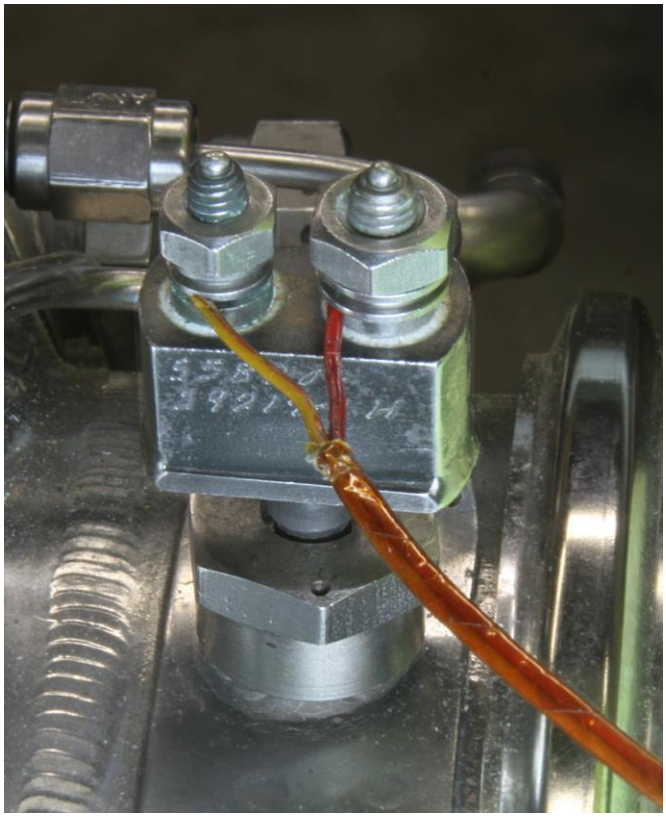
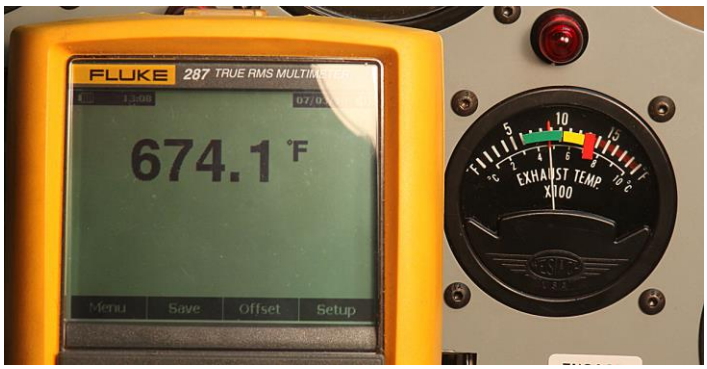
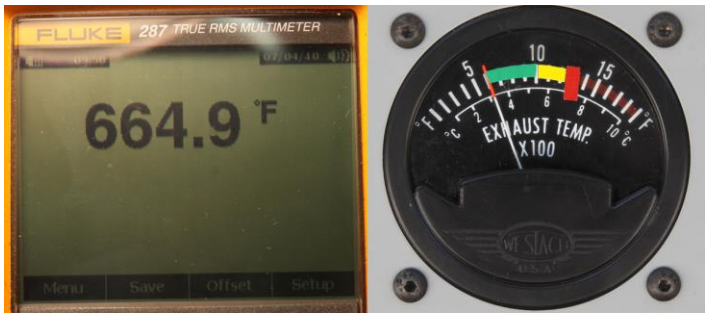


This is the EGT sensor that came with the Solar T-62T-32 turbine engine. It's a type-k thermocouple. Thermocouples are very simple devices consisting of two dissimilar metals bonded together at one end to form a junction. The junction produces a small electrical voltage when heated. Type-k thermocouples use chromel and alumel wire and the junction sensitivity is approximately 41 µV/°C. This particular thermocouple appears as multiple junctions in parallel in the Solar T-62T-32 maintenance manual (see schematic on next page.) That would have the effect of averaging the temperature of all the junctions along the length of the probe.

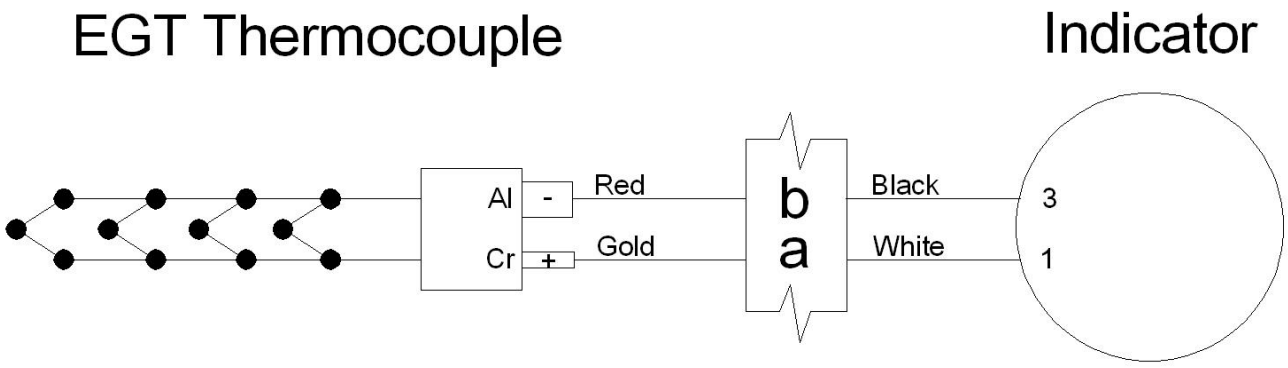
Here's where it gets tricky – any point in the circuitry between the thermocouple and the indicator, where a junction is formed between dissimilar metals, will also act as a thermocouple junction and introduce an error voltage. This other junction is referred to as a 'cold junction'. There's always a cold junction somewhere since the chromel and alumel wire are eventually going to have to connect to dissimilar metals, usually at or near the indicator. In a precision thermocouple the cold junction is submerged in ice water and held at 0°C. Since the temperature of the cold junction is precisely known, it can be compensated for to produce an accurate reading. We're not that fortunate. Westach assumes the cold junction is near the indicator and is at a temperature of 75°F and they calibrate their indicator accordingly. They say that the indictor will read one degree low for every degree the cold junction is raised above 75°F. But is this particular thermocouple designed to connect to type-k thermocouple wire, or standard aircraft wire? This is a critical question. If the chromel and alumel are brought all the way out on the two thermocouple studs then I'm not introducing a cold junction if I use type-k thermocouple wire which uses chromel and alumel wire. But if the thermocouple is designed to interface to regular aircraft wire then I'm introducing another cold junction by using type-k wire. And if the thermocouple is designed to mate to regular aircraft wire then the cold junction must be inside the probe. If so, this would introduce a very large error and would probably be compensated for when marking the face of the generator set's EGT indicator. Switching to the Westach indicator could further confuse an already confusing situation since the two indicators could be calibrated completely differently.



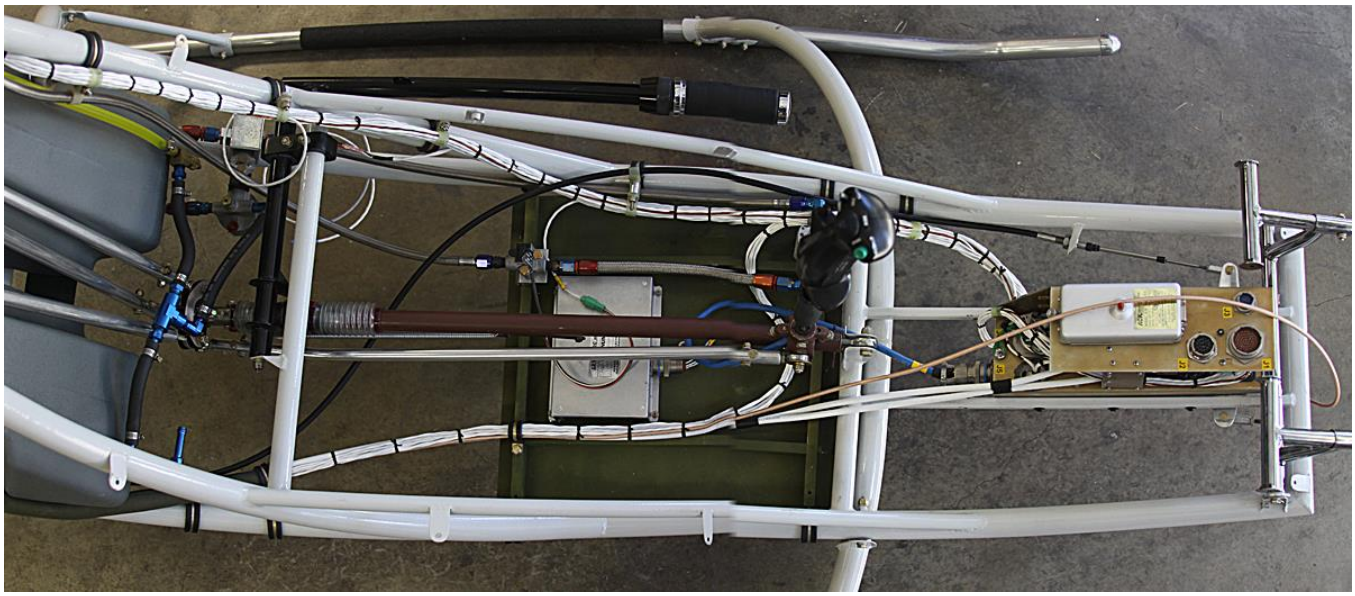
I temporarily hooked the ship's thermocouple to the EGT indicator using aircraft wiring. Then I attached my Fluke thermocouple to the ship's thermocouple and heated them both up with a temperature-controlled soldering iron that was cranked all the way up to 850°F. The temp stabilized as you see here. The EGT indicator appears to be reading about 200°F high. That's unacceptable.



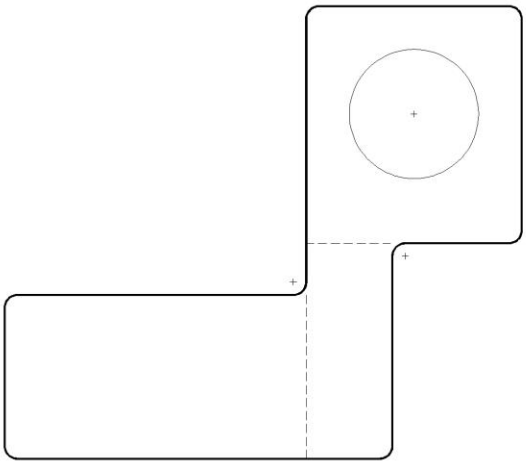
Here's the same test using the type-k thermocouple wire. The interface to regular aircraft wire is at my interface chassis at the base of the instrument pod (see below.) This is obviously a much more accurate reading. Now the indicator appears to be reading about 50°F low. In both tests I have no way of knowing if the Fluke thermocouple is really seeing the exact same temperature as the EGT thermocouple.

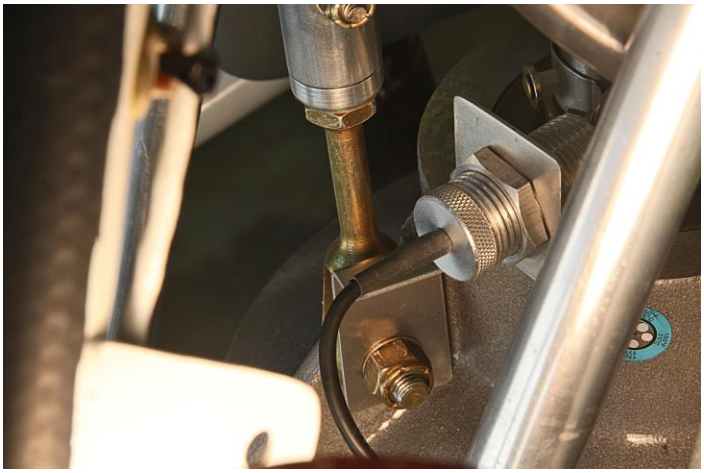


Here's the wiring layout. If the hand engraving on the thermocouple is correct then the large stud is alumel and is the minus polarity. The small stud is chromel and is the positive terminal. By convention red thermocouple wire is always minus but the plus color may vary. I'll swap the thermocouple wire around and do one last test just to confirm. Yes, swapping the thermocouple wire's polarity caused the indicator to read about 175°F low so my wiring is correct as shown above. The only major deviation from the Westach suggested configuration is that they want you to somehow make a connection to their regular jumper wire that has crimped tin-plated female terminals. I assume they mean for you to double over the thermocouple wires at the ends to make an interference fit with the female terminals and then stuff them into the terminals. That strikes me as extremely crude so I simply crimped my regular gold-plated terminals on the two wires and inserted them into my mil connector. That means I have a cold junction between the alumel and chromel wire and gold instead of tin. That will produce a different junction sensitivity than what Westech expects. I'm willing to live with that as a trade-off to get a much more reliable connection. If the EGT consistently reads 50°F low I can live with that.



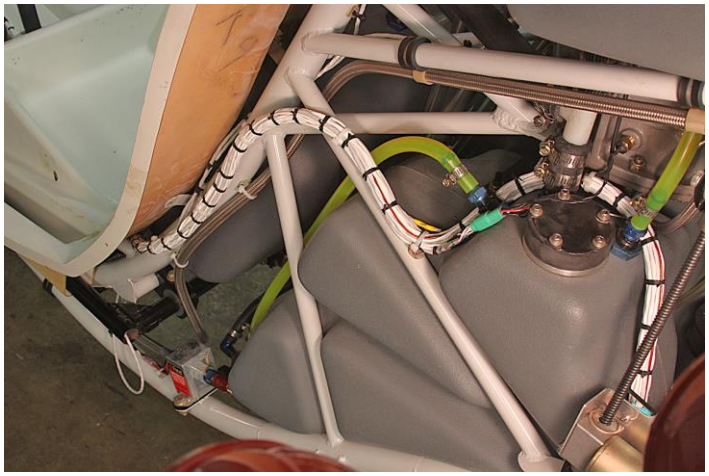
I've final installed the directional controls, the cyclic, the collective, and all of the cabling that will be covered by the seat pan. I'm now ready to finish off the final sanding of the seat pan and take it off to be painted. Once that's done I can install it and final install the instrument panel, the auxiliary tank, and the seat back.





While I'm still able to access the bottom of the rotor shaft I fabricated a bracket to mount the second Hall Effect sensor that I'll eventually use to measure torque. I laid it out using AutoCAD, plotted it full scale, cut out the paper with scissors, folded it into shape, and then checked the fit. Once I got the paper version to fit the way I wanted, I transferred the drawing to sheet metal and made the bracket. In the picture to the right you're looking at the top of the transmission and the forward transmission mount. I'm using an after-market mount sold by Hap Miller.

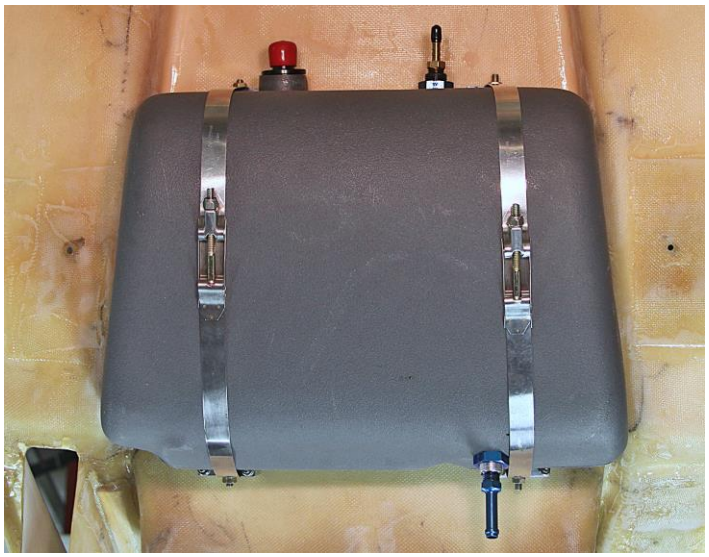
The bracket is bent in three places; two where you see the dashed lines on the drawing, and then the top portion is twisted counterclockwise to aim the sensor towards the center of the shaft. I'll go ahead and run the wiring down to the interface panel so I don't have to tear the cabin apart later on when I get around to creating the torque meter.



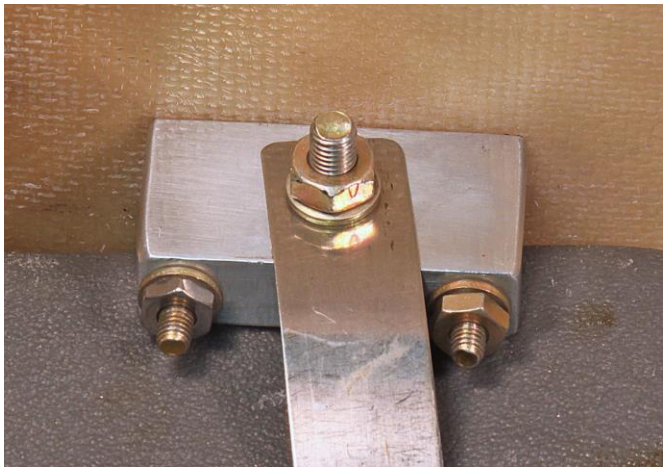
Oops! I thought I'd finally finished with wiring and I began to get the aux fuel tank ready to mount to the back of the seat pan. That's when I realized that the left hand cable harness interfered with the auxiliary tank. I had to disconnect the harness, pull it completely loose, and then reroute it around the outside of the frame tube. I also had to relocate the braided fuel line for the same reason. The aux tank is jammed between the frame tubes and there is zero room.

Initially I used Adel and Nylon clamps to secure the harness and fuel line (see picture at top of page 243) but I found that the thickness of the Adel clamps was enough to keep the aux tank from fitting between the frame tubes. I finally switched to Click Bond tie-wrap mounts.

The aux tank dictates the lateral alignment of the seat pan in relation to the frame since it's a snug fit into the recess in the back of the seat pan (see below) and then it jams into the gap between the frame tubes. It's best to get this all finalized before drilling the seat pan mounting holes that secure the seat back to the frame. I didn't do that and I'm lucky that the holes still line up.



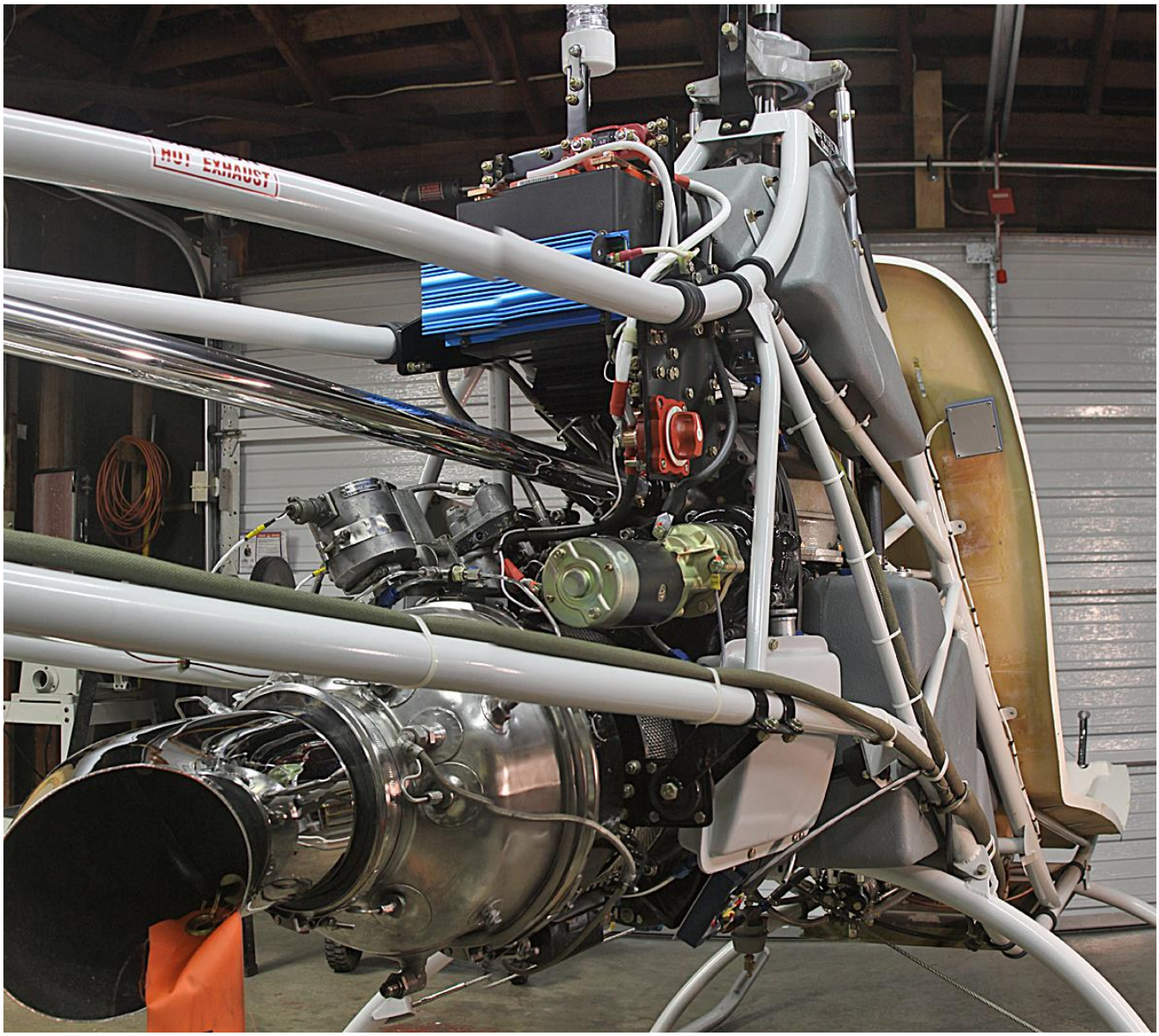
Here you see the auxiliary fuel tank temporarily mounted to the seat pan. Because of the taper it must be inserted from the bottom. It's a jam fit.



The Marman clamps are attached to the seat pan hard points in four places with ¼" bolts. Each attachment point is secured to the seat pan with two 3/16" bolts using fender washers on the far side to spread the load. The washers will be covered by the seat back cushion. Since I'll have this tank on and off many times before its final installed I'm using standard non-locking nuts for now.

Here's the view from the left side of the ship. This view shows the completed wiring harness now attached to the frame with about fifteen Click Bond tie wrap mounts and several Adel and Nylon MS25281 clamps. I may go back and cover the harness with Nomex Roundit later.

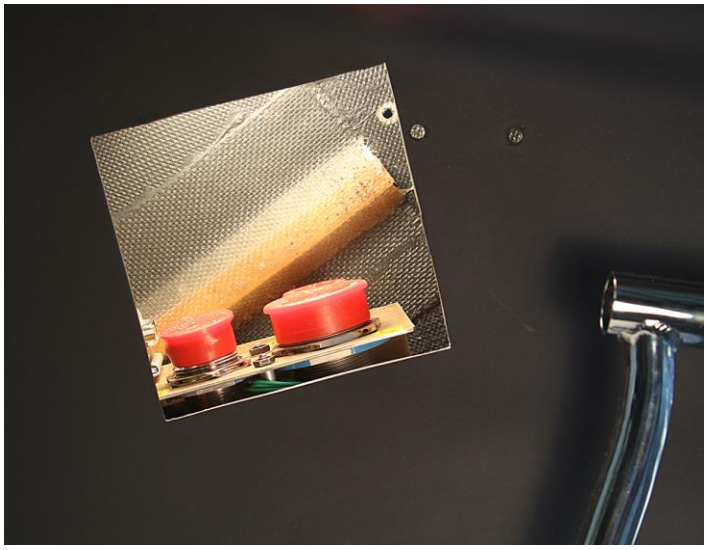
The auxiliary tank is visible directly behind the seat back. Getting the tank and the seat back installed takes a shoe horn. You can't pre-attach the tank to the seat pan because the combination won't fit into the frame. The tank has to be put loosely into position in the frame, the seat pan installed over the top, and then the tank secured to the seat pan. It's difficult to get your fingers into the area around the tank once everything is in position so I hope I don't have to do this many more times.



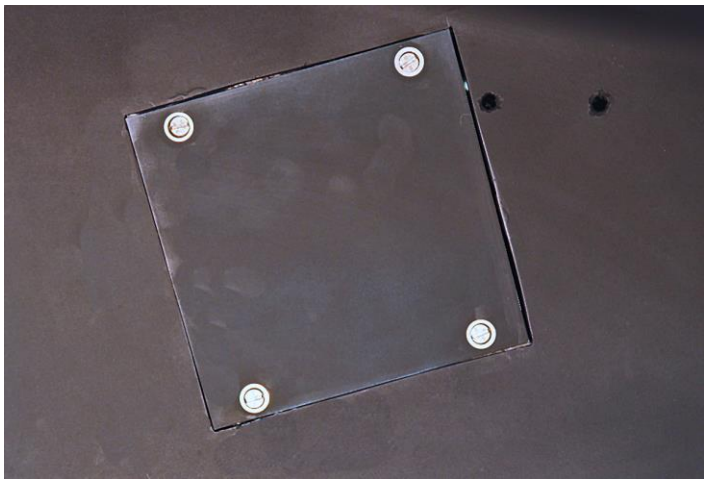
Here's a stitched picture of the right side of the ship. Since the main harness uses the bottom frame tube to access the area under the seat pan it bypasses the tight area around the auxiliary fuel tank, making this side much simpler. On this side I simply tied the harness to the frame using tie wraps and no Click Bond mounts. I might switch to the mounts once I'm satisfied with the routing.

The wiring that ends in the small box at the top of the seat pan is the communications wiring for my headset. The headset will plug into a jack mounted in the box and the coil cord will hang down my right side and away from the collective.

I'm starting on the details in and around the seat pan and instrument pod. My plan is to get the cabin halves back on for a fit check and then locate and install my pitot tube, my static port, and my lower strobe light. Once I get those external items in place I'm going to take the helicopter to a local cover manufacturer and get an estimate on covers for the cabin and rotor head. Then I'll need to install the doors and start thinking about paint.



I'm adding an access panel to the right side of the instrument pod so I can get to the top instrument panel cable connectors where they connect to my interface chassis. I'll use Camlock fasteners to secure the cover. I've also drilled two small access holes on the other side of the seat pan to allow calibration of my altitude encoder.



Here's my first attempt at a cover plate. I'll probably go back and replace that plate with one that fits a little tighter. I have a Grizzly T21322 7-1/2" Mini Shear Brake on order and cutting and bending small parts like this panel should be a lot easier without having to do it at work each time.

If I were starting over I'd design the interface chassis for easy access from the left side and move this access hole to the other side. I forgot that the right hand door is normally bolted shut.

I'm moving on to the fiberglass now. I've secured the cabin halves to the seat pan using nut plates, and I have the wind screen attached using Cleco clamps. I'm a long way from painting the seat pan and the cabin but here's a partial list of work remaining before I think about painting the seat pan:

Seat Pan and Cabin

- Final trim cabin halves
- Make access panel cover for instrument pod.
- Increase right foot pedal clearance
- Mount collective lower stop bolt
- Make leather cyclic boot
- Make cyclic boot mounting bracket then drill mounting holes
- Cut seat belt slots and finish shoulder harness slots
- Find and cut Seat back foam
- Install seat back snaps (wait for paint?)
- Install pitot and static air ports
- Locate and wire bottom strobe light
- Install remaining fuel hoses
- Get quote from manufacturer for covers (install rotor hub)

Before final install of seat pan

- Mount headset holder
- Make transponder cable

Frame

- Safety wire clutch pivot bolts?
- Mount new top clutch bolt
- Mount tail skid plug
- Drill drainage holes in skid and bottom of vertical tail
- Mount horizontal tail fin and align
- Install Throttle pot

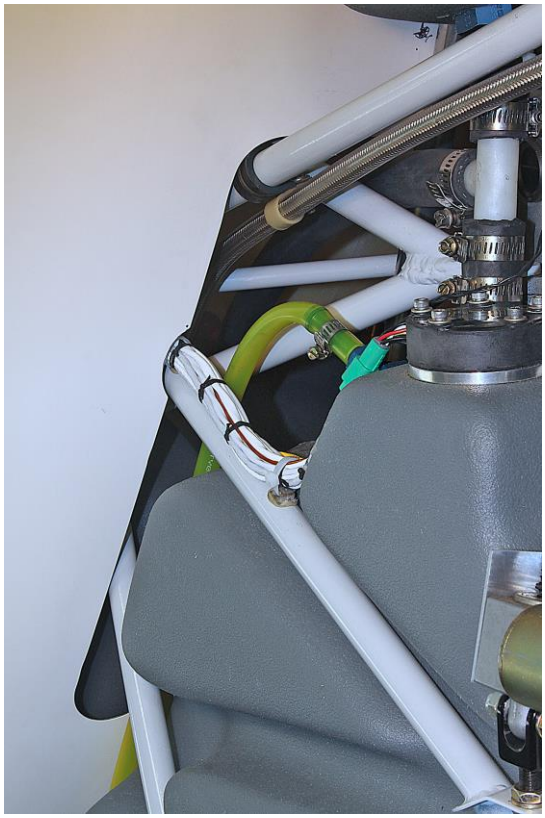
Engine

- Make new start fuel solenoid bracket

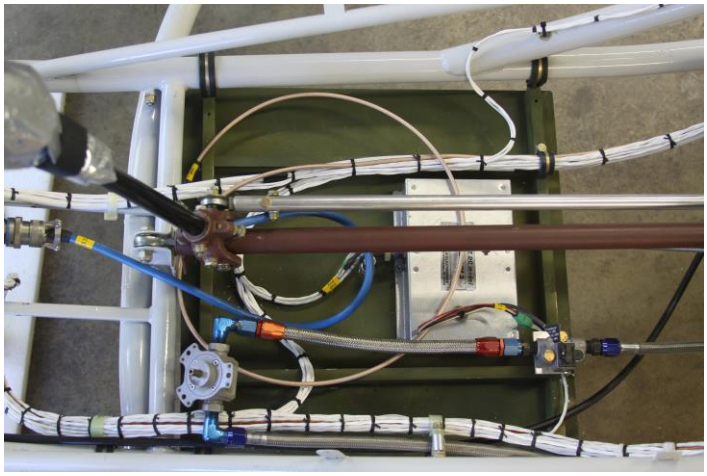
Instrument Panel and Electronics

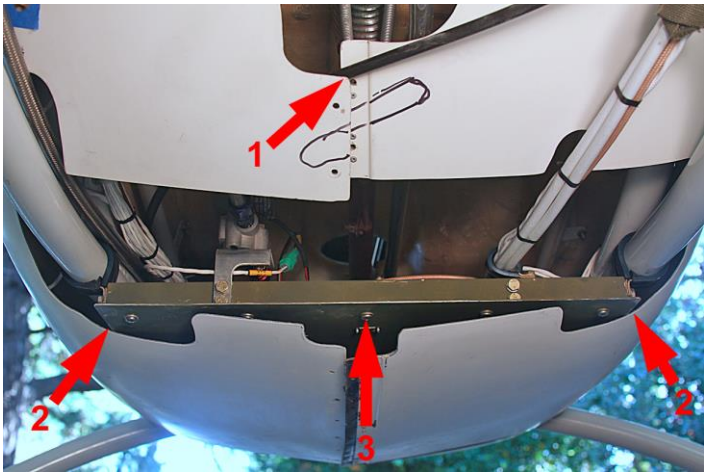
- Start Fuel switch not labeled on cyclic grip – make label
- Air Speed – Blue autorotation from 60-65, remove 50-65 green
- Design low voltage alarm and set at 11.4 volts.
- Change low fuel indicator to low voltage alarm (need new label.)
- Safety wire blind altimeter and engine cannon plugs

There's a lot of fiberglass finish work that the builder needs to do. Quite a bit was already done by previous builders but I ended up changing most of it. The two cabin halves need to be trimmed fairly extensively to clear all the various mechanical components. The process of getting all the openings trimmed correctly requires a repeated cycle of installing the cabin, marking areas to trim, removing the cabin, cutting and grinding, and then reinstalling the cabin to check progress. I use an air grinder and sanding discs for the purpose.

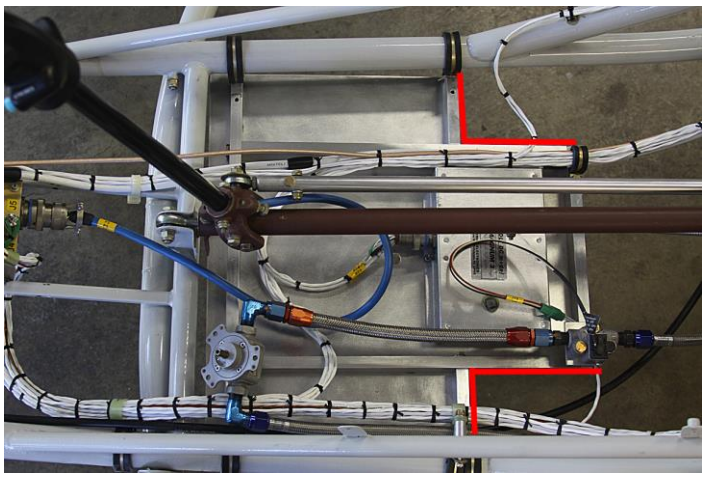


Here's an example of two areas that I've trimmed on the left cabin half. I'm satisfied with the one on the left but the hole on the right still needs to be enlarged slightly. This is the back of the collective which a previous builder had already painted. It seemed ok to me so I left it as is, but you can see that the fiberglass has already scraped the paint away where there is rubbing. Powder coating would have produced a much more durable finish. I was having the same problem with the seat pan tearing up the cyclic as well as the forward control rod to the swash plate. I slit some of the large fuel hose lengthwise and slipped it over those parts to protect them. It's worked very well.

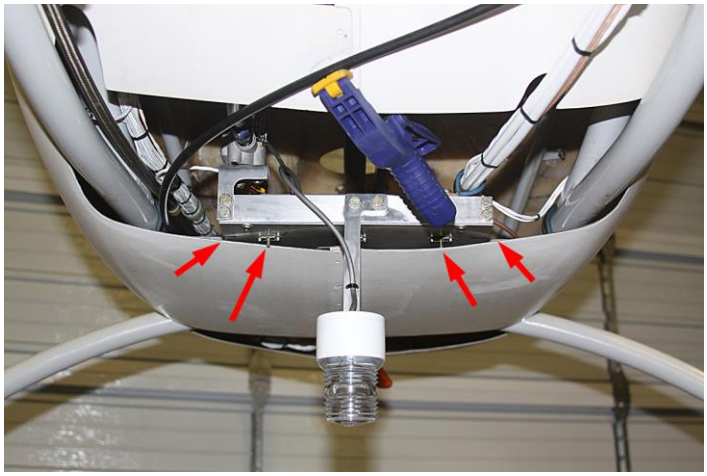




In my initial design of the tray that I've installed under the seat pan I didn't pay sufficient attention to the clearance inside the cabin. I ran into an interference problem at the back of the panel on both sides (#2 in picture at right.) I also have a problem with the direction control cable from the pedals to the tail rotor. I don't want to cut slots as I've sketched (# 1.) I'll attach the lower strobe light to the rear of the tray (# 3.)



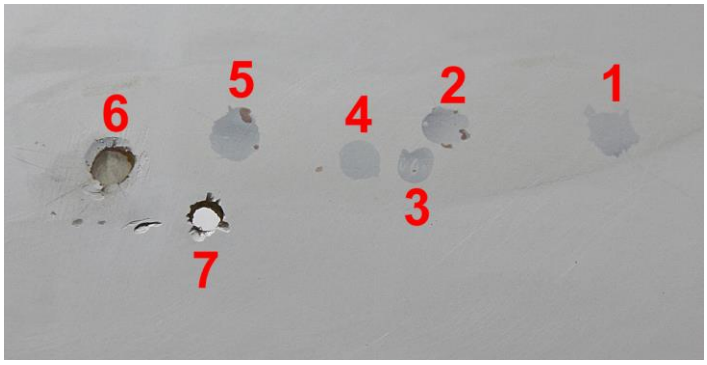
After another cycle of cabin and seat pan removal and reinstallation I modified the under-seat tray by removing the area outlined in red on either side (picture at left.) I also stripped the zinc chromate which I was never happy with. I've rerouted the control cable so that it enters the forward area without needing its own cutout and I'll trim the forward sections one last time to make a clean straight line across from side to side per my black line. That should remove all of my interference problems. I'll also need to make an access hole for the transponder antenna. I thought that it would be completely hidden inside the cabin enclosure but it will need to protrude through a hole.



This is the view after trimming the bottom of both cabin halves and installing my lower strobe light. I'm still not comfortable with the clearance at the edges of the shelf (outer arrows), and two of the six screws I'm using to secure my strobe electronics are also in the way slightly. I think I'll remove those two. The four remaining screws are strong enough to lift the entire helicopter off the ground. That box isn't going anywhere, even with two screws removed.

I managed to catch a shot of the lower strobe firing. The pattern is two blinks of the top strobe, then two blinks of the lower strobe. The pattern repeats about once every five seconds, and any time either main strobe fires the tail strobe also fires. It should help me be seen during daylight hours. I'm not planning on any night flights and the ship's exterior lighting does not meet FAA requirements for night flight.

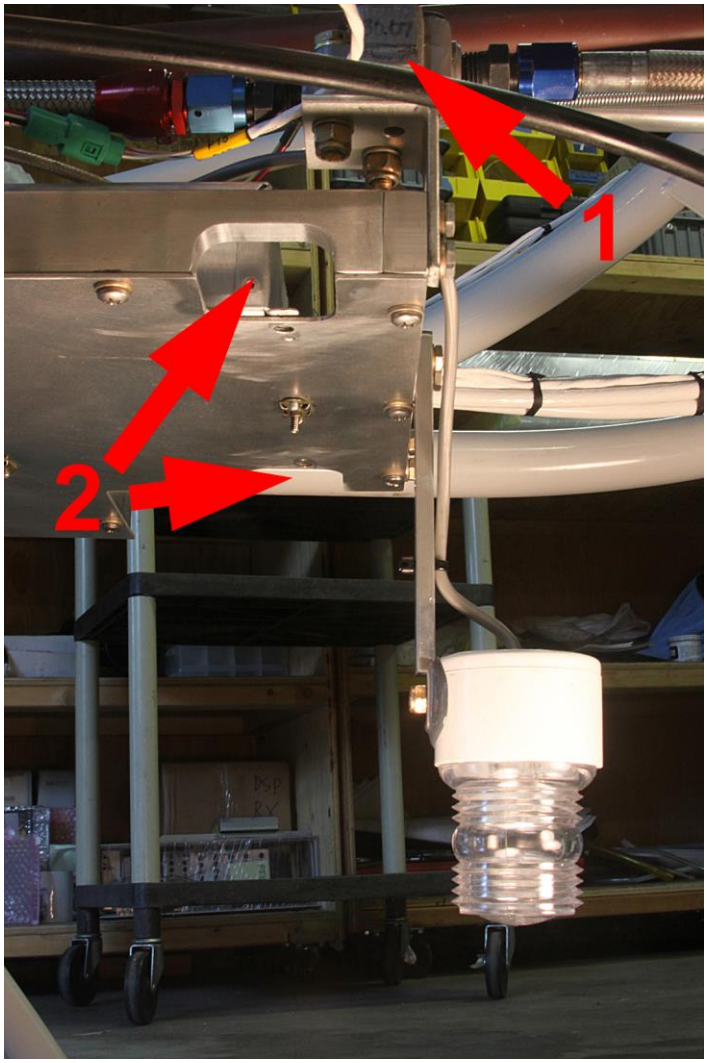
After all this work I've managed to check off one item on the list on page 248.



The auxiliary tank installation affects the alignment of the seat pan, and the seat pan alignment affects the cabin halves. That's caused me to have to move a few holes. When I took a close look at this particular hole I realized that the previous builder(s) had already drilled and filled 6 holes. My poor cabin looks like a piece of Swiss cheese. For the record, I inherited number 6 and filled it in and moved to hole #7!

I also have a number of voids and dings to fix. These are right in front where the chin window goes and it will be noticeable. I'm using polyester resin and mixing in chopped fiberglass or glass microspheres, depending on the application.

Here's what those voids look like after applying resin mixed with microspheres. I made a sandwich of a piece of Mylar and a wooden tongue depressor and clamped it over the voids to hold the resin in place and give me a smooth surface. The resin won't stick to the Mylar and the resulting surface is very smooth.



I'll need to make one more pass to fill those small remaining voids and then I'll start laying out the location of the nut plates that will secure the chin window.

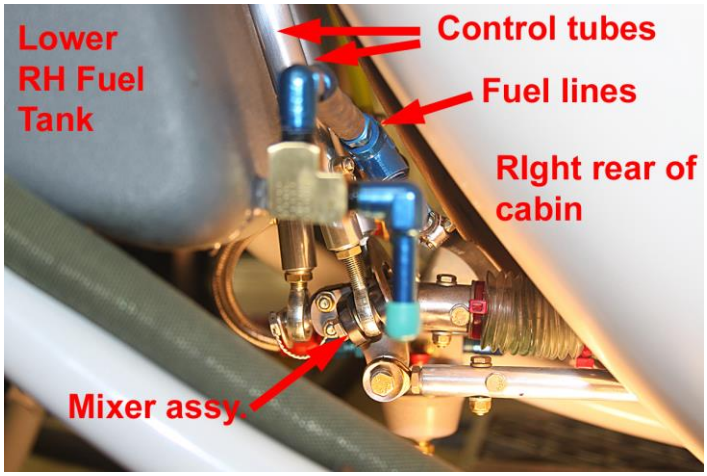
While I waited for the resin to cure I went back to work on the tray under my seat. I machined two cutouts on either side to improve the clearance between the cabin shells and this tray (arrow 2.) I hope this will fix the clearance problem I illustrate at the top of page 251. I also removed the two outer nut plates that hold the back of the strobe electronics box. If I still have a problem I'll raise the entire tray about one inch.

I've now had this tray in and out so many times that I stripped two of the mountings and I had to fix them with Helicoils.

Arrow-1 points to the fuel flow transducer which is mounted on a simple bracket. It hasn't changed but this is the first good picture I have of it.

The latest modifications to my under-seat tray look ok. There's very little clearance between the bottom of the tray and the cabin. I might have to tweak this area later on to prevent wear from rubbing. If I had to do this again I'd simply raise the tray one inch.

The cabin shells are very thin and flexible, and their shape shifts around as more attachment screws are installed. This impacts the alignment of the cutouts and the exact geometry of the cabin, so it's a circular process.

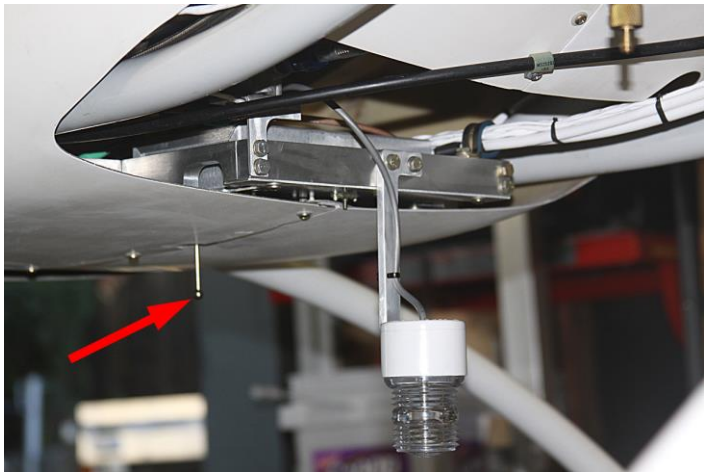


The area between the lower fuel tanks and the rear of the cabin is very cramped. In flight everything in this area moves except the fuel lines. I don't want those fuel lines to rub against the swash plate control tubes that run up from the mixer. I need a new plan…

The bottom fittings on the group-1 main fuel tanks screw directly into the polyethylene. I'd bonded them with 3M structural adhesive but they popped loose while working with the tubing. I've ordered a special adhesive and I'll try again once it arrives. More on this later…

Now that the cabin is back on I can work on the chin window. I still need to repair some dings on the front of the cabin and finish the repair of that void I photographed at the top of page 252, but now I can set the location for that nut plate and install the remaining ones as well.

As I was setting the instrument pod in the cabin for this picture I discovered that it's impossible to get it in or out without removing the cabin. The pod won't make it over its aluminum bracket at the bottom of the pod. The bracket needs to be inside the pod, not in front of it. Once the wind screen and the chin window are installed removing the cabin becomes a major production.



Other than paint, and installing the pitot tube and static port, the underside is almost complete. The red arrow points to the transponder antenna. The brass piece in the upper right is one of two fuel drains. Before a flight I can drain a sample of fuel to check for contamination from water or debris.

The next big project associated with the cabin and seat pan will be the doors. They're going to be a fairly big project involving everything from heating and bending steel rod to more fiberglass grinding and adhesive bonding.

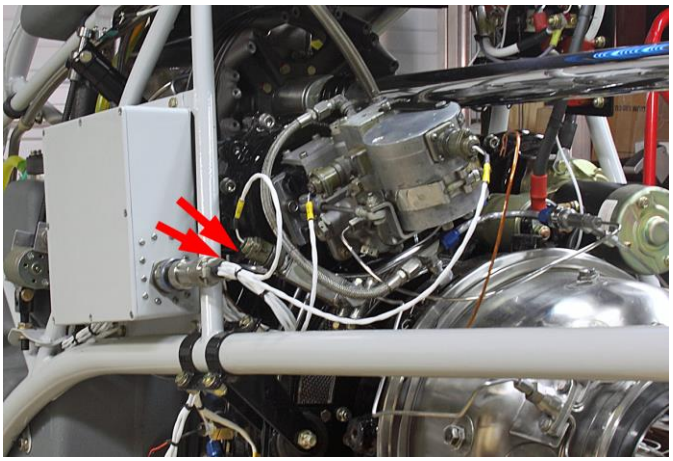
The cabin structure consists of the fiberglass seat pan and two cabin halves, and the Plexiglass windshield and chin window. They all come together to form a structure like an egg shell. When they're all secured together the cabin becomes very rigid, but each element affects the others. The windshield is especially critical to the overall final cabin shape and affects the location of the mounting holes where the cabin halves mount to the seat pan.

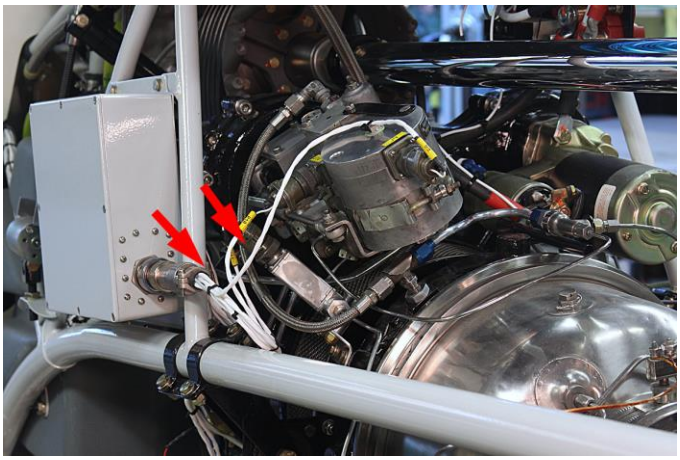
The windshield comes slightly oversized and must be trimmed to fit into the recessed channel that's formed into the cabin fiberglass halves. For maximum reliability I want the edge of the windshield and chin window to be as far from the screw holes as possible but still fit into the recess. I've been trimming material away a bit at a time using my belt sander followed by several grades of wet and dry hand sanding. The edges must be completely smooth and free of burrs and scratches to prevent stress risers that can turn into cracks later. With the windshield secured by Cleco clamps I can check how I'm doing by running my fingernail along the inside between the Plexiglass and the cabin. If there's a gap then I know the edge of the Plexiglass is riding up the side of the recess and needs to be trimmed.

In this picture I need to remove a little more material and also smooth the edge more to remove those small rough scratches made by the belt sander.

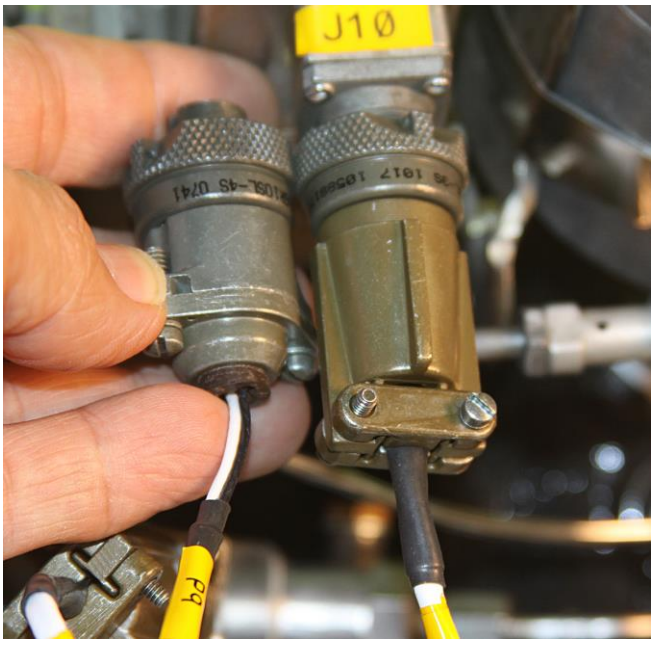
As you have undoubtedly realized, I tend to switch from project to project. I tired of fiberglass and Plexiglass dust and switched to my cabling once again.

I haven't been happy with the cable routing around the top of the engine. The individual cables were too long and unsupported and could flap around during flight. Most of these are flight-critical and I don't want them failing. I also had to build a new support bracket to reorient the main fuel solenoid and give it more clearance from the engine controller plug (red arrows.)





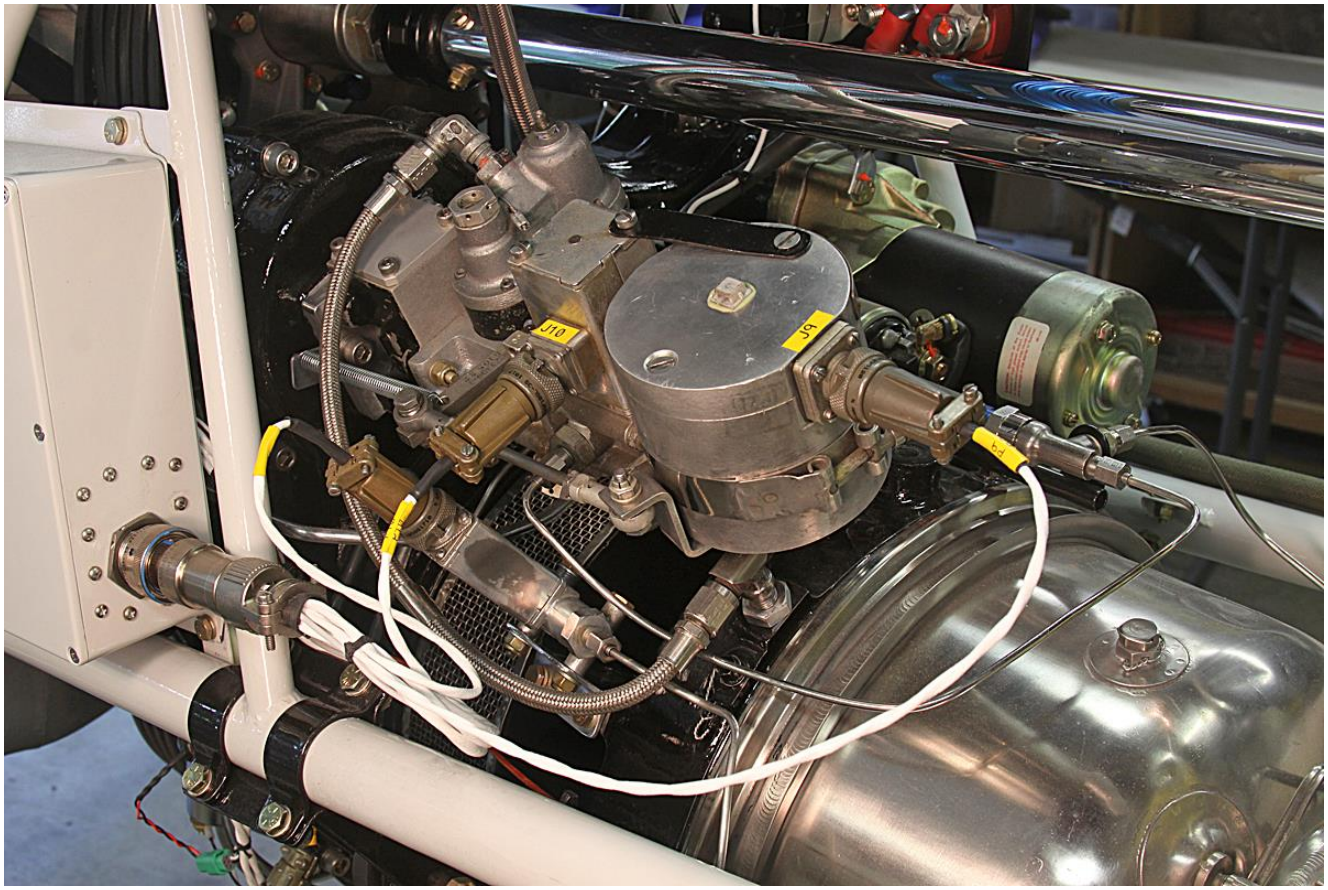
Here's the before and after views from left to right above. Now I have more clearance for the main fuel solenoid and the wiring is much more secure, but after thinking about this overnight I've decided to replace all three of these Cannon connectors with a type that has a strain relief backshell. The existing connectors don't adequately protect the individual wires from vibration.



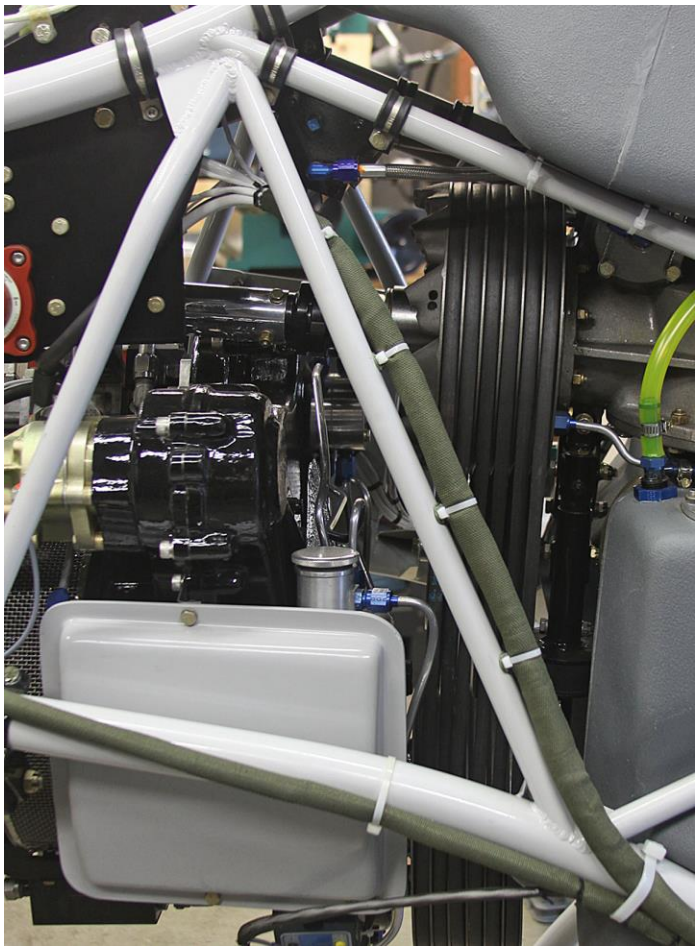
The connectors I have installed now (left) don't have any strain relief for the cable. Continued flexing during flight could cause a conductor to eventually fail. I'm switching to the version on the right. This backshell includes a strain relief clamp that captures the cable and produces a much more secure installation.

Here's the information on the connectors:

	2-Pin Straight Plug	3-Pin Straight Plug
Mfg. Part No.	MS3106F10SL-4S	MS3106F10SL-3S
Mouser Part No.	654- MS3106F10SL-4S	654- MS3106F10SL-4S



This is the final configuration with the new connectors installed. It's much better than my previous efforts. I would have preferred a right-angle connector for P9 to the throttle actuator but they're very expensive and no one stocks them. I plan to safety wire all of the circular mil connectors using .031 brass wire.



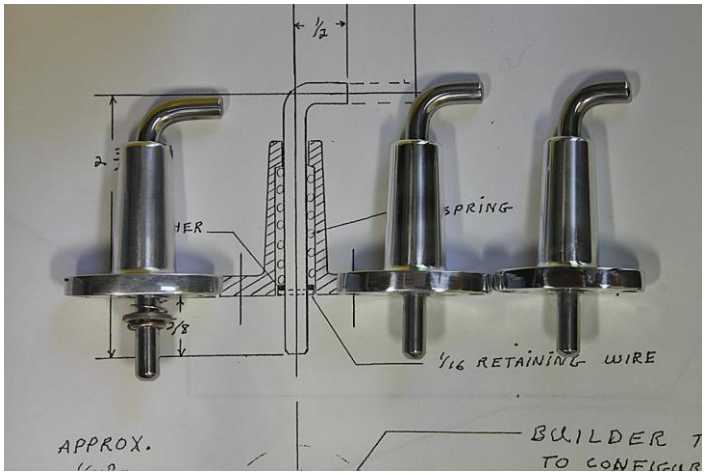
I'm jumping from project to project… Click-bond adhesive comes is a small foil dual-pack that contains enough adhesive for about eight to ten tie mounts if you work really fast. The adhesive has a working life of about five minutes or less. After deciding to put that one mount on the throttle actuator I needed to find a good use for the remaining adhesive. I decided to install a few more tie mounts to the right hand frame tube that the harness follows to access the battery box.

I grind a small spot down to bare metal and then prep it by rubbing the spot with acetone. The tie is then applied over the bare spot.

The tie wraps securing that part of the harness now attach to the mounts instead of going all the way around the frame tube. It's cleaner and more secure. After taking this picture I did the same thing to the cable harness going aft towards the rear strobe light and antenna.

While waiting for the Click-bind adhesive to cure I switched to the cabin door project…

Here's an example of typical kit parts that need finishing. They're part of the door latch assembly. They come from the factory as you see on the left. I milled off most of the excess material using my mill (middle), and then used my disk sander to rough out the final shape, and finally I finish it off using my deburring wheel and then the polishing wheel (right.)

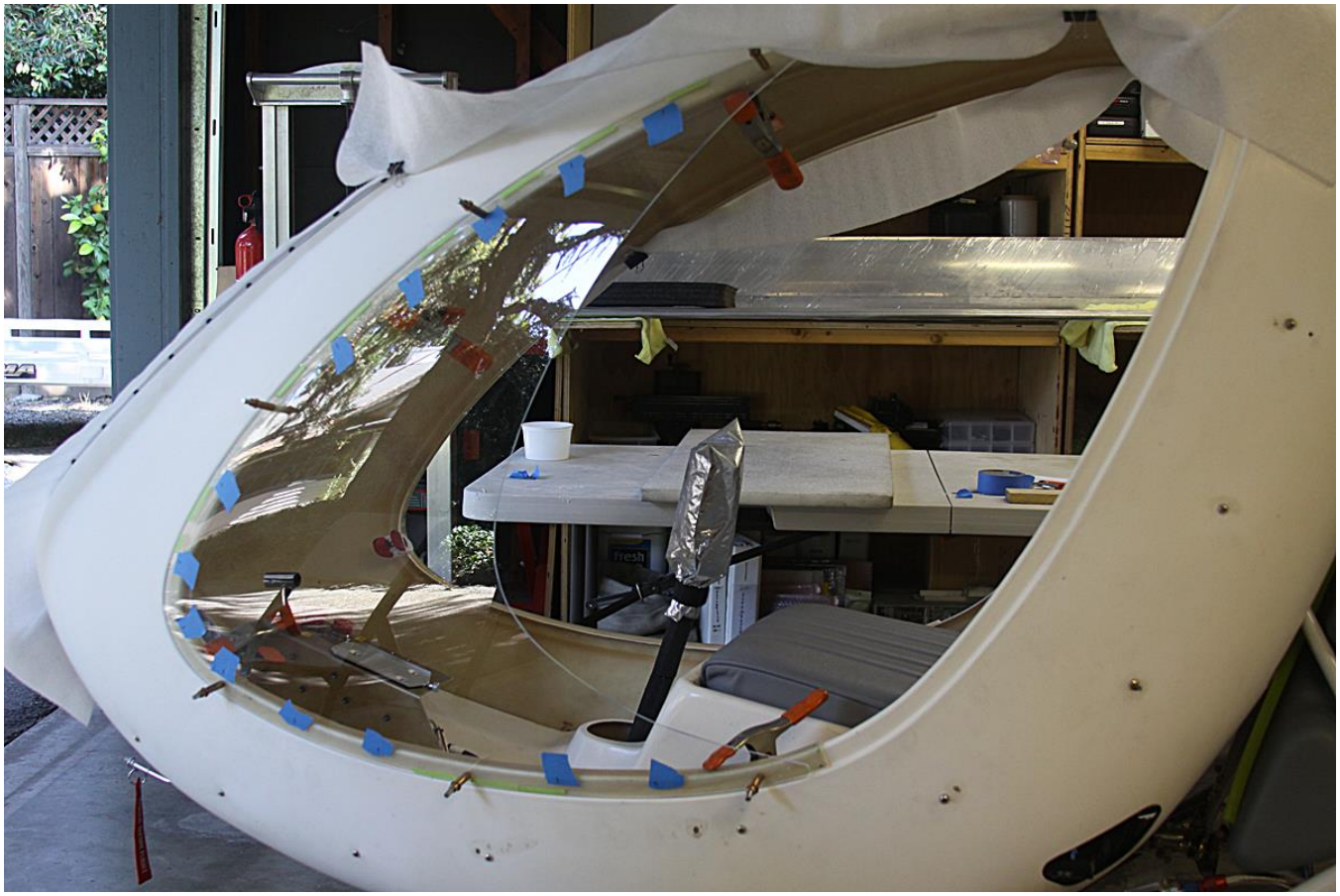


The kit comes with regular ¼" steel rod but I switched to 304 stainless for the handles. The rod needs to be heated red hot and bent. There is also a 1/16" hole that gets drilled in each rod for a retaining pin, and a mounting hole on each side of the housing.

Once those steps were completed I hit everything with my polishing wheel. I've only assembled one latch because they mount on a curved surfaces and I'll want to grind the bottom to match. Once I locate their position in the frame I'll come back and finish them off.

This little project is an example of satisfying the FAA's "51% rule". Kit builders needs to build at least fifty one percent of the kit to qualify for an FAA Repairman's Certificate. The FAA Says, "A certificated repairman may perform or supervise the maintenance, preventive maintenance, or alteration of aircraft or aircraft components…" This means that you don't have to hire an A&P mechanic to work on your aircraft. You can do the work yourself. It only applies to your aircraft so it doesn't make you an A&P mechanic.

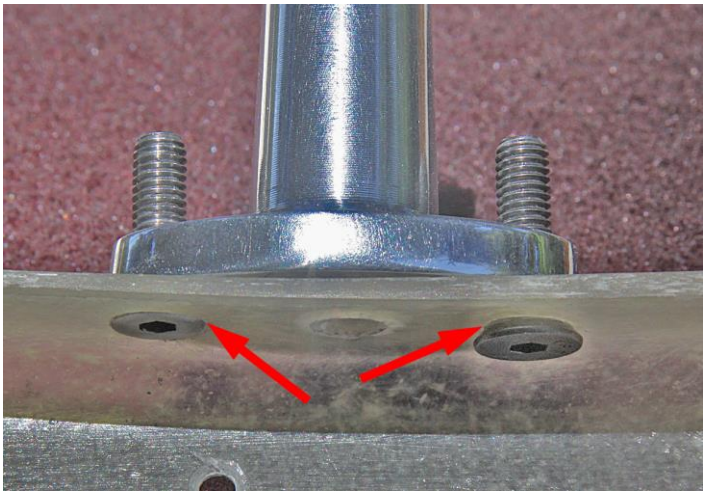
I fabricated the door latches per the print, and I've cut and sanded the fiberglass door frames per the factory construction DVDs. Now I'm ready to press on. I'll be riveting and bonding the Plexiglass half-windows to the frames. To prepare, I've watched the section on the doors several times and taken notes. There are a number of tricky steps and I don't want to ruin an expensive part or do a sloppy job.



After trimming the fiberglass door frame the Plexiglass half-door needs to be fitted. Both pieces are very flexible so the first step is to partially attach the Plexiglass to the door frame by drilling one mounting hole at either end of the bottom and securing the two pieces with two Cleco clamps. Then I mounted the assembly into the cabin and the frame was secured against the mating cabin opening all the way around. I used the orange clamps you see on the inside. Once that was done the top of the Plexiglass was lined up with the frame and its position all the way around was captured. If you look very closely you can see strips of 1/8" green fine-line masking tape around the edges. Those are to show me where the frame and the Plexiglass line up. In some places they are even, but in others the Plexiglass extends over the edge of the frame.

I removed the door assembly, drilled four more mating holes and secured the two pieces with more Cleco clamps. In this picture it's back in for another fit check before drilling the remaining holes. Here are the next few steps:

- Drill remaining mounting holes (using a dull drill or a special Plexiglass drill)
- Countersink outer side of Plexiglass holes and inner side of fiberglass holes
- Mark inner interface between Plexiglass and door frame with fine-line tape
- Mask Plexiglass and remove from frame
- Sand inner surface of Plexiglass to prep for adhesive using 220-grit wet and dry
- Sand outer surface of door frame to prep for adhesive using 150-grit garnet paper
- Locate three door latches and grind bottom surface to mate with door frame
- Drill door latch holes through frame and cabin lip
- Apply adhesive and mate pieces together using countersunk rivets



Before I can bond the Plexiglass to the fiberglass door frame I have to locate and drill all of the mounting and access holes for the three latches on the left hand door. (The right hand door is bolted in and has no latches.) I could do it after the Plexiglass is bonded but then I'd risk scratching it and have poorer access.

Mounting these latches is a very tricky process. The instructions say to carefully countersink the fiberglass, but not so far as to weaken the hole, and then secure the latch assembly with the supplied countersunk screws (right arrow.) Once everything is in place you're supposed to grind off enough of the protruding screw head as necessary to make it flush with the fiberglass. I didn't like that approach because it's too easy to tear up the surrounding fiberglass so I decided to grind down the screw heads now as I'm fitting each latch.

There's a limit to how far you can grind the screw head before you run out of the hex in the middle that you need to tighten the screw. Once I removed as much material from the screw head as I could, and still get an Allen wrench in, I went back and adjusted the depth of the fiberglass countersink to make the head flush (left arrow.)

The instructions call for drilling clearance holes in the latch housing and then using nylon locknuts to secure the housing. I decided to tap the housing so I could grind the screws off flush and lock them in with thread locker. I think that will look nicer. The screws are not going to rattle loose in flight because they will be sitting on top of the mating cabin lip – even if the thread locker were to fail.

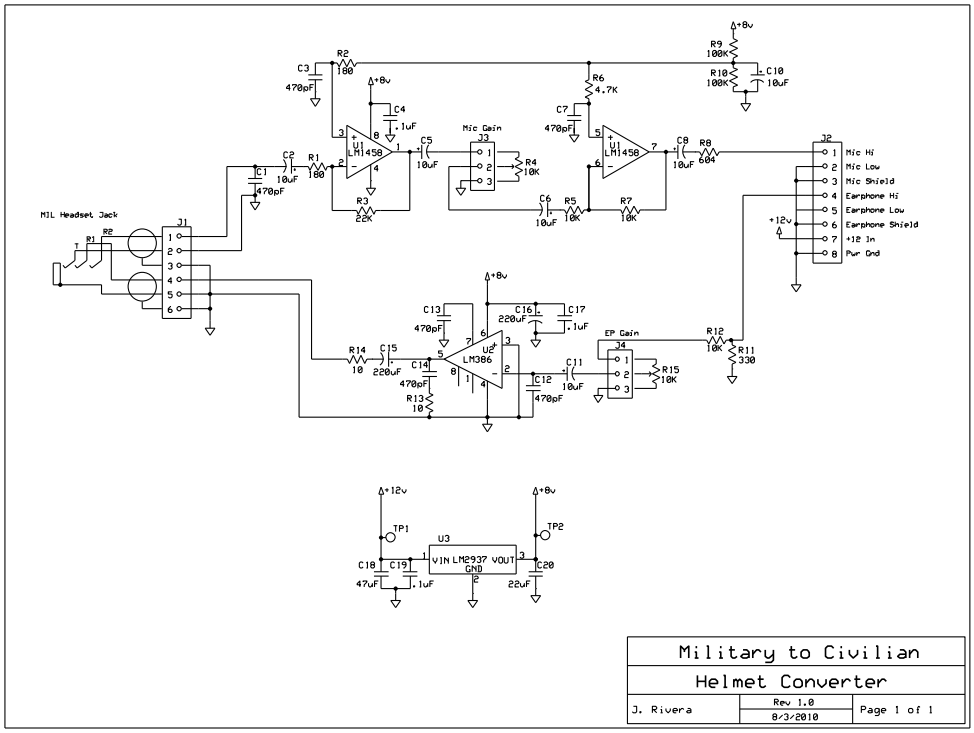
Here are my two choices. I think I'll stick with the tapped holes and flush screws.

These close-up photographs sometimes reveal details I missed. It looks like I need to go back and do more polishing to get rid of those tool marks.

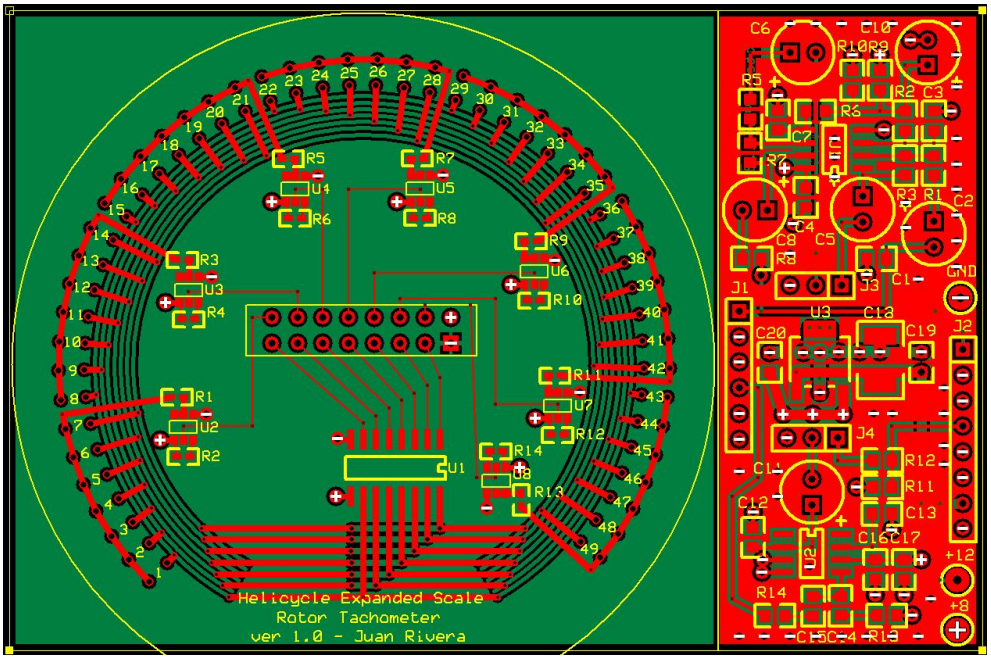
I applied the adhesive and riveted the Plexiglass to the fiberglass last night. This evening I ground the pop rivets flush with the inside of the door and popped it into place. The next step is to fabricate and install the door hinges and then trim the door frame. I found a few dulled-up areas where the two windows must have rubbed together during shipment. I'll have to polish those out.

I also found and trimmed some dense foam for my seat back. Once I'm satisfied with that I'll have to locate and install the snaps that will secure the seat back leather to the seat pan. In this picture the seat back is just propped in position.

I've decided to pick up a military SPH-4B helicopter helmet. I think it's a prudent safety item, especially when flying a brand new experimental helicopter. I can easily envision a botched autorotation caused by a mechanical failure or engine malfunction leading to a roll-over. In a roll-over there is nothing between your head and the ground except a thin bit of fiberglass. The helmet could make the difference between an easily survivable accident and a major life-threatening injury.



Military helmets are fitted with microphones and earphones that are incompatible with civilian radios so they either need to be replaced or their inputs and outputs need to be converted. I pulled a schematic from another pilot's web and it looked well designed. I modified it slightly and decided to have some printed circuit boards made up and try it out.



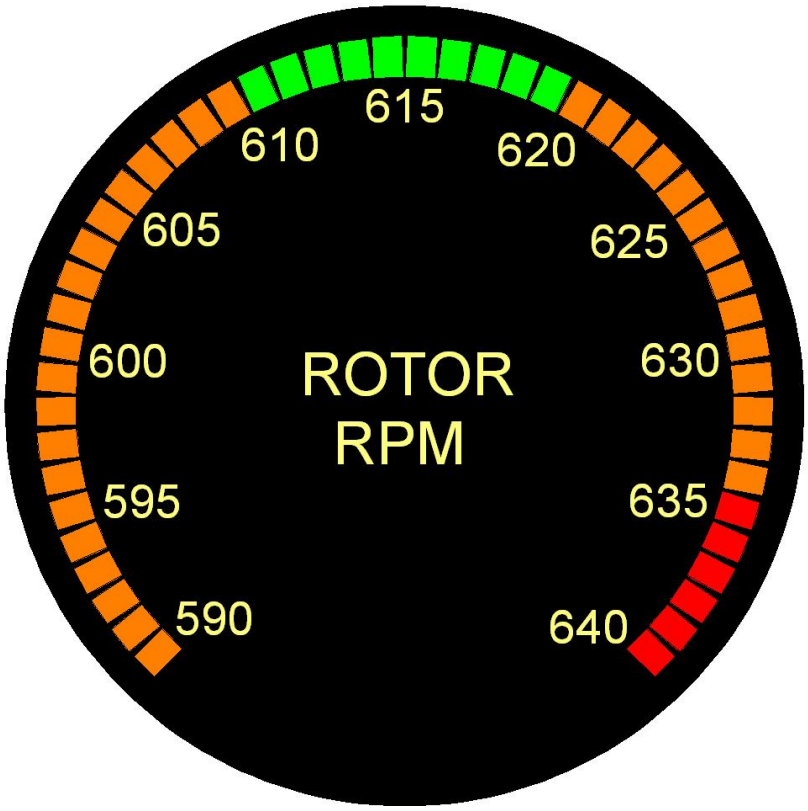
I completed the expanded-scale rotor tach LED PCB design and I had a bit of space left over on the right. I managed to cram all the components for the military-to-civilian converter board into the remaining space. With luck I'll have a helmet and a finished board to try in a few weeks…

LED #	RPM	BAND
1	590.00	
2	591.02	
3	592.04	
4	593.06	
5	594.08	
6	595.10	
7	596.12	
8	597.14	
9	598.16	
10	599.18	
11	600.20	
12	601.22	
13	602.24	
14	603.27	
15	604.29	
16	605.31	
17	606.33	
18	607.35	
19	608.37	
20	609.39	
21	610.41	
22	611.43	
23	612.45	
24	613.47	
25	614.49	
26	615.51	
27	616.53	
28	617.55	
29	618.57	
30	619.59	
31	620.61	
32	621.63	
33	622.65	
34	623.67	
35	624.69	
36	625.71	
37	626.73	
38	627.76	
39	628.78	
40	629.80	
41	630.82	
42	631.84	
43	632.86	
44	633.88	
45	634.90	
46	635.92	
47	636.94	
48	637.96	
49	640.00	

I'm thinking of scaling my expanded-scale rotor tachometer per the chart on the left and the indicator drawing below. The green band and the red line are specified by the factory.

Everything about this scale will be controlled by software. The scale does not have to be linear. Each Led can be set to any point.

The front plate below will be made from a printed polycarbonate with a clear window for the light emitting diodes to shine through. My plan is to mount the meter into an empty Westech housing. The first prototype will interface to the existing rotor RPM alarm circuit board which will not fit into the housing. Since the housing is plastic I'm not sure I want to place the processor in there anyway since it could cause some localized EMI.



Tuesday 10 August – I have the components for the expanded scale rotor tachometer circuit board. Now I'm waiting for the circuit boards themselves. They should have shipped today by second day air so I should have them late this week. I found a company that looks like it could make the instrument's front plate and I've been waiting for several days for a response from them. I have a buddy at work that will do the heavy lifting and program the processor to make the circuit come to life. That will probably take a few weeks. I have an extra Hall Effect sensor that I chuck up in my variable speed mill to simulate a main rotor in motion. I also have access to very accurate test equipment that does the same job.

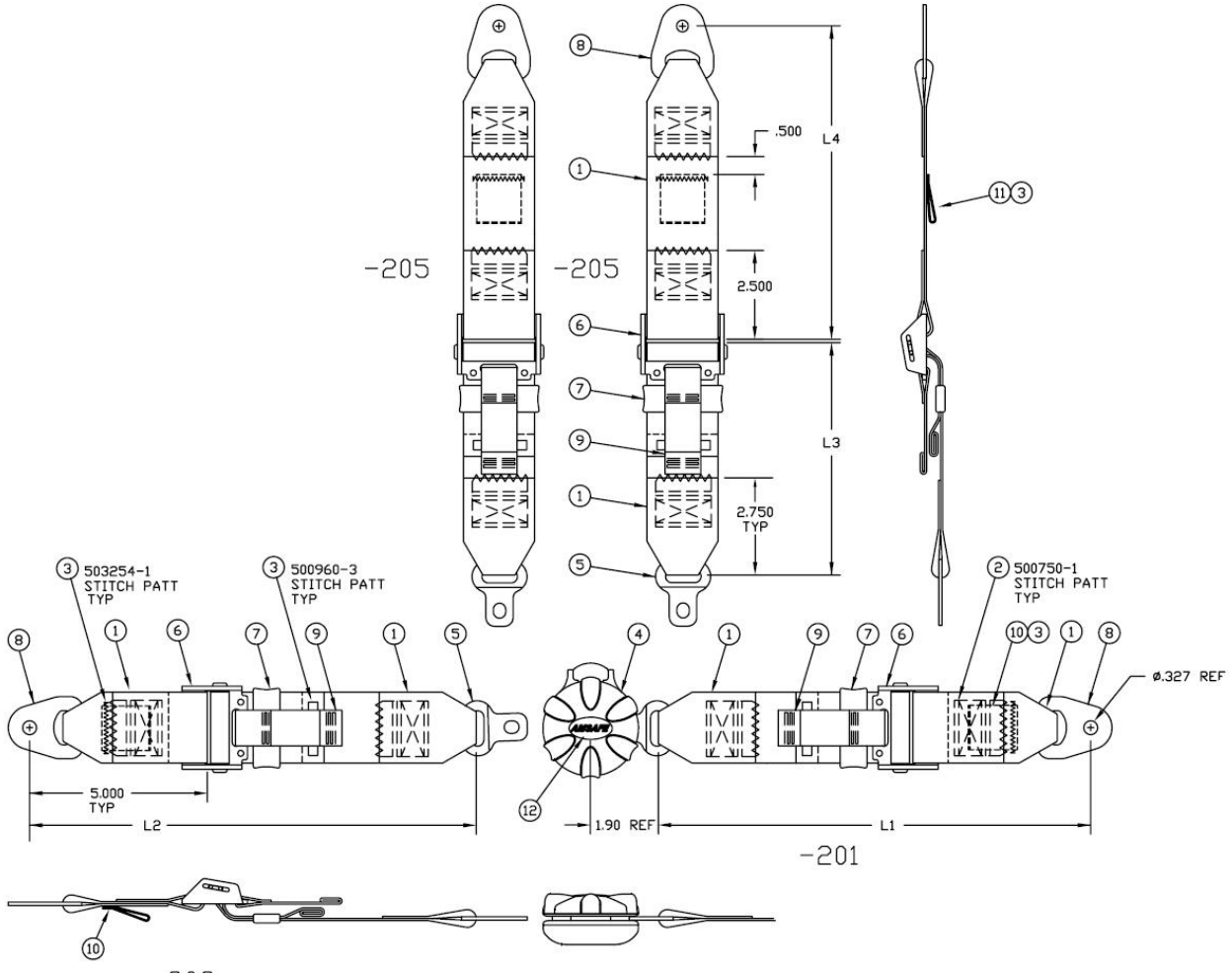
I finished the right hand door over the weekend and have that mounted in place temporarily on the cabin. I got ahead of myself and applied the adhesive before I remembered to countersink the rivets -- front and back side. I went through about ten pairs of Nitrile gloves trying to keep adhesive from getting on the Plexiglass, but I managed to get some on anyway, and then scratched the Plexiglass in a frantic effort to get it off before it set. I was able to polish those scratches out this afternoon and all is well that ends well.

I want to take the cabin off so I can get back to work on the seat pan but I'm stuck waiting for the local aircraft cover guy to measure the cabin and give me a quote. I've been waiting for almost two weeks. And lastly, I found a company that I think can do my paint job. I want a three-part candy paint called Monterey Red that was used on 2006 and 2007 Corvettes. I'm not at all sure it's legal in my county so it might have to be painted in another county where the volatile organic compound (VOC) regulations are a bit looser. I'm told that these three-part paints are extremely difficult to touch up. That paint looks fantastic on a co-worker's Corvette so I think it will be worth the gamble. If I do go with the Monterey Red I'll have to be very careful not to scratch it (hence the desire to get on with the cover.)

I'm also waiting for the delivery of my new SPH-4B helicopter helmet. I also have all of the parts I need for the military to civilian converter circuit board. I'm not at all sure I can fit in the cabin with the helmet on or that it will even fit my head, so I may end up reselling it with the converter board later. Time will tell… (I can't fit in the cabin with the helmet so I'll be selling it. Damn!)

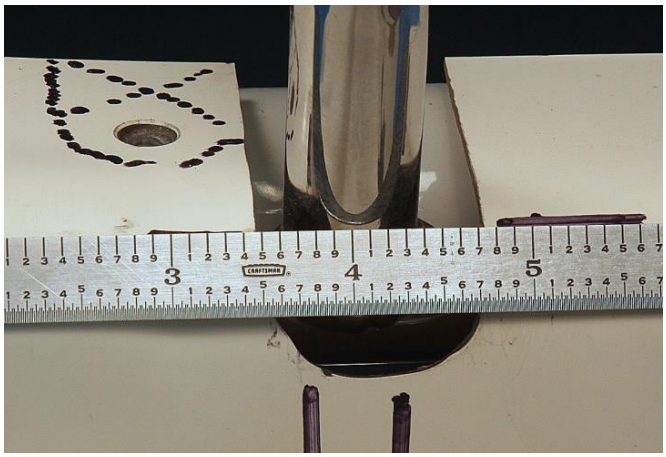
Saturday 14 August 2010 – I gave up on the cover guy. I've been waiting three weeks for him to get around to me. I pulled the cabin off so I can get back to work. I'm going to concentrate of getting the seat pan ready for painting.

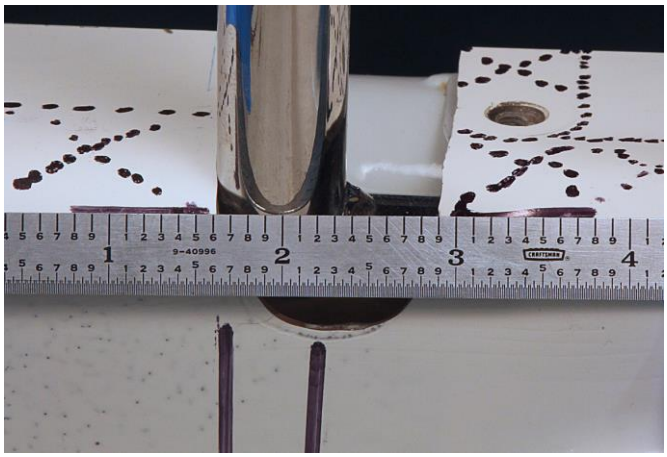
One item to complete is the width of the seatbelt and shoulder harness access holes in the seat pan. Once I decide on the restraint system I can complete those access holes.



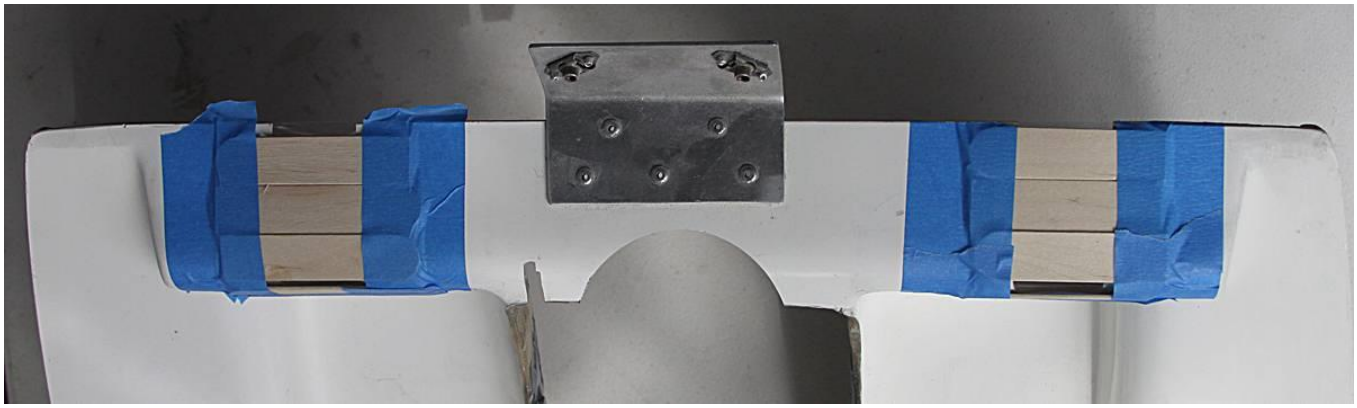
Amsafe in Phoenix manufactures many variations of TSO'd aircraft restraint systems. This one definitely is not cheap but it has a rotary buckle and adjusters for all the straps. I want the adjusters so I can wiggle around in the cabin during engine start and then snug everything up for flight, and also be able to loosen the shoulder harness in flight with one hand if necessary. And I like the rotary buckle since you can release yourself with one hand and exit the aircraft in a hurry in an emergency. With so much time and money invested in this project, why skimp on safety?

Now it's time to move to the other end of the seat pan…

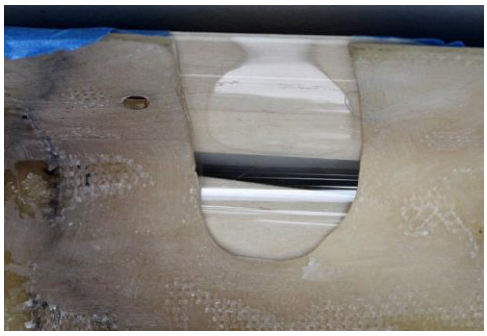




I managed to completely mess up these foot pedal cutouts in the floor pan. I didn't pay attention to the video and cut out the slots along the outlines on the fiberglass. Then I watched the video where you're told to not use those marks because they might be off. I enlarged the slots to make the pedals fit and then compounded my problems by switching from fixed to adjustable pedals which required another enlargement of the slots. Eventually I ended up with the mess you see above. I've been worrying about what to do about this disaster for almost a year, but I can't put it off any longer. I need to fix these before I can get my seat pan painted. I was so nervous about attempting this that I spent hours looking for a fiberglass repair facility that I could take it to. I couldn't find anyone except boat yards. I feel a bit more confident after patching a few holes so I'm going to give it a try. After all, it can't get much worse!

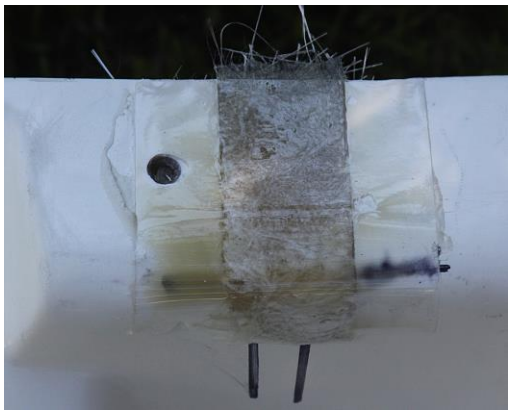


I've formed molds on the top side using tongue depressors over Mylar sheets. I was going to use thin aluminum sheets over the Mylar but I couldn't get the sheet to conform to the curve.

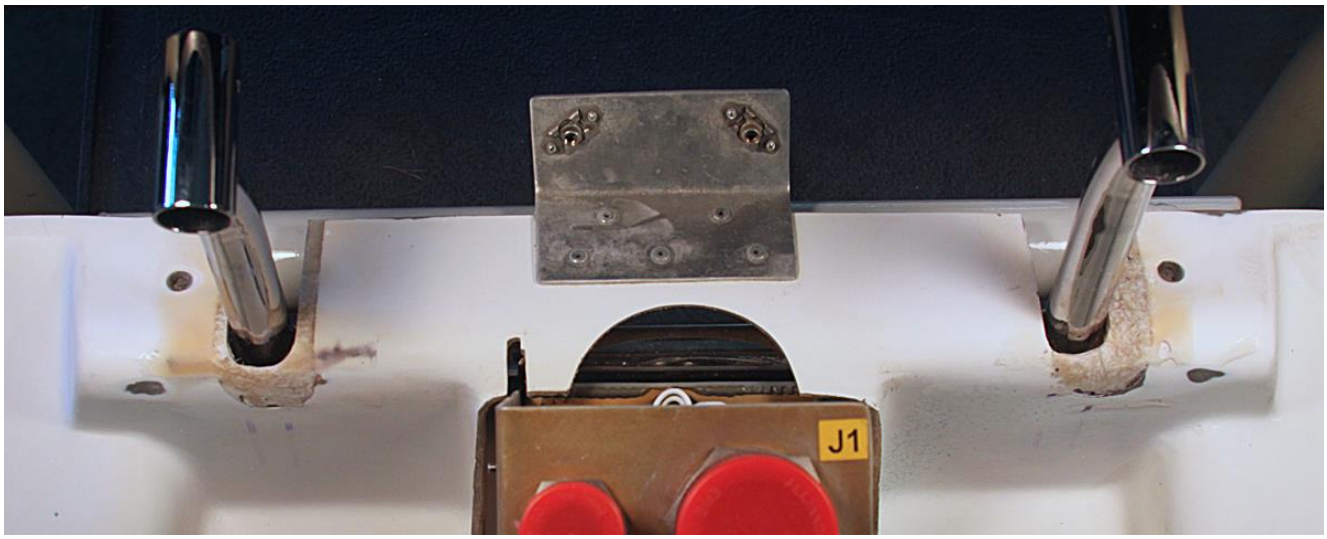


The Mylar will prevent the resin from sticking and give it a nice smooth finish. If I'm lucky it will conform to the existing curved surface and I won't have too much sanding to do.

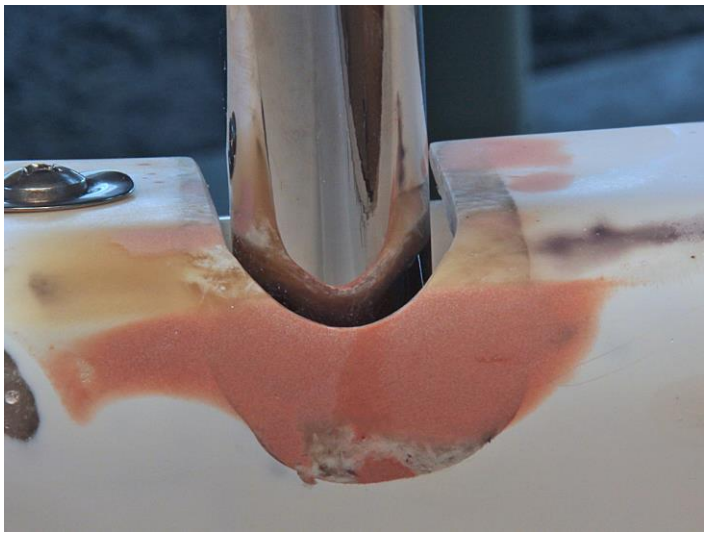
I'm going to completely fill in both slots and then cut new slots. In some areas the direction control tubing is almost touching the inner side of the seat pan so I've ground the inside down as far as I dare to make room for the new fiberglass.



I laid up the fiberglass using a Tap Plastics polyester resin. The tongue depressor/Mylar backing conformed to the shape of the front surface as well as could be expected so a minimum amount of sanding should smooth it out. I'll add one more layer on the back side to increase the strength. Once I cut out the new slots I'll find out if the patches are strong enough. There shouldn't be much stress in this area so I hope it will be sufficient.



I decided not to bother with the second fiberglass layer. This stuff is tougher than I expected. Here's a look at the slots after roughing them in. I still need to trim the slots, fill a few pits and finish sand. Then these two mini-tasks will be complete. It's a very definite improvement over the disaster at the top of the previous page! (The slots really are straight but the camera has distorted the image.)



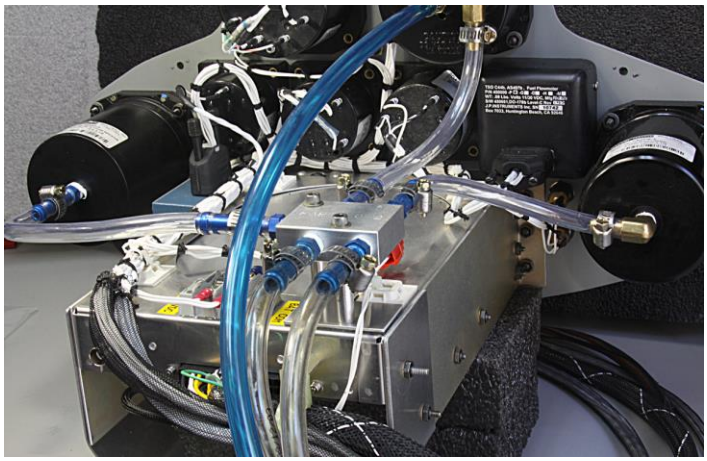
Sweet! Here's the left pedal slot after filling in pits and irregularities with Bondo and then sanding with 400-grit wet and dry. You can see how huge and off centered the original hole was compared to the new one. I must admit, I've very proud of my job. I've been worrying about this for a long time. Before beginning this project I had never worked with fiberglass and I completely lacked confidence. I think this is a good lesson for anyone contemplating taking on the construction of a Helicycle. Have faith! You'll be amazed at what you can do with the support of other builders and some perseverance!

21 August – Yesterday I dropped the seat pan off at the paint shop. I should have it back next week. These guys are perfectionists and found several areas that they felt needed further attention. They'll spend about two hours cleaning up some of the areas that I missed and then shoot it with PPG Delfleet polyurethane. I picked a color that's a close match to BMW steel gray metallic. It should look nice against my lighter gray leather seat.

I know what I want on the exterior of the cabin but I still need to decide on the cabin interior and the restraint system colors. I'd like to use the same leather for my cyclic boot as I used on the seats if it's not too thick to sew. I also ordered three yards of a 4-layer car cover material made by Kimberly-Clark called 'Noah'. I've given up on the aircraft cover company here in town so I'll try to make my own. We'll see how that goes… I want to have a cover ready to protect my exterior paint job because I know it's going to be expensive!

This feels like a huge step. I want to finalize and document everything that will be inaccessible under the seat pan once I install it, hopefully for the last time. I don't want to risk chipping my nice pedal slots by installing and removing the pan any more than I absolutely have to. About all that I have left under the seat is to fabricate the transponder antenna coaxial cable and move my harness slightly to clear a seatbelt strap.

In addition to finalizing everything under the seat pan I should be able to final install the instrument pod and panels, so I need to finish those up as well.



I purchased a 5-port manifold from Aircraft Spruce and connected all of the static lines. The input comes from the static port in the belly and the four outputs go to the altimeter, VSI, and air speed indicator, and to the encoding altimeter that feeds the transponder. The blue line will attach to the pitot probe and also goes to the air speed indicator. That instrument uses the difference between ambient static pressure and ram air pressure to determine air speed.

I've been going around the helicopter doing a mental failure mode and effects analysis – asking 'what if?' of each component. There are a number of flight-critical items on the Helicycle. I don't think the factory instructions mention this, but I decided to safety wire the two modified AN4 bolts that act as pivots to the clutch jack screw follower. If these work loose in flight the clutch will certainly disengage and you'll be headed down. The instructions may call for service-removable Loctite but I trust safety wire more.

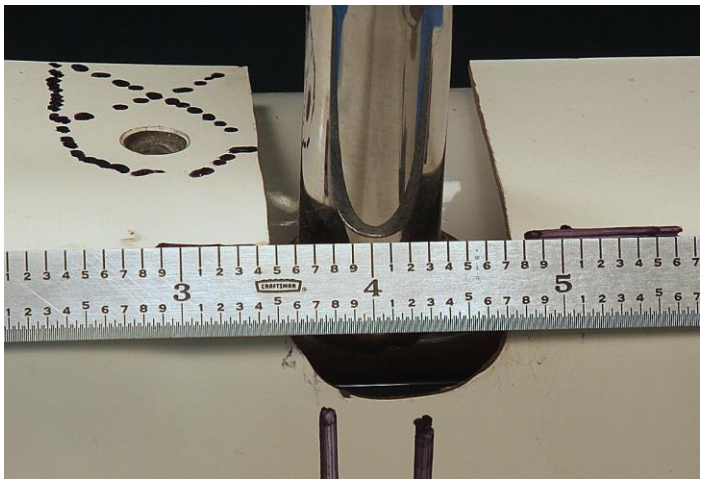
24 August 2010 -- The seat pan is back from the paint shop and looking great! The metallic jumps out in the bright sun but it isn't very noticeable in the shade. Even though it will be covered by the cabin I had the back side shot with the same paint, just to darken it up. I was going to use Zolatone but I don't think it's worth the trouble. I'll use Zolatone on the inside of the cabin though. I've been waiting for this next step – matching the Zolatone to the seat pan. The paint scheme is coming together in a series of steps. I'm also getting webbing samples from the harness company. I'm thinking of using a dark gray. Am I stuck in a rut?

The chip in the picture on the left is Zolatone 20-59 Lilith Charcoal. It looks like a great match. Zolatone is a non-reflective coving that uses two different materials that don't mix, in this case white and gray or black, and it's very tough! I have the inside of the cabin sanded down to remove all the sharp jagged strands of fiberglass. That's the only prep that I'll do to the cabin interior other than strengthening the areas under the doors.

My next color choice is the safety harness. I picked out the manufacturer and model I want on page 265. Now I need to decide on the color. The factory sent me eleven shades of gray to look at.

My choice for the restraint webbing is 8053 Thundercloud gray. Here it is along with the Zolatone interior color chip. It's not easy to decide because everything looks completely different when the lighting changes. This picture was taken under an overcast sky. The picture of the chip on the previous page was taken in direct sunlight. Fortunately I'm not trying to match colors. All I'm looking for is a pleasing blend of grays so these choices will work for me.

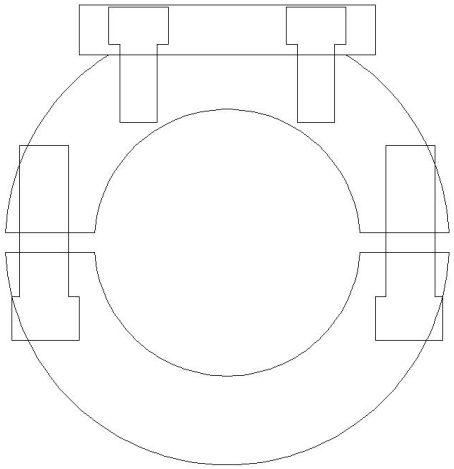
And here's one last look at a foot pedal slot, before and after. All's well that ends well, but there is a lesson here – the seat pan is very abrasive and during construction you'll be taking it on and off many times. Over time it scrapes up everything it touches including the pedals, the cyclic and collective, and the swash plate control tubes. I've covered most of them using rubber hose but I forgot to protect the pedals. I'll need to do some polishing.



I've been planning to come up with a way to shoot in-flight high-definition video for some time. I've been looking into small compact HD camcorders that use flash memory and don't have any rotating components such as a tape recorder or hard drive since they don't handle vibration or acceleration well. Yesterday I found what I was looking for at Costco. This camcorder can record four hours of video at a resolution of 1,920 x 1,080 pixels on its internal 32GB flash memory. It measures 2.4 x 2.5 x 4.9 in. and weighs 9.5 ounces.

I want to be able to move the camera around the ship and point it at whatever I'm interested in such as the tail rotor or tail rotor drive shaft, the swash plate, and so forth. For that I need a way to clamp the camera to the 1.375" diameter frame tubing. I have no way to machine a round hole that size so I started looking for clamps on the internet. I found this aluminum shaft collar at Grainger. I think I can make a camera mount out of two of these that will get the job done. I'll mount a top plate to two of these collars.

My plan is to simply start the recording while I'm doing my pre-flight checks and then forget about the camera until I land.

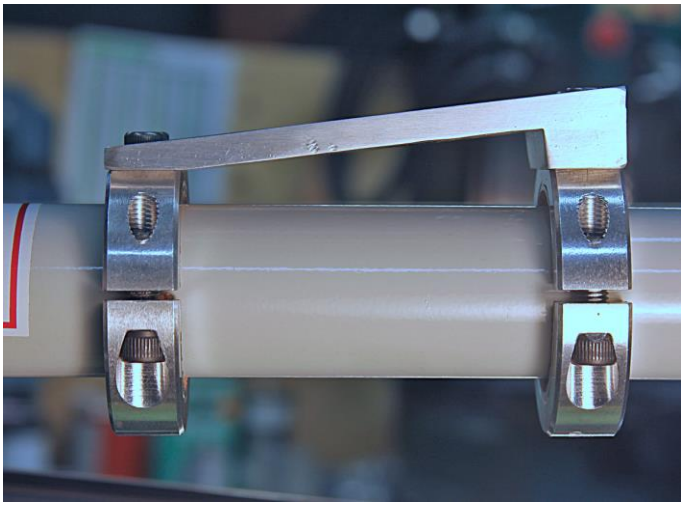


I drafted up the end view to get the dimensions the way I wanted and then fired up my milling machine. On the top plate I'll make a series of tapped holes in an arc around the mounting bolt that I can screw a smaller screw into. That screw will protrude into a hole in the bottom of the camera to keep it from rotating. That way I can offset the camera in several positions by selecting which hole I use. Then I'll cover the plate with cork to provide support and friction for the camera base. This plan will limit me to shooting along the vertical axis of the tube I'm clamped to but it's a start.

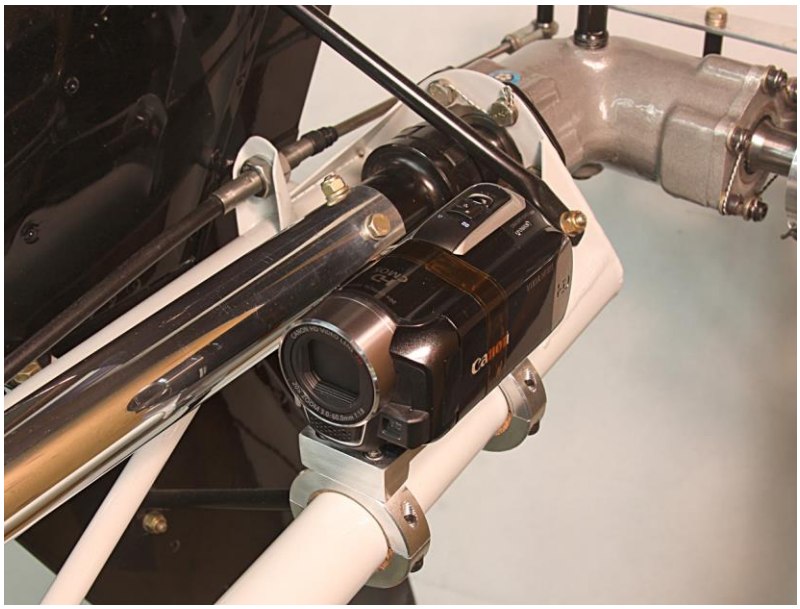
Adding adjustable tilt would be more complicated and I have months to think about how to do that. There's also the question of vibration. There may be too much vibration for good imagery. Adding vibration isolation would be another complication I'll save for later. I also want to find a way to mount the camera inside the cabin (a completely different mount) so it can shoot the instrument panel. I want to do this so I don't destroy the clean looks of the cabin or create a safety hazard. That's won't be easy since the cabin is so small. The camera would almost have to be behind my shoulder and just off to the side of the seat back. I don't want it anywhere near my head.

On work nights I don't get much done, but two nights ago I managed to bore out both sets of clamps on my camera mount using a fly cutter. I definitely don't recommend this approach. The cutter has a blade on one side and as it goes around it causes an unsymmetrical load on the mill. The poor mill, the table, and the vice were jumping around in an alarming way in spite of my attempts to ease through the material. I would never do that again. The other problem with the fly cutter is that it has no precise way to set the blade. You just eye-ball it and clamp it down with Allen screws.

Once I got the machining completed I was able to find some 1/8-inch cork at the local hardware store last night and glue it to the inside of the clamps with 3M general purpose spray adhesive. Now I don't have to worry about scratching my paint. Over the course of two evenings I was able to fabricate the two mounts you see below – one flat and one tilted up slightly. Since taking these pictures I've replaced the cork on the mounts with sticky-back Velcro.



I can place these mounts anywhere I want on the frame tubes to get shots of the belts, cabling, the drive shaft, and so forth. I'd call all of those engineering test flight video.



But here's the one that I think I'll really get to enjoy. The camera is in a very potentially dangerous location right next to the tail rotor and its drive shaft so I'll want to be completely sure that it stays put and nothing flies off or changes position. I think I can do that. I'm not quite there yet, but if I replace the cork in the clamps with rubber, and safety wire the hardware to prevent loosening in flight I think it will be a workable location. I'll also want to compensate for the aft CG change. Check out the next page to see what the shot looks like…

I think this location will produce some spectacular video. You'll see a lot of the rotor disc which will really be something. Remember, this is a compressed and shrunken-down version of the original still. I can't wait to see what the video will look like on a 50-inch monitor in high definition mode! I hate to say it, but I like this location much better than the side-mount on page 275, and that mount was a lot more work to build. This shot is like flying in close formation with the helicopter.

Now for the instrument panel… To test the camera resolution I held the camera against the back of the seat pan to the right of the seat and shot some video. Here's a freeze frame from that video. The high resolution version is spectacular. You can download the 5MB compressed version from the Helicopter menu. As a data acquisition tool I think it will be fantastic.

Here's where I had the camera located to shoot the instrument panel video on the last page. I was thinking of building a shelf that would attach to the back of the seat pan and to the cabin interior. Those two surfaces would give me a nice stable and sturdy mount.

The front of the camera is behind the seat back and out of the way of the shoulder harness. I don't think it would be a safety hazard in this location. I could tap into the communications audio and feed it to the camera on one channel and leave the other channel for ambient microphone audio.

There's just one problem… The cabin is a snug fit and I think the spot I had in mind is going to be blocked by my shoulder or shirt. I'll have to give this some thought. I'll have to make a temporary mount for the camera and do a few test shots to nail this down. I don't want it near my head so I don't have a lot of options.

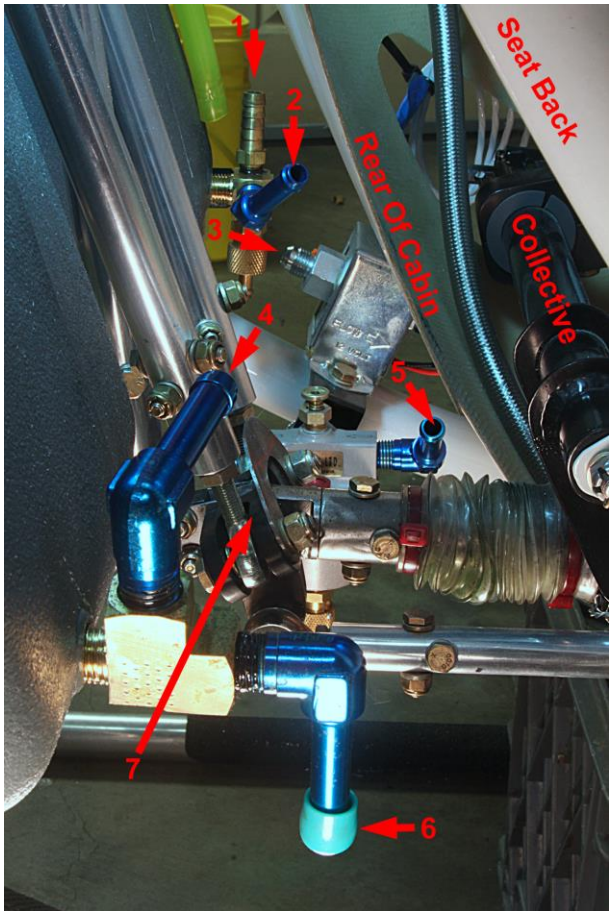
I'll finish this page once I figure out a plan…

I've updated these pages so many times that they now jump backwards and forwards in time. Please excuse the awkward time warp…

I decided to make an exterior mount inspired by Stan Foster's great video. I used the same mounting plate from the top of page 272 and modified it by drilling a few more holes and tapping one at an angle for the support rod going from the mounting plate to the tube next to the fuel tank. The bottom piece tying the two collars together is ¼" 6061-T6 aluminum, the vertical piece is a 'U' channel scrap from the hardware store and the rod is stainless steel, all from my scrap bin. There's a solid insert at the top of the 'U' channel that ties it to the mounting plate. If I have vibration I'll add another rod directly to the side of the cabin. I could drill a small unobtrusive hole in the cabin and then epoxy a threaded aluminum piece on the inside to pick up the rod. I'll have to think about that. In the event of a roll-over I don't want that rod impaling me when the mount gets squashed against the cabin.

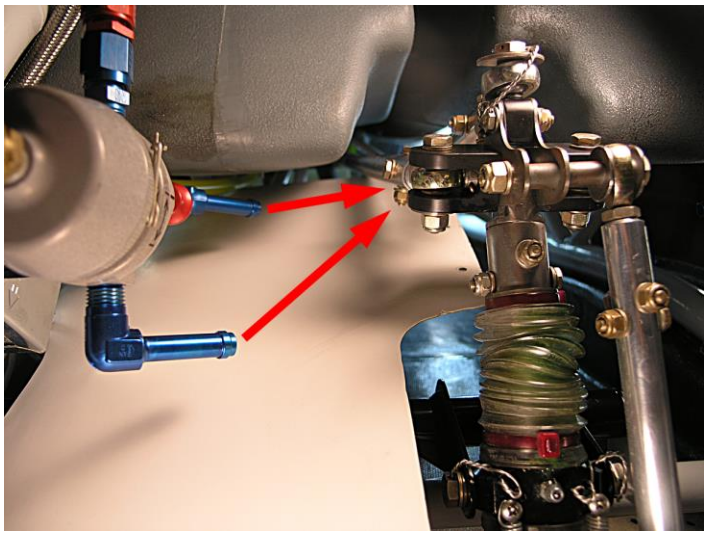
I'll test this mount on Hap Millers Helicycle in a few weeks at a fly-in in Rio Vista put on by Gerry Nolan.

I grabbed the ugly shot on the following page as the sun was setting. I've got the cabin and collective lit with incandescent lights and the sun is glaring on the driveway, so the color balance is a mess, but you can see how the shot is framed and get an idea of the video resolution. I think this will look great if the vibration isn't a factor, especially on my 50-inch plasma hi def monitor!



02 September 2010 – I plan to work on my cabin cover next. I have three yards of Kimberly-Clarke Noah. It's a synthetic 4-ply material that's designed to repel water but allow water vapor to escape. It also has UV protection. I'd like to have that ready before I get the cabin painted because my garage is dusty and I want my paint to be perfect. I'm not at all sure the old family sewing machine is up to the job. We'll find out soon…

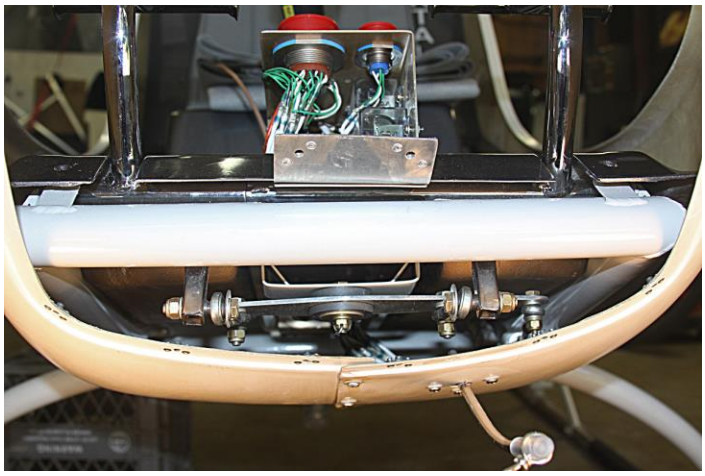
The first step is to put the cabin back on. In this picture I have the left side of the cabin installed and I'm looking in from the right side towards the bottom. I haven't been happy with the way I had my fuel lines routed. They were rubbing on the mixer tubing that connects to the swash plate. There's a lot going on in the area. Arrow 1 goes to the sight tube. Arrows 2 thru 6 point to fuel fittings that all get combined with the aux tank (not shown in this picture) and fed towards the engine. Arrow 7 points to the mixer. As the name implies, this is where the collective and cyclic inputs are combined to control the swash plate. There are five tubes connected to this assembly and I want them to be free of interference.



Here's the view looking up from below. These two lines need to cross behind the mixer and the three tubes going up to the swash plate. I was thinking of simply removing the rear cabin fiberglass from this area but I'm starting to think that there is a low pressure area towards the back of the cabin during cruise flight that would tend to want to pull the cabin away from the seat pan. The cabin is only attached to the seat pan with eleven 8-32 screws on each side. I think they should be tied together to help form one rigid structure. That means I don't want to remove any more material from this area. Instead I think I'll try to tie the tubing and fittings to the back side of the cabin with tie wraps. That might maintain the clearance I want in a low-tech but perfectly adequate way. While I'm thinking about how I want to approach this I'll put the cabin back together and get started on the cover project…

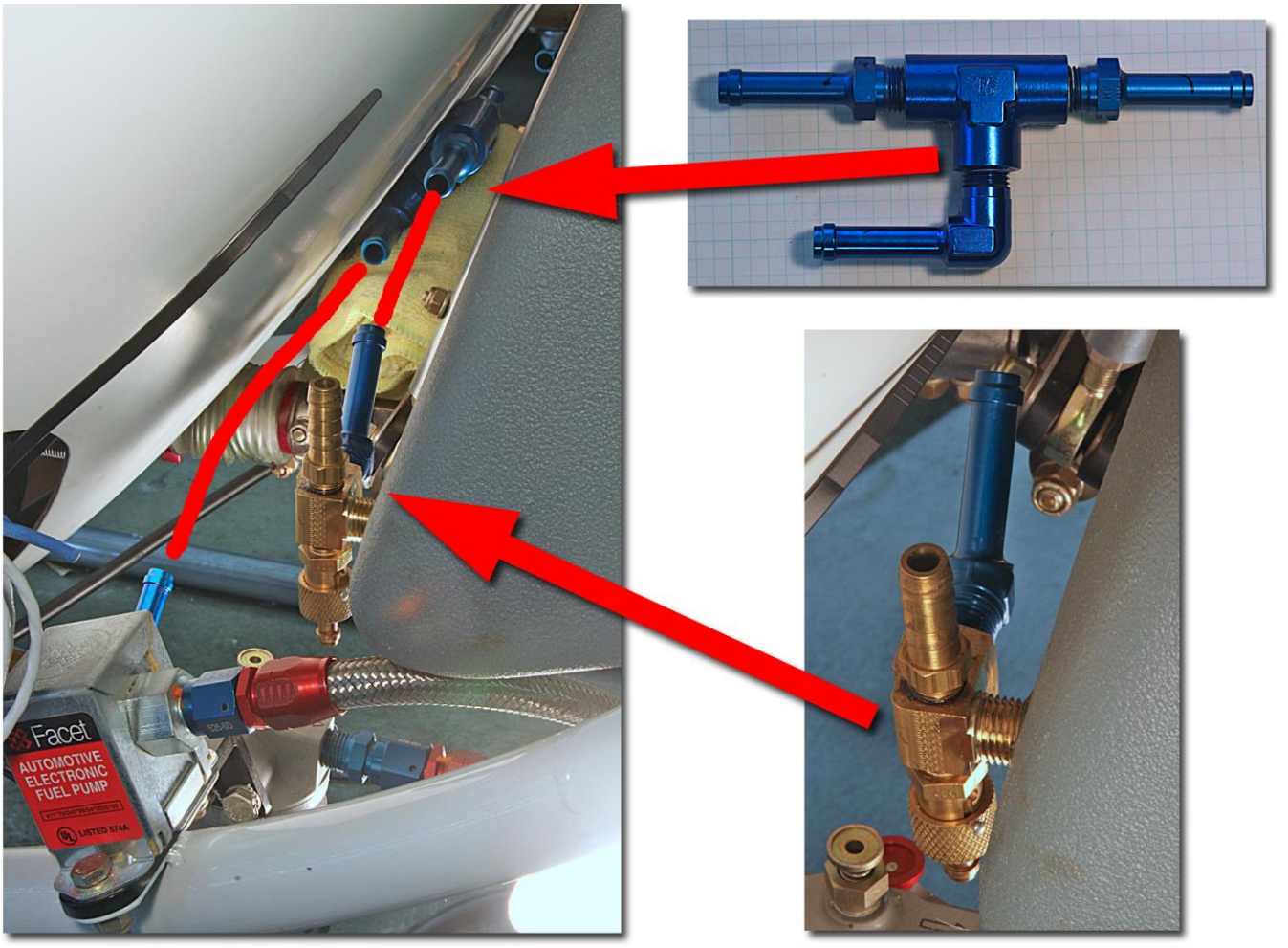
Before I get back to installing the other half of the cabin and the windshield I stopped to put my experimental placard in place. The FAA requires all experimental aircraft to have a placard near the "entrance to the aircraft". I doubt that they had the Helicycle in mind when they came up with that rule, but the left side is the entrance and there's my placard. I laid it out on-line using the vendor's software in about two minutes, clicked a few icons and in a few days it arrived ready to install. It's made of 3M vinyl. I used white Arial bold with a thin black border. Getting it perpendicular was the only tricky part since the rotor shaft is tilted slightly by design and I have a pronounced starboard list after sitting for two years.

Ok, back to the cabin cover project… Now I have the right cabin half back on. The picture below is the view looking straight in from the front and showing the directional control pedals and linkage below the seat pan. I want to capture as much detail as I can because once I get the cabin painted and installed, I don't want to have to remove it any more than absolutely necessary. It's very difficult to get the cabin on and off without scratching something. It's really a two or three-person job and I've been doing it alone by bracing the side with my knee while I hunt to line up a screw hole. Not good!



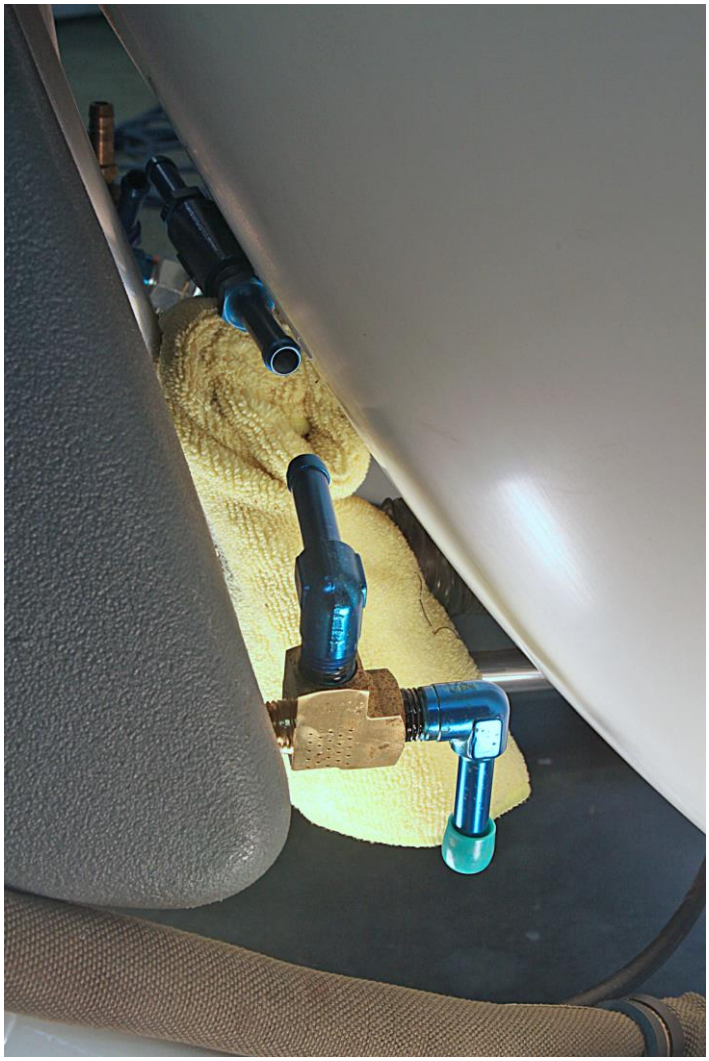
The last step is to install the windshield, the chin window, and the doors since they fix the overall shape of the cabin and turn it into a rigid structure…

The cabin cover project is on hold until I get another three yards of Kimberly-Clarke Noah fabric. I picked up a couple twin Jeans/Denim needles that will stitch two simultaneous rows about an eighth-inch apart, and outdoor, waterproof, UV-protected polyester thread. Soon I'll have everything I need to make the cover except a pattern. That's going to be the tricky part.



While I'm waiting for the remaining fabric I'm back to the fuel system. I've decided to mount the 'T' assembly (upper right) against the back of the cabin using tie-wraps. In the picture at the left it's held in position with a rag. One of the tubes I'm trying to avoid is just visible peaking out from the side of the tank. I should have good clearance between those tubes and the fuel lines connecting to the 'T'.

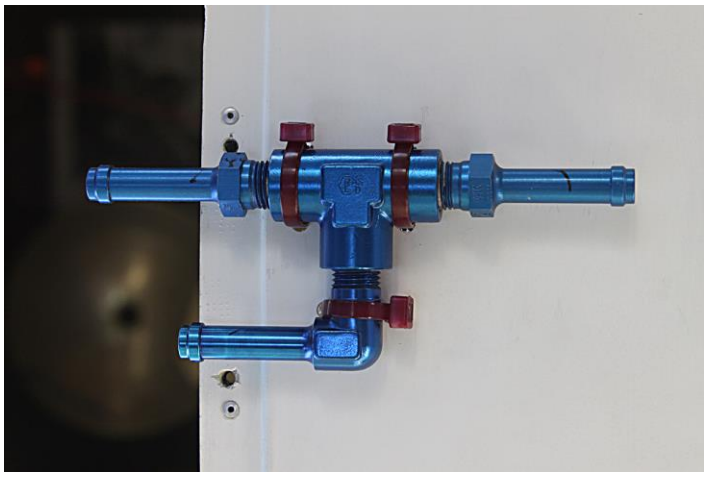
The fitting assembly at the bottom of the left main fuel tank (lower right) has an AN844-6D 45º hose fitting that I can point up and slightly away from the tank for a nice straight shot to the top of the 'T' and the brass fitting at the top of the assembly will connect to the sight gauge made from Tygon tubing. The bottom of the 'T' connects to the input of the Andair Gascolator filter.



The right side is much simpler. The right side of the 'T' connects to the right-angle hose fitting. I'm going to rotate the brass fitting slightly from the vertical to point the hose fitting up towards the 'T' and also rotate the fitting slightly away from the tank and towards the back of the cabin.

The Build-1 kits have fuel tanks that have pipe threads tapped directly into the polyethylene tank. The newer kits have a much more robust way of mounting the fittings. I've haven't had much luck sealing these fittings and creating a configuration that I was satisfied with. The rubber fuel lines exert quite a bit of force on the fittings and they tended to rotate slightly and I ended up with small leaks. I tried several sealants such as Teflon tape and Permatex aviation Form-A-Gasket. When those didn't work I tried two different 2-part epoxies, but bonding brass to polyethylene is very difficult. Polyethylene is a class of plastic called LSE (Low Surface Energy), and LSE materials are difficult to bond to. Now I've found a specialized 2-part epoxy that is especially formulated to bond metals to LSE plastics.

I can't try the new epoxy until I remove the cabin since it blocks the removal of the right hand fitting assembly. I also have to be very careful not to damage the epoxy bond or tear up the threads while attaching the rubber fuel lines. Isopropyl alcohol makes a good lubricant but getting the tubing onto the fittings takes a lot of force and those tank threads are delicate. This project will be easier without the cabin in the way.

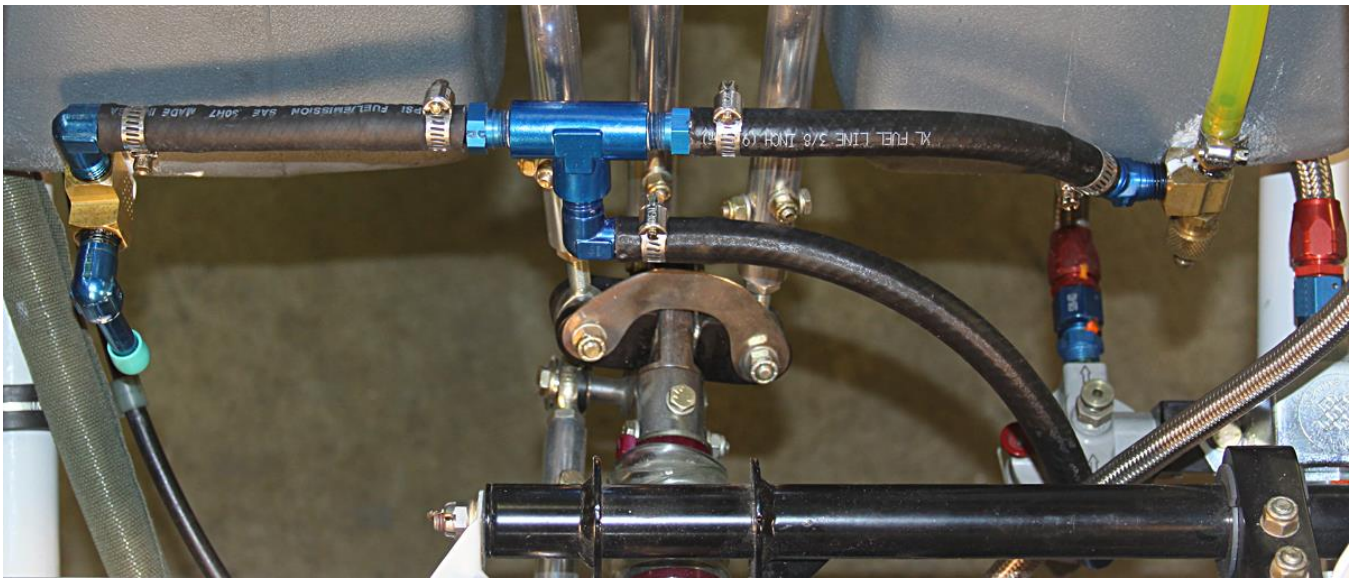


Here's the 'T' assembly mounted to the bottom of the right hand cabin half with three tie wraps. I made sure I didn't block one of the screws that attach the two halves.

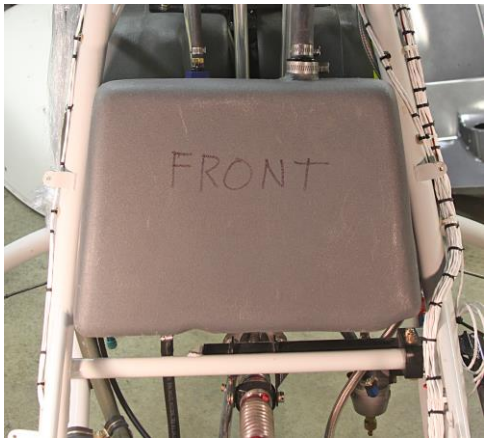
I sanded down the exterior area of the tank and cleaned it with isopropyl alcohol, then cleaned the brass fitting with acetone. I applied Bondit B-4811, a two-part, adhesive that is designed to bond dissimilar materials such as polyethylene and metal. I hope this works because it's very expensive. To make the bond as sturdy as possible I ran the fittings in almost all the way so I could run the epoxy from the body of the fitting to the fuel tank exterior and not depend on the adhesive bond in the threads alone. That material always tends to be squeezed out as the fittings are installed. The epoxy will be cured in 24 hours and I'll see how things look.

By the way, the brass fitting at the bottom is a spring-loaded drain. By pushing up and twisting I can drain a small amount of fuel from the bottom of the tanks to look for water and foreign material during my pre-flight checks.

I'm inching closer to final installation of the seat pan and instrument panel…



Here's the final configuration. The 'T' is about three-quarters of an inch in front of the tubes, and that's about where it will end up when it's tie-wrapped to the cabin. The remaining hose fitting on the left of the picture connects to the auxiliary tank.



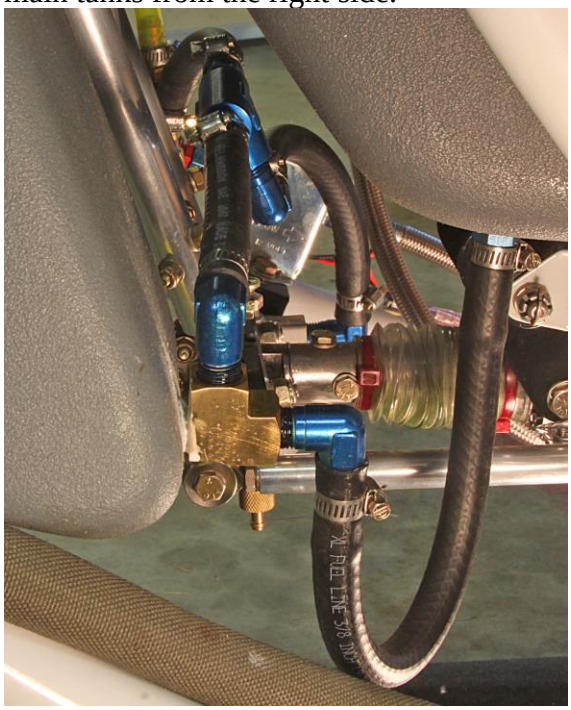
05 September 2010 – The auxiliary fuel tank is now connected. It will be clamped to the back of the seat pan. The next step will be to fill up the tanks and check for leaks. I should use kerosene or jet fuel but I have nowhere to store it once I'm done. I could leave it in the tanks but it's not a great idea to let fuel sit for many months, and if I have a leak I'll need to drain it out and put it somewhere, so I'll use gasoline for this test. I can use gasoline in my vehicles when I'm done.

Notice the routing of the left-hand cable harness (right side of picture.) I had to go around the outside of the seat pan bracket to avoid pinching the harness, and also stay clear of the seat belt.

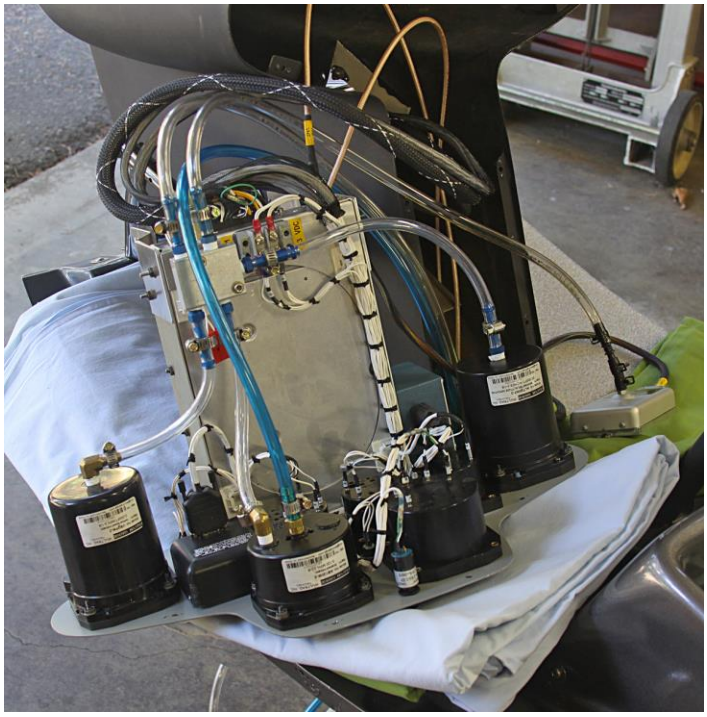
I think I've installed my seat pan for the final time. I hope so because it's a lot of work.

I've installed the pedals, fuel shutoff valve, collective friction, and the Bose headset and holder. The cyclic boot, heel skid plates, instrument pod and panels, harness, and an engraved manufacturer's plate remain to be installed. Once the airworthiness certificate is issued I'll attach the plate to the left side of the seat per FAA requirements.

Here's the view looking between the aux and main tanks from the right side.



Now that the seat pan is installed for the final time (I hope!), I can install the instrument panels…



Left – With all the cables and tubing hanging out the upper panel looks nasty, but once the upper panel is in place and the cables are cleaned up it doesn't look bad. I want to have enough length on the cables so I can pull the panel out to work on it if necessary. If I need to I can completely remove this panel and take it into the shop.

Right – This is the inside the instrument pod looking at the top of my interface chassis. My access panel just visible on the right side of the picture turned out to be a great help in lining up and securing the cables. I can reach most of the connectors through there and I can also get my hand behind the panel to reach both BNC coaxial connectors.

Left – The lower panel goes in last because it overlaps the top panel. This panel is a lot less work to install because there's only one cable.

Where I have the mating connector located I can't get enough fingers in there to mate or de-mate the connector so if I need to get the panel completely disconnected I'll have to take the helicopter apart. I can always bring the panel out where you see it which should be good enough.

Right – This is the underside of the interface chassis as viewed from the front. The clear tube will go to my static port and the blue tube goes to the Pitot tube. I see one screw that I need to shorten so it doesn't abrade the tubing…

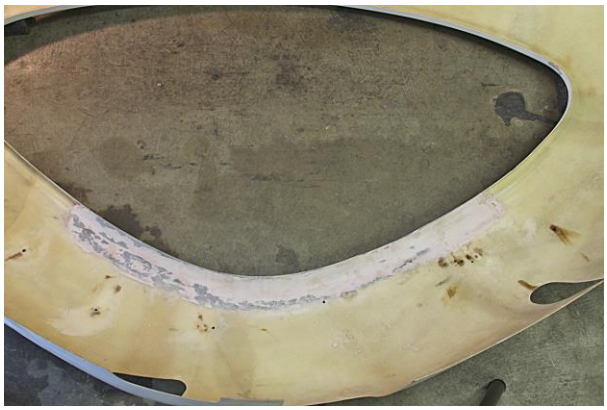
Next page – The instrument panels are now installed with a minimum number of screws since that's the way the factory wants it for the checkout. There's some cosmetic molding that goes around the front edge of the pod. I'll put that on once the checkout is complete since it will make it more difficult to remove the panel.

I discovered one mistake; in all of my thrashing around with the pedals it never occurred to me to pay attention to the space <u>between</u> the pedals. They're so close together that they rub on the instrument pod. Fortunately they're much wider than my shoes. I'll have to cut off about three eights of an inch from the inside of each pedal and then get the side stops welded back on. That will destroy the chrome plating so they'll have to go back and get chromed again. If this is the worst mistake I make I'll be a very happy Helicycle builder.


AIRSPEED
VERTICAL SPEED
ALT
ROTOR RPM
ENGINE TEMP
ENGINE RPM
FUEL
ICOM
IC-A210
120.10 119.50
1200
PRESSURE ALT
FL 004
GOV
FUEL
MFS
ALT
INST
CLUTCH
START
AVIONICS
FUEL PUMP
COMM
XPDR
STROBE
FUEL FLOW

Saturday 11 September – On page 276 I bonded the lower fuel tank brass fittings to the bottom of the polyethylene main tanks using Bondit B-4811, a two-part adhesive especially blended to bond dissimilar materials. I decided to do a pull test on a scrap, so I bonded a brass fitting to an old tool box. Between the pictures on page 276 and this one you get a good idea of the concept of surface energy. A good example of low surface energy is the hood of a highly polished automobile. Water beads on the surface and doesn't wet. When the water spreads across the surface smoothly then the surface has high surface energy. At the molecular level the surface energy is what causes the adhesive to bond to the base material. Brass has high surface energy, and notice how the adhesive flows out to a very thin concave meniscus. There's a lot of attraction between the adhesive and the brass. The bond to the polyethylene looks slightly convex, but still encouraging.

Update: After a two-day cure it took 25 pounds of force to pull the fitting loose. The bond to the polyethylene failed and the adhesive came off with the fitting. That's what I expected. Not bad!



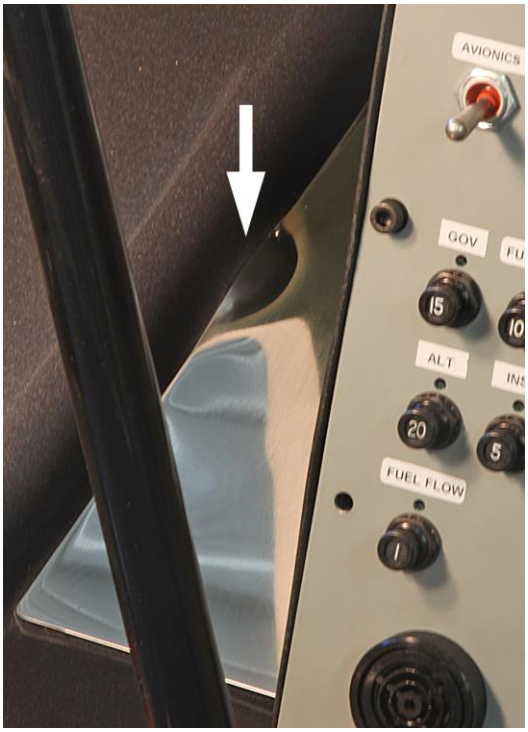
I've also been reinforcing the bottom of the cabin door lip area on the left side. Hap warned me that people tend to put all their weight on this lip while getting in and out of the cabin. The entire cabin, including the door lips, are very thin fiberglass and wouldn't hold up well to heavy forces. I started with long stranded fiberglass patching material and then went over that with body filler. Once I get that blended in went over it with glazing putty. I also took this opportunity to scoop out a section of the lip where my knuckles will be when I raise the collective.

Here's a closer look from the side. You can see where I've scooped out the lip for more clearance near the collective throttle.

Now that the left side is done I'll do the same on the right side. That way the cabin won't get busted up when people use the door lips to lift themselves up and get adjusted in the seat. I can't imagine actually letting anyone sit in my baby, but I suppose it's possible…

The foot plates are installed. I made them out of .031" stainless and polished them using three grades of rouge. I secured them using sticky-back Velcro so I can remove them as needed.

The only tricky part is dealing with the seat pan bump on the left side (white arrow.) I chose to hammer out a matching bump rather than cut around it. It was easy.



I don't have much left to do to finish off the inside of the cabin:

- Install cyclic boot (in the mail)
- Chrome and install modified foot pedals (in the mail)
- Paint interior with Zolatone (waiting to decide on camera mount rod – see pg. 275)
- Install restraint system (on order and due in one week)
- Finish off door hinges and mount to cabin

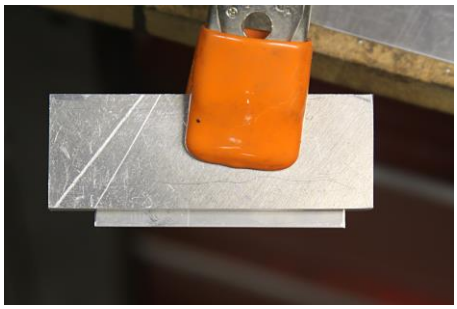
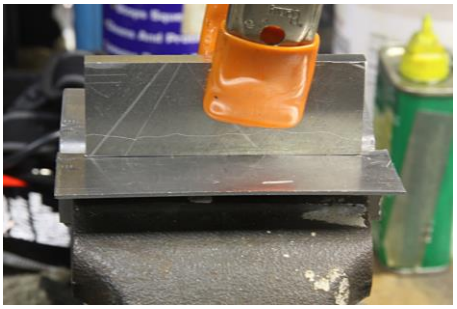
I received my cyclic boot this afternoon from Hap Miller Industries, Custom Aircraft Interiors Division. It looks fantastic! It's from the same aviation leather I used to make the seat. I found it on eBay. It's from the British Isles.

The only thing remaining to do inside the cabin (other than paint) is to install the modified pedals and the restraint harness which should both be here in one week. Eventually I'll add a timer and a GPS that will mount to the interior of the cabin somewhere near the instrument panel. I'll deal with those items much later.

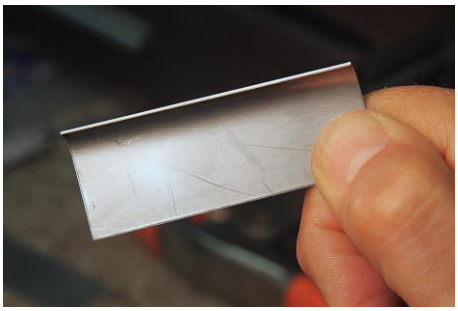
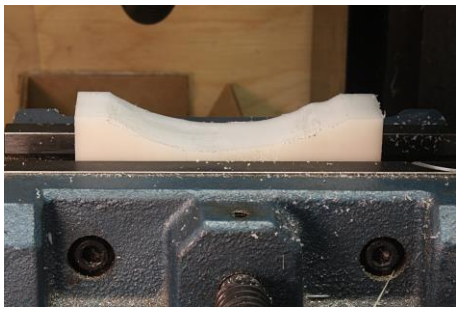
The modified pedals are back from the local chrome shop. (They were manufactured by the Steel Fabrication / Thin Wall Tubing division the Hap Miller Industries.) Now I have about 3/8" clearance between the inside of the pedal and the instrument pod.

Notice how ugly that end looks where the two sections bolt together. Here's an example of the little touches that you can do to make things nicer. Hap machined two aluminum plugs for his pedals. The ends are chamfered and polished and they look great. Eventually I'll want to do the same thing to mine. I imagine that Hap will have these for sale soon and add them to all the other goodies he's come up with.

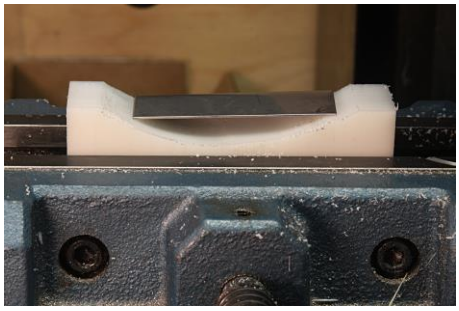
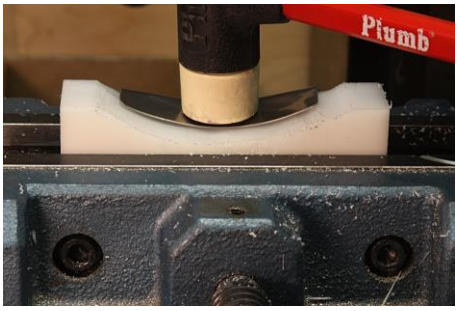
Hap Miller mentioned that I should install striker plates on the left door lips so I don't damage my paint. The top and bottom ones are extremely simple because the area is essentially flat. The one in the front is an entirely different situation because it is in a curved area. I decided to give it a try using .031" stainless steel. I started by cutting sure rectangular pieces that were about 1"x2". The first step was to make a lip for the outside of the plate so the pin will ride up over the lip and not hit the paint. That part didn't seem too hard.


I used a scrap of ¼" stock to act as a guide, dropped it into my vise, clamped it down, and removed the guide.

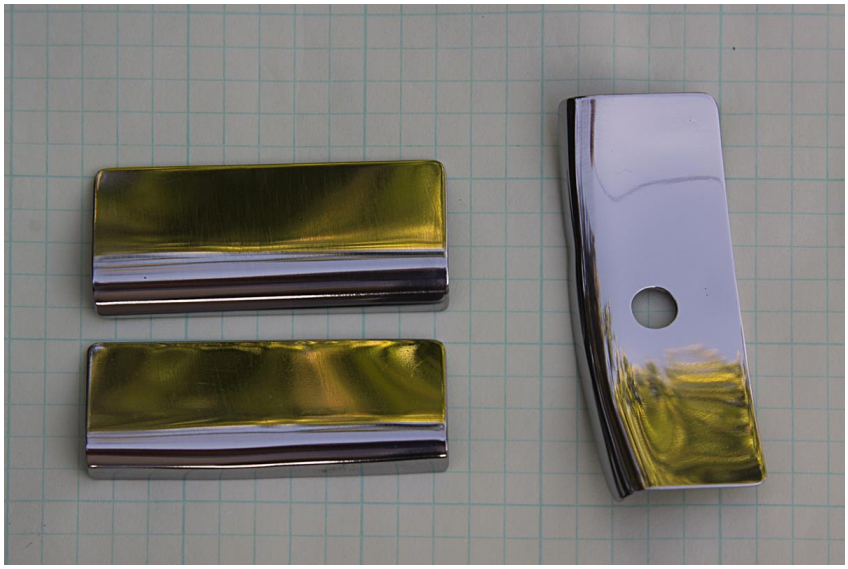
Then I used the guide to roll the piece over the jaw protector and finished it off with a few taps of my hard rubber hammer. That left me with the lip you see in the center picture. Next I made myself a form by tracing the curve on the door onto a piece of Delrin I had in my junk box. I milled out the general shape and then cleaned it up using a half-round hand file.

The next step was to place the flat piece in the form and gently tap away at it until it took the shape I wanted. Now comes the tricky part… As the piece takes the shape of the large radius it tends to straighten the lip. I found that I could clamp the piece against the form by squashing it against my largest fire extinguisher. Then I was able to go along the lip and tap it back into the shape I wanted.

Here's the roughly formed part. It still needs to be deburred and tidied up and then polished. And of course the hole will need to be drilled in the correct location. I'll also drill two holes on either side for rivets.

Here's a preliminary fit check on the left, and the almost-finished plates after polishing below. A few more holes and these will be ready for installation.



02 October 2010 – I've mounted the three striker plates on the left door lip, and I've learned a few things… 1) If you're going to do this, do it BEFORE you drill the mating holes for the door latches because the thickness of the plates moves the door just enough to throw your hole alignment off. 2) Don't bother polishing the plates until you're completely finished because they'll be all scratched up by the time you get everything fitted.

I've been working on this striker plate / door fitting project all day. It's been a lot of work and I'm still not satisfied. I want to be able to get that door unlatched with one hand. In an emergency I might not have the use of both hands if I'm injured. Right now the latches all stick unless I pull in slightly on the door with one hand while pulling up on the latch with the other. I might be able to improve the situation with a bit of grease but I don't want to make a mess unless I have to. The latches tend to bind up on the housings if there is any friction and that's the problem.

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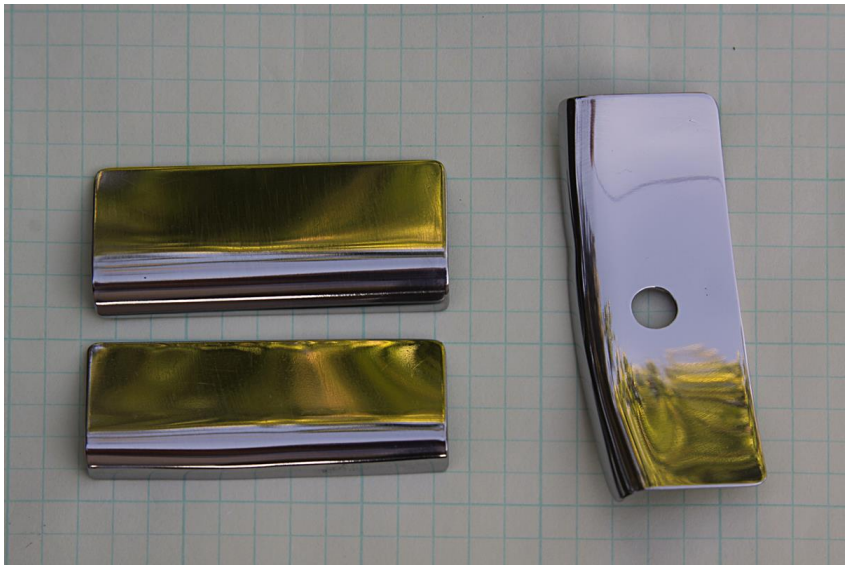

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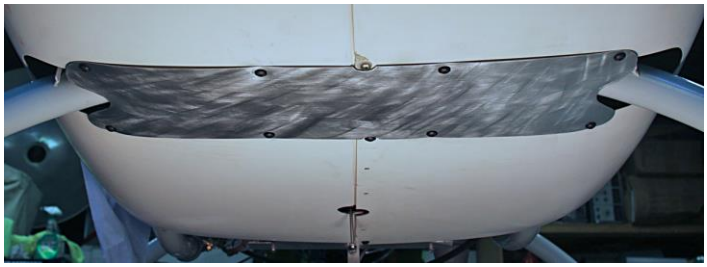
Among other things Eagle R&D wants a picture of you sitting in the cabin with your feet on the pedals. I suppose it's to prove that you can reach the pedals. I got my modified pedals back from the chrome shop yesterday and installed them. I took this opportunity to grab that picture while I have the right side of the cabin removed. I'll have to remove the left side of the cabin to install my seat belt and shoulder harness. I expect it to arrive in a few days. Now I'm worrying about damaging my seat pan paint with the buckles…



10 October 2010 – It's true. The last ten percent of the project takes ninety percent of the time. I've been working on the small details that I need to attend to before I can think about painting the cabin. I fabricated this forward gear cover plate from .031" 6061-T6 supplied for the purpose. Match-drilling and installing the eight nut plates into the fiberglass while working upside down is a strain on the neck but the job came out looking reasonably well. I've scuffed the aluminum with 600 grit wet and dry but to do it right I should prep the aluminum with an etch and then Alodine it. Then it should be primed and finally painted. I'll leave all of the painting to the experts but I want to do as much of the prep as I can to keep the cost down.

Last week I received a revised restraint system assembly drawing from Amsafe for my approval. They added another trim and finish code to match my specifications. The drawing is signed by engineering, design, quality, manufacturing, marketing, and planning, and the FAA was notified of the change. They're treating me the same way they treat Boeing or any other customer that orders a critical flight safety component. I told them I wanted the webbing to be gray and they sent me 13 samples of different gray webbing to choose from. I wanted to be able to release the shoulder harnesses during engine start so I can lean forward to reach all of the switches on my lower panel. When I had trouble visualizing how the shoulder harness adjuster worked I was sent one side with all the fittings. This may be overkill for my Helicycle but I appreciate working with professionals that take their work seriously. I should see the harness in a few weeks.

While I've been waiting for my restraint system to arrive I started building a box to house my main rotor blades during trailering. I still need to create a lid and deal with hinges and latches.

The box is eleven feet long and made from ¾" Maple plywood. The pieces are glued and screwed. I countersunk the screws and filled the holes with wood dowels which are sanded smooth. I'm using satin polyurethane for a protective coating. The interior dimensions are the same as the factory shipping crate so I can reuse the same interior hard foam lining.

I'll put handles on the ends once I'm finished and also come up with a pair of small removable wheels that I can put on one end when I need to move the box. With the blades in it, it will be fairly heavy and the wheels will make life easier.

06 November – I received my restraint system and finally had time this morning to install it. Oops. I screwed up a dimension and the seat belt adjusters are jammed into the side of the seat. Now I'll have to sort that out with the manufacturer which will probably take another three weeks. While I wait I'll try to get the lid of my blade box completed.

21 November – I've been so busy at work I haven't had any time to play. Amsafe, the harness manufacturer, is going to fabricate another seat belt and rotary buckle assembly for me at no charge. They've been fantastic to work with and I'm going to be very happy with the restraint system. Once they get their drawing set revised anyone will be able to order this harness by part number. That should make life fairly easy for the next guy.

Here's a look at the Amsafe restraint system. I like the rotary buckle because you can easily get out of the harness with one hand. This is important because you might only have one hand that still works after a crash. You just twist the knob and all the straps pop loose except the one that you've designated as the fixed side. I made the right side fixed to keep the buckle from interfering with the collective.

The adjusters are simple to operate (one adjuster for each of the four straps.) To loosen a strap you grasp the small black piece (1) and pull away from the buckle. To tighten a strap you grasp the free end of the strap (2) and pull towards the buckle. I need to loosen the shoulder straps during start up so I can reach all of the switches on the instrument panel. Then I want to be able to tighten the shoulder harness for flight. Again, this is a one-handed operation. I wish I was closer to the instrument panel so I could avoid the need for this, but that's the way it ended up and it's not something that would be easy to change. If I end up having to switch transponder codes or do much frequency changing in flight I'll have the same issues – one of the drawbacks of urban life.

Meanwhile I'm still putting the finishing touches on my rotor blade box. I bought hinge stock from Aircraft Spruce and I'm currently mounting the lid to the box. I still need to Varathane the lid and add hardware closures and a few miscellaneous odds and ends.

28 November 2010 – I completed the box to hold my main rotor blades when I'm trailering the Helicycle. I made two small dollies with castors that I can place on either end so I can easily move the box around in the garage. Eventually I'll make a removable axle assembly for one end so I can move it on and off the trailer, and over a rougher surface. I can use the ground handling wheels that came with the kit. I upgraded the original wheels for go cart wheels that are much wider and work much better over soft grass, especially when the helicopter is full of fuel.

I really didn't need to build this box now but I needed a place to store one blade while polishing the other. The shipping crate was fine, but it took up a bit more room than this box and it would have to be replaced sooner or later. It was also very heavy and hard to move. Now I can glide this box around the garage with finger pressure.

I salvaged the handles at either end from my junk box and robbed the two latches from a transportable shipping container. The hinge came from Aircraft Spruce. The only thing left to do is to add a thin flexible stainless steel cable to either end to keep the lid from opening too far and stressing the hinge.

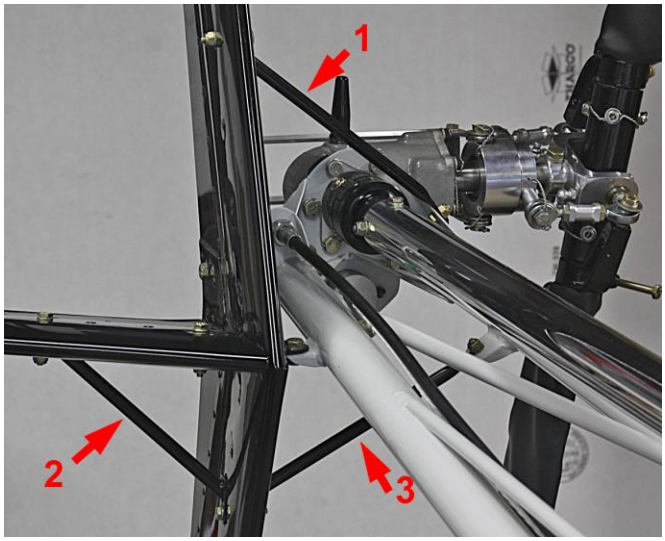
I've decided to put off painting the cabin and proceed to completion. I've been procrastinating for months and I can't decide on a color. I want to get in the queue for checkout sometime in the spring of next year so I need to get my FAA inspection completed and get my airworthiness certificate and send all of my paperwork into Eagle R&D as soon as I can.

Thursday 02 December -- I started to finish off the installation of the throttle potentiometer which attaches to the end of the collective assembly last night. There's a rod that runs down the middle of the collective and mates to the pot via an aluminum bushing. The bushing has a threaded hole in it that mates to a hole at the end of the threaded rod. A previous owner drilled that hole in the wrong location and then tried to correct his mistake by ovaling out the hole. I'm going to have to scrap that piece since there just isn't enough material left to safely drill another set of holes. Unfortunately the throttle is epoxied to the end of that shaft. I may have to scrap several fairly expensive parts to recover from this one bad hole. (I was able to get the throttle grip loose and disassemble the assembly.)

While I'm thinking about recovering from previous owners bad workmanship I'm also going to scrap the brass bushing that extends out the rear of the tail rotor drive shaft and into the coupling for the same reason. It had holes drilled in the wrong locations and by the time I got it right there were a few too many holes in the bushing. It would probably be just fine but I'll go ahead and scrap that part too. I also want to make a strain relief for the throttle.

I've started working with Adam Valdez the local DAR in our area to get the paperwork ball rolling. I'm going to activate my N-number and work towards getting the airworthiness certificate. I want to get on Eagle's checkout waiting list and shoot for next spring for my checkout. Adam has already been a big help and I'm looking forward to meeting him in person.

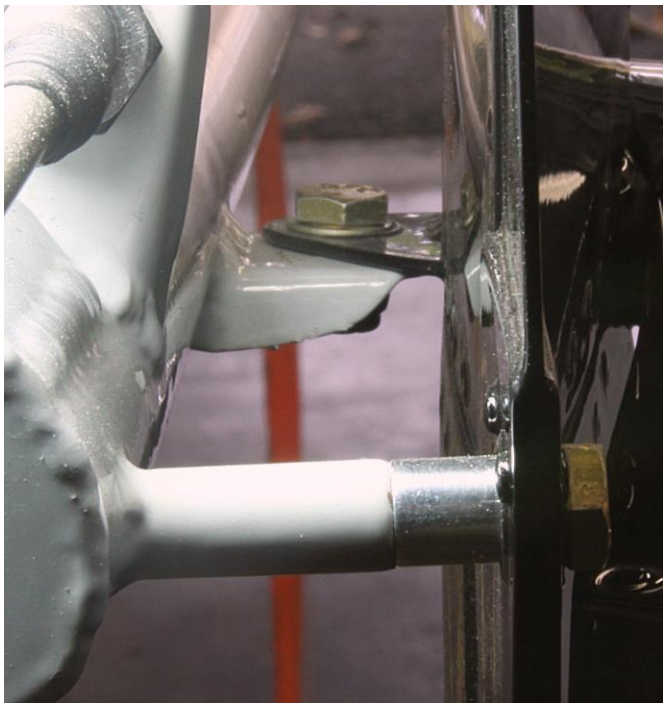
Saturday 04 December – Part of the paperwork / certification / checkout process is gathering up all the information required by the FAA and the factory. The factory requires pictures of a few items that I hadn't bothered to capture. One is the tail fin mounting details.



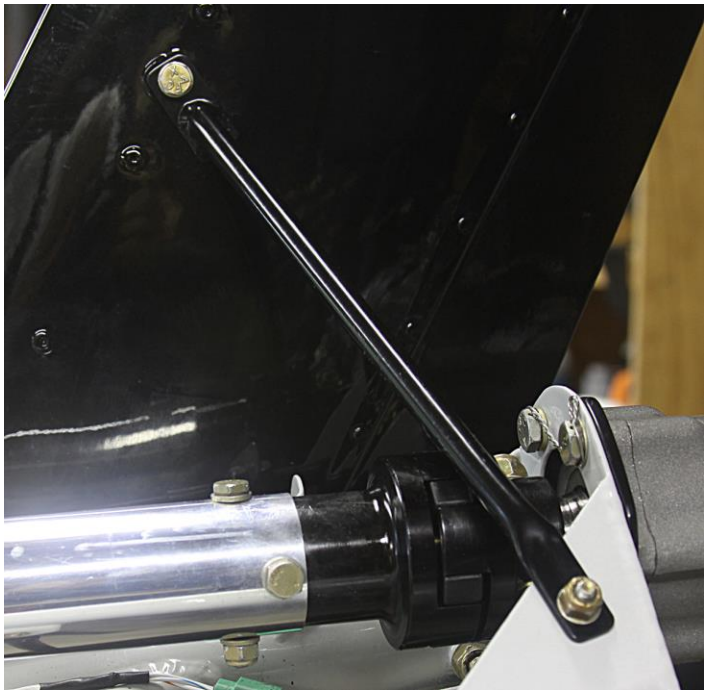
The tail fins are braced with three supports. The standard kit has you make these from chromoly steel tubing by squashing the ends in a vice, but I chose to have Hap Miller make me a set by welding flat mounting tabs to the tubing.

The fins and all of the supporting pieces were then sent off to the paint shop for a high gloss black paint job.

The tail fin assembly mounts to the frame with a single bolt at the front, right at the intersection of the vertical and horizontal fins. You can just see it in this picture.



Here's a view looking forward. You see that pivot bolt at the front. The angle of the vertical stabilizer relative to the long axis of the helicopter is adjusted by adding or removing space from the rear mounting location (foreground of the picture.) In my case I needed to add a spacer to get the angle correct.



Here's the top vertical support detail, labeled #3 on the previous page. Care has to be taken here to make sure the tubing is clear of the tail rotor driveshaft coupling. That's why the bottom end is mounted to the outside of that triangular plate.

Its standard aircraft practice to always mount vertical bolts pointing down. That way, if the nut comes loose, you might get a few more minutes of use before the connection fails completely. If the bolt is pointed up, as I have it here, and the nut comes loose, the bolt will drop out and the connection will fail. I took this into account but elected to mount it this way so I can keep an eye on it easier during my preflight inspection. It's a locking nut that's never been used before and I know it's functional because I'm the one who installed it.

Here's the lower support for the horizontal fin, labeled #2. You can see the tabs that were welded to the tubing.

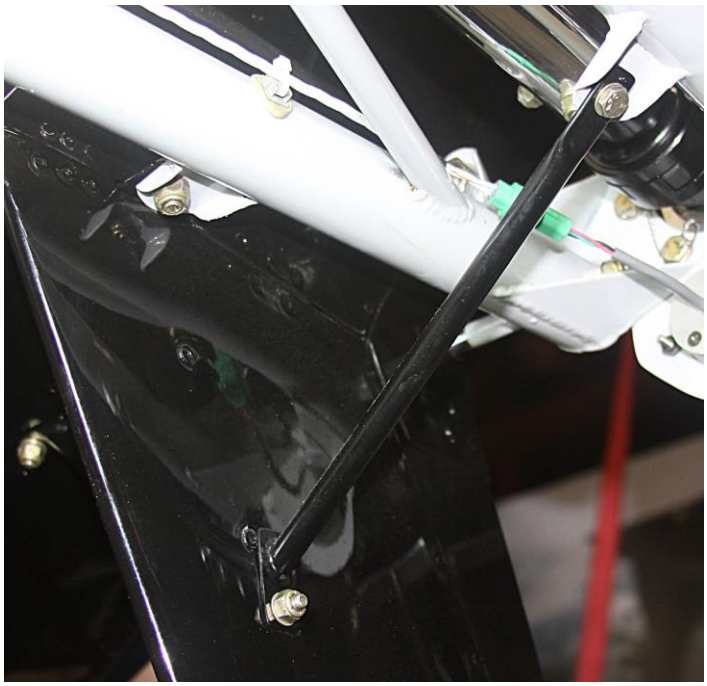
One more standard aircraft practice is to always have at least two threads showing through every nut. I just made it on the top bolt. I can always go to the next length if necessary. Sometimes I catch things like this when looking at my pictures.

The bolt in the upper right of the picture requires an explanation. The angle of attack of the horizontal fin is determined by this bolt. After carefully aligning the fin, relative to the main rotor shaft, a hole is drilled through the fin, the tubing inside the fin, and a smaller tube that extends out from the vertical fin assembly. The smaller tube is a tight fit into the larger tube so the fin is free to rotate along the axis of these tubes.

Here's how I did the alignment… I have a Mitutoyo Pro 3600 digital protractor that measures angles to hundredths of a degree. It has a feature that allows you to set any angle to zero by pressing the "Alt Zero" button. This allowed me to place the protractor against the forward side of the main rotor shaft and set my zero to that angle. Once done, all subsequent readings were relative to that angle. I could then set the angle of attack of the horizontal stabilizer and drill my mounting hole.

Of course it wasn't quite that easy. I measured the thickness of the chord, divided by two, adjusted for the thickness of the trailing edge of the fin, and then taped a drill bit of that diameter to the trailing edge.

Once done I could rest the protractor on the drill bit and at the widest part of the chord and know that it was perpendicular to the center line of the fin. Once that was done I could set my angle and drill a small pilot hole, check my alignment, and enlarge the hole in steps and finally use a reamer to finish off the operation. I taped a discarded manila folder to the vertical fin to keep from scratching the fin with my drill chuck.

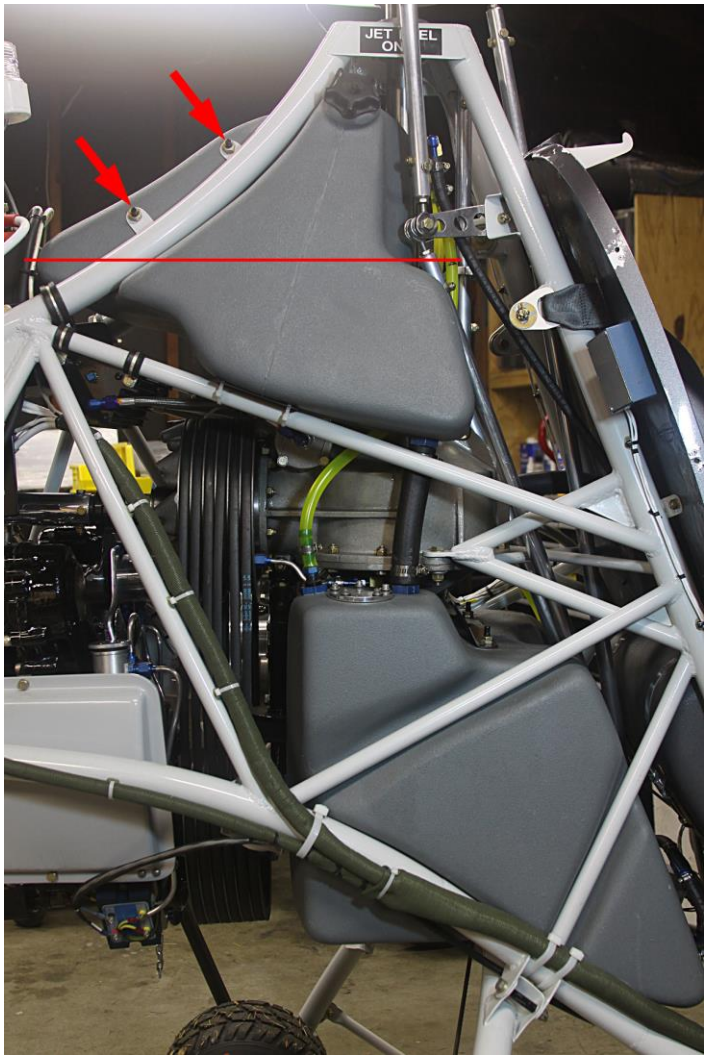


And here is a shot from below of the third support. That wraps up this project. If necessary the factory checkout pilot will be able to make tweaks to my alignment by changing the width of the spacer (vertical fin alignment) and ovaling out the bolt hole I just mentioned (horizontal fin angle of attack alignment.)

Sunday 05 December – This is a half day project. I milled this little strain relief to go on the side of the throttle potentiometer housing. Bad things would happen if a wire came loose from this pot in flight so I want to make sure it's firmly attached. Now that I know it fits properly I'll paint it black.

The only difficult part was making that large radius in the bottom. I scribed it out using the housing as my template and then used a large mill to carefully follow the scribe line. The last step was to chuck the housing in the mill, wrap 600-grit sandpaper around it, secure it with tape, and use that to finish off the radius. I had to be carful not to tear through the sandpaper and scratch up the housing but it worked out well. The little black clamp came off of a used connector in my junk bin. It has two ridges that help grip the cable.

The shield of this cable is tied to a common point at the engine controller's enclosure along with all the others that connect to the controller. The other ends of the shields, like this one, are all floating and insulated with heat shrink tubing to prevent ground loops. You could think of the enclosure and all of the shields as acting in the same way as your skull and spine. All critical circuitry is enclosed in bone. In the case of the electronics everything is enclosed in a metallic shield with the "brain" in the enclosure and the "nerves" inside the shielding which is simply an extension of the enclosure.



Sunday 12 December 2010 – Yesterday I cocooned my Helicycle in stretch wrap, loaded it on my trailer, and hauled it up to Rio Vista Airport where Gerry Nolan has a hanger. It's a white knuckle drive on some of California's most beat up freeways. Tractor trailers have completely destroyed miles of the slow lanes. The result is a very rough and bumpy ride. The shocks the helicopter is subjected to bouncing down the freeway are exactly opposite of the loads it is designed to withstand in flight and this is not good!

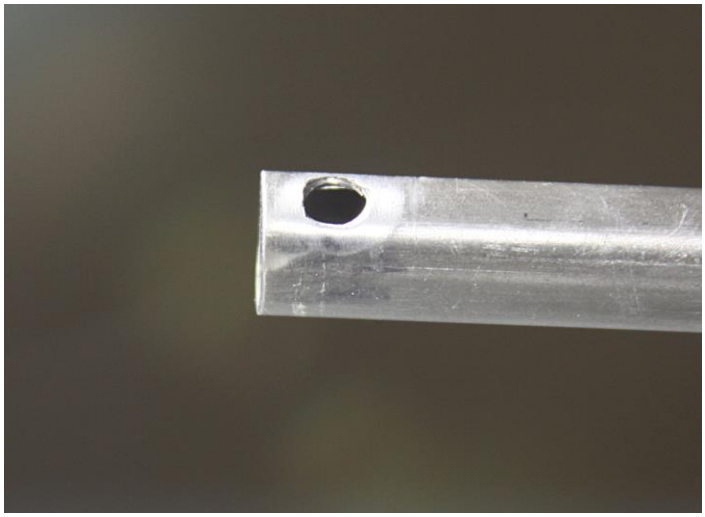
The reason for my trip was to say hello and also to take advantage of Jerry's 100-gallon portable fuel tank with digital metered dispenser. It's a first class setup and it allowed me to accurately calibrate by sight tubes and do one last leak check now that the auxiliary tank is final installed along with all of the plumbing. The red line in the picture is the 22 gallon level. As you can see, I can probably put another three gallons on board but 22 gallons is already enough fuel for one and a half hours of flight and that's a long time in a helicopter.

There were no leaks anywhere so the special adhesive I used on the bottom fittings worked perfectly (pg 281, 286.) We stopped at 22 gallons because I still had to drain the fuel back out again through my small fuel drain and get it back into Jerry's tank, drive back home, and get the ship off the trailer and back into the garage before it rained.

The two red arrows point at two of the four attachment points for that top tank. I'd already tested those for leaks when I did this the first time and nothing has changed so I feel safe not having filled the tanks to the brim. The engine, transmission, and tail rotor gear box have all been filled with oil for many months and they're all solid too.

My plan is to do my checkout at Rio Vista and keep the ship up there for the flight testing period which is usually 40 or 50 hours. I'll have to start thinking about renting a hanger…

15 December, 2010 – I'm going back and replacing a few parts that have been bothering me. This is the throttle pot end of the tube that controls the pot. There is supposed to be one hole drilled through the end that is captured by a bolt. A previous builder had already drilled an oversized hole in this tube and it wasn't in the correct location for my installation, so I rotated it 90 degrees and drilled my own holes. It would probably last forever and no one would ever know, but it was keeping me awake at night so I decided to scrap it and start over with a new tube.



Here's the new tube. You can see how much oversized this hole was. That would have led to a lot of slop in the throttle. The idea here is that a bushing mounts to this tube with a 3/16" bolt that goes through a threaded hole in the bushing and then into the hole drilled into this tube. When I was playing with the old tube I noticed that the steel tube was tearing up the bolt threads which then damaged the tapped threads in the aluminum bushing when it was removed. This time I ran a tap through the bushing and into the tube so this hole is also tapped – no more messed up threads. It's a small thing but now the bolt is happy.

The tube mounts into a cylinder and it's secured with a spring pin. The plastic piece with the fingers is the friction grip which is epoxied to the cylinder.

The knurled black anodized piece screws to the plastic piece and compresses the fingers as you tighten it, increasing the friction. I picked up the grip at the local Harley Davidson dealer. It's a friction fit over the metal cylinder.

Before I drilled that hole in my new tube I positioned the throttle grip so the seam would not be under my palm at full power.