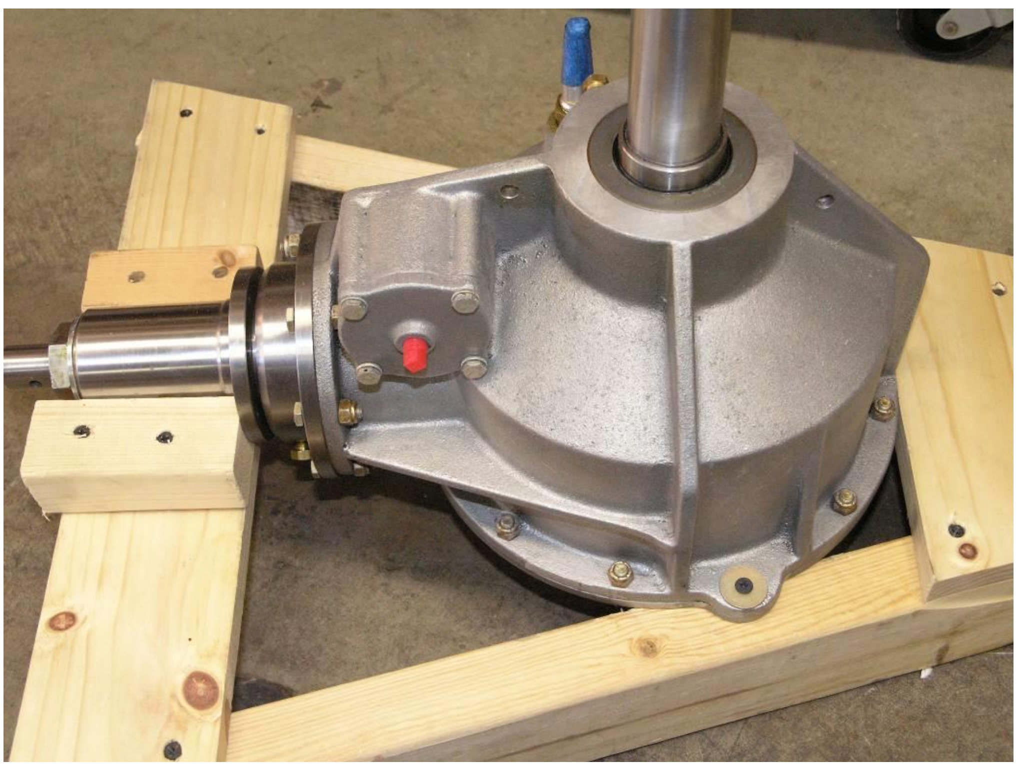
Builder’s Log -- Helicycle N750G

July 30 – Helicopter arrives minus the engine which was sent directly back to the factory for rebalancing.

I dragged the crates up the driveway with my car…

August 1 - I organized the parts and stored them in roll-around carts that I built



I also built a mounting jig to hold the transmission

August 2 - The Helicycle frame is now up on the skids

August 3 – I began inventorying the parts and inspecting the work that had already been done by the three previous owner/builders. Here is a partial list of work that was completed when I purchased the kit:

- Skid tubes drilled
- Tail rotor drive shaft mounting holes drilled (very poor workmanship.)
- Right hand transmission mounting bracket drilled
- Cabin halves attached with nut plates
- Holes drilled in instrument panel mounting frame rails
- Tail rotor assembled
- Tail fin assembled

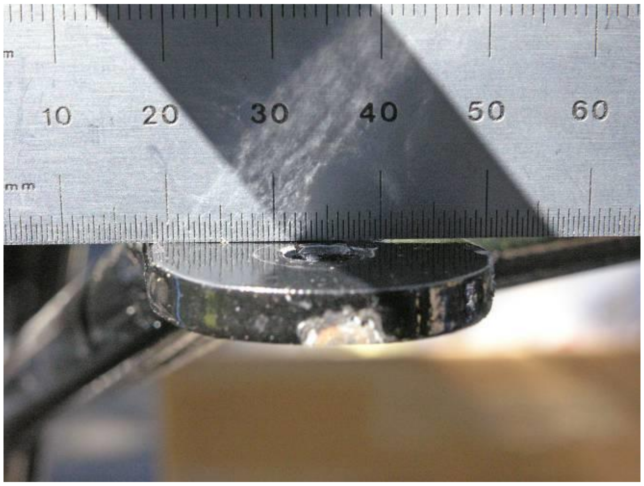
The overall quality of the workmanship is poor and I may have to replace some components.

August 3 – I used my Genie Lift to raise the transmission into position on its mounting brackets for a fit check. I needed to do this lift in several stages.

The Genie Lift would not reach far enough so I clamped a 2x4 onto it as seen in this picture and then attached my hoisting line to the 2x4.

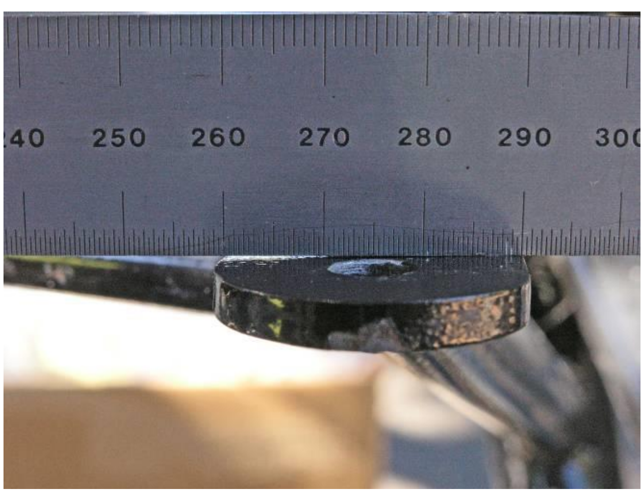
I temporarily braced the transmission as shown here while resetting the Genie Lift for the last lift. Care needed to be taken not to scratch the main shaft. I initially shielded it using red rags but finally stopped to cover the shaft more thoroughly using two manila folders wrapped around the shaft and taped into position.

After placing the transmission on its mounts I discovered that the mounts were out of alignment and the right hand mount had weld material that interfered with a proper mount.



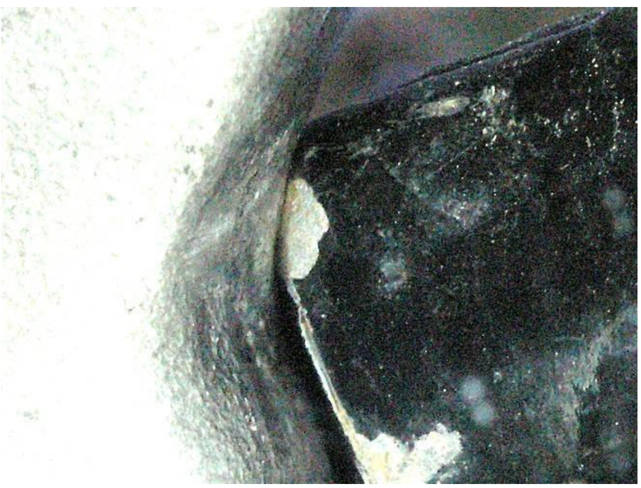
By placing a straight edge across from the left hand mount to the right hand mount you can see that the left mount needs to be bent slightly counterclockwise. The right hand mount also required slight readjustment.

This inspection mirror view of the bottom side of the left transmission mount slows that the weld bead is well clear of the transmission case.



Here you can clearly see that the right hand transmission mount needed to be straightened. This was done using a large Crescent wrench.

Using the inspection mirror interference between the weld bead and the transmission case can be seen in this picture of the right hand mount underside (the highlighted circle).



This enlargement shows the interference clearly. Using an air grinder and a flat file I was able to easily remove this portion of the weld bead and clean up the surface for a proper mount.
Once the transmission was mounted in place using the left hand mounting bracket, it was offset as detailed in the construction video to account for torque loads in flight. The process is to stretch a string from the transmission drive shaft center directly down the center line of the tail and secure it in the middle of the tail rotor gear box mounting plate.

Next, a straight edge is held flush with the transmission pulley shaft and a measurement is taken from the straight edge to the string at the location of the first bearing mounts. Then a measurement is taken on the opposite side of the string using the same process. The transmission is to be offset by approximately ¼ inch. In this case the hole had already been drilled in the right hand mount and it proved to be in the correct location.

Next, the transmission is slowly raised into position using the two mounting bolts and locking nuts. I used automotive feeler gauges to measure the gap between the transmission and the mounts as I raised it into position. In some cases shim washers are required to even the gaps but these mounts appear to be properly alighted and no shims were required. I will check this again before installing the transmission for the last time and I will also replace the hardware since I cannot tell how many times the locking hardware has been used.

I next inspected the tail rotor drive shaft sections and their bearing assemblies. Here is an example of very poor workmanship. These two bolts should be at right angles from each other. The hardware also appears to be well used and slightly corroded. I will replace it all including the tubes. (NOTE: New tubes arrived on August 30)

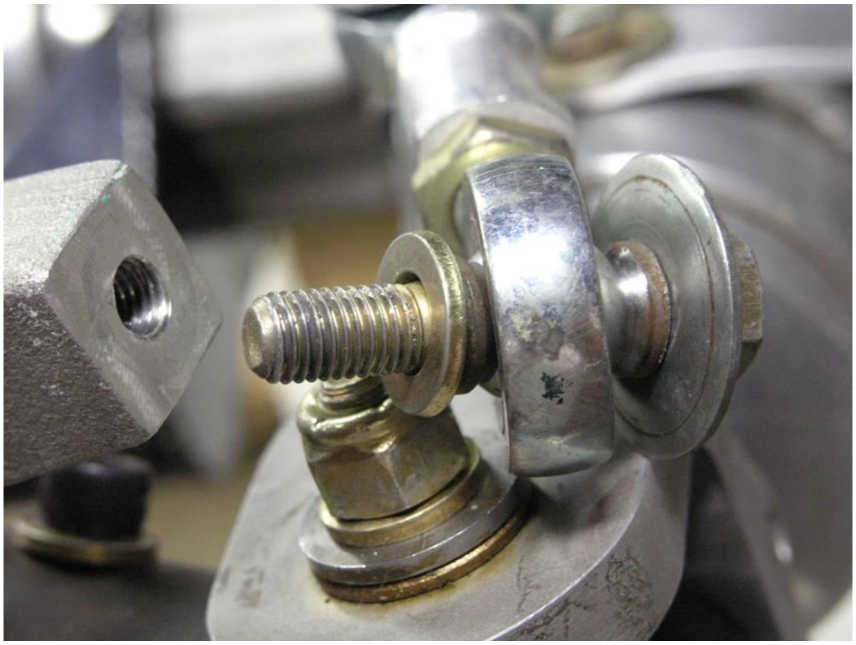
The transmission is mounted to the frame in two places. These two mounts carry the entire weight of the ship and all the aerodynamic loads.

August 11 – I've mounted the transmission, the tail rotor drive shaft, the T/R gear box, and the tail rotor to check fit.

I am finally working on a portion of the project that was not already done by one of the previous owner/builders. I'm using an air grinder to clean up the fiberglass seat pan molding.

August 12 – The ship is very tail heavy already so I build a stand to support the tail.

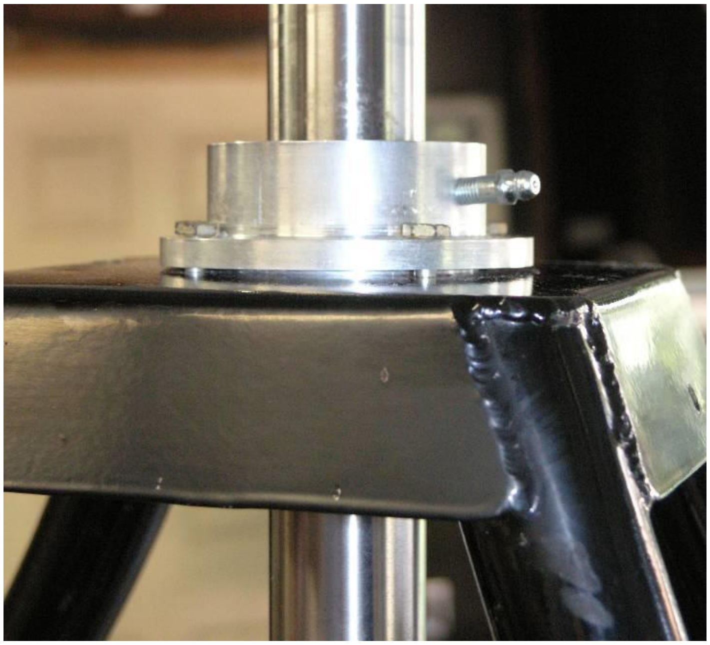
August 13 – I have been suspicious of the tail rotor drive shaft since the hardware showed signs of corrosion and the components were filthy and looked very used. This evening I was taking a close look at the tail rotor which was supposedly preassembled at the factory. I noticed that one of the bolt/washer stacks that attach the bearing end rod to the pitch horn was loose. When I attempted to snug it up the bolt bottomed out.



In this picture you can see that the bolt has run out of threads and there is also evidence of corrosion. All of the components appear to be scraped and dinged.

Here is a detail shot of one of the chamfered spacers from that stack. I will scrap these out.

Here's more evidence that the tail rotor driveshaft and tail rotor components are in extremely bad shape. Both coupling spiders are completely shot and full of cracks. As I mentioned, all of the hardware associated with the drive shaft appears to have been pulled from a junk yard after years sitting in the weather. All of this will be replaced before final assembly. (NOTE: New rubber spiders arrived August 30.)



14 August – This upper main rotor bearing assembly belongs underneath this mounting plate in the group-1 kits. But since I have it here I have an opportunity to measure the shims that I will need once I mount this assembly underneath the plate. Looking from the top and using automotive feeler gauges I measure the following:

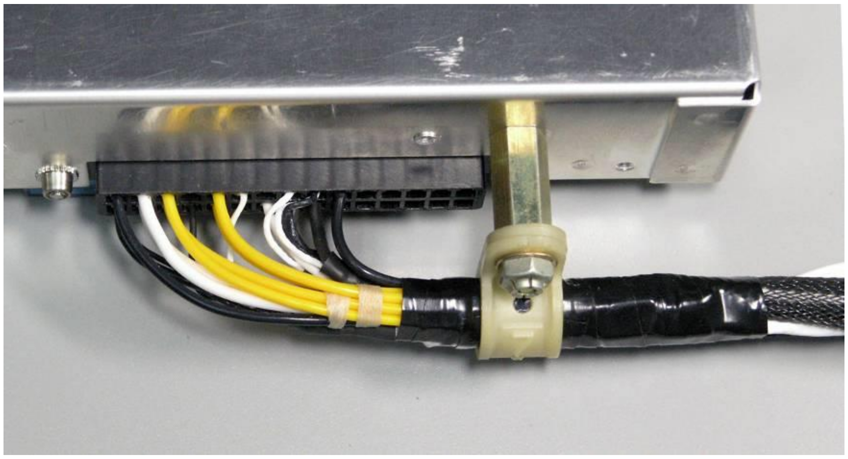
- Left forward: 0.036"
- Left rear: 0.000"
- Right forward: 0.080"
- Right rear: 0.045"

These gaps will be reversed when mounted from below.

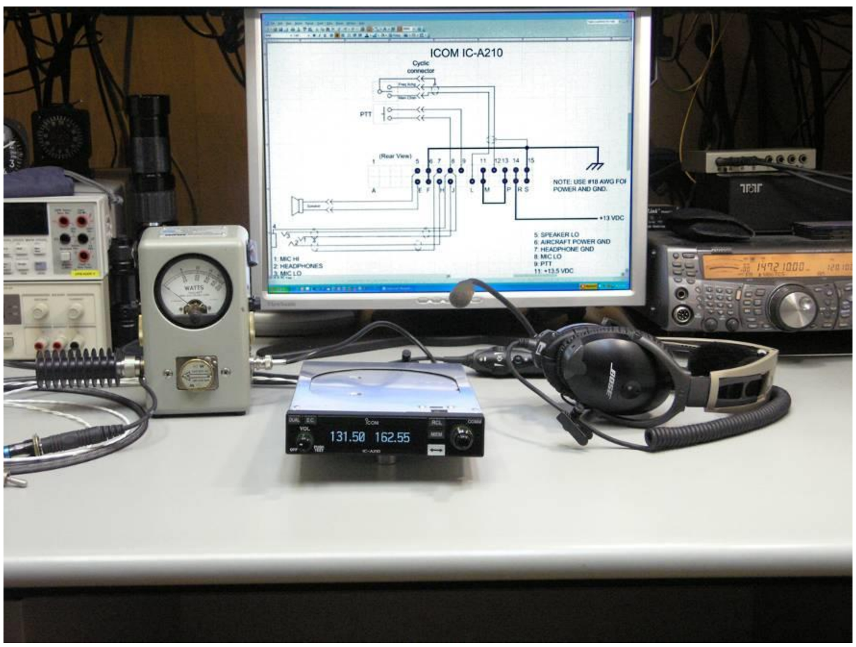
Today I also made skid shoes from PVC pipe that is clamped to the skids with stainless steel hose clamps. This is necessary since I can not move the chassis in or out of the garage with ground handling wheels on, and with the transmission installed. The main rotor shaft is too tall. I'll have to drag it over the rough asphalt and I don't want to tear up the skids.

Here is a picture of one of the replacement chamfered spacer, P/N 21-115. They are all very rough on the bottom side and needs to be deburred.

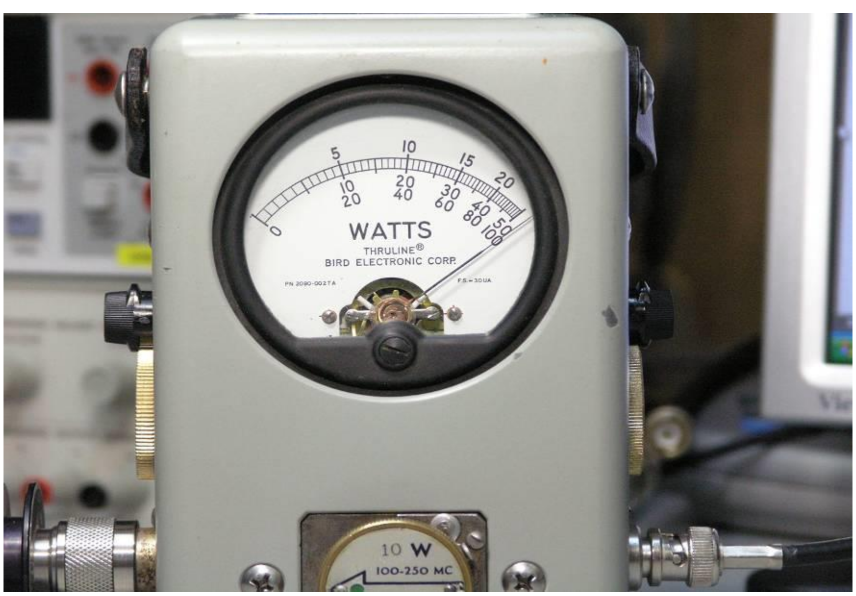
Here is the spacer after cleaning the burr off using 600 grit and then 1500 grit wet and dry sandpaper. I'll coat it with a dab of grease to prevent corrosion.



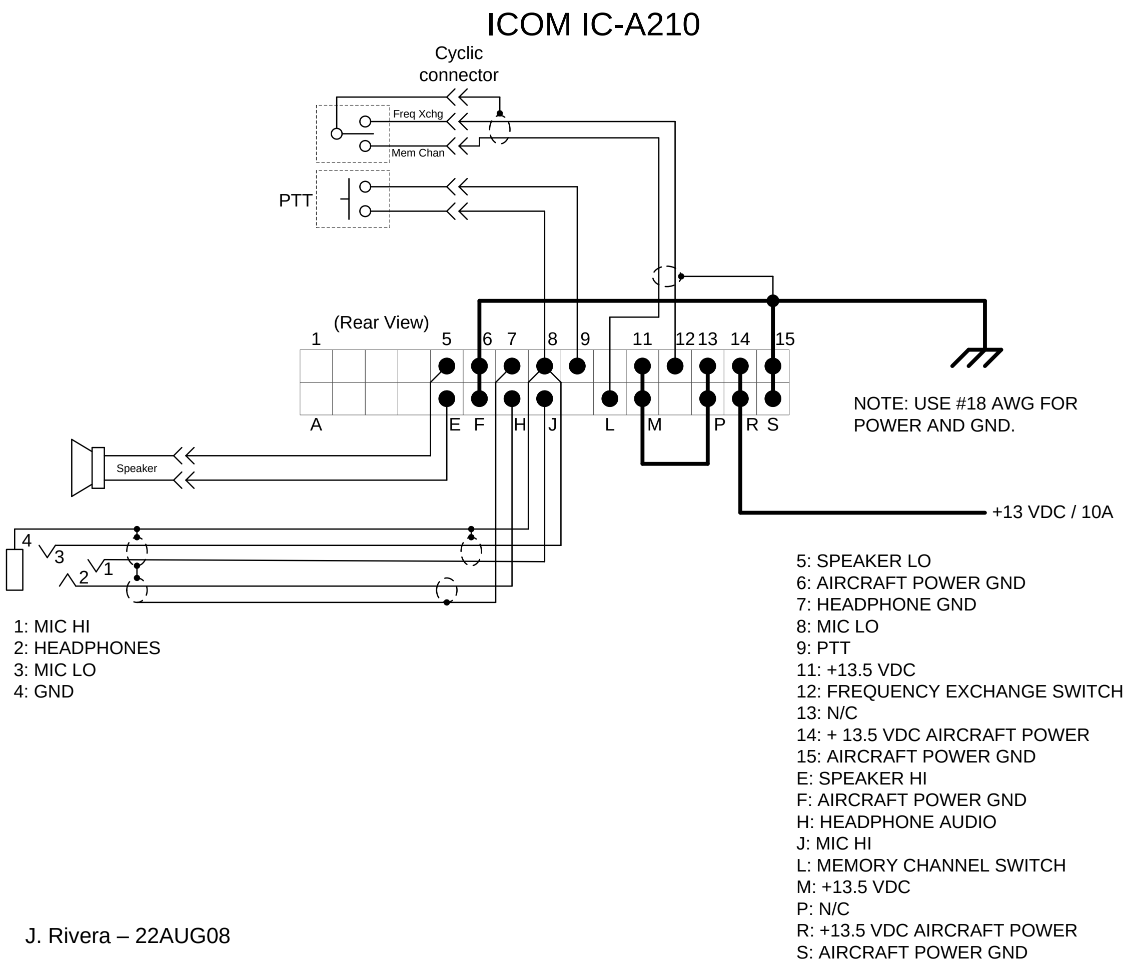
22 August – My Icom A210 VHF transceiver arrived a few days ago. It's taken me several days to design and fabricate the interconnecting cable harness. Here it is installed in the radio shelf with an Adel clamp for strain relief.



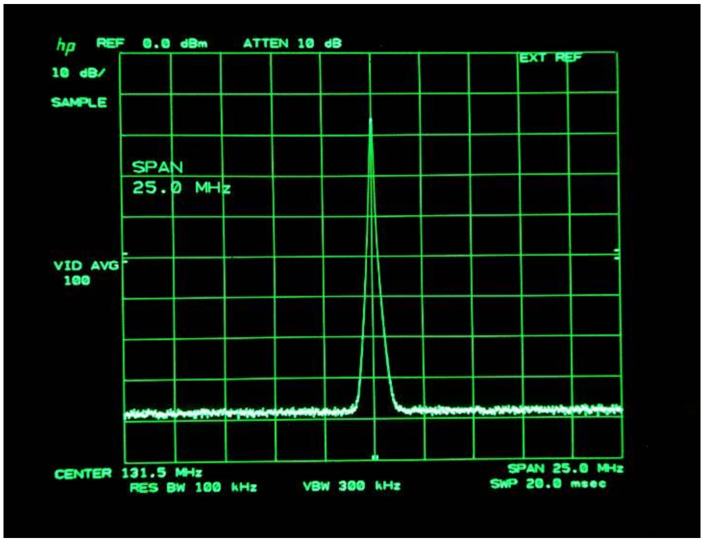
The radio is connected to a Bird 43 wattmeter with a 100-250 MHz, 10-watt element and a dummy load attached.



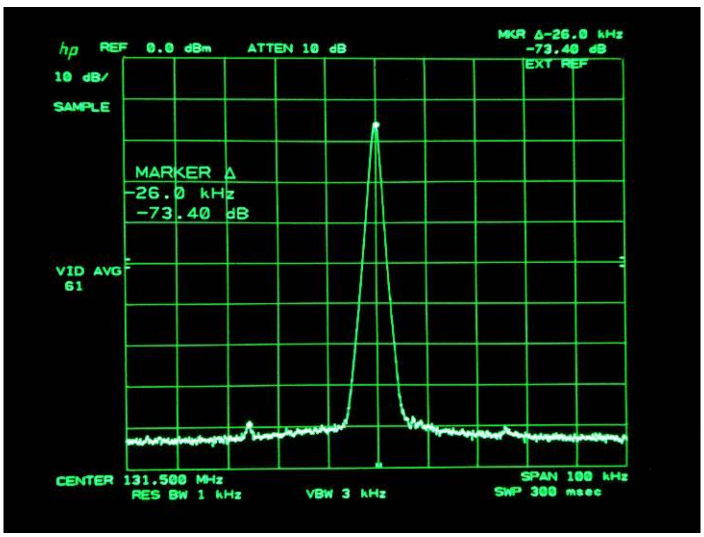
The transceiver is rated at an output of 8 watts but on the bench it's pegging the wattmeter with a 10 watt element installed (bottom scale.)



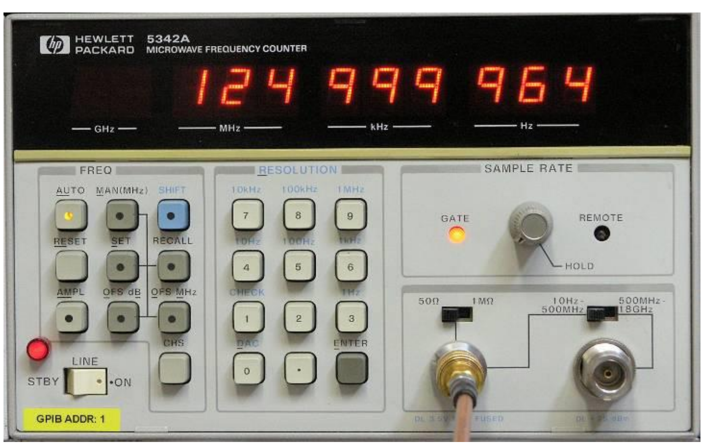
This is the wiring diagram for the interconnect cable.



This is the spectrum of the IC-A210 transmitting a carrier with no modulation. The spec for spurious emissions is -60 dBc (decibels below the carrier.) This transmitter exceeds that spec by more than 10 dB over a 25 MHz span.



There's a small spur at 26 kHz, probably switching power supply ripple. It's down 73.4 dBc.



The IC-A210 is off 36 Hz at 125.000 MHz in this bench test. The spec is ±5 ppm, or 625 Hz.

Bottom line – the radio is performing as expected and exceeding the transmitter specifications for output power and spurious emissions.

23 August --

Now that I can generate RF I wanted to take a look at how the antenna would perform on the Helicycle frame. The antenna bracket for the build-1 kits is too small and will be replaced, but for now I bent the protrusions out of the way, ground off the paint and mounted the antenna using one screw. This will be my 'No Ground Plane' configuration. It's fairly typical of most Helicycle antenna installations (from an RF standpoint only.)

Going to the opposite extreme I mounted the antenna on a convenient piece of aluminum and attached four ground radials using clamps. It makes no difference if the antenna is facing up or down as long as there are no conductive obstructions in the area. The Helicycle frame really has no affect on the antenna and is only serving as a handy stand to rest the antenna on.

Although this is completely impractical it will give me an idea of what I need to do. This will be my 'Large Ground Plane' configuration.

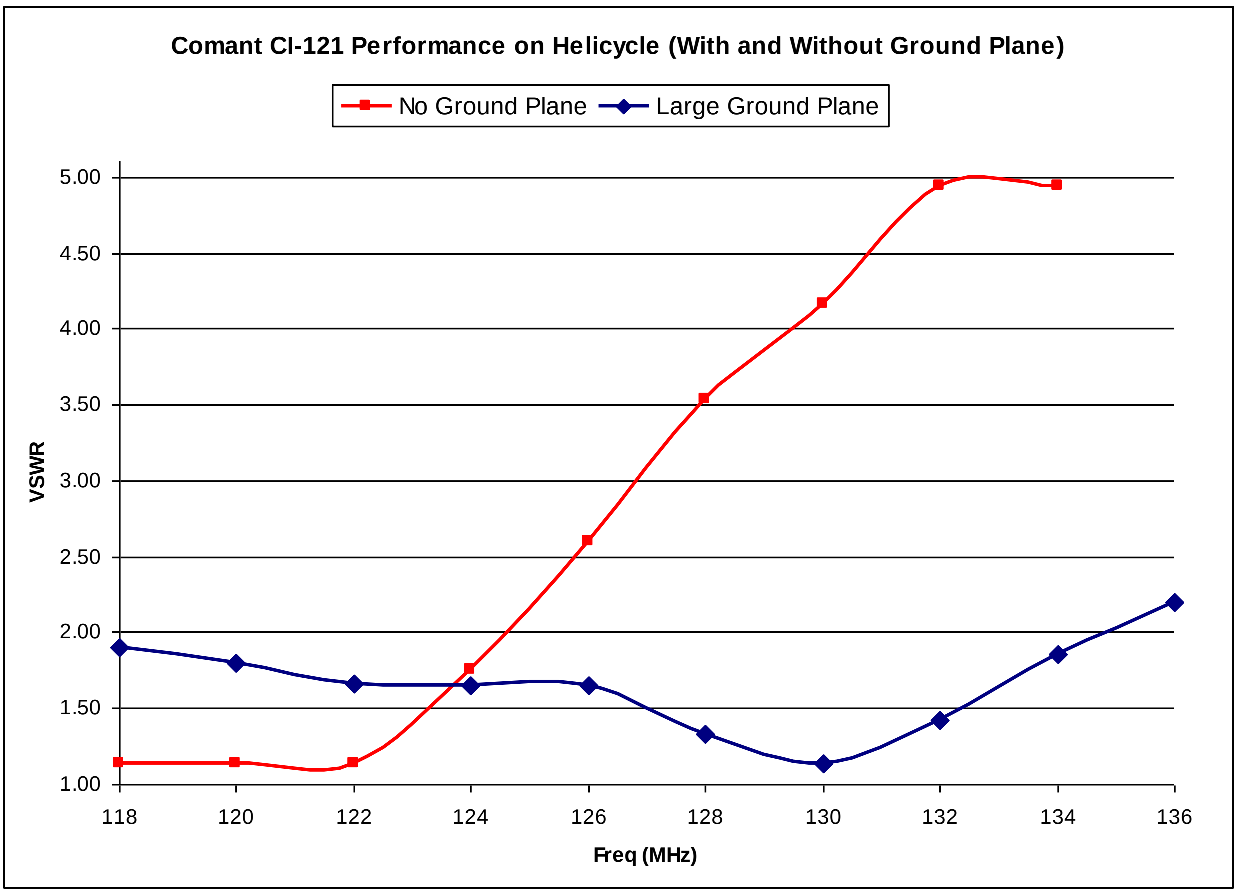
The results on the next page show that a ground plane is definitely required. The difficult challenge will be to design one that will fit within the bounds of the frame and provide the antenna performance required. At this point I'm not convinced that it can be successfully accomplished.

The charts on the next page show my initial test results. The antenna is specified to have a VSWR of 2.5:1 across the aviation band from 118 to 136 MHz. Anything much above that is going to cause problems in the form of reduced communication performance and increased EMI.

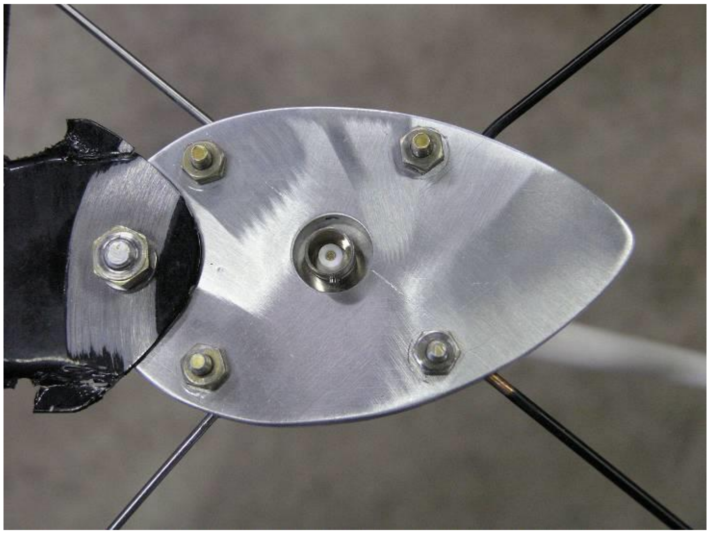
Builder's Log -- Helicycle N750G

NO GROUND PLANE				
Freq (MHz)	**Forward Power (W)**	**Reflected Power (W)**	**Return Loss (dB)**	**VSWR**
118	9.7	0.0	-23.74	1.14
120	9.6	0.0	-23.69	1.14
122	10.0	0.0	-23.87	1.14
124	8.0	0.6	-11.24	1.75
126	6.6	1.3	-7.05	2.60
128	6.4	2.0	-5.05	3.54
130	7.2	2.7	-4.26	4.16
132	10.0	4.4	-3.56	4.94
134	10.0	4.4	-3.56	4.94
136				

LARGE GROUND PLANE				
Freq (MHz)	**Forward Power (W)**	**Reflected Power (W)**	**Return Loss (dB)**	**VSWR**
118	7.2	0.7	-10.12	1.91
120	8.6	0.7	-10.89	1.80
122	9.6	0.6	-12.03	1.67
124	10.0	0.6	-12.21	1.65
126	10.0	0.6	-12.21	1.65
128	10.0	0.2	-16.97	1.33
130	10.0	0.0	-23.87	1.14
132	10.0	0.3	-15.21	1.42
134	10.0	0.9	-10.45	1.86
136	10.0	1.4	-8.54	2.20



It's painfully obvious that the common Helicycle configuration (the red series) used by most builders (no ground plane other than the frame itself) is not producing a functional antenna installation. This could explain why so many builders have had major problems with EMI getting into the engine control as well as their instruments. This will not be an easy fix.



Now that I have some preliminary data it's time to try something more practical. I fabricated this mounting plate from ¼-inch aluminum and drilled 4 holes to accept four radials.

I can now experiment with different lengths to see what affect they have on overall performance.

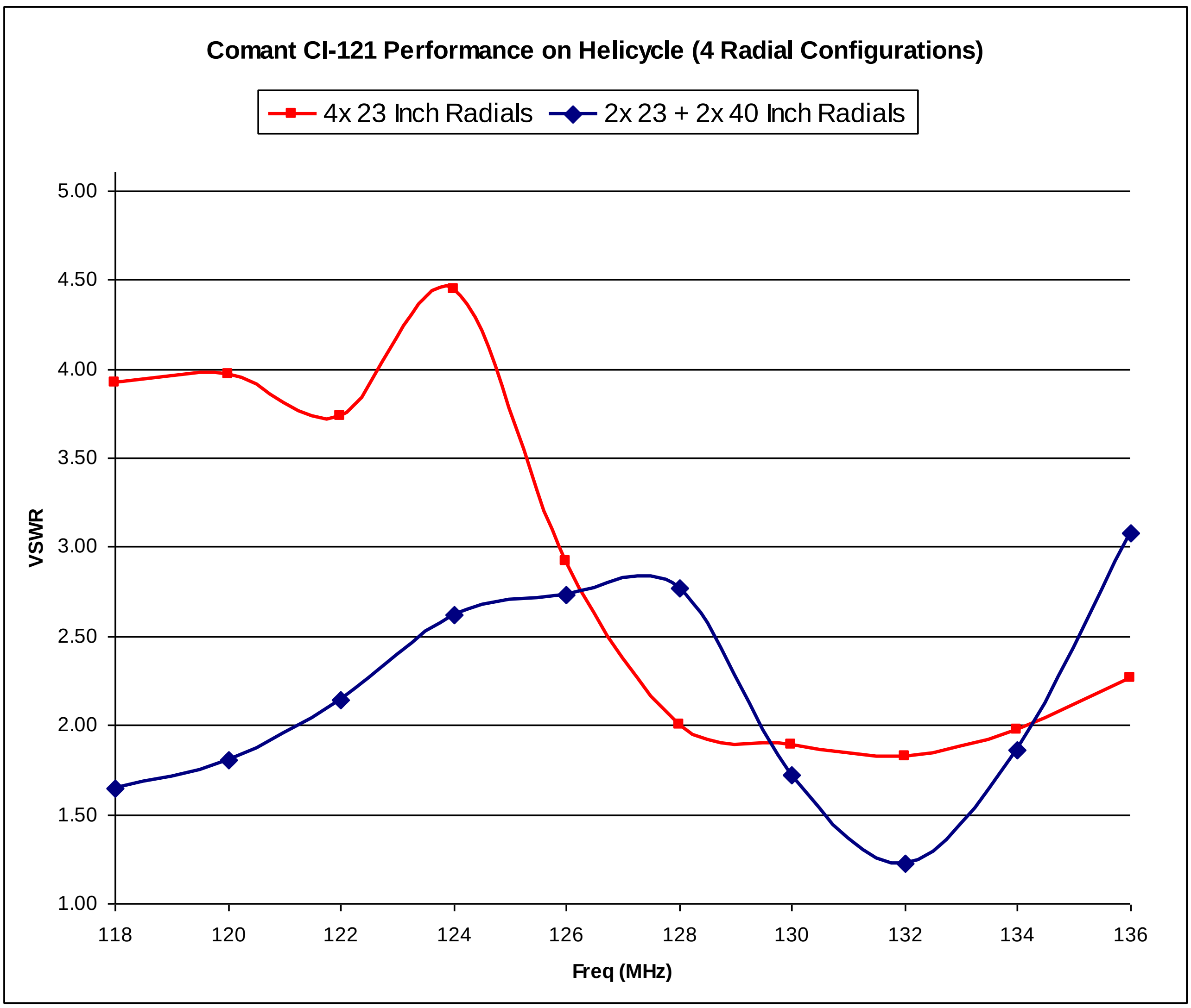
I first tried four 23-inch radials and then replaced the two rear-facing radials with 40-inch lengths. The test results seem to confirm my theory that the rear radials will have more impact on performance than the forward pair since the antenna slopes to the rear.

If my target is to have a VSWR of 2.5:1 or better across the entire aviation band then the mix of two ¼-wave and two 40-inch radials seems to be heading in the right direction. Of course I am not considering the practicality or safety of actually flying radials at this point. They could present a hazard to unsuspecting children who could be poked in the eye, and if they came loose in flight they could end up in my tail rotor.

The first step is to see if I can make this antenna work and then I'll worry about practicalities. The initial test results follow.

4x 23" RADIAL MOUNTED ON FRAME				
Freq (MHz)	Forward Power (W)	Reflected Power (W)	Return Loss (dB)	VSWR
118	5.4	1.9	-4.53	3.92
120	7.0	2.5	-4.47	3.97
122	9.0	3.0	-4.77	3.73
124	10.0	4.0	-3.98	4.44
126	10.0	2.4	-6.20	2.92
128	9.0	1.0	-9.54	2.00
130	8.4	0.8	-10.21	1.89
132	8.2	0.7	-10.68	1.83
134	8.4	0.9	-9.70	1.97
136	10.0	1.5	-8.24	2.26

2x 23" + 2x 40" RADIAL MOUNTED ON FRAME				
Freq (MHz)	Forward Power (W)	Reflected Power (W)	Return Loss (dB)	VSWR
118	10.0	0.6	-12.21	1.65
120	7.3	0.6	-10.84	1.80
122	6.8	0.9	-8.78	2.14
124	7.0	1.4	-6.99	2.62
126	8.8	1.9	-6.66	2.74
128	10.0	2.2	-6.57	2.77
130	10.0	0.7	-11.54	1.72
132	10.0	0.1	-19.96	1.22
134	10.0	0.9	-10.45	1.86
136	10.0	2.6	-5.85	3.08



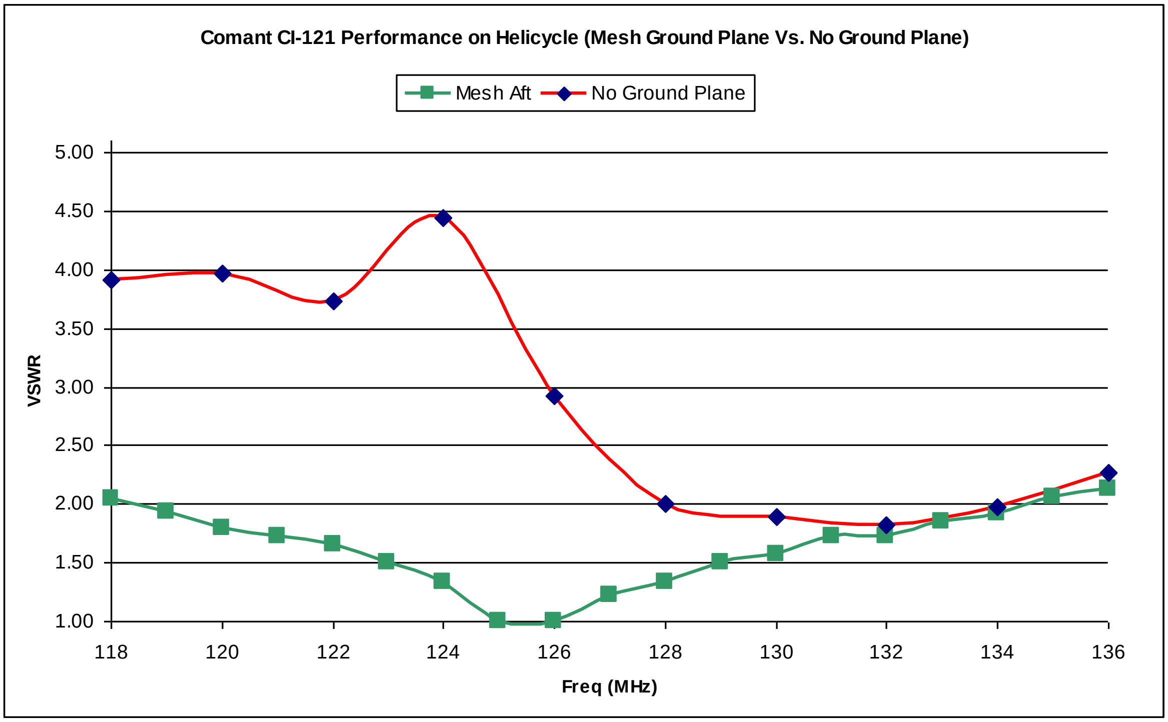
Clearly a bunch of radials are not going to work for a number of reasons. But mesh contained inside the structure is an option. It won't create too much aerodynamic drag from the main rotor downwash and it's easy to implement. At VHF frequencies the mesh could have large spacing between elements – say, several inches. After all, the four radials I was playing with look like a crude mesh to the antenna. Here's my first mesh implementation:

I picked this particular mesh because it was available at home depot. I think I'd opt for something that resembled a barbecue grill, have it welded in this area, and then powder coated with the frame when the time comes. It's well connected to the antenna mount by the nuts and bolts and just tie-wrapped to the frame over the paint.

This looks like it might be a slightly more practical solution, but how does it actually function? Let's run a test series and see…

MESH GROUND PLANE AFT OF ANTENNA				
Freq (MHz)	**Forward Power (W)**	**Reflected Power (W)**	**Return Loss (dB)**	**VSWR**
118	7.6	0.9	-9.26	2.05
119	8.8	0.9	-9.90	1.94
120	10.0	0.8	-10.96	1.79
121	10.0	0.7	-11.54	1.72
122	10.0	0.6	-12.21	1.65
123	10.0	0.4	-13.97	1.50
124	10.0	0.2	-16.97	1.33
125	10.0	0.0	-40.00	1.00
126	10.0	0.0	-40.00	1.00
127	9.7	0.1	-19.82	1.23
128	9.5	0.2	-16.75	1.34
129	10.0	0.4	-13.97	1.50
130	10.0	0.5	-13.00	1.58
131	10.0	0.7	-11.54	1.72
132	10.0	0.7	-11.54	1.72
133	10.0	0.9	-10.45	1.86
134	10.0	1.0	-10.00	1.92
135	10.0	1.2	-9.20	2.06
136	10.0	1.3	-8.86	2.13

This time I took data every MHz…



The red data is the antenna without any ground plane – just mounted on the plate. The green data is the antenna mounted under the mesh. Remember, the manufacturer's specification called out a maximum VSWR of 2.5:1 across the aviation band. Here the actual maximum is 2.13:1 right at the band edge.

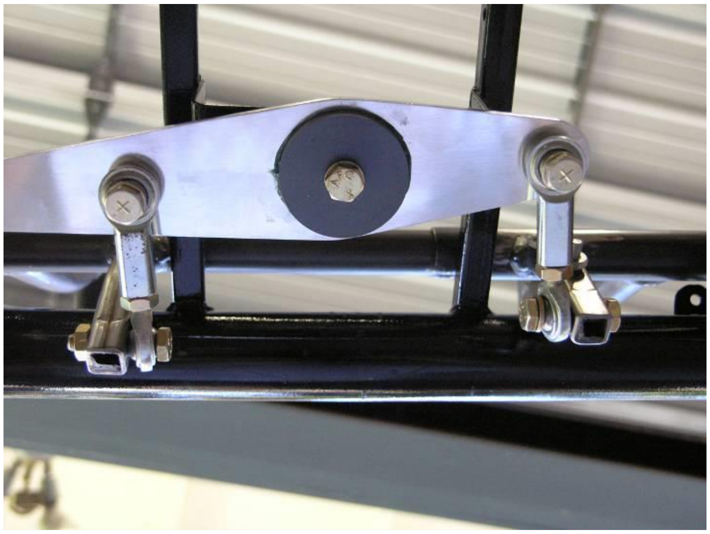
Another indication that the antenna is functioning properly is that is has its best performance right in the middle of the band and tapers off gracefully on either side. This antenna is a resonant device and it's clearly tuned to the middle of the aviation band.

I don't think bonding the ground plane to the frame will have any affect one way or the other. I am concerned with galvanic corrosion where the aluminum antenna base meets the steel frame. It's critical that the antenna base be in intimate contact with the ground plane.

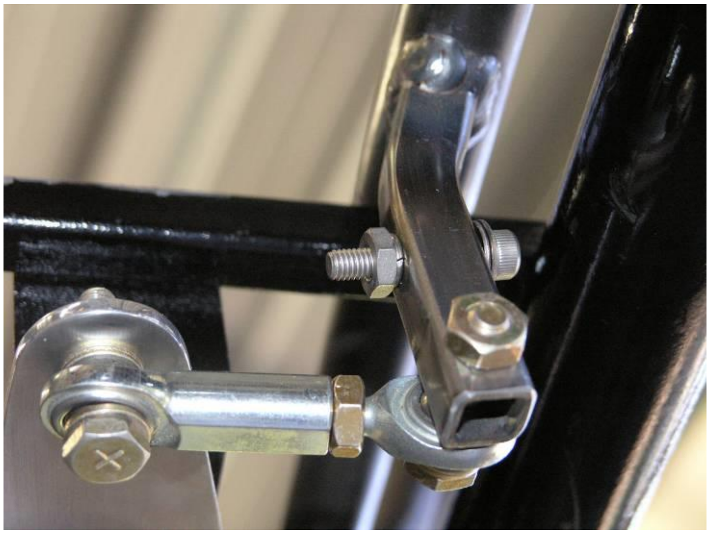
When I find a better material for the ground plane I'll do more testing.

August 30 –

This evening I began installing the directional control pedals and linkage for a fit check. The pedal tubes must be ground to size to fit within the two support brackets. The left pedal tube rides inside the right tube and must be slightly longer to prevent the right tube from binding against the mounting hardware.

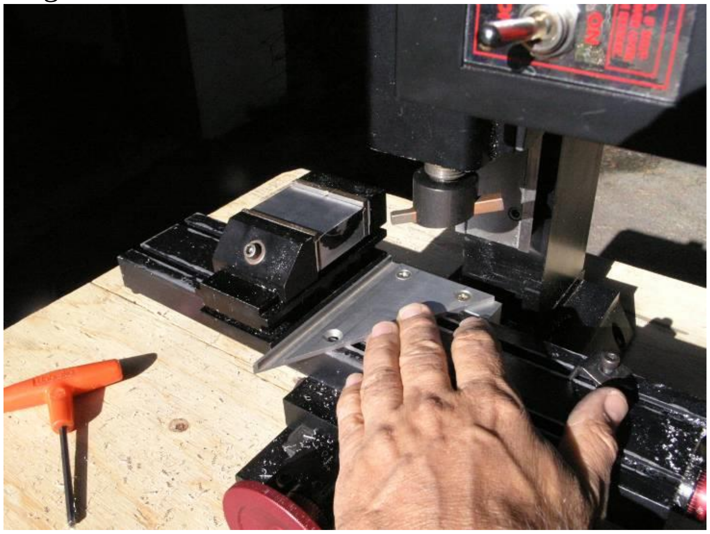


Here's the view from below.



A hole is drilled in the square lever arm of the right pedal and a bolt and washer stack is installed to act as a stop. Two washers produced the correct amount of travel from stop to stop.
I'm using standard nuts instead of locking hardware at this point since parts are constantly being removed.

August 31

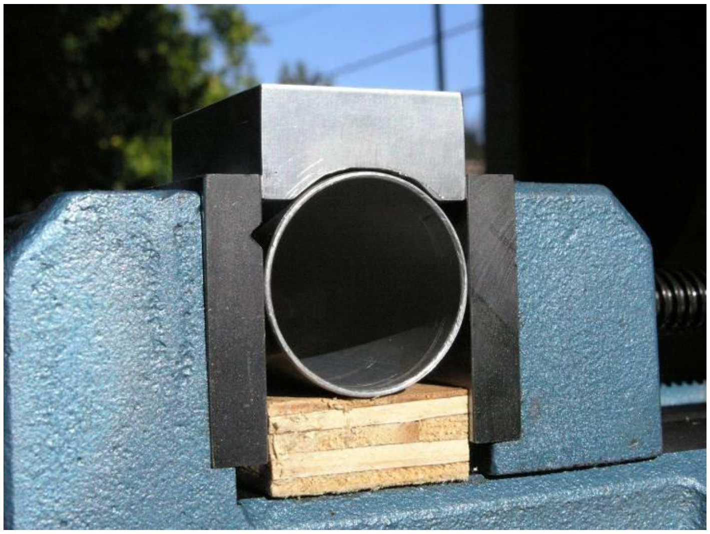


I'm replacing all of the tail rotor drive shaft tubes along with the coupling spiders and the tail rotor coupling to the drive shaft due to very poor workmanship by previous owners.

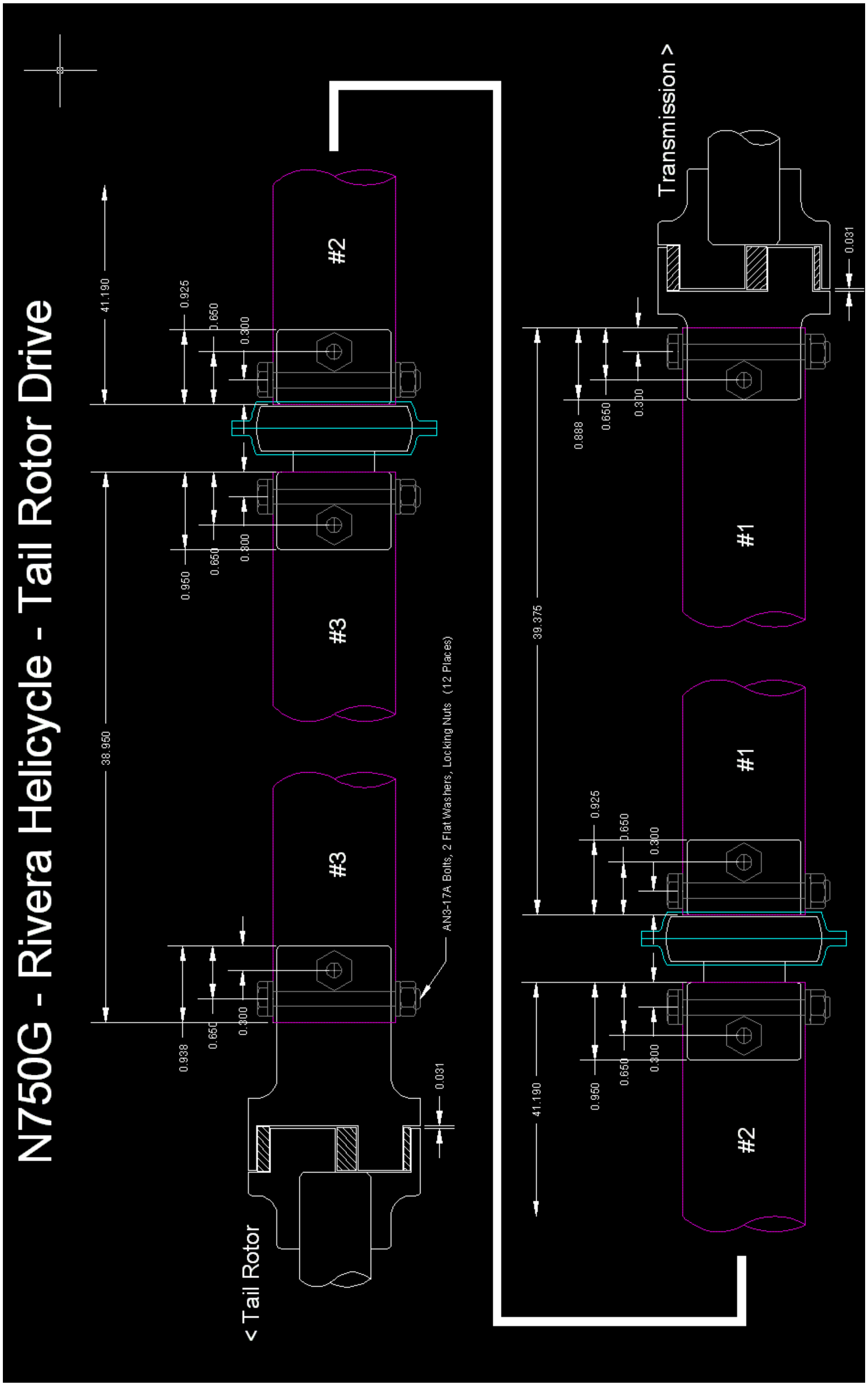
Two 3/16" AN bolts attach the bearings and couplings at each end of the three drive shaft tubes. The location and placement of these bolts is critical. To help with alignment I made a drill jig using my Sherline mill.

The jig will sit on top of the tube and guide my drill into the two precise locations I need.

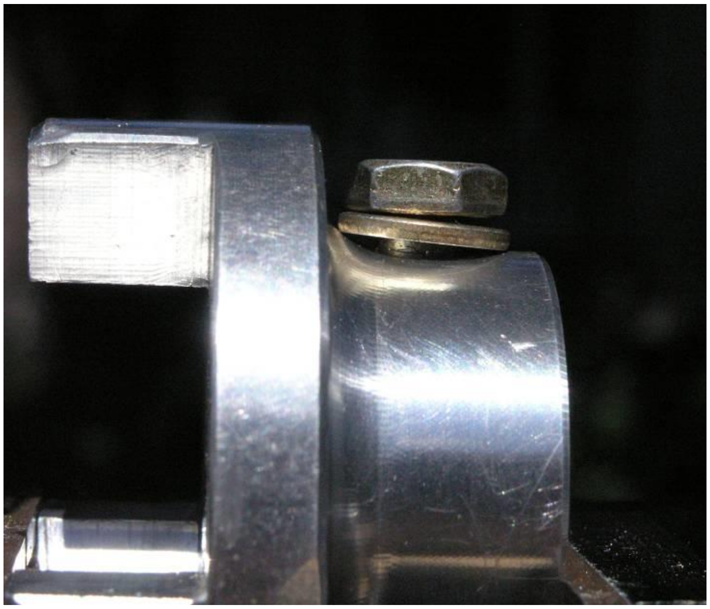
NOTE: Later on I purchased a larger milling machine and never used this jig and the drill press.



I'll make two guide holes in the jig to guide the drill directly through the center of the tube and the bearing or coupling assembly that fits inside. The two holes are 90 degrees offset and I'll make another attachment for my digital protractor so I can rotate the tube exactly 90 degrees. The plywood in the bottom will allow the drill to penetrate the bottom of the tube without damage to my vise.


N750G - Rivera Helicycle - Tail Rotor Drive
Transmission >
< Tail Rotor
#1
#1
#2
#2
#3
#3
AN3-17A Bolts, 2 Flat Washers, Locking Nuts (12 Places)
41.190
38.950
39.375
41.190
0.925
0.650
0.300
0.950
0.650
0.300
0.938
0.650
0.300
0.031
0.888
0.650
0.300
0.031
0.925
0.650
0.300
0.950
0.650
0.300

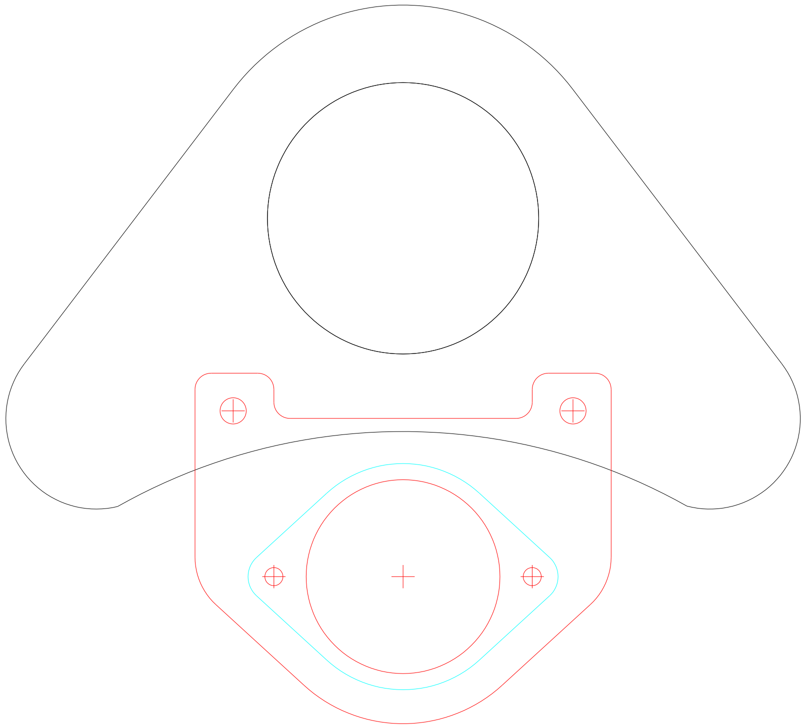
My sketch of the dimensions for the tail rotor drive is on the previous page. I've standardized on two offsets from the end of the tube – 0.300" and 0.650". These provide a 1 radius offset from the end of the tube and between bolts. If all these dimensions check out I will drill the two guide holes in my drilling jig.

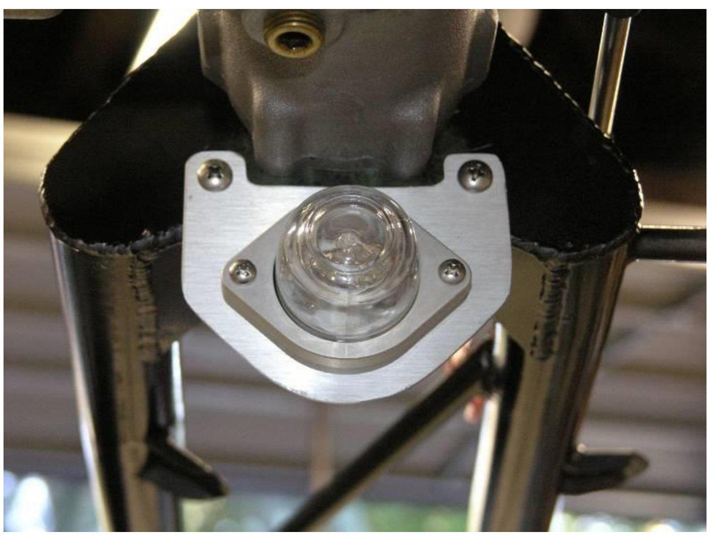


September 1 –
This morning I spent two hours carefully match-drilling this tail rotor coupling's ¼" bolt holes. They had to match the existing gearbox shaft and not have any slop. Slop in the old coupling was caused by ovaling out the hole by a previous builder. The final sizing was done using a reamer and it came out perfectly.

I noticed that the flat washers do not have a flat purchase on either side. This is true for the transmission coupling as well.

I milled flats into both sides of the coupling as seen here. They do not extend across the entire width of the washer because I did not want to remove any more material than necessary. I will repeat this process for the transmission coupling next.

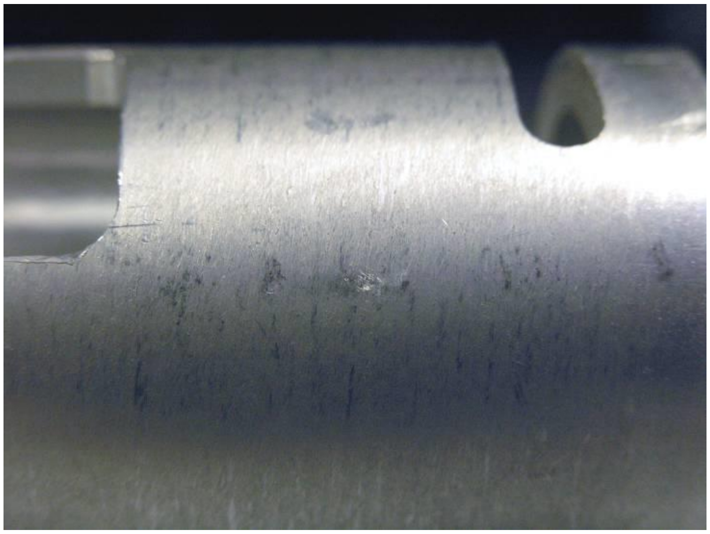




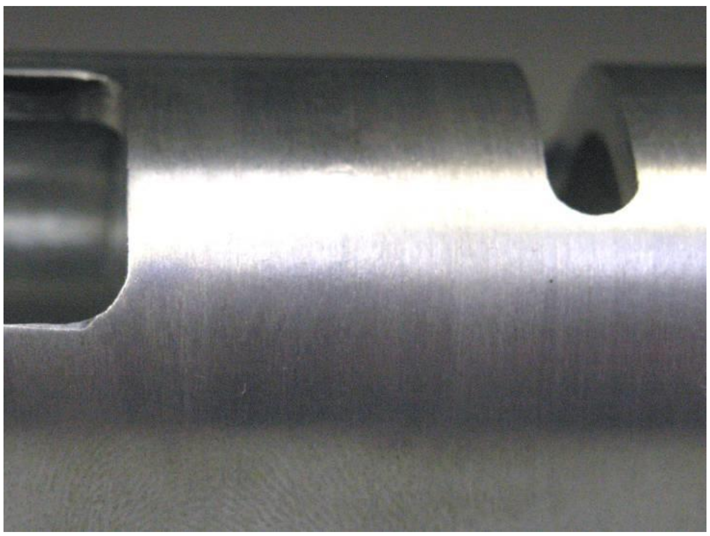
September 2 – I designed and fabricated my tail strobe light bracket last night from .060" aluminum and mounted it this morning.

Rather than using 4130 chromoly steel and welding it into place, I decided to use aluminum and mount it with screws.

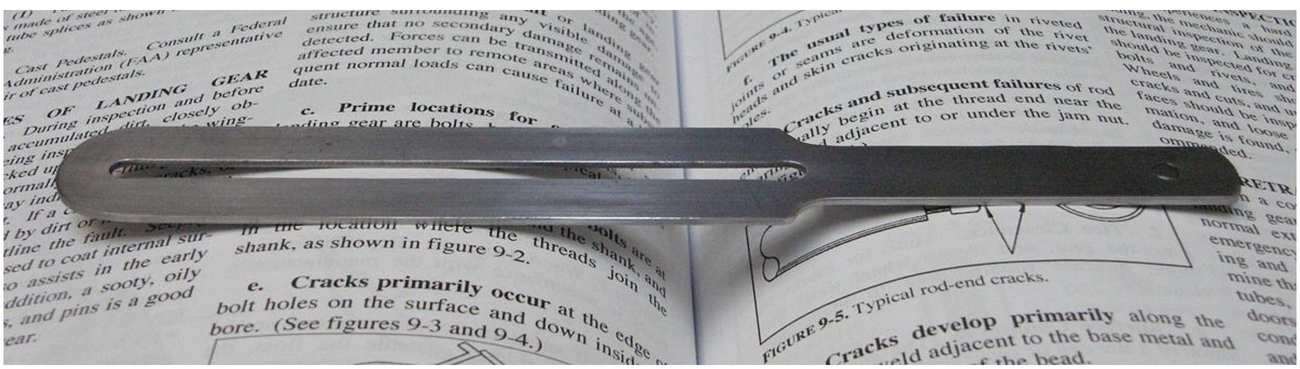
I'll have it powder coated with the frame.



I spent several hours today cleaning up machined parts. This is an example of one fresh out of the bag.



Here's the part after deburring and a light buffing. Later I will Alodine most of the aluminum parts.



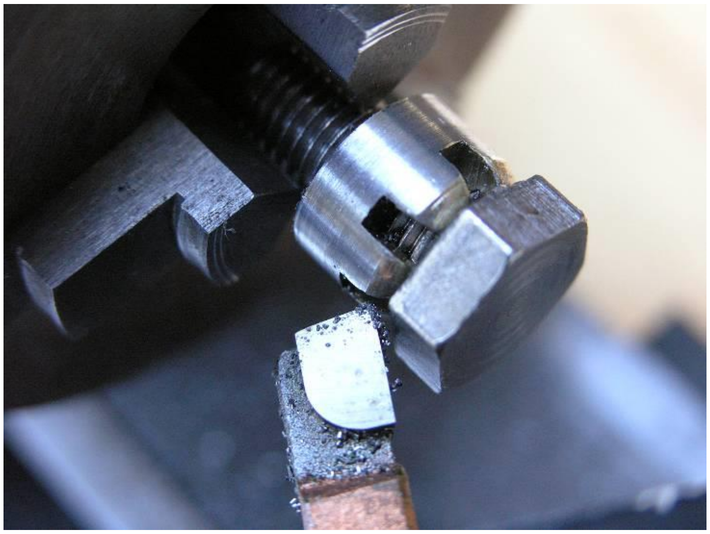
I also milled material off the right hand end of this steel collective friction slider. It took over one hour. I spent the entire day doing Helicopter related work and this is all I managed to accomplish.

September 03 –
Today I planned to start on the mixer assembly. Hap Miller suggested drilling small dimples around the mounting hole of this mixer end piece to create spots where grease could be placed.

I drew up a template using AutoCAD and printed it out 1:1.

I used the template to center punch my hole locations…

Here's the finished part with 8 dimples on either side.

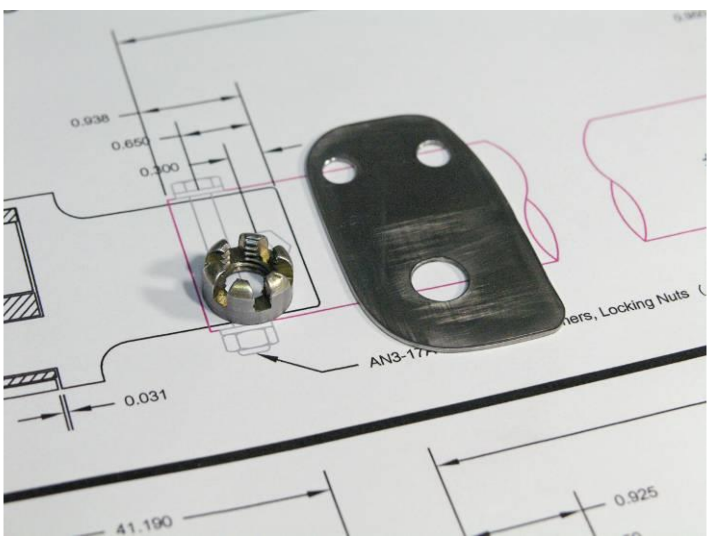


The mixer assembly is a sandwich that is held together by a modified bolt and castle nut. Both the bolt head and the nut must be turned on a lathe to remove the hex heads. They drop into counterbored recesses as will be seen on the next page.

In addition to rounding off the hex head on the castle nut, it needs to be milled down to reduce its height.

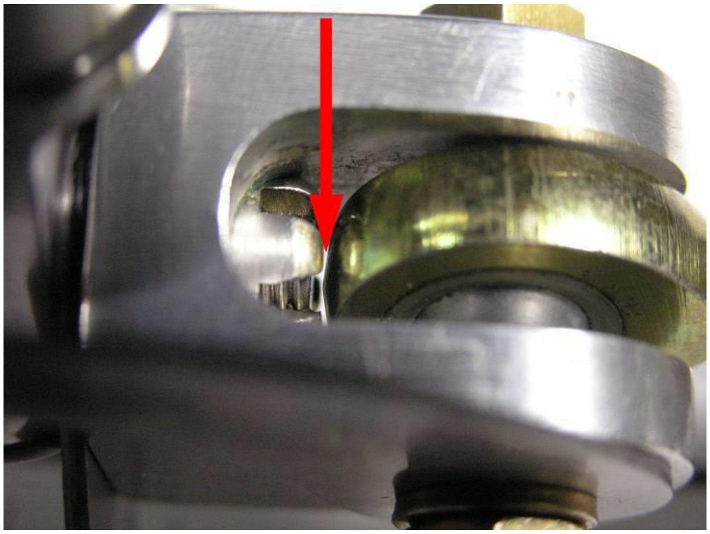
After finishing the work shown above and assembling the mixing assembly I found that the piece shown on the previous page seemed to slightly bind at one end of its travel, as it was rotated. I discovered that the pieces that fit inside of the assembly (the piece in the previous page plus one other) were 0.31" thinner than the inside dimension of the steel welded piece that forms the heart of the assembly.

To get around this 0.031" discrepancy I fabricated a 0.031" thick stainless steel shim. It doesn't look like much but it required a trip across town to the metal supplier and considerable effort to complete.

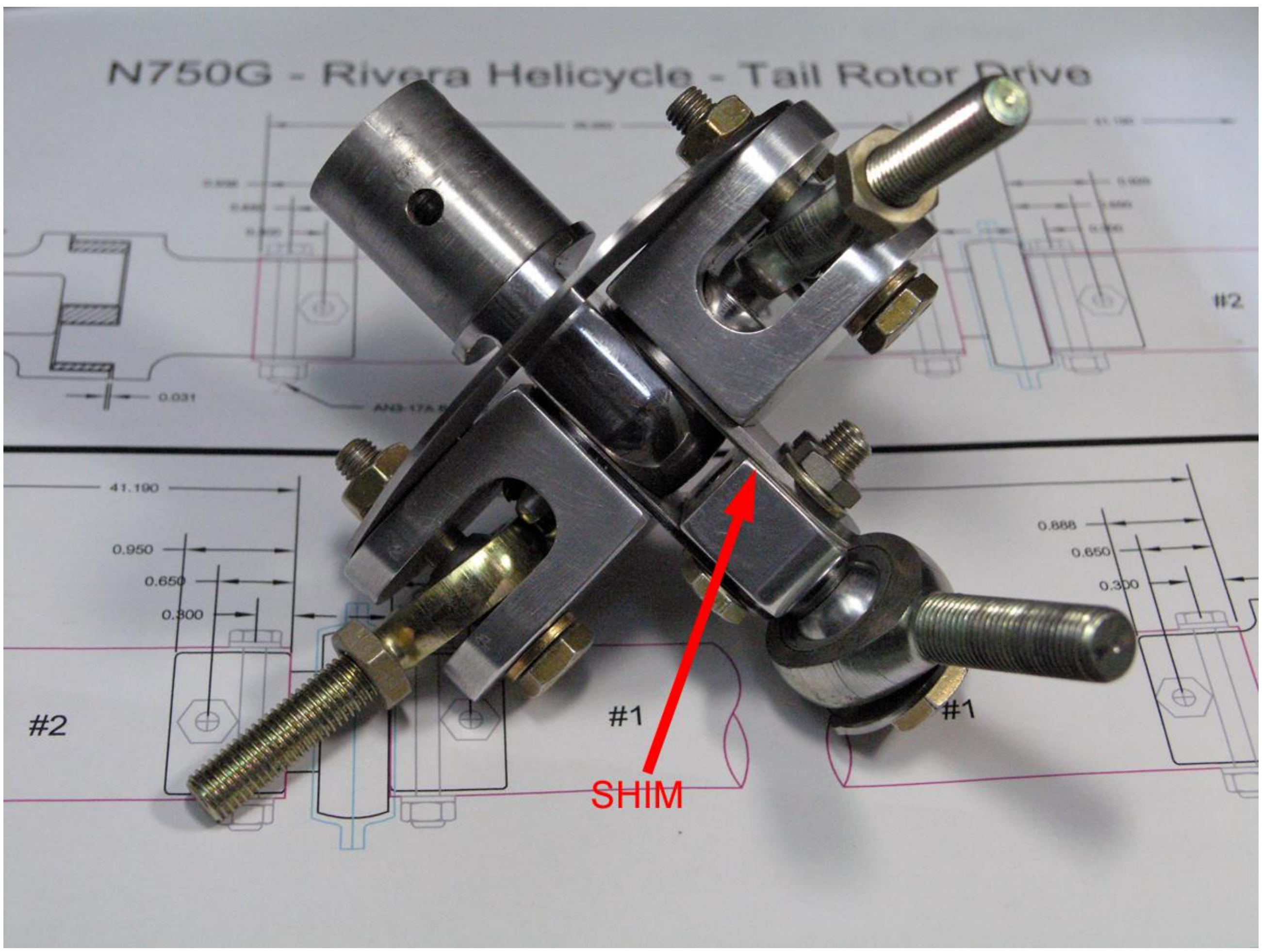


Here's is the finished shim and the modified castle nut. The shim completely fixed the binding problem and I am now ready for the last step.

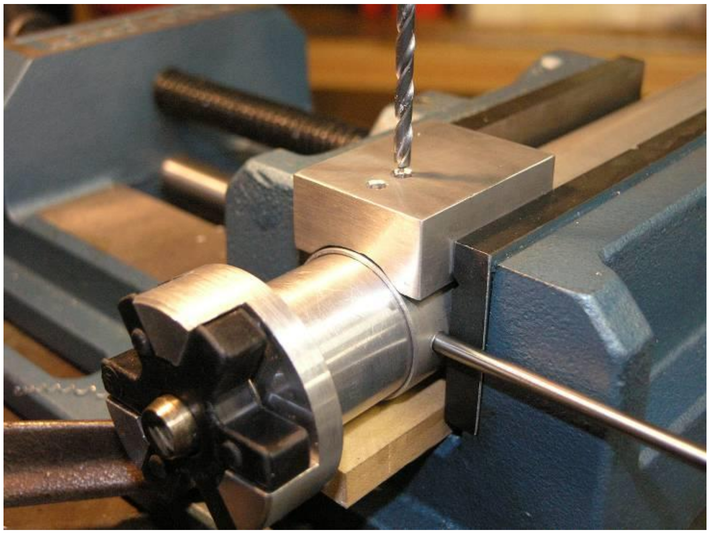
The assembly needs to be adjusted for the proper amount of friction and then I have to drill a cotter pin hole in the end of the bolt to hold the castle nut in place.



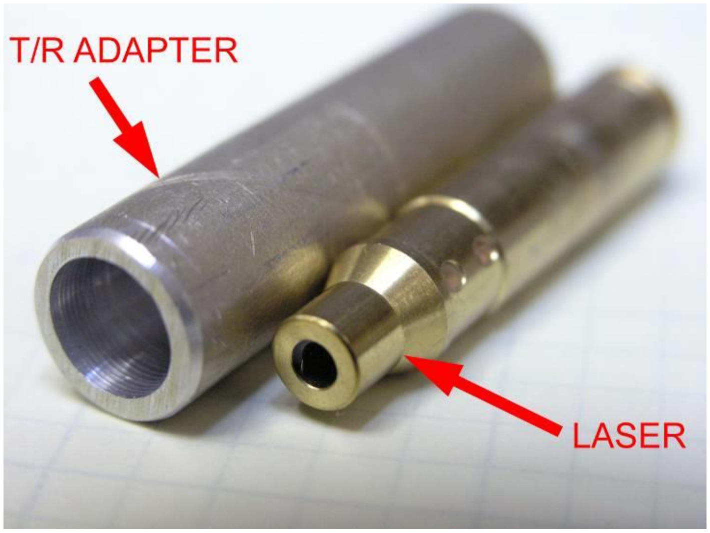
Here you can see the very tight clearance between the rod end and the top of the shortened castle nut (red arrow.) The last step will be to drill the cotter pin hole in the end of the bolt. NOTE: Accepted practice is to always have a minimum of two threads protruding from the end of a nut but in this case there simply is no room. It's a trade off between the amount of material I take off of the nut and the depth of the counterbore.



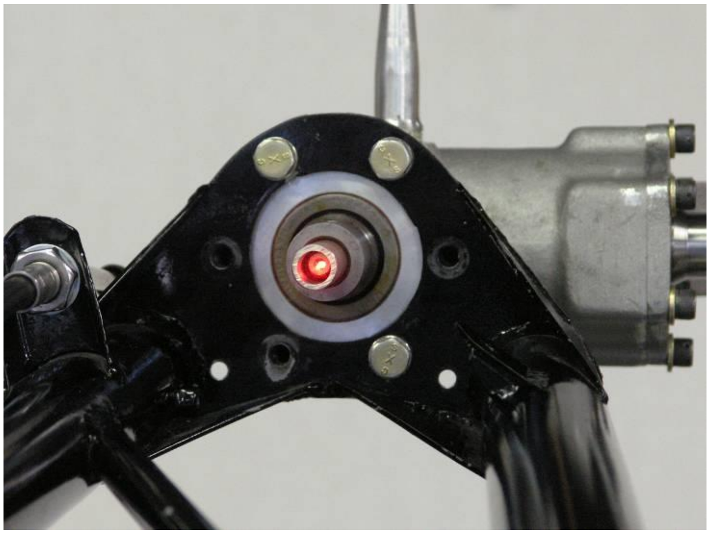
Here's the almost completed mixer assembly. You can just see the 0.031" shim. All that remains is to Alodine the aluminum parts, drill the cotter pin hole in the bolt and install the pin and replace all the regular nuts with locking hardware.



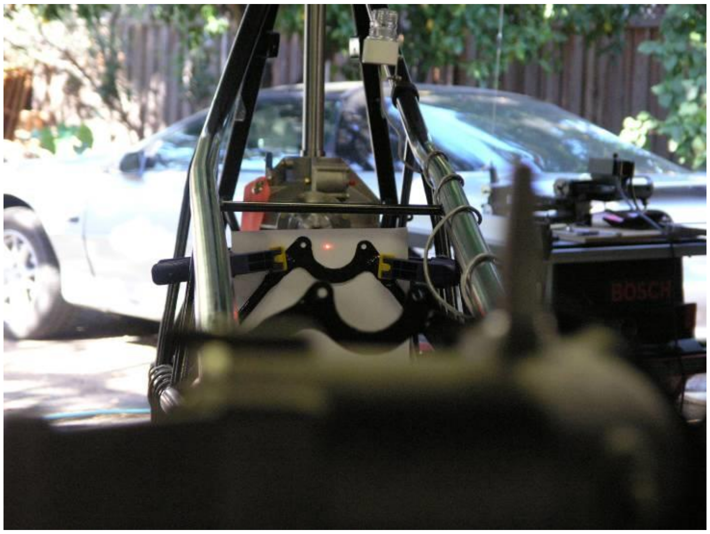
September 4 –
Today I started working on the tail rotor drive shaft tubes. I used my drilling jig for the first time. The drilling process actually has about 15 steps so I won't write it up here. I use two drills and a reamer to size the hole, and then I relocate the tube and the jig for the second hole. I use the reamer shank to rotate the tube exactly 90 degrees as you see in the picture. I am now ready to start the second hole.



Before the rear tube can be sized the tail rotor gearbox needs to be shimmed to align the shaft down the long axis of the ship. I made this adapter (shown on the left) that takes a laser that's used to site in gun sites. The laser goes inside the adapter and the adapter just fits inside the tail rotor gearbox driveshaft. I can then use the laser to dial in the necessary shims.

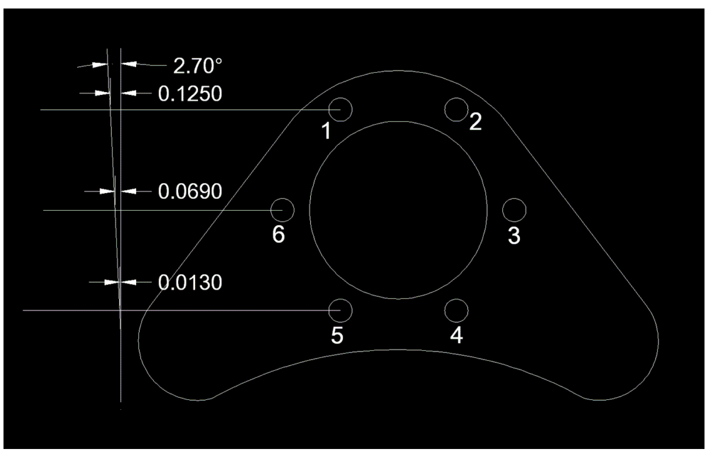


Here you can see the laser inserted into the tail rotor drive shaft. By fiddling with the placement I was able to true up the alignment so the dot didn't move on the transmission as the tail rotor shaft was turned. In this picture I am using three bolts in a tripod fashion and placing washer stacks between the gearbox and the plate to true it up.



Here you can see the laser hitting a paper target in front of the forward bearing mount. At first the dot was about 3 inches too low and off to the left.

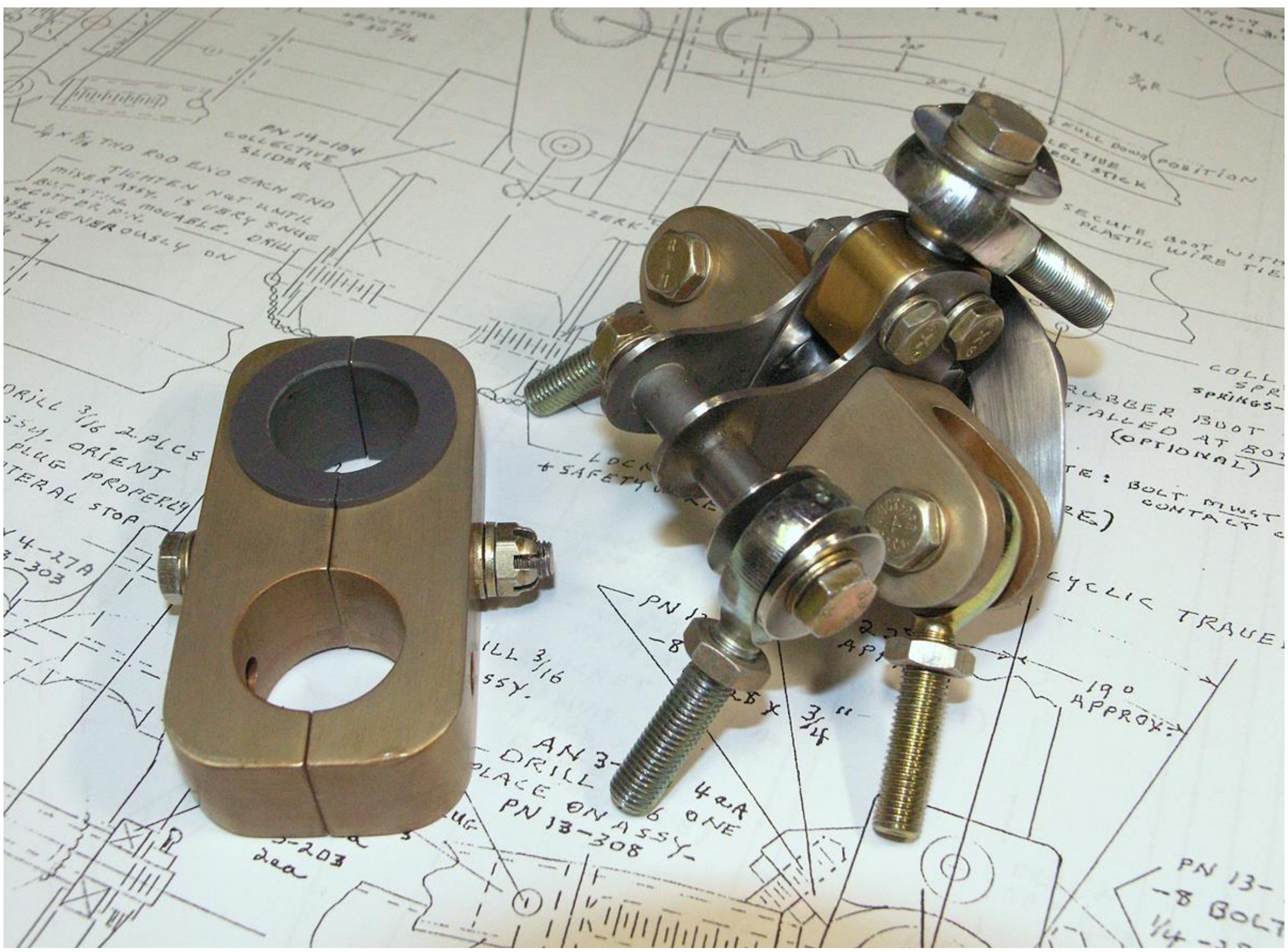
I was eventually able to get the dot to go through the hole in the transmission drive shaft. I then took the measurements that follow.



BOLT #	Measured Gap
1	0.125"
2	0.097"
3	0.040"
4	0.0"
5	0.013"
6	0.070"

I measured the wedge-shaped gap behind each bolt using automotive feeler gauges. It's very subjective since I'm measuring a wedge with a flat gauge, but I tried to get a snug fit with the gauge centered under each bolt hole. When I run the numbers for the right side of the transmission (left side of the drawing since this is a rear view) they match well and show that the plate is tilted 2.7 degrees from true. Adding shims to align the gearbox impacts the length of the rear drive tube. I failed to take this into account so my rear tube is slightly short by about a tenth of an inch. I'll deal with that tomorrow.

September 5 –
I decided to Alodine a few test parts. Alodine is a trade name belonging to Henkel Technologies. Here's what they say – "Alodine 1201 is a chromic acid based conversion coating for aluminum and its alloys… The coating formed will be gold to tan in color and become part of the aluminum surface. This product is approved to MIL-DTL-81706A and is listed on the QPL…" I've worked with Alodined parts for many years and it's very widely accepted in the electronics and aerospace world.

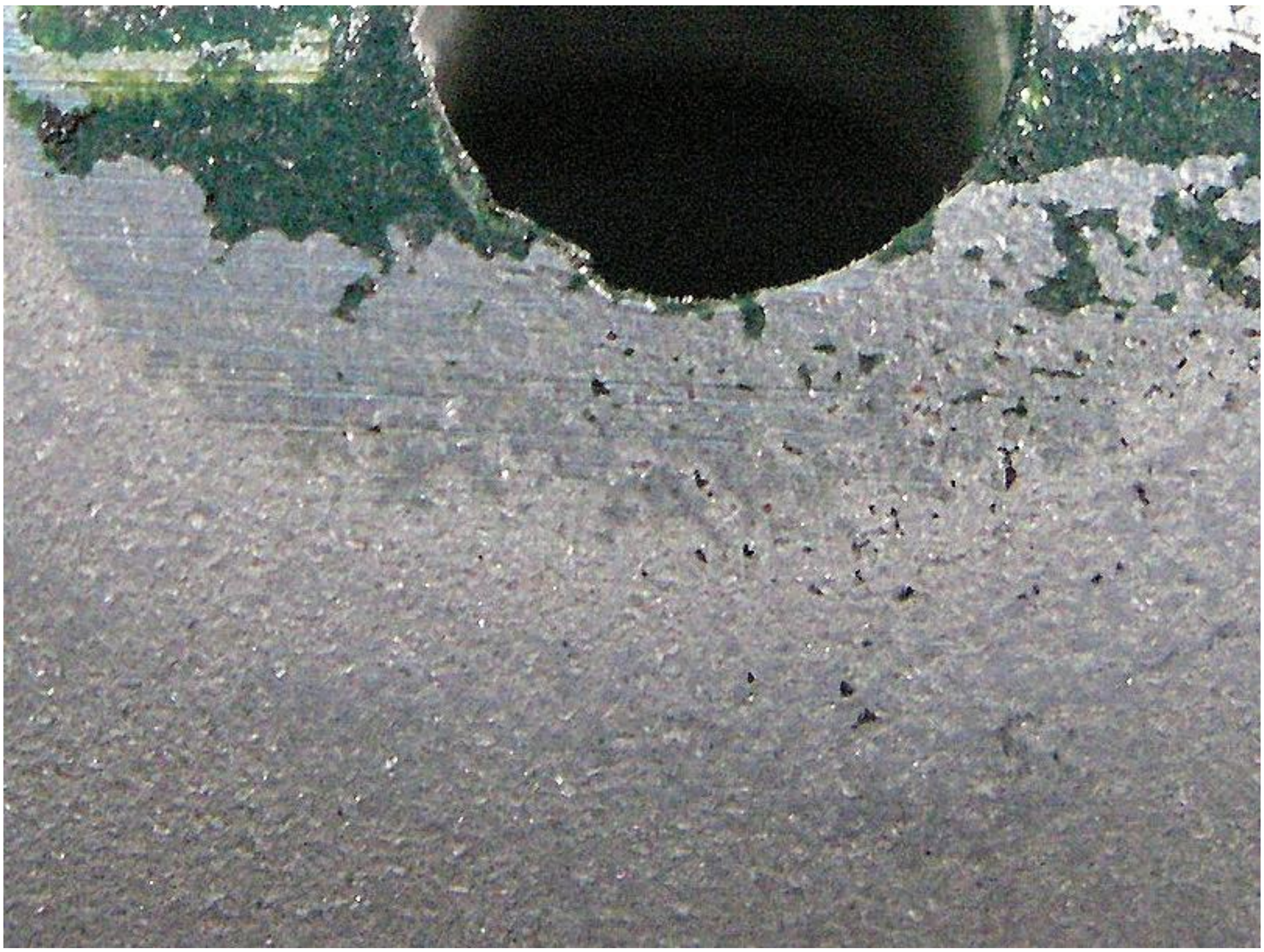


Here's a few of the finished Alodined parts.

September 7 –
Yesterday I installed the collective and cyclic controls and the mixer and push-pull tubes. The tubes had been previously drilled and their end plugs installed. They all had a dull appearance – even the hardware.

The surface is completely pitted. In the picture below it’s obvious that one of the previous builders decided to blast everything with an abrasive. Why, to remove the green paint? He didn’t bother to remove the hardware and just blasted over it.

These tubes are stressed and are critical to flight. All of these pits must be blended out to prevent stress risers that could develop into cracks. I can’t afford to have one fail. If I can’t blend these pits out then I’ll have to scrap all of the push-pull tubes and order new parts.



I’ll have to think about how I want to proceed with these tubes. There is no room for error. I’ll come back to it later.

This afternoon I started mounting the seat pan. The square rails that mount the instrument panel are not centered in the frame and it caused me a great deal of grief as I tried to grind off enough fiberglass to get that seat pan to fit. I finally managed to jam it in but I'm not happy about the way it came out.

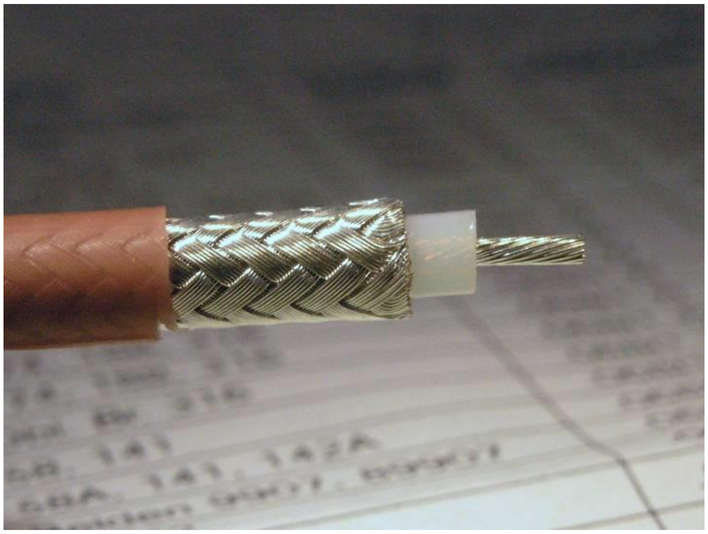
The hardest part of the project was drilling one blind hole near the left hip area of the seat.

I finally came up with a vector approach – a known distance and angle from the screw to the left. I used a scrap of aluminum to locate the distance between the two screws by drilled two tight clearance holes. Next I installed two 4-40, 1-inch screws to rest the level on. Here you see the drilling fixture held by the guide bolt on the left and the blind drilling nut plate on the right. The relative angle of my jig was 1.09 degrees.

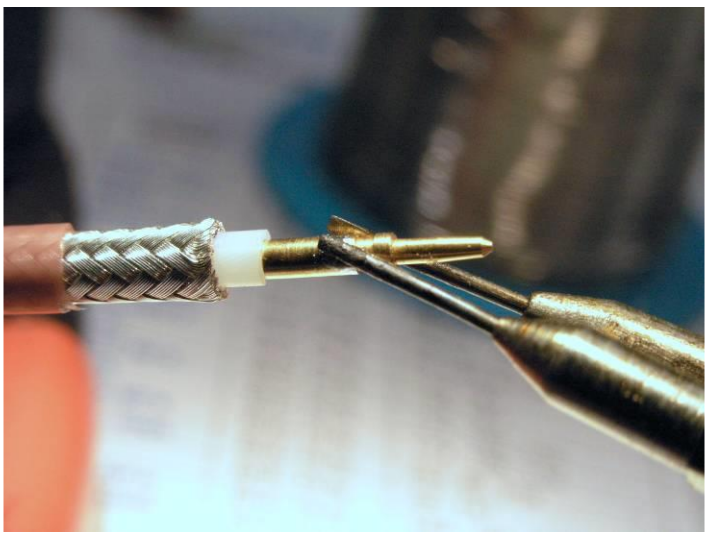
Next I mounted the seat pan to the frame, installed the left side of my drilling fixture and then adjusted the angle to the same 1.09 degrees. I taped the fixture down and then drilled a small pilot hole in the middle of the fixture's guide hole. I could see the end of the drill sticking through the nut plate and it was only off slightly. I elongated the pilot hole to correct for the error and then drilled out the screw clearance hole as seen here.

The seat pan is now installed in the frame. I still have much work to do here:

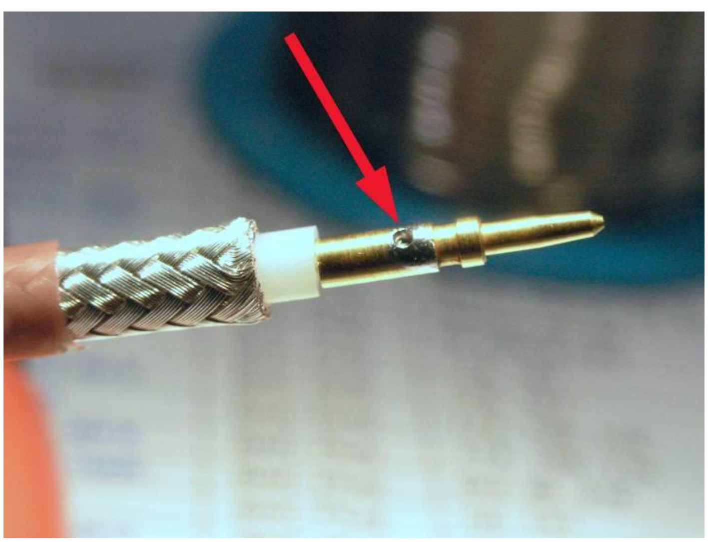
1) Cut two access holes on the front side of the seat, behind each thigh. Install nut plates and cover the holes with two black hard anodized switch panels. Builders who have mounted switches directly to the seat in this area have found that there is no way to access the wiring without splitting the cabin in half and removing it. These panels will make modifications and repairs much simpler.
2) Fabricate a cover plate to hold down the cyclic boot. More nut plates are installed around the cyclic cut out to match the cover plate.
3) My communication headset coil cord will plug into a jack on the right side away from the collective. I'll need to decide where to mount that.
4) Mount brackets for the collective friction assembly and a down stop bolt to limit the lower travel of the collective.
5) Mount the instrument panel over the rectangular hole in the front.
6) Add filler to shim up the uneven gap between the instrument panel mounting rails and the seat pan on both sides.
7) Mount snaps on either side of the seat back to hold the cushion in place.
8) Use Bondo to clean up dings in the surface prior to painting.



September 14 –
I fabricated my VHF comm. Cable using RG-400. It's double-shielded coax with a PTFE dielectric. Both shields and the center conductor are silver-plated copper. This cable is far superior to RG-58.
The first step is to strip the cable to the dimensions required for the particular connector you are using. It's especially important not to disturb the wrap of the inner conductor or it will never fit inside the pin.

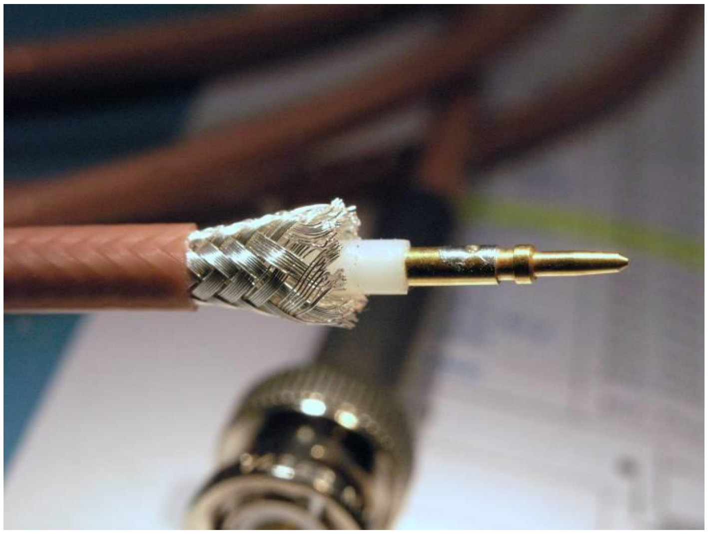


You'll need to very carefully feed very small diameter SN63PB37 rosin core solder into the hole in the side of the pin. It's extremely difficult to do with a soldering iron without getting solder all over the pin. I used special electrical tweezers for the job. They are designed for this task and pass a current through the pin and heat it that way. It makes the job much easier.

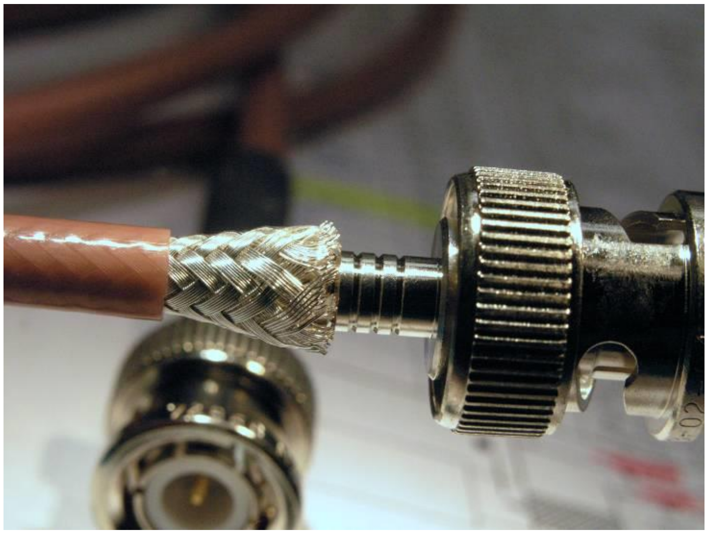


The solder must wick up inside the pin and form a good bond with the inner conductor without flowing out onto the outside of the pin. The red arrow points to the small hole where you feed the solder. It also serves as an inspection hole. The inner conductor must be visible through that hole and completely coated with solder, but the individual strands must be visible.

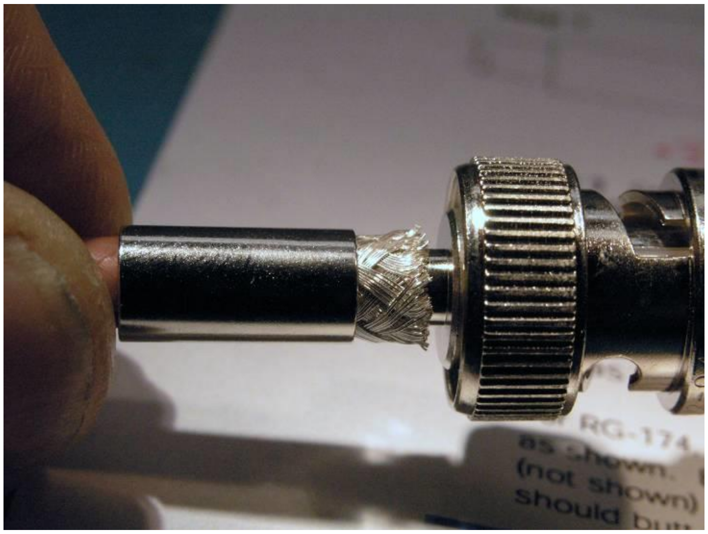
The job of the flux is to remove oxide and contaminates and it prepares the metals to accept the solder. You must always use rosin core flux and never acid, but even so the flux is slightly corrosive and should always be removed using a Q-Tip and isopropyl alcohol.



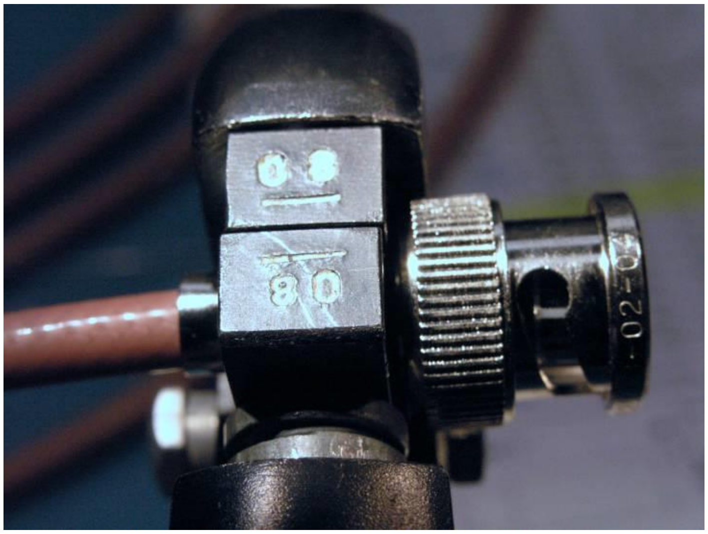
Next the braid is slightly fanned out by wiggling the inner conductor. This will allow the connector body to be installed under the braid without pushing the strands back.



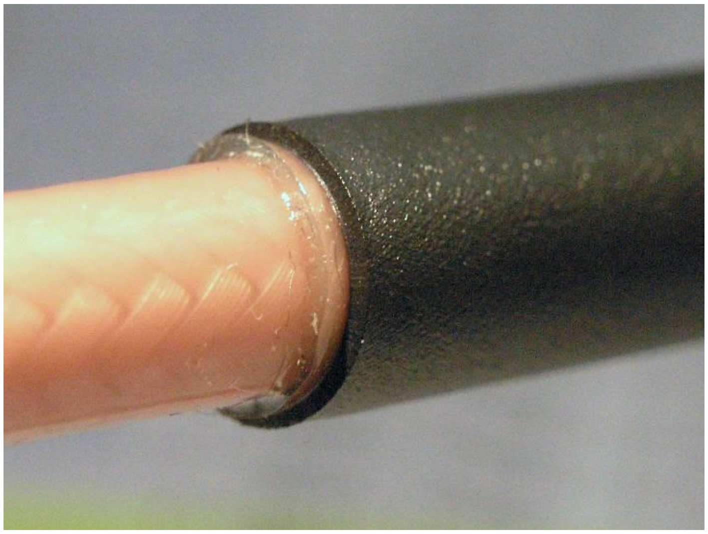
The connector body can now be installed. The particular Amphenol connector I chose snaps into position when that little nub in the middle of the pin's body pops into position inside the connector. This helps prevent the pin from being pressed back into the connector during use.
Once the connector is in position the braid will extend back over the groves in the connector body.



Next the ferrule is slid up over the braid until it is flush with the back of the connector…

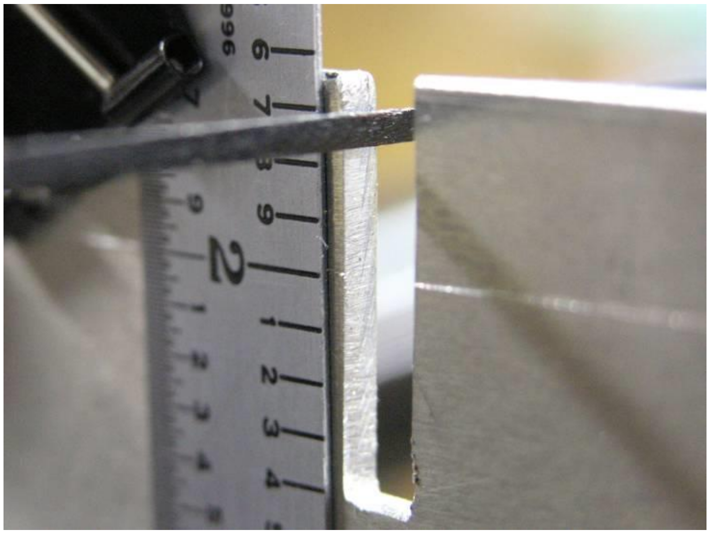


Now the connector is ready to crimp. The exact dimensions of the die are called out in the connector manufacturer's spec sheet and it has to be exactly the right size. I'm using a .810" die. This crimp tool does a hex crimp which is the most common type. Once the connector is crimped it should be firmly attached to the cable and you should not be able to twist it in relation to the cable. This is critical.



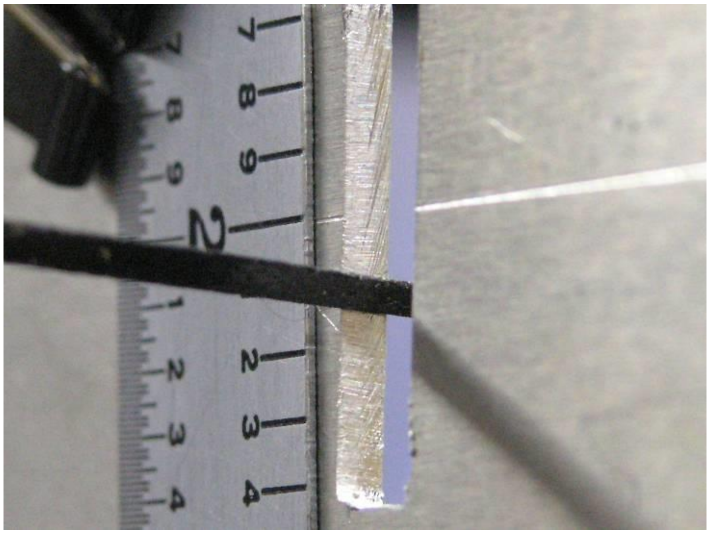
The last step is to install a section of two-layer heat-shrink tubing over the connector ferrule and the cable to create a weather-tight seal. The clear inner layer of the tubing melts and is forced into every crevice when the outer tubing shrinks as you see here.
These 14 foot cables have an insertion loss of 0.6 dB at 125 MHz. This is normal. (13% of the power will be lost in the cable and dissipated as heat.)

October 4, 2008 –
I've put off cutting the new tail rotor drive shaft tubes to length because I didn't want to make a mistake, and I was never convinced that the bearing brackets were in alignment. Today I decided to make a simple jig that would allow me to characterize this misalignment. I stretched lacing cord from the center of the transmission drive shaft to the center of the tail rotor gear box input shaft as seen here.



The jig is held in position with the bearing mounting hardware and has a slot in the center to accept the lacing cord. The scribe lines run from the center of one mounting bolt hole to the other and the string should line up with the lines. The steel rule is set with the two inch line on the scribe line.

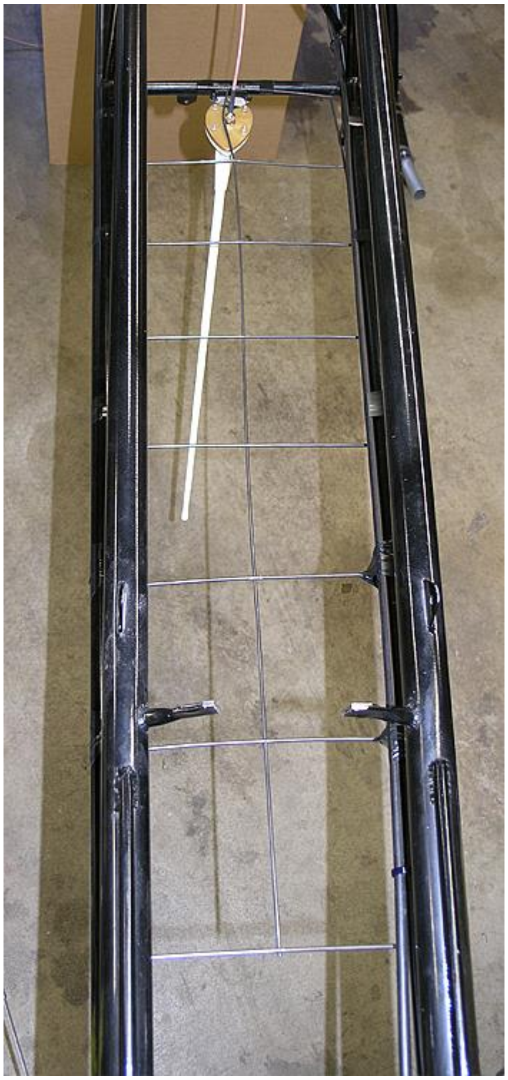
As seen here, the rear bearing would be almost 0.30" too low. This is a huge error.



The forward bearing would be about 0.15" too high. I'll watch the construction video again to see what BJ had to say before I start grinding the bracket mounting holes…

I also labeled the six switches on my cyclic grip. The cyclic is the stick that you grip with your right hand. It controls the orientation of the rotor disc and makes the helicopter go right or left, or forwards or backwards.

Helicopters are aerodynamically unstable which means that they will not remain upright for long is left on their own, and small helicopters don’t have autopilots so you need to fly the helicopter all the time. Since taking your hand off the cyclic in flight is a bad idea it’s great to have control over as many things as possible from the cyclic grip.

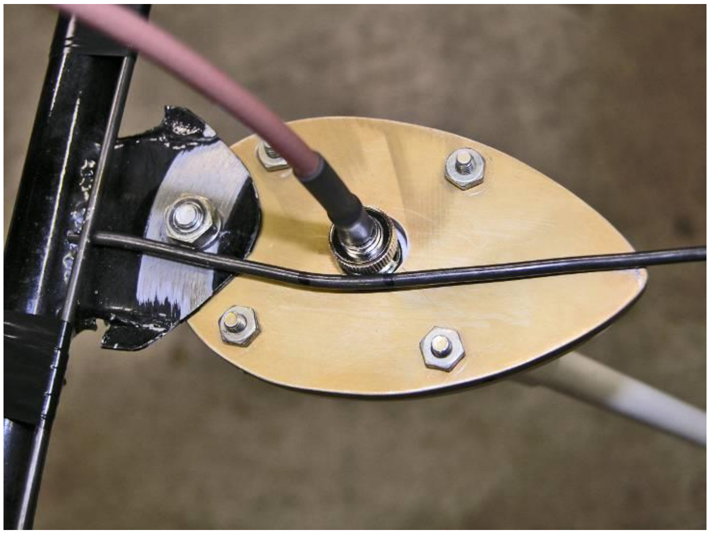


October 12, 2008 –

This is the final ground plane configuration. It's welded steel mesh with 6-inch spacing.

The spacing needs to be no more than one tenth of a wavelength at the highest frequency which works out to 8.68 inches so the 6-inch spacing is perfect.

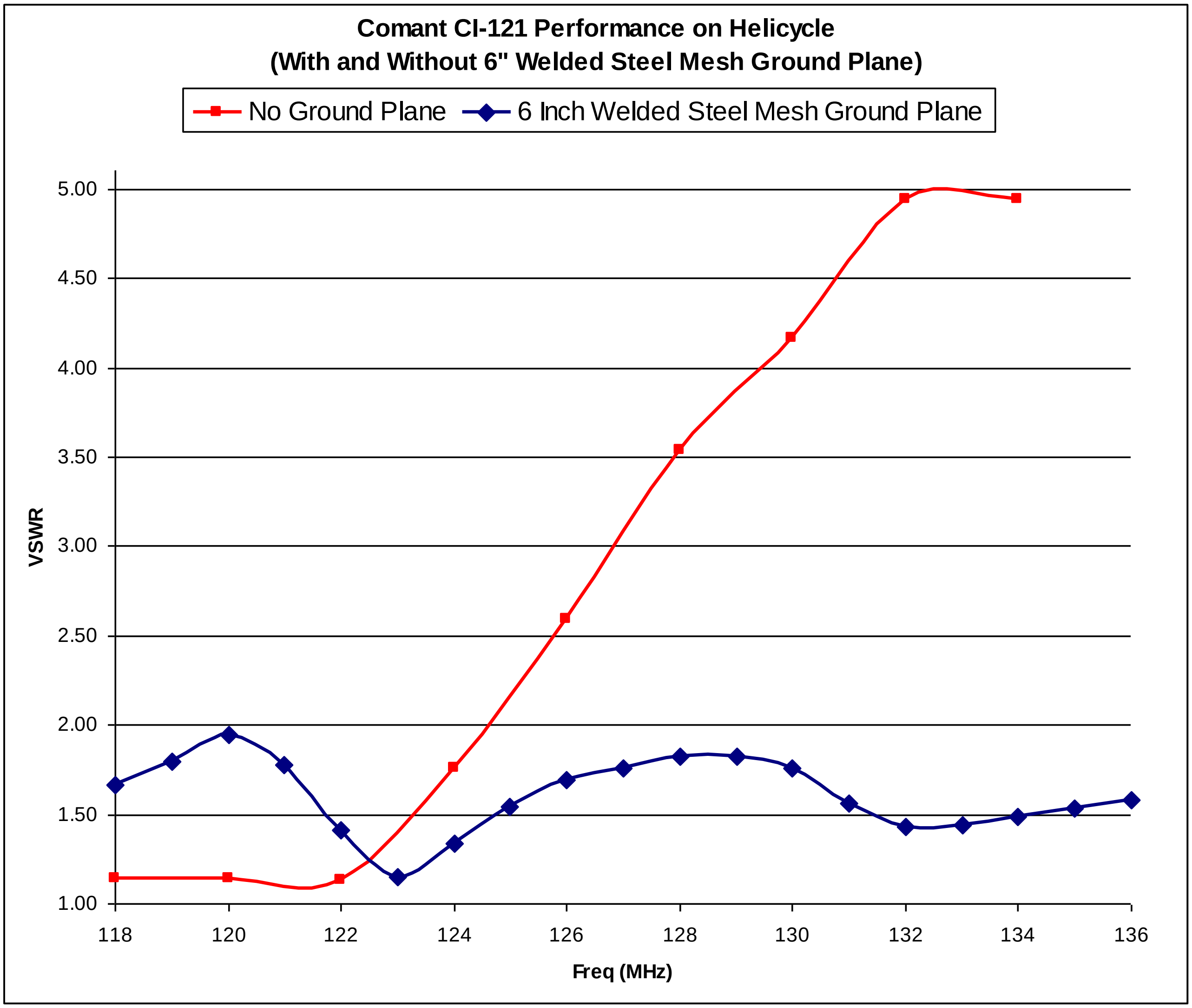
I plan to have the mesh welded to the frame and powder coat everything at once.



Here's a detail showing that the ground plane currently is not very well bonded to the antenna mount at all. It also isn't bonded to the frame. I currently have it held in position with electrical tape.

Now to test it out…

6-Inch Welded Steel Mesh Ground Plane Aft of Antenna				
Freq (MHz)	Forward Power (W)	Reflected Power (W)	Return Loss (dB)	VSWR
118	7.2	0.5	-12.03	1.67
119	7.4	0.6	-10.90	1.80
120	7.8	0.8	-9.88	1.94
121	9.0	0.7	-11.09	1.77
122	10.2	0.3	-15.30	1.41
123	10.2	0.1	-23.01	1.15
124	9.6	0.2	-16.79	1.34
125	10.0	0.5	-13.46	1.54
126	10.5	0.7	-11.75	1.70
127	10.5	0.8	-11.18	1.76
128	10.5	0.9	-10.66	1.83
129	10.5	0.9	-10.66	1.83
130	10.5	0.8	-11.18	1.76
131	10.5	0.5	-13.21	1.56
132	9.6	0.3	-15.04	1.43
133	9.3	0.3	-14.90	1.44
134	9.1	0.4	-14.14	1.49
135	9.1	0.4	-13.56	1.53
136	9.8	0.5	-12.91	1.58



The results speak for themselves. The antenna manufacturer specifies a maximum VSWR of 2.50 across the aviation band. As shown by the blue plot, the maximum VSWR is less than 2.0 and that's very good. You can also see what sort of results is obtained by simply mounting the antenna on the mounting bracket with no ground plane. I believe the lack of a ground plane is responsible for many of the EMI problems that Helicycle owners have and are experiencing.

With this 6-inch mesh the ground plane will be unobtrusive and not introduce any noticeable drag. It should go a long way towards providing me with a reliable electrical system with a minimum of EMI problems. Time will tell…

19 November, 2008 –

For the past few weeks I've been out of town on a business trip. Before I left I took my frame up to Hap Miller's shop. Since my kit is a build-1 all of the engine brackets and many others are not correct for the turbine engine. Hap and Zack helped me resolve all of the missing and incorrect bracketry. Here Zack is welding the rear bearing mount bracket in the correct position based on my earlier diagnosis. We first had to fabricate a new bracket out of .050" chromoly sheet.

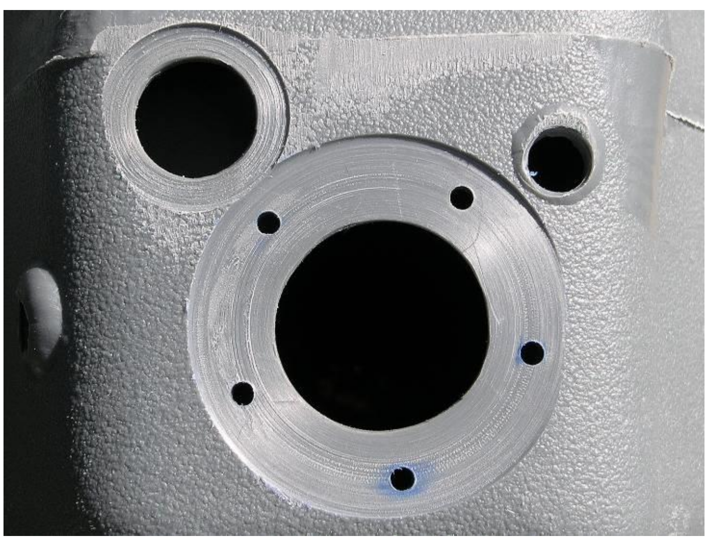
The three of us (Hap standing and Zack welding) spent an entire day working on my frame. I owe them both a huge debt of gratitude. There are many small differences between the older frames and the current versions and fortunately Hap knows exactly what they all are. Now that the frame is up to the current configuration I can get started in earnest. My plan is to delay having the frame powder coated until I've fit checked everything. Then I'll have it stripped of the old paint and powder coated locally.

Here Zack and I are positioning the fuel pump brackets in preparation for welding.

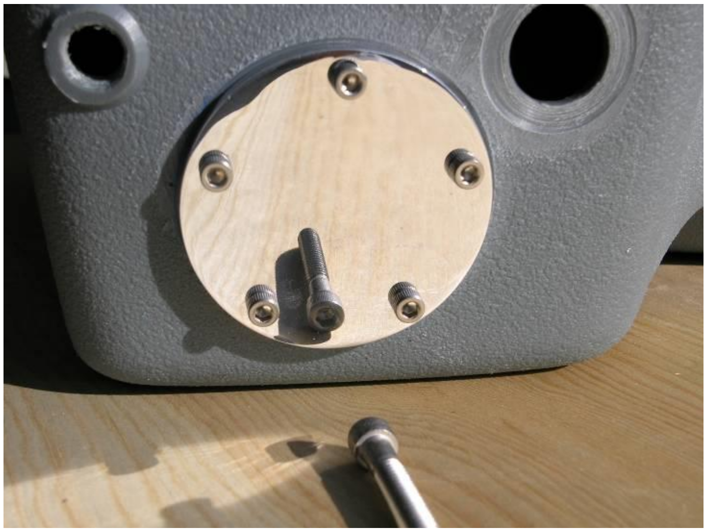
The long bracket between the two of us is one of the idler pulley brackets. This one has to be precisely aligned with the transmission shaft. It's critical that it be as close to perfect as possible. We used a digital level to match it up, both vertically and horizontally by tipping the frame upright and on its side. Positioning and welding just this one bracket probably took the three of us at least half an hour.

It's time to move on to the fuel system. The first step is to greatly enlarge the holes that are circled on the two bottom tanks. They allow access into the tanks, and the optional Westberg fuel probe is mounted in the left tank. Care must be taken to leave enough room for the nuts that secure the fittings for the fill and vent lines. Notice how different the two tanks are…

The lower tank access covers need to have their mounting holes drilled so that they can be used as templates to locate the mounting holes in the tanks. The holes on the right hand tank cover plate are set at even offsets of 72° and that can be done using a rotary table as shown here. The left tank's access cover holes are not evenly spaced and must match the Westberg fuel probe. Three of the holes are 72° apart but the other two are offset. The actual fuel probe was used as the drill guide for those two holes. In this picture the o-ring groove can be seen.



Here's a detail picture of the left tank, with the rough surface area around the holes recessed and smoothed. This is especially important on the large opening so that the o-ring will seat properly and seal the tank. Since the surface of the tank falls away towards the edges, the large hole must be as close to the two smaller holes as possible but still leave enough room for mounting hardware. This tank takes the Westberg fuel probe so the 5 mounting holes are not quite equally spaced. They needed to be aligned carefully to orient the fuel probe and its wiring.



Here’s the right hand tank’s cover plate temporarily installed after polishing. I’ve decided to not anodize these parts since they look so nice as they are.

I really got this cover to a mirror finish but it took me at least one hour.

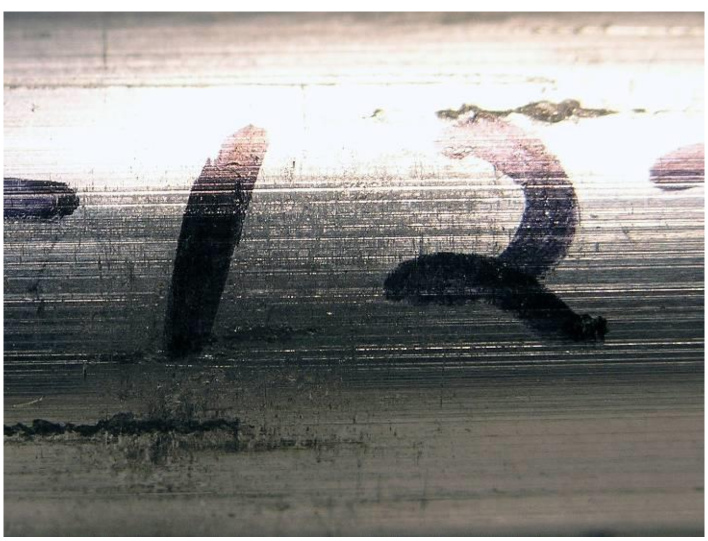
Now that all the brackets are welded into position to bring my group-1 frame up to current standards, I can place the tanks into their final locations and match-drill the mounting holes. The top tank is held in position by two bolts on each side. Here you can see two of the mounting brackets.

The bottom tanks are each held by one bracket at the bottom and three spreader plates – one at the top and two at the bottom that force the tanks apart. I polished all of my small aluminum parts and took them to the plating shop for anodizing, including the spreader plates. Once they are back I can install the various fittings on the tanks and drill the mounting holes for the spreader plates. I have a lot to do before I can permanently mount these tanks but I can determine hose lengths at this point.

Once the two bottom tanks are all blocked into position and as far forward and down as they can go, it's time to match-drill the mounting holes into the tanks, using the mounting brackets as guides.

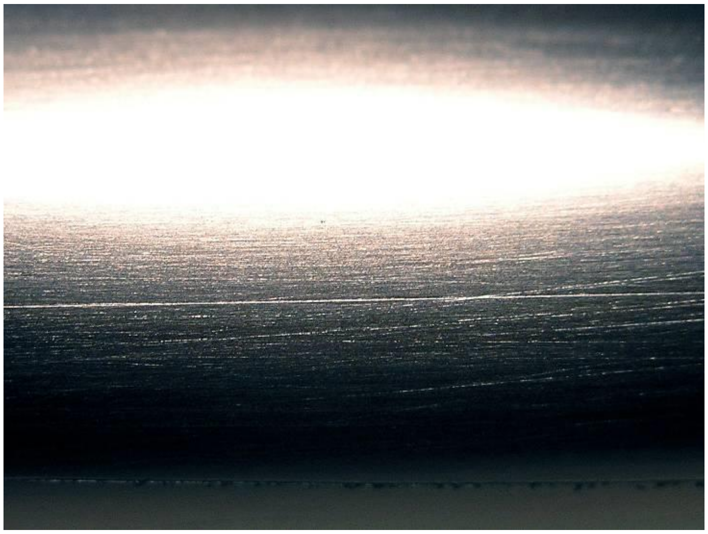
Now for some polishing…

One of the many projects associated with building this helicopter will be polishing hundreds of aluminum parts. Now is a good time to get going. Here are two typical pieces. These happen to be pitch links that attach to the main rotor blades. One has been polished and the other has not.



To the left is a close up of one of the pitch links before beginning. Notice all the mill marks, dings, and scratches. They all need to be removed. Aside from improving the appearance of the parts, polishing will retard oxidation by eliminating all of the microscopic pits and voids where corrosion can begin. It will also be easier to inspect polished parts for damage.

Here's that same pitch link after sanding with 600 grit wet and dry paper. Most of the large scratches are now removed.



Here's the same piece after sanding with 1500 grit. At this point I noticed that deep horizontal scratch seen here. I could actually feel it with my fingernail.

One reason for polishing is to remove these potential sources of cracking that could lead to structural failure.

I went over the deep scratch with the deburring wheel and then repeated the hand sanding with 600 and then 1500 grit sand paper. The large scratch is now gone. I'll take out the rest with two types of polish.

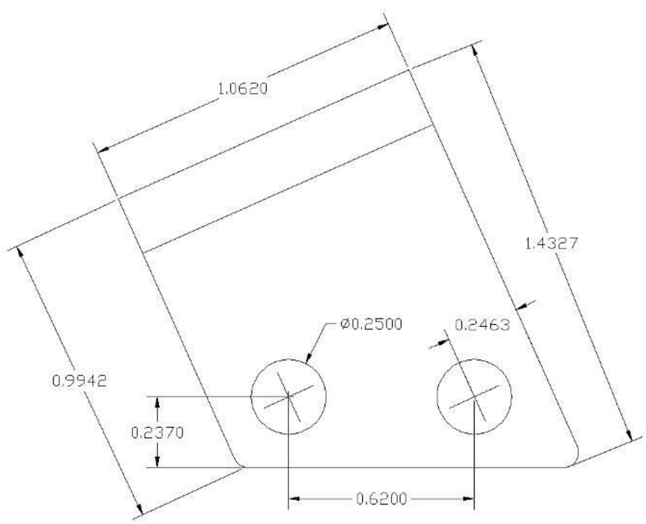
Here's the finished part after hand polishing with Nuvite grade-C medium fine and grade-S fine polish. I finished up the hand polish with my Makita buffer.

I have five grades of Nuvite polish from a very course grade that feels gritty, to a finish polish that feels like hand lotion. Which polishes are used depends on the state of the material. After going over most pieces with 1500 grit sandpaper I use the medium fine and finish polishes. If the part is small I polish it by hand. If it's large enough I switch to my Makita car buffer.

So far it's been easier to strap the buffer down as you see here and move the piece over the buffer. I have three separate wool buffers pads that are used for very coarse, coarse, and fine polishing. It's important to keep the coarser compounds from contaminating the finer buffing pads since they will introduce swirl marks.

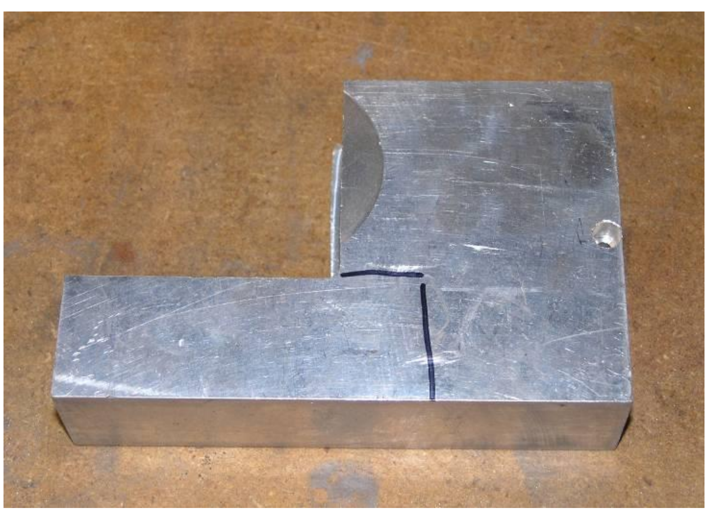
I have cotton flannel cloths on order that I'll use for the final buffing.

Here's an example of a typical small machining job. I need to mount my Andair Gascolator right here behind and below the fuel pump. (The Gascolator traps water and prevents it from reaching the engine and also acts as a fuel filter.) The fuel pump will sit on the bracket in the foreground with the Gascolator bracket sandwiched under it. I want the Gascolator to sit vertically as you see in the picture which means I need to design a bracket that will include a 24° angle in the design. I measured the 24° angle using my digital protractor.



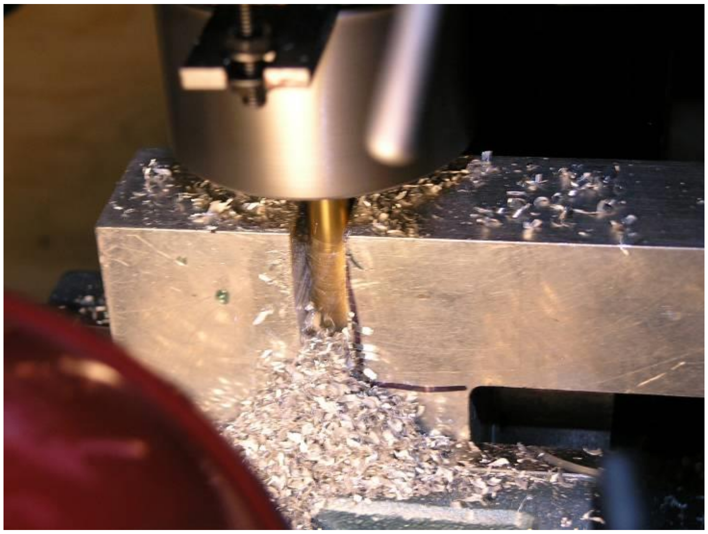
I sketched out my bracket idea using paper and pencil and then used AutoCAD to layout the critical portion and dimension it. There was no need to get carried away drawing the entire bracket in AutoCAD since it is so simple.

I'll need to begin with a chunk of aluminum that is approximately 1.1" x 1.5" x 3.5".

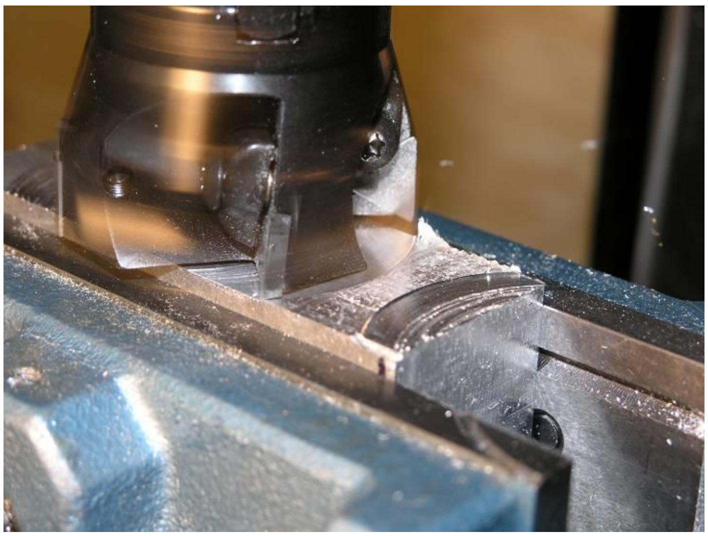


Here's a piece of what I think is 6061 aluminum. I hope I'm right since mixing alloys at the anodizer can cause ruined parts. Various alloys take different amounts of current during the anodizing process and if this is 2024 I'm going to end up with scrap.

I'll start by cutting out the piece where I have marked it with a felt marker.

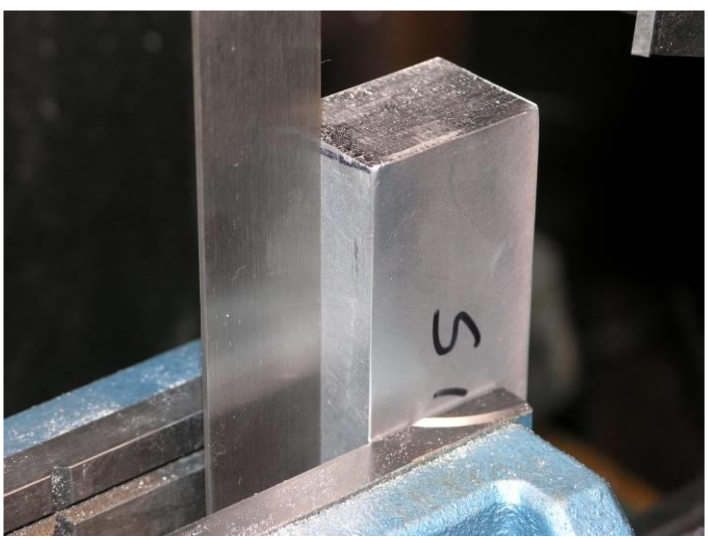


The first step is to cut off the portion I don't want using an end mill. The section I want to keep is at the right. If I had a band saw or a powered hack saw I would have used that, but I don't.

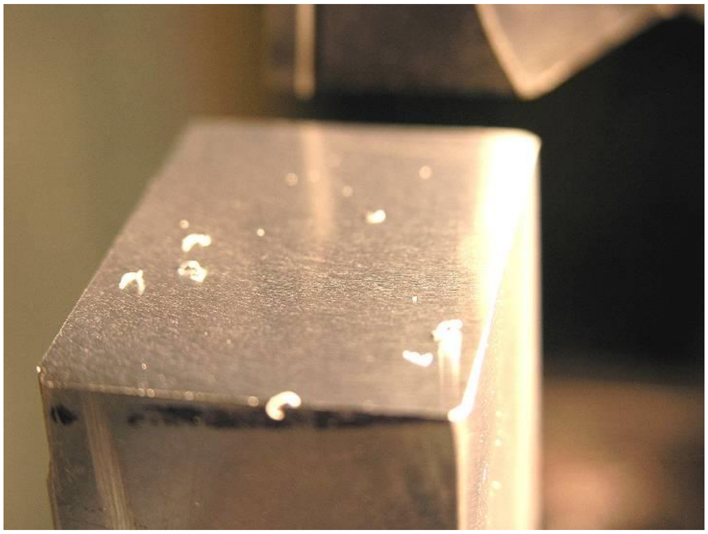


Once the raw piece was cut I began surfacing the top, bottom and sides using this fly cutter. I can take off a wide swath of about 0.050" of material with each pass. When I got close to my final dimension I used a dial caliper to see how much more material I needed to remove. Then I used the calibrated controls on the mill for the final few cuts.

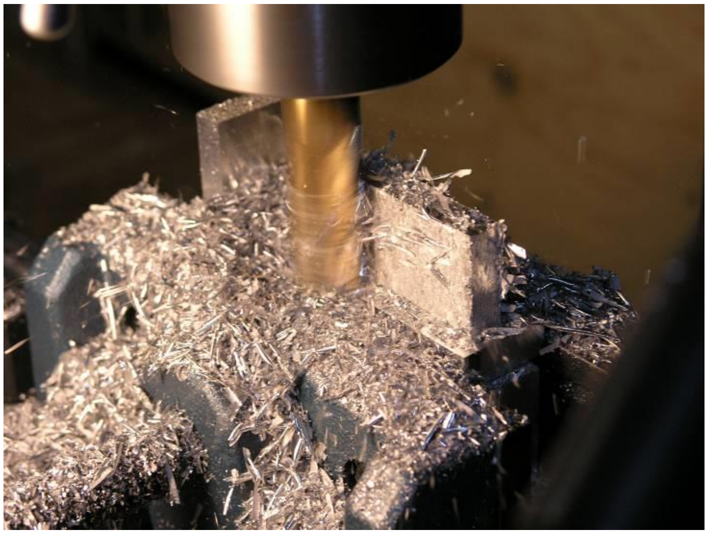
This bracket doesn't have too many critical dimensions so I was content to keep my tolerances to about ±0.005".



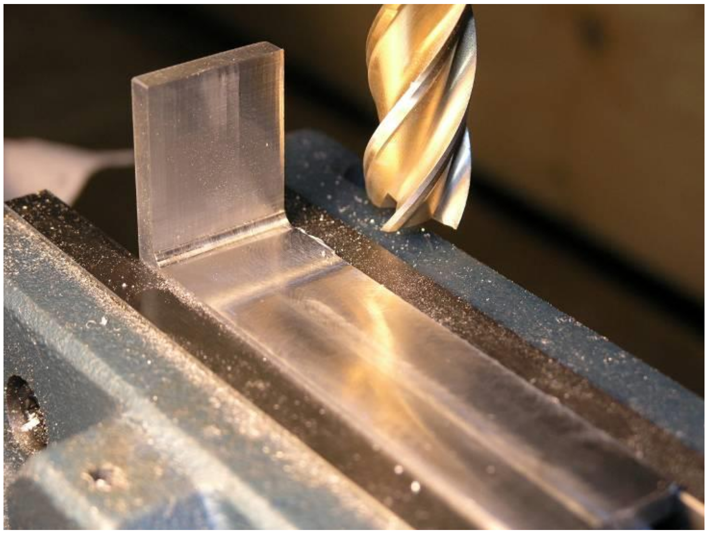
Once the bottom and sides were finished I set up to surface the end that will form the Gascolator attachment surface. I used a precision square to make sure that the piece was exactly vertical.



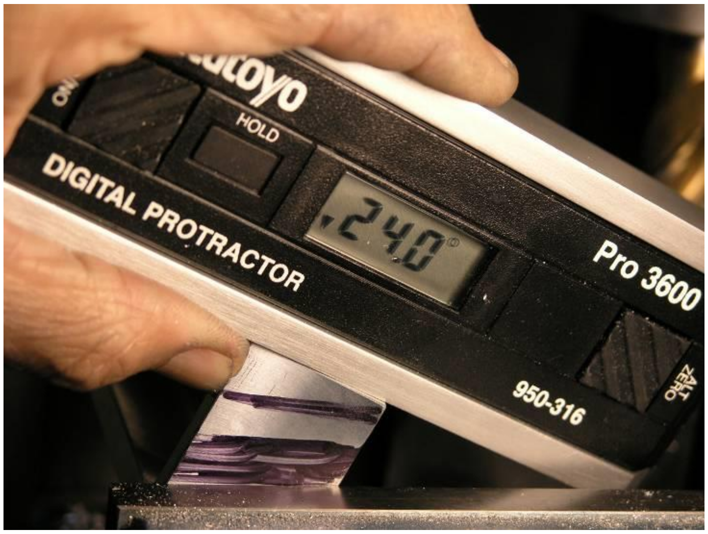
Here's that surface after machining. It's very smooth and won't take much work to polish.



Once the outer dimensions were machined and surfaced I used a ¾" end mill to remove the unwanted material, leaving the right angle bracket shape. I made it ¼" thick and drilled a 1/8" hole across from side to side where the bracket makes a 90° bend. That will act as a radius for that bend.



With the undesired material removed you can see the 1/8" hole I drilled to radius the bend.



Once the part was machined more or less into shape I marked the direction of the 24° angle using a felt marker so I wouldn't make a bone head mistake and cut it in the wrong direction. Then I used my digital protractor to clamp the piece in my machinist vise at the correct angle prior to machine off the excess.

Here's the finished piece after making the final milling operation, drilling and deburring the mounting holes, rounding off the fuel pump end and polishing it. The part is now ready for type-2 black anodizing.

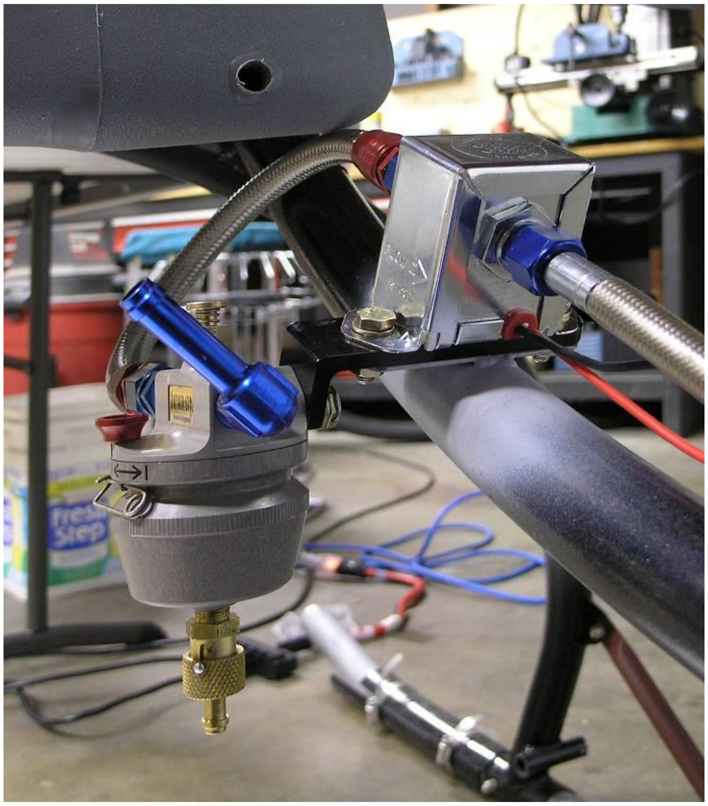
From the time I first got the idea for this bracket, until I took this picture, this little part probably took at least one entire day of labor to fabricate. Now it's off to the plating shop with about 50 other aluminum parts for black anodizing…

The bracket is now anodized and the fuel pump and Gascolator are mounted. Fuel will flow by gravity into the Gascolator via the blue 90° fitting in shadow under the fuel pump, then be pumped around the Aeroquip line with the red fittings, through the pump, and off to the main fuel shutoff valve via the second Aeroquip line at the left.

The Gascolator bolts are safety wired to prevent them from working loose. This is the first safety wiring I've done on this project.

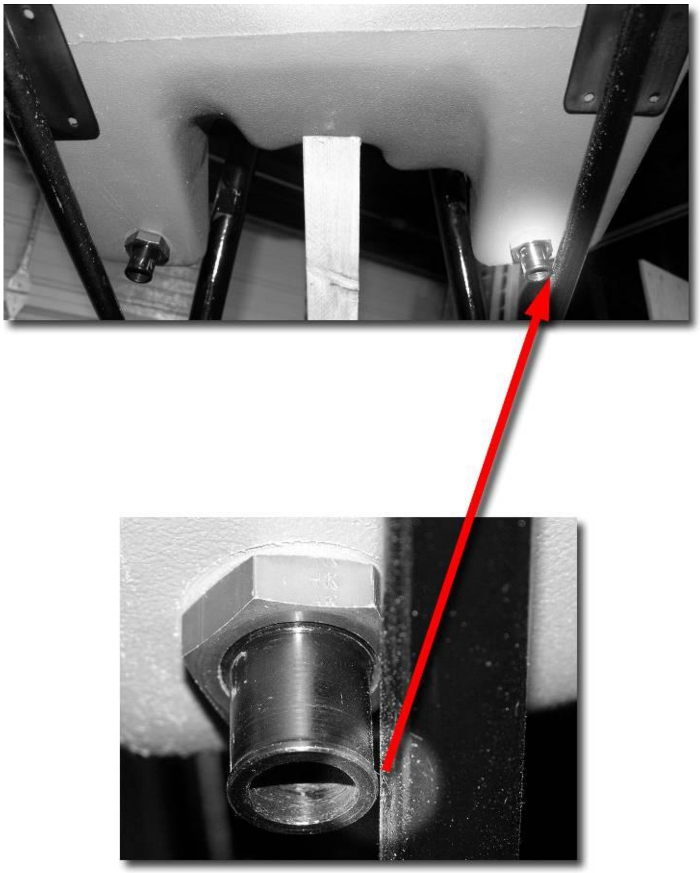
Here's a view of the assembly mounted on the frame's lower left tube looking forward from below the lower tanks. The 24° angle on that bracket aligns the Gascolator vertically, so that bracket worked out just right. The Aeroquip fuel line between the Gascolator and the pump clears the tube and just clears the lower left tank as you can see. I'm satisfied with this little project!

The hose is Aeroquip 601-6/AE701 and the fittings are Aeroquip 816-6D. The drain valve at the top of the Gascolator is a SAF-AIR CAV-110 and the one at the bottom is a SAF-AIR 1250H. I've replaced all of the factory brass hardware with aluminum AN aircraft hardware whenever possible. (AN hardware is always blue in color.) I also replaced the fuel pump. The factory pump had internal pipe threads. This one has flared tube fittings that mate directly with the Aeroquip fuel lines.



This picture is looking towards the rear and shot from where the seat will be. I still have to decide what to do with the lower tank drains. The hole in the tank is the lower left drain. It's so close to the bend in the tank that I might not be able to use the tank upgrade fittings. Hap suggests using epoxy and an AN plug to seal these holes and then mount the larger upgraded fittings underneath the tanks. So far that looks promising.

The brass nuts holding the fuel pump will be replaced with locking nuts when the assembly is installed permanently. The FAA says fiber or nylon locking nuts should not be reused if the nut cannot meet the minimum torque requirements since they wear out. It's safer to just throw lock nuts out if they've been used even once and use new ones. I try not to use my lock nuts at all at this stage in the project.



Well, I finally finished all the plumbing holes in the top tank, match-drilled the mounting holes, installed the drain fittings, and washed out all the debris.

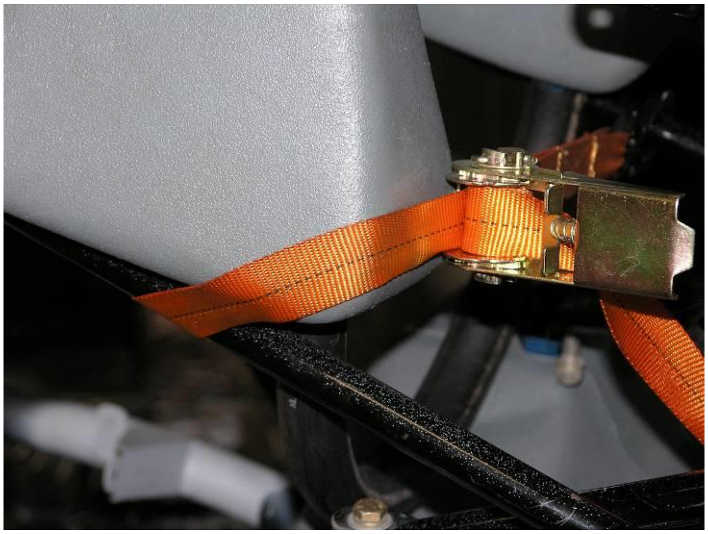
I wedged it into position (using the 2x2 in the middle of the picture) to check alignment of the mounting holes and discovered that the right hand drain fitting is almost touching the frame.

There isn't enough room to install the drain hose and hose clamp without them rubbing against the frame tube. I can't oval out the hole and slide the fitting over because the hole needs to be perfectly rounded and exactly the correct size so the drain fitting's o-ring will seal properly. If I try to bend that tube slightly I'll be introducing all sorts of stress into the frame and probably twist it out of alignment. This is not good. I may have to scrap that tank and they're expensive.

I checked with another builder and his right hand fitting is almost as close as mine. Every frame is slightly different and maybe the tanks are too. I've tried to be as careful as I can but things like this occasionally catch me by surprise. These holes were already drilled so there wouldn't have been much I could do except to cock the tank sideways in the frame slightly and that isn't a good idea either.

I have an idea – I can replace this fitting with an adapter to a 37° flared fitting and then use Aeroquip fuel lines instead of the much larger rubber hose provided. It's much more expensive and the flow out of the top tank will be considerably less. This could be a very serious concern since you could be fooled into thinking that all your tanks had been filled when in fact only the top tank was full and fuel was still running down the smaller lines to the two bottom tanks and the aux tank. I believe this happened to someone and it resulted in an in-flight flame-out and forced autorotation when he ran out of fuel. I'll have to give this a lot of thought before I decide what to do.

After checking on the Helicycle Builder's group on Yahoo and chatting with Blake at the factory and Hap Miller I had a fairly good list of suggestions. I decided to try something simple and inexpensive first…



First I boiled up a big pot of water in the kitchen. Then, after sealing the bottom drains, and mounting the tank using the four o-ring screws, I poured the hot water into the tank.

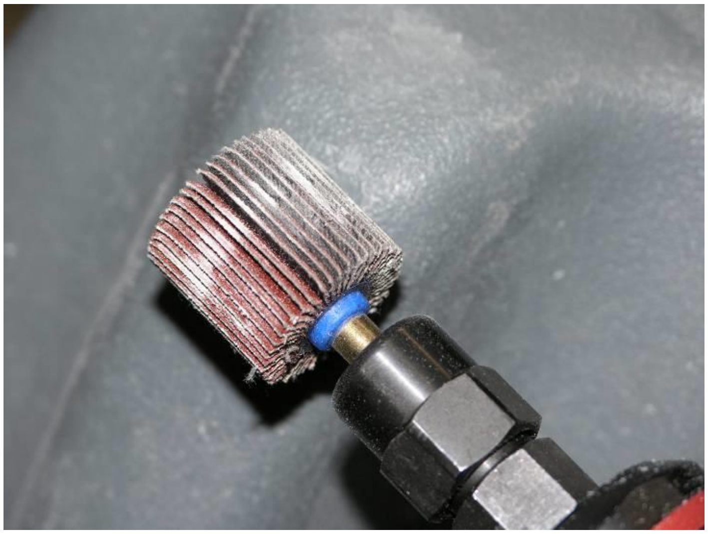
I let it sit for a few minutes and then I pulled the right hand lower portion towards the middle of the frame using a nylon cargo strap as you see here. With the strap pulled tight I had a pretty good clearance on the right hand drain. I let it sit for a while and then drained the hot water out and quickly ran lots of cold water through the tank to cool it in its new form.

Here’s the result. That worked out fairly painlessly and now I have enough room to get that hose in there along with its clamp and not rub against the frame.

I think the tank may tend to return to its previous shape but it looks ok at the moment…

Note – Within six months it returned to its original position.

In the earlier kits the fittings were screwed directly into the polyethylene tanks. That bump with the hole is where a typical fitting would mount. Things have changed for the better and now a threaded adapter with an o-ring seal is installed in the tank and the fuel fitting screws into it. All of the new parts are available as a tank upgrade kit which I purchased. The fittings were bare aluminum and the nuts were blue anodized. I sent all of my bare aluminum parts out and had them black anodized as you see here.



The first step in upgrading the tanks is to flatten the bump…

Then the enlarged hole might need to be offset so that there will be enough of a flat area on the inside of the tank to allow the o-ring to seal properly. You can see that this fitting is going to mount on a raised area of the tank that is barely larger than the fitting itself.

I've marked out the offset location of the enlarged hole in preparation for grinding. I used several different sized burrs to enlarge the hole and then finished up with a large rat-tailed round file and a deburring tool.

It's important not to get carried away and make the hole too large because the o-ring mounts right at the edge of the hole.

Since some of these fittings are located on areas of the tank that are not absolutely flat inside I needed a way to make a nice flat surface for the o-ring to seat. I fabricated this tool out of scrap aluminum and a bolt and nut. The piece at the far end of the tool has 180 grit sandpaper glued on the side facing the camera and 400 grit on the other side. The idea is to insert this tool into the tank and pull it through so that the sand paper is up against the inside of the tank. The round piece sandwiched between the sandpaper and the nut acts as a guide to keep the tool centered in the hole.

Once the tool is inserted into the tank and pulled through I chucked it up in my air drill and started grinding. I tried to hold an even angle while grinding so that the surface would be nice and flat. Every now and then I'd take the tool out and take a look using an inspection mirror. Trying to hold the flashlight and the mirror and take a picture for the log proved to be impossible.