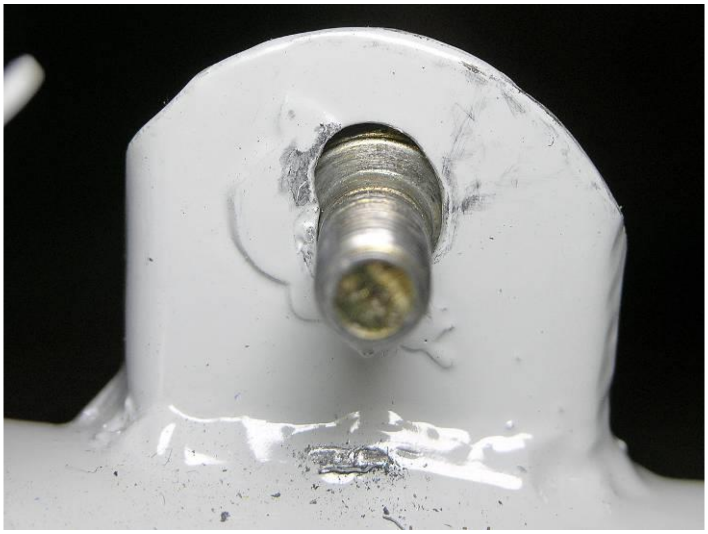
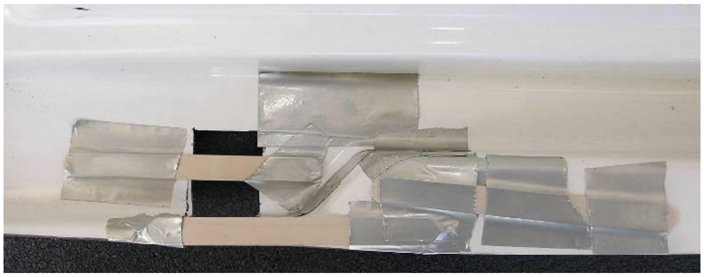


Sunday morning May 10th -- I wish I'd caught this before I had the frame powder coated. This morning I decided to install the directional control pedals. I had the pedals chromed and they look fantastic but when I began mounting them I discovered another example of extremely poor workmanship from one of the three previous owner/builders. You're looking at the right hand mounting bracket for the pedal assembly, with the mounting bolt inserted in what should be a tight-fitting hole. This hole has been completely butchered.

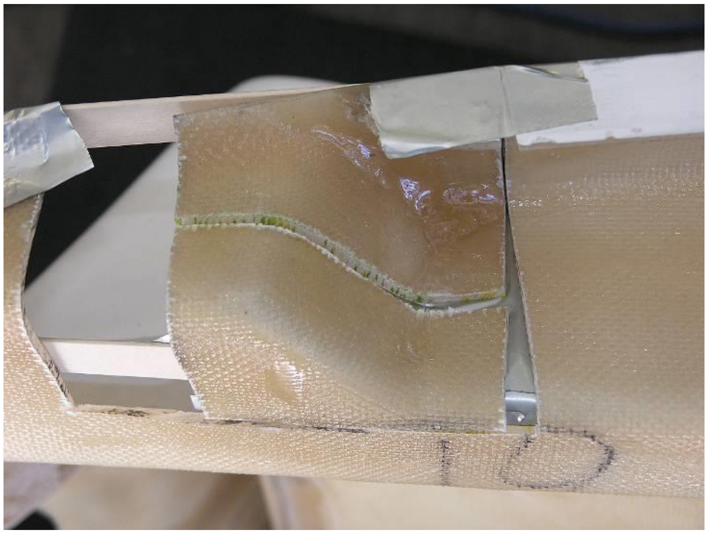
If you're thinking of buying a partially completed Helicycle you need to be very careful. My kit was already third hand. There's just no way for a potential buyer to examine a kit and tell if there are problems. It's only after spending hundreds of hours working on it that you'll develop the knowledge you need to inspect a kit, and even then I think it's impossible to check everything. I'm not suggesting that purchasing a partially completed kit is a bad idea, but I believe the value of the kit depreciates once someone starts working on it. It's not until it's bought off and flying that its value might increase – it's just my opinion.

In my case there were just too many previous owners. It's not the end of the world, but I may have to cut this bracket off and have a new one welded on which will trash the paint. I really don't like the design of this mounting scheme to start with.

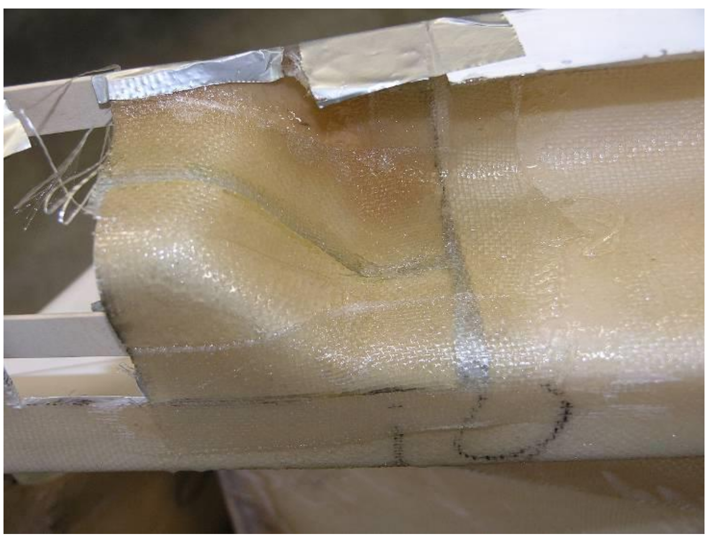
The pedals mount to brackets at either side using aluminum bushings. The bushing gets greased and safety wired but aluminum gals and doesn't make a good bearing. The inside of the tube is rough which doesn't help. I used a honing tool to clean it up but it's a very crude design. BJ was trying to put out an affordable kit and I understand that, but this particular area bothers me. It's certainly safe, but it's crude.



While I think about what to do with the pedals I picked back up on the seat pan collective well. The throttle grip at the end of the collective was bumping into the side so I needed to enlarge it. Here's the piece I previously cut out held in place with Popsicle sticks and aluminum tape.

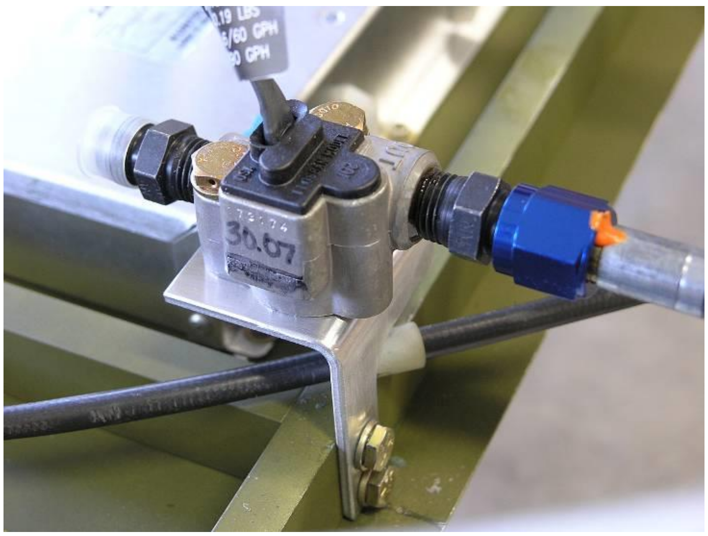


It was more complicated than I though. The well slopes so I had to cut that section with the compound bends in half horizontally to spread it apart. So now I have two separate pieces to glass into place. I used the 1-inch glass tape that I picked up last week. I through I was working very fast but I was surprised when I finished this little project and started to clean up. When I picked up the paper cup with the resin it was already set and very hot. I'll have to remember how fast that resin set up.



Here's my first real effort at fiberglassing. I tried to use the resin sparingly so it won't fill in the gaps and ooze to the other side. The next step will be to fill in the two big holes – this one to the left and the monster hole I cut for the master electrical power switch when I was planning to mount the batteries under the seat.

This is a perfect place for the transponder antenna (red arrow.) There's no need to worry about its proximity to your seat. There is a null on the top side of the plate and the average power transmitted by the transponder is low. People get confused by the published output power which is several hundred watts. That's peak power, not average. The transponder spends most of its time waiting for an interrogation signal and then responds with a short digital pulse stream and shuts back off. RF in non-ionizing radiation and the mechanism of injury is thermal heating which is a function of the average power, not peak power.

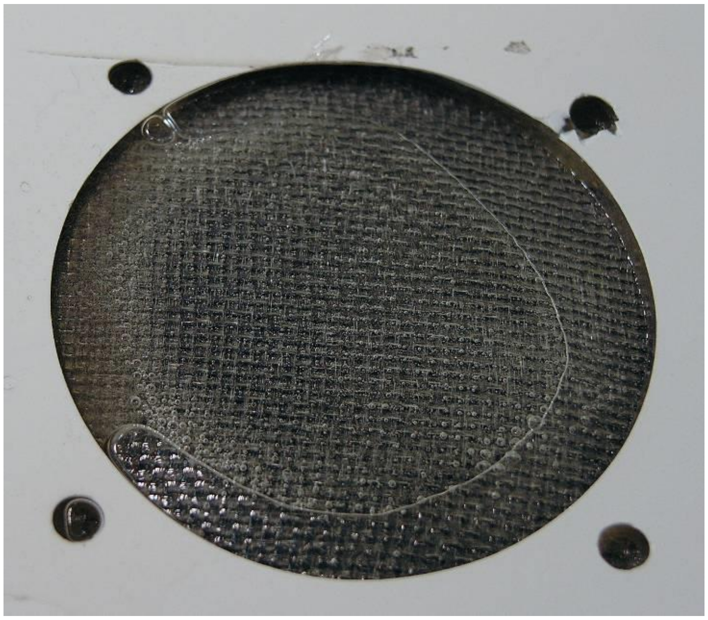


Meanwhile, back on the top side… I mounted the fuel flow transducer on this bracket I carved out of a bent piece of aluminum I had in my goodie bin. Now that this is secured in place I can size up the Aeroquip line from the Andair main fuel valve. I put a dab of Torque Seal on each fitting to remind me that it's completed. I'll also be able to tell if anything is coming loose during a preflight.

Per the manufacturer assembly instructions I fabricated the last Aeroquip fuel line linking the fuel flow transducer to the main shutoff valve and I happened to look inside the line. I didn't like what I saw so I pushed a small cotton gun patch through the line using a long tie-wrap. Here's what came out the other side. It's mostly rubber mixed with a few reflective bits that must be steel fragments from sawing the hose. I pulled the other line I made earlier and found the same thing.

Juan Rivera

May 9, 2009 – This is what the project looks like after a little over nine months of steady work. I'm very pleased with how the project is going. I've probably averaged at least twenty hours a week so that would put me at about eight hundred hours. I've certainly learned a lot.



This is the front side of the large hole I cut to mount the electrical master switch. I covered this side with a piece of aluminum sheet that I belt slightly to conform to the surface, and I lined it with Mylar. The resin has flowed across most of the hole and formed a perfectly smooth surface as far as it went.

Suggestion from Tap Plastic – measure the resin and catalyst in separate cups. Then mix them together and pour from cup to cup to insure that you have all the material thoroughly mixed. That way you don't leave part of the catalyst on the side of the cup and mess up the mixing ratio.

And this is the inside of the collective throttle well. The top piece is a tad too wide where it rolls down into the well at the left side of the picture. I'll have to sand that radius down. Also the fiberglass didn't make that lip at the top of the wide area. I'll have to cut that out and try again. I'll also reinforce the rear side of both patches.

One last item to close out is this fuel tank cover plate. Sealing it with Permatex Aviation Form-a-Gasket was a disaster because that stuff stays gooey and mixed with the polish when I tried to shine it. I switched to 3M Marine Fast Cure 5200 adhesive sealant because it was flexible and available at Tap Plastics. It looks like it will do the job. Once I get the tanks installed I'll leak check them and find out.

(This turned out to be bad idea #2…)

In my haste to finish these cover plates and get them behind me I forgot the reason they're there in the first place. You need access through the hole to install the mounting hardware. Duh! When I pulled the covers back off I was surprised to see that the sealant inside the fuel probe area was still a paste and hadn't set up. That makes perfect sense since it's a one-part adhesive. It dries with contact to the air. It has also oozed down inside the tank which got me thinking of the likelihood that it was not impervious to fuel and would probably deteriorate and end up clogging my fuel filters. I found a fuel tank sealant at Aircraft Spruce and considered that, but Hap Miller had a much better idea, so here's plan #3:

This is one of the #8 socket head cap screws that are used to secure the fuel cover plates. I've added a small tight-fitting washer and a Buna-N o-ring. Buna-N is the best choice for compatibility with jet fuel.

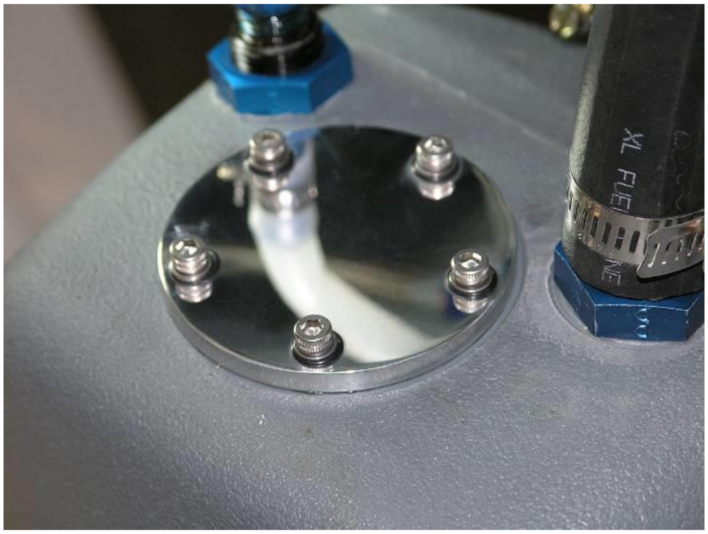
The o-rings came in a pack of 20 for $3.50 from Motion Industries – part no. 1 00192 S 20606.

The next step is to carefully countersink the top of the fuel probe and right hand cover plate to provide a seat for the o-ring when it's compressed…

In the process of trying to mount the fuel probe I managed to drop the nut plate in the left tank. While looking in there with a flashlight I found these blobs stuck to the bottom where they oozed out during my second attempt. I know for a fact that this stuff breaks down in Acetone in a few hours and now I suspect that it doesn't like jet fuel either. I'm sure it would end up as scum clogging my fuel filter sooner or later. Getting it out was not easy. I had to pry it loose with a rod and then use a flexible grabber to pull it out. I attached a clean rag to the grabber and jammed it into the tank and worked it around after that. It came out with lots of small specs of unknown material. Now the inside of that tank looks pretty clean. I'll do the same for the other tank.

Based on this experience, and assuming that the o-ring method doesn't leak, I'd stay away from forcing sealant down the mounting holes as a way of sealing the tanks.

Juan Rivera



After dropping the nut plates three times I finally managed to get both sides sealed up. If you're as coordinated as I am I'd suggest getting a hardware store grabber because it will come in handy. It's a flexible tool with four little fingers that spread out when you push on a plunger at the other end.

I may need to go back and increase the size of these very small washers. At least this method looks a lot nicer than the first two attempts. I'll find out if it works tomorrow.

I have the lines to the aux tank stubbed off and I haven't decided whether or not to install that tank. Tomorrow I'm going to fill the tanks to test for leaks and then run the electric boost pump to test the free-flow flow rate using the JPI 450 fuel flow meter. I'll take the output of the line to the engine and loop it back around and into the top tank. I'm also hoping to flush out any remaining debris now that everything is sealed up tight.

These small washers were too small and one of the o-rings bulged out from under it and I had a small leak. I swapped out all of the washers for larger ones and tried again. The next time all of the cover plate and fuel probe screws sealed up perfectly but I managed to squash one of the large diameter o-rings that are under the fuel probe. I'll have to replace that one and try again.

I managed to get fifteen gallons of gasoline into my tanks before I found the two leaks. The larger washers fixed the first leak but I'll need another o-right to fix the second one.

I used one electric fuel pump to pump fuel into the tanks from the red containers and the ship's pump recirculated the fuel from the engine fuel line back around and into the fill port. I wanted to get enough flow going to try to wash out any debris that might have accumulated. When I cleaned out the Gascolator all I found were a few pieces of lint from the rags I used to clean the inside earlier.

This leak test also gave me a chance to check out the JPI fuel flow meter and measure the free-flow flow rate which measured 27.8 GPH. That's encouraging and shows that the electric boost pump can easily provide the twelve to thirteen gallons per hour that the engine consumes.

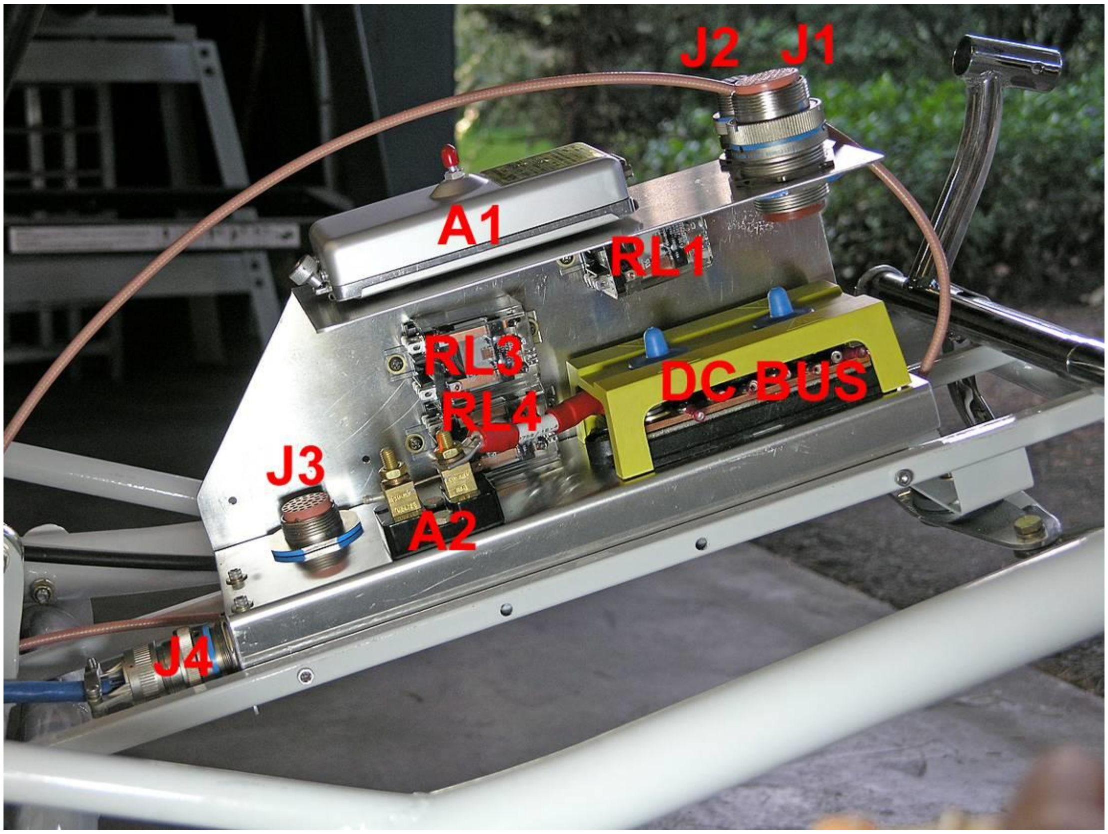
Juan Rivera

It's starting to look like a helicopter now! I've installed the directional control cable and the pedal assembly which is now preliminarily rigged. I also fabricated a plate that mounts at the bottom of the instrument pod (in the foreground with blue painter's masking tape on it.)

I'm making a bracket that will mount a circular military connector at the back where the blue cyclic cable is sitting. All cables will enter the instrument pod underneath this plate which will mount all of the interfacing connectors – also circular military style. The only exceptions will be RF coaxial cables which will exit out the front and go directly to the radios.

Looking into the back of the lower instrument pod bracket you see where the cyclic cable will plug in. I'm not a huge fan of rivets or nut plates so I'll just screw this bracket down with two 6-32 screws and locking nuts. If I thought I'd ever have to remove it while it's mounted in the helicopter then I'd use a couple of nut plates on the bracket.

Sunday, May 17 -- Once I started this project I realized that I needed to revisit my earlier design and look at it from a higher level (see next page.) I want to be able to disconnect a few connectors and remove the top instrument panel completely and also swing the bottom one out to gain access to the bottom of the pod. I also need to be able to do maintenance on the components and adjust the encoding altimeter.

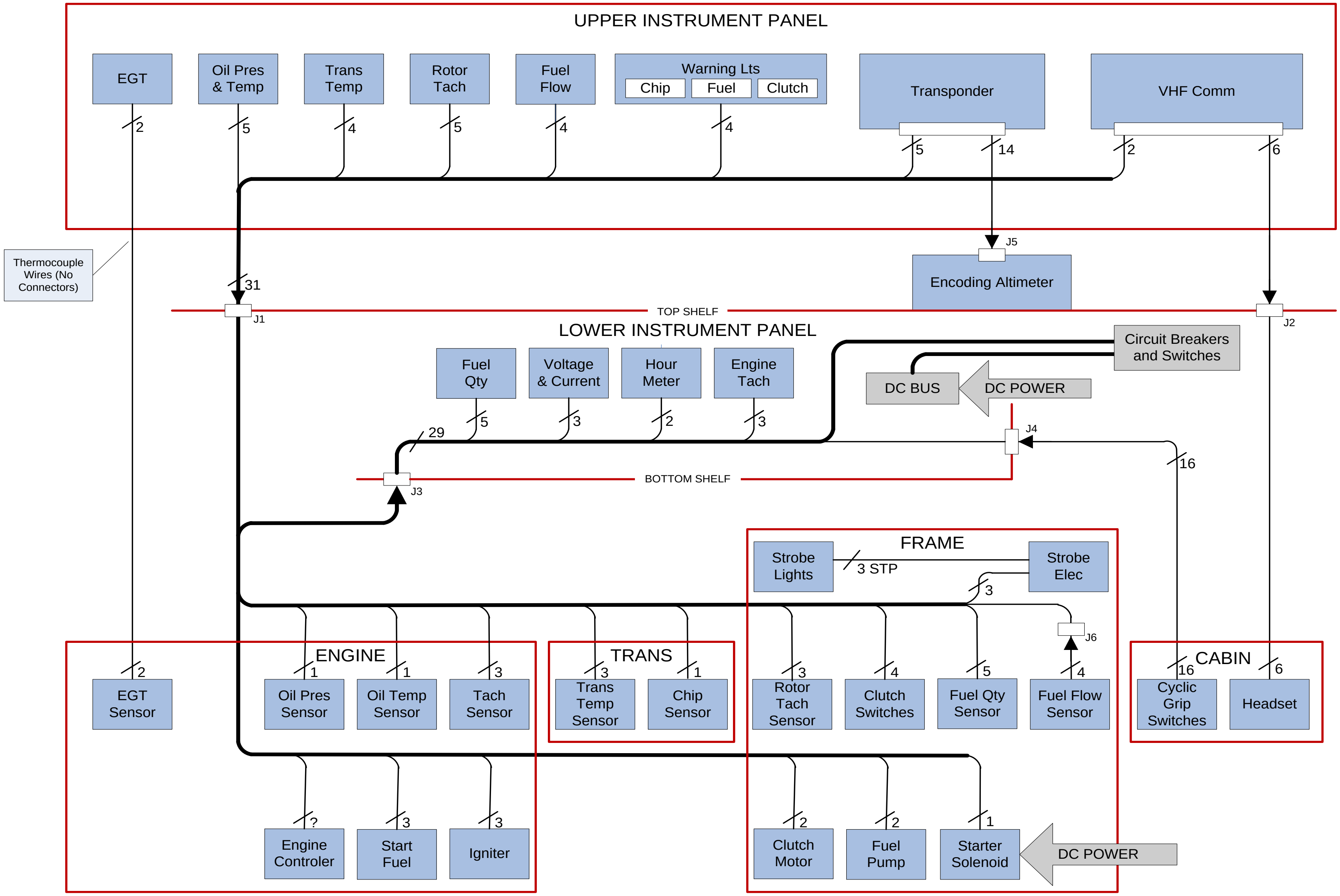


Wednesday May 20 -- Here's the half finished lower chassis. It will sit in the bottom of the instrument pod behind the lower panel. I'll describe the major pieces:

J1) Upper instrument panel interface
J2) Headset to the VHF Transceiver interface
J3) Lower instrument panel interface
J4) Cyclic grip interface
RL1) Starter solenoid control relay
RL3,4) Clutch engage and disengage control relays
A1) Encoding altimeter interface to the transponder
A2) 20-Amp Ammeter shunt
DC Bus) Distribution point for all electrical power

The block diagram on the next page shows a high-level view of the entire electrical system as I see it now.

Helicycle N750G Electrical Block Diagram



On the next page I've placed my wiring interconnect drawing. It includes all of the sensors, actuators, and wiring associated with the engine and transmission. This is the first time I've been able to get a handle on what exactly gets connected to the engine. Since I don't have my engine yet, it's been hard to drill down to the level of detail I need to design my electrical system.

For the most part I've followed the factory design with a few important difference dictated by my desire to improve on the EMI mitigation techniques implemented by the factory. If properly implemented the factory design works but I'm not comfortable with it. Here's a short explanation of why:

When you think about EMI (Electromagnetic Interference) you have to look at four aspects:

- Radiated Emissions
- Conducted Emissions
- Radiated Susceptibility
- Conducted Susceptibility

The first two are going to be generated by the VHF transceiver when I key the push-to-talk switch. Since the whole point of the transmitter is to radiate RF energy all we can do is try to send it off into space and keep as much energy away from our sensitive electronic equipment as possible. I'll take the first bullet first – if the antenna is functioning the way it's intended it has an omni-directional pattern in the horizontal axis. The pattern should look like a donut with the antenna element pointing down through the hole. If the antenna is not properly matched, which will happen is no ground plane is available, then the pattern will be distorted and it's impossible to know where that RF energy is going, and a portion will be reflected back from the antenna and never be radiated at all. So a properly operating antenna is the first thing to tackle and I've done that. That takes care of radiated emissions. The next bullet deals with energy that is conducted from an emitter via wiring. By using good quality double-shielded coaxial cable I've done what I can to minimize leakage in the coax. This will reduce coupling into other wiring as much as possible, but braided shielding is only 80 to 90 percent effective. I'll take care not to bundle the coax with other wiring to minimize coupling.

The next two bullets deal with reducing susceptibility of electronic equipment to EMI. The interfering energy can arrive in the same two ways – either through the air (radiated) or through a wire (conducted.) We attempt to minimize radiated susceptibility by shielding the equipment inside of metal enclosures. But all enclosures are not equal. Any small openings or cracks can reduce the effectiveness of the enclosure. I've tossed out the factory sheet metal box design and gone to a die-cast aluminum enclosure that I think is an improvement, but it's not perfect. Ideally the lid would mate to the enclosure with nicely machined surfaces and a metallic EMI gasket. I'm going to lap the rough surfaces to get them as smooth as I can but I probability wont have a gasket in the lid since I don't have the material and the lid doesn't lend itself to a gasket. It may be good enough.

The next aspect of shielding to minimize radiated susceptibility is to shield all of the wiring. And if possible to use twisted pair wiring for all balanced signal lines[1].

---

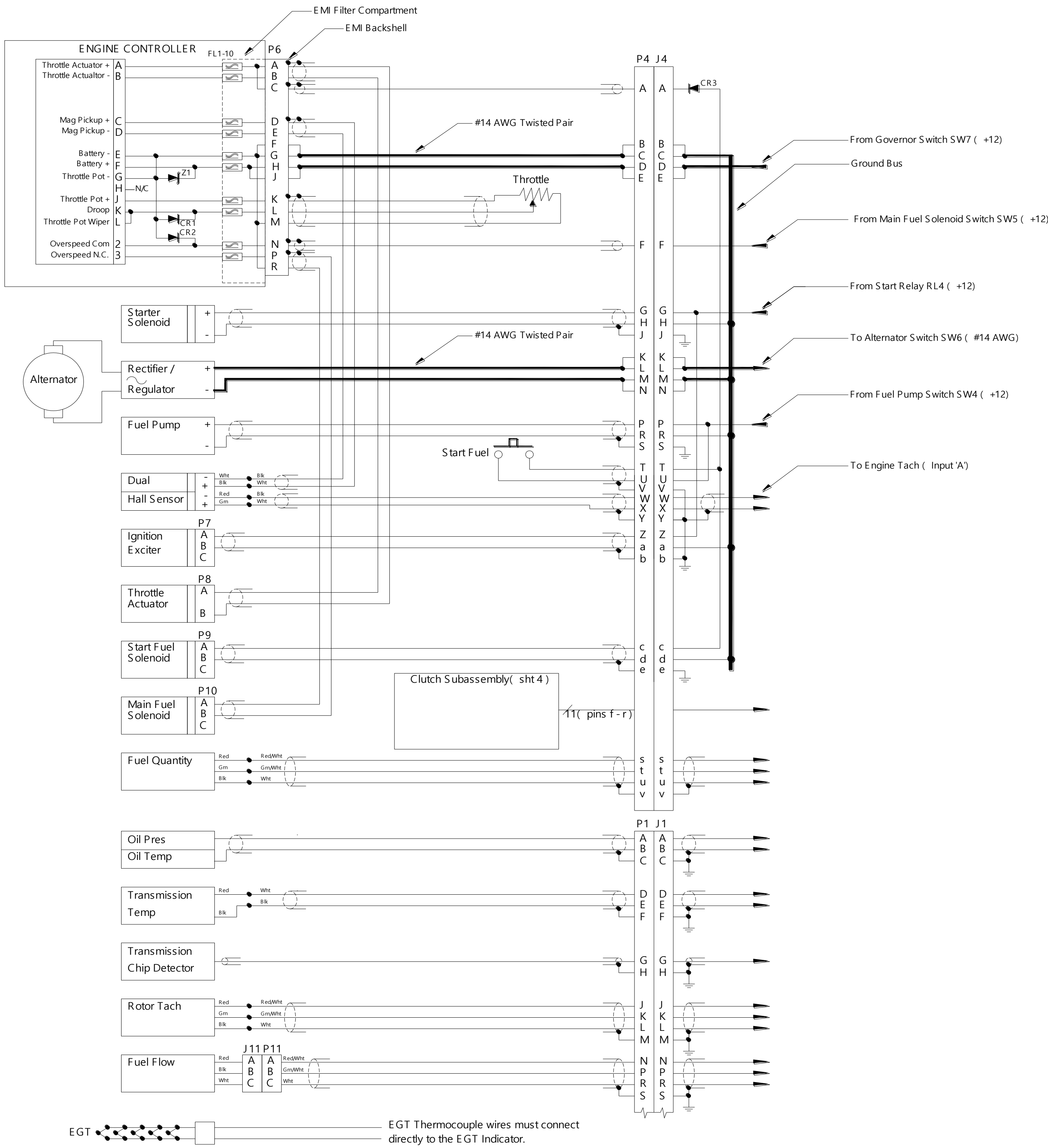
[1] Coupling into the wiring from adjacent conductors is cancelled out by the twists.

This type of wiring is called STP (shielded twisted pair.) Shielding wiring is not as straight forward as it may sound. You need to avoid ground loops which are multiple current paths. You normally do this by floating one end. In my design I've tried to do this in two ways – by having one common DC ground point at the DC power bus in the instrument panel, and by connecting all of the engine control line shields to the main engine control connector's backshell. I'm using a special backshell called an EMI backshell that is especially designed for this purpose. To visualize this scheme think of the cable shields as extensions of the chassis. The idea is to have one continuous shield that encloses the engine controller and all of its wiring. As wires pass through intermediate connectors on their way to a final destination the shields are carried through the intermediate connectors without being grounded (they "float".) When the wiring finally reaches its destination the shield stops and again, it is not grounded. By only grounding the shield at one location, usually the source, I've prevented ground loops. I may not have been 100% successful because the oil temp/pres sensor uses the engine as its ground. Also some of the indicators use single-ended inputs, meaning that the common input to the indicator is the power ground. So instead of the signal traveling neatly up a shielded cable from the sensor to the indicator, the ground return path takes a circuitous route through the engine frame, across a braided ground cable, up the -12 DC power line to the DC bus, and then up the ground return to the instrument. There's nothing I can do about that except to throw away all the inexpensive sensors and instruments, so I'll live with it.

Now we come to the last bullet – conducted susceptibility. In spite of my best efforts some RF energy is going to couple into the aircraft wiring. After all, I'm radiating 10 watts of energy in close proximity to the wiring and the sensors. So something has to be done to filter the EMI as it comes into the shielded enclosure where the engine control is located. The electronics industry has been dealing with EMI for decades. In top-quality equipment, for the military or aerospace, all sensitive electronics is usually housed in a two-compartment milled enclosure with an EMI gasket on the lid. All wiring enters the first 'dirty' compartment. The wiring must then pass through the adjacent wall leading to the second compartment where the electronics is housed. The common wall contains EMI filters that are specifically designed for the application, so the EMI stays trapped in the first compartment.

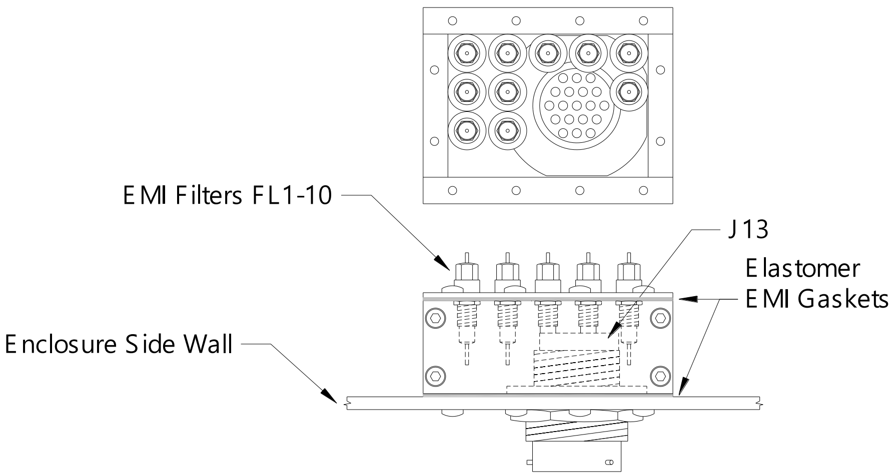
In the pages that follow the engine subsystem schematic you'll see my implementation. I milled the small box from ¼" flat stock and screwed the side together with socket head cap screws. The box surrounds the engine control connector J13 and is secured to the side of the enclosure with twelve 4-40 screws. I've fabricated EMI gaskets that mount between the small box and the enclosure and between the small box and its lid. That should keep the small box completely RF-tight.

Penetrating the small box into the large enclosure are ten Tusonix EMI filters – one for each line. These filters have an insertion loss of 75 dB between 100 MHz and 1 GHz. So energy passing through the filters anywhere in the aviation band will be reduced in power by a factor of approximately thirty five million. That should do the trick!

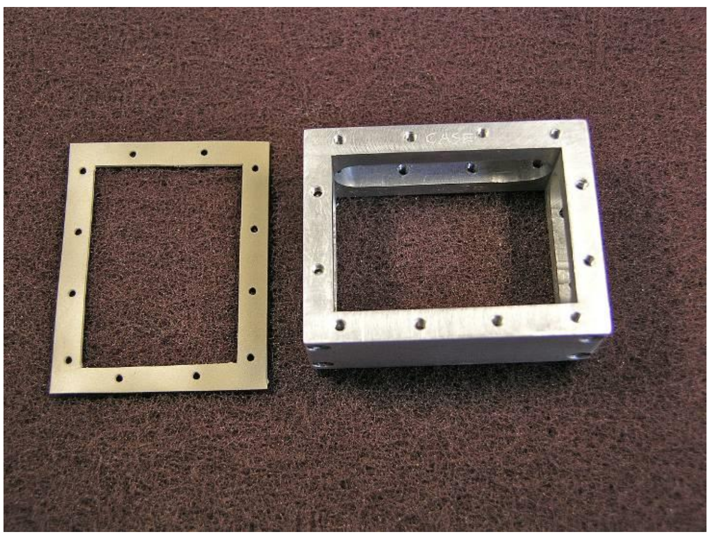

EMI Filter Compartment
EMI Backshell
ENGINE CONTROLLER
FL1-10
P6
P4 J4
CR3
Throttle Actuator +
Throttle Actualtor -
Mag Pickup +
Mag Pickup -
Battery -
Battery +
Throttle Pot -
N/C
Throttle Pot +
Droop
Throttle Pot Wiper
Overspeed Com
Overspeed N.C.
Z1
CR1
CR2
#14 AWG Twisted Pair
Throttle
From Governor Switch SW7 (+12)
Ground Bus
From Main Fuel Solenoid Switch SW5 (+12)
From Start Relay RL4 (+12)
To Alternator Switch SW6 (#14 AWG)
From Fuel Pump Switch SW4 (+12)
To Engine Tach (Input 'A')
Starter Solenoid
Alternator
Rectifier / Regulator
Fuel Pump
Start Fuel
Dual Hall Sensor
P7
Ignition Exciter
P8
Throttle Actuator
P9
Start Fuel Solenoid
P10
Main Fuel Solenoid
Clutch Subassembly(sht 4)
11(pins f - r)
Fuel Quantity
P1 J1
Oil Pres
Oil Temp
Transmission Temp
Transmission Chip Detector
Rotor Tach
J11 P11
Fuel Flow
EGT
EGT Thermocouple wires must connect directly to the EGT Indicator.

Juan Rivera

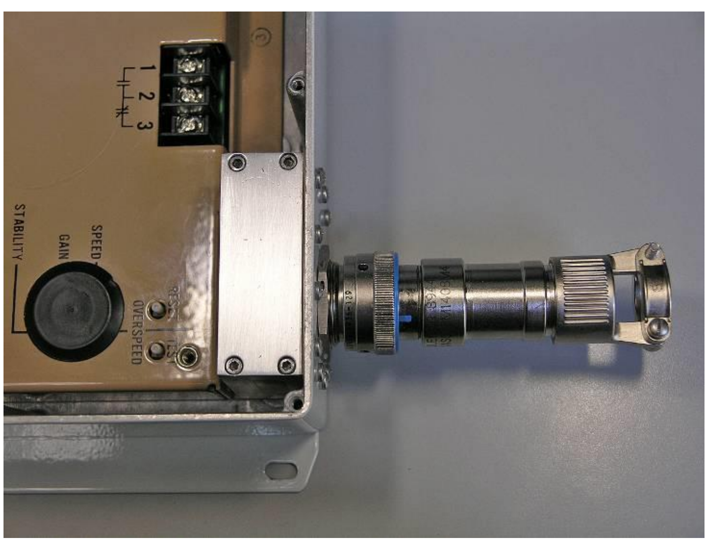
EMI Filter Compartment Within Engine Controller Enclosure



Unless it's extremely simple I always CAD my design and then work off of the drawing. This little box is absolutely crammed with components. I should have made it wider but my electrical design changed several times after the box was already built and I didn't want to start all over again.



This is the finished EMI enclosure with one of the elastomer EMI gaskets. I surfaced the top and bottom sides after attaching the four pieces. Match-drilling the twelve mounting holes to attach this box to the engine control enclosure, and the lid to the box, is an example of why a drill press isn't really up to the job. It's almost impossible to maintain the accuracy you need to make all these holes line up. In spite of my best effort I still needed to get out the jeweler's rat tail file and oval out a few holes in the lid.



Here's the EMI box mounted along with its gasket. It was a very tight fit and I should have used a larger enclosure, but this is what I have and it will just fit if I modify the controller chassis slightly.

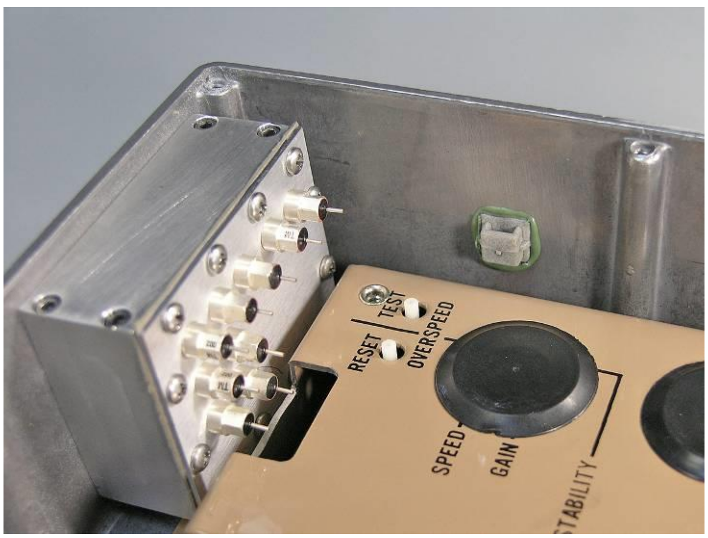
You can see the twelve screws that hold the EMI box to the side of the enclosure. It's much easier to line these up using a mill!

You also see the special EMI backshell on the connector.

Juan Rivera

I discovered some great epoxy-bonded fasteners from a company called Click Bond. I've installed three small tie wrap mounts to secure my wiring harness. Each mount is attached to a disposable fixture that holds it in place while the epoxy cures. The fixtures have double-back tape to secure them to the surface, and they are designed to apply pressure to the mount while the epoxy cures.

Lockheed/Martin is using these products on the F35 Joint Strike Fighter so they should be pretty good for the Helicycle too!



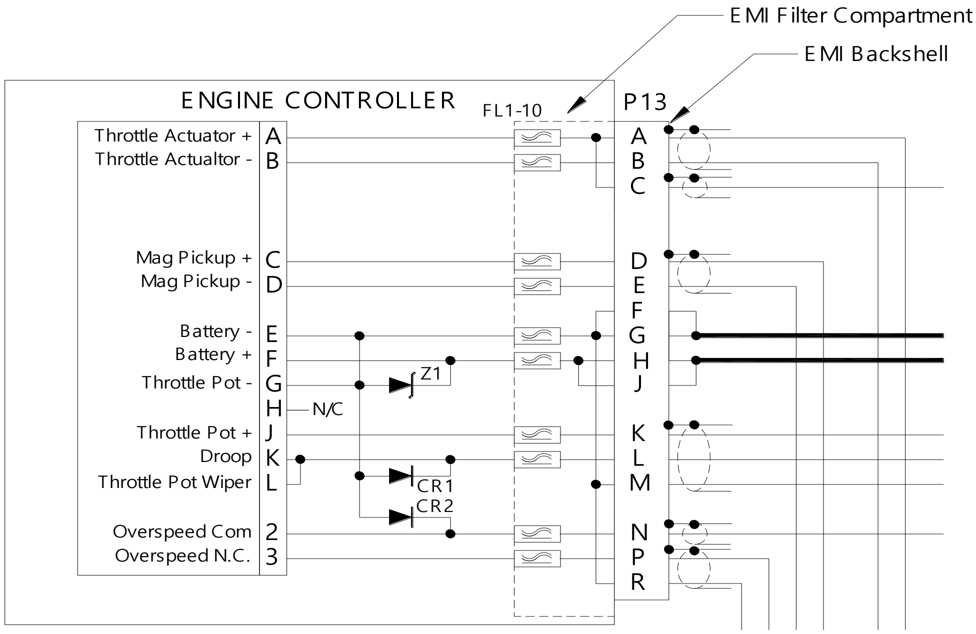
Here's what the mount looks like after the disposable fixture is removed. Notice how tight my box is. I had to mill a cutout in the controller's case to clear the EMI filters.

I almost made a very common mistake and mixed my power grounds with RF grounds. They are completely different and need to be treated differently. RF ground wires need to be as short as possible and go directly to the chassis. The connector's EMI backshell takes care of that. But I had the –12 V power going to chassis ground inside the EMI enclosure

There are two things wrong with that; first, the DC path to the main enclosure and the controller electronics would be through the EMI gasket and it isn't designed to pass a lot of current. Secondly, the -12 V input to the engine controller is floating (I checked.) If I ground it to the chassis as I had planned then I have a ground loop. One path would be via the ground return cable to the ground bus and the sneak path would be through the case to the aircraft frame, back through the common ground point near the starter, and then back to the ground bus via the starter DC return. This is the sort of subtle design flaw that can cause weird problems to crop up.

I'm now floating all of the grounds in that chassis. All ground returns go back through the +14 ground return cable to the ground bus just like they're supposed to. I just have to add one more EMI filter to the lid since this picture was taken and I'll be ready to wire it up.

Juan Rivera



Here's a detail of the engine controller chassis showing how all the DC returns go straight back to the ground bus via P13, pins 'F' and 'G'. All of the RF shields still terminate directly to the case via the EMI backshell. This is a critical distinction that most folks don't understand.

Just to get this straight in my head, here's the plan: +12 V from the bus passes through circuit breaker CB7 and switch SW7 and out to the cable harness via two pins in connector pair P4/J4. I'll use two more pins for the ground return to the ground bus. I doubled up the pins since they are not rated for the expected current. Coming out of P4 I'll splice each pair of #18 wires to a single #14 wire, and since #14 shielded twisted pair cable is not readily available I'll settle for twisting them with no shield. Did I mention why wire pairs are twisted? It's because the electric field in any adjacent wire will cancel itself out every time there is a twist. This minimizes coupling between adjacent conductors.

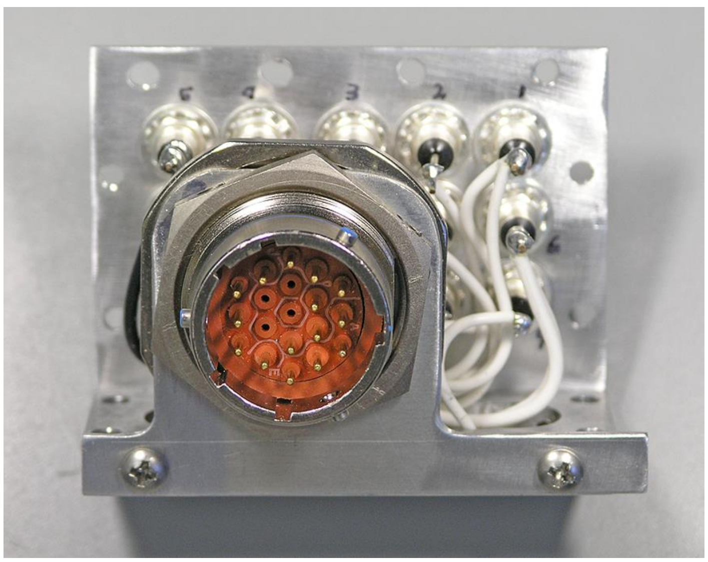
As you can see, the ground returns for the throttle pot and the main fuel solenoid use the same path via pins 'F' and 'G'. The same goes for the three diodes. All the ground returns are tied to that battery minus terminal 'E'. That's the ground reference for everything inside that box. The result is that the RF shields and grounds are tied directly to the box, which will be bonded to the frame, but the DC grounds are tied directly to the DC power ground bus.

In spite of my best effort I'm sure there are a few bugs in the design. I may have the polarity backwards on a few sensors and I'll probably have to swap a few pins around but the basic concept is sound. It's taken me a good week to get to this point but now I'm ready to heat up the soldering iron and finish off this chassis.

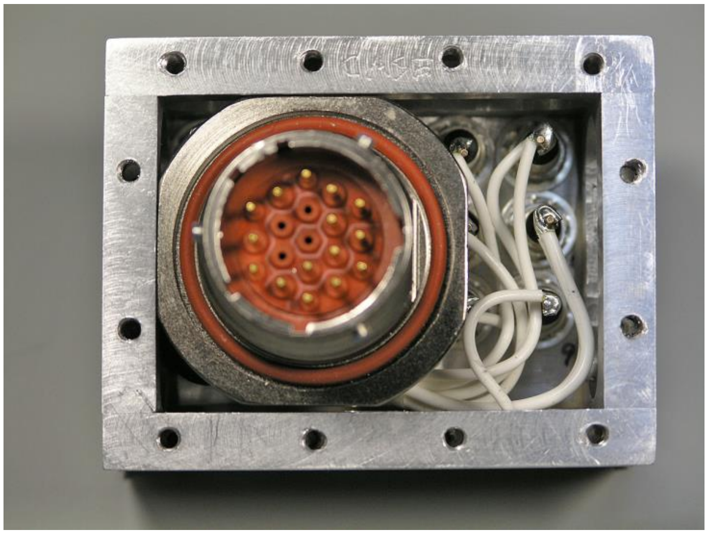
Juan Rivera

Now that I'm getting ready to actually wire something, here's a look at one of the male contacts I'll be inserting into my circular military connector. You can see that it's got a number of good features; it's machined and not stamped, and its gold plated. Gold is not the greatest conductor but it is extremely stable and doesn't corrode. Its mate will also be gold plated. This is important. Never use dissimilar material is the two mating contacts. It can cause galvanic corrosion.

Typical of this type of quality pin, it has an inspection window so you can verify that the wire is fully inserted into the pin. Also notice how the pin is crimped. Four dies come in 90 degrees apart and compress the crimp portion from four sides. For this to be an acceptable crimp the compressions have to be located between the painted lines and they are. My crimping tool is a surplus Daniels M-1700A. Before you start looking for one you should price these connectors. They're expensive. I happen to have some after a lifetime of scrounging but I'd opt for something less expensive if I had to buy them all new.



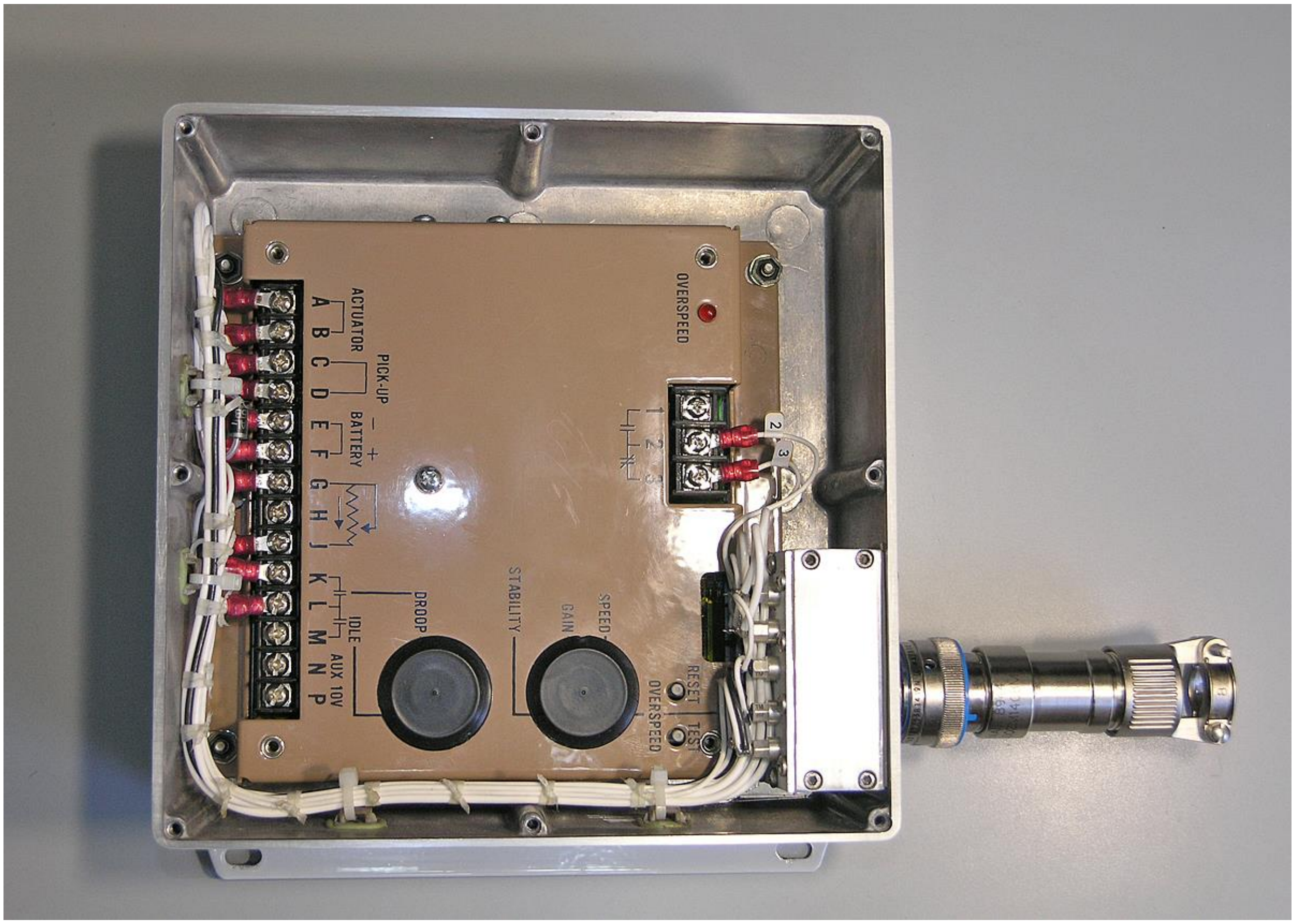
Since the space is so tight inside the EMI compartment I made a jig to hold the connector in the exact position where it will end up. This allowed me to do the wiring while I have room to work. It's standard practice to fill the connector with contacts even if they are not all used. I forgot and now I can't get in there since they push in from the rear, so this will have to do. I'm not planning to leave the Helicycle out in the rain so it shouldn't be a problem.



The EMI enclosure is ready to install. As you can see, I had this size connector in mind when I made it.

The soldering job is completely functional but would never pass a soldering inspector. There's a reason that the airlines all eliminated hand soldering on their aircraft back in the early eighties. As I may have mentioned, soldering is a difficult skill to master and it's very volatile. It takes constant practice and refresher training at least once a year to stay competent. Several years ago I was certified to hand solder per ANSI IPC-A-610 but I haven't maintained my certification and it shows. I'll be glad when I have this side tucked out of sight.

I have to make one more EMI gasket and then screw this unit to the engine control enclosure. That will wrap up the tricky part. Once this unit is installed then all I have to do is fabricate the wiring harness that will mate the EMI filter outputs to the engine controller. I'll have more room to work and I'll try to do a better soldering job!



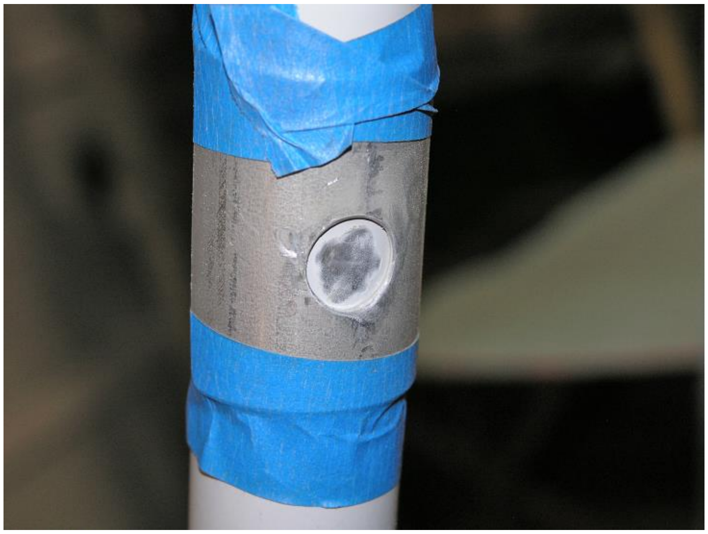
June 06, 2009 -- This is the completed engine control unit with its EMI filter assembly and the mating connector with the EMI backshell in place. If I did this again I'd use a slightly larger enclosure and make the EMI assembly larger too. The Click Bond mounts are extremely strong. I tried to remove one by heating it up with a heat gun per the manufacturer's suggested procedure. In the end I had to machine it off with my mill. I'll be attempting to use these on the frame over the powder coat. I found a source for these in small quantities for about $1.25 a piece.

I'll grind off the powder coat on the mounting tabs on this enclosure and also on the frame mounting tabs to get a good electrical bond. It's not a good idea to bond aluminum to steel because you can end up with galvanic corrosion if moisture gets into the joint. I don't anticipate ever exposing the Helicycle to the rain so I'll just need to keep an eye on this as time goes by.

One last thing – I lapped the top of the enclosure to get a smooth surface. If the lid doesn't make good contact with the enclosure then all my planning and work will come to nothing. Once I get the Helicycle running I plan to check for EMI susceptibility by keying a 5-watt VHF amateur radio portable unit and moving the antenna along the cable harnesses and the enclosure while the engine is running. I'm a long way from having to think about that right now. I still don't have my engine.

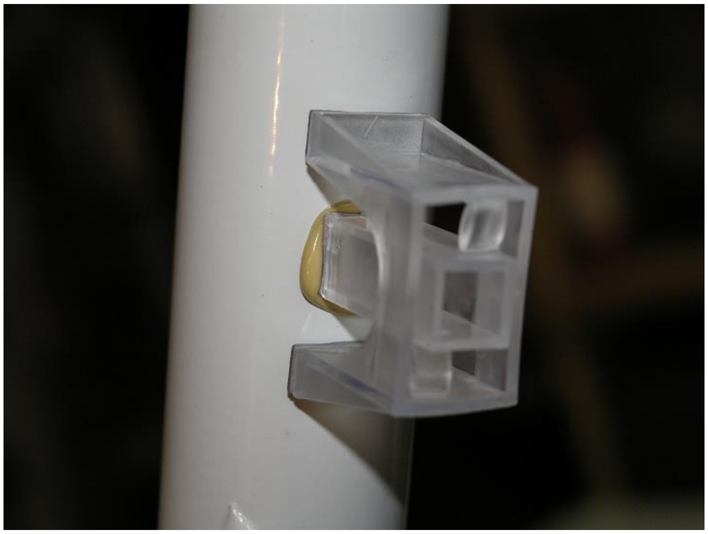
Remember me saying that the Click Bond tie wrap mount was almost impossible to remove from my engine controller's enclosure? I had to mill that thing off after attacking it with a heat gun!

I was impressed enough to decide to use them on my frame. I had a scrap of tail rotor drive shaft tubing lying around and it turned out to be perfect for making a shield so I could scrape the powder coat away from the area where the mount would be attached without accidentally damaging the surrounding finish.



The inner diameter of the tail rotor tubing was a perfect fit for the outer diameter of the large tubing used on the frame, so after drilling an appropriate sized hole and deburring my shield I put it to work…

Once a spot was cleaned off I was ready to install a mount. There's enough epoxy in each kit to mount at least five of these little mounts but you have to work fast before the epoxy sets up. I opted to do three this first time on the frame. This stuff really puts out some fumes so be sure you have lots of ventilation. I toss the used epoxy outside.

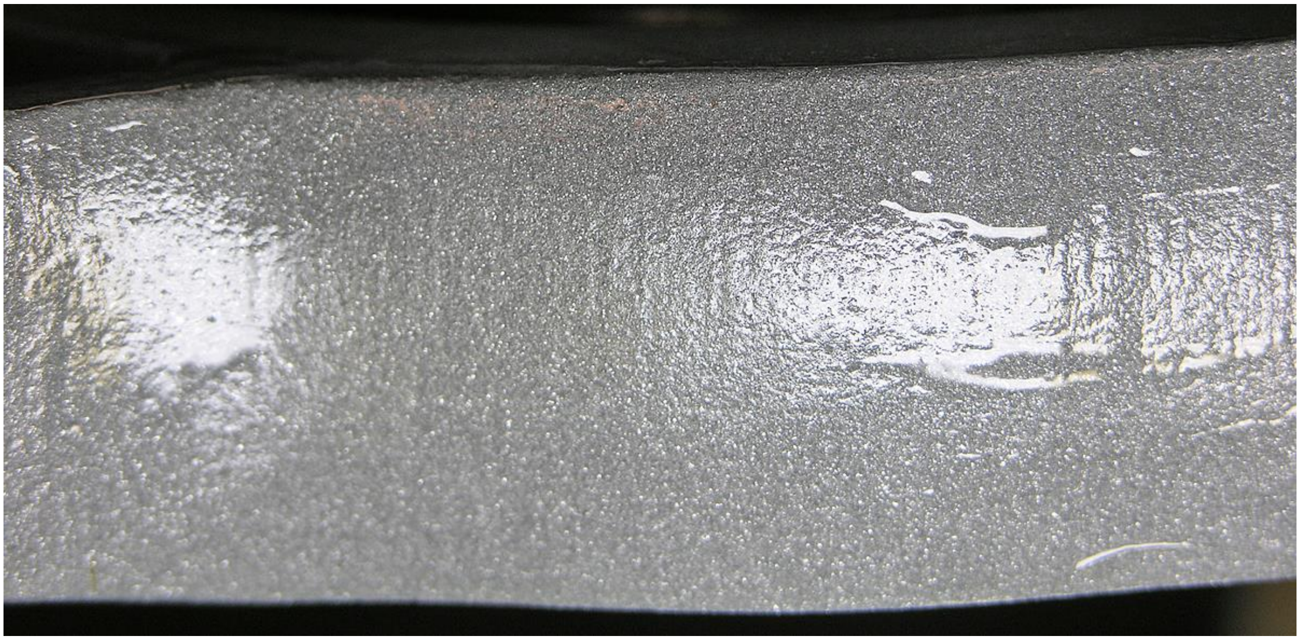


Here's the plan -- Mix the two-part epoxy from the kit provided and goop a dab on the tie wrap mount. Peel the backing tape off of the double-back tape on either side of the mounting fixture, line it up over the sanded spot and stick it down. Once the fixture is in place press on the center section to actuate the fixture and plastic springs force the tie wrap mount down against the surface. After the adhesive has cured sufficiently remove the fixture with pliers and discard. Flyaway strength is reached in 30 minutes, 90% ultimate strength in 1 hour.

Juan Rivera

And here is the bonded tie wrap mount ready to go. Notice how the epoxy color has changed. When it's mixed it's almost white, and by the time it's applied it's already started to turn brown. After an hour it looks green.

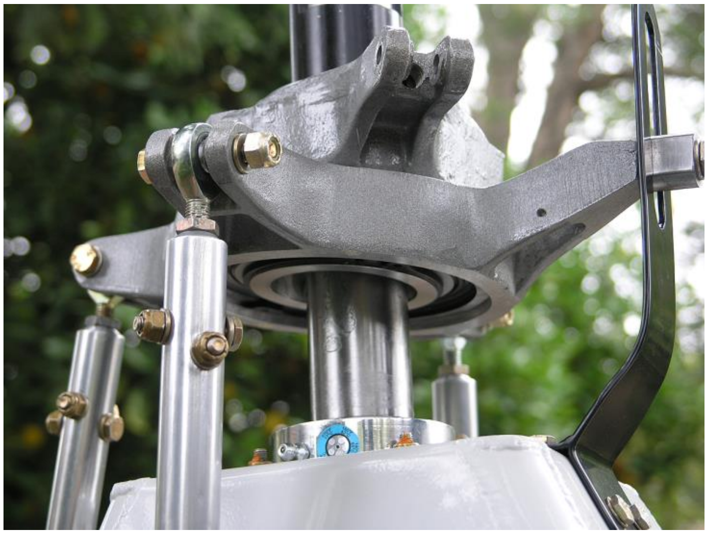
While the Click Bond fasteners are curing I picked up a PVC plumbing 'T' at the hardware store, ground it down to match the shape of the top of the swash plate and sealed it with a fast curing silicon sealant. The gap between the movable and fixed sections is sealed with ¼" plastic tubing that I pulled into the gap. All the other routes to the bearings are blocked with aluminum tape. Once the sealant cures in a few days I'll be able to blast the swash plate with ground glass and coat it with the corrosion preventative, Glisten. Once the swash plate is prepared I can mount it on the rotor shaft and attach all of the control tubes that I prepared months ago. I'm going to display my Helicycle at the Vertical Challenge air show in one week so I'll be working to get it as ready as I can. With the control tubes installed, and no seat pan, it will be easy to see how helicopters are controlled. Perhaps I'll educate a few youngsters that will grow up to become aircraft mechanics or pilots. You never know…



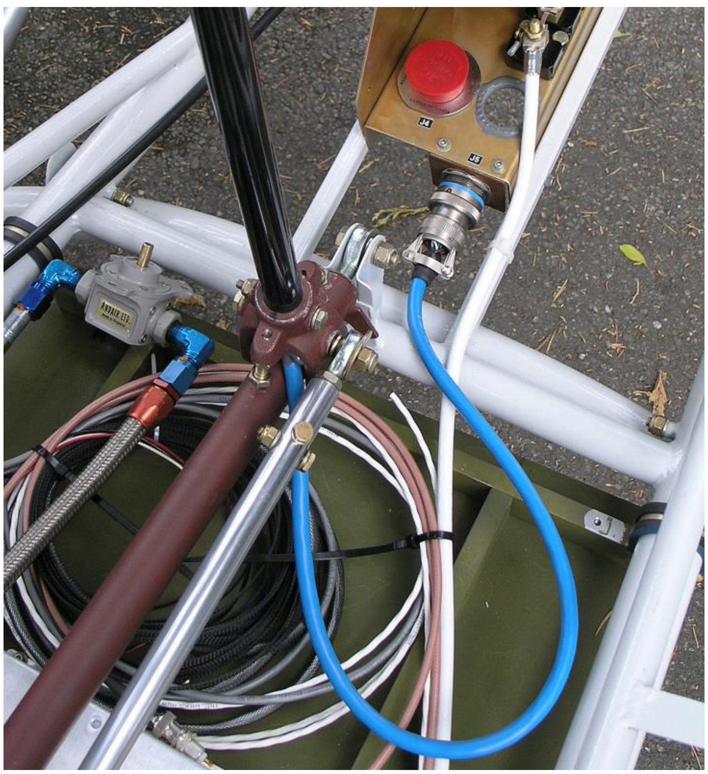
I won't repeat my description of blasting the parts with ground glass and applying Glisten. You can read about the transmission treatment on page 67. This is what the fixed portion of the swash plate looks like after blasting and coating it with Glisten. It has a nice shiny appearance. It can take as long as one week to complete cure, depending on the weather. As soon as it does I'll start mounting all of my control tubes.

I may not have mentioned that I didn't take into account where my thigh would be when I machined my cyclic control tube. Once I had my seat installed, and the foot pedals modified and in place, I found to my profound dismay that the comfortable position for my right hand was directly below the cyclic grip. This in itself wouldn't have been a major problem but for the fact that I sealed the cable into the tube with epoxy at the bottom end (page 108.) The net result is that I had to tear the cable out to get the cyclic grip loose from the tube. I've shortened the tube and machined the various holes in the end so now I will set about rewiring the cable. It's going to be a tad tedious since there are six switched in that grip and they're not all easy to reach.

The reason the location of your thigh is important is that you need very precise control of the cyclic. The best approach is to use your wrist and fingers to make minute adjustments while resting your forearm on your thigh to steady it.

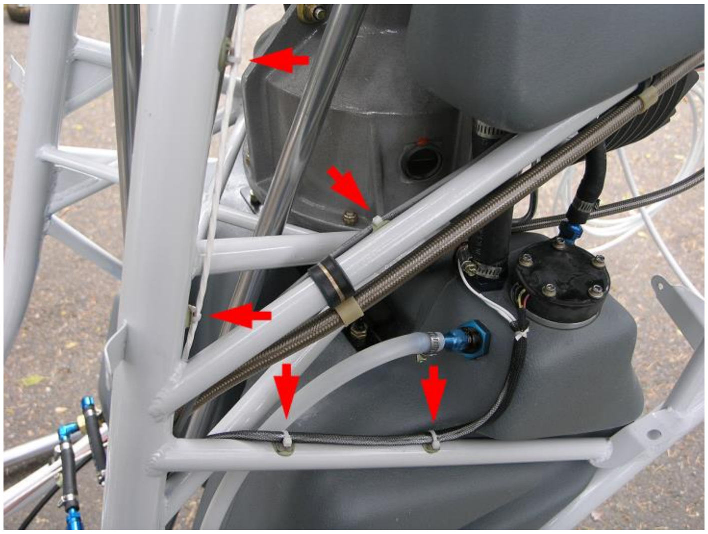


The swash plate is now installed on the main rotor shaft and the control tube hardware is finger tight while I line everything up. It took two days for the Glisten to cure enough to handle without leaving finger prints.

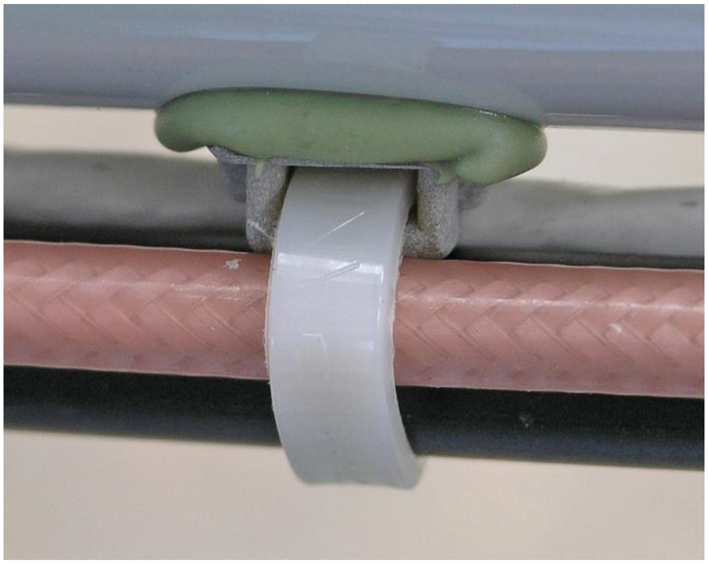


The Infinity cyclic grip and the cyclic control tube are also installed. You can see what I had in mind for the interface to the ship's wiring. The cyclic plugs into my interface chassis using a circular military connector. This allows me to pull it out as an assembly without having to chop wires.

To the left of the picture you can see the Andair main fuel shutoff valve and the Aeroflex fuel lines. The valve mounts to the underside of the seat pan with three screws.

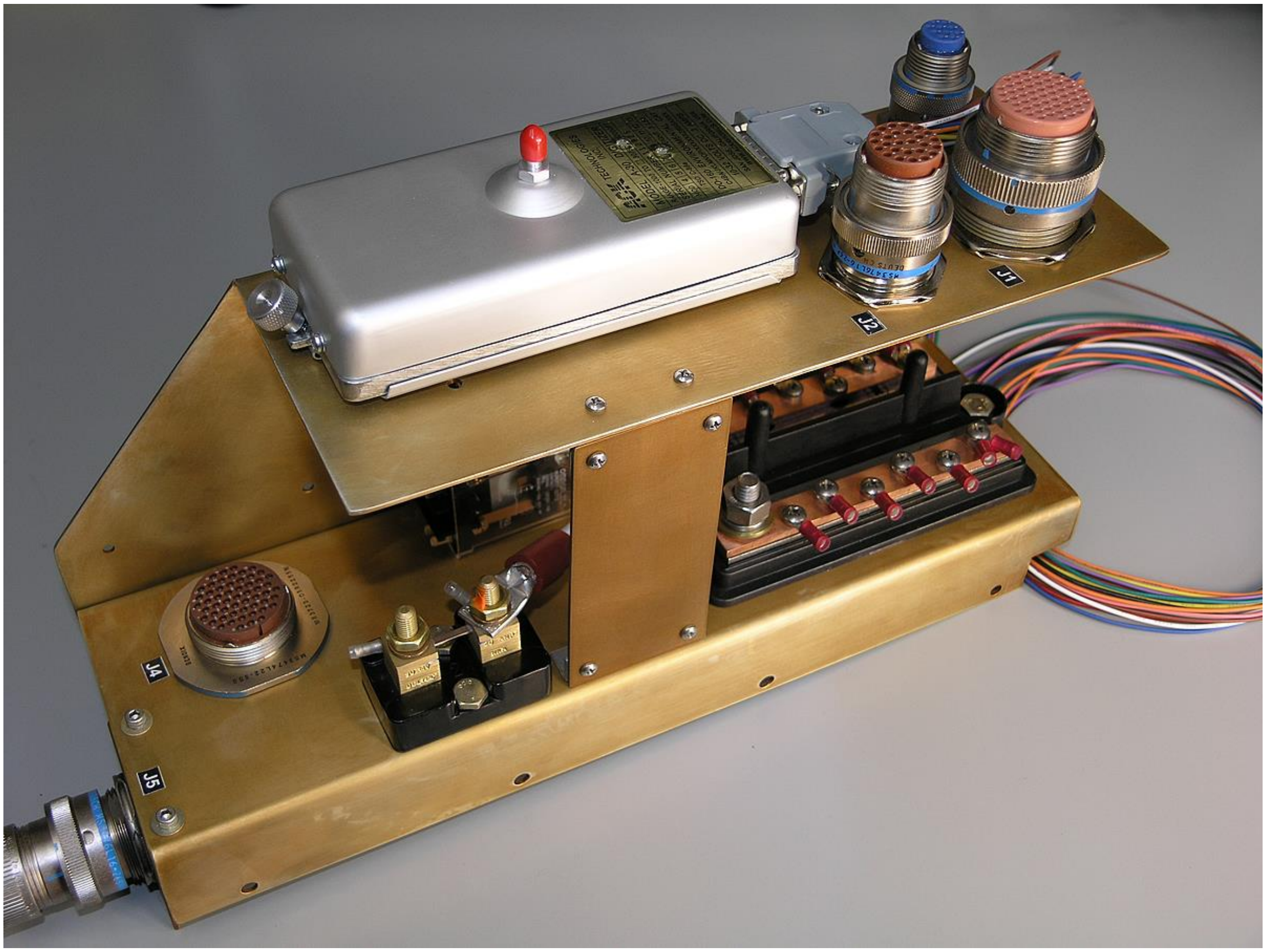


I'm also embracing the use of Click Bond fasteners. I've installed about 25 of them throughout the frame and I have another 25 on order. I'm using the size-3 cable tie mounts, P/N CB9302V3 from 'The Flight Shop'. Their web site is http://www.theflightshop.com and they cost $1.25 a piece plus a $5 handling charge and shipping. Be sure to order the Click Bond adhesive as well (P/N CB200.) It comes in 3.5 gram packets that are good for about 5 mounts at $1.25 a pack. Work fast because the adhesive sets up in minutes. Because the fasteners are designed to mount on a flat surface I would not advise trying to use the larger fasteners. The radius of the tubing becomes a problem.



Here's one last shot of one of the size-3 mounts on my tail. I'm using a standard sized tie wrap to secure the tail rotor control cable, a coaxial cable, and one shielded twisted pair cable. You can see that the mount isn't much larger than the tie wrap but it's made from a very tough material and has plenty of strength.

I'm finally starting to get to the wiring, the one area where I have some manufacturing experience. I completed the wiring inside the engine controller enclosure and now I'm going to begin the internal wiring inside the instrument pod interface chassis. Here's a picture of the chassis I made:



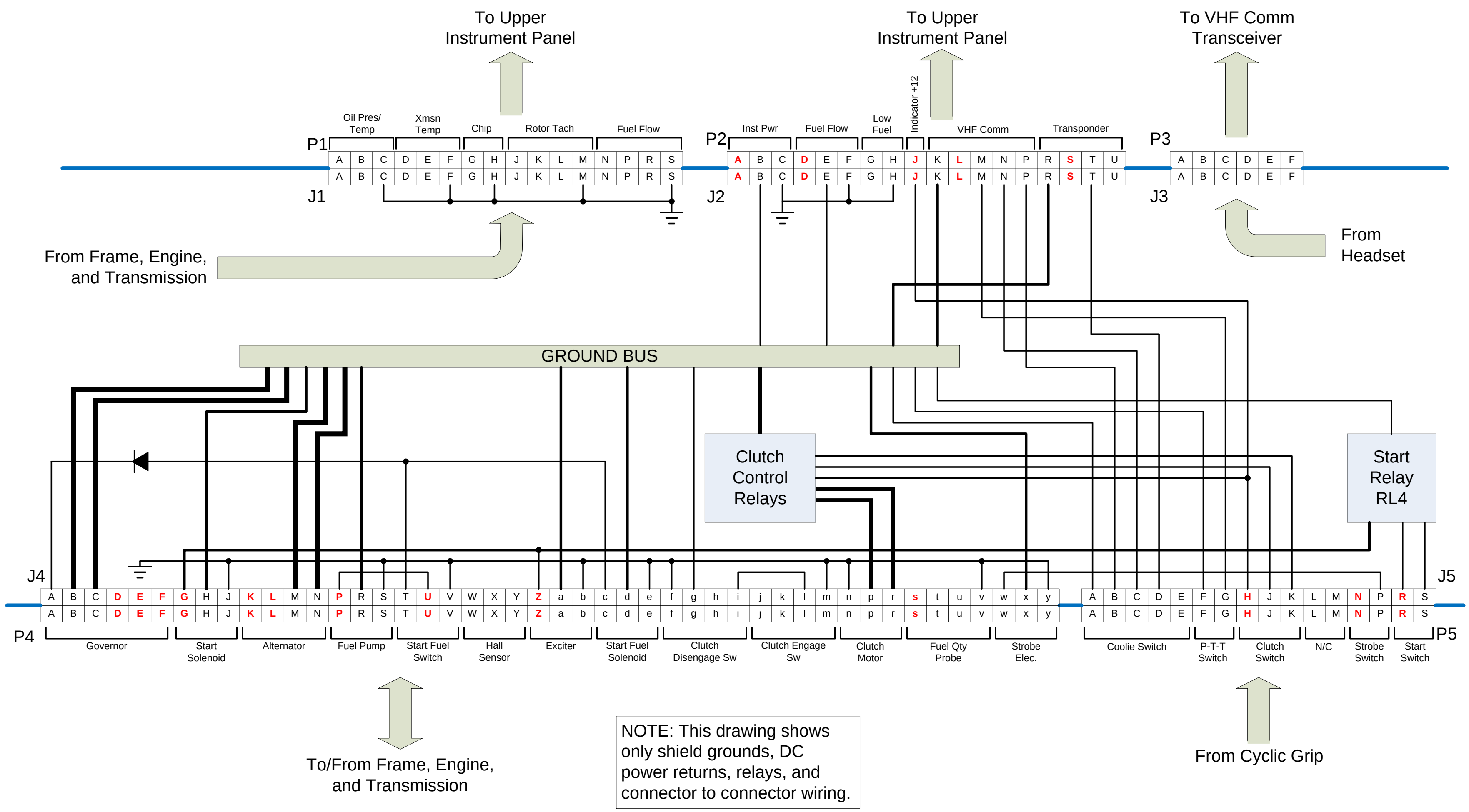
The top instrument panel will connect via the three circular mil connectors on the top of this chassis. The bottom of the chassis contains the ground and +12V buses, the current shunt that feeds the voltage and current meter, and the clutch and starter relays. The cyclic grip cable connects to J5 and the ship wiring will connect to J4 and J1.

The aluminum box on the top of the chassis is the encoding altimeter that feeds altitude data to the transponder. Whenever the transponder is interrogated from the ground or another aircraft it responds with a digital pulse train that includes aircraft altitude, along with a code number that is assigned by the air controllers and manually set by the pilot. That data block is then matched to your aircraft N number and it automatically tracks along with your radar location on the air controller's scope.

The wiring block diagram is on the next page…

Juan Rivera

Instrument Pod Interface Chassis Wiring Diagram



The block diagram on the previous page shows most of the internal wiring inside the instrument panel interface chassis. It does not show any +12V power or any of the wiring that goes to the instrument panels themselves.

In this diagram I've made a clear distinction between the two different types of grounds; DC power returns, and shield grounds. The DC power returns all go to the ground bus which is tied directly to the negative battery terminals. The shield grounds tie to the chassis. This is important and easy to confuse.

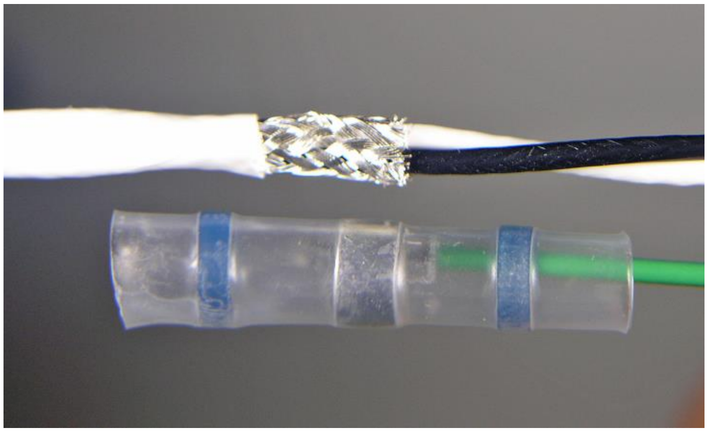
I'm also shielding as much of the wiring as I can to minimize electromagnetic interference (EMI) to my engine controller and the instruments. If the devices I'm wiring to permit it I'm using shielded twisted pair wiring (STP) to further reduce EMI. All +12V and ground return wires qualify unless they are included in a larger cable. As I mentioned, the twists cancel out energy that is coupled to the wiring by adjacent conductors and visa versa. Nothing is perfect so particularly susceptible or noisy cables will be bundled separately on opposite sides of the frame if possible.

Looking at connector P4 on the block diagram you'll see that there are ten shields that need to be grounded to the chassis from that connector – pins J, S, V, b, e, f, m, n, v and y. I'll be running short jumpers from the connector to a ground ring. Here's a picture of the ring:

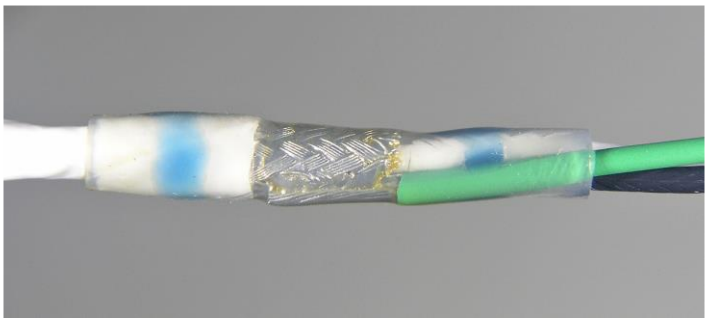
This particular ground ring has ten wire holes and will mount to the chassis next to the connector with a machine screw. Each wire is pre-tinned, bent into a 'J' shape, installed in one of the holes, and soldered.

I mentioned while doing the engine control wiring that soldering is extremely difficult to do well and almost impossible to do perfectly. It's a very volatile skill that needs to be refreshed often. This is a much better example of good soldering, now that I've had some recent practice. You can see that there is a good fillet around each wire with good wetting of the base material. You can also see the individual strands through the solder. This might even pass a soldering inspection! By the way – ALWAYS use 63/37 rosin core solder and NEVER use acid flux. Acid flux is for plumbers. You're not building a toilet. You're constructing an aircraft!

When passing the shield through a connector you need to switch from the shield's braid to a wire. There are several ways to do this. The simple way is to strip the braid back, solder a wire to it, and then cover the joint with some heat shrink tubing. This is fine, but there is another way that is much cooler than that.

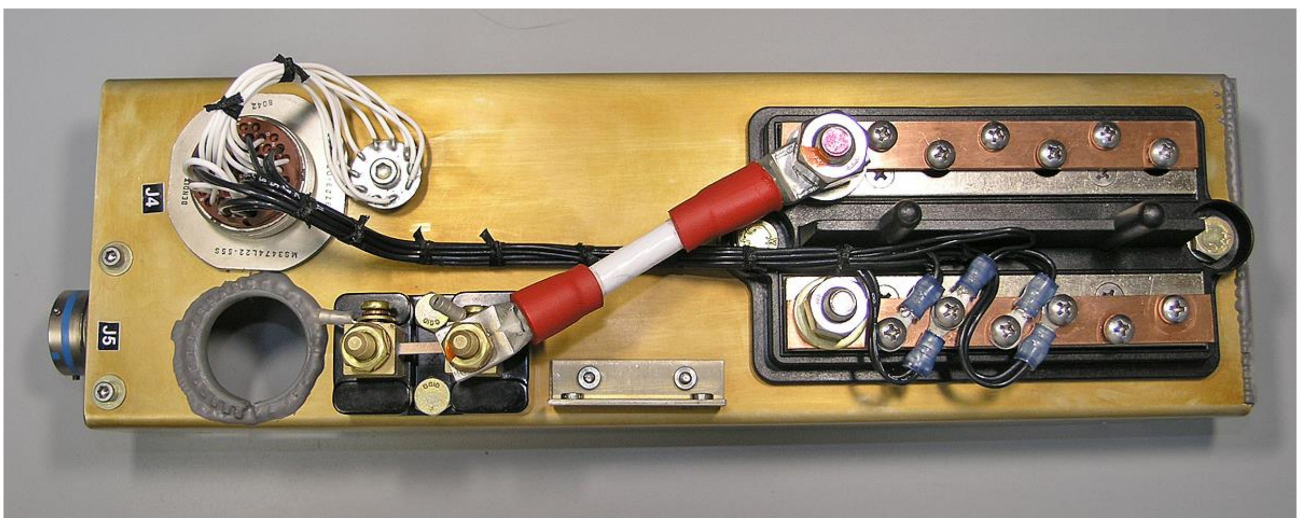


The STP cable is prepared as you see by exposing the wires and cutting the jacket back to expose the shield for about one quarter of an inch. Next I'll slide this Raychem solder sleeve[2] over the cable and heat it up with a heat gun. Contained inside this heat shrink tube is a solder preform that contains just the correct amount of solder and flux to solder the green wire to the shield. Then the two blue bands melt to form a seal and the tube shrinks to secure the whole assembly up tight.



Here's what it looks like after it's been heated. Isn't this great? The tubing is clear so the joint can be inspected.

These sleeves come in several sizes. I'll be using two to cover all the STP cable sizes I plan to use on this project.



Here's a view of the bottom tray showing the wiring to my connector J4 so far. The white wires ground incoming shields to the chassis and the black wires are all DC returns that go to the isolated -12V bus. The -12V bus then connects with a #2 cable directly to the negative terminals of the two batteries. This bus assembly came from a boat shop. It used the steel plates you see under the copper as the bus material. I added the copper to reduce resistance and losses. I've used #18 and #20 wire depending on the current I expect. Doubling up two wires to a terminal I should just have enough spots for all my DC returns.

[2] Mouser Electronics P/N 650-CWT5122

My current electrical design assumes that the lower instrument panel and the instrument pod interconnect chassis are permanently connected via cabling. Then more I think about that the less I like the idea. I'm going to add another connector so the lower panel can be removed from the ship just like the upper one. The basic concept is simple enough – everything comes together in this chassis from throughout the ship and all the various pieces will connect via circular mil connectors. My documentation is starting to leave something to be desired. It's getting confusing and I don't want to worry the test pilot when he finally gets a look at my ship. Once I sort this out I think I'll make a spread sheet that breaks out each sensor/indicator pair and shows the wiring path from end to end. That will make testing and troubleshooting very easy. If something doesn't work I can ohm out the path for that particular element and refer back to my block diagrams and schematics as needed.

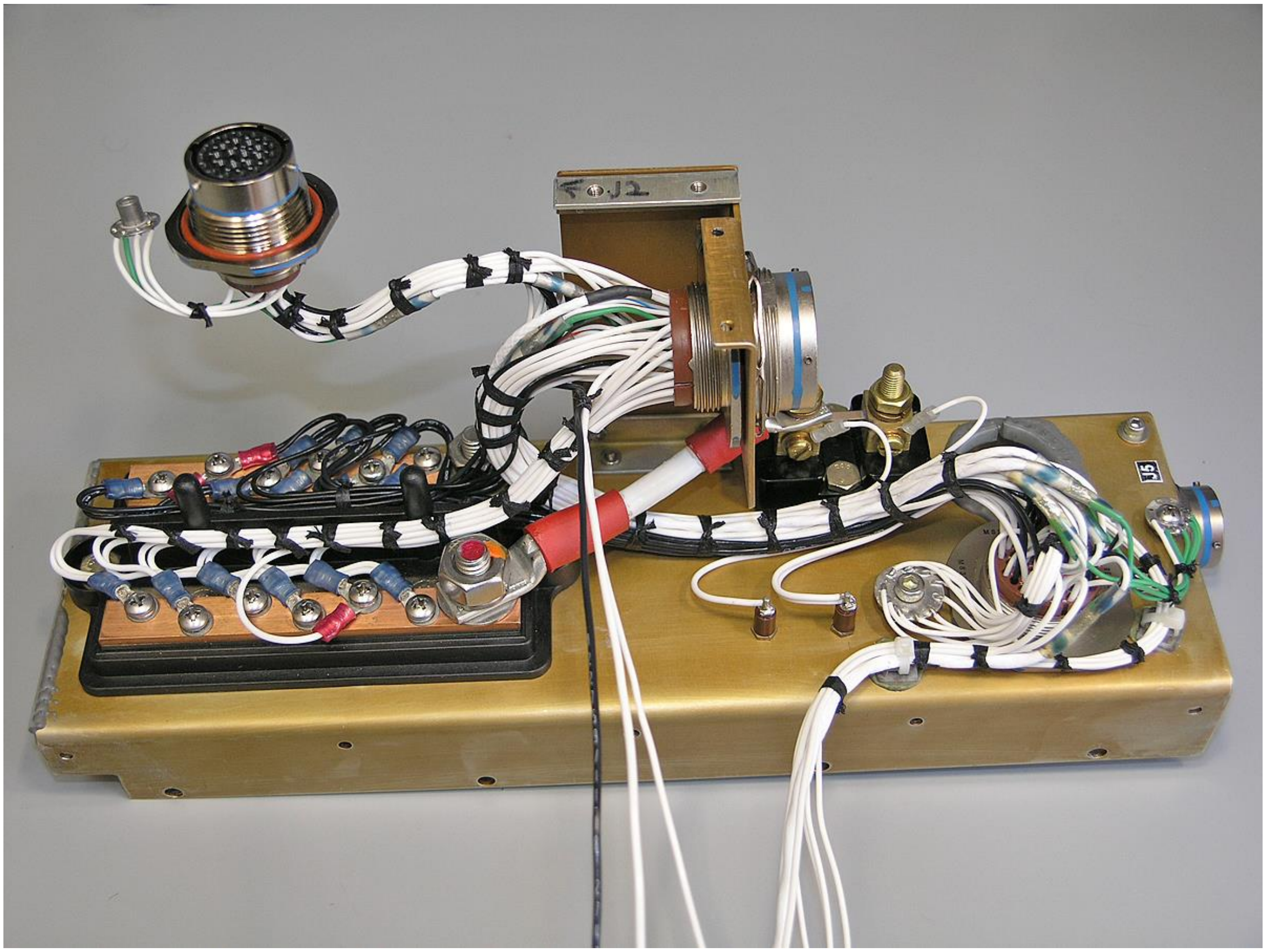
I should mention the reason that I show diodes across the relay coils. When a switch that controls a relay, or any other inductor, is opened the circuit energizing the relay is rapidly broken. As the magnetic field in that coil collapses it creates a very large voltage spike. It's called 'counter EMF'. That high voltage spike can cause the switch contacts to arc. The arcing damages the switch contacts and can lead to premature failure.

The idea behind the diode goes like this; a diode conducts current in one direction only. Install the diode across the relay coil contacts so that it doesn't conduct current during operation, but when the magnetic field in the coil collapses and creates a voltage with a reverse polarity the diode will conduct and the pulse of current will circulate in the loop formed by the coil and the diode, thus preventing damage to the switch. The rule of thumb is to make sure that the diode has at least ten or fifteen times the voltage rating of the DC voltage rating of the coil. Since we're working with thirteen volts the minimum diode voltage rating should be 130 volts, but why take a chance. Use the same 1N4004 diodes that Eagle already selected. These have a 400V/1A rating and they're easy to find. I actually settled on 800 volt diodes. They were $0.07 a piece.

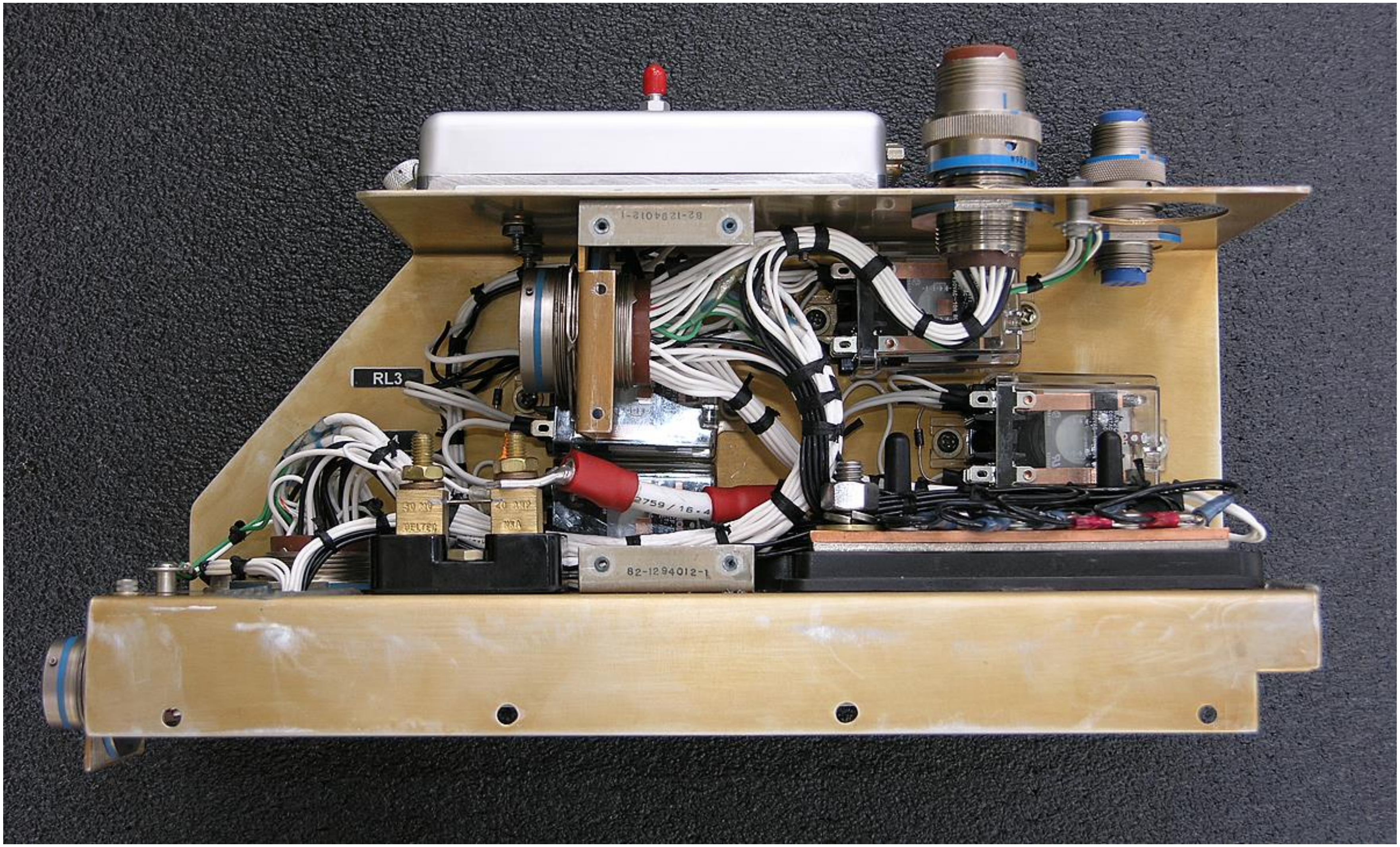
The reason I have relays at all is to increase the current handing capacity of the little cyclic grip switches. Depending what is being switched, these contacts need protection too. The clutch motor presents a special case since the voltage applied to that winding can be either polarity.

I fabricated this plate to mount new connector J6 that will interface to the lower instrument panel. I milled the plate and used a chassis punch for the large hole. I don't have a sheet metal brake so I ran into work and did the bending there. I Alodined the part using chemicals from Aircraft Spruce.

Juan Rivera



10 July, 2009 -- I redesigned the wiring to accommodate the J6 interface connector to the lower instrument panel. The chassis is almost completed. The picture above shows the new lower instrument panel connector at the top/middle of the picture. It’s the one with the most wiring. Once I wire in the relays, and add one diode to the two brown stand-offs in the middle of the chassis, this particular project will be complete. It doesn’t look like all that much work but I probably have about 100 hours in this chassis including the initial design and engineering drawings. I’ve ohmed out every wire at least once so there should be a minimum of errors when it comes time to put it to use.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18 July, 2009 – That's the completed instrument pod interface chassis on the previous page with the front support plate removed for clarity. I thought I was done at least three times and then thought of modifications to the design that added more components and wiring. This time I'm really done.

I have a lot crammed into this chassis and I probably should have made it a tad taller. Wiring the relays and getting them installed in the back of the chassis was a chore. Every change usually meant cutting all those spot ties loose, adding more wiring and then lacing up the bundles again and again.

Now that this chassis is completed, along with the engine controller with the EMI protection circuitry, the rest of the wiring should be very straight forward. The cyclic grip switches connect to the connector at the bottom left. The lower instrument panel connects to the large connector inside that faces to the left, and the top connector with the wire bundle attached connects to the upper instrument panel. The smaller connector with no wires attached at the upper right will carry the headphone cabling from the seat pan to the VHF transceiver in the upper instrument panel. And the missing connector whose mounting hole is just visible at the upper right carries wiring between the upper instrument panel and the frame. The four relays in the back isolate the small switches in the cyclic grip from the starter solenoid, the start fuel solenoid, and the clutch motor.

For a one-off chassis designed from scratch I think it came out looking acceptable. Anyone who is interested can download all of my schematics as one .PDF file. If you choose to copy my design you assume all risk since none of my wiring has been tested or approved by Eagle R&D. Without a ready supply of these miniature cylindrical MIL-C-26482, Series 2 connectors this chassis would be very expensive to reproduce. The remaining components are inexpensive.

19 July, 2009 – I'm going to rethink the diode I show across the starter contactor. I discussed the reason for putting a diode across a relay coil to suppress the counter EMF voltage spike that can destroy the switch contacts of the switch that controls the relay on page 150. Everything I said is true but I didn't mention the fact that the way all suppression circuits work is by slowing down the collapse of the magnetic field which reduces the amplitude of the counter EMF voltage spike by slowing down the opening of the relay. While saving the controlling switch contacts it can also degrade the life of the relay contacts. It's a trade-off. You can eliminate the arcing of the switch contacts but increase the arcing of the relay contacts. I've added several .PDF files to my reference area and Leach has a great write-up on this subject. From what I'm being told, the starter draws as much as 900 Amps so the contacts on the contactor need to open as quickly as possible to minimize the duration of the arc and limit damage. I'm going to have to come up with a more sophisticated suppression circuit. Fortunately I'm controlling an intermediate relay with the cyclic grip switch and the relay has fairly robust contacts compared with the small grip switch. Actually, my first cut at this will be to eliminate the suppression circuit completely and see how bit an arc the relay is subjected to when it opens the contactor coil. If it doesn't look too bad I'll leave the suppression circuit off of that coil resulting in the fastest possible opening of the contactor and the least damage to those contacts.

I also purchased a clamp-on ammeter that can measure up to 1000 Amps DC. Once I get my engine I can confirm the current draw for myself.

Juan Rivera

November 29, 2009

About four months have passed since I wrote the previous page. I've been extremely busy at work and I became so bummed out waiting for my engine, that after sixteen months of waiting I didn't enjoy working on this project so I stopped.

Well, now an engine is shipping out to me tomorrow and my paying job has slowed down slightly, so I'm back at work on the Helicycle. I didn't quit completely. I've been busy designing a rotor RPM alarm which is documented separately. I also managed to get some progress made on cleaning up my seat pan. It's just about ready to go now.

While waiting for the latest fiberglass application to set I decided to replace the bushings that the foot pedals mount on. Hap Miller made some nifty bushings that have a Delrin sleeve over the aluminum plug. I disassembled the foot pedals so I could swap out the plugs and I was shocked to see a huge about of rust pour out of the tube.

This is just what came out after running a paper towel through the tube.

Here's a close up.

And here's a look inside the tube. The depth of field of the camera is very narrow so only a small band is in focus, but you get the idea.

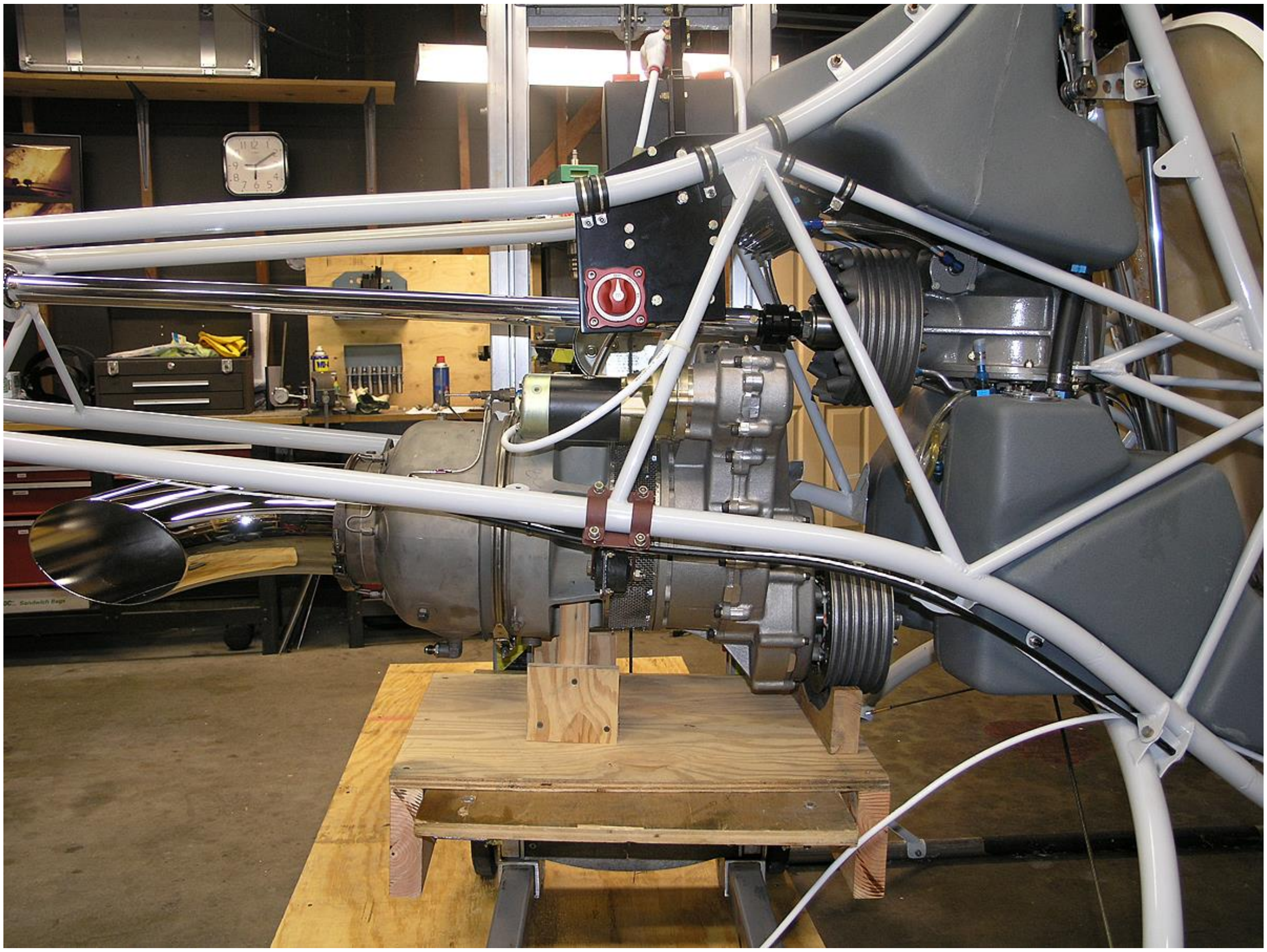
I wonder if acid was left inside after the tube was chromed. This is not good. If this part fails in flight I'll be in big trouble.

I'll alert the Builder's Group and see if anyone else has seen this before.

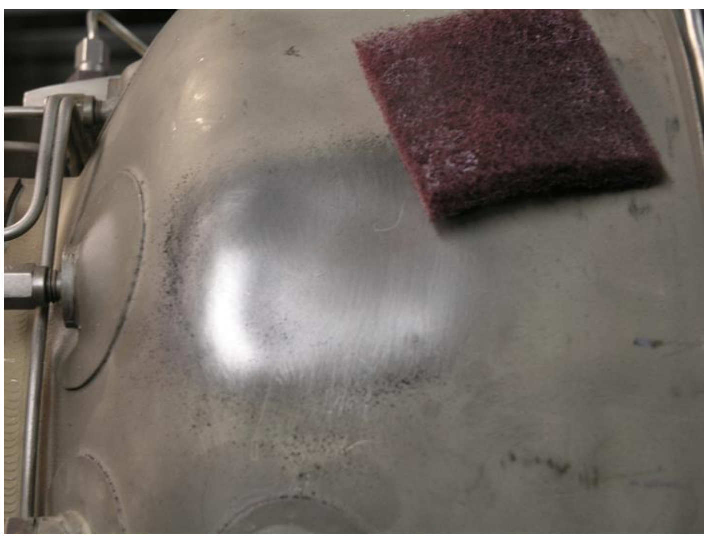
Friday, 05 December 2009

My engine arrived last night about 8:00 PM. I've been waiting for it for a very long time! The first order of business was to get it out of the packing crate. I made a stand for it out of wood. I used a central 2x6 support with a slot that captures a web at the bottom of the engine. It's also supported under the pulley. I raised the stand up on 2x6's so I can get under it with my trusty Genie Lift to pick it up. The Genie Lift is like a hand truck on steroids.

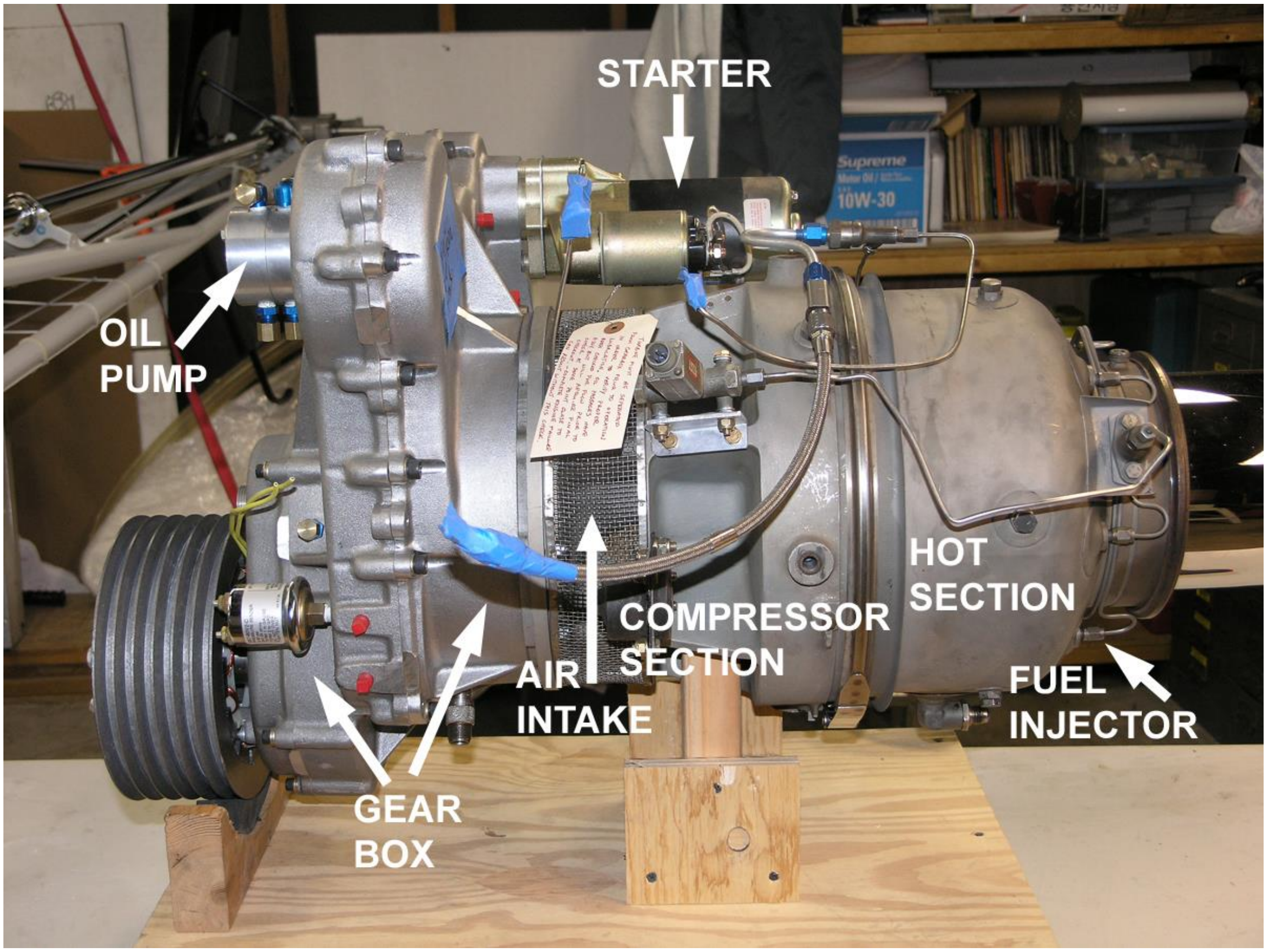
The next step was to build a raised platform for the Genie Lift so it could maneuver over the left hand skid which is right in the way. The platform is ¾"-inch plywood supported on six 2x4's. I cut a small clearance hole for the rear end of the left skid which sticks up slightly higher than a 2x4. Here's what it looks like from the left side:



Here's the view from the right side, showing the bottom of the Genie Lift and the engine stand I built. Now I can very easily crank the engine up and down and move it around. This is going to work out well. It's been a long time getting to this point!



The first thing I'll be doing to the engine is to clean it up as much as I can. Here, I've used a Scotch-Bright pad to shine up a spot on the Combustor Housing.

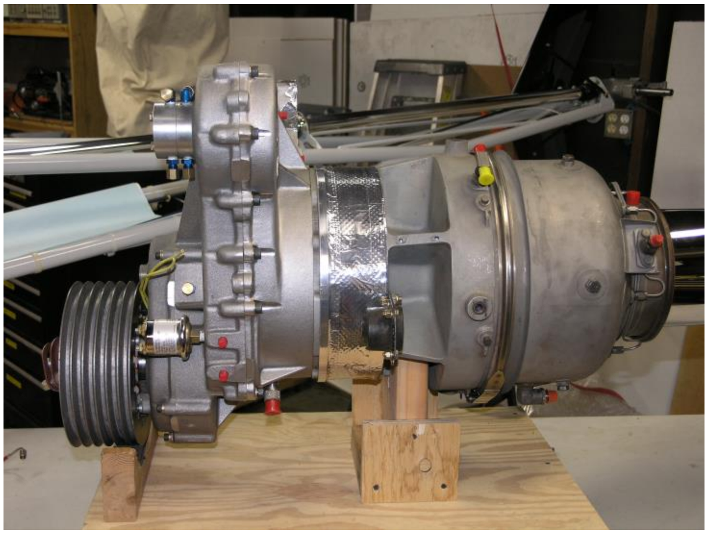


The engine is a Solar T-62T-32. Thousands of these turbine engines were manufactured for the military for use as 60 kilowatt ground power units and auxiliary power units (APU) for several helicopters. The engine runs on jet fuel of kerosene and is rated at 150 horse power at 61,091 RPM. The compressor and turbine wheels are mounted on a common shaft. Air is drawn in through the air intake and compressed in the compressor section. Fuel is then injected through six injectors around the circumference of the combustion section and ignited. The hot gas turns the turbine as it exits through the tail pipe. The common shaft also drives the gear reduction and accessory drive to power the fuel and oil pumps and the large pulley at the front. The engine is rated at 150 horse power but derated to 90 for use in the Helicycle. This engine is designed to run continuously at maximum power and is extremely reliable.

The surplus engines are modified by Eagle R&D. The entire gear reduction and accessory drive section is replaced with a new unit that they manufacture. The 24 volt starter is also replaced with a 12 volt unit. The engines are torn down and inspected, and then run under full load on a dynamometer.

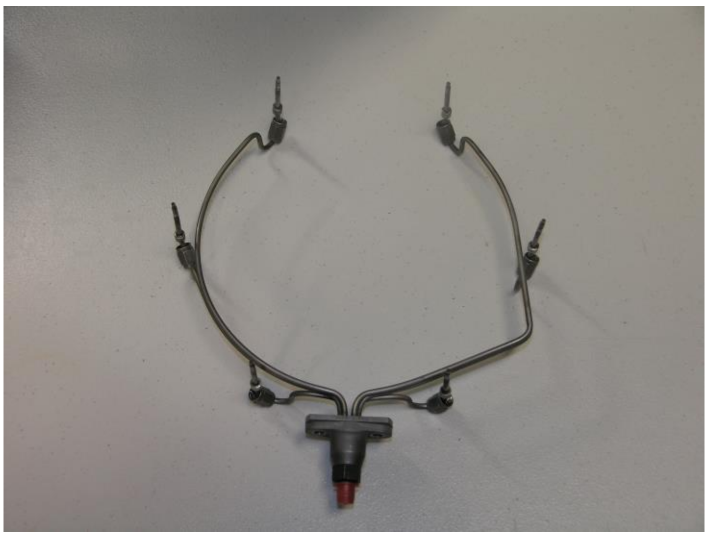
The fuel control assembly is not attached in this picture and will be overhauled and calibrated at the factory and should show up in a few weeks.

Juan Rivera



I removed the starter and all the plumbing as well as the tail pipe and sealed up all the opening in preparation for cleaning. I also plugged all open fittings with plastic caps.

I'm going to start on the combustor assembly.



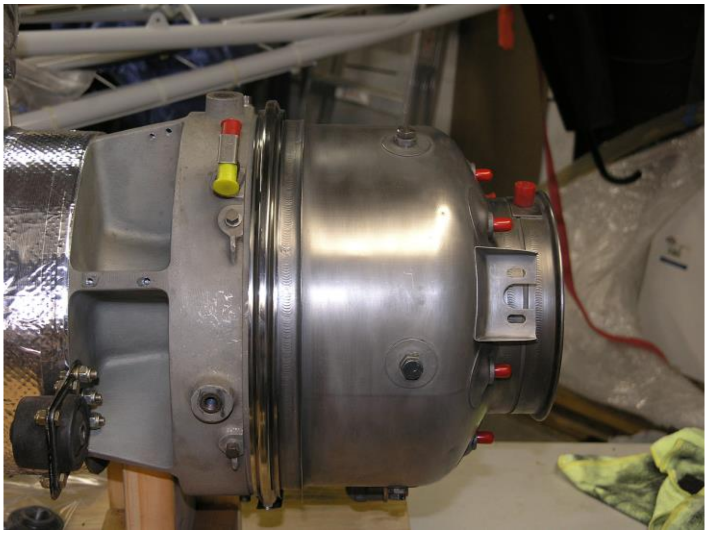
The fuel manifold is located in the rear of the engine and feeds six fuel injector nozzles. I removed it prior to cleaning the combustor assembly.

The large piece at the bottom of the picture contains a 10-micron in-line filter.

Here's a close-up of one of the injectors. The hole is not much bigger than a human hair. That's the reason for the 10-micron fuel filter in the manifold. The fuel is actually filtered multiple times before it gets to the injector.

In spite of the very small size of the injector nozzle, the engine burns about 12 gallons per hour.

Here's the view looking in the exhaust with the tail pipe removed. The hot gas spins this turbine; the turbine shares a common shaft with the compressor that sucks fresh air in through the air intake. The shaft also drives the gear box and accessory drive.



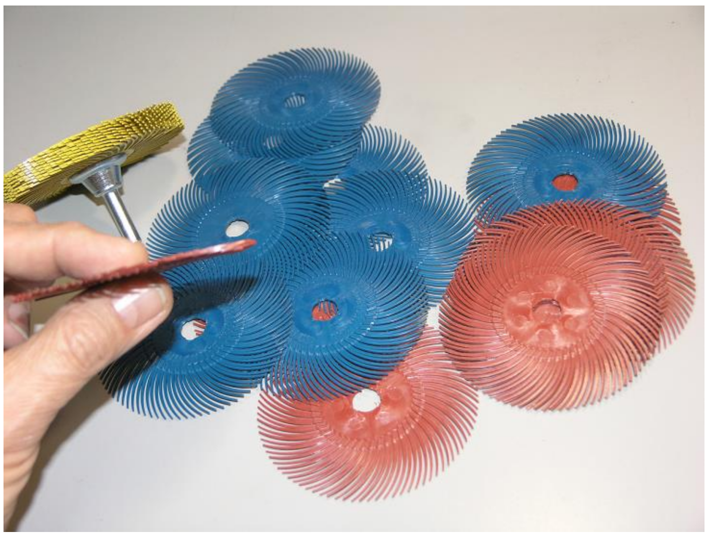
This is what the combustor assembly looks like after several hours of rubbing it with a Scotch-Bright pad. It's held to the turbine assembly (the compressor section) by a Marman Clamp. I was able to take that clamp off and polish it using my buffing wheel which saved a lot of time. I'll have to look into mechanizing my cleaning and polishing or it will take forever...

Well, I managed to put in two 12-hour days this weekend and I think I've gotten a lot done. I also finished up my fiberglass work on the seat pan and re-mounted it on the frame.

Tomorrow during my lunch hour I plan to see if I can find some crushed walnut shells and consider blasting the turbine assembly with those to brighten it up. I've carefully covered the air intake using aluminum tape to keep debris out. I used ground glass on the transmission and tail rotor gearbox but I think that might be a bit too aggressive for this application.

Tuesday, 08 December 2009 –

Does the Combustor Assembly look any brighter? 3M came through for me with the greatest little mini weed-whacker disks. I spent about one hour going over the Combustor with eight of these disks threaded onto my pneumatic cut-off tool. I used a fairly course 80 grit abrasive (the abrasive is molded into the plastic.) It left a satin texture. I've ordered two progressively finer versions that I will pick up tomorrow…

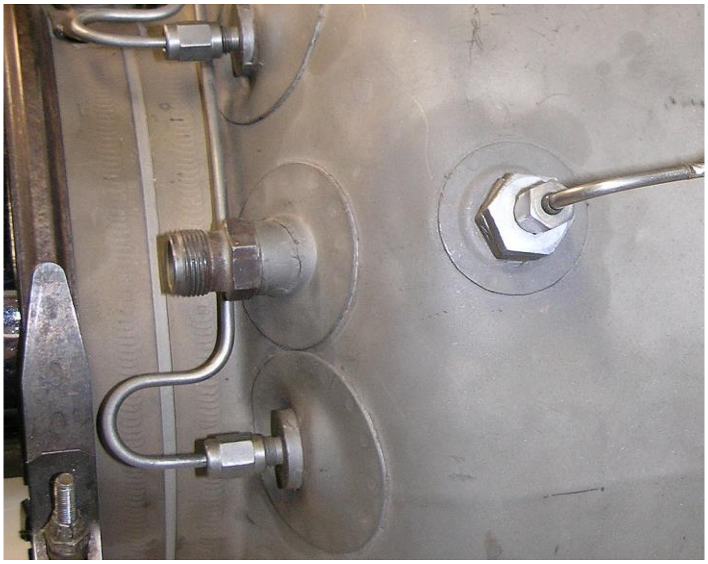


Wednesday, 09 December 2009 -- I now have three grades of these 3M Bristle Discs. Each type is color coded depending on the grit. They are very thin and can be stacked to produce whatever width you need. I purchased mine from R.S. Hughes Co. They use an abrasive mineral called Cubitron that seems to be imbedded into the plastic.

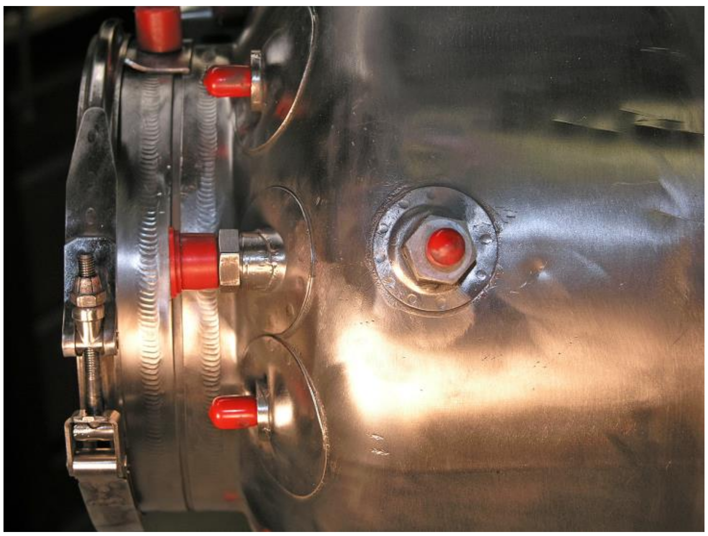
Here's the scoop:

GTIN(UPC/EAN)	Color	Description	Grit	Price
0 00 48011 30126 6	Yellow	Radial Bristle Disc Thin Bristle, 3 in x 3/8 in	80	$2.20
0 00 48011 30128 0	Red	Radial Bristle Disc Thin Bristle, 3 in x 3/8 in	220	$2.20
0 00 48011 60398 8	Blue	Radial Bristle Disc Thin Bristle, 3 in x 3/8 in	400	$2.20

WARNING! Wear a full face mask when using these discs. Those individual little bristles break off without warning.

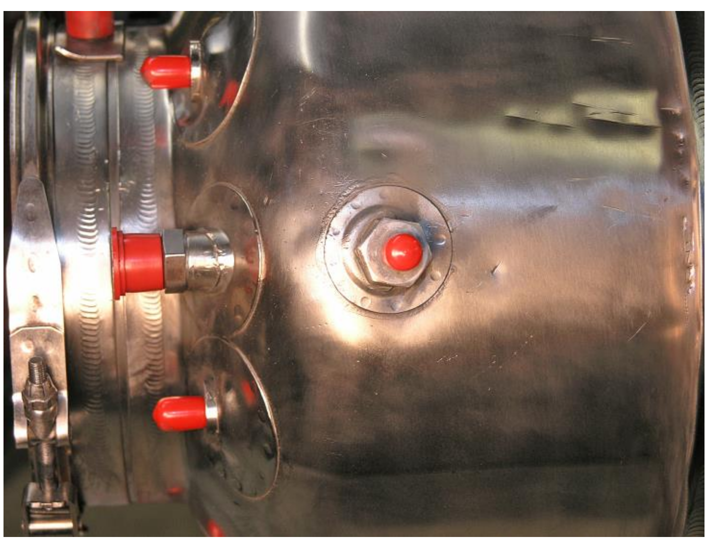


Here's a close-up of the right rear of the Combustor Assembly as it came out of the crate. Notice the corrosion inside the Marman Clamp and the general dull appearance…



Here's the same area after going over it with a Scotch-Brite pad and then hitting it with the yellow 80-grit 3M Bristle Disc. I polished up the Marnam Clamp using my buffing wheel since I could easily remove it from the engine.

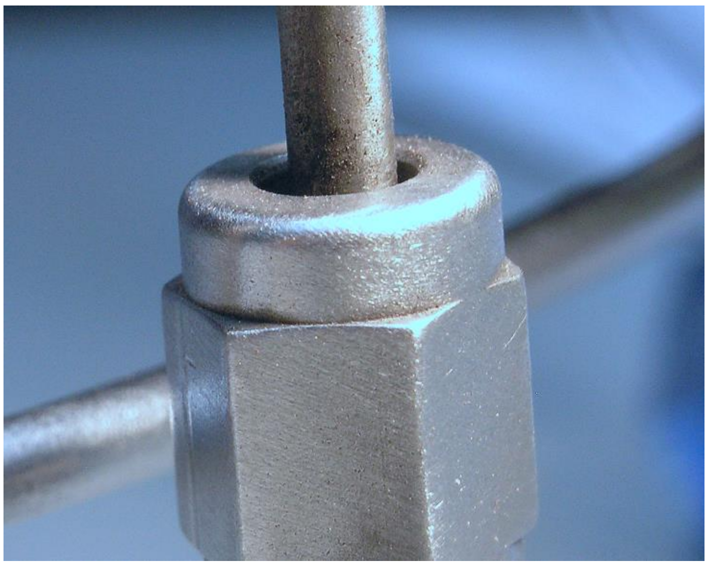
Next I'll go over it all with a stack of eight 220-grit red discs and then the 400-grip blue ones. It's about 45 degrees in my garage so I may not get too far…



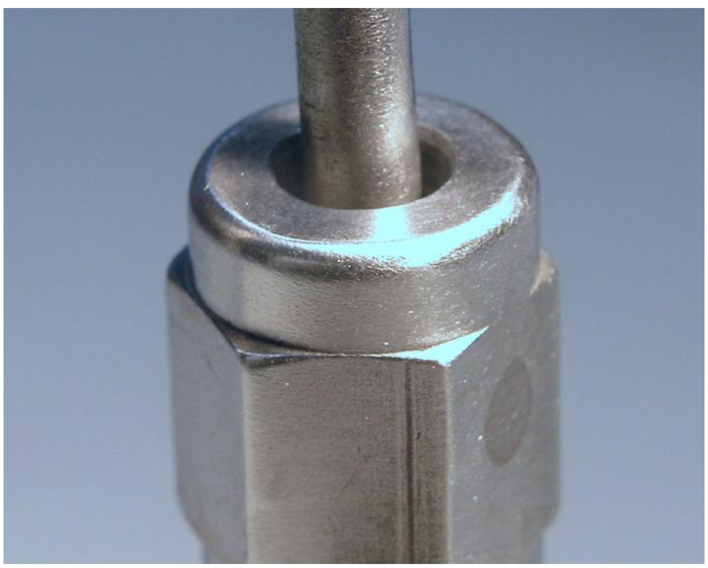
And here's the same area after about thirty minutes with the 120 grit and then the 400 grit discs. You can see that the grain is smoother. I'm down to a fine satin finish. I'm not trying to take out the dents, dings, and deep scratches. I just want to brighten it up a bit. It will never compete with the chrome tail pipe so this may be about as far as I want to go, at least for now. I'll have to wait for a sunny day so I can really see what I have. My garage lighting isn't that great.

Friday, 11 December 2009 –
This morning I dodged rain showers and took the engine out to my blast chamber (my driveway) and blasted it with crushed corn cobs. I was shooting for crushed walnuts but Granger didn't have any. I'm not sure this did anything but scatter corn cob pieces all over the yard, but the engine was pretty clean to start with and the POR-15 I plan to use comes with its own aluminum wash so this was just a precaution.

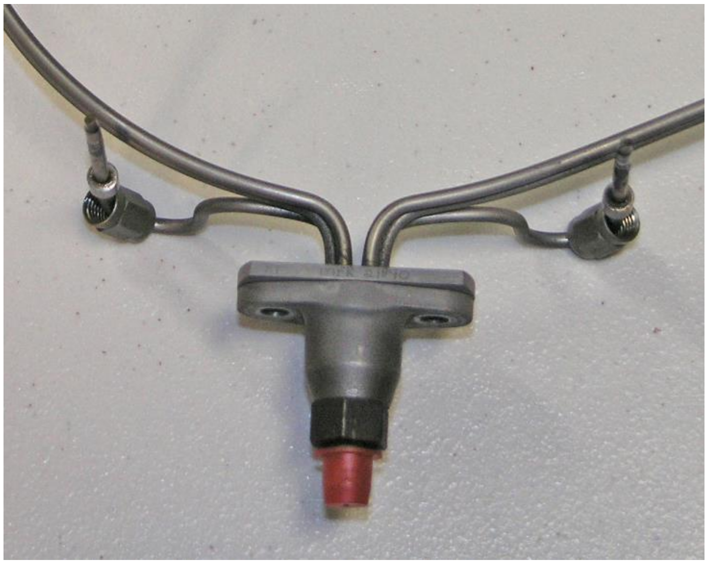
Once the rain started I headed back into my garage and cleaned up the fuel manifold using the yellow 3M bristle discs. The manifold came out looking very shiny and I decided to take a close-up for the log…



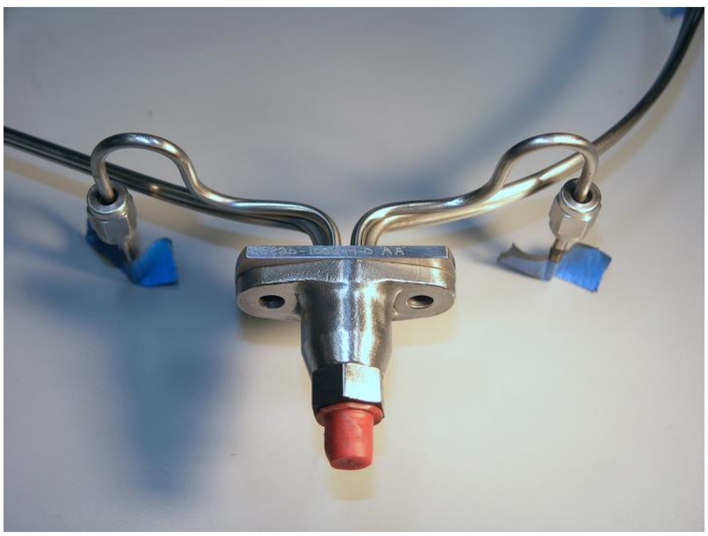
I had no idea those little plastic fingers were quite so aggressive. It certainly got rid of all the corrosion but I'll have to go over everything with the finer grades and then take another look. To the eye the manifold looks beautiful but obviously this is much to rough a finish.



Here's the same fitting after going over it with the blue 400-grit 3M Bristle Disc.

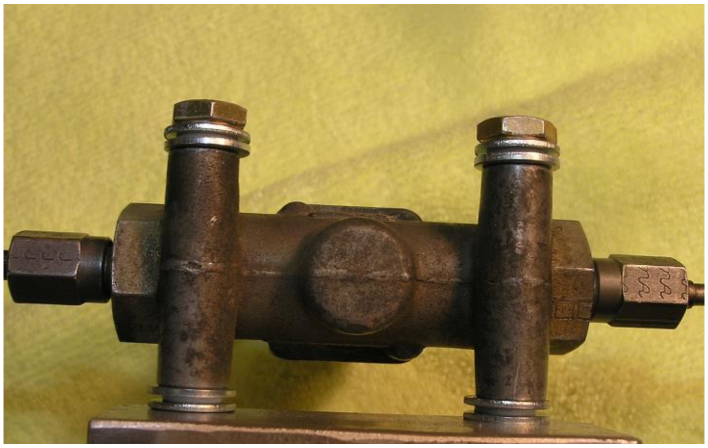


Here's a close-up of the Distribution Boss at the input to the fuel manifold as it came out of the crate.



Here it is after a few hours with the yellow and blue 3M Bristle Discs followed by 1500-grit wet and dry sandpaper and a white Scotch-Brite pad. I'm not sure the white pad did anything.

My previous attempt to hang the engine turned out to be very front-heavy so I made a lifting fixture to support it when I need all around access. This time I got the balance right, at least when none of the accessories or the pulley are installed. I can always make alternate locations for the eye bolt as the CG changes. This method only blocks a very small spot under that socket head cap screw on the right.



Sunday, 13 December 2009 -- I have a few remaining bits and pieces to clean up. This is the fuel shutoff valve as it arrived. Those washer stacks include a small nylon washer between the metal ones and the bracket just visible at the bottom of the picture looks home made. This is not the stock configuration as shown in the maintenance manual and the bracket doesn't look like Eagle R&D fabricated it so I'm slightly puzzled about the function of the nylon washers. I'll have to check on this…

Here's the fuel shutoff valve after a few minutes with the Bristle Discs. For some reason the blue discs are flying apart. Little bristles hit my face shield every time I use them. Without that face shield and safety glasses it would be very dangerous work.

I'm concerned that I may be taking a protective coating such as Alodine off as I clean these parts. I'll go over them with clear POR-15 just to be safe.

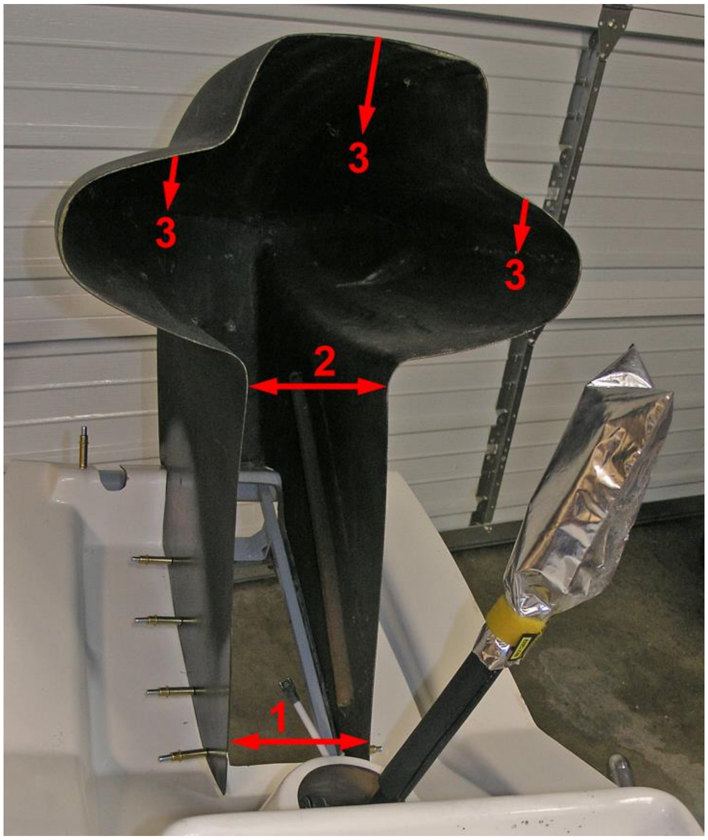
Once I finish up these last few pieces I'll set this aside until I receive the fuel control. I should get that in a few weeks. It's very complicated so I'm going to be hesitant to disassemble it to clean it up. I'll have come up with a plan. A grubby fuel control sitting on a shiny-clean engine isn't going to look good at all.

This is the last cleaning and polishing remaining to be done until I get the fuel control, with the possible exception of the Combustor. I can leave it as it is or try to polish it – I haven't decided. I wasn't going to show any more before and after pictures but this Purge Valve came out nicely.

This is "before"…

And this is after... On the body I used the same two grades of 3M discs as before and then I went over the stainless lines with 1500-grit wet and dry and then two grades of Nuvine polish. I used the same two grades of polish on the aluminum line but skipped the sand paper.

I'm going to switch gears until the fuel controller arrives and see if I can get my instrument panels dialed in and then send the .DXF file off to have them laser cut and black anodized. The instrument pod is quite flexible so the exact shape of the top panel is difficult to nail down with any precision. I have the seat pan set in place using cleco's, along with the pod.



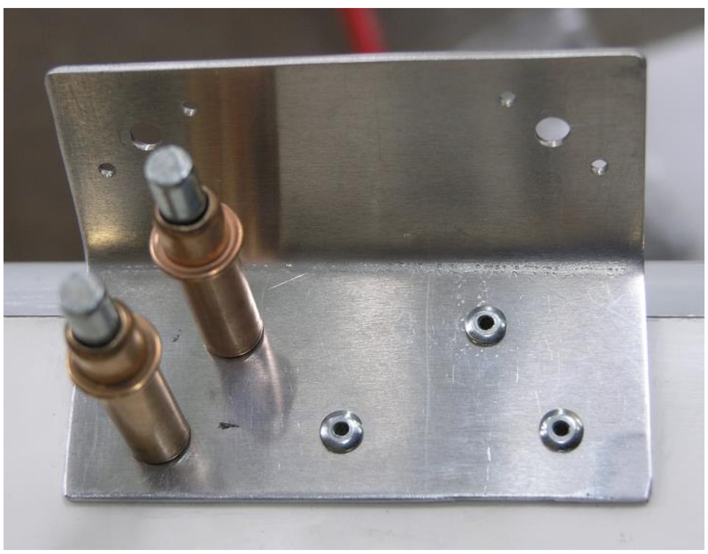
Here's the instrument pod in position on the seat pan. There are two instrument panels – a lower rectangular panel and the top panel with the multiple curves.

The width at the bottom of the lower panel area (1) is wider that at the top (2.) When I push the sides apart slightly to get dimension 2 to match dimension 1 the top surfaces (3) come down, changing the shape and size of the top panel.

In addition, if the pod is slightly off to the side then correcting that offset will further distort the shape of the top instrument panel.

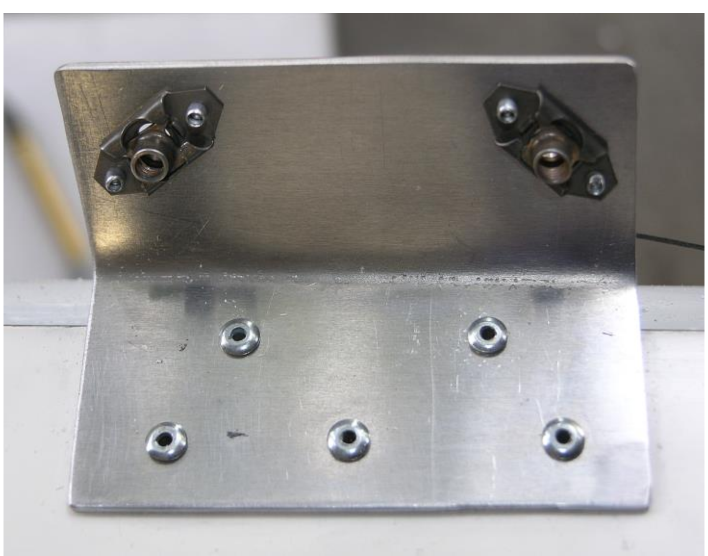
After procrastinating since last May I finally got up the courage to try to patch the large hole I cut to mount my main battery switch and also finish enlarging the collective well (I started this on page 122.) I had never worked with fiberglass and I was apprehensive. But I had no choice. Hap Miller gave me a hand and I finished it off last week. I glassed in the under side using glass cloth and Tap Plastic resin. Then I filled in the front using Dynatron Dyna-Hair and sanded it down using a progression of wet and dry sandpapers. Finally I filled in the pits using micro-spheres mixed into more Tap Plastic resin, and of course, another round of sanding to smooth it out. It looks ugly but it's nice and smooth to the touch.

While I was at it I glassed the back side of the seat pan around the mounting holes and filled them in. I remounted the seat pan and re-drilled the mounting holes to correct my first attempt which was slightly offset. I also repaired a bunch of small dings and nicks.



Now back to the instrument pod project… I fabricated this simple bracket out of 0.060" 6061-T6. It's attached to the seat pan at the very front and helps to support the instrument pod. There is an aluminum doubler plate under the fiberglass to add strength. I lined up all the holes using clecos as you see here, and then riveted the bracket into place.

After spending about one hour making slight tweaks to two of the eight mounting holes that secure the instrument pod to the seat pan, I had it lined up and centered. Then I used the two large holes at the front of the bracket as drill guides to drill mating holes in the instrument pod at the lower front.

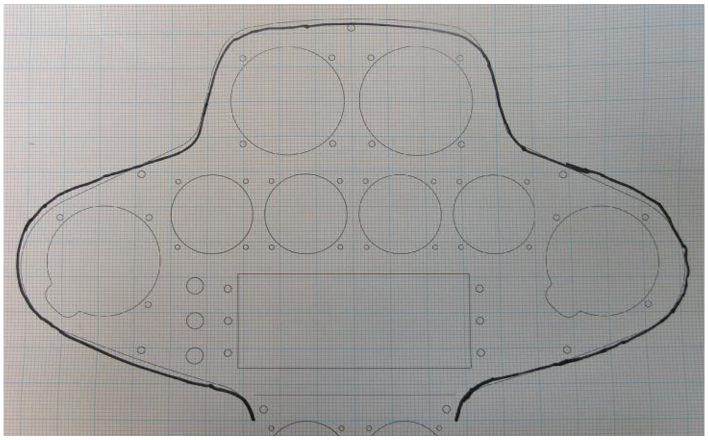


Then the pod came back off and I riveted these two nut plates on to the bracket to finish it off.

So now the instrument pod is firmly attached to the Seat Pan with ten screws and it looks like I have it centered up nicely. The idea with the string is to run it from the center of the upper bearing bracket straight back along the seam line of the pod and use that to center it up. It’s very close.

Now I can really get started trying to determine exactly what shape I need for my upper instrument panel. I’ve had all the instruments and radios for many months just sitting on a shelf. It’ll be a great moral-booster to get that panel finished off!

The next step was to get a piece of plastic 6-1/2” wide and tape it into the lower panel area to further firm up the pod and insure that the lower sides were parallel and not bowed. Next I went all around the inside of the pod where the upper panel will be and taped it off with cellophane tape. Then I took a plastic cutout that Hap Miller loaned to me and placed it into the upper panel area and filled in all the gaps with Bondo as you see. Once it sets I can pull it out and I’ll have a good template that matches the unique shape of this particular pod. If all goes well the Bondo won’t stick to the fiberglass and I’ll be able to get the template out with a minimum of fuss.

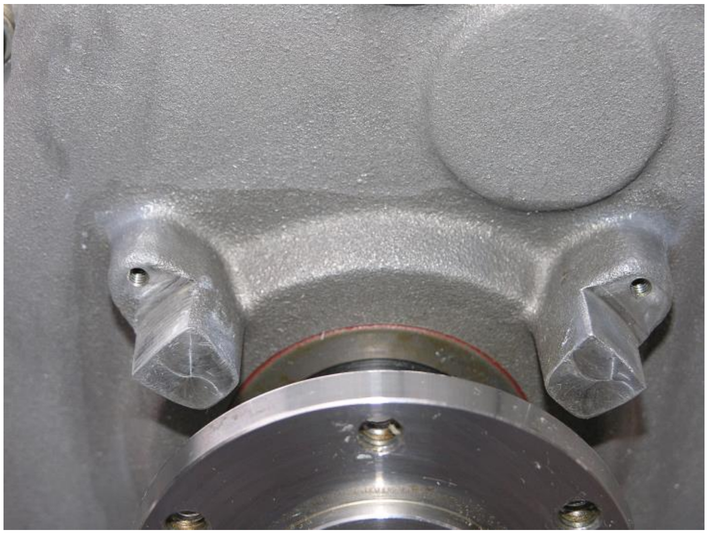


The next step was to trace the outline of the template over the 1:1 AutoCAD plot that I made from BJ's drawing. I added a 0.10" grid to my drawing so I can see exactly how far off I am and correct my drawing. Once I have that done and double-check clearances for all the instruments I'll be finally ready to send the file off to the fabricator to have my panel laser cut. Of course I'll make another 1:1 plot to make sure the drawing matches the template…

<ins>Saturday 19 December</ins> – I decided to paint my engine gloss black using POR-15. There is an elaborate preparation required using two different liquids. The last one has to be kept wet for fifteen to twenty minutes and then rinsed off with water.

I sealed off the areas I didn't want exposed to the chemical prep, including the bearing oil seal in the front and then went to work. Here, the engine is washed off and ready to dry.

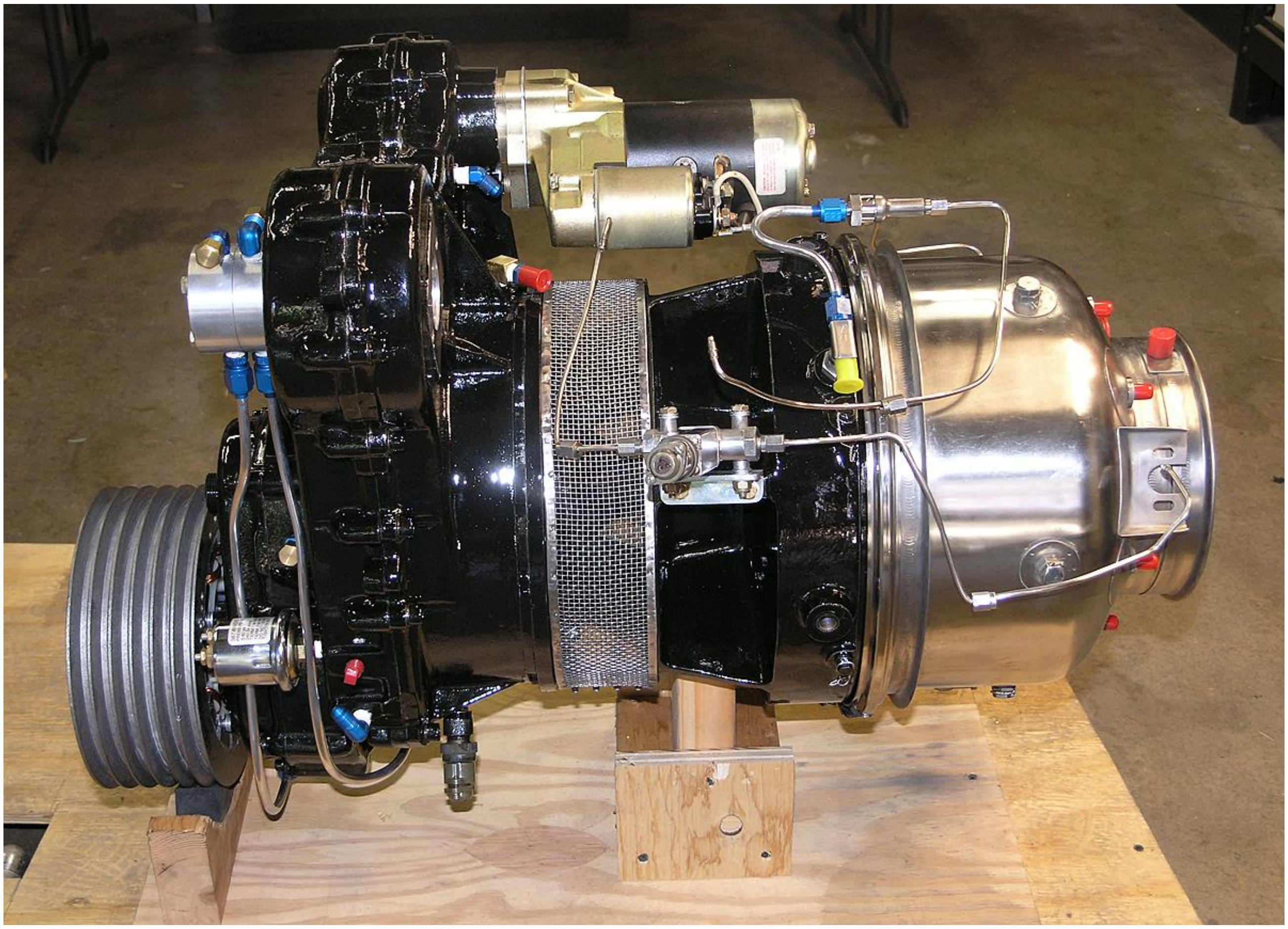
Here's a look at how I sealed up the front bearing. The calking was supposed to be fast but it was still gooey in places after applying it last night. It was messy getting it all off after I was done.



You can see in this picture that the chemical prep did alter the raw aluminum. The portion that was sealed up is darker.

After I washed everything off I blew the engine off with air and then warmed it up with my heat gun and let it sit for an hour or two. The POR folks warn you to be sure the metal is bone dry or you'll get little bubbles in the paint. I may have jumped the gun since I see a few of those bubbles now that I've painted it.

And here it is drying in my garage. It'll look a lot different with all the accessories installed. I think this will look good with my gloss black tail fins. The POR-15 sets up with humidity and it's been on the verge of raining lately so it should set pretty fast. Once it's gotten past the tacky stage I can take it outside where the light is better and see how I did. It's hard to tell in the garage.

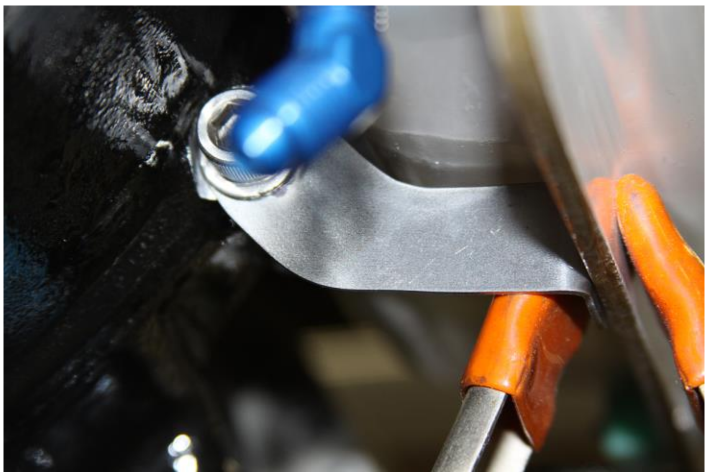


Sunday Afternoon 20 December 2009
I've been putting cleaned-up bits and pieces back on the engine and now I've started on the oil lines that get fabricated as I go. I have two completed that connect to the oil pump and go to the sumps. One huge chunk that is missing is the fuel controller. It's still at the factory and should be here in a few weeks. I probably have about ten hours work left at least just mounting accessories and making the remaining oil lines. I polish each line before I install it. It only takes a few minutes and I think it looks much nicer.

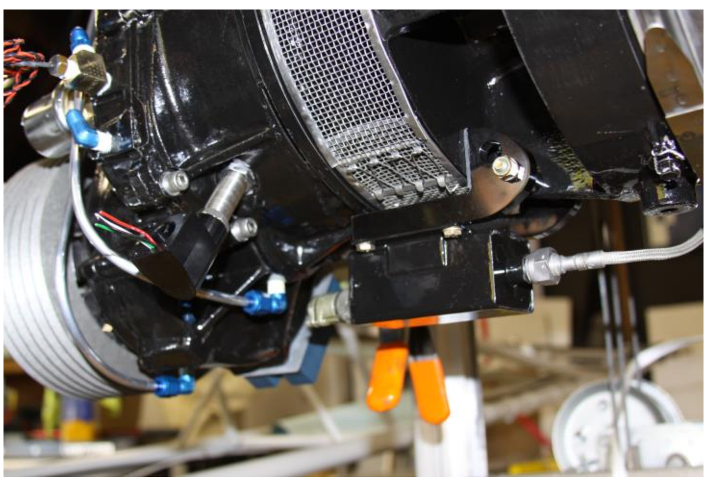
In addition to the missing fuel controller I still have to mount the oil filter, the igniter module, and several sensors. Among the tasks that I completed today was to safety wire ten fittings.

The black section at the left of the picture is the gear reduction housing, the silver screen in the middle is the air intake, the black and gold piece at the top is the starter, and the cylindrical aluminum part at the upper left is the oil pump.

Thursday, 24 December 2009 –
For the past few days I've been installing various accessories on the engine. This is the custom Hap Miller oil sump. It's held on with two stainless steel brackets that you make. There are no drawings so you're on your own. For some reason this sump fits a little differently than most folks.

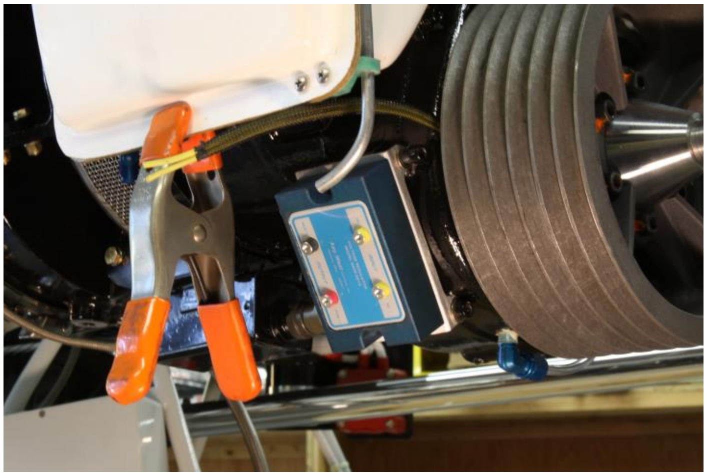


This is the lower oil sump bracket. The factory says to make both brackets out of a strip of stainless that's provided. But I had to make a dog-leg to get around the bottom of the sump since it sits a tad lower than expected. This is typical of the sort of work that needs to be done. I made a cardboard cutout and then copied it to the stainless bracket that you see. To make the bracket I used a hacksaw, my deburring/polishing wheel, a drill press, six progressive sizes of drills, a machinist vice, and a ball peen hammer.



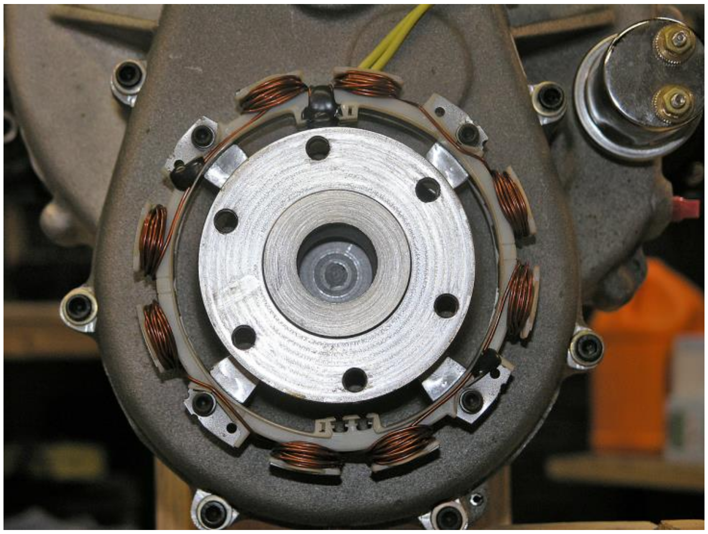
The black box hanging under the engine is the igniter electronics that produces a spark to start the engine. I haven't tried it yet but it should go, "snap, snap, snap…" Once the engine is running this is shut off.

The igniter box is mounted to a web at the bottom/center of the engine. I'm using mounting hardware that Hap Miller sells. There is one bracket on either side of the web and the assembly is mounted using a single ¼" bolt through a hole in the web that you drill. The thin gray vertical strip on the face of the bracket is a 0.080" thick piece of rubber. I attached a piece to both brackets using 3M industrial-grade pressure sensitive adhesive. This will keep the brackets from tearing up my paint and insure a nice snug fit.



The blue box under the oil sump is the rectifier/regulator for the alternator. It's also mounted on a customized bracket.

The alternator is simplicity itself – I think it's taken from something like a riding lawnmower. It consists of a ring of coils that fits nicely behind the pulley. Glued to the pulley are a series of magnets. As the magnets pass over the coils they produce electrical current. Simple!



Here's the alternator windings as they look with the pulley removed.

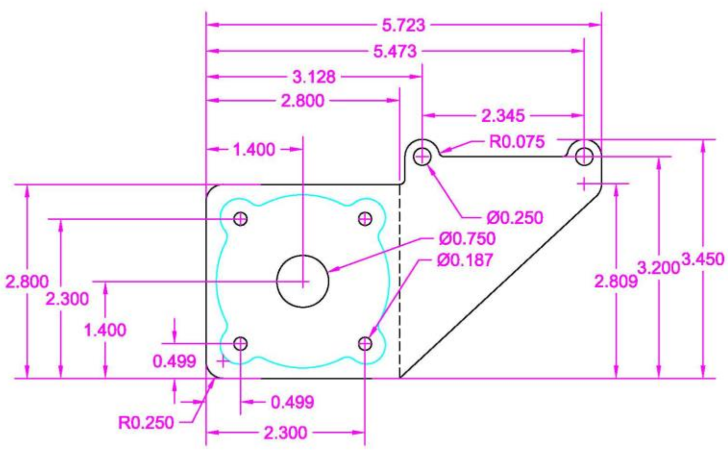
I rotated the winding assembly around to the left so that the leads come out at the left on the picture and nearer to where the rectifier/regulator is mounted.

I should mention that almost no one seems to be using the supplied rectifier/regulator. They all use the blue colored one I have. It's made by a company in Florida.

Well, now that I have my oil sump brackets in place it's time to drill the mounting holes through the fiberglass sump and the brackets. Then I can temporarily attach the sump and start fabricating more of the oil lines. I still have to decide how I want to mount my oil filter assembly. The factory says to make a simple clamp out of another piece of that stainless steel strip they provided but I'm not sure I want to do that. One of many little things to think about…

As the builder of a home-built aircraft I have a lot of latitude as to how I build the kit. Figuring out how I want to mount my oil filter is just one of hundreds of little details where I have some latitude.

Engine Oil Filter Bracket (0.063" 6061-T6)



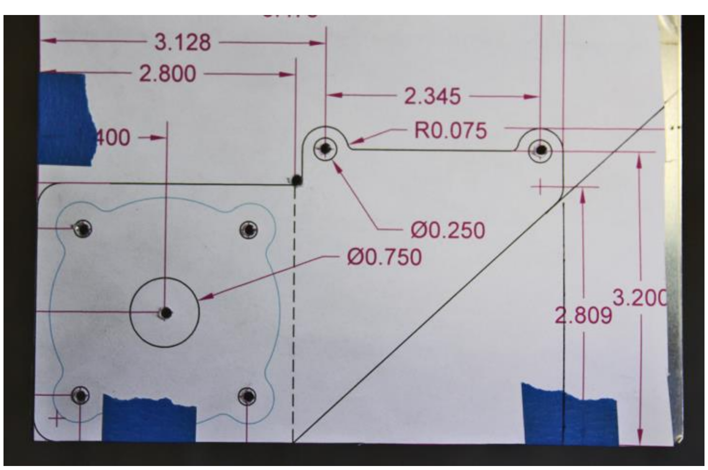
25 December, 2009 –

I didn't like the strap clamp idea that the factory suggests to mount the oil filter so I'm going to make a bracket. The dashed line will be a 90° bend and the bracket will mount on two of the ¼" socket head cap screws that secure the two halves of the gear case. The oil filter will sit on the shelf formed by the bend and be secured by the four 3/16" bolts that hold the filter together.

After using AutoCAD to design the bracket I printed the drawing out full size so I could take a look to make sure I didn't make an obvious mistake. The sloped side allows the AN fitting to clear the bracket.

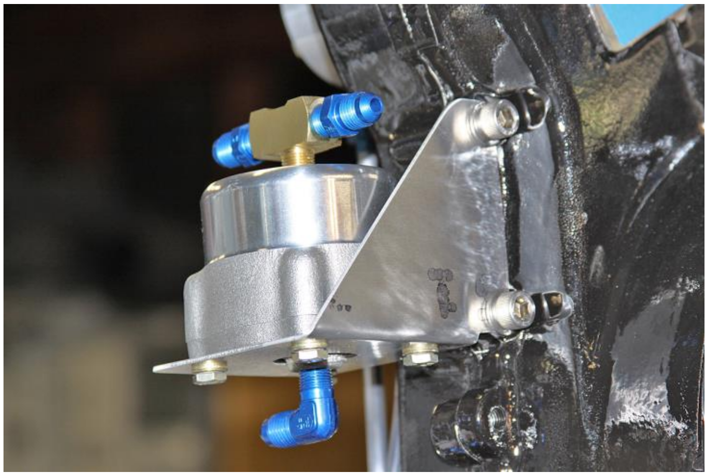
Next I'll cut out the plot and see how the mounting holes line up on the engine.

OK. That looks like it will work so it's time to cut and bend some sheet metal.



I actually don't need all the dimensions on the drawing. I use the print as a template and simply tape it to the sheet metal. I center punch the holes using the center marks on the drawing.

Now that I have all the pilot holes drilled I can make my cuts and the bend I need at work (I don't have sheers or a brake and trying to make a nice bend using a vice doesn't work.)



And there's the finished bracket. I ran out of paint. When it shows up I'll paint all the bare aluminum brackets gloss black. I'll give the oil filter a clear coat.

There's always a chance this won't fit in the frame without a tweak (see page 182.) I can slot the mounting holes on the shelf and slide it in about a quarter of an inch if necessary. Or I can always make a new bracket. It wouldn't be the first time…

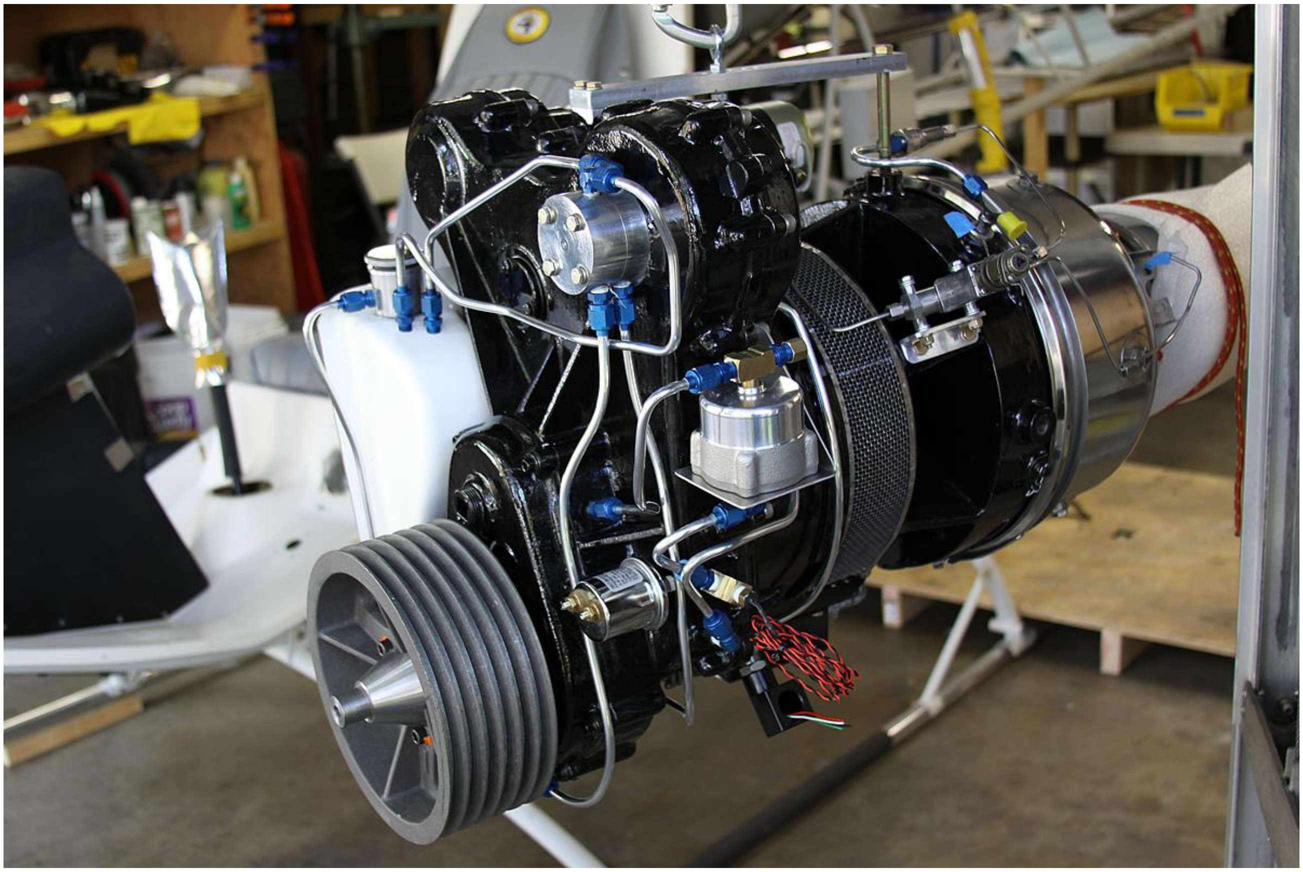
Now that most of the lubrication accessories are in place I can get back to plumbing. All the oil lines are ¼" aluminum with flared ends and AN flared fittings. Unlike automotive fittings aircraft flares are thirty seven degrees. I use a small tubing cutter, an aircraft flaring tool, and a tubing bender from Aircraft Spruce. Once the fittings are installed and the ends flared, I sit down for a few minutes and polish each tube. If I need to I can use the tubing bender to make fairly complicated or tight bends, or just do them by hand if they're gradual.

After I give the oil filter a clear coat I'll final-install the fittings using some Teflon tape to seal them up. For now I can fit all my tubing since nothing is going to move. Once all this is done, I only have a few things left to do to the engine:

- Clean up and install the fuel control (once it arrives from the factory)
- Decide on cable routing on the engine and install Click-Bond cable tie anchors as needed
- Decide whether or not to polish the combustion assembly
- Terminate the alternator wires at the regulator
- Install a mil connector on the dual hall-effect sensor (engine RPM transducer)
- Paint the oil sump and final-install it
- Once everything is connected, fill the sump with AeroShell synthetic turbine oil 500
- Spin up the turbine on the starter to circulate the oil

Before I spin up the turbine I'll temporarily hook up the oil pressure gauge and the engine tachometer. I will also capture and plot starter current. If I can I'll also capture battery voltage while I'm doing all this.

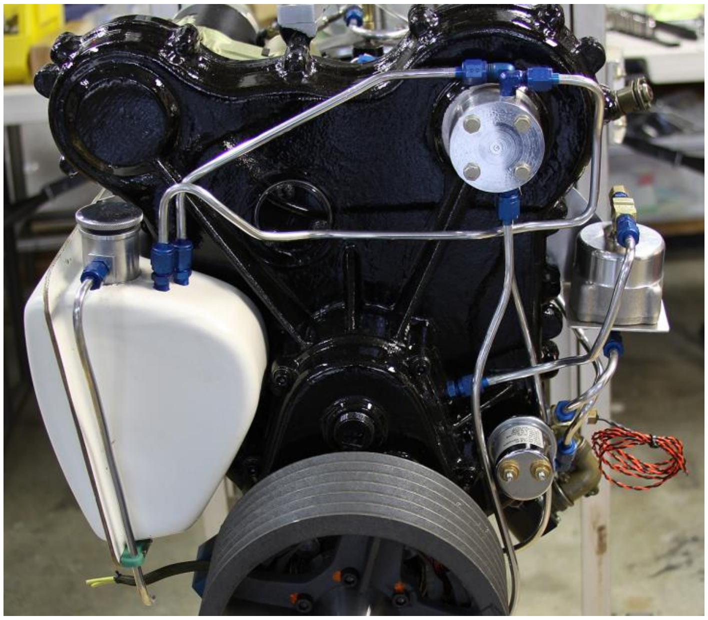
I used to be around a lot of synthetic aircraft turbine oil (SATO) when I worked as a non-routine line maintenance mechanic at United Airlines many years ago. I never thought I'd be using it one day in my own turbine-powered aircraft!



26 December, 2009 –
All of the lubrication components are now installed. The builder is supplied with a coil of tubing and a package of fittings. Most of those lines were simple to make, except for the one at the top of the engine and closest to the camera – the one that loops around and goes to the white oil sump. It's got eight bends in it and it took me about four tries to get it right.

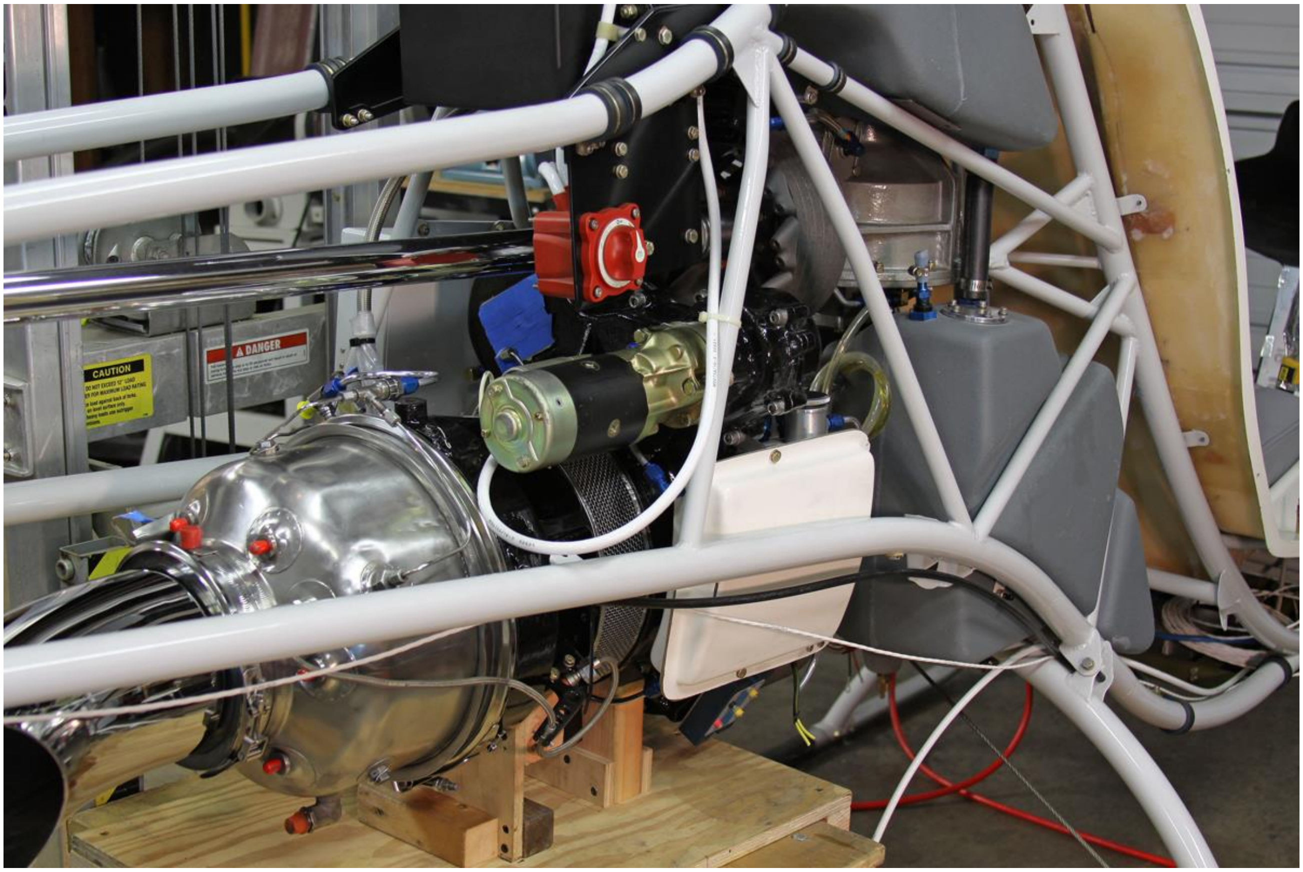
Here's a run-down of the major visible components in the lubrication subsystem; the white tank on the back side of the engine is the oil sump, the cylindrical aluminum piece at the top is the dual-section scavenger pump, and of course that's the oil filter in the foreground. The cylindrical component at the bottom of the engine is the oil pressure transducer. And the very small device with the coil of red and black wire attached is the oil temperature transducer.

And here's one more piece that's ready to final-install. This is the engine's hall effect RPM sensor with its mating connector. I think Eagle sells the black piece so you can mount a Cannon connector on it. I may have gotten it from Hap Miller. I can't remember. I had it anodized.



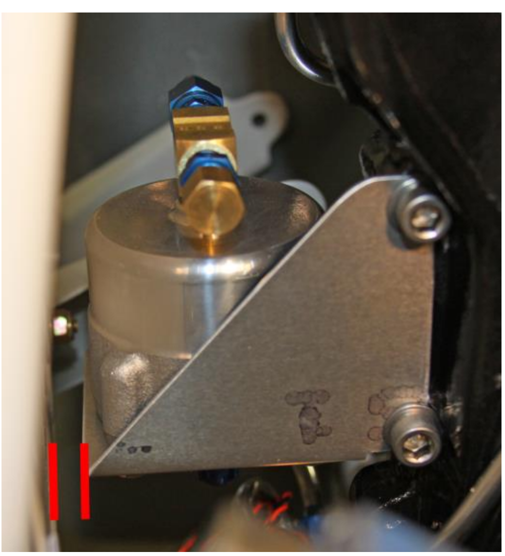
Hap Miller added a second oil return fitting to the top of the oil sump that he modifies. The factory DVD has you bring those two scavenger pump return lines together into a brass 'T' and then run a single return from the 'T' to the oil sump. The 'T' is tie wrapped to a small bracket that you attach to one of the bolts on the gear case front. I wasn't crazy about that idea. Hap's solution is much better. I would have preferred to bring both return lines out the left side of the scavenger pump but I couldn't get that fitting to budge and I didn't want to risk breaking it. It took me several attempts to get the tube that exits out the right side of the pump bent the way I wanted it. It passes between the two inlet lines at the bottom of the pump and then angles around a rib on the gear case.

Here's a close-up of the really nice improvement that Hap Miller makes to the oil sump. Instead of a cheap press-on oil cap he machines a new riser and a cap with an o-ring. The cap is knurled and polished to a mirror finish. It's a great improvement in my opinion. These fittings will all come out when this sump gets painted and then final-installed with Teflon tape to seal them up. I've tried several different sealants and the liquid ones are all messy to deal with. I'm going back to Teflon tape, at least until something leaks.

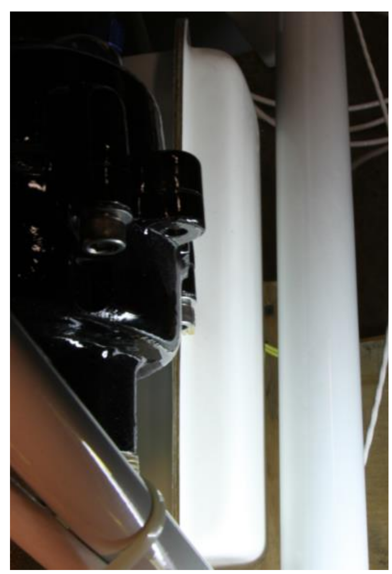


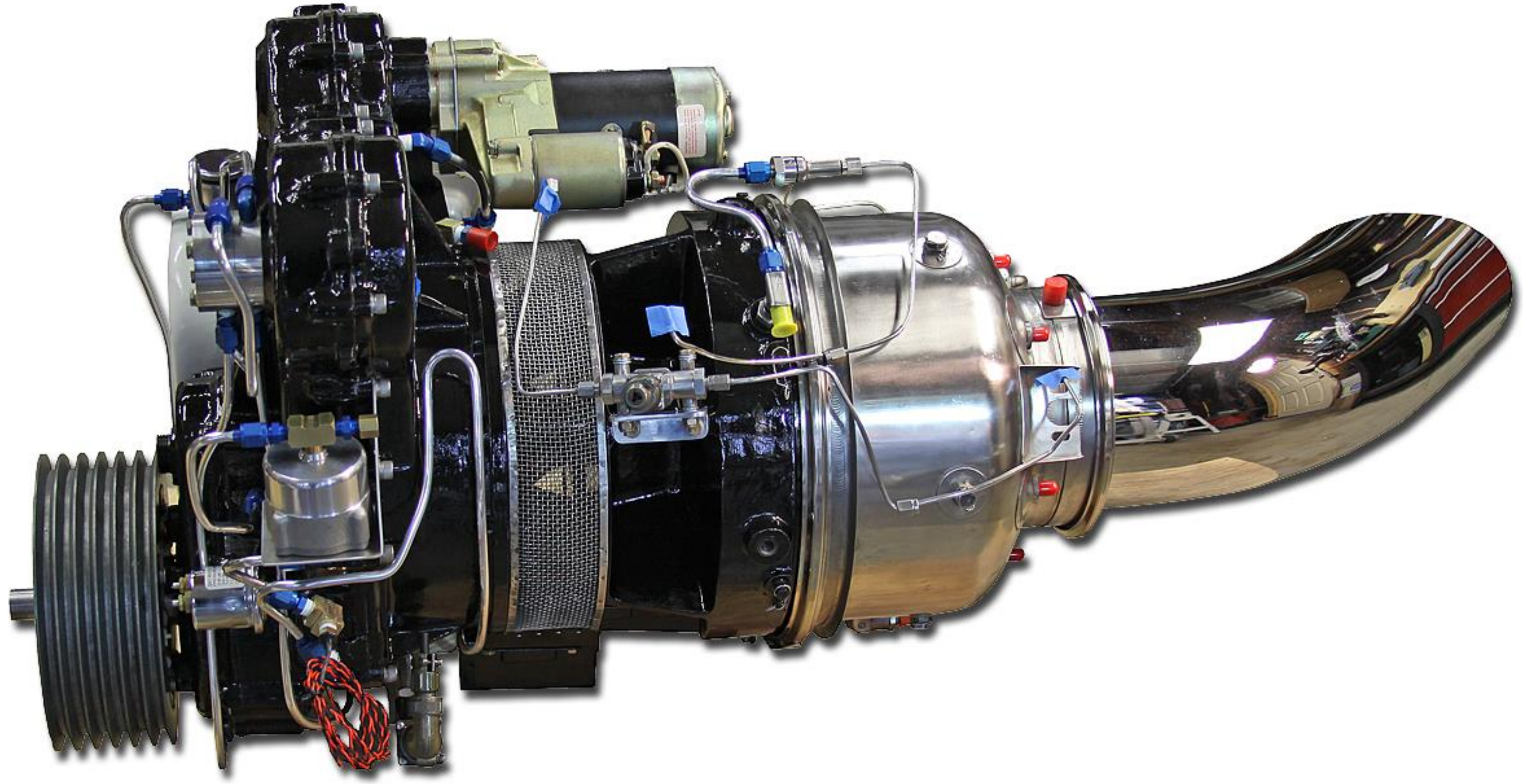
Monday, 28 December – I decided to do a preliminary fit check. I had to make a new stand now that I have components under the engine. It should do the job and the Genie Lift continues to be a great tool.

The fit is amazing considering that this helicopter was originally designed for a 2-cycle snow mobile engine. The turbine engine fit is absolutely perfect. Check out the next two pictures…

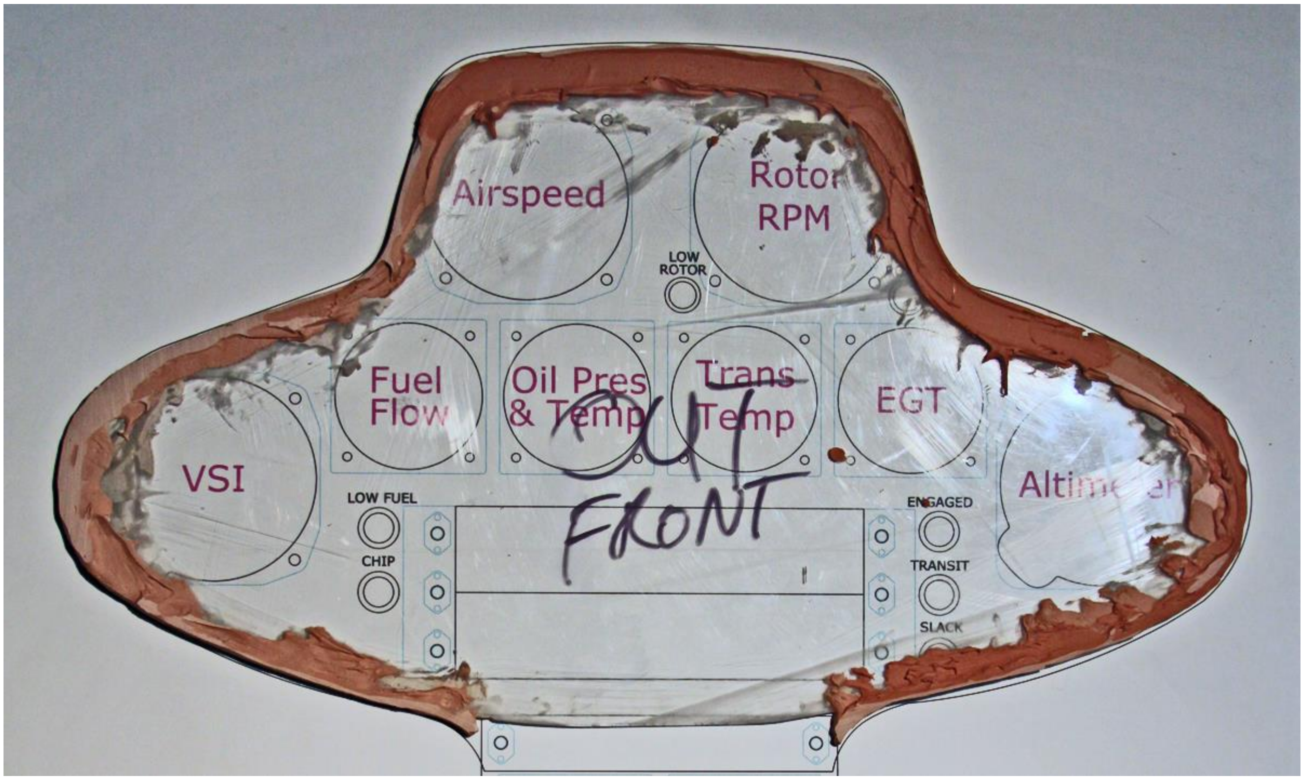


See the gap between the two red lines in the picture to the left? That's the clearance between the oil filter and the left frame tube, and the picture to the right shows the clearance between the oil sump and the right frame tube. They're both about a quarter of an inch.
As soon as I paint my engine mounts I'll have to see if the previous builders managed to get the mounting holes in the correct location. They don't have a good track record so far.



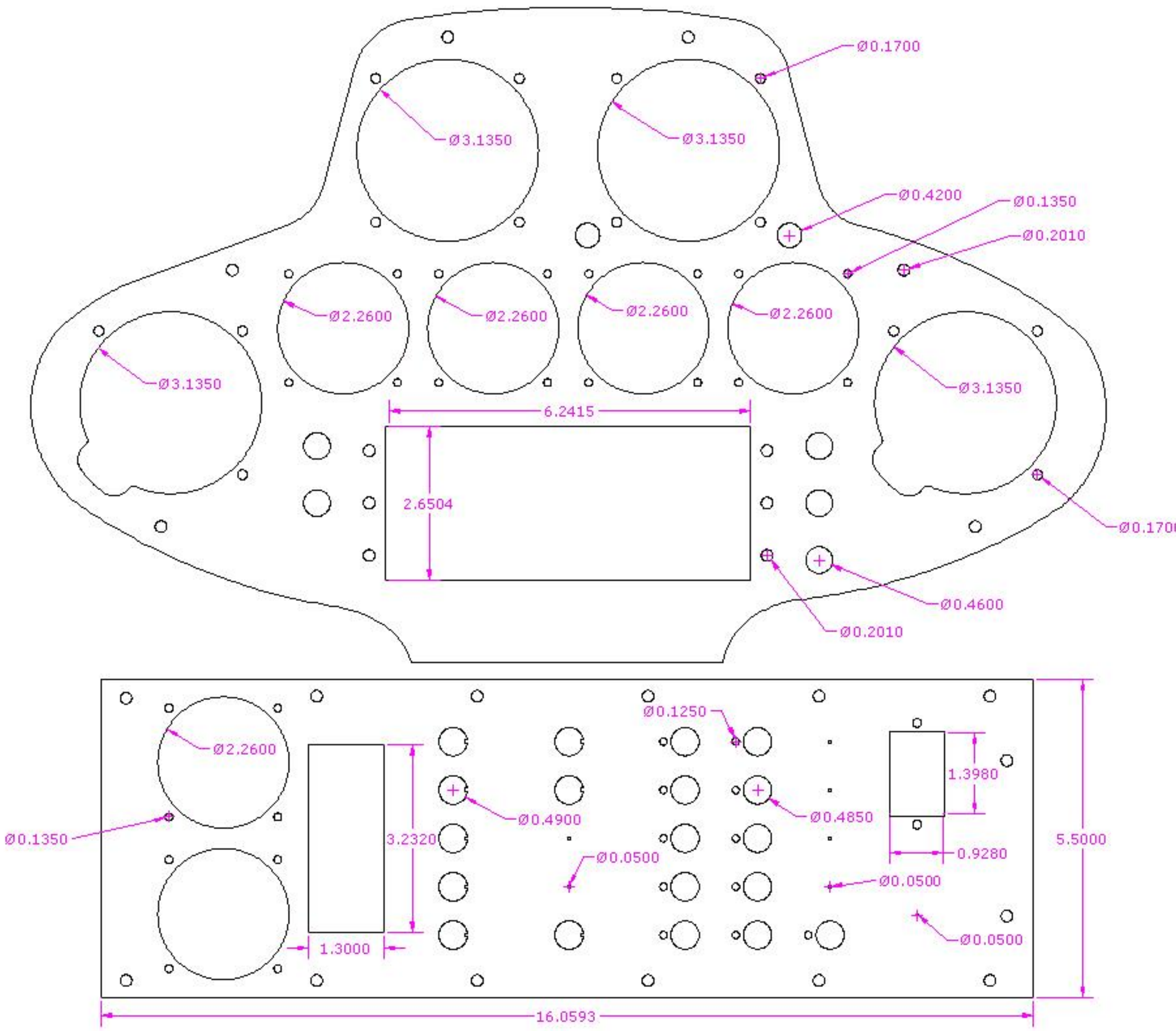


I couldn't resist one last picture before I move to another project. This is the way the engine looks at the moment. I'm going to use this as my screen-saver at work. It took longer to Photoshop the background out than it did to do the work! (I shot this before I did the fit check.) Other than painting a few brackets all I need is the fuel control to finish this off, unless I decide to try to polish the combustion assembly…



While I wait for more POR paint I'm switching back to my instrument panel. The pod is not exactly symmetrical – the two sides are about 3/8-inch different. I borrowed this plastic template from Hap Miller and fit it to my pod by squishing Bondo into the areas around the sides that didn't fit. Then I fiddled with the CAD drawing until I got it to the point you see. It took about five tries to get this close. All of those compound bends in the drawing are difficult to deal with. The pod is flexible and I think this will work.

By the way, if you try this use something to line the inside of the pod so the Bondo doesn't stick to it. I used some common cellophane packing tape and it seemed to work well enough.



The next step is to drag out everything that will mount in the panel including all of my instruments, switches, circuit breakers, and mounting hardware and double-check the dimensions. I've decided to have the panels powder coated so I need to leave 0.004" clearance around everything to account for the thickness of the coating. Once I'm sure of the fit then I'll convert this file to a .DXF exchange file and send it off to the laser cutting shop. I'm going to use 0.063" 6061-T6 instead of the 0.050" that Eagle supplies. I'm going to end up having to put ballast in the front anyway so I might as well make the panels a bit sturdier so they don't wobble around in the pod. By the looks of my dimensions, I laid this out thinking I would have the panels anodized. I'll probably have to enlarge all the holes by 0.008".

You'll see some small 0.050" holes near the switch and circuit breaker locations (middle of the bottom panel.) I've decided to mark the exact location of any future additions by having these small holes cut in those spots. I have room for two more toggle switches and four more circuit breakers. I don't think these holes will be annoying and they'll make it easy to drill any future mounting holes and easily get them exactly located.