Dual Horizon 1 EFIS and EIS

I ordered my Grand Rapids Technology Horizon 1 dual screen single AHRS system with integrated Engine Informantion System at Oshkosh 2005. I delayed the order in November when Sandy called me and told me it was finally ready to assemble and ship. At OSH I told them I wouldn't be ready for at least two months, so the delay was mine. I'm sure they didn't mind the delay with all the OSH orders they got.

Besides the dual screen option, I also ordered the fuel flow monitoring, the AIRINC 129 interface (for the Garmin 480) as well as the internal WAAS GPS. I wanted all the bells and whistles.

When the order came (18 pounds), I was surprised at how much stuff there was. I laid it out on the kitchen table. It looked like a daunting pile of bags wires and papers. I looked at the installation

instructions and began to read them. I thought to myself "these instructions are of little help". I had read them through on the GRT website a couple times. With the parts in my hands, I just didn't get it. Then the light turned on when I saw a cable wiring instruction manual. Duh, it was separate from the installation instructions. I hadn't seen that before, and it turned out to be the key to getting this project started.

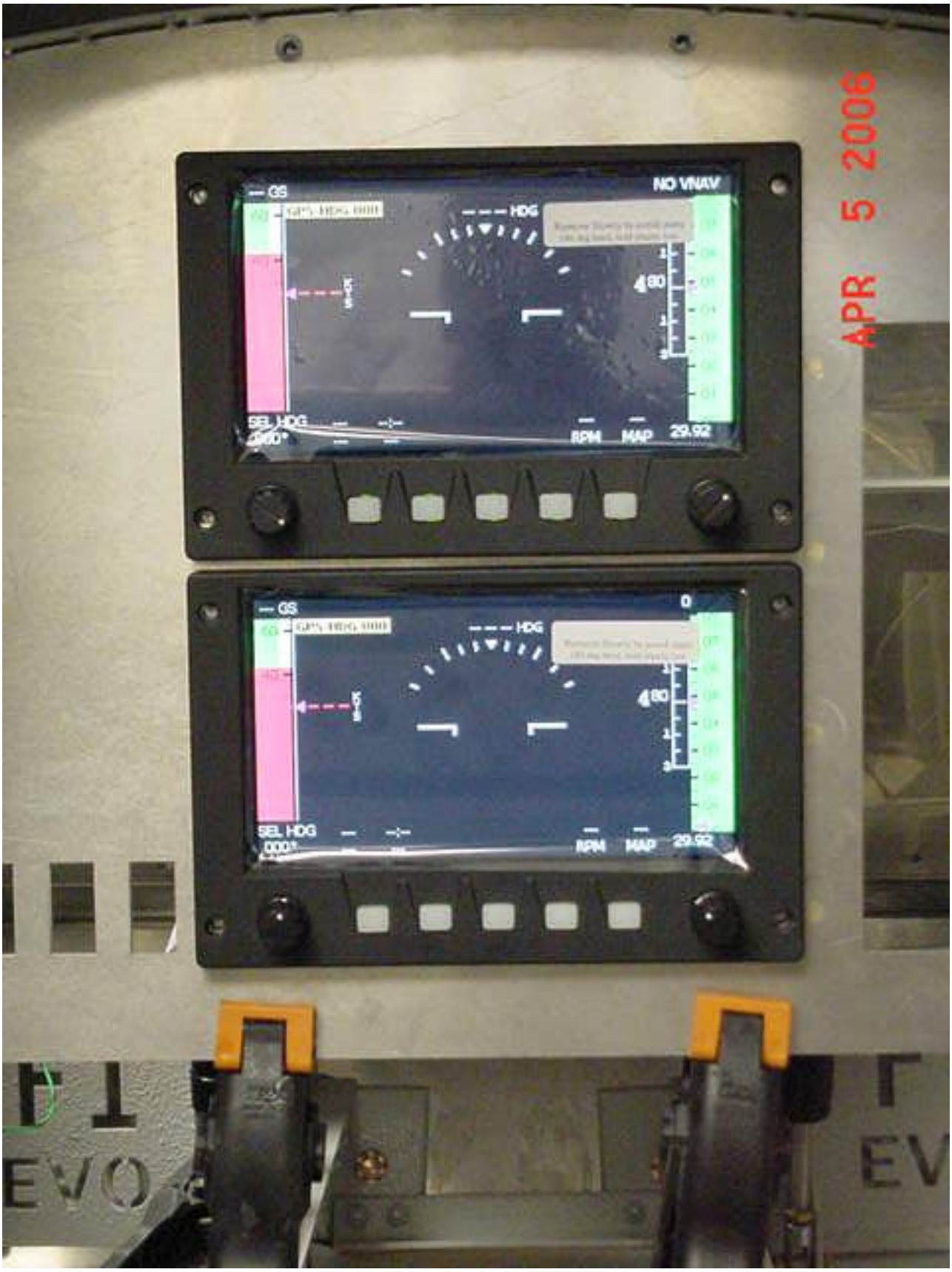
The manual isn't exactly cookbook, but so far it seems to be fairly complete. I had a hard time figuring out which monitor was DU (Display Unit 1) and which was DU2. Finally, after reading the wire code layout, one of the 3 factory prewired, interlinked 25 pin cables has a brown wire on it. Guess it's up to me which monitor to call DU(1), but it makes a difference on the wiring. The DU(1) is the unit you HAVE to use to setup some parameters in the system once you get it up and running.

I was anxious to at least test run the units (Boys and Toys, you know...), so I set the DUs in my panel. A perfect fit. And I set the AHRS on my avionics center shelf. I had that located perfectly as well. I had also determined that the bottom monitor (DU) would just clear the shelf due to the cant of the instrument panel. That was just right, and I was glad that I had my instrument panel extended 1 inch at the bottom. So far, so good.

I took the rats nest of the main cable (3 - 25 pin connectors with up to 20 feet of many, MANY color coded wires) and laid it out on the table. I displaced the unconnected wires, bundled and marked them, and set them aside. I took a tape measure and approximated the distance between all the pin connectors at the back of the DU's and aft side of the AHRS with the units sitting in my instrument panel. Then I cut the yellow and brown wires. My DU's and AHRS are only about 8 inches apart, and I think there was at LEAST 2 (if not 4) feet of wire pinned for those connections. I wanted to reduce the amount of excess wire, so I cut, stripped and crimped new female pins on the DU pin connectors. I set the cables in place on the units (just resting in my panel). I liked the result!

The manual tells you that although the units are internally fused, you still should use circuit protection. I'm still trying to decide whether to have 3 power sources to each unit, and whether to use blade fuses, circuit breakers, or just use fusible links on the wires. I'm leaning toward the latter. In the mean time, I wanted to power up the units to see what they looked like. I stripped the 3 red and 3 black wires that power and ground each of the units and just used some alligator clips and a fuse block I had laying around with a 5 amp fuse in it, and clipped the EFIS wires to my main bus. A flip of the master... and.... SUCCESS!


EFIS Power Up
EFIS software integrity check: PASS
EFIS software version: 26 Date: 2005-01-06
AHRS software version: 0.17
Navigation database integrity check: PASS
Navigation database date: 2005-07-07
AHRS Communication: OK
GPS Communication: FAIL
EIS Communication: FAIL
Speed/Distance units: Knots, nautical miles
ACCEPT
APR 5 2006
EFIS Power Up
EFIS software integrity check: PASS
EFIS software version: 26 Date: 2005-01-06
AHRS software version: 0.17
Navigation database integrity check: PASS
Navigation database date: 2005-06-09
AHRS Communication: OK
GPS Communication: FLAGGED
EIS Communication: FAIL
Speed/Distance units: Knots, nautical miles



PRETTY COOL!! I gave the units time to do their checkouts, pressed the ACCEPT buttons and checked out the color screens. Oh yes, these are going to be sweet. The color in the pics look crappy, and don't give you a real idea of how nice they looked in the panel. Also, the protection film is

still on, and it makes the colors a bit darker than they really are. I'm in no hurry to remove the film, but I was still impressed.

Let the real wiring BEGIN!

Wiring Notes:

The AHRS doesn't need OAT, but the EIS does. So if you have a Horizon 1 and EIS, run one of the OAT probe wires to a splice into the gray wire of the EIS. Remove the gray wire from the AHRS cable. The other OAT can go to about any ground, preferably close to the unit. Mine went to the E-bus ground.

The EFIS has 3 power inputs for the 3 units (AHRS, 2xDU). I have a dual battery system, so rather than have separate wiring to each battery with a switch, I chose to have dual wiring to the E-bus and a 5 amp fuse. IOW, I crimp spliced the three power wires to the unit and ran a single 18 AWG wire to the bus. Times two. If the primary fuse blows, or I have to switch to secondary power, I have two independent sources of power. I may end up putting a remote switch and a direct to battery spliced line in to the backup battery for a 3rd source of power. But I can't imagine that I would ever need a 3rd source of power. I may end up putting a 3rd battery up on the avionics shelf, and a remote switch, just in case I blow my whole electrical system (extremely unlikely). For now, KISS.

When the master switch is on, the EFIS is on, even during engine start. This may be hard on the units, but it's easier to contend with. I want it all turned on at the beginning. I want to look at the display units before engine start. Later on, I may re-configure the wiring to cut out the display power so that they shut off when the engine is cranking.

The EIS has a green/black wire that you splice to the DUs. The single serial out of the EIS goes to a single serial in on each of the DUs and can be a simple splice 1 into 2.

EIS (Engine Information System)

The EIS may not strictly be avionics, and probably should be covered somewhere else. But my Grand Rapids Technology EIS is directly linked to not only a bunch of engine components, but is really visualized by the EFIS. The EIS is the 6000 model for 6 cylinder engines. GRT still ships the original unit, and I suppose you could actually put it in your instrument panel, as builders have been doing for years. But I think the faceplate looks like shit, and there are so many pages with so little information, I chose to just hide the unit under the boot cowl, behind the instrument panel.

I fabricated a center avionics shelf that I screwed to the back of the instrument panel, and it is also screwed to the stainless firewall. It is level with the three axes of the ship . The main reason to build this shelf was to have a place directly behind the EFIS Display Units (DUs) to mount the AHRS. The AHRS is the guidance system and brains of the EFIS system. I also plan to mount the Plasma III electronic ignition modules on a separate self mounted over the top of the AHRS on the center avionics shelf. This was also a good place to mount the EIS unit.

The instructions that come with the EFIS and the EIS are definitely not cookbook. They appear to be fairly complete, but still leave a few details to the imagination. Where the EFIS has locations for 3 power inputs (but only one ground), the EIS only has one power input. And you can use up to a 5 amp fuse. After mounting the EIS unit to the pair of .025 formed brackets on the Plasma EI shelf, I gathered up the 2 EIS cables and figured out what each one was. The EGT/CHT cable is pretty easy to figure out. The wires are twisted pairs, 6 each for the EGT and for the CHT. They are inserted into the 25 pin connector in numerical order, so each twisted pair corresponds to each cylinder in order, and is also displayed for each cylinder in order on the monitor. I separated the wires and labeled the pairs, and put some shrink tube over the bundle at the EIS pin connection.

The other 25 pin connection cable is a little tougher to work with. Each wire is a different milspec wire color, so that makes it easy. But all the instructions give you is a diagram and suggestion as to what each wire connects to. In my case, there are 6 aux inputs, and I will probably use them all... as long as the input voltage doesn't exceed 5 volts. Well, that screws up a second battery voltage monitor.

Most of the wires from this cable are going back to the engine compartment.

I decided to separate the power and ground wires (red and black... how easy is that!?!) from the EIS and run them to the E-bus with the AHRS and DU power and ground wires. I used a bit of plastic conduit and zip tied it to the bottom of the instrument panel under the avionics stack. Then the wires loop over behind the keyed ignition and then down the right sidewall through the #2 bulkhead to the E-bus. There, the power wire works off a 5 amp fuse (the smallest smart glow size) and the ground wire is attached to the E-ground bus there, too.

There is no switch for the EIS unit. When the master is on, the EIS (and the EFIS) comes on. That way, you can monitor your engine and fuel status from the get go. When the master comes on, the LED readout of the EIS instantly turns on, self checks and displays the first page of information. The unit has pages and pages of parameters that are all changeable and configurable for many variables. That task looks daunting and I don't even have the thing connected to any components yet.

The first glitch was how to attach the serial output from the EIS to the DUs of the EFIS. Well, the EIS has one green/black wire, and the DUs EACH have a green black wire. Seems simple enough. Guess I'll get a splice connector, shorten the wires and run the one EIS output direct to the two DUs. I went ahead and emailed GRT before cutting any wires and asked just to be sure I wasn't missing anything.

Next confusing part was the OAT temperature sensor. Seems the EIS, the AHRS AND each of the DUs have input for this, too. The OAT sensor only has two wires. Time to email GRT for recommendations on that one, too. The OAT sensor has to have some kind of power to it...

Wiring notes:

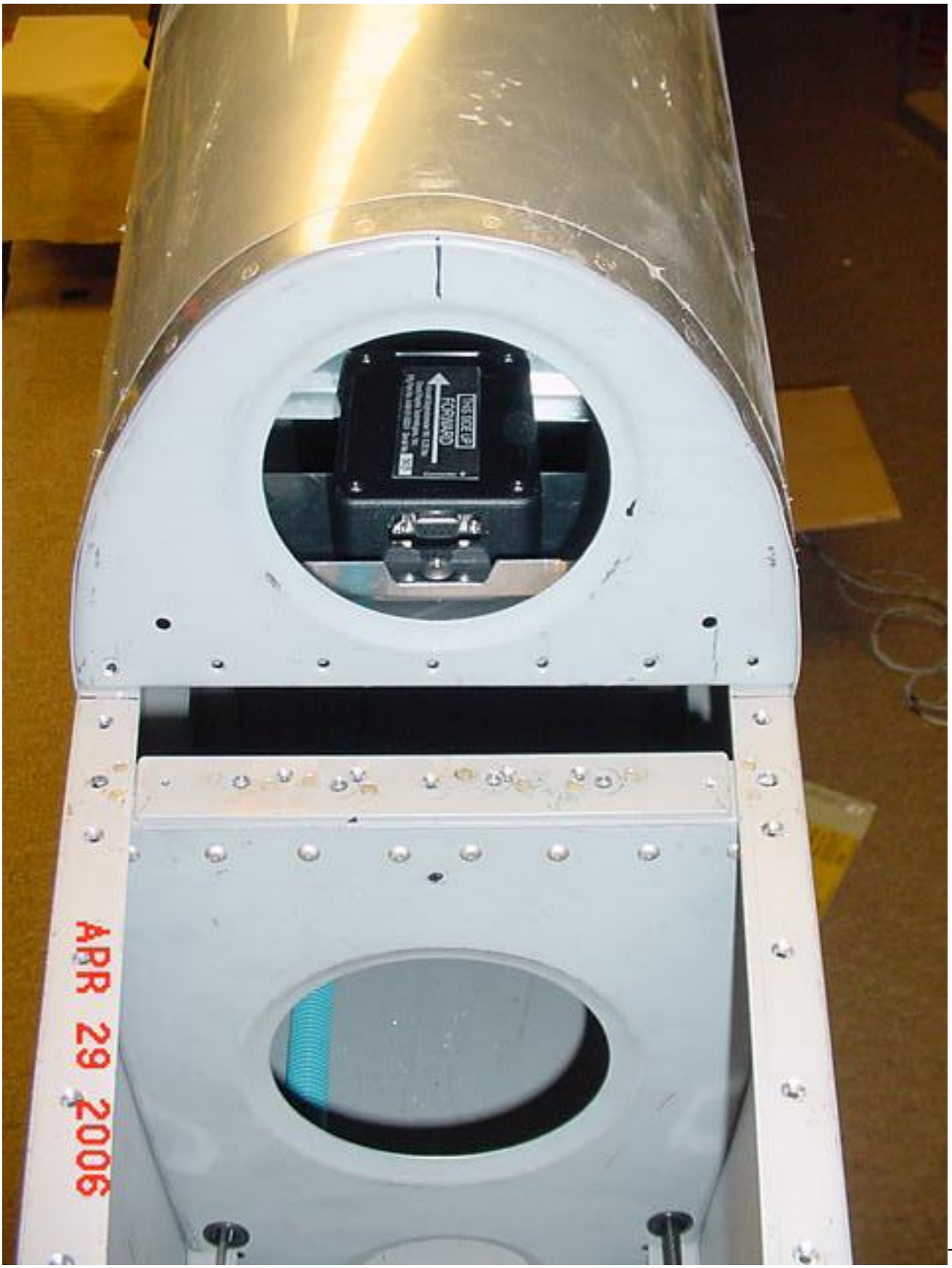
The OAT probe gets wired to the gray wire on the EIS, not the AHRS. Then the EIS tells the DUs what to display through it's serial connection. The AHRS does not need OAT input, so just skip wiring the OAT to the AHRS (unless you don't have the EIS).

The green/black wire of the EIS can be spliced to the same of the DUs. The serial out of the EIS goes to the G/B serial in of the DUs. Crimp a simple 1 into 2 spice.

I ran the single power and the single ground wires of my EIS to the E-bus. When the master is on, the EIS is on. 5 amp fuse.

GRT Magnetometer

The GRT instructions for the magnetometer are pretty complete and straight forward. Essentially, you want to keep that little black box away from anything electrical or magnetic. So you want to try to keep it 18 inches from ferrous metal and power lines, as well as a good 5 feet from antennas. Also, it has to mount within .5 degrees of the AHRS. Well, I went to a lot of trouble to level the AHRS with the ship so that it might make locating the magnetometer a little easier. I have the EVO wings, and have NO idea where I could locate the thing. I decided to put it back in the empennage. That has some drawbacks: it actually is close to about 6 AN3 bolts and nutplates, and if the thing needs serviced, more than likely I'll have to remove the vertical stabilizer. However, the nice thing about putting the magnetometer in the location I used is that it is automatically level with the ship (except for the twist inherent in the factory fuselage).



The location I used for mounting the magnetometer is just forward of the aft turtledeck bulkhead. It's just inside the big hole in front of where the veritical stab mounts to the tail. I used a 3/4 x 3/4 formed angle to make the front bracket. It sits on top of the longeron from side to side. The angle ended up a little over 9 inches long. I beveled the ends so that it sat flush and snug against the skin. I went ahead

and used #6 stainless screws and nyloc nuts to install it. I measured the exact middle of the bracket and drilled a hole for a #10 screw so that the middle of the magnetometer would sit centered in it's forward bracket. I made another bracket out of another formed angle of .032, but this one was about 3 inches wide. I made it just small enough to fit through the inspection hole at the aft end of the turtledeck. This bracket is not that much narrower than the front angle bracket. I also used a pair of #6 stainless screws and nyloc nuts to fasten that bracket to the tops of the longerons. I wanted to rivet the brackets in place, but there was just no way I could get in there. As it was it took me almost 3 hours to make these brackets. WHEW!

I measured the middle of the aft bracket as it sat snug between the turtledeck skins. I drilled for another #10 mounting screw on the bracket to sit the magnetometer smack dab in the middle of the plane. Since both mounting holes are centered and the brackets sit on the longerons used to level the ship, no further physical leveling of the magnetometer is required. Well, that's my story, and I'm sticking to it. Later on, I'll have to go through the adjustment program in the EFIS to get it all set up properly. Probably will have to allow for some interference from nuts and bolts in the area. Otherwise, this thing is out of the way of most everything electronic and ferrous!

Don't worry if the magnetometer in the picture looks offset a little. The cameraman was not quite centered, and neither is the label with the arrow on it. You'd think that if GRT though getting this thing set up properly was THAT critical, at least they'd put the ARROW on STRAIGHT.

Note that my angles sit with the web upwards. IOW, they sit completely on top of the longerons and go upward from there. I had to bevel the web a bit to allow for the converging curvature of the turtledeck. Also, note that I had to make a rather large and deep notch in the bracket to allow for a pin connector to screw on the back of the magnetometer. Yes, that weakens the bracket a bit. The magnetometer, however, is about as light as a feather. The drag from the cable would probably weigh more than the unit itself, so I think the two formed .032 angle brackets are more than sufficient to support the magnetometer.

Now to wire it up... I ran the 6 wire cables from the AHRS down the right side of the instrument panel and then around the battery to the forward stick bay. Here the 6 wire bundle will have to penetrate the wing spars though the carry through. Then I ran the magnetometer wires along the right side inner wall. I swapped the wires to the left side of the ship under the baggage floor, using a piece of 1/2 inch conduit under the elevator push tube. I then ran the bundle through the existing conduit to the tail end of the turtle deck. A couple of the pins broke en route, and the wires weren't the same length, so I cut them and crimped all new pins. A little shrink wrap and then screwed together the connector housing, some zip ties to restrict the wires away from the push tube and cables and it's time for a test run.

BTW, the instructions from GRT say to use brass or nylon for mounting the magnetometer. I bought a couple #10 screws and nuts in each material and found that both of them were not sturdy enough for my tastes. The brass was too soft without locking washers (could have used thread locker, I guess) and the nylon would not stay tightened and the nut wanted to jump threads on the screw. So I just used non-magnetic stainless steel. Hope it works OK.

I powered up the EFIS and found that the horizon and ball and slip indicator were slightly off. Hmmm... guess the fuselage IS leaning to the left and bit, with the tail sitting a bit wonky. IOW, the artificial horizon seems to be working properly.

EFIS Upgrade: Memory, Hardware and Software

Fall 2006 I was working in the cabin installing plumbing for the fuel system. I decided to sit in the cabin and make airplane noises. While playing with the EFIS, I noticed that it had last year's software, so I decided to try to update it. That's actually pretty easy.

When I first was looking at the GRT Horizon I, I thought I would have to get a laptop and take it in the plane with me to update any software. Not the case at all. There are USB ports in the back of the units for input and output. I saw that GRT had system software updates. It was just a matter of copying the software from GRT's website onto a USB memory stick, plugging it into the back of each unit, and then going through the menus looking for update prompts. It was pretty painless.

The GRT Horizon I

EFIS units are somewhat like large PDA's. They run on Windows CE. They do have an accommodation on the motherboard to accept a Type I pc adapter and a compactflash memory card. GRT will tell you that they have only tried a 32 MB cf card, but that it is likely that a 2 GB card will work. At this point in time, I didn't feel like spending $100 for 2+ gig cards, but found 1 GB cards for under $30. 1 gigabyte has room for a LOT of software.

I opened the units (13 screws to remove the case) and simply pressed the adapter to position. It can only go in one way. Easy. Then I pressed the cf card to place and closed the case.

The EFIS software system didn't seem to recognize that I had preloaded the memory cards with all the upgrade software. The unit still prompted me to load the software from the USB port. So I re-copied the upgrade software to a 256 MB USB memory stick and used that in the USB port.

EFIS TERRAIN Data

The GRT system now has detailed terrain data for the entire world available for installation into the EFIS. I had to first update the system software (via USB memory stick). Supposedly, there's not enough free memory in the stock DUs,. so you are prompted by GRT to add memory to each of the units to store the terrain data. I wouldn't be surprised if the memory upgrade can be used for more than just terrain data in the future. The website has instructions on what and how to install for memory upgrades.

I had preloaded all the most recent software from GRT onto the compactflash memory card, but the units didn't seem to recognize it. I finally ended up copying the TERRAIN_NW.DAT file onto my USB memory stick, and then changing the file name to TERRAIN.DAT . GRT's release notes say that this isn't necessary, but that's what it took to get the EFIS system to upgrade/input the software. Finally, I got the "operation complete" message on the EFIS screen. Now I have terrain data in each DU for all of North America, not just the US, which is the "default".

Garmin Stack

Fall of 2007 I finally had a rolling chassis in my hangar. Time to cough up the dough and get some radios. I stuck to my original plans and ordered a Garmin stack from Start Avionics in Georgia. They asked for a check for the full amount in advance, and 3 weeks after they get (clear?) the check, they will wire up the radios (and the TruTrak Digiflight II) and ship it to me.

The top of the stack is a Garmin GMA 340 audio panel. I do fly IFR, so I wanted the marker beacon and other features of the audio panel tying all the radios together.

The key radio in my stack is the Garmin GNS 480. That is actually a Garmin AT. It has been WAAS enabled for years, where the 430W and 530W just came on line earlier this year. I figure that with 4 or more years in service, the 480 is probably the way to go. It operates like a flight director. That doesn't mean much to me, but evidently those that "fly the line" in the big iron seem to think this is the way to go. At least the general format/function is familiar to them (not me).

The "backup" or "secondary" nav/com is the Garmin AT SL30. I really didn't need another GPS, both the 480 and the GRT EFIS have WAAS enabled GPSs in them. However, I did want a solid back up com and nav with a glide slope. The Garmin AT SL-30 and SL-40 (no NAV) radios have some great features and are very reliable.

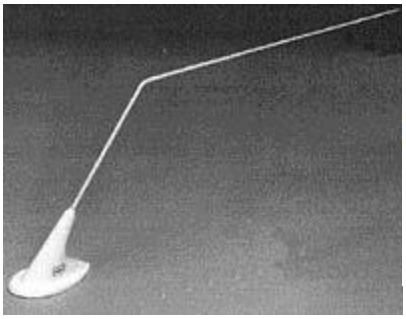
The transponder is a Garmin GTX 327. Nothing fancy here (although it is solid state and "digital"). I didn't opt for the traffic and whatnot on the more expensive models, I just didn't think it necessary with my type of flying.

Antennas

The radios don't come with antennas (exception: GPS antenna with GNS480). So I figured out what all I needed and made an order with Aircraft Spruce. I already bought some RG400 cable, but no BNC connectors, so I ordered some of those, too. I hope my friend Jeff Tucker can help me crimp the cables and install and test the radios. In fact he offered to actually MAKE me a couple com radio antennas. More on that later.

Note: Stark Avionics recommends a special splitter made by Garmin to use with a combined NAV antenna. That costs an extra $125 in 2007. Evidently the NAV signals interpreted by the Garmin radios is picky, so the Garmin splitter converts the signals to something more tolerable and useable by the radios.

The main COM antenna is



your basic bent whip AV-17. I decided to hang one from the empennage

belly somewhere.

The marker beacon antenna is a "boat" type AV-569. Maybe I can put this under the cowl and mount it facing downward under the engine. More than likely it'll end up at the front of the belly, close to the transponder antenna and the firewall.

The transponder needs to pick up DME, so I bought the AV-22 stick and ball type basic antenna. Maybe slows me down .32 knots over the low profile aerodynamic models. Cheap, simple. durable.

The NAV antenna is a combined VOR and Glide slope "wisker" antenna. I bought a CI-158C "V" DIPOLE VOR ANTENNA. Most builders put the antenna up on top of the vertical fin. I'm considering putting it on the empennage under the horizontal stabilizer, near the tailwheel. That makes the cable run a little shorter and easier. It also lessens the likelyhood of someone poking their eyes out. Hopefully it will also keep a cleaner look to the airframe.