
Diamond DA40


Cessna 182/206


Mooney Ovation2 GX/Bravo GX

Guidance for Designated Pilot Examiners and Certified Flight Instructors on using Garmin G1000 Equipped aircraft for Instrument Rating Training and Practical Examinations

GARMIN
1200 E. 151st St.
Olathe, KS 66062
USA
913.397.8200
CFI_Tools@garmin.com

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Introduction

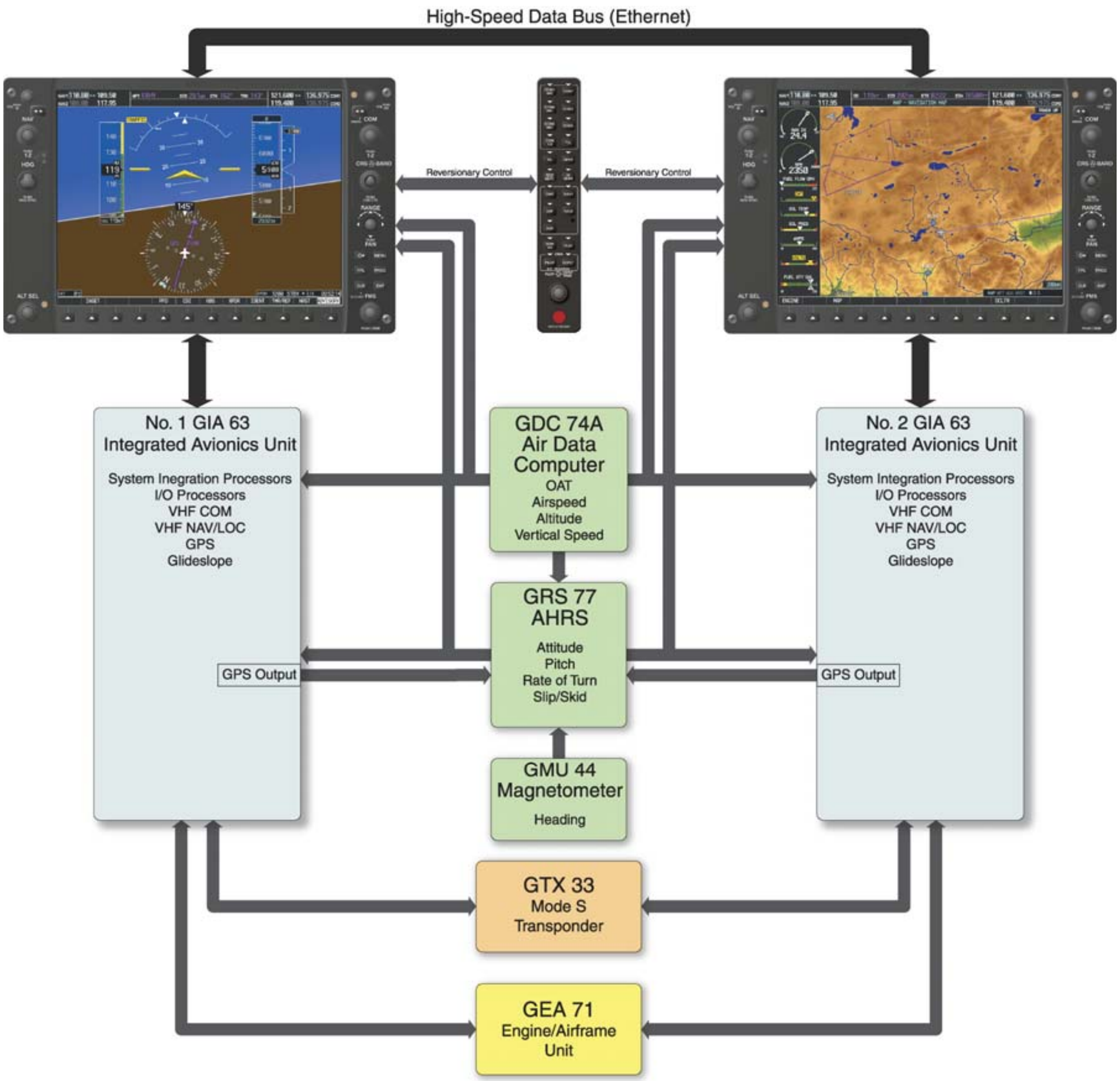
The purpose of this document is to provide; (1) an overview of the typical G1000 potential failure mode operations, and (2) sample system operation/failure mode scenarios that correspond to the applicable sections of FAA-S-8081-4D, Instrument Rating Practical Test Standards.

Garmin recognizes the importance of proper flight examinations in aircraft using the G1000 integrated avionics system in establishing long-term improvements in the General Aviation (GA) safety record. To accomplish this, Garmin has developed this guide so the Designated Pilot Examiner (DPE) and Certified Flight Instructor – Instrument (CFII) can properly prepare a pilot for the instrument rating by simulating realistic failure modes, as well as in the DPE development of their plan of action.

The system description and recommendations are Garmin's recommendations only and are superceded by the aircraft manufacturer's recommendations and documentation for each particular model of aircraft. The basic system architecture between many aircraft is similar, although the location of the actual components of the system will vary, as will the location and grouping of circuit breakers. Engine instrumentation presentations will also be the other main differentiation between aircraft at the request of the aircraft manufacture and the actual engine/propeller combination used with the aircraft. Therefore, it is important to review to the aircraft manufacturer's documentation for each model of aircraft.

G1000 System Overview

The G1000 integrated avionics system consolidates all communication, navigation, surveillance, primary flight instrumentation, engine indication system and annunciations on two (or three) LCD (liquid crystal diode) displays and one (or two) audio control panels. All of the components of the G1000 system are Line-Replaceable Units (LRU). This modular approach allows the various components to be mounted either behind each of the displays or in remote locations in the aircraft based on the needs of the aircraft manufacturer. Below is a sample system schematic (Fig.1) that represents the G1000 components used in a typical single-engine, GA aircraft. (Note: Autopilot interfaces are not shown as they vary from aircraft to aircraft.)



[Fig.1]

Components

The main components are the two GDU 1040 displays used for the Primary Flight Display (PFD) and the Multifunction Display (MFD) and the two GIA-63 Integrated Avionics Units. These components are interfaced to each other via a proprietary high-speed digital databus system that is Ethernet based. All other components from the AHRS, ADC, Transponder and

Engine/Airframe Interface unit, use combinations of analog RS-232, ARINC-429 and RS-485 interfaces.

The GDU 1040 displays are identical in hardware and their display presentation is controlled via configuration modules that are part of the wiring harness, which determines the type aircraft (ex. C182) and their mounting position function as either a PFD or MFD.

> *Failure Mode(s):* If one display should fail, the primary flight instruments and engine indication system will be displayed on the remaining screen [Fig. 2]. This will remove any moving map presentation from the system. This operating mode is called “Reversionary Mode” and may be detected automatically by the system or initiated manually by using the red, Backup Mode button located at the bottom of the audio control panel.

[Fig. 2]

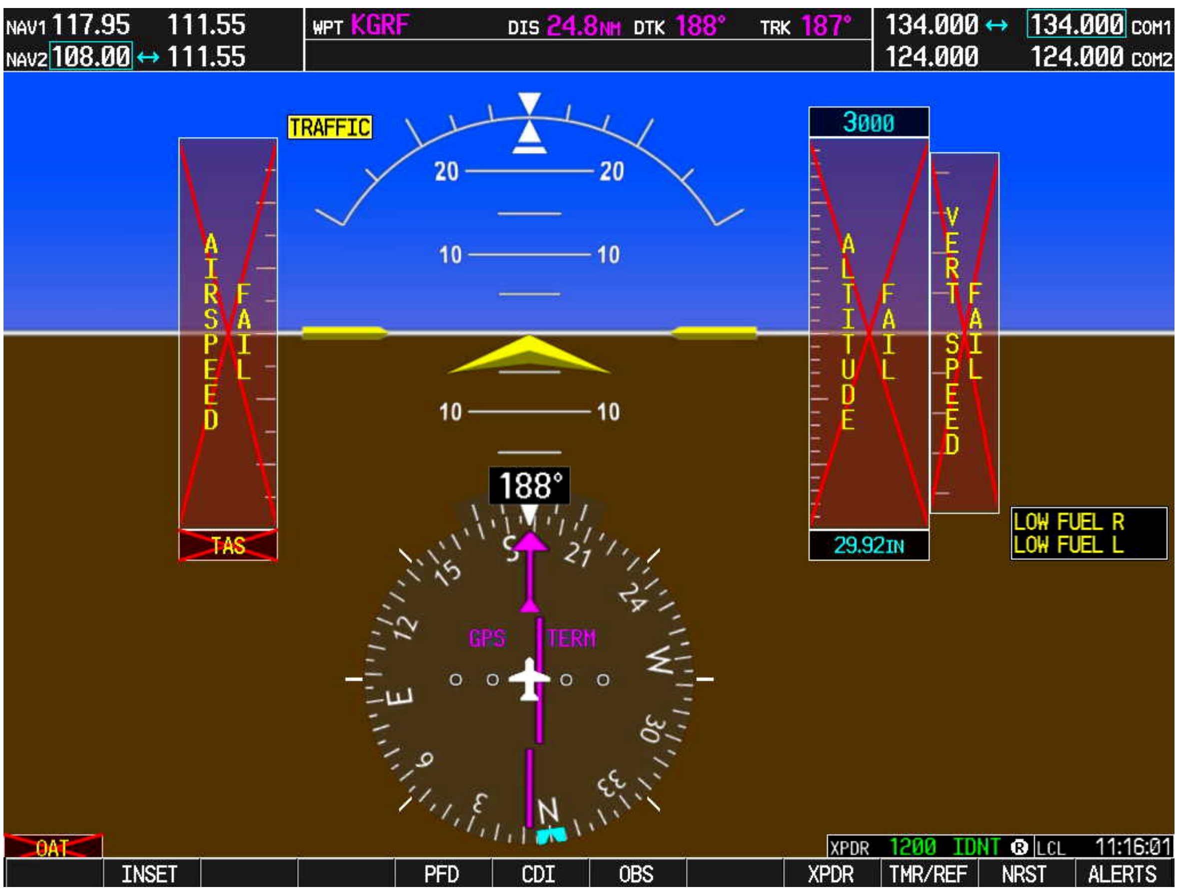
The GIA 63 units serve as the main interface hub for the individual components of the system. All key items such as the GRS 77 AHRS, GDC 74A ADC, GTX 33 Mode-S transponder and GEA 71 Engine/Airframe Interface provide inputs to both GIA units. This allows for a higher level of system redundancy and integrity as various data is cross-checked to ensure proper operation of the system. The only component that does not connect directly to the GIA units is the GMU 44 magnetometer. It is interfaced directly to the AHRS as it provides the magnetic heading input to the AHRS system. The GIA 63 units also contain the communications radios, navigation radios to include the VOR/LOC/GS receivers and a GPS receiver.

> *Failure Mode(s):* If a GIA 63 unit fails, the respective COM/NAV/GPS will be lost and the pilot will use the other COM/NAV/GPS. The remaining GPS unit will automatically take over any active GPS navigation without pilot input. A red “X” will appear over the COM/NAV frequencies as an indicator of this failure and an alert annunciation will appear to the right of the altitude/vertical speed tapes on the PFD. The remaining GIA 63 will continue to provide all interface and system integrity functions if one of the two goes off-

line. If both GIA 63 units should fail, the AHRS and ADC will continue to provide data directly to the GDU units, although no navigational or communication capabilities will be available. Partial failures in the GIA units are more likely to occur than a full component failure. The COM/NAV/GPS and interface components are independent inside the GIA 63 so the pilot would most likely experience a loss of only one of those items such as the COM component, rather than the entire GIA 63.

The GDC 74A is the Air Data Computer (ADC) for the system. It brings in the standard pitot and static inputs, as well as Outside Air Temperature (OAT). This allows the system to automatically calculate most “E6B” calculations, such as: Density Altitude, True Airspeed, as well as Wind Speed and Direction at the aircraft’s current altitude.

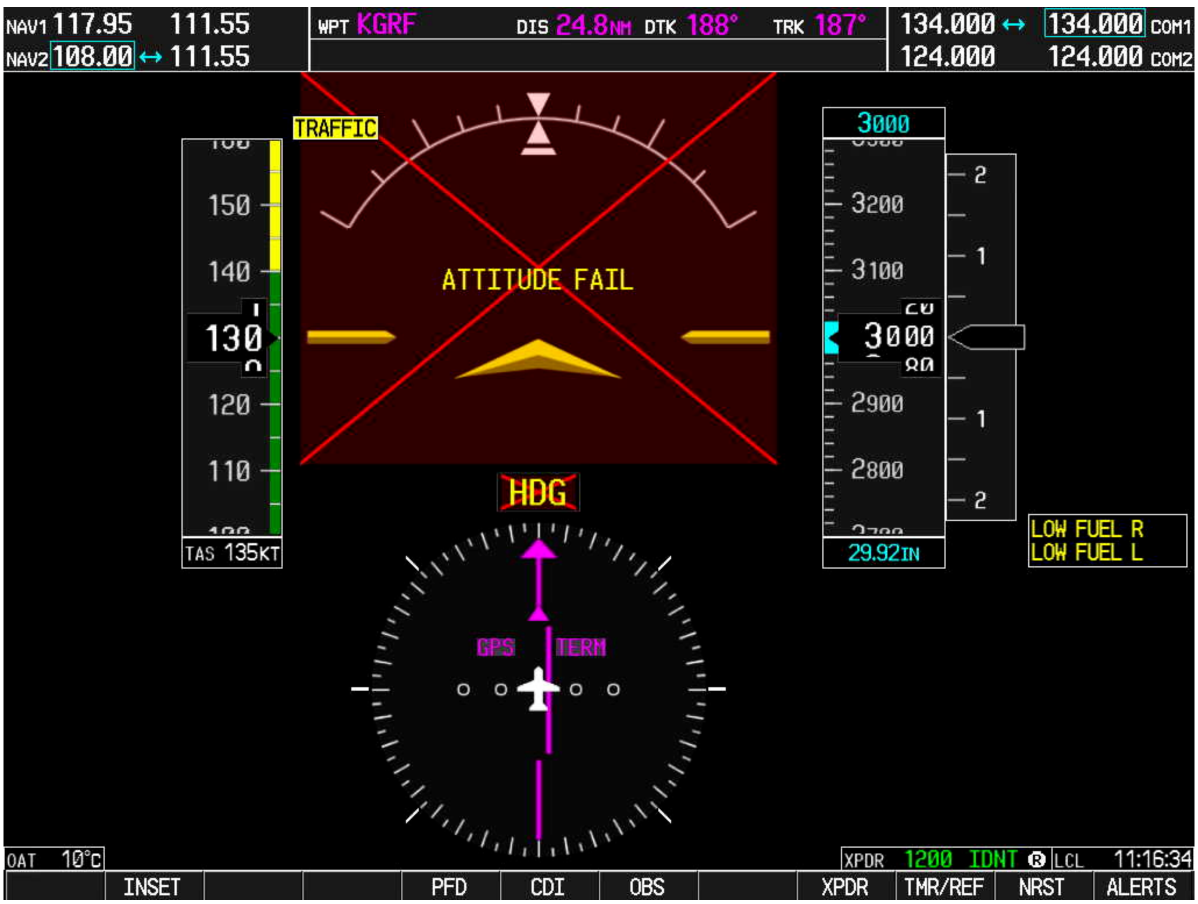
Failure Mode(s): If the GDC 74A should fail, the PFD presentation of the airspeed, altitude, vertical speed, OAT and TAS would have a red “X” over each item as shown in Fig. 3. In this instance the pilot would refer to the standby altitude and airspeed indicators installed in the aircraft. Obstructions of the pitot static system can be cross-checked between the PFD and the standby instruments and have results consistent with non-G1000 aircraft (Zero airspeed on takeoff, etc.). If the OAT probe should fail, a red “X” would appear on the TAS box and the OAT box and E6B type calculations would need to be completed manually. It is also important to note that pressure altitude reporting for the transponder will be lost, leaving it to operate as Mode A only which, can cause issues if operating in Class C and B airspace.



[Fig. 3]

The GRS 77 AHRS provides attitude and turn rate presentation on the PFD. It also is interfaced with the **GMU 44 magnetometer**. The GMU 44 is an tri-axial magnetometer, which allows the system to measure horizontal components of the earth's magnetic field, as well as the vertical component. The GRS 77 and GMU 44 are solid state components that require very little initialization time (less than 1 minute) and can initialize while moving during taxi and in flight at bank angles of up to 20 degrees. The AHRS operates well in absence of other inputs that provide aiding such as the GPS, air data and the magnetometer.

Failure mode(s): If the AHRS should be detected to not be operating properly when compared the other aircraft sensors such as the GPS, ADC and magnetometer, all attitude presentations will be removed from the PFD and replaced with a large, red "X" and the words "Attitude Fail". Refer to Fig. 4. This action is designed to take place before any hazardous or misleading information (HMI) is presented to the pilot and is a significant improvement over conventional mechanical gyro systems. If the GMU 44 should fail, only the stabilized heading data will be lost, as in Fig. 5.



[Fig. 4]

[Fig. 5]

The GTX 33 Mode-S and GTX 32 Mode-C transponder provide the ground radar surveillance capability to the G1000 system. These units are both solid state and require no warm-up time. As installed in most aircraft, the units will both transition to an ALT reporting mode at a ground speed of 30kts. This is designed to minimize pilot workload when at the threshold of the runway. Proper operation can be visually verified by looking at the transponder window on the PFD and ensuring that the appropriate mode is in green and the “R” for reply is showing the system being interrogated. Typically, only one transponder is installed per aircraft and may be of type, Mode-S or Mode-C. The GTX 33 Mode-S transponder also will receive and present (if selected) airborne traffic using the FAA provided TIS (Traffic Information Service) system.[1]

> *Failure mode(s):* If the transponder should fail, a red “X” will appear over the transponder window of the PFD and an advisory message will appear.

The GEA 71 Engine/Airframe Interface is the main point of input into the G1000 system of all engine instrumentation, to include manifold pressure, engine RPM, oil temp/pressure, electrical system information, exhaust gas temperature (EGT), cylinder head temperature (CHT), fuel data and vacuum system information, with the later depending on the aircraft. This can even include other annunciation’s such as those associated with doors and canopies being open.

> *Failure mode(s):* If the GEA 71 should fail, all engine/airframe data will be lost. A much more likely scenario is one in which EGT/CHT probes fail, or other engine/airframe sensors become inoperative. Those items will have a red “X” over them as an indication of that failure, similar to the loss of a COM radio. Advisories may also appear, depending on the aircraft.

[1] For more information on TIS, refer to: http://www.tc.faa.gov/act310/projects/modes/tis.htm

The GMA 1347 Audio Panel controls the selected communications frequencies to be transmitted on and/or received. The GMA 1347 is a solid state design and uses digital audio for all normal operations. The operation is conventional when compared to other audio panels. Pressing the COM/MIC buttons selects the COM frequency to be used for both transmitting and receiving over the selected com. Pressing the COM button will only allow the selected COM frequency to be monitored. The same is true for use of the NAV buttons. The intercom controls are located at the bottom of the audio panel with the small, inner knob controlling pilot volume and the outer, large knob controlling co-pilot and passenger volume. The audio panel is auto squelch enabled and also has a clearance recorder capability. The reversionary mode button for the GDU 1040 displays is located at the bottom of this component.

> *Failure mode(s):* The GMA 1347 has an analog emergency mode in case of the failure of the component that will automatically connect the pilot to COM #1. This allows the pilot to retain communication capabilities over one COM radio, even though the audio panel/intercom system is inoperative.

<u>Sample system operation/failure mode scenarios for FAA-S-8081-4D</u>

With the emphasis on Single Pilot Resource Management (SRM), Aeronautical Decision Making (ADM) and Risk Management (RM) certain aspects of the use of the G1000 system should be evaluated. In FAA-S-8081-4D, these aspects are covered under the "Special Emphasis Areas" in the categories of collision avoidance, CFIT and ADM and risk management. These items include:

- ✈ Use of and knowledge in the operation and limitations of the terrain awareness system that is part of the G1000
- ✈ Use of and knowledge in the operation and limitations of TIS traffic awareness in aircraft equipped with a GTX 33 Mode-S transponder
- ✈ Use of weather-related systems, either lightning detection devices or the Garmin GDL-69/69A weather datalink receivers

In the section concerning the "Aircraft and Equipment Required for the Practical Test" mention is made to APV approaches.[2] APV approaches can be "ILS-like" in their lateral and vertical navigation cues, yet the minimums are not sufficient to be considered a precision approach, hence the reference to them only being used for the non-precision approach requirement. APV approaches require a TSO C-146 GPS/WAAS navigator, which will not be available for the G1000 system until sometime in 2005.

Currently, all aircraft with the G1000 integrated avionics suite also have installed as standby or backup instruments an attitude indicator, altimeter and airspeed indicator. This is a change as previously the mantra was "altitude, airspeed and needle and ball." The main advantage to using a standby attitude indicator is the ability to control the aircraft by providing a direct indication of pitch and bank. With no yaw indication in case of an AHRS failure the applicant should be evaluated on the ability to maintain positive control, as well as prudent aircraft maneuvering when compensating for the lack of yaw information. It has been a practice for years in the turbine community to use only an attitude indicator for backup pitch and bank information without reference to yaw, and by all accounts has shown good results.

In this same section, the requirement is made that the applicant demonstrates knowledge of and the ability to "utilize an autopilot and/or flight management system (FMS). In the G1000, the FMS functions are very similar to those used in the Garmin GNS 530/430 series units. This should help pilots familiar with the GNS 530/430 make the transition to the G1000 system. This functionality includes the process of creating a flight plan, direct-to navigation and selecting, loading and activating an approach procedure. Autopilot operation is dependent on the make and model of autopilot installed and is not covered in this document, except in reference to some

[2] Refer to the Aeronautical Information Manual, page 1-1-21 for more information on the Wide Area Augmentation System (WAAS) and APV approaches.

operational modes consistent with that listed in the Designee Update, Special Edition on Testing in Technologically Advanced Aircraft.

In the various Areas of Operation, normal preflight practices still apply, to include knowledge of aircraft systems, aircraft flight instruments and navigation equipment and the instrument cockpit check. Where the process diverges is in Areas of Operation IV and VII-D. The following items will help provide guidance in the method of which to evaluate system failures and how to simulate them.

Areas of Operation Section IV – Recommendations for failure simulation

The tasks listed in this section cover flight by reference to instruments. As part of the PTS, the examiner is expected to evaluate the applicant with both a full panel and partial panel using the backup instruments. In the case of the G1000 equipped aircraft, failures are most easily accomplished by the use of pulling circuit breakers. This will help ensure realistic failures are simulated for the G1000 system. The table below gives recommendations for simulating various partial panel configurations. (Due to the differences in autopilot interfaces, the recommendations for autopilot engagement are generic and may not be suitable for all aircraft.)

Failure to simulate	**Examiner action**	**Applicant action**
Loss of AHRS and ADC* (simulates loss of all primary flight instrumentation)	Pull AHRS and ADC circuit breakers	Control the aircraft by reference to the backup attitude, altitude and airspeed indicators, engage the autopilot if it is rate based and has its own gyro source in roll mode
Loss of AHRS (attitude and heading)	Pull AHRS circuit breaker	Control the aircraft by reference to the backup attitude indicator, engage the autopilot if it is rate based and has its own gyro source in roll mode
Loss of ADC (airspeed, altitude and vertical speed)*	Pull ADC circuit breaker	Control the aircraft by reference to PFD attitude presentation and the backup airspeed and altitude indicators, (engage the autopilot in roll, HDG, or NAV mode)
Loss of PFD	Pull PFD circuit breakers – *note: this action will not allow the tuning of the COM 1/NAV 1 radio, COM 2 must tuned to the proper frequency and in use*	Control the aircraft by reference to the MFD in reversionary mode (this mode also removes all moving map presentations)

**Note: When the ADC is failed, pressure altitude data is no longer available to the transponder. This will result in the transponder only being capable of Mode A (no altitude reporting) capability. Therefore, failing the ADC should be avoided in Class B and C airspace or within the Mode C veil of Class B airspace, without the required coordination with the appropriate air traffic control facility.*

Area of Operation Section VII, D – Recommendations for failure simulation

This area only applies to Task D and unless weather and other circumstances dictate that a precision approach should be used, per the PTS guidance. The same table listed above can be used to create a realistic scenario. As noted in the Designee Update, Special Edition on Testing in Technologically Advanced Aircraft, appropriate use of the autopilot should be evaluated either in verbal questioning or be demonstrated by the candidate in the case of an AHRS failure. It is important to note that use of the autopilot during an AHRS failure will typically limit the autopilot to operation in roll mode.

Conclusion

The G1000 system allows for realistic failures to be simulated safely. It also does not require a substantial change to the approach to administering the practical examination. Aircraft system knowledge is still important in order to understand the various failure modes and to take appropriate corrective action.

As previously mentioned, recommendations from individual aircraft manufacturers supercede any guidance provided in this document. Detailed system data can be obtained from the aircraft's Pilot Operating Handbook and/or Approved Flight Manual Supplements (AFMS).

Technology, such as that found in the G1000 integrated avionics system have the potential to bring a higher level of safety to the general aviation fleet. This can only occur if those pilots operating aircraft with this equipment are properly trained and held accountable to the Practical Test Standards. As part of Garmin's commitment to safer skies, any specific questions or recommendations about this document and the G1000 system as it is to be used for the instrument checkride can be forwarded via email to CFI_Tools@garmin.com. For general questions, please visit http://www.garmin.com/support to email Garmin's aviation technical support specialists.