

421C UPGRADE: ONE THING LEADS TO ANOTHER

by Max Nernheim



The Beginning

Departing the TTCF seminar in Camarillo, CA last September, the sun was below the horizon and a haze layer had formed. Just after rotation as I was transitioning to the instruments, my attitude indicator started bobbing and rolling. Fortunately, I could still make out the actual horizon. I climbed above the haze and was able to complete the flight VFR but that event was the tipping point that launched a major panel upgrade for my 421.

Thinking back over the years, I realized I had had multiple engine instrument failures as well. I decided right then to replace as many of these old style, mechanical instruments and gauges as possible. That meant a PFD/MFD combo with a state-of-the-art engine monitor. The new JPI 960 fit the bill. It replaces all engine instruments, up to 4 fuel gauges, monitors all CHT's and EGT's, turbine inlet temps, intercooler discharge temps, system voltage, fuel flow, and alternator output. In addition, if connected to a GPS, it also calculates MPG and fuel remaining at waypoints. Fantastically, it also gets rid of the troublesome tach generators!

Why Garmin?

The MFD/PFD choice was between the Aspen and Garmin G600. The diagonal screen size of each half of the G600 is 6.5" vs. 6" for each Aspen screen. However, the G600 screens are more square, resulting in more screen area than just the 0.5" extra diagonal would indicate. At the AOPA summit in Long Beach last fall, I was able to put my hand on both units and the G600 seemed to run considerably cooler. This was probably the result of a larger cooling fan on the G600 and would be a definite advantage at my home base in Phoenix where summer temperatures can reach 50 C (122 F) in the SHADE. Most electronic components have a manufacturer specified upper limit of 85 C (inside on the hot circuit board) and every 10C increase in operating temperature will roughly halve the lifetime of an electronic component.

I also wanted XM radio. Garmin charges twice as much for this! However, I also wanted to display the XM data/weather on a separate MFD that I would use primarily as a radar display. This display would replace the older, non-supported Avidyne unit that I had used as radar display for my existing RDR130 weather radar (a more powerful version of the RDR160). My MFD choices were either an Avidyne MX500 or a Garmin GMX200. Since each manufacturer's XM radios can only talk to their own equipment, if I went with any Aspen or Avidyne component, 2 XM radios and 2 subscriptions would be needed. With a Garmin system, the G600, the 530/430, and the GMX200 could all receive the same XM link. The larger screens of the Garmin, synthetic vision, interoperability with other components, one XM receiver/subscription for all units, radar display option, reputation for making reliable avionics, and cooler operation all made the G600 the clear choice for me. Ease of installation that both systems touted in their different ways was not a consideration since I wanted to redo the entire panel layout. The redundancy of an Aspen system with its dual AHRS and dual batteries did not sway me because I felt the G600 would be very reliable (cool operating temps), and I prefer to have backup systems driven by different technologies

- i.e. air driven.

A series inquiries to other owners led me to Executive Aircraft Maintenance (EAM) of Scottsdale (KSDL). They had performed a number of successful panel retrofits including a Cessna 414A. It was a beautiful piece of work. EAM then set up a test flight in a Piper Jet Prop with dual G600's. Besides convincing me that the Jetprop was a really nice airplane, the flight also demonstrated the intuitiveness of the G600.

The Installation

One of the reasons for picking EAM was the openness of the people working there. I was allowed to walk through the shop, see airplanes being worked on and talk to the people doing the work. I valued having the resources of a mid-sized organization behind a large avionics upgrade in case unforeseen problems arose. In addition, Bill Forbes, the avionics manager, promised that the quote was guaranteed and there would be no surprises.

I spent considerable time planning the panel layout. I consulted with half a dozen flying friends as well as EAM's CAD designer. One idea was to keep all critical information up high, in plain

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view. The old layout had the altitude preselector with its indicating lights placed behind the yoke. A deliberate movement forward was needed to see it, make sure it was in the right mode, had captured altitude, and was operating correctly. The new layout has the altitude preselect in plain view on top of the audio panel, making operation and visual confirmation easy. The A/P switch panel is moved to right below the G600, also in plain sight. The A/P OFF light was placed on the left side of the preselect panel, and the GPSS/Heading switch on the right. Intuitive. The altitude alert indicator was placed in the middle and on top of the G600, right on top of the G600 altitude “tape”. Logical!

The two small alarm displays from the JPI960, one for each engine, were placed on the top left and right side of the G600 (seems obvious, but I have seen these placed in the middle of the panel away from the direct view of the pilot!). The spoiler control and indicator used to be low and hidden. Now they are in easy view and reach right under the glare-shield.

To reduce the clutter, as many switches, post lights, and labels as possible were replaced with Eaton switches with built-in lighted labels. The switches have custom lettering that can be ON or OFF when the switch is engaged or not. On some, the lettering on the top half of the switch face is lit up when the switch is OFF, and both top and bottom switch face lit up when the switch is engaged/ON. On other switches the top switch face is lit while the switch is in one position, and the bottom half of the switch face lit in the other position. The Eaton switches were expensive, but do a truly great job of cleaning up the panel. Green switch backlight is used for non-critical items like GPSS

steering, Traffic Extended Callout, and both transponders. Critical switches for takeoff and landing, like spoiler and prop phasing control, have orange back-light. The resulting reduction in clutter, improved work flow and safety awareness is amazing.

Rob, the avionics tech that did most of the installation and Eric (the CAD guy)



Everything communicates! Tying everything together in a way that ensures easy and seamless operation is a tribute to both Garmin engineering and my installer, Executive Aircraft Maintenance of Scottsdale. The logical layout was the result of 10 different CAD revisions!

also suggested using light-rings for the round (backup) instruments. The light ring is placed on the back side of the instrument panel, between the panel and each circular gauge. Since each round gauge had 2 post lights, and there were 9 gauges, this reduced the panel clutter by 18 post lights!

After 7 CAD revisions, I printed the panel layout in 1:1 scale on 11x17 paper and used scissors and tape to create the full size panel. Instrument photos were downloaded from websites, printed out, and taped to the panel mock-up. One of the later ideas was to move the JPI 960 towards the top of the panel to make it easier to scan during the takeoff roll. The backup attitude indicator was placed along the upper left side of the G600 in order to match the horizon level of the G600 as closely as possible. This makes for a safer transition to the backup instrument in case of a primary failure.

Revision 10 was the final CAD layout of the panel. We decided to construct the panel in 3 pieces to make it easier

to service later on. The panel was CNC cut and came out more accurate than anyone could measure. Great!

The Project Grows!

The headliner had to be partially removed to install antennas and wiring. Hence it was a good time to replace it and install upgraded soundproofing. AZ Aircraft Interiors, was called in. Since a new headliner would not look good with old and faded window frames, we decided to redo these as well. The window frames and the pilot/copilot armrests were removed from the airplane and covered with the same material used for the headliner. Since new window frames would not look nice with 31 year old drapes, new drapes were also ordered. The seats and other parts were done by the last owner. These last new interior pieces made the interior match and look great.

One thing leads to another! The original air conditioning has never worked for more than a couple of weeks at a time. It got a thorough inspection while everything was opened up. A lot of debris was flushed from the system. I investigated installing a new compressor and other mechanical components, however, I learned it would cheaper to buy a new Keith electric system. I received advice to the opposite, but I have had so much trouble with the old system, and heard so many good things about the Keith system, that I decided to go the new route. The original A/C system was driven by a hydraulic pump off the right engine. The Keith air is all electric, so the switch meant we could eliminate the hydraulic pump. Good. The not so good part was there would be a 2 month delay in getting the out-of-stock Keith system. It took another

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couple of weeks to install the system and run the wires and hoses run through the bulkhead into the cabin. The old AC components were installed around the C.G. of the airplane. The new system was installed under the floor in the nose baggage compartment in what used to be a sunken baggage area. The Keith system added 22 pounds and shifted the C.G. by 1 inch forward. Fine. It would cost \$10K to add a 20 gallon fuel tank behind the right engine where the old AC used to be, so I decided the 270 gallon fuel capacity already in the airplane was sufficient, and left the space empty.

The JPI 960 engine monitor has two remote boxes that interface to sensor transducers from the left and right engines and fuel tanks. The transducers sense engine and exhaust temperatures, oil temps, fuel level, fuel flow, etc. The marketing material says to mount the boxes right behind the engine to make the wiring and installation easy. However, there was no space for them anywhere in the wings or nacelles, so

they were placed under the cabin floor. As a result, the original 16 foot sensor wire harnesses ended up too short. JPI, to their credit, fabricated and shipped us a new 25 foot harnesses in just a couple of days. In retrospect, having the boxes under the floor has worked out fine, and might even be preferred due to the stable environment there. Only a single serial cable is routed from each box to the panel mounted display, reducing clutter and eliminating handling (breaking) of sensor wires during instrument removals/repairs. A good outcome.

This last year I started using the Apple iPad running Foreflight in the cockpit. It is an invaluable tool. To keep it charged during long flights while running its internal GPS, we installed extra 28V power outlets by the pilot and copilot, as well as one behind the copilot bulkhead for use by passengers. A 10 amp circuit provides enough power for a portable DC/AC converter for passenger laptops/electronics. Even with all the avionics in the plane, the Foreflight application is still the preferred tool for trip

planning, weather research, and approach plates in the cockpit. The 3G version of the iPad has built-in GPS enabling positioning on charts and plates while flying.

EAM has quite a diverse customer base which enabled me to acquire some other nice upgrades. I was able to pick up a used RDR2000 vertical profile radar and a Garmin GMX200 for a reasonable cost. Because we had to remove the headliner, I also decided to upgrade one of my GTX327 transponders to a GTX330 with ADS-B and TIS capability. EAM was able to sell my used 327 to another of its customers.

With all the upgrades completed, it was time for the test flight. The first thing that struck me was the accuracy of the JPI960. If any RPM or manifold pressure is exceeded by even the smallest increment above a limit, the numbers

will change to red. At first it is a little annoying to see the RPM go 10 or 20 RPM's into the red on takeoff, but after thinking about it, it is obvious that the old analog gauges were also over the limit, but the gauge resolution was not fine enough to show it. The feeling of the airplane is drastically different. Now, it feels like a piece of precision equipment. Once something is set, a very predictable and accurate response occurs. The Garmin G600/530/430 worked flawlessly.

A Final Addition

Just as my project was nearing completion, Garmin announced their new GTN replacements for the 530/430. Press reviews were favorable (yes, I know they always are!) and additional internet research was intriguing. Sometime after the first test flight, I asked Bill, the avionics manager, how expensive a trade-up to the GTN's would be. He gave me a very reasonable quote that included what I'd receive selling my 530/430. The installation started two days later. All but one connector have to be changed on the GTN series vs. the GNS series so a lot of rewiring is needed. The positive part of the GTN series is that Ethernet is now used to connect the pieces together, and they all "talk" for added reliability and redundancy. A surprise is that even the 330/327 transponders can be controlled from the GTN's. Now, if I don't feel like stretching, the transponder operation can be controlled by touch screens! The 750 controls the 330 transponder, the 650 controls the 327 transponder.

The most striking characteristic of the 750 is the size of the display. It's larger than even the GMX200 display, and quite a bit larger than the individual G600 screens. It is truly a large cockpit display, and Garmin created a magnificent user interface, making the unit easy and intuitive to operate. For those that are old school and want to control frequencies and waypoints by 2 rotary knobs, the GTN's even have these in the lower right corner! Just push the "direct to" button to start dialing in KXYZ, just like a 530/430. Another striking thing is how nicely the G600/GTN750/650/GMX200/GTX327/330/

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XM-receiver/active traffic/stormscope interface with each other. Much credit goes to EAM for knowing how to hook up all the pieces in such a networked fashion. XM-radio data, stormscope, and active traffic is transparent on the MFD side of the G600, the GTN750, and the GMX200. The same data can be pulled up on any of them. Right now, active traffic is on 3 screens, and the 330 TIS traffic is displayed on the GTN650. It works great. The only thing missing in the 750 so far is the display of DME distances to VOR stations. The GNS530 would display both the VOR name and the DME distance to the VOR in the VOR frequency box. The GTN's only display the name.

Because of the installation challenges and high cost of a new autopilot, I decided to keep my old Cessna 800B. Unfortunately, Garmin has been too busy with new avionics to focus on certifying the GAD43 autopilot adapter for the Cessna 800B so I kept the old attitude gyro just for the 800B. Surprisingly, the 800B has performed better than expected. In retrospect, I suspect that some of the A/P "problems" I had before were pilot induced. The operational controls and indicators were not in plain view. As a result, the A/P might have been in a different mode than me and it got the blame, not me, for "acting up!"

Lessons Learned:

- Do all the upgrades at the same time. That way the plane is only taken apart only once.
- Plan for considerable downtime.
- Spend some extra money on instrument back-lighting and Eaton switches to de-clutter the panel.
- Put important controls and indicators along the top of the panel (or in plain



This closeup of the center stack shows the new logical layout and uncluttered look of my new panel. Note the lighted Eaton switches and their strategic locations.

view), and group them according to function.

- If a new panel layout is planned, spend sufficient time planning and mocking it up.
- In order to do some "hangar flying"

a 20Amp/24V power supply is needed. This panel draws 17A/24V with everything on and the radar in standby.

Most Enjoyable Results

- 1) The relatively small incremental cost for the interior upgrade made a huge esthetic difference.
- 2) Being able to rely on the JPI engine sensors 100% and having many more operational parameters available.
- 3) Having most instruments linked together and being able to display "anything anywhere".
- 4) Situational awareness, especially synthetic vision. If you have a problem figuring out up and down while flying with synthetic vision that shows mountains and terrain going by on the bottom of the display, you should not be flying!

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5) Friendliness and intuitiveness of the GTN menu system. The GNS530/430 can do almost the same functions, but while going back to a GNS530 during my annual Simcom training this summer I realized it is like comparing MS-DOS with VGA graphics to Windows 7 in HD!

6) The Keith Air has worked every time.

Least Enjoyable Results

1) The menu system on the JPI960. Press and hold “next” to go back! Press “next” 15 times to see output of left and right alternator (the other 14 in-between are MPG, temperatures, etc.). Since the buttons are “soft” buttons, why can’t the display reflect exactly what the buttons will do?

If the JPI960 had mimicked the user interface of the GTN series, it would be a truly excellent product. At present, it is still a very nice monitor, but it is annoying having to read and remember the manual.....

2) The Garmin data-update process before the PilotPak was released: Downloading the 18 required databases took hours! Now, the Garmin PilotPak option has a batch download option where all databases in each device can be programmed in one sequence. The pricing is also more reasonable.

Summary

The 421C is a very stable airplane with a quiet and comfortable cabin. My new panel raises the avionics capability to match the capability of the airplane.

Combined with interior upgrades it makes the Golden Eagle look and feel like a much newer airplane, but with performance and comfort no longer offered in any new piston powered airplane. After installation, we weighed the airplane. It gained 1 pound, and the C.G. shifted 0.2” rearward. Not bad!

Wishlist: Strakes. 4-blade props and another 100 knots. Stay tuned.

