Max Trescott's G1000 Glass Cockpit Handbook

Max Trescott, Master CFI

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By Max Trescott

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—Max Trescott

Chapter 1:
The Glass Cockpit Revolution

There's a quiet revolution going on in general aviation—one which will save lives and is destined to change forever the way small planes are flown. The glass cockpit is taking the industry by storm.

The Garmin International Inc. G1000 is driving much of that change into small planes and soon, into Very Light Jets (VLJ). Savvy pilots and flight instructors, seeking to stay on the leading edge of their profession, will embrace the change. If you're one of these pilots, this book will help you to transition smoothly into one of the thousands of G1000 glass cockpits now being shipped each year.

Historically, change has come extremely slowly to general aviation, particularly when compared to the consumer electronics or even the automobile industries. Many of today's airframes were designed 50 years ago and the biggest change that's occurred since then was moving the tailwheel from the back of the plane to the front! The only other major visible changes have been to the navigation receivers in the cockpit.

Yet, change is nonlinear. The airplanes I fly today are, in almost every respect, the same ones I learned to fly in over 30 years ago. Other than the advent of the nosewheel fifty years ago, the only other major changes were the introduction into the cockpit of Loran navigation receivers in the 1980s and GPS receivers in the 1990s. For those of us accustomed to seeing rapid change in other parts of our lives, change in general aviation seemingly moved on a geological timescale—the change was there, it was just hard to detect during our short life spans!

However, in the two-year period beginning in 2003, the general aviation industry converted from shipping no glass cockpits at all to equipping approximately 90% of all new small airplanes with glass cockpits! In 2003, Cirrus Design led the way by shipping the Avidyne Entegra glass cockpit in their SR20 and SR22 aircraft. In 2004, Diamond Aircraft Industries and Cessna Aircraft Company began shipping the Garmin G1000 in some models. By 2005, nearly every major manufacturer was shipping glass cockpits, and they were reporting that, when offered as an option, over 90% of their customers were choosing the new glass cockpits!

No one could have predicted the rapidity of this change, least of all the hundreds of thousands of pilots around the world who will eventually use them. While the manufacturers were able to make a total shift to “glass” in two years, training pilots will take longer, since the more than 200,000 airplanes that exist today without glass cockpits will continue to constitute the majority of the fleet for years to come.

The advent of the glass cockpit comes at a time when there’s been a rebound in the industry. In the past, small changes in the economy have been amplified into huge swings in the production of small aircraft. Hence the saying “when the economy gets a cough, general aviation gets double pneumonia.” While past upswings in new airplane sales were driven by the economy, the current renaissance is driven by innovations such as the glass cockpit and safety systems such as parachutes and airbags. Hopefully the current growth cycle will continue and glass cockpit aircraft become widely available.

Glass Cockpit Benefits vs. Risks

To many pilots, the benefits of glass cockpits are not intuitively obvious until they’ve flown in one. Until then, it’s easier to focus on the perceived increase in risk posed by using a system more heavily dependent upon an aircraft’s electrical system. “You won’t find me flying one of those in the clouds,” was the comment of one flight school manager.

What they may not realize is that the electrical systems of glass cockpit aircraft have been beefed up, and the glass cockpits themselves have tremendous redundancy. Whereas in the past, electrical system failures were common and often went unnoticed until the battery was completely drained, the new systems notify pilots immediately of a problem. In addition, standby batteries are often included to allow even more time to land or reach fair weather.

Single points of failure have also been largely eliminated. Today, most critical components have multiple backups. Losing any one component still leaves modern glass cockpit pilots with far more instrumentation and data than they normally would have after losing a component in traditional aircraft.

The benefits of flying any glass cockpit system are substantial. According to a University of Iowa study, glass cockpits lead to increased situational awareness on three levels. First, they lead to a better perception of the current environment, since data is presented in ways that pilots can more quickly absorb. Next, they increase comprehension of the current situation. Finally, they provide a better projection of the future status of the pilot and aircraft. They also decrease pilot workload, since data is presented in a more integrated format on larger displays.

System reliability is also enhanced. Traditional mechanical gyros have a lifetime of perhaps 1000-1500 hours. As they get older, Heading Indicators, for example, drift and need frequent adjustment so they remain synchronized with the compass. In contrast, the modern Attitude Heading Reference Systems (AHRS) last five to ten times longer and never need resetting, since they're automatically slaved to an electronic compass.

Traditional gyros are often driven by vacuum pumps with a lifetime of as little as 500 hours and, when these pumps fail, the gyros fail in an insidious fashion. When a pump fails, the gyros, which run at 18,000 rpm, slowly spin down over five minutes. As they slow, they start to tilt almost imperceptibly. An unsuspecting pilot, who has received virtually no warning of the vacuum pump failure, may follow the tilt of the gyro and slowly lead the plane into an unusual flight attitude. If this occurs while in the clouds, the result can be fatal. Modern glass cockpits don't use vacuum pumps for any of the primary flight instruments. Also, when a failure does occur, it's immediately obvious since a large red X replaces a portion of the instrument display.

One very real danger is that glass cockpits draw pilots' attention into the cockpit and away from scanning outside for other aircraft and terrain, particularly during transition training. The brilliant color displays demand attention, and even the most conscientious pilots will find themselves looking outside less. However, one study has shown that the traffic displays found in most glass cockpits, which graphically depict the location of other airplanes in the vicinity, actually help glass cockpit pilots visually spot traffic faster than pilots in traditional cockpits. Also, a large manufacturer's training department reports that after G1000 transition training is completed, pilots are returning to looking more outside the cockpit. If you do want to go "heads down" to focus on the system, you should advise your copilot, so that he or she will dedicate themselves to looking outside for traffic.

Another potential risk is the increased mental workload due to the inherently more complex software interface of glass cockpits. Programming the systems can distract a pilot from the primary task of flying the aircraft. There is also some risk of dependency upon the automation. To stay proficient, pilots will need to balance the time they spend hand flying an aircraft versus using the autopilot, so that their skills remain sharp in both areas. This risk may be somewhat overstated, however. Airline pilots work with high levels of automation, and little is said of any degradation in their basic flying skills.

Enhanced Safety & More Training

The biggest legacy of glass cockpits is bound to be the enhanced safety they provide. For example, terrain awareness databases built into most glass cockpits, that show whether the rocks are above or below you, should save thousands of lives in future decades. The use of the advanced autopilots found in these aircraft will also lighten pilot workloads and enhance safety.

Already lives are being saved by a simple advancement that predated glass cockpits by only a few years—the low fuel indicator. Cessna started shipping their aircraft with these warning indicators in the late 1990s, and they're now integrated into the G1000-equipped aircraft Cessna ships. Over 5,000 aircraft have these indicators, and none has had a fuel exhaustion accident. In contrast, in 2003, 147 general aviation aircraft accidents in the United States, or nearly 10% of accidents, were caused by fuel mismanagement. Other recent safety innovations include carbon monoxide monitors, shipped first on Columbia aircraft, and airbags shipped first on Cessnas.

An Air Safety Foundation publication on Technically Advanced Aircraft (TAA)—which includes all aircraft with glass cockpits—states that these aircraft have the potential for increased safety, but to "obtain this available safety, pilots must receive additional training in the specific TAA systems in their aircraft." Also, piloting in the future will require "a more mental approach."

Pilots accustomed to flying the gauges will find a paradigm shift as they transition into TAA aircraft. In addition to getting the feel for flying and landing a new aircraft, they'll now need to spend additional time learning to "navigate" through the software menus and softkeys. Most pilots will rise to this new challenge, though some will prefer the old methods of navigating an airplane.

Summary

The glass cockpits are here and they're bringing unprecedented levels of information, automation and potential safety into the small aircraft cockpit. Now, the challenge is for the pilot community to get additional training and develop a new orientation toward "programming the cockpit" so they can derive the full benefits of these new technologies. The bottom line is that glass cockpits are here to stay, and savvy pilots are already flying these safer, easier to manage aircraft, which are even more fun to fly!

Chapter 2:

G1000 Benefits

Some glass cockpit benefits are common to all systems and were previously discussed. Others are unique to each avionics manufacturer's design. The field is not static, however. Relatively few features are proprietary and manufacturers continue to play a game of leapfrog with each other. While some benefits discussed here are unique to the G1000 as of this writing, by the time you read this they may have been incorporated into other manufacturers' glass cockpit products.

Gary Burrell and Min Kao, former employees of King/Bendix®, founded Garmin in 1989, and used a contraction of their respective first names to name the company. It's been said they envisioned a product like the G1000 from the time they founded the company. Since 1997, they've shipped over 50,000 GNS 430 and GNS 530 GPS units. If you're proficient in using one of these units, your transition to the G1000 will be easier, since many of the programming steps are similar, if not identical.

Aviate, Navigate & Communicate on a Single Display

The single biggest benefit of the G1000 glass cockpit, compared to competitive products, is that it allows you to aviate, navigate and communicate from a single 10-inch display. In contrast, competitive products have pilots looking in multiple places to see data and reaching in multiple places to operate controls.

The disadvantage of this should be obvious. Pilots need to check their primary instruments constantly to monitor the attitude of their aircraft to verify that it's flying straight and level, climbing with wings level or whatever the case may be. It's easy to get distracted while flying and failing to monitor airplane instruments can be fatal. Two accidents, which occurred while operating IFR in the clouds, clearly illustrate this point.

In 2000, an aircraft climbing out of Santa Rosa, Calif., on an IFR departure, was performing well until the pilot got a call from the controller pointing out that his transponder was not operating. Shortly thereafter, the airplane spun out of the clouds and crashed into a lake, although radar did capture one report from the now operating transponder. This accident would not have occurred in a G1000-equipped aircraft. Not only would the pilot have a 10-inch wide horizon showing him whether his wings were level, but the transponder would have automatically switched to the ALT mode as soon as the plane took off and started flying faster than 30 knots.

Another crash occurred in 2003, while an aircraft was on an instrument approach to the Reid-Hillview airport in San Jose, Calif. In this case, a controller gave the pilot an incorrect tower frequency. The pilot spent more than a minute changing frequency, calling the wrong tower, entering the correct frequency and calling the correct tower. About that time, he noticed that he was in a descending right turn, that he had turned 90° from his course, and was impacting terrain. In a G1000-equipped aircraft, the pilot would have been looking in the upper right hand corner of the PFD (Primary Flight Display) to set frequencies. He would not have been able to miss the 10-inch wide horizon tilting to the right as he descended into terrain.

The lesson is simple. Pilots cannot afford to be distracted from their primary task of flying the airplane. With the increasingly complex airspace and increasingly complex aircraft systems, a pilot can get overloaded to the point where he cannot keep up with the demands of flying the airplane. Having to look away from the instruments and reach for controls that are not adjacent to the instruments contributes to these distractions and makes it more difficult to fly safely.

These accidents could also have been prevented if the pilots were using their autopilots. All glass cockpit aircraft are equipped with modern autopilots that work far better than most older ones. FITS (FAA Industry Training Standards) strongly emphasizes use of the autopilot, particularly when pilots are programming the system. Use of the autopilot also reduces the workload and frees pilots to concentrate on higher level tasks.

Integrated, Customizable Information

From a human factors standpoint, the G1000 is unique in that it tightly integrates all relevant information onto a single display panel and has all of the relevant controls adjacent to the display. With the exception of the engine instruments, which are on the MFD (Multifunction Display) during flight and don't require constant attention, a G1000 pilot can do everything from the PFD. For example, a pilot can modify a flight plan, monitor his position on a map, monitor other nearby aircraft, set all radio and navigation receivers, call up information on nearest airports and monitor flight and navigation instruments—all from a single display. This is close to finding the Holy Grail of flight instrumentation in a small plane.

You can easily add and subtract information from the G1000 PFD as desired. In a minimalist configuration, the display shows the primary flight instruments, radio frequencies and status information on the transponder and the next GPS waypoint. From that base configuration, you can add a map to the PFD and configure whether it displays various combinations of topography, traffic, lightning, terrain awareness, and obstructions. The map range can be adjusted manually or automatically.

In another part of the display, you can choose to bring up, modify and continuously display the flight plan. Alternatively, information on the nearest airports can be displayed, or system status alerts can be reviewed. If the aircraft is so equipped, DME, ADF and RMI bearing information can be added to the display.

If you're a renter, or an owner who has your aircraft on leaseback, you will need to check the settings before you take off, since the prior pilot may have customized the settings for his or her preferences. For example, it could be confusing if you didn't notice that the map is in the North Up orientation, when you're used to flying with Track Up.

TIP

Don't touch the displays with your finger! You'll leave oil on the screens and could scratch them. The scratches cannot be repaired, but you can place a protective film onto the display. The film can be ordered from many companies; be sure to specify the size precisely.

Clean the display only with a solution and soft microfiber cloth that's safe for anti-reflective coatings, such as those sold for cleaning eyeglasses. Never wipe or clean with a cloth alone—always use the solution in conjunction with the cloth.

Multiple Paths Simplify Reaching Your Data

The G1000 employs the same technique that good software developers have used for some time. Some software is intuitively obvious—if you happen to think exactly like the developer! If you don't, it can be very frustrating and nearly impossible to figure out.

Other software seems intuitively obvious at first, since when you try something, it often seems to work the way you want it to. The trick, which may not be obvious, is that the software developers have built in alternate ways to perform a function. Not only does the software seem like it's designed for your preferences, but it's designed for other people's preferences, too!

The G1000 is similar in that it often has multiple ways to perform a function. If you're familiar with programming a GNS 430 or GNS 530, your preferred way to load an instrument approach may be through the PROC and MENU keys. You might not even notice that softkeys, located along the bottom of the display, will also allow you to load an approach. The functions of softkeys change with context, and often they are the fastest way to reach information on the G1000.

In some cases, you're forced to use a particular user interface. For example, the Flight Management System (FMS) knobs are used heavily to program the G1000 system. Often, you can use only the larger or the smaller of these concentric knobs to perform a particular function. Use the wrong knob, and you get something different from what you intended. In other cases, however, software designers made it easier by allowing you to use either knob to make a selection.

Since this book is intended to be a comprehensive treatment of the G1000, we've tried to present all of the different ways—some of which aren't found in the current manuals—you can access a function. As a user, however, you only need to remember one way to perform an operation. In general, you'll find that using the softkeys on the MFD will save keystrokes versus using the MENU and PROC keys. However, if you want to learn one set of techniques for programming the GPS that works equally well on both the MFD and the PFD, you may want to focus on learning to use the MENU and PROC keys.

Information, Not Just Data

We live in a world where we're surrounded by *data* and somehow we're expected to process it to derive the *information* we need. The G1000 does an outstanding job of taking that raw data and turning it into useful information.

In one of the simplest cases, the airspeed display tape has "Speed bugs," which point to some of the many, important to remember airspeeds. As a flight instructor, I'm constantly jumping into different airplanes and one of the first things I ask a client is what the Vx and Vy airspeeds are for their airplane. This tells me two things—whether they know them, and whether they're what I think they are.

The G1000 takes care of this issue. As the aircraft accelerates and reaches rotation speed, a reference bug labeled "Vr" appears alongside the speed tape. Now, pilots don't need to remember Vr—they know to rotate when they reach the first speed bug. Other bugs for the best angle of climb Vx, best rate of climb Vy, and best glide speed Vg are included in the G1000. The manufacturers' specified speeds are loaded into the system, though you can change those values or turn off the bugs all together.

Human factors specialists determined years ago that humans can grasp data more quickly when it's presented graphically. The G1000's Fuel Range Ring is a great example of this. It's one of my favorite features, which is ironic, since I originally scoffed at its usefulness.

The first time I flew back from the Cessna factory in Kansas with a client in a new T206, we wanted to avoid making an extra fuel stop. The MFD showed our destination airport between the fuel range ring that indicated our time to fuel exhaustion and the ring that indicated our time to reaching reserve fuel (which we had defined as one hour of fuel).

Uncomfortable with that, yet still wanting to reach our destination, we began experimenting with different power and mixture settings. Very quickly, we found power settings that moved the reserve range ring beyond the destination airport, and indeed we arrived with nearly 20 gallons remaining in the tanks. With other glass cockpits, we could have found the same *data* manually, but with the Fuel Range Ring we got instant *information* graphically.

Display Redundancy

Much is made—sometimes too much—of what will happen under various flying scenarios. For example, some pilots worry out of proportion about infrequent scenarios—such as engine failure and midair collision—versus more frequent occurrences such as night flight (which has several times the daytime accident rate) and the almost always fatal inadvertent VFR into IMC accidents.

Likewise, when pilots think of glass cockpits, they're quick to worry about what will happen if the display fails, when it's more likely that an alternator will fail. Nonetheless, the G1000 is unique in its ability to continue displaying the primary flight instruments even after a PFD failure! Its unique reversionary mode recombines data from the PFD and MFD to create a new combination of information that appears on whichever display is still functional.

Lose a PFD and you still see the flight instruments and engine display, though you have to look at the right side display. Lose an MFD and you get the same combined information on the left side display. In the unlikely event you lose both displays (and you don't wake up from having a nightmare), you still have use of the three standby instruments.

Obviously, the loss of an alternator and subsequent draining of the battery would lead to the loss of both displays. However, all G1000 implementations include an additional battery and sometimes a second alternator. This provides much redundancy and virtually eliminates single points of failure where losing a single component would result in disaster.

Real-time Data

Real-time data is available in most glass cockpits, so while this is not a large G1000 differentiator, it's still worth describing the benefits. Traffic Information Service (TIS) and Traffic Advisory Systems (TAS) are common functions; both make visually spotting other aircraft much easier. Stormscopes® provide real-time lightning data, and XM Satellite's aviation weather subscriptions provide near real-time displays of virtually the same graphical weather products that you're able to get sitting in front of your computer on the ground.

For example, you can call up a satellite picture to see whether clouds have moved in from the coast obscuring your home airport, or another weather product showing the cloud top heights so you can estimate the severity of a storm and whether you're likely to encounter freezing rain. Radar pictures, mapped in near real-time relative to your current position in the air, can also be called up so that you can see where cells are located and plan a route around them.

Note that you shouldn't use these radar pictures to pick your way through storm cells. Rather, use them strategically to steer well around the weather. Remember too that the radar data is a minimum of eight minutes old, and much can change in that time.

Aviation weather subscriptions can also provide SIGMETs and AIRMETs. These warnings of significant weather, are virtually indecipherable when given over the phone by Flight Service Stations, unless you happen to know the location of every VOR they reference to describe the boundaries of the affected area. Via the G1000, SIGMETs and AIRMETs are shown graphically on a map, and you can read the full text of the warnings. Real-time Temporary Flight Restriction (TFR) data is also available.

Summary

Each manufacturer's glass cockpit implementation has unique strengths and weaknesses and all will improve over time as new revisions are introduced. All of them can help general aviation reach new levels of safety. What's most important is that you as a pilot fully understand all of the nuances of the system you fly, so that you always know what the system is doing now and how to make it do what you need to do next. Ultimately, fully understanding your system is going to reduce your workload, enhance safety and make flying even more enjoyable.

Chapter 3:

G1000 System Overview

The Garmin G1000 is a flexible system of interchangeable hardware modules and software tailored to the needs of individual aircraft manufacturers. Most piston-powered aircraft have the two-display version, while high-end aircraft including the Cessna Mustang jet use a three-display version. While it's not necessary to understand the system architecture to operate the G1000—and you can skip ahead to Chapter 4 if you wish—knowing the architecture can be helpful in understanding the ramifications of the failure of one or more system components.

In addition to the displays, there are a number of hardware modules that make up the system (figure 3-1). In most aircraft, these are located in the tail cone; in others the modules are behind the instrument panel, but hidden from view. Placing the electronics in the tail adds one aerodynamic benefit. In most aircraft, the wing provides lift, while the horizontal stabilizer actually generates a downward force, balancing the aircraft around its center of gravity, but also requiring the wing to generate additional lift. Placing the electronics in the tail reduces the amount of down force required from the tail, the amount of lift required from the wing, and makes the aircraft slightly faster.

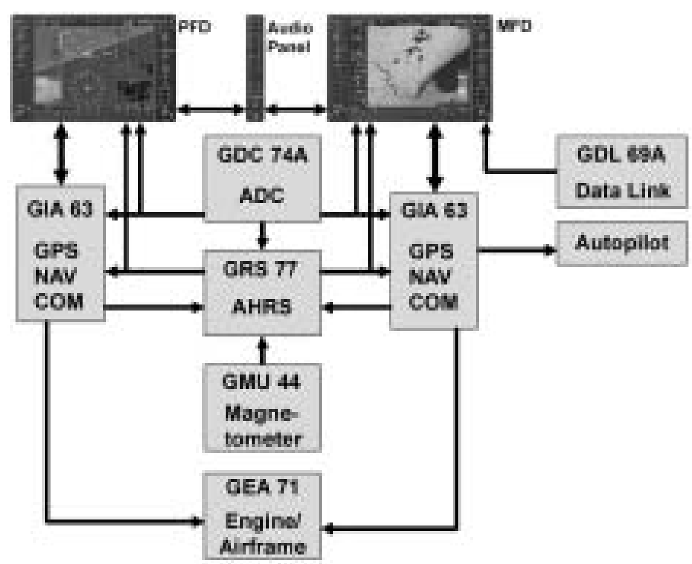

Figure 3-1 The G1000 is a modular system.

All hardware modules are line replaceable units (LRU) for quick service. A technician pulls out the faulty unit and replaces it with a known good unit from inventory. The faulty unit is repaired, goes back into inventory, and eventually into another aircraft. Your module that started life in a Mooney may end up in a Mustang jet! You may also save time by not having to take your airplane to a separate avionics shop, as some aircraft service centers will be authorized to swap G1000 LRUs. Finally, one-stop shopping when you take your plane in for maintenance!

While much of the hardware may be the same, whether you're flying jets or propeller-driven aircraft, the software is different—though similar—for each model. Thus when you jump from one G1000 aircraft into another, the instruments will appear the same, but the implementation of some features may vary, or may not exist at all if a manufacturer chose not to implement them.

When you buy a new plane, not only will you receive a copy of the Pilot Operating Handbook (POH), but you'll also receive a CD with a copy of the software loaded onto your system. In some cases, maintenance personnel may need this disk to reload the software onto your system after it's been serviced. You'll want to keep the CD in a safe place, particularly if it's a rental aircraft used by many people. In addition, when the G1000 is first turned on, you should verify that the aircraft's software version is correct—in case software for another airplane model was inadvertently loaded after your system was serviced.

G1000 Displays

Figure 3-2 Manufacturers can now choose from 10, 12, and 15-inch displays. *© Garmin Ltd. or its affiliates*

The most prominent part of the G1000 system is the full-color displays that pilots use to interact with the system. Most aircraft use two GDU 1040s, which are 10.4-inch diagonal displays that are physically identical (figure 3-2). That keeps costs down, since service centers will only need to stock a single part which can be used to replace either display. The display on the left (pilot's side) is configured through software as a PFD, while the display on the right is configured as a MFD.

In aircraft like the Beechcraft G36 that use the integrated GFC 700 autopilot, a nearly identical display, the GDU 1043, is used for the MFD. The key difference is that the bezel of this display includes additional keys that control the autopilot functions.

Current plans are for some high-end aircraft, such as the Cessna Mustang, to use a three-display version of the G1000. In these installations, the outer two displays are identical 10.4-inch displays, both configured as PFDs, so the pilot and copilot have identical views of the primary flight instruments. A third 15-inch display, located in the center of the instrument panel, serves as a MFD. Garmin recently announced a 12-inch version of the display, giving manufacturers yet another option for tailoring the G1000 to their aircraft.

The GDU 1040 and GDU 1043 displays use thin-film transistor (TFT) technology, which provides a wider viewing angle than older flat panel displays, and is easily readable in most sunlight conditions. Physically, each display is 7.7 by 11.8 inches and 3.5 inches deep. Electrically, it's an XGA type display with 1024x768 pixels of resolution and capable of displaying 262,144 colors. The color capability is fully used when displaying topographical maps, which appear equal in quality to a printed map. A built-in graphics accelerator refreshes the display 30 times a second, rendering excellent, flicker-free graphics.

Cockpit lighting in many general aviation (G.A.) aircraft has been atrocious, and here the G1000 shines—literally. Backlighting has been added to the display, and pilots can control the intensity of each display individually as well as adjust lighting of the engraved labels on the display bezel.

Each display has two slots for SD-type memory cards. The lower slot is occupied by a memory card which contains the terrain and obstruction databases. Pull that card and the data's gone. The other slots are used to update the internal GPS databases and, by some manufacturers, to provide electronic checklist capability.

GIA 63 Integrated Avionics Units

If the G1000 displays are the beauty of the system, then the two GIA 63 integrated avionics units are close to being the dual brains of the system (figure 3-3). Each of the units, designated GIA1 and GIA2, contains a complete GPS receiver, VHF COM radio, and VHF NAV receiver. These functions are relatively independent of each other so if, for example, the COM radio fails, the GPS and NAV receivers in that LRU might continue to operate. In addition, if an entire GIA 63 fails, the second GIA 63 will still provide GPS, COM and NAV receiver functions for the aircraft, though some autopilot functionality will be lost.

The first GPS, either GPS1 or GPS2, to acquire a signal becomes the active GPS. The other one becomes a hot spare which can take over at any time. If the active GPS subsequently fails, the hot spare becomes active and there is no loss of functionality.

Figure 3-3 The GIA 63 is similar in functionality to the Garmin GNS 530.

The COM portion of the unit has 16 watts of transmit power and is designed for 8.33 kHz radio channel spacing, now in use in some parts of the world. You can easily reconfigure the system from 25 kHz spacing to 8.33 kHz spacing by making a change on the System Setup page in the AUX page group.

The GIA 63s communicate with both displays via a High-Speed Data Bus (HSDB) Ethernet connection. When the GPS database is updated by the user though slots in the displays, a copy of the data is stored in both GIA 63s, so it is still available if one unit fails. Updating the G1000 is quick and easy since you only have to update the two displays, taking 20 to 30 seconds each.

To update the database, download data from the Internet via a subscription service onto a SD card. Insert the card into the PFD's slot and turn on the master switch. The system will ask if you want to update the database. Press the ENT key for yes or the CLR key for no. After the update is complete, move the SD card to the MFD's slot, turn on the Master Switch (and, for some manufacturers, an Avionics switch) and repeat the process.

GMA 1347 Audio Panel

The GMA 1347 provides all of the features of modern audio panels. It allows you to select the radios on which you're transmitting and receiving, and lets you listen to any of the navigation radios to identify a station. It also integrates an intercom system, marker beacon receiver and a digital clearance recorder.

The audio panel is mounted in most aircraft between the PFD and MFD, and it communicates with the GIA 63s using an RS-232 connection. At the bottom, it includes a Display Backup button, which can be pushed in an emergency if one of the displays were to fail. When pushed, it displays the primary instruments on whichever display remains.

Figure 3-4 The GDC 74A processes air data from the pitot-static system. *© Garmin Ltd. or its affiliates*

GDC 74A Air Data Computer

The GDC 74A Air Data Computer (figure 3-4) processes information from the pitot-static lines, which bring in data about the air outside the plane. For example, it provides information on pressure, altitude, indicated airspeed, vertical speed, outside wind direction and strength, and total air temperature.

Vertical speed information has the same lag (approximately 6 seconds) that you find in a traditional VSI, so don't chase these indications excessively. Total air temperature, which includes the heating effects of the airplane moving through the air, is used to calculate outside air temperature (OAT). The GDC 74A also provides altitude information to the transponder.

Figure 3-5 The AHRS is a solid-state replacement for mechanical gyros. *© Garmin Ltd. or its affiliates*

GRS 77 Attitude Heading and Reference System

The GRS 77 Attitude Heading and Reference System (figure 3-5) or AHRS is one of the key components that helped bring glass cockpit technology into the price range of general aviation aircraft. This AHRS was developed initially by Sequoia Instruments, which Garmin purchased in 2001. It was the one of the first low-cost, solid-state replacements for mechanical gyros.

Historically, gyros were first replaced in military aircraft using expensive laser-ring gyros that cost $75,000 and up. The GRS 77 is unique in that not only does it use accelerometers for position data, but it also uses GPS and magnetometer data to provide an accurate reference at a relatively low cost. If either of those external sources is unavailable or sending invalid data, then data from the air data computer is also used.

It's also fast to initialize. On the ground during start-up, all instruments are usually available within 45 seconds. In addition, the GRS 77 AHRS can be reinitialized in flight, should power be interrupted. Reinitialization can occur even while the airplane is in a bank of up to 20°, and some factory pilots have seen it reinitialize in up to a 45° bank. In contrast, the reference systems in some other glass cockpits, including jet aircraft, require that the system remain motionless for several minutes during initialization and the systems cannot be reinitialized in flight.

Figure 3-6 The Magnetometer senses an airplane's heading. *© Garmin Ltd. or its affiliates*

GMU 44 – 3 axis magnetometer

Future pilots may never have to adjust a Directional Gyro or Heading Indicator to the correct compass setting again—and again if the gyro is wearing out—because of the GMU 44 3-axis magnetometer (figure 3-6). Generally located in the wing, this device does the work of

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