# NAV III Avionics Option
## Engineering - Product Brief

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## NAV III Avionics Option Overview

Cessna Single Engine has utilized the Honeywell/Bendix King avionics line since restart in 1996. The avionics options increase in option functionality, going from the Standard, to NAV I, and then NAV II. The addition of the NAV III avionics option offers an integrated EFIS avionics system that will compliment our already strong line of choices for the customer.

Following a review of all the existing avionics packages and avionics programs under development the NAV III avionics option Cessna chose was the Garmin G1000 Integrated Cockpit System. Quietly over the past year Cessna Single Engine and Garmin have been developing the G1000 installation for the Models 182T and T182T, followed by the Models 206H and T206H. This installation is not an STC.

*What will the avionics systems consist of, and what aircraft enhancements will the NAV III option give the customer?*

First, the NAV III's most visible feature is the two large LCD displays on the completely redesigned instrument panel. The G1000 configuration chosen was the PFD and MFD in a two-display configuration. A feature packed digital audio panel positioned between the two displays completes the visible Garmin G1000 components. Another noticeable enhancement is a lighted switch panel, replacing the old engine instruments cluster, and a lighted circuit breaker panel positioned in front of the pilot and below the control wheel. Moving to the center of the instrument panel positioned for both the pilot and co-pilot's use are the backup flight instruments consisting of the airspeed indicator, attitude gyro, and altimeter. Above the engine controls the Honeywell KAP-140 Dual Axis autopilot with Altitude Preselect and GPS Roll Steering functionality completes the instrument panel and its new, clean look.

*Where did the avionics stack go?*

The G1000 utilizes remote avionics units controlled through the two large displays and the audio panel. Behind the MFD are the engine/airframe interface unit, airdata computer, and rate sensor for the autopilot. In the tailcone is the heart of the G1000 system: AHRS, Mode S transponder with TIS, and two communication/navigation/interface units. Also installed on the aft avionics shelf is the BFGoodrich WX-500 Stormscope as standard NAV III equipment. Located out in the left wing is the full three-axis magnetic field sensor, which replaces the flux valve used in the HSI installations.

*To install this advanced of an avionics system the aircraft must be all electric – right? Wrong.*

With the design choices placed on keeping the aircraft simple yet redundant for the primary flight functions we continued to use the same airspeed, vacuum attitude gyro, altimeter, and non-stabilized magnetic compass. The continued use of the non-electric backup instruments avoids the old saying of "all your eggs in one basket" along with reducing the complexity, weight, and cost required to ensure that the electrical power never fails. That is great for the certification effort, but for the customer they want the glass running and backup instruments to stay exactly that – we agree. So, the power distribution system utilizes the same split bus design for the electrical and avionics buses with an additional essential bus ready to take over.

This essential bus has a standby battery and battery controller which constantly monitor the main electrical system voltage and when required will automatically power the essential bus and all the equipment redundantly connected to it. The standby battery charges through the electrical bus, but is isolated from being used by any equipment not connected to the essential bus. Health of the standby battery will be checked during normal "Before Starting Engine" procedures by the use of a simple test switch. A green light indicates that the battery has enough capacity to power the PFD, primary flight sensors, engine monitoring, and a single NAV/COM/GPS in excess of thirty minutes. This system is installed as a customer enhancement, not required equipment. The aircraft now has the normal power distribution system supporting all equipment, standby battery powering the essential bus, and the non-electric backup instruments.

Other features of the NAV III are the full engine monitoring, lighted instrument panels and improved crew cabin lighting. Installed as standard equipment with the NAV III option is the full engine monitoring suite of sensors and the G1000 engine/airframe interface unit. This enhancement allows for full monitoring of the engine parameters for precise engine control and setup. Improved crew cabin lighting with the use of LED overhead lamps and integrated dimming built into the overhead panel adds dimmable crew area cabin lighting to the 182 models, and reduced system complexity of the dimmable lighting used in the 206 models. Favorable reviews made this a Block Point 2004 enhancement for non NAV III aircraft as well. With the cabin lights turned down the lighted switch panel and circuit breaker panel add that final touch to an already impressive instrument panel ready for flight whenever it is required.

Use of the most advanced avionics system seen in GA piston singles, new aircraft enhancements, and simple but safety oriented design concepts give the customer a market-leading product with value, muscle and world-class appeal.

## Garmin G1000 Product Information

The advanced G1000 integrated cockpit system provides a highly integrated avionics system consisting of the following units:

**GDU 1045 – CONTROL DISPLAY UNITS**

The centerpiece of the G1000 system is the GDU 1045 Control Display Unit. The GDU's provides a 10.4" size, high resolution (1024x768) LCD display, which is sunlight and wide viewing angle readable. Incorporated in the bezel of the GDU are the controls for all the remote avionics units that make up the G1000 system. Use of dedicate side controls which perform the same function on either the PFD or MFD, and soft key buttons along the bottom of each display make the GDU's the avionics control center, positioned right in front of the pilot. The same GDU is used for either the PFD or the MFD; the displays role is determined when connected to the avionics harness. An infrared port is built into each display bezel to accommodate for future data entry and retrieval using a PDA. Each display can work in reversionary mode in the unlikely event of a failure of the either the PFD or MFD.

**GMA 1347 – DIGITAL AUDIO PANEL**

The GMA1347 Digital Audio Panel and Marker Beacon Receiver is designed to be placed vertically between the two displays. The GMA1347 provides four intercom modes: ALL, PILOT, COPILOT, and CREW. Capacity of the audio panel allows for the support of crew (Pilot, Co-Pilot) and up to eight additional passengers. Support for three communication radios, dual navigation radios, DME, ADF, and auxiliary audio input are built into the audio panel with more capacity available when using external switches and annunciations. Manual selection of the big red reversionary button located on the audio panel places both the displays in reversionary mode. Automatic playback functionality with two minutes of record storage and pilot controlled rewind in ten second intervals.

**GDC 74 AIRDATA COMPUTER**

The GDC 74 Airdata computer provides all the dynamic and static pressure computations using internal absolute and differential pressure transducers, and an OAT probe. Pressure altitude, calibrated airspeed, true airspeed, vertical airspeed, and total outside air temperature are provided to the various other sub-systems that required this data for primary, reversionary and redundancy. Verification of the airdata computer performance has been shown from –1,400 feet to 55,000 feet, over temperature ranges of -55°C to +85°C.

### GRS 77 – ATTITUDE HEADING & REFERENCE SYSTEM (AHRS)

The all solid-state GRS 77 AHRS provides the package for all the inertial sensors required for attitude output to the G1000 system. The use of solid-state technology inertial sensors, and leveraging additional attitude information from other G1000 components make this AHRS a superior product. Technical advantages of this AHRS system are:

- Superior Performance over the entire flight envelope by using patented algorithmic approaches and taking in additional attitude information from the other integrated G1000 subsystems.
- On the move initialization of the AHRS to correctly determine attitude information. Other AHRS units require several minutes of stationary initialization before attitude information is available.
- In-Flight initialization of the AHRS at bank angles up to 20 degrees. Not possible with the competition, so any momentary loss of power and/or AHRS interruption the AHRS is gone for the rest of the flight.
- High integrity and reliability of the AHRS generated attitude outputs due to the cross checks of all the attitude information in the G1000 subsystems making it quicker for the AHRS to identify a sensor failure that could lead to potential HMI (Hazardous and Misleading Information).
- Lower cost AHRS since the system can use lower cost sensors; takes advantages of all the other integrated sub-systems that are required for other functions and leverages them to help compute superior attitude data.
- High availability of the AHRS since it does not require any one sub-system for continued operation. Reversionary modes can utilize data from GPS systems, airdata computer, and magnetometer.
- Solid state, so no mechanical parts to wear and small lightweight package design.

### GMU 44 MAGNETOMETER

The magnetic field vector information for the AHRS is provided by the full three axis GMU 44 magnetometer. Unlike the flux-valve used in the HSI installations that provide only planar magnetic field information, the GMU 44 magnetometer can provide full three-axis magnetic field information in all flight attitudes.

**GIA 63 – COMMUNICATION, NAVIGATION, & INTERFACE ADAPTER UNIT**

The GIA 63 is the data hub for most all of the G1000 sub-systems, most installations use two GIA 63's per aircraft installation.

Communication features of the GIA 63:

- Communication transceiver tuning from 118.00 to 136.990 MHz, 8.33 or 25 kHz user selected.
- 16 watts transmitting power.
- FM immunity per ICAO Annex 10.
- Digital audio interface with the GMA 1347 audio panel.
- Emergency audio channel used to bypass the audio panel.
- Separate power supply from other internal components.

Navigational features of the GIA 63:

- VOR/ILS localizer receiver tuning from 108.00 to 117.95 MHz in 50 kHz increments.
- ILS Glide Slope receiver.
- IFR GPS (TSO C129a) with future upgrade to (TSO C146) Wide Area Augmentation System WAAS planned following completion of initial G1000 certification.
- VOR audio and identifier output

The GIA 63 uses multiple communication standards, including Ethernet data bus, to provide interface to a wide variety of avionics systems.

**GTX 33 – MODE S TRANSPONDER with TIS**

The GTX 33 Mode S Transponder provides the required ATC transponder and altitude reporting capabilities. Included with the GTX 33 is the Traffic Information Service (TIS) functionality. Some of the TIS capabilities and details are:

- TIS data link communication typically within 55 nm of a Mode S radar capable site. Most of these are in location where there is the highest traffic densities.
- TIS data when established provides estimated position, altitude, altitude trend and ground track information for up to 8 aircraft within 7 nm horizontal range and +3,500, -3, 000 feet of the aircraft.
- TIS data is derived from the same radar used by ATC and is updated approximately every 5 seconds.
- Altitude data for each intruder aircraft in 100 ft increments based off of the same Mode C altitude data provided ATC. So altitude separation data same as TAS level traffic.

**GEA 71 – ENGINE / AIRFRAME UNIT**

Providing the data acquisition and signal conditioning for all the engine sensors, airframe sensors and discrete signals the GEA 71 is the interface between the aircraft and the G1000 system. The GEA 71 can be configured to handle analog, digital & discrete I/O to meet the specific requirements of the aircraft. Digital output of measured voltages, currents and discrete input sources along with providing sensor excitation make the GEA 71 the only interface required. A data stream of all measured sensors and signals is provided to each of the CDU units for redundancy.

## Cessna Airframe Enhancements

Changes made to the aircraft to compliment the advanced avionics system and separate the NAV III EFIS installation from the competition:

**AVIONICS SYSTEMS**

Standard avionics systems other than the G1000 system include the Honeywell KAP 140 Autopilot system and the BFGoodrich WX-500 Stormscope. The autopilot provides Dual-axis, Altitude Preselect Flight Control System with GPS Roll Steering functionality. Roll Steering enables the GPS navigational inputs to control the autopilot and automatically perform course changes and intercept the course to the next active waypoint. The WX-500 provides weather mapping of electrical discharges (lightning) up to 200 nautical miles away, and can maps this activity for hazardous weather avoidance on the large MFD or PFD inset.

**ELECTRICAL SYSTEM**

The electrical system has an added essential bus that is used to provide an additional layer of redundancy to the electrical system to help support the continued operation of the G1000 system in the case of an electrical power supply failure. This essential bus works by being wired, diode protected, to the each of the split primary buses. The standby battery is charged by the ship system during normal operation. A standby battery controller monitors the primary bus voltage and when ship voltage drops below a determined level the standby battery on the essential bus provides the power. The standby battery system is operated with the use of a three-position switch “OFF”, “TEST”, and “ARM”. The test position checks the battery’s health and if a minimum level of capacity is verified a green test light located adjacent to the switch is illuminated. When in the arm position the standby battery is ready to supply a second source of power to the PFD, AHRS, airdata computer, magnetometer, engine/airframe interface, and a single NAV/COM/GPS for in excess of thirty minutes.

**LIGHTED INSTRUMENT PANELS**

To enhance the advanced instrument panel design two new panels were developed, a switch panel and circuit breaker panel. An evaluation between conventional EL panels and newer technology LED panels showed that the LED panels provided a high reliability (useful life greater than 5000 hours), at a lower cost. The internally lighted LED technology panels were chosen and a dramatic increase in cabin lighting capabilities can best be appreciated by seeing for yourself. The new panels also incorporate component grouping and text markings that aid the pilot in determining the systems and buses that each switch, dimmer, and circuit breaker reside on and control.

## NAV III Future Options

### FLIGHT INFORMATION SERVICES (FIS)

The FIS option will be available in 3Q04, and will use the currently in development GDL 69A Satellite Data Link. The GDL 69A provides satellite-based weather products offered in various subscription package levels. Wiring provisions will be standard for all NAV III aircraft, this is also true for the first NAV III aircraft produced before the FIS option is available. Limited specifics are known about the product at this time due to the early stages of the product. The move from the GDL 49 Weather Data Link system was to provide a more powerful system that will compliment the G1000 system.

### XM AUDIO ENTERTAINMENT

The GDL 69A is more than just FIS data link weather. The provider for the weather data is XM Satellite Radio and with the FIS the XM radio package is right there. Cessna chose to offer the GDL 69A transceiver; the “A” is the XM radio functionality. There is a GDL 69 without XM radio functionality that will not be offered. The aircraft will come standard with all the wiring to support the XM radio functionality. XM Satellite Radio subscription will be required for this service. Available with the GDL 69A in 3Q04.

### TRAFFIC

The standard traffic system on the NAV III aircraft is TIS (Traffic Information Service), this functionality comes with the GTX 33 Mode S Transponder and will provide traffic data link information at Mode S primary radar sites in the greatest traffic density areas in the US. The system will be standard and will be available at NAV III product introduction. Refer to the FAA and Aeronautical Information Manual for the Mode S TIS coverage, and system details.

Available in 3Q04, TAS (Traffic Advisory System) level traffic functionality will be offered as an option on the NAV III aircraft. The use of the Honeywell KTA 870 TAS system provides active interrogation of all Mode A/C and S traffic within 40 nm of the aircraft. Wiring provisions for the KTA-870 system will be standard on all NAV III aircraft.

**TERRAIN AWARENESS & WARNING SYSTEM (TAWS B)**

Available in 3Q04, TAWS B (Terrain Awareness and Warning System) will be offered as an option on all NAV III aircraft. Standard on the NAV III aircraft from initial product introduction is relative terrain and obstacle clearance mapping displayed on the MFD and PFD inset. For customers wanting increased terrain awareness beyond the built in active terrain features the TAWS B functionality will be provided and is an all software enhancement to the G1000 system as installed in the NAV III aircraft. Beyond the mapping of threatening terrain and obstacles the TAWS B option will provide "Alerts" of the following conditions: Reduced required terrain clearance, imminent terrain impact, premature descent, excessive rate of descent, negative climb rate or altitude loss after takeoff, and descent to 500 feet above the terrain or runway elevation during a non-precision approach. For correctness when speaking about all the terrain avionics options the use of EGPWS (Enhanced Ground Proximity Warning System) is a marketing name associated with Honeywell IHAS products like the KMH 880 installed as an option in the NAV II aircraft, TAWS is the industry equivalent name. TAWS B is not mandated for our aircraft.

**"3D" Terrain**

Still in work with the FAA on the requirements needed to display "3D" Terrain on the PFD for enhanced situational awareness. It will happen and actually has been turned off on the G1000 system pending agreements with the FAA. Current FAA thinking is that to show "3D" Terrain, TAWS B will also have to be installed in the aircraft. Pursuit of this functionality will follow TSO submittal of the G1000 system. This will be a software enhancement, similar to the TAWS B option, and will probably be bundled with the TAWS B certification in the NAV III aircraft. Expected availability 3Q04.

**AUTOMATIC DIRECTION FINDER (ADF)**

Available in 3Q04, ADF navigation functionality will be offered as an option in all NAV III aircraft. The installation will require the use of the Bendix/King KR 87 ADF Receiver currently installed as an option on all NAV I and NAV II aircraft. An RMI style navigation indicator will be displayed on the PFD, and tuning will be performed on the KR 87 mounted below the KAP 140 Autopilot (above the engine controls). Wiring provisions will not be standard and initial NAV III aircraft produced before the certification of the ADF installation will not have ADF provisions installed.

**ELECTRONIC CHARTS**

Jeppesen JeppView/FliteDeck or equivalent electronic charting services will be supported in the future. Plans for the implementation will follow initial certification of the NAV III and G1000 system and can be expected in the 2005 timeframe.

## Competitive Advantages

Garmin's G1000 integrated cockpit system has many competitive advantages over the other avionics products:

- The G1000 is a complete and truly integrated avionics suite. Competitive systems on the market today are primarily display systems with varying levels of additional sensors driving the displays. No competitive system available today (in this class) has integrated communication, navigation and surveillance radios, among other items. Garmin designed and builds all components of the G1000.
- The G1000 incorporates the highest resolution displays in its class. The G1000 utilizes vivid XGA displays with industry leading viewing angles and remain brilliant in direct sunlight conditions.
- The GRS 77 AHRS system provides highly accurate attitude and heading information, the unique capability to reliably align while taxiing or in-flight, and unprecedented integrity-monitoring capability. To these ends, it leverages GPS, air data, and 3-D magnetic field information from a solid-state magnetometer, which in turn enables the integration of all of the elements of a traditional strap-down AHRS, at a fraction of the typical cost. Although it benefits from GPS, air data, and magnetometry, the GRS 77 AHRS outputs safe attitude despite the prolonged loss of any one of these complementary subsystems. There are no known competitive AHRS systems on the market that can align while moving, let alone in-flight. The competitive systems must remain stationary, typically for 3 or 4 minutes, so they may align properly. If a competitive system fails in flight, the pilot must land the aircraft to initiate the alignment process.
- The philosophy of the G1000 design is to minimize component part numbers or 'flavors' of individual components. This is possible by incorporating configuration modules in the G1000 wiring harness, which in turn program the modules once installed to the aircraft's configuration. The benefit of such a design is a higher level of field support, given the ease of stocking a small number of components.
- Data link weather. Garmin has teamed with Weather Works and XM Satellite Radio to provide data link weather capability in the United States. The advantage of the XM solution is that it's a broadcast system with high bandwidth, and complete coverage to the ground since it's satellite based. A competitive system uses a slower request/reply satellite system, and another competitor uses a ground-based system with excellent bandwidth, but it has coverage issues from line of sight transmission and not being fully deployed across the United States. The XM partnership will also provide XM satellite radio to the cockpit, another industry exclusive at this time.