriate installation locations or aging wires to lighting systems that have lost effective insulation. This will cause the heading indication to turn yellow intermittently. This indicates that the heading indication is periodically unable to verify its reliability.

STANDBY FLIGHT INSTRUMENTS (GI 275, G5)

Standby Flight Instruments are critical to IFR certification and redundancy of essential systems. Every IFR certified panel will have back up instruments of at least a GI 275, G5, analogue instruments, or a combination of those. If the standby instruments fail the pilot should land as soon as possible for service.

Failure Modes

Flight Display and Electronic Instruments: If the standby instruments fail (complete or partial) the focus should remain on the primary instrumentation.

NAVIGATION (GTNXI, GTN, GPS 175, GNC 355, GNX 375, GNS)

IFR flight navigation directives are controlled using the navigator (regardless of series). Failure of this system will result in a loss of navigation signal to the corresponding HSI or CDI. Response to these failures will largely depend on the availability of a second navigator, which may or may not be required depending on your operations. If a navigator fails, the pilot should land when practical for service.

Failure Modes

Flight Display: If the primary navigator fails and a second compatible navigator is configured then it can be selected through the CDI selection to GPS 2 or NAV 2 as appropriate.

Note: The G3X touch has an internal VFR navigator. In an emergency this could be selected as "Internal" and used for enroute navigation.

Electronic Instruments: If the primary navigator fails, a secondary navigator may be configured to a number 2 CDI. Refer to that system for guidance.

Note: Many transponders rely on GPS signal from a WAAS navigator (as opposed to having their own WAAS GPS antennae) to achieve ADS-B compliance. Failure of GPS could fail your ADS-B response to ATC. As a result, it could be a violation of ADS-B required airspace to operate regardless of flight condition. Advise ATC as appropriate for airspace. This should be considered when testing GPS failure simulations.

TRANSPONDER

The transponder is used for aircraft position reporting to ADS-B. Following the 2020 ADS-B requirement all areas requiring Mode C also require ADS-B compliance. If the transponder fails and is required for the current type of operation (IFR flight plan, airspace, altitude, etc.) the pilot should land as soon as practical for service.

Failure Modes

Flight Display and Electronic Instruments: Transponder failure will most commonly manifest a full failure or a loss of GPS. Full failure (without a second transponder) has no backup action to be taken by the pilot. Advise ATC as appropriate.

AUDIO PANEL

The audio panel controls the source, volume, and squelch of various communication radios, navigation radios, intercom, and annunciations. If the audio panel fails, the pilot should land as soon as practical for service.

Failure Modes

Flight Display and Electronic Instruments: Audio panel failure will result in the system reverting to "Fail Safe" mode. This will allow a single frequency to be received and transmitted on. This will default to the Comm 1 and is controlled through that interface.

ENGINE MONITOR

The GEA (Garmin Engine Adapter) consolidates values from temperature probes, fuel transducers, tachometers, and more as a useful display of engine performance and status. If the GEA fails, the pilot should land as soon as possible for service.

Failure Modes

Flight Display: In the event of a GEA failure portions or all the engine instrument display fields will be annunciated with a red "X." There is not normally a backup for engine instrumentation so caution should be used in configuring and landing as soon as possible for servicing.

Electronic Instruments: In the event of a GI 275 EIS failure there is not normally a back up for this information. Exercise caution for configuring and landing as soon as possible for servicing.

RECOMMENDATION FOR FAILURE SIMULATION: INSTRUMENT TRAINING AND CHECKRIDE

The following recommendations are provided as an option for use in the Instrument Check ride pursuant to FAA-S-ACS-8B, Section VII, Task D *Approach with Loss of Primary Flight Instrument Indicators.*

Method 1: Single Instrument Failure- Instrument Stickers (Preferred)

The use of instrument stickers is the lowest risk way of training the instrument failure skillset without damaging the equipment. Garmin recommends the use of suction cup based instrument stickers that attach without the use of adhesives. Light weight sticky notes may also be helpful as long as they are not left for a long duration or exposed to direct sunlight.

Flight Display:

TXI and G500: The TXi and G500 will present the most challenge with the use of instrument stickers especially if synthetic vision is left engaged. Use of multiple instrument stickers may be used to obscure the miniature airplane enough to add value in a failure practice scenario.

G3X Touch: The G3X Touch PFD should be setup to display Round Gauges for testing single instrument failure. Select the HSI> More Options> PFD Presentation> Select Round Gauges. Attitude Presentation> Select Round Gauges. This allows the examiner or instructor to instrument sticker cover only the attitude indicator and have a presentation similar to that of an analogue six pack.

Electronic Instrument:

G5 and Analogue Instrumentation: A single sticker over the desired instrument will provide adequate loss of instrumentation. It is also suitable to select the power button and decrease screen brightness to the point that it is not feasible for the applicant or student to read the indicator correctly. This would prevent the G5 HSI from reverting to PFD mode.

GI 275: Depending on the configuration of standby instrumentation the GI 275 may have a sticker placed over the device. For configurations with x2 GI 275s this may present a loss of more instruments than just the attitude indicator. Small instrument stickers or sticky notes that have been cut to size may be used to obscure only the miniature airplane indication of the GI 275.

Method 2: Display Failure-Power off/Circuit Breaker

The following method should be used with caution and infrequently. This method should never be attempted in Instrument Meteorological Conditions (IMC) because this is not a simulated failure. The method described is inducing a real failure into the system through power loss to the LRUs. In some cases this can be an effective training tool but should be implemented with significant judgment and discernment.

Flight Display:

TXI: The TXi is equipped with a power button on the bezel of the display. Hold the power button and select "Power Off." The screen will countdown to power off and then go black. Any applicable reversionary modes and appropriate pilot actions should take place.

G3X Touch and G500: The G3X and G500 displays will have circuit breakers assigned in the panel. Pull the corresponding circuit breaker to remove power from the system and the screen will go black. Any applicable reversionary modes and appropriate pilot action should take place.

Electronic Instrument:

G5 and Analogue Instrumentation: The G5 is equipped with a power button on the bezel of the instrument. Hold the power button to power down the unit. The screen will countdown to power off and then go black. Any applicable reversionary modes and appropriate pilot actions should take place.

GI 275: There is no power off option in flight for a GI 275. An instrument sticker must be used to simulate a full failure of the GI 275 Attitude Indicator. The GI 275 AI in a primary position will not allow you to use the shut down option from the system menu (like an MFI version). Furthermore, by pulling the circuit breaker with an active ground speed the device will indicate an external power loss and revert to battery power to continue functioning.

CAUTION: Do NOT attempt power loss simulations in IMC. The methods stated above are actual system failures and may result in unsafe conditions if used in IMC.