GARMIN

G1000™

guide for designated pilot examiners and certified flight instructors

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TABLE OF CONTENTS

LIST OF FIGURES

Technology, such as that found in the G1000 integrated avionics system has the potential to bring a higher level of safety to general aviation (GA). However, this can only occur if pilots operating aircraft with such equipment are properly trained and held accountable to the Practical Test Standards (PTS). The purpose of this document is to provide both an overview of the typical G1000 potential failure modes and sample system operation/failure mode scenarios that correspond to the applicable sections of FAA-S-8081-4D, Instrument Rating Practical Test Standards, so that the Designated Pilot Examiner (DPE) and Certified Flight Instructor – Instrument (CFII) can properly prepare pilots for the instrument rating by simulating realistic failures and teaching appropriate failure response plans.

The system recommendations provided in this document are Garmin's recommendations only and are superseded by the aircraft manufacturer's recommendations and FAA-approved documentation for each aircraft model. The basic G1000 system architecture is similar across many aircraft models. However, the location of the actual components of the system, the location and grouping of the circuit breakers, and the engine instrumentation presentations vary between aircraft. Therefore, it is important to review the aircraft manufacturer documentation for each aircraft model.

***NOTE:** As part of Garmin's commitment to flight safety, any specific questions or recommendations about both this document and the G1000 system as it is to be used for the instrument check-ride can be sent via e-mail to "**CFI_Tools@garmin.com**". For general questions, please visit "**http://www.garmin.com/support**" to correspond with Garmin's aviation technical support specialists.*

The G1000 integrated avionics system consolidates all communication, navigation, surveillance, primary flight instrumentation, engine indication system and annunciations on two (or three) liquid crystal displays (LCDs) and one (or two) audio panels. All of the components of the G1000 system are line-replaceable units (LRUs). This modular approach allows the various components to be mounted either behind each of the displays, or in remote locations in the aircraft, based upon the needs of the aircraft manufacturer. Figure 1 is a sample system schematic that shows the G1000 components used in a typical single-engine, GA aircraft.

***NOTE:** Autopilot interfaces are not shown, for they vary from aircraft to aircraft.*

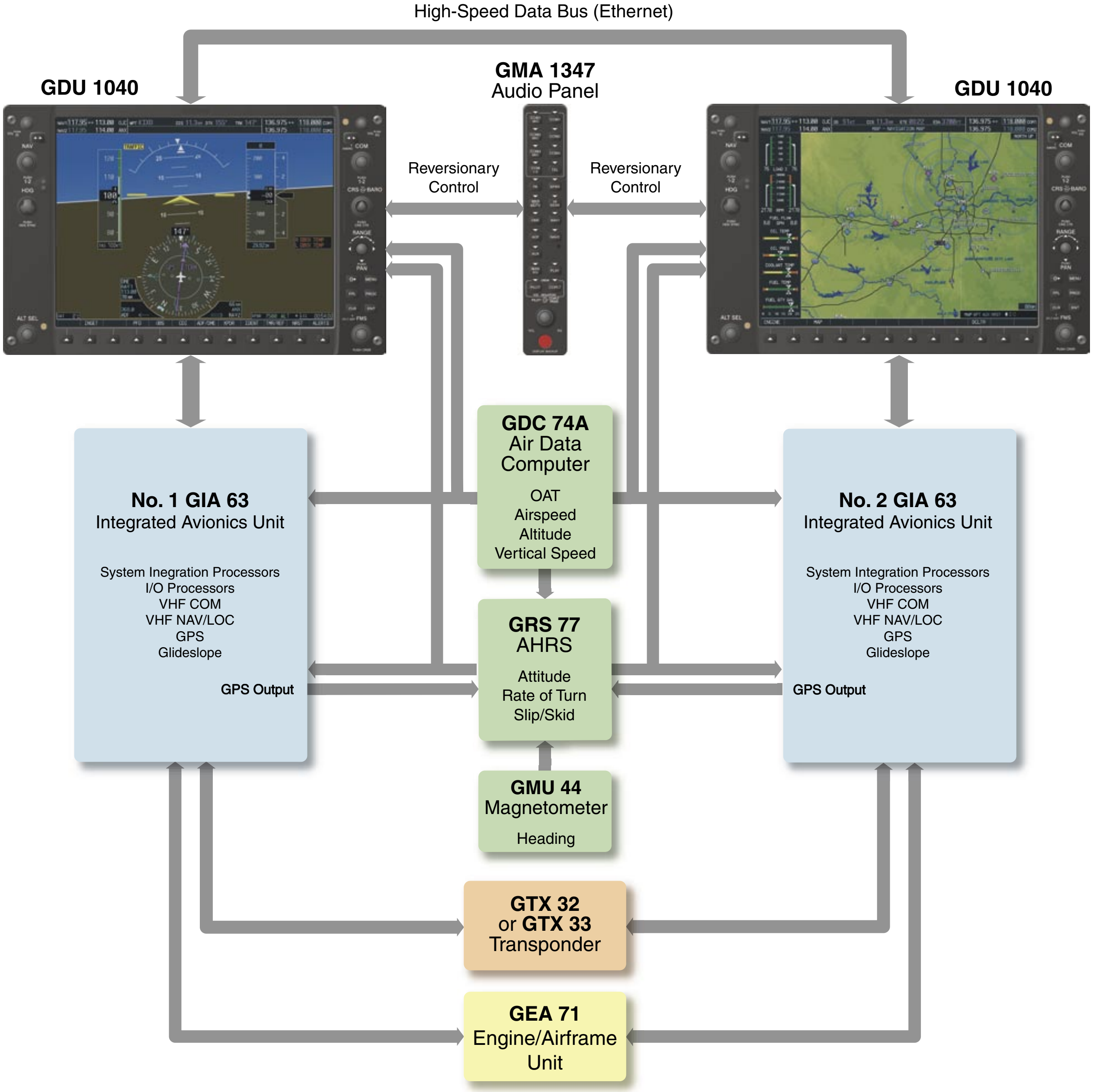

Figure 1 G1000 System

The main components of the G1000 system are the two GDU 1040 displays used for the Primary Flight Display (PFD) and the Multi Function Display (MFD), and the two GIA 63 Integrated Avionics Units (IAUs). These components are interfaced with each other via a proprietary Ethernet-based, high-speed digital databus system. All other components, such as the Attitude and Heading Reference System (AHRS), Air Data Computer (ADC), transponder and Engine/Airframe Interface units, use combinations of RS-232, ARINC 429 and RS-485 interfaces.

GDU 1040

Both GDU 1040 displays are identical in hardware. The aircraft wiring harness determines whether the display functions as a PFD or an MFD (see Figure 2). A configuration module within the PFD connector contains aircraft-specific backup configuration data.

Figure 2 GDU 1040 (PFD Shown)

Failure Mode(s)

If one display fails, the primary flight instruments and Engine Indication System (EIS) are displayed on the remaining screen. No moving map is presented in this mode (see Figure 3). This operating mode is called “reversionary mode” and may be either detected automatically by the system, or initiated manually via the red **DISPLAY BACKUP** button located on the lower portion of the audio panel.

GIA 63

The GIA 63 units serve as the main interface hub for the individual components of the G1000 system. All key components, 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 63 units. This allows for a higher level of system redundancy and integrity as data is cross-checked to ensure proper system operation. The only component that is not connected directly to the GIA 63 units is the GMU 44 magnetometer; the latter interfaces directly with the GRS 77 AHRS to provide it with magnetic heading input. The GIA 63 units also contain the communication and navigation radios that include the VOR/LOC/GS and GPS receivers.

Failure Mode(s)

If a GIA 63 unit fails, the associated COM/NAV/GPS receiver data is no longer available and is automatically replaced by the COM/NAV/GPS receiver data from the other GIA 63 unit. The operative GPS receiver automatically takes over any active GPS navigation (without any pilot input). A red "X" appears over the COM/NAV frequencies to indicate GIA 63 failure (see Figure 4) and an alert annunciation appears to the right of the altitude/vertical speed tapes on the PFD. The remaining GIA 63 continues to provide all interface and system integrity functions. If both GIA 63 units fail, the AHRS and ADC continue to provide data directly to the GDU units, although no navigational or communication capabilities are available. Partial failures in the GIA 63 units (such as failure of the COM component) are more likely to occur than full component failures since the COM/NAV/GPS and interface components are all independent inside the GIA 63.

GDC 74A

The GDC 74A is the ADC for the system and receives the standard pitot and static system inputs as well as the outside air temperature (OAT) input. This allows the system to automatically perform most E6B calculations, such as that of density altitude and true airspeed.

Failure Mode(s)

If the GDC 74A fails, the PFD presentations of the airspeed, altitude, vertical speed, OAT and true airspeed (TAS) display a red "X", as shown in Figure 4. In this case, the pilot should refer to the standby altitude and airspeed indicators installed in the aircraft. Certain obstructions of the pitot static system can be verified by cross-checking the associated PFD indications with the standby instruments. These PFD indications should be consistent with the readings found in non-G1000-equipped aircraft (zero airspeed on takeoff, etc.). If the OAT probe fails, a red "X" appears both on the TAS box and the OAT box, and E6B-type calculations should be completed manually. Pressure altitude reporting for the transponder is also lost. That is, the transponder can only work in Mode A and can no longer provide the information necessary for operating in Class C and B airspace.

GRS 77

The GRS 77 AHRS provides attitude and turn-rate presentation on the PFD and is interfaced with the GMU 44 magnetometer. The GMU 44 is a tri-axial magnetometer which allows the system to measure both the horizontal and vertical components of the earth's magnetic field. Both the GRS 77 and GMU 44 are solid-state components that require very little initialization time (less than one minute) and that can initialize while moving during taxi and in flight at bank angles of up to 20 degrees. The GRS 77 AHRS can still operate in the absence of other reference inputs such as those from the GPS receiver, ADC, or magnetometer.

Failure Mode(s)

If the system detects that the GRS 77 is not operating properly when compared to other aircraft sensors, such as the GPS receiver, ADC, or magnetometer, all attitude presentations are removed from the PFD and are replaced with a large, red "X" and the words "Attitude Fail" (see Figure 4). Failure indications are designed to be displayed before any hazardous or misleading information (HMI) is presented to the pilot. This represents a significant improvement over conventional mechanical gyro systems. If the GMU 44 fails, only the stabilized heading data is lost.

GTX 33/GTX 32

The GTX 33 Mode-S and GTX 32 Mode-C transponders provide the ground radar surveillance capability to the G1000 system. Both transponders are solid-state units and require no warm-up time. As installed in most aircraft, these units transition to an ALT reporting mode at a ground speed of 30 kt. This is designed to minimize pilot workload when at the threshold of the runway. Proper operation can be verified by looking at the transponder box on the PFD and ensuring that the appropriate mode is displayed in green and that an "R" indication appears, indicating that the system is being interrogated. Typically, only one Mode-S or Mode-C transponder is installed per aircraft. The GTX 33 Mode-S transponder also receives and presents (if selected) airborne traffic, using the FAA-provided TIS (Traffic Information Service) system.

NOTE: *For more information on TIS, refer to "http://www.tc.faa.gov/act310/projects/modes/tis.htm".*

Failure Mode(s)

If the transponder fails, a red "X" appears over the transponder box of the PFD (see Figure 4) and an advisory message appears.

GEA 71

The GEA 71 Engine/Airframe Interface is the main processing unit for all engine instrumentation data, which includes manifold pressure, RPM, oil temperature/pressure, electrical system, exhaust gas temperature (EGT), cylinder head temperature (CHT), fuel and vacuum system—the latter depending upon the aircraft. The EIS can also contain annunciations such as those associated with doors and canopies.

Failure Mode(s)

If the GEA 71 fails, all engine/airframe data is lost. However, a much more likely scenario would be one in which the EGT/CHT probes would fail, or in which other engine/airframe sensors would become inoperative. Those items would display a red "X" to indicate this type of failure (see Figure 4). EIS-related advisories may also appear, depending upon the aircraft.

GMA 1347

The GMA 1347 is a solid-state digital audio panel that integrates NAV/COM audio, intercom system and marker beacon. The unit operation is conventional when compared to that of other audio panels. Pressing the COM/MIC buttons selects the COM radio to be used for both transmitting and receiving communications. Pressing the COM button only allows the selected COM radio to be monitored. Pressing a NAV button activates/deactivates the audio for the corresponding NAV radio. The intercom controls are located on the lower portion of the audio panel; the small knob controls pilot volume and the large knob controls copilot and passenger volume. The audio panel is auto-squelch enabled and also has clearance recorder capability. The reversionary mode (**DISPLAY BACKUP**) button for the GDU 1040 displays is located on the lower portion of the GMA 1347.

Failure Mode(s)

In the event of failure, the GMA 1347 has an analog emergency mode that automatically connects the pilot to COM1. This allows the pilot to retain communication capabilities over one COM radio, even though the audio panel/intercom system has become inoperative.

Figure 3 Reversionary Mode

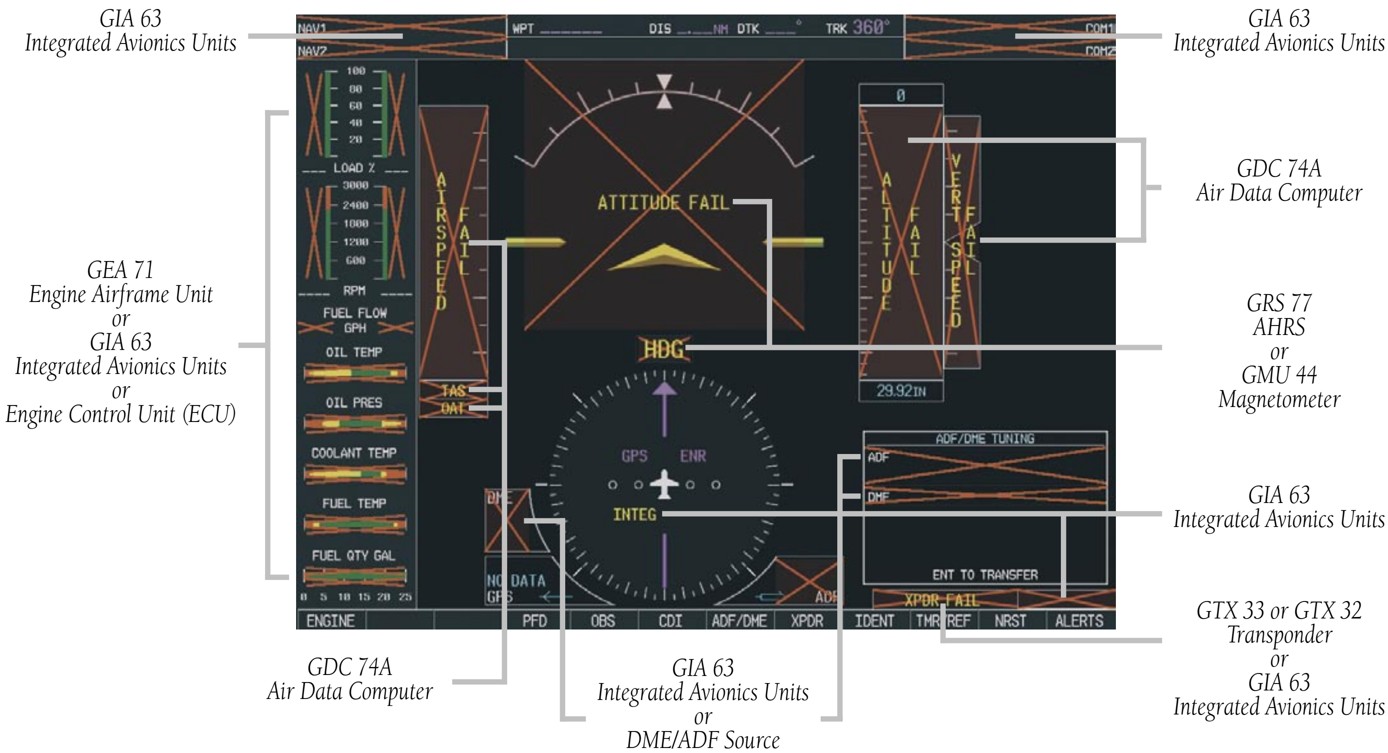

Figure 4 G1000 System Failure Indications

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

***NOTE:** Recommendations from individual aircraft manufacturers supersede any guidance provided in this document. Detailed system data can be obtained from the aircraft Pilot Operating Handbook (POH) and/or Aircraft Flight Manual Supplement (AFMS).*

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

- Use of and knowledge in the operation and limitations of the terrain awareness system that is part of the G1000 system.
- 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, such as either lightning detection devices or the Garmin GDL-69/69A weather datalink receivers.

Approaches with vertical guidance (APVs) are mentioned in the section concerning the "Aircraft and Equipment Required for the Practical Test". APVs can be ILS-like in their lateral and vertical navigation cues, yet the associated minimums are not sufficient for these approaches to be considered precision approaches, hence their being used only for the non-precision approach requirement. APVs require a TSO C-146 GPS/WAAS navigator, which should be available for the G1000 system sometime in 2005.

***NOTE:** Please refer to the Aeronautical Information Manual (AIM) for more information on the Wide Area Augmentation System (WAAS) and APVs.*

Currently, all aircraft with the G1000 integrated avionics suite are also equipped with an attitude indicator, an altimeter and an airspeed indicator as standby or backup instruments. This is a departure from the mantra "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 the event of an AHRS failure, the applicant should be evaluated on the ability to maintain positive control, as well as on prudent aircraft maneuvering, when compensating for the lack of yaw information. Within the turbine community, it has been the practice for years to use only an attitude indicator for backup pitch and bank information without reference to yaw. By all accounts, this practice has shown good results.

In the same section, the applicant is required to demonstrate the ability to utilize an autopilot and/or flight management system (FMS). In the G1000 system, the FMS functions are very similar to those used in the Garmin 400/500 series units. This should help pilots familiar with these units make the transition to the G1000 system. The FMS functionality includes the process of creating a flight plan, direct-to navigation and selecting, loading and activating an approach procedure. Autopilot operation is dependent upon the make and model of the autopilot installed and is only covered in this document in reference to the operational modes consistent with those listed in "Designee Update, Special Edition on Testing in Technologically Advanced Aircraft" by the AFS-600 (the FAA Regulatory Support Division).

Normal preflight practices still apply in the various Areas of Operation. This includes knowledge of aircraft systems, flight instruments and navigation equipment as well as the instrument cockpit check. However, the PTS diverge in the Areas of Operation IV and VII-D. The following subsections help provide guidance as to the method with which to evaluate and simulate system failures.

AREAS OF OPERATION SECTION IV: RECOMMENDATIONS FOR FAILURE SIMULATION

The tasks listed in this section cover flight by reference to instruments. According to the PTS, the examiner is expected to evaluate the applicant's use of the backup instruments with both a full panel and a partial panel. In the case of the G1000-equipped aircraft, failures can be simulated in two ways. The preferred method is to use the dimming controls on the G1000 system combined with the reversionary mode button on the lower portion of the GMA 1347 audio panel. The other, less desirable method consists of pulling various circuit breakers.

***NOTE:** It is important to follow the aircraft manufacturer's recommendations for failure simulation, for they supersede any guidance provided in this document.*

Using the dimming controls and the reversionary mode is straightforward.

To dim the displays:

1. Press the **MENU** key on the PFD (while no other data windows are active) to display the Setup Menu window.
2. Turn the large **FMS** knob to select the display to be dimmed ('PFD DSPL' or 'MFD DSPL').
3. Turn the small **FMS** knob to switch dimming from 'AUTO' to 'MANUAL' mode and press the **ENT** key.
4. Turn the small **FMS** knob counterclockwise to decrease the display brightness.

To put the displays in reversionary mode:

1. Press the **DISPLAY BACKUP** button located at the bottom of the GMA 1347 audio panel.

The following table shows typical configurations using the display dimming function to simulate failures.

Failure to Be Simulated	Examiner Action	Applicant Action
Loss of primary flight instruments on the PFD (AHRS, ADC failure)	Dim PFD.	Control the aircraft by reference to the backup attitude, altitude and airspeed indicators.
Complete loss of PFD	Dim PFD.	Manually initiate reversionary mode and control aircraft via reversionary mode presentation on the MFD.
Loss of MFD	Dim MFD.	Manually initiate reversionary mode and control aircraft via reversionary mode presentation on the PFD.

***NOTE:** Appropriate use of the autopilot should be observed to reduce pilot workload and maintain positive control of the aircraft. It is important to verbally quiz the applicant on the operation of the autopilot based upon the data presented in the table associated with the use of pulling circuit breakers (see following page).*

The following table gives recommendations on simulating various partial panel configurations by pulling circuit breakers.

***NOTE:** Due to the differences in autopilot interfaces, the recommendations for autopilot engagement are generic and may not be suitable for all aircraft.*

Failure to Be Simulated	Examiner Action	Applicant Action
Loss of AHRS and ADC* (simulates loss of all primary flight instruments)	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 the 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. This action prevents the tuning of the COM 1/NAV 1 frequencies; COM 2 must be tuned to the proper frequency and must be 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 has failed, pressure altitude data is no longer available to the transponder. As a result, the transponder loses its Mode C (i.e., altitude reporting) capability. Therefore, without the required coordination with the appropriate air traffic control facility, failing the ADC should be avoided in Class B and C airspaces, or within the Mode C veil of Class B airspace.*

AREAS OF OPERATION SECTION IV: RECOMMENDATIONS FOR FAILURE SIMULATION (Cessna Nav III)

Cessna does not recommend pulling circuit breakers as a means of simulating failures on the Garmin G1000. Pulling circuit breakers—or using them as switches—has the potential to weaken the circuit breaker to a point at which it may not perform its intended function. Using circuit breakers as switches is also discouraged in Advisory Circulars 120-80, 23-17B, and 43.13-1B. Additionally, a circuit breaker may be powering other equipment (such as avionics cooling fans) that could affect the safe operation of other equipment.

Failure to Be Simulated	Examiner Action	Applicant Action
Loss of AHRS and ADC* (simulates the loss of all primary flight instruments)	Press the **MENU** key on the PFD. AUTO is highlighted in the PFD DSPL field. If AUTO is not highlighted, activate the cursor by pressing the small **FMS** knob. Turn the large **FMS** knob to move the cursor to the AUTO field. Turn the small **FMS** knob, select 'MANUAL' from the Setup Menu window and press the **ENT** key. The cursor moves to the backlighting percentage field. Turn the small **FMS** knob counterclockwise; adjust the backlighting value to the lowest value (0.14%).	Control the aircraft by reference to the backup attitude, altitude and airspeed indicators; engage the autopilot in roll mode.
Loss of PFD	Press the **DISPLAY BACKUP** button on the lower portion of the audio panel. Press the **MENU** key on the MFD and use the method described above to dim the PFD.	Control the aircraft by reference to the MFD in reversionary mode (this mode also removes all moving map presentations).
Loss of MFD	Press the **DISPLAY BACKUP** button on the lower portion of the audio panel. Press the **MENU** key on the MFD. Use the large **FMS** knob to move the cursor to the AUTO field adjacent to the MFD DSPL field. Use the procedures above to dim the MFD.	Control the aircraft by reference to the PFD in reversionary mode (this mode also removes all moving map presentations).

***NOTE:** * The simulated loss of AHRS and ADC cannot be accomplished individually in the Cessna Nav III aircraft. In this case, the applicant must simulate navigation on a desired course during en-route or approach operations by using the moving map display. In order to determine more precisely the horizontal distance from the desired active leg, the applicant or the examiner may select the cross-track (XTK) data bar field option on the MFD.*

AREA OF OPERATION SECTION VII, D: RECOMMENDATIONS FOR FAILURE SIMULATION

According to the PTS, this area only applies both to Task D and unless weather and other circumstances dictate that a precision approach be used. The table presented on the previous page can be used to create a realistic scenario. As noted in the "Designee Update, Special Edition on Testing in Technologically Advanced Aircraft" by the AFS-600 (the FAA Regulatory Support Division), appropriate use of the autopilot should be evaluated either via verbal questioning or, in the case of an AHRS failure, via actual demonstration by the applicant.

***NOTE:** The use of the autopilot during an AHRS failure typically limits the autopilot to operation in roll mode.*

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