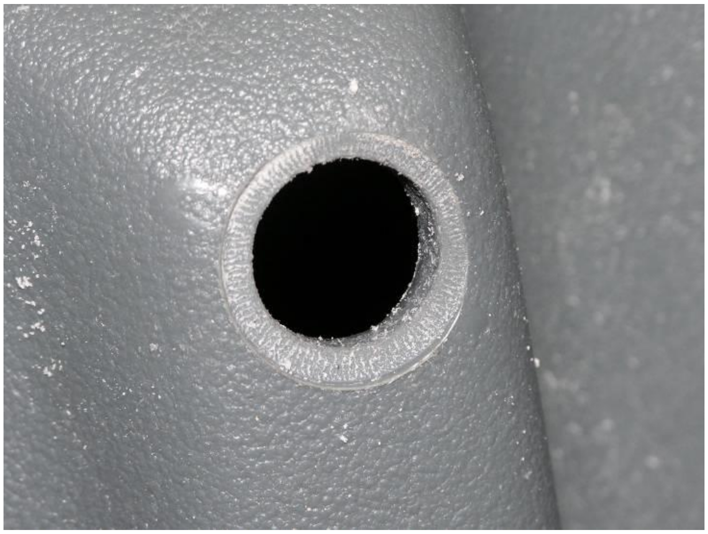
Once the inside was complete I switched the tool around and did the same thing to the outside to give the nut a flat surface.

In this picture you can see that I'm about due for another piece of 400 grit sandpaper.



Here's a finished hole ready to accept the upgraded fitting. I didn't bother going over the outside surface with the 400 grit since the nut will not be a problem.

The next challenge was to really crank down on the nut to mount the fitting. As soon as it began to tighten the whole fitting began to turn. I needed a way to keep the fitting from turning while tightening the nut. I didn't want to ding up the threads so I couldn't just grab the fitting with pliers.

Finally I hit on the idea of sawing a split in one of the nuts and using it as a clamp by squashing it over the fitting with Vice Grips. It matched the threads on the fitting so it wouldn't damage them.

The next problem was that my Crescent Wrench wouldn't fit under the Vice Grips. I made myself a wrench out of a piece of ¼" aluminum stock. I over-sized it so that it only made contact with the nut at the edges and didn't ding up the anodized surface of the nut. Problem solved.

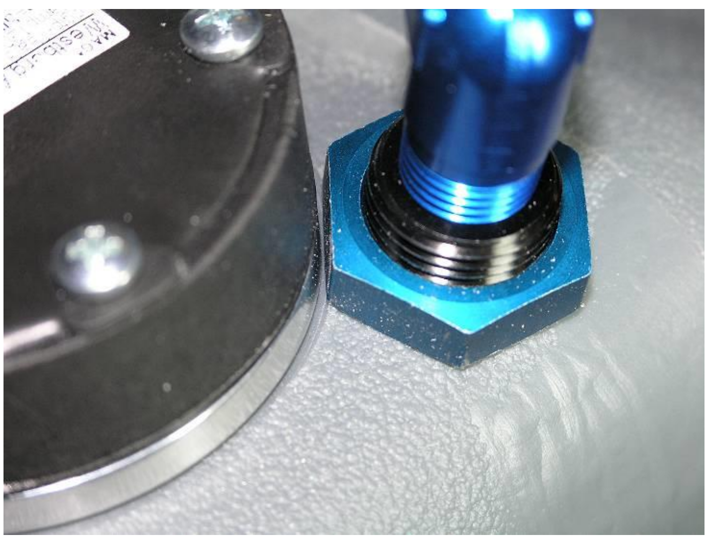
Oh… The top tank drain fitting stayed where I put it so the interference problem is also solved.

Juan Rivera

I’m almost done doing the fuel system upgrade. Here’s a shot of the bottom left tank showing the three fittings for fuel fill and air bleed to the top tank, the sight gauge that will connect to the fitting on the left, and the capacitance fuel probe (in black.)

The probe extends down from the black portion to the bottom of the tank. The electronics are potted in the black portion.

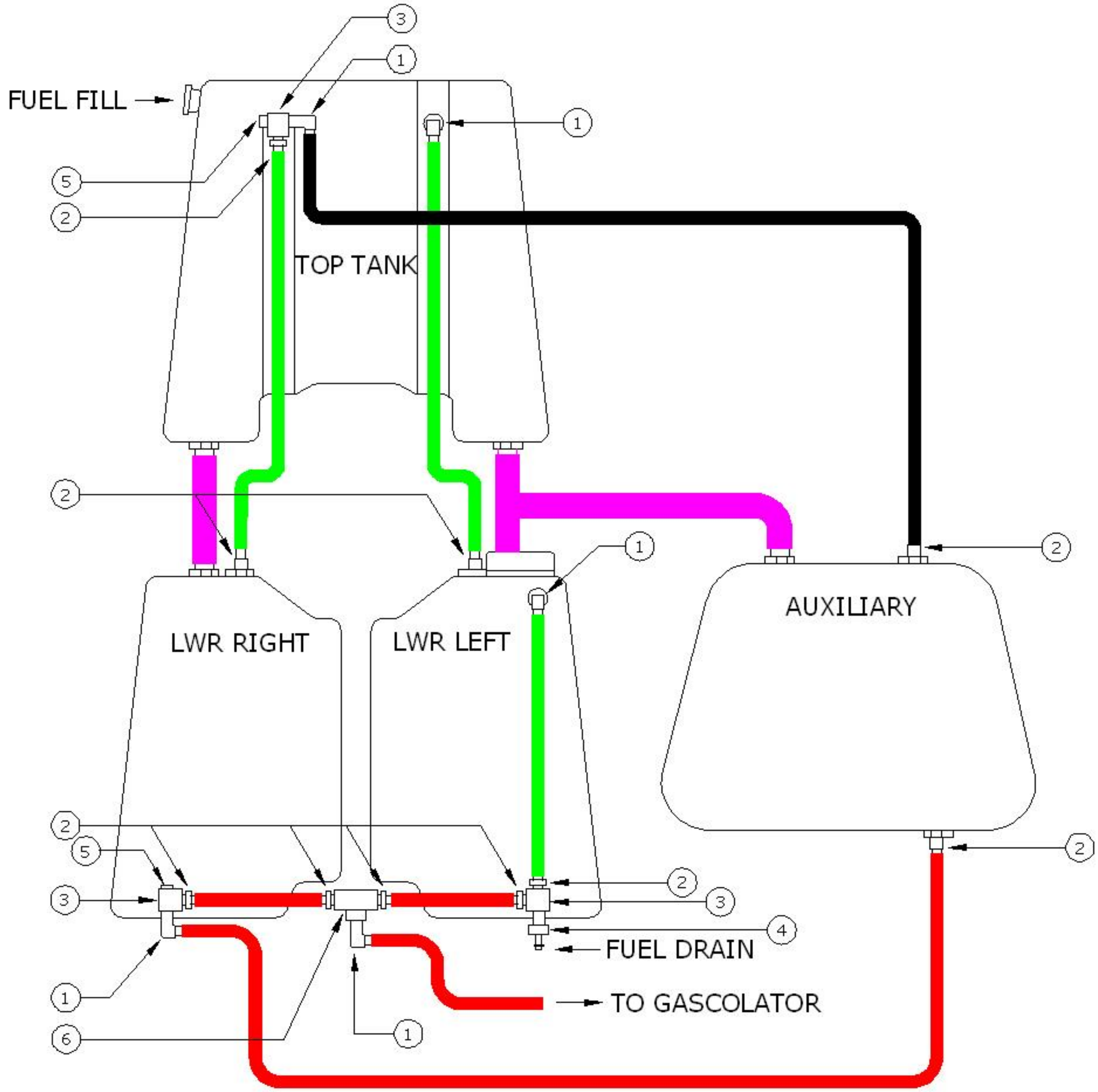
Right now the upgrade adapters have been final-installed but the attached fittings and the fuel probe are just finger tight for this picture. I have to clean all the debris out of the tanks by first washing them with hot soapy water and then removing any remaining water by rinsing in isopropyl alcohol. Finally, I’ll leak check the tanks by filling them with a few gallons of gasoline. Once all that is done I can secure the fuel probe and fittings. I still can’t mount the tanks until I get the frame power coated. Then the top tank goes in for good, then the transmission, then the two lower tanks. I’ve got a lot to do before I’m ready to paint the frame so the tanks will wait for a while yet.



I’m glad I saved the hardest fittings for last. This one is jammed up against the fuel probe and the curvature at the edge of the tank. I had no room for errors.

That polished aluminum piece under the black fuel probe has an o-ring around the outside edge on both sides. It will seal the fuel probe to the tank. The only problem I see is that the o-rings are on the outside of the five mounting screws. That means that fuel can leak up the screw holes. If the o-rings were inside of the mounting screws this wouldn’t leak at all.

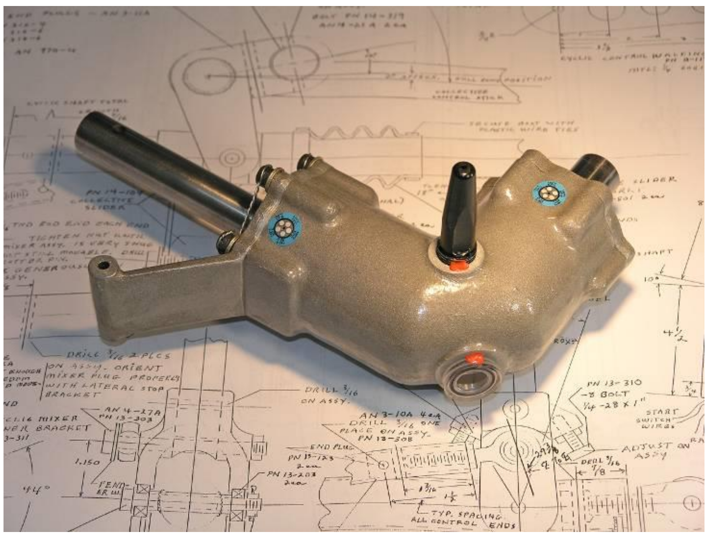
I’ve modified my configuration per a suggestion from Hap Miller. Normally there is one air bleed line from the two lower tanks to the upper tank. This is normally done by teeing the two lower tank bleeds together. Rather than do that I have two separate bleed lines as you see on the next page (the two top green lines.)



FUEL SYSTEM AS VIEWED LOOKING AFT

The fuel system consists of four individual tanks – top, lower left and right, and an optional auxiliary tank if you weigh less than 180 pounds. Total fuel capacity is 21 gallons. Fuel is pumped into the top tank and gravity feeds the other three tanks via the violet lines. As pressure builds up in those tanks the trapped air bleeds back into the top tank via the three air bleed lines that connect to the top of the top tank. The green lines are clear polyethylene tubing and serves as sight gauges. Fuel reaches the engine through the red lines via a gascolator, a fuel pump, and a main shutoff valve. All the tanks can be drained using the drain valve at the bottom of the lower left hand tank (right side of schematic.)

Bill of Materials (Items not included in Helicycle Kit)			
Item	**Qty**	**Part No.**	**Description**
1	5	AN842-6D	Hose Elbow, Pipe Thread, 90°, ¼" pipe to 3/8" Tube
2	10	AN840-6D	Hose Nipple, Pipe Thread, ¼" pipe to 3/8" Tube
3	3	24-510	Modified 90° Street Elbow, ¼" NPT (factory supplied)
4	1	1250H	Lock Open, Saf-Air Drain Valve, 1/8" NPT
5	2	AN913-1D	Plug, Square Head, 1/8" NTP
6	6	AN917-2D	Tee, ¼" Internal Pipe Thread

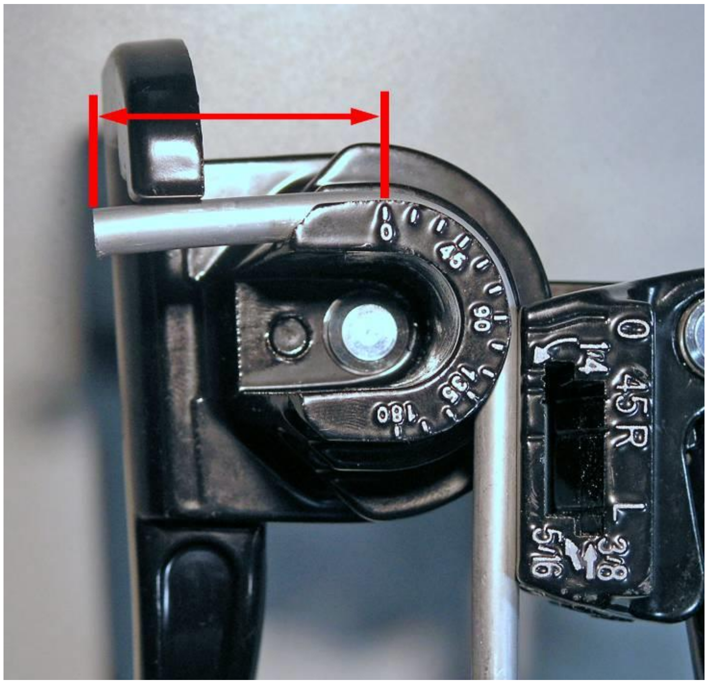


I'm stuck waiting for some fuel system parts so I decided to work on the tail rotor gear box. It comes completely assembled and ready to go but I wanted to preserve the bare aluminum by blasting it with ground glass to enhance the appearance of the casting. Then I coated it with a two-part top coat called POR-15 Glisten PC. Here's the result after I brushed on two coats.

The two round blue labels are temperature indicators. Each contains five dots that turn black at a different temperature from 140°F to 180°F. This will allow me to monitor the maximum bearing temperature in those critical areas. The orange dots are dabs of Torque Seal, a thick quick-drying lacquer that will chip off if the oil level sight or the breather starts to loosen. This is a simple and effective way to insure that they aren't coming loose. Everything on the helicopter will be locked into place, or where that isn't possible it will be marked with Torque Seal. I'll check these items during pre-flight and post-flight inspections.

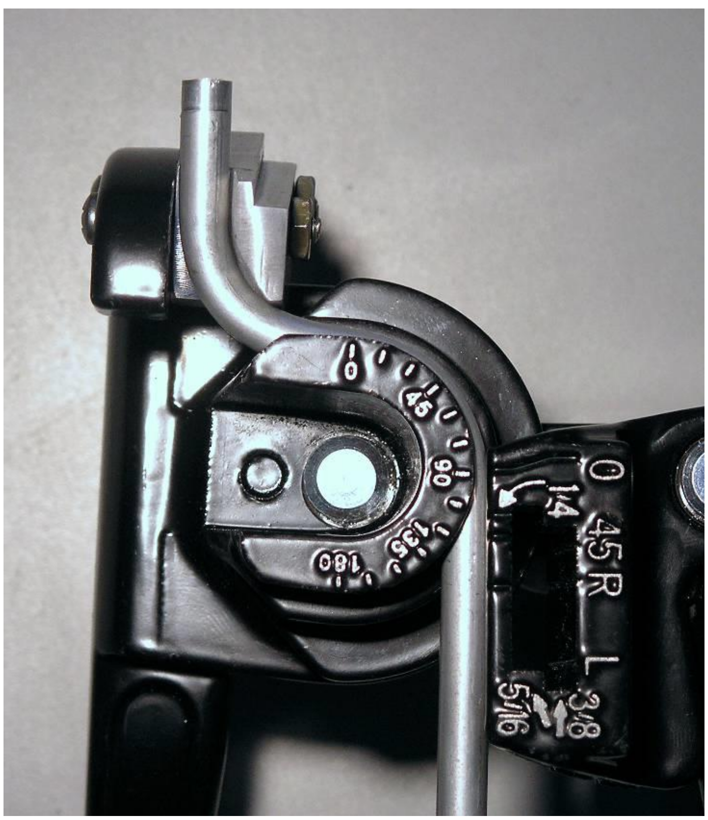
Here's a close up of the tail rotor shaft end showing the safety-wired attaching bolts. I'm using a method called "double-twist" where the wire is fed through a hole in the bolt head, twisted, and then routed to the next bolt in a manner that would prevent the tendency of the bolts to loosen. For right hand threads the wire is installed as you see. The end of the wire is bent under and inwards to prevent the sharp ends from causing a safety hazard. The job is made easier using safety-wire pliers – a tool that twists the wires when a knob is pulled. Other methods of securing parts from loosening during operation include locking nuts and cotter pins. I'll be using all three methods on the Helicycle.

Juan Rivera



My tubing bender arrived while I was waiting for the parts to come back from the painter. The stock tool can't get close enough to the end of the tube to make the bends I will need for the transmission. The red lines show the shortest length the bender will handle before starting a bend.

I managed to mess up a few of the pre-made tubes I purchased from Eagle R&D so I ordered a flaring tool from Aircraft Spruce. I'll make my own tubing. With luck I can cut down the area after the bend and flare it myself since most of my tubes need a bend very close to the flare, at least on one end.



I made a simple addition to the bender on my mill. It allows me to get much closer to the end of the tube and also closer to existing bends.

Now that the tail rotor gearbox is ready to go I decided to start on my transmission exterior. It's been sitting around along with everything else since the kit was originally purchased about 5 years ago and it looked nasty. In this close up you can see a lot of oxidation plus what looks like spatters of some unknown substance.

My plan is to blast it with ground glass as I did with the tail rotor gearbox and then spray it with Glisten instead of brushing it on.

After replacing all the hardware with temporary hardware and carefully masking off the bearings and other sensitive areas I set up my blasting booth. Well, ok, I really don't have a booth exactly but the driveway will have to do. I wore leather gloves, and goggles under a full face shield. I had to take a shower afterwards to get all the ground glass out of my hair and I can't reuse the glass since it got mixed with dirt and leaves, but it worked. I also ended up with ground glass in my ears so perhaps this is not the ideal way to this. It's not as bad as it sounds. It looks and feels like beach sand.

Here's a picture of the area after finishing up. The glass tends to stay put since its heavy. I didn't have any trouble sweeping it up.

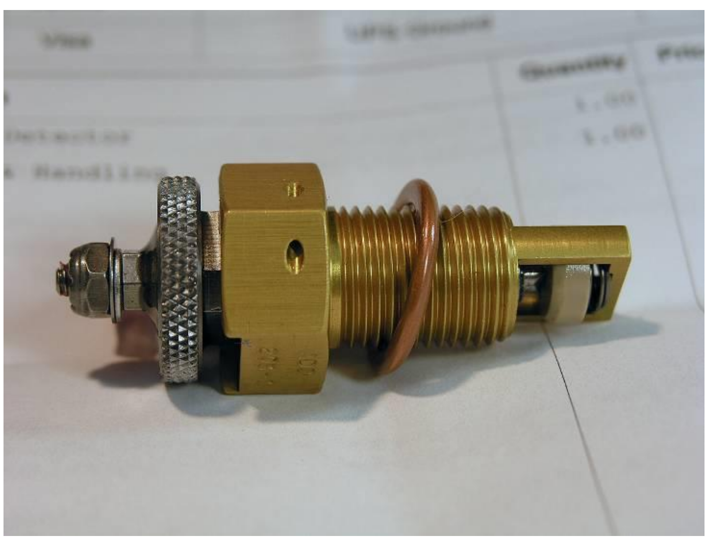
The gun only cost about $20 and the 5-gallon can of ground glass was about $35 at Grangers. You will need a big supply of compressed air. I have a 1 horse power compressor with a 17 gallon tank that I purchased at Sears. I had to stop often to let the compressor catch up.

Juan Rivera

Here’s what it looked like after it was blasted. It has a nice sparely appearance. I should mention that to protect the main rotor shaft and bearing I dropped a piece of PVC pipe over it and sealed it up with bathtub calking from the hardware store. The calk didn’t hold up at all and I could have ended up with ground glass down in my bearing where the seal is. That wouldn’t be a good thing. I should have spent more time getting this right. External oil tubes run around the outside and attach everywhere you see a red plug. Mine were missing when I bought the used kit so I’ll have to deal with this later.

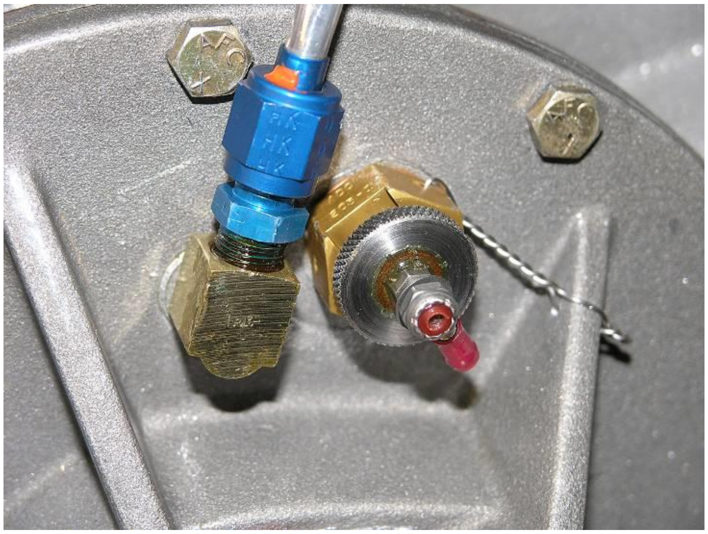
Here’s how it looked after spraying two coats of Glisten. It dries to a tacky state in about half an hour, depending on the moisture in the air, but it takes about 4 days to completely cure. I moved in into my shop where I can keep it warm to speed things up. Once its cured I’ll replace the temporary hardware with the aircraft hardware and install all of the plumbing.

While the Glisten cures I switched to the main rotor hub. I wanted to include pieces with the tail fins I having painted to avoid another minimum lot charge.



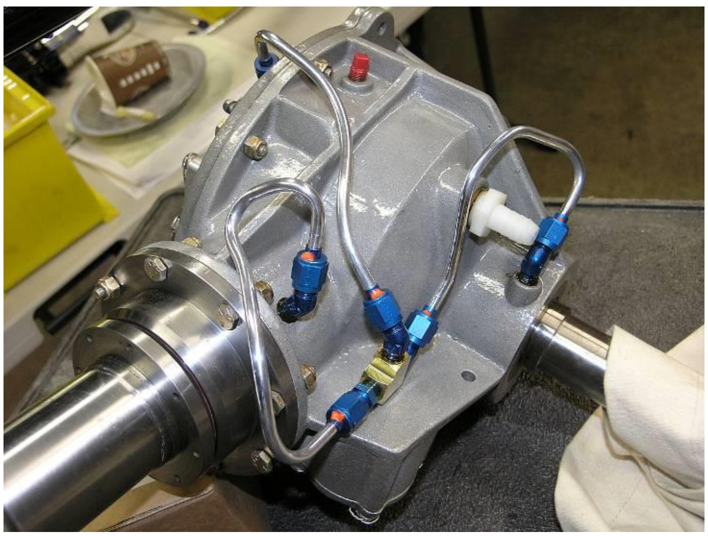
I’m adding this to the transmission. It’s called a chip detector. There are two contacts at the end separated by a small air gap. There is also a small magnet at the tip. If there are any ferrous metal shavings in the oil they will be attracted by the magnet and, if there are enough, they will bridge the gap and close the circuit lighting a warning light on my instrument panel. If the transmission is grinding metal I’ll want to get on the ground as fast as possible. There will also be a transmission oil temperature indicator on the instrument panel.

Juan Rivera



Here's the chip detector installed at the bottom of the transmission, torqued to 120 inch pounds, and safety wired.

I've never bent or flared tubing before. It was a challenge. There are quite a few oil lines on the exterior of the transmission. Normally they are already fabricated and installed on the transmission when it arrives but mine were lost in the shuffle. The group-1 transmissions are different than all the others so the kit of tubing I purchased from the factory didn't fit. I had to learn a few new skills. You can see several of my rejects on the bench behind this piece. It has several compound bends and it took me quite a while to get it right.



Here's that tube after polishing, installing, and adding a dab of torque seal to each AN fitting. This particular tube has to pass under the pulley without touching.

Here's a look at that tube after placing the pulley in position. I have plenty of clearance so the transmission plumbing is now complete.

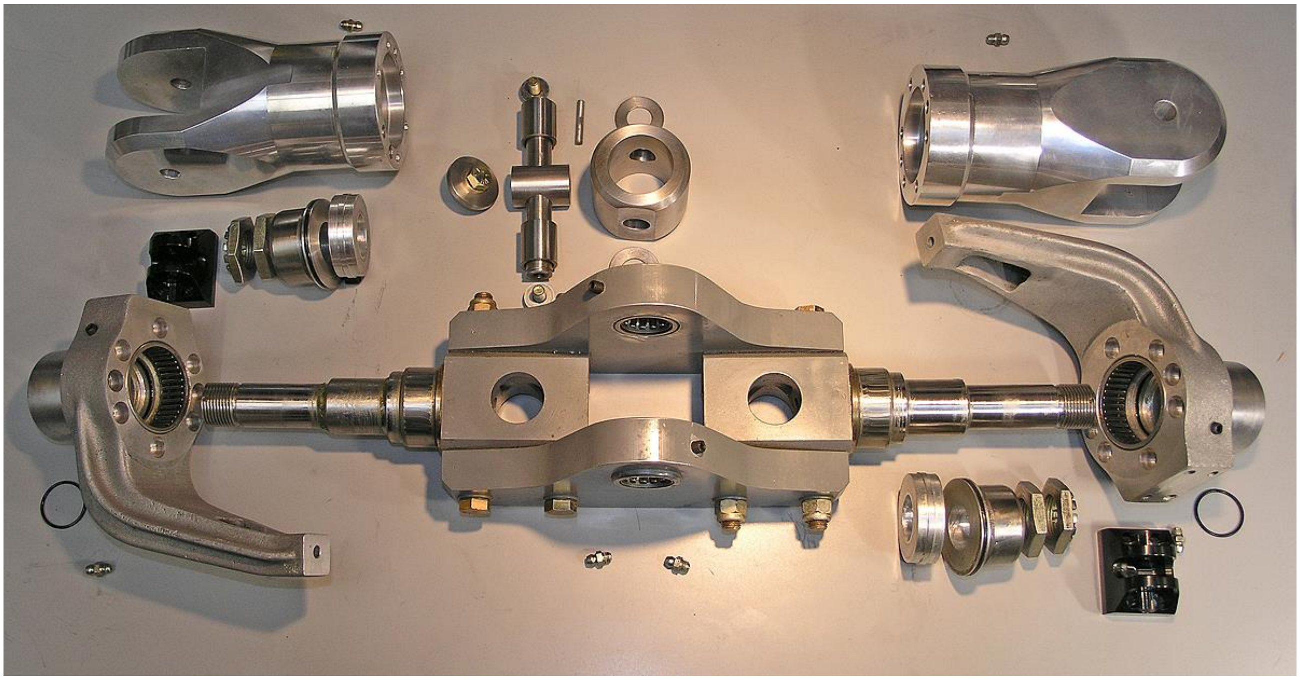
I have two tasks left to do before setting the transmission aside - apply anti-corrosion protection to the inside of the main rotor shaft and seal it with a wooden plug and then apply corrosion protection to the outside of the main rotor shaft. I will be covering the bottom half of the main rotor shaft with a clear two-part ceramic coating called Evershield.

I tied a piece of rag to an aluminum tube and soaked it with "Corrosion X". Then I ran it in and out of the main rotor shaft several times. It picked up a lot of metallic particles and crud (See below.) Now it's all set to seal up.

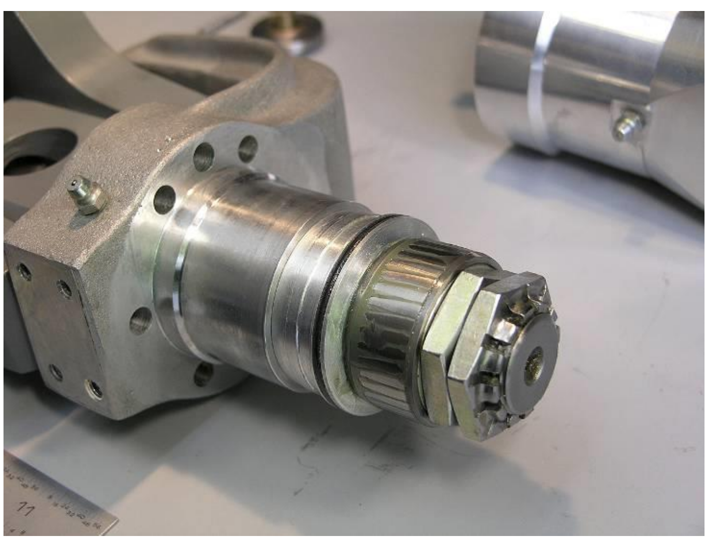
The Evershield has to be mixed by weight so I was fortunate to have a triple-beam scale. It also has to be mixed in a clean glass jar. I raided the kitchen for that. The mixture must be shaken every five minutes until it turns yellowish in color, then it must sit for one hour prior to application. I put two coats on the lower main rotor shaft and all of the oil lines using a small cloth. Then I warmed the transmission up using a heat gun to speed curing.

I've been at this project for seven months now and I think I'm about half finished. So far I'm very satisfied with my progress. Tomorrow I'll bypass the oil cooler path with a hose, fill the transmission with lubricating oil ($50 per gallon!) and attach the drive pulley. Then I can turn it over and pump some lubricant to the bearings.

I think there are two things that set this helicopter apart from all other kits, aside from the fact that it’s powered by a turbine engine. The first is the superb transmission and the other is the magnificent main rotor hub. Check this out:



There are so many precision parts in this hub that it obviously cost serious money to design and manufacture. The central section with the two precision ground shafts is made of steel. The pitch horns are cast aluminum and they’re hollow. I carefully masked off all the critical areas on the central section and the pitch horns and hauled them off to the paint shop. Since the alignment of those two shafts is absolutely critical the hardware will be painted over. Normally I would disassemble everything before painting but if I did that they would have to go back to the factory to be reassembled.

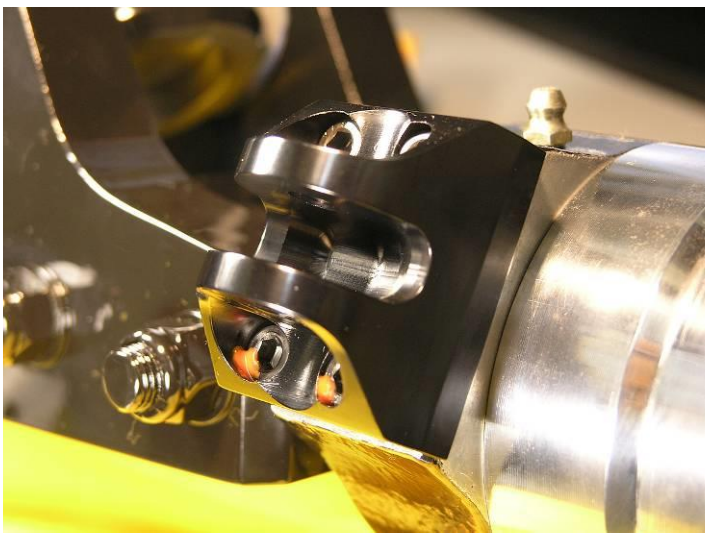


This picture shows the pitch horn and stack-up of parts that go on each shaft. Most items are marked to show which side they go on. This is a precision assembly and you can’t swap parts from side to side.

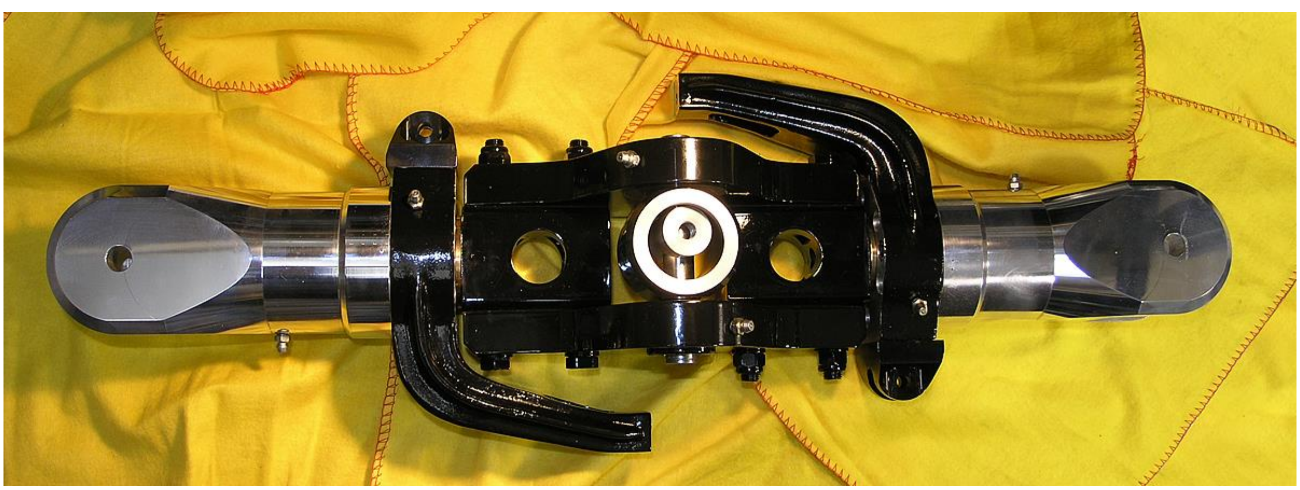
If you look at the previous picture you can see that the needle bearings visible inside the pitch horns will mate up with the inboard bearing race in the picture to the left. Hidden at the other end of the pitch horn is another set of needle bearings and they mate with the outer bearing race just inboard from the two nuts.
There are also a number of o-rings, some of

which you can see and some that are hidden inside the pitch horns.

Here's one last picture of one of the blade grips – another gorgeous CNC machined part. I polished the end of this grip so you can see the difference between before and after. I took out the machine marks on the flat sides using Nuvite extra course polishing compound using a flannel cloth attached to my palm sander. The rest I did by hand using their Grade S finish polish. I masked the interior of the grip using adhesive-backed aluminum tape then I replaced all the grease fittings with temporary ¼-28 set screws to insure that the bearings don't become contaminated.



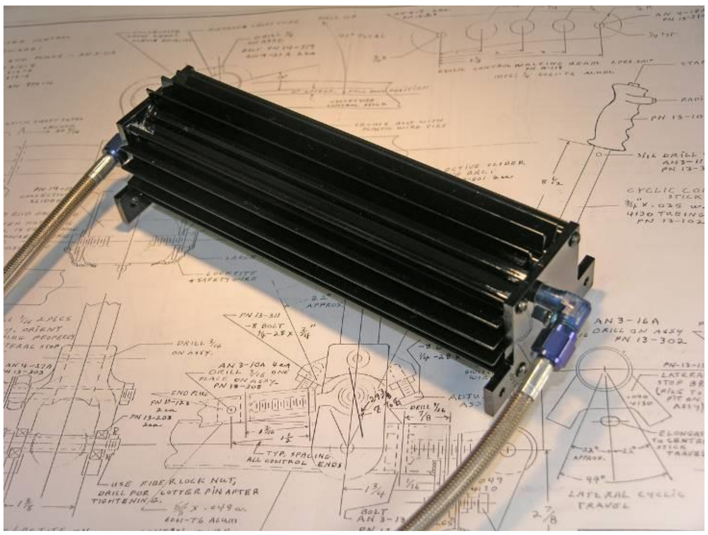
Once the parts returned from the paint shop I attached the drag link clevis mounts using eight ¼-20 x 7/8" alloy steel socket head cap screws. Each screw was cleaned with acetone and then installed using a dab of Loctite 242 thread locker. After the bolts were tightened I applied a dab of torque seal so any loosening of the bolts will be noticed during inspections. The black anodized clevis mounts match the painted pitch arms perfectly.



The hub is now reassembled after painting with a two-part polyurethane gloss black. The paint used was Cardinal 6409-08 which is 90% reflective.

While the paint shop was busy I spent many hours installing and removing the cabin halves, each time marking areas that were causing interference. I’m very close to bringing the frame to the shop for powder coating. I was planning on a gloss white but I think I’ll have the frame coated with a light gray. I also found a leather cow hide on eBay that was advertised as aviation leather. I’m planning to send the hide to Eagle R&D to use as the material for my seat.

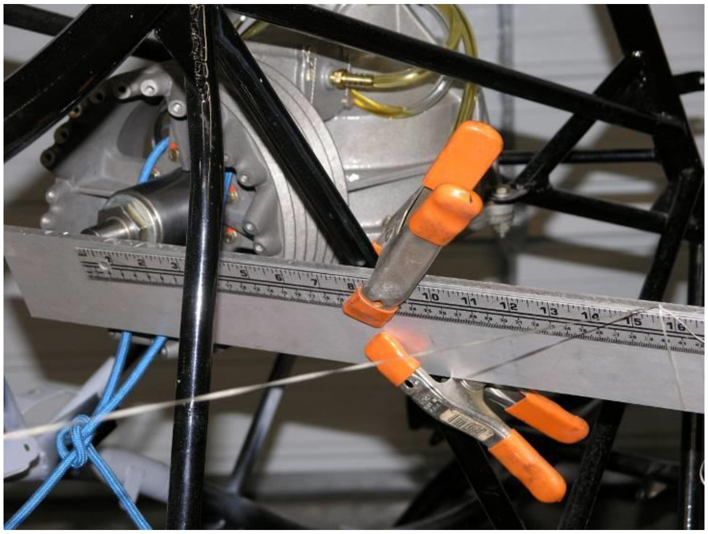
The paint shop also did my tail rotor blades and tail fins but there were problems with all of them so they are going to repaint. I’m using the same gloss black on those items.



Here’s one last item that I had painted. This is a transmission oil cooler and filter that’s made by Moroso and modified for the Helicycle by Hap Miller. It will mount right behind the top fuel tank.

Most of the engine and flight instruments will be modified by adding colored tape as you see on the airspeed indicator. Green is the normal operating area, yellow is caution and red is the never exceed speed. This is where the term, “red line” comes from. The yellow band between 65 and 70 MPH is the autorotation speed range. If you loose power or have to chop the power due to a tail rotor malfunction then you can bring the helicopter in by using the stored energy in the rotor system and the helicopter’s altitude. It’s called an autorotation. During an autorotation the pilot will be watching his airspeed and main rotor RPM very carefully while searching for a good landing spot. The idea is to slow the helicopter and cushion the landing by using up all of the stored energy. Airspeed and vertical descent speed should both reach zero as the rotor system runs out of energy.

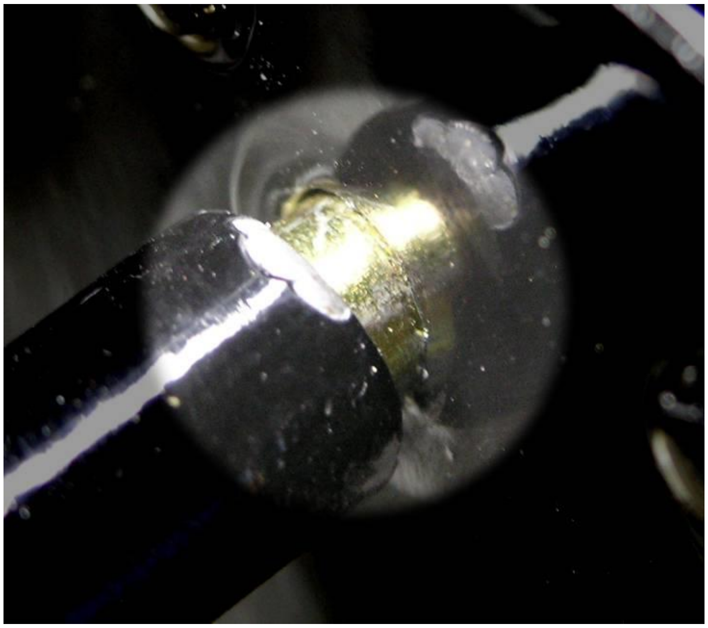
Juan Rivera



The drawings call for the vertical tail fin to be offset with the leading edge to the right. You set this up by stretching a string that is 15 to 17 inches offset to the right over the top of the vertical tail fin. Then you line up the chord with the string.

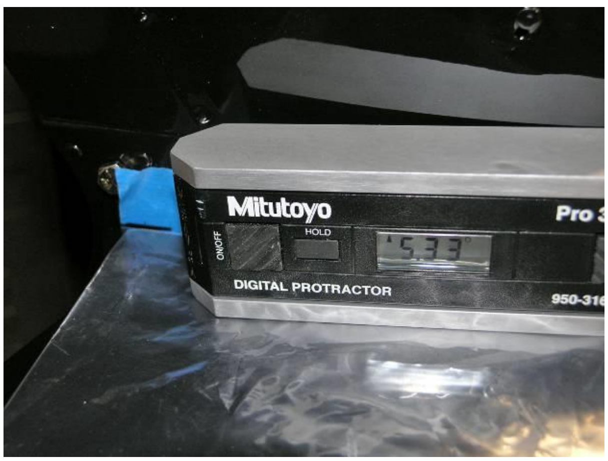
I used the center of the transmission drive shaft as my center point. The transmission is slightly offset to account for torque but it will be close enough and can be changed during flight test.

I adjusted the pitch of the vertical tail fin with the string offset as you see in the top picture – about 16-inches from the transmission drive shaft center.



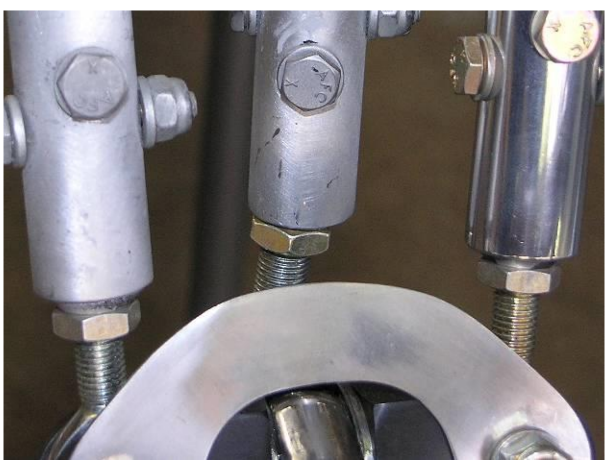
That resulted in a gap of about 0.125 inches. If I offset the string 17-inches then the gap goes away.

To align the horizontal tail fin you first have to shim under the skids to line the main rotor shaft to 90 degrees.



Then you adjust the mean chord to 5 degrees of positive pitch (trailing edge down.) I've marked the point on a piece of masking tape. The next step is to fabricate three support tubes that will secure the fins in place.

(That's a plastic bag the level is resting on. I don't want to scratch my paint.)



I'm progressing on several fronts. My goal is to get my frame powder coated so I can start final component installation. To insure that the seat pan is centered properly I had to install the transmission, all of the cyclic and collective control components, and the swash plate. I needed the seat pan in its correct position so I could install the cabin, and so on and so on.

One of the previous owners of this kit either sand-blasted or acid-etched all of the control tubes and associated hardware. It not only looked ugly but might have compromised the structural integrity of the tubes. I am replacing them all with new ones which I am polishing by hand. You can see a new polished tube on the right and two of the tubes I inherited on the left. Notice that the nuts and bolts have also been blasted or etched. Not on my ship! I'm also replacing all of the hardware.

Juan Rivera

Each tube gets the same treatment. A threaded end-plug is installed at each end of each tube and held in place by two AN aircraft bolts and lock nuts. I machine the two bolt holes at right angles from each other as you see. The holes are machined in three stages – first a small pilot hole is drilled then a slightly undersized hole and finally I ream the hole to the exact size. I leave the reamer in the first hole and use it to line up the second hole at right angles. Then the holes are deburred, the tubes get a final polish, and the hardware is installed. The process takes about one hour per tube.

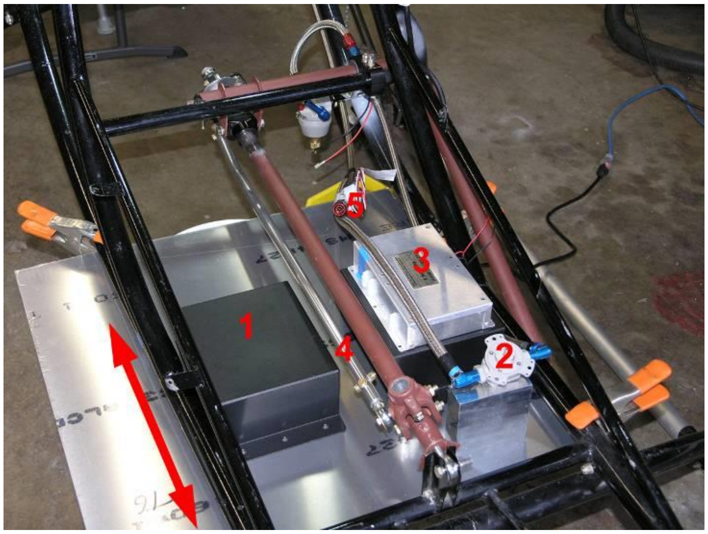
Once all the end plugs were installed I gave everything that was polished a corrosion treatment using Evershield. The stuff is very expensive but it only took about a thimble full to coat all the tubes, the main rotor blade grips, and a few assorted pieces. In hot weather these would all dry in half an hour but in the winter in my unheated garage it could take almost one week.

Replacing all of the control tubes turned out to be an all-day project but it was worth it. If the Evershield works as advertised these parts should stay nice and bright. In addition to looking good I think it will be easier to detect any problems. With all of the control tubes in place I could finally check for interference between the tubes and the frame and the aux tank. There isn't any which is great. The cyclic control tube that runs horizontally to the mixer was cut down by almost an inch to chop off the holes that a previous owner had drilled. That moved the mixer forward and away from the frame cross arms that the control tubes pass near. On stock machines these tubes sometimes rub on the cross arms and the factory suggest that you bend them slightly to alleviate the problem. Shortening the cyclic tube is a much better solution.

The next step is to tear everything out and haul the frame back up to Hap's so his son Zack can weld on four brackets. I'm going to put a plate under the seat and mount the batteries and the fuel flow transducer on the plate. I'll modify the seat to allow access. We'll also make the tail fin support bracketry.

I purchased an entire cow hide on eBay that is supposed to be gray aviation leather. Once the brackets are welded to the frame I'll be about ready to have the frame stripped and powder coated. I want to pick the frame color after I get a look at the leather since I want to have the seat cushions made from it. Every time I hear a truck in the evening I run out to the driveway to see if it's the UPS guy with my leather. Everything hinges on powder coating my frame. Once that is done I can install pieces for the final time.

Juan Rivera



I'm going to mount my two Odyssey PC680 batteries under the seat to help keep the center of gravity in the ballpark. The batteries will mount on either side of the cyclic control rods (4.) The batteries will be secured on either side using the black brackets (1.) In addition to the batteries I will mount the fuel flow transducer (5) and the strobe light electronics (3.) The second battery will be underneath this chassis, partially hidden from view. The Andover fuel shutoff valve is the gray unit in the front (2.)

To allow access I'll modify the seat pan by adding a hatch and also cut holes in the bottom tray to allow inspection of hard to reach areas. Each battery weighs about fifteen pounds so the bottom tray will need to be very strong. In this picture I have an aluminum sheet clamped into position so I can fool with the component locations. The final bottom tray will only extend back as far as the arrow head on the left.

This particular project is going to take very careful planning. Clearance around the cyclic control rods is critical to flight so nothing can be allowed to interfere. I also have to consider how I'll do maintenance and inspection of these parts once the seat pan and cabin are in place. Everything will have to come in and out through the hatch in the bottom of the seat if at all possible. Otherwise I'll have to tear the cabin off and that's a huge effort once it's final installed.

CHANGE OF PLAN…

Hap Miller convinced me that I'd regret putting the batteries under the seat. They're too critical to hide in a hard-to-see location. I'm still going to put the shelf under the seat and install the fuel flow transducer and the strobe light electronics box there, but I rethought the battery location and came up with a different plan…

It feels like I've been working on this new battery box location for two weeks now but it's been slightly less than that. The new location is directly behind the top fuel tank. That introduces risks that I need to seriously consider…

The batteries I selected are the same ones that most Helicycle builders have chosen. They're sealed lead-acid batteries and they're about the size of motorcycle batteries. Each one weighs slightly more than fifteen pounds. That's a total of over thirty pounds that I have to contend with.

Here you can see the battery box temporarily held in position with clamps for this picture. My main concern is that they will be located above the tail rotor drive shaft. If they came loose and fell the helicopter might be so badly damaged that it would be uncontrollable. I certainly don't want to find out.

Here's a closer view. I've fabricated the bracketry for one side. Since the frame tubing is bent upward and inward at this location it was fairly tricky. The box is attached to two vertical pieces that are tapered six degrees towards the front side to account for the inward slant of the tubes. The vertical piece you see with the clamp across it will be attached to the plate below the clamp. Everything is fabricated from 6061-T6. The side bracket is ¼" plate and held in place with four Adel clamps. That should give me redundancy in case a clamp or the attaching hardware fails in flight. To keep it from sliding back down the frame I've straddled the spider area where the lower three tubes attach to the top tube.

In this picture you can see one reason that a milling machine is much better than a drill press. Because the side panels slope inward at about six degrees I have several pieces that are machined at that angle. The three bolts that secure each side piece are an example. With the milling machine I was able to tilt the head and drill the holes and counter-bore the area under the bolt heads.

Here you can see that the side plates slope in towards the front. Even with temporary hardware only finger tight the box is completely rigid. With a total of 8 Adel clamps securing it to the frame it isn't going anywhere. (I only have 4 clamps on for the picture.) When it is final-installed all the hardware will either be secured with locking nuts or with 242 Loctite.

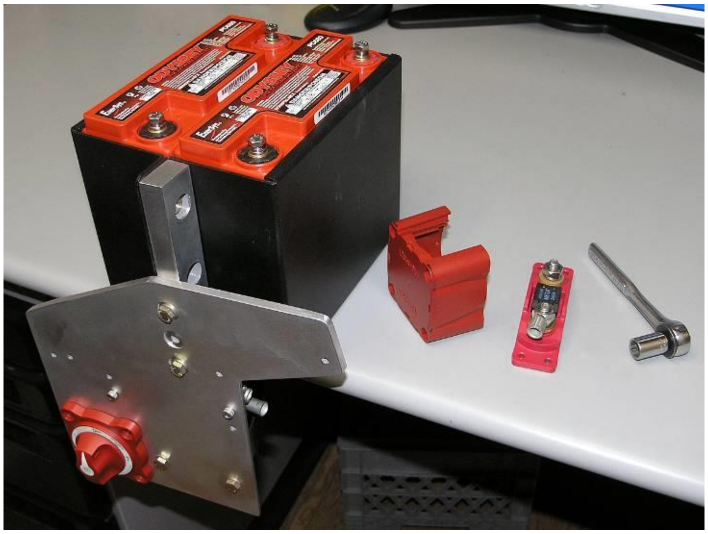
My plan is to mount the battery master switch, a 200-Amp fuse, and the starter solenoid on the right side plate. That will keep all of the high current wiring very short and the result will be maximum voltage to the starter and minimum loss in the wiring.

HALF-WAY POINT!

I've been working on the Helicycle for seven months and averaging at least 20 hours a week. I took the frame to be powder coated two days ago and sent my leather and seat foam back to Eagle R&D to have them make my seats. Once I get the frame back I can finally start installing components for the final time. That will be a huge step for me. I can't wait to get started!

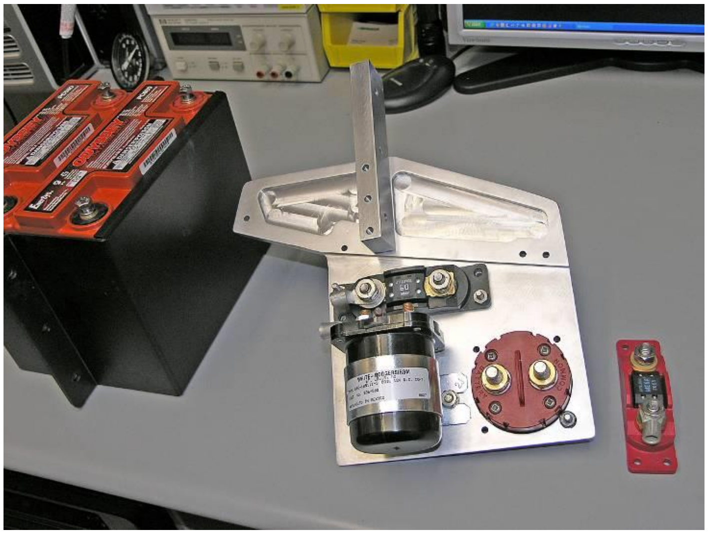
While I'm waiting for the frame to be powder coated I'm polishing my skids and finishing the battery box and high-current DC power wiring. I'm designing this as I go.

Juan Rivera



Here's a shot of the right hand panel with the master DC power switch in place. I've milled out material from the back side of the plates to lighten the assembly.

The battery master switch is manufactured by Blue Sea Systems. It's a higher quality switch than the one that comes with the kit – and it looks much nicer.



This is the inside of the plate showing the 60-Amp fuse that will protect the DC power cabling to the instrument panel. To the right is a 200-Amp fuse and holder that will protect the battery from a catastrophic short circuit. I'll mount it as close to the plus battery terminals as I can. The black cylinder at the lower left is the starter solenoid. The idea here is to concentrate all of the high-current components and wiring close to the batteries and the starter. This will minimize IR losses.

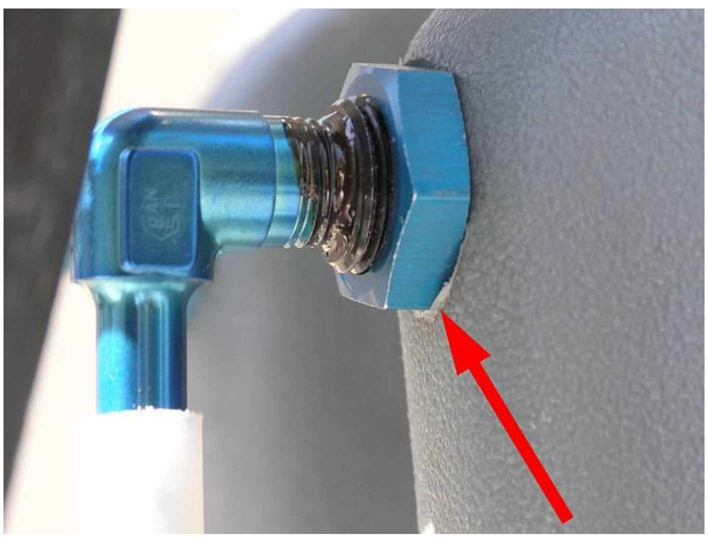
I still need to design and fabricate several things at the top of this assembly. I want to make two copper bus bars to tie the two batteries together. I'll need to find a source for copper. I'll also need a piece that will span across the top of the batteries to mount the 200-Amp fuse and support the battery cabling. I'm also thinking of using this assembly to support the top strobe light.

I'll be working on all of these little mini-projects while I wait for the frame to get powder painted. I've selected TGIC (Triglycidyl isocyanurate) powder which is a thermosetting resin – one of two classes of powder coatings. TGIC powders have great adhesion characteristics, corrosion resistance, and exterior durability. They can be cured at lower temperatures than urethanes and have shorter cure cycles. They also provide good edge coverage – all good characteristics for this application.

The frame is now powder coated as you see here. Finally I can start final installation of components! It’s taken seven months to get to this point.

The first order of business is to install the main tank and check it for leaks. It’s held in place by four o-ring sealed custom threaded studs that you install from the inside by fishing them through the fueling port with a piece of safety wire. Then you torque them down with a brass nut and use a dab of Loctite 242. And finally a second nut is used to back up the first one. I finished that installation about 1:15 AM this morning. I was so anxious to get going I couldn’t stop.

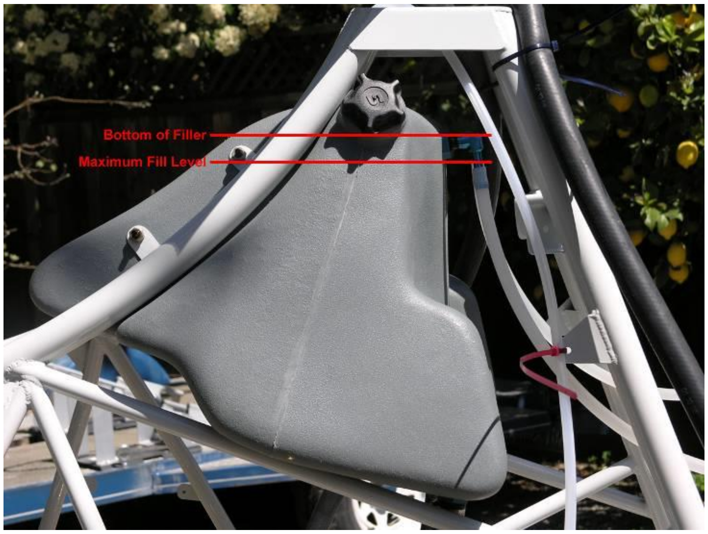
This morning I moved the frame around the side of my house into a gravel area and filled the tank with gasoline to the brim using an automotive fuel pump. The picture shows how I looped long lengths of washing machine hose from the bottom drain fittings back above the tank to seal them off. I also tied the two breather fittings at the top of the tank to each other using a length of polyethylene tubing. The tank took about seven gallons to fill.



Both of those breather fittings at the very top of the tank were seeping so I drained a small portion of fuel to get the level below the fittings. I thought they might leak since there really isn’t enough room to install these fittings. These were part of the factory upgrade kit but the newer tanks must be slightly different.

I don’t see a way around this problem. There simply isn’t enough of a flat area to form a seat for the o-ring on the inside. Lowering the fuel level about 2-inches below the filler port gets it below these fittings so I really don’t consider this to be a huge problem. I’ll give the tank three hours sitting in the hot sun to make sure there aren’t any more leaks but so far it looks good. The through-holes that absolutely have to be tight are the four attachments that secure the tank to the frame and the two lines at the bottom that feed the two lower tanks. If the tank makes it through the next three hours I’ll drain it and install the transmission and the top bearing.

Juan Rivera



The top red line is the maximum that you can possibly get into the tank without it sloshing out. And the second red line is the maximum level I can safely fill to without developing a slow leak. I think I'll make a placard showing this level just to be safe. In practice I doubt anyone would fill the tank to the very brim but its better not to take chances.

Well, just as I was about to begin installing my transmission I remembered that I still needed to seal off the main shaft with a wooden plug to keep water from accumulating inside the shaft. After a short search I found a suitable piece of lumber. Let's just say that I'll have to stoop a bit next time I mop.

This little Sherline lathe has sure come in handy. The head can be swapped out to a milling bed but now I have the Grizzly so I never do that anymore. Anyway, I turned the piece of mop handle down to a snug fit for the main shaft…

Next I gooped the plug up with a two-part epoxy called J-B Weld…

Inserted it into the main shaft and pounded it down…

And here’s what it looks like after I carefully cleaned off the upper part of the shaft using Acetone.

Now I can finally install the transmission and the top bearing assembly!

I use a Genie Lift to hoist the transmission. I have to clamp a 2x2 to the platform so I can extend over the main shaft as you see in the picture to the right. Right now the helicycle is tail heavy so I weigh the front down with a can of ground glass. Since the Genie Lift can only go so high I have to make the lift is several stages. In this picture I’ve lifted it off of its mount and then set it down on the white stool and reset the lift. Now I’m raising it up from the stool.

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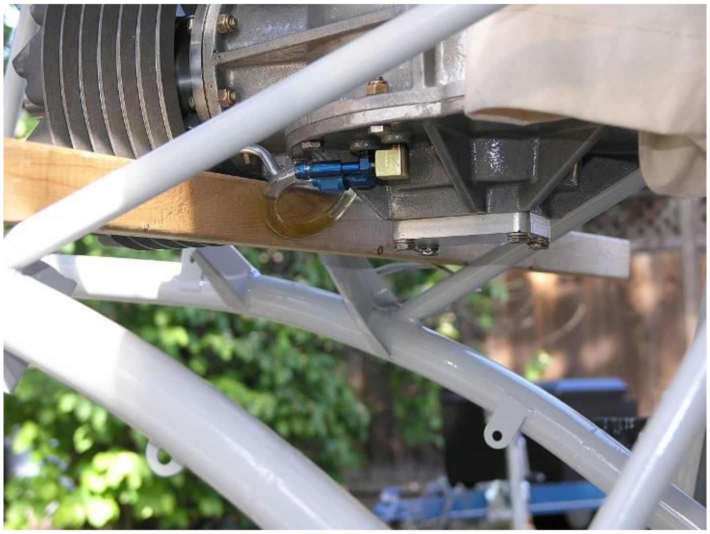
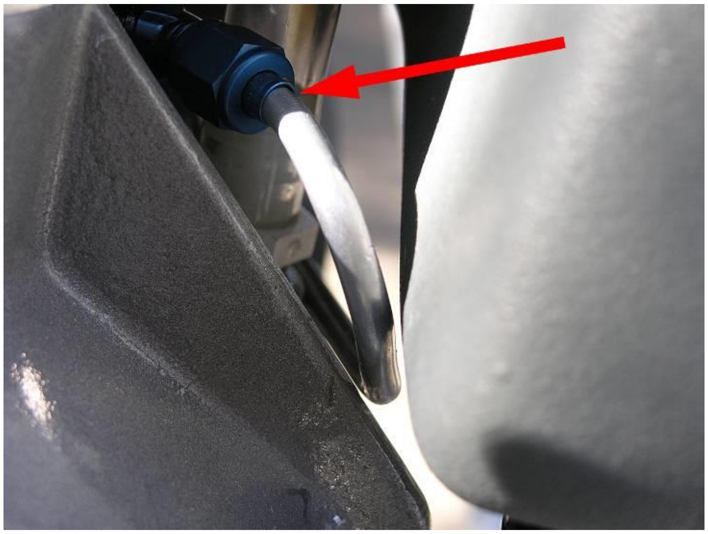
Now I've made it to a point where I can slide a 2x2 into the frame to hold it for another reset on the Genie Lift.

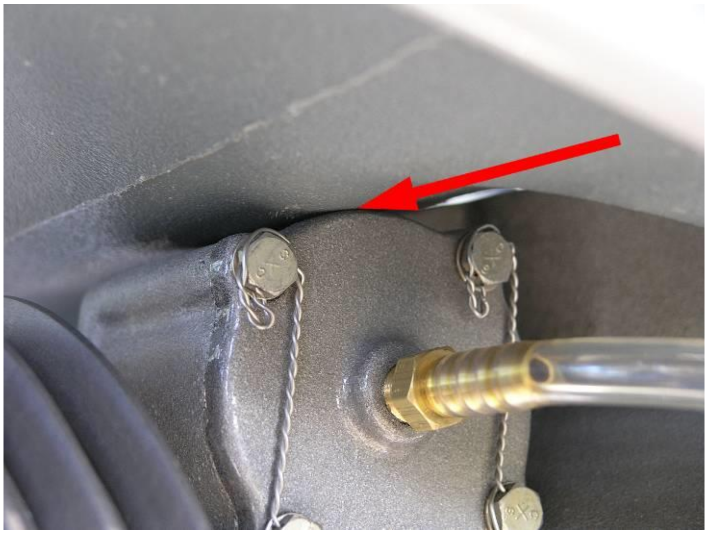


It's a very tight squeeze as the transmission is lifted towards its final position so I have to be very careful not to break an oil line or scrape the anti-corrosion finish.

As I mentioned, everything is a very tight squeeze so proper prior planning is a good thing. Fortunately I was able to squeeze the top bearing assembly past these fittings.

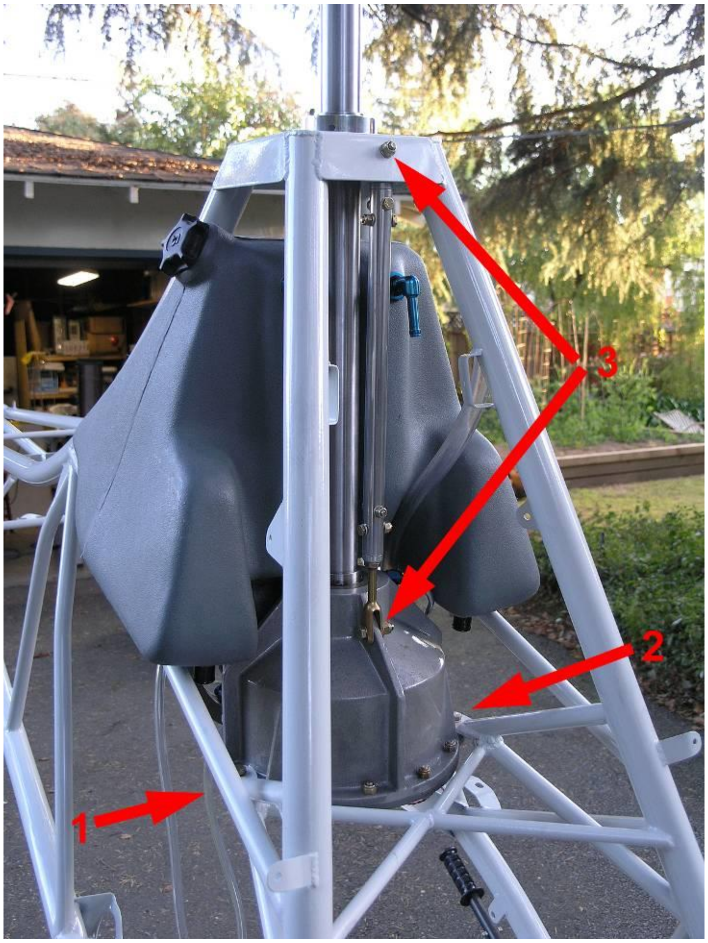


When I fabricated these oil lines I didn't count on a clearance problem here. This line has to squeeze between the transmission case and the top fuel tank. When I bent it out of the way the bend all happened right at the fitting. I'll have to remember to keep a close eye on this and make sure it doesn't leak. Maybe I'll replace it after I have a rest…



The transmission oil filter housing is pushed up against the bottom of the top fuel tank now that I have everything in place. I'm not too crazy about this but the tank also squashes against the frame on both sides so perhaps this is normal. I'll have to check into this…

With the transmission secured into position the main shaft is perfectly aligned with the mounting hole for the top bearing in the Bonnet. Months ago one of the first things I did was to tweak the transmission mounts with a large "persuader" so that there wouldn't be a side load on the top bearing and undo stress on the transmission mounts. I think this came out perfectly. Tomorrow I'll mount the top bearing.



Here's a picture of the top fuel tank and the transmission installed for the final time (I hope!)

The transmission mounts to the frame in three places. The housing mounts at #1 and #2 and a vertical strut (#3) completes the mounting. The helicopter is suspended from these three points in flight. The main rotor lifts the rotor shaft, the rotor shaft lifts the transmission via an internal thrust bearing, and the transmission case lifts the helicopter.

It's taken two full days to get to this point. Tomorrow I'll start mounting the transmission oil cooler. It's an automotive after-market unit that Hap Miller sells along with the very nifty vertical transmission mount. Hap's is much nicer that the factory version which I think we are supposed to make out of a piece of chromoly tubing by heating the ends and squashing them flat. I had the oil cooler painted gloss black. It'll look slick against the light gray frame.

Tomorrow I'll also stick a dab of Torque Seal on the nuts so I will notice any tendency towards loosening. I don't think most people bother with this but I'm in favor of taking every precaution I can and this is an easy one.

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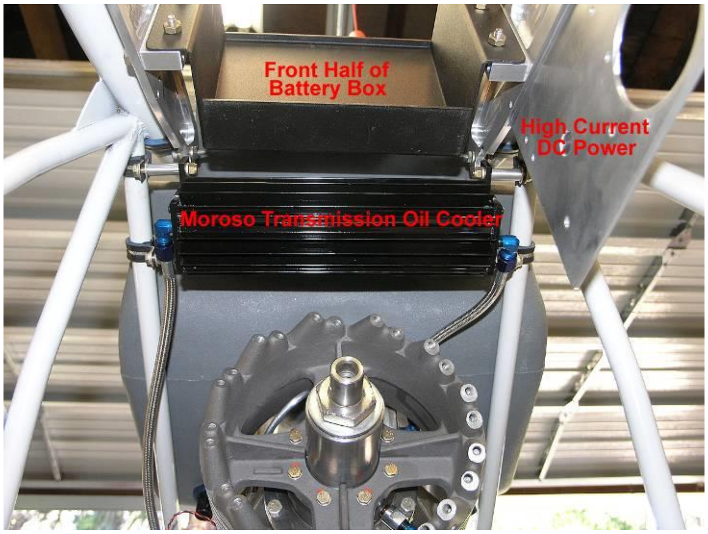
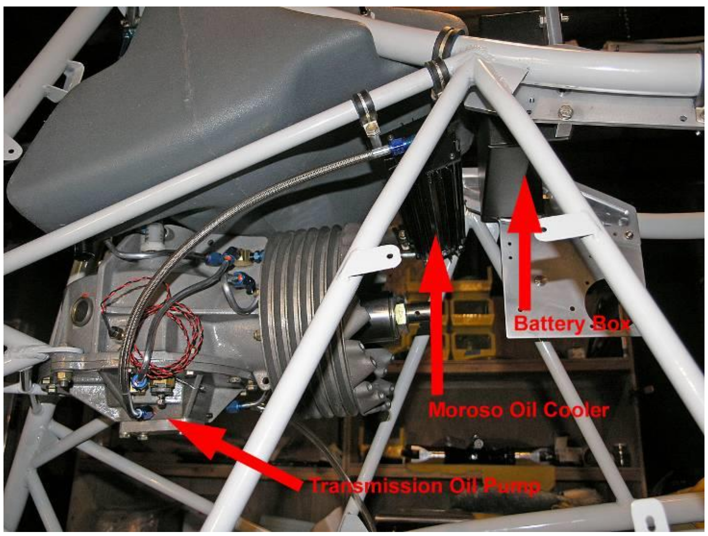
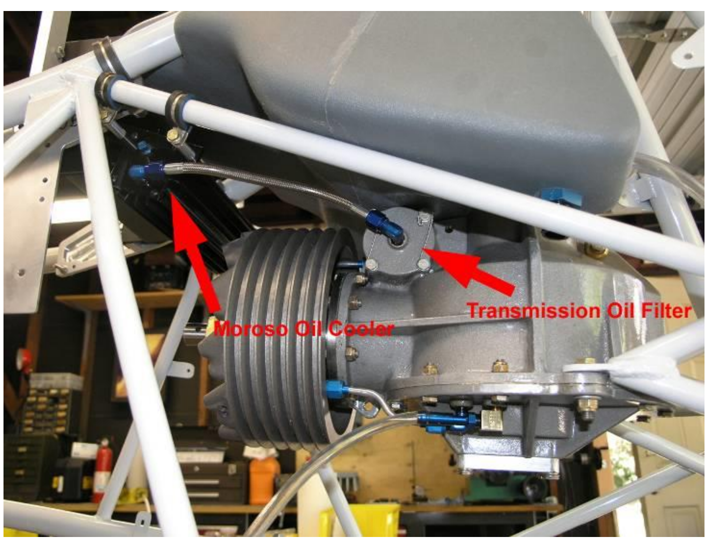


I've installed the Moroso oil cooler temporarily along with the battery box side plates and the front half of the box. This picture is looking forward from below. The tail rotor drive shaft is driven from the transmission shaft at the center of the gray pulley.

The Moroso oil cooler is a stock item that Hap Miller modifies for the Helicycle. It's normally bare aluminum but I decided to paint this one gloss black.



Here's a view from the left side…

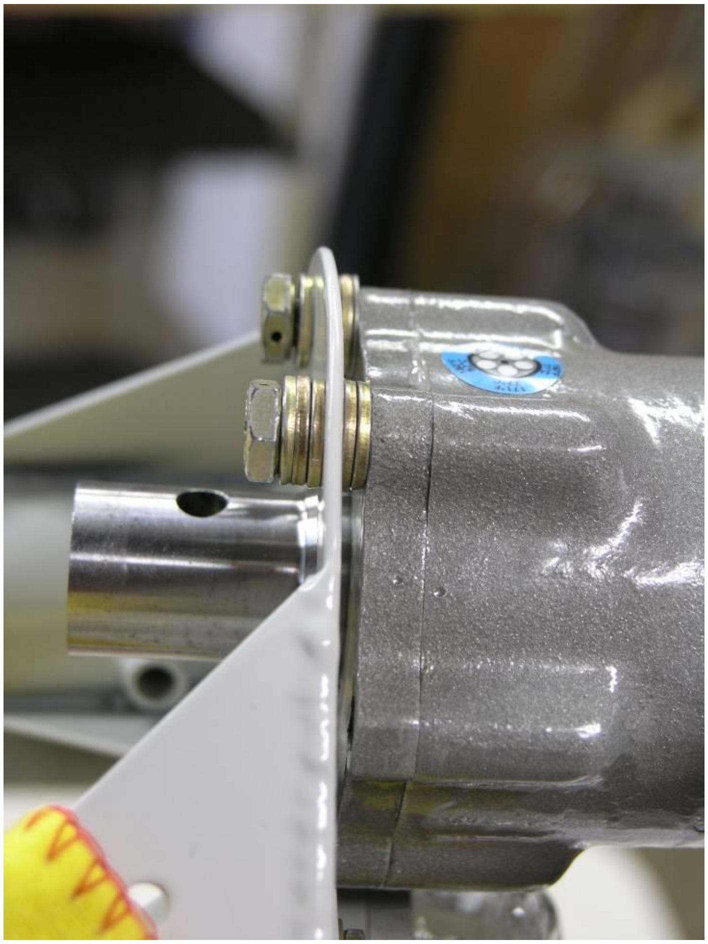


And here's another view from the right side.

Once I have the battery box assembly completed I'll have it black anodized. I have a bit more to do yet…

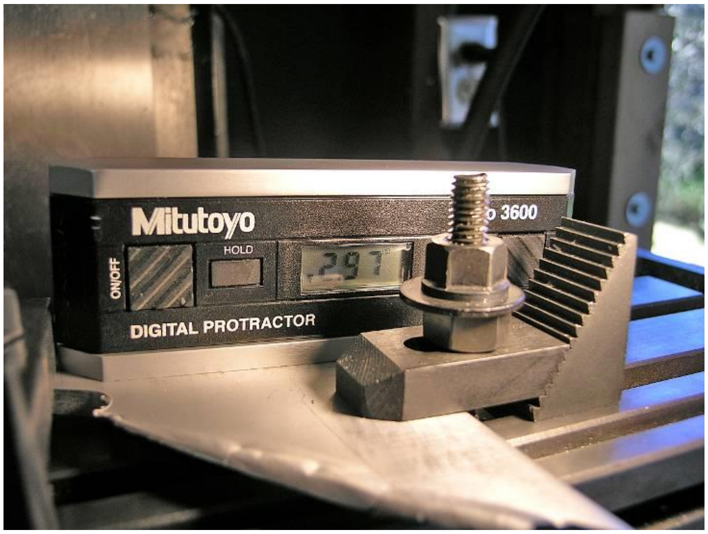
Here's something I need to attend to. The main shaft barely clears the garage door. I can't get it in with the ground handling wheels attached. That means I have to drag it into the garage and scrape up my skids. Once it gets a tad heavier that will no longer be an option, and once the rotor head goes on it will stick up even further.

I think I'll have to cut out a section of this header but it looks like a structural member and I don't want the garage to collapse on my Helicycle. One more little side project to deal with…



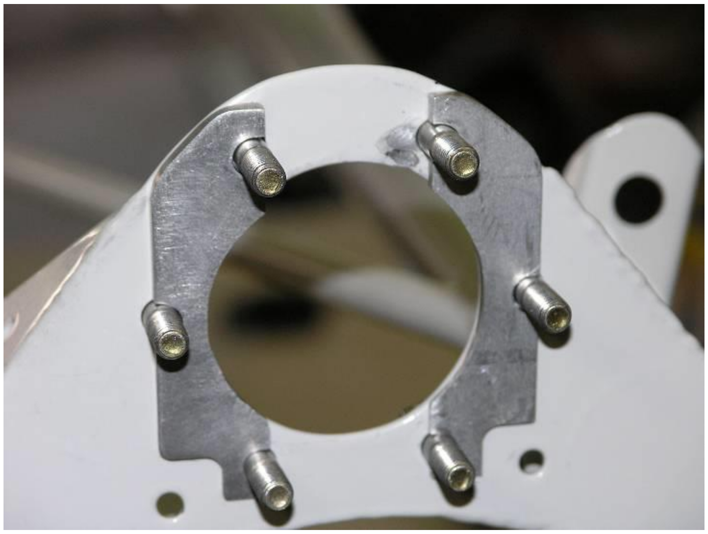
Time to change projects… Now that the transmission is mounted I can install the tail rotor gearbox and the driveshaft. The first order of business is to line up the gearbox shaft so it's pointing directly towards the transmission shaft. I need to do this so that the gearbox coupling runs true and true.

I fabricated a bushing so I could insert a laser that's normally used to align gun sights into the gearbox shaft. I found that the gearbox mounting plate was way off. Initially I was going to use stacks of washers to shim the gearbox as I described earlier and as you see here. I decided that this was a crude solution for two reasons – I couldn't make a stack of washers the exact thickness I wanted, and wedge-shaped shims are really what are called here.

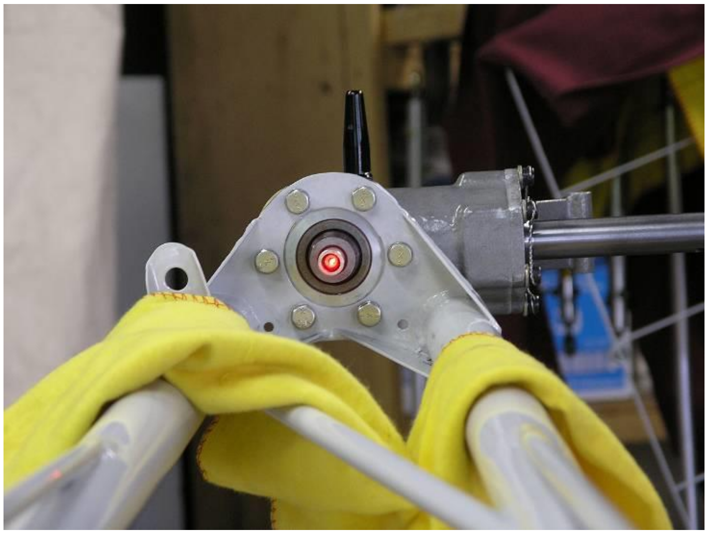


After determining that I needed a shim that was a 3 degree angle I grabbed a scrap piece of 6060T6 aluminum and clamped it down using a drill that could be rolled under one end of the piece to get the angle I wanted. 2.97 degrees should be close enough. I sure love this digital protractor…

Making myself a 3 degree wedge-shaped piece proved to be the easy part. From this piece I cut two blanks for the two sides of the gearbox. In this picture I'm getting ready to cut the wedge from the larger piece of scrap.

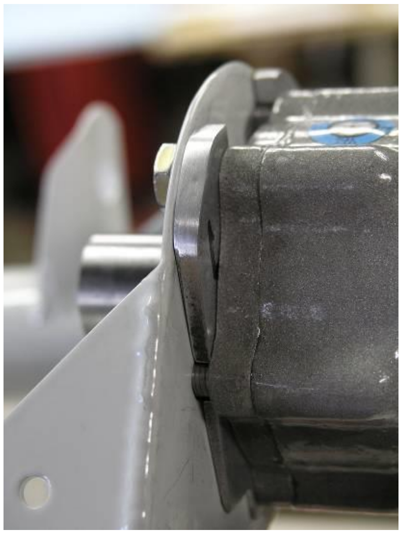


After many more hours of shaping the shims to clear the bolts and the tail strobe light I ended up with this. These shims can't possibly come loose since they are held in place by the bolts on either side.



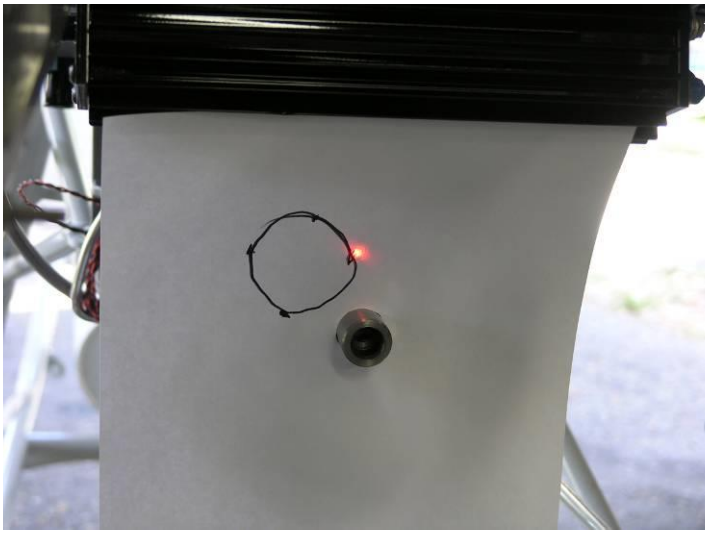
Now it's time for an alignment check with my new shims. As I mentioned, the laser fits inside of the gearbox shaft.

The rags are to keep me from banging up my new paint job while I'm screwing these bolts in and out with a ratchet.

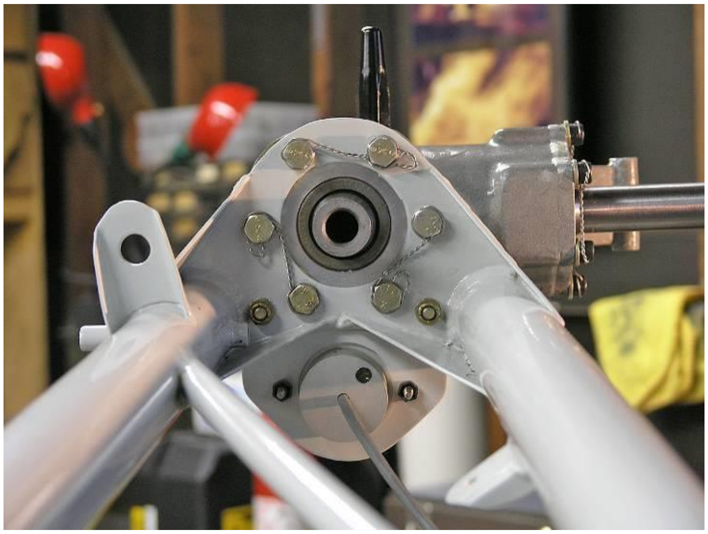


This is what the shims look like in place. They took care of the vertical misalignment of the mounting plate, but the plate is also pointed to the left. That left mw with two choices – either reduce the thickness of the left shim by about 13 mills or increase the thickness of the right hand shim. I had some .010" brass shim stock so I made another shim out of the shim stock and sandwiched it on the right side.

I'll need to get three different length of AN bolts drilled for safety wires to finally attach the gearbox for the final time. Once that's done I can start on the tail rotor drive shaft.

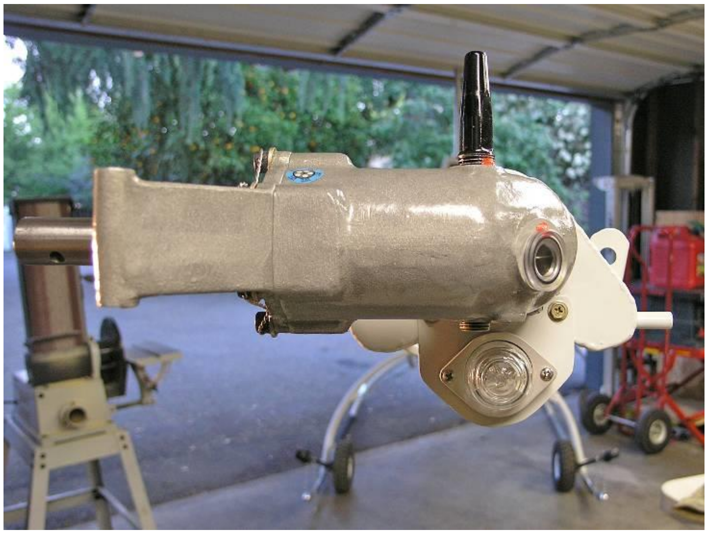


For my target I cut a shaft sized hole in a piece of paper and attached it to transmission shaft. Since the laser isn't exactly bore-sighted down the axis of the gearbox it makes a circle when the gearbox shaft is turned. The center of the circle represents the true direction. It's off about 2-inches, but at a distance of almost eleven feet that's pretty good, and way better than it was. I can torque the frame by hand enough to move the dot an inch or two so there isn't much reason to improve on this.



That's it for the tail rotor gear box. I used three slightly different sized AN bolts to account for the thickness of the shims. Some already had safety wire holes and some I had to drill using a jig made for the purpose. The next project will be to install the tail rotor drive shaft.

That's my rear strobe light under the gear box.



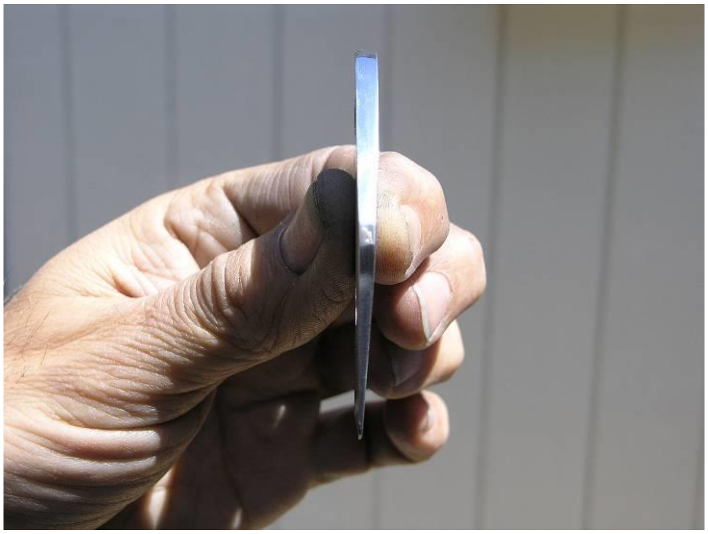
Here's a view from the rear. The blue circle at the top of the gear box is a temperature sensor. It has five small white dots that turn black when the rated temperature is reached. This particular one spans a range from 140°F to 180°F. There in another one over the input bearing. I'll check these after each run to make sure the bearings are not overheating. You can see the lubrication sight gauge on the right side showing that the gear box is half full of oil.

Oh oh!!! Once I began looking at the tail rotor driveshaft I realized that what I thought was an acceptable error on the gearbox alignment was actually too far off. So I cut the safety wires, pulled out the shims, and started over. With the gearbox mounted to the mounting plate without any shims the alignment was completely off – not even close (see picture.) The laser should be shooting right across the top of the two pieces of paper I have clamped to the bearing mounts and hitting the center of the transmission shaft.

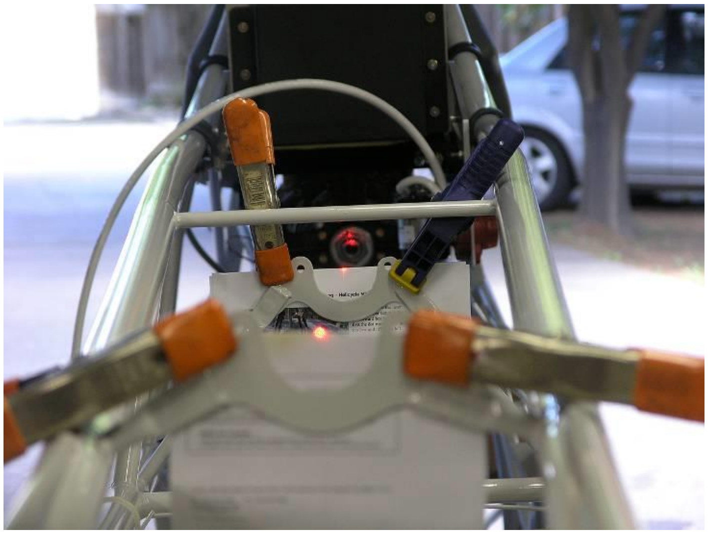
Juan Rivera

To improve over my last effort I needed to reduce the overall thickness of the shim on the left. That meant that the gearbox needed to tilt up and to the right, resulting in the need for a shim that tapered in two dimensions. After the experience of making the last pair of shims I thought I had developed enough experience with my mill to give it a try.

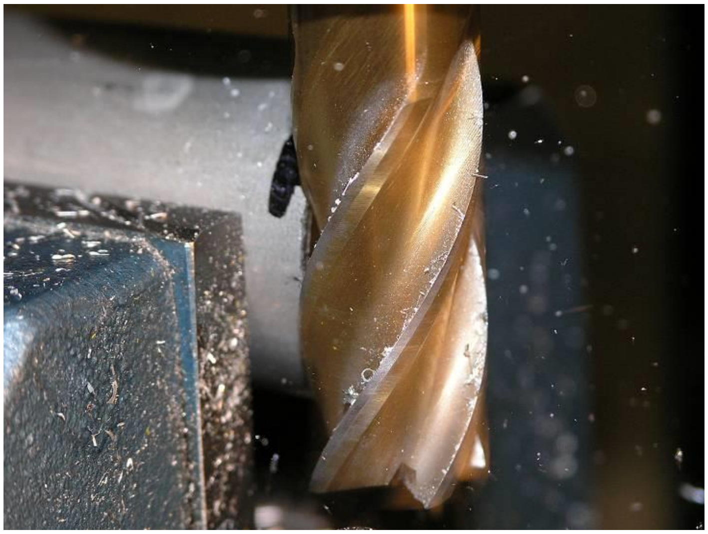
Here's the top view of the new shim showing the taper in that axis.



And here it is rotated 90 degrees. This shows the taper in the vertical axis that will tilt the shaft up.

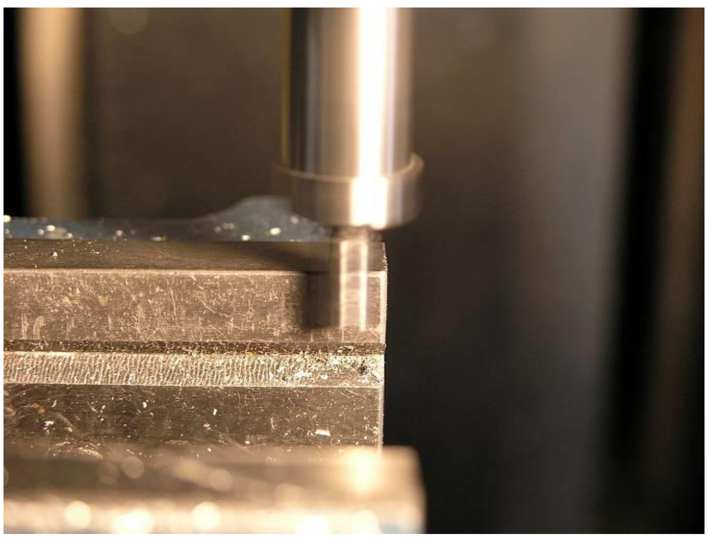


Now I'm happy. You can see the laser just skimming the top of both pieces of paper and hitting right at the top of the transmission shaft. Way back when the frame was being brought up to the current configuration to handle the turbine engine I ground one of those brackets off and replaced it since the old one was so far off. Everything should go smoothly from now on – the brackets are properly lined up and the tail rotor gearbox is dialed in now.



I had to replace all of my tail rotor drive tubes since the mounting holes were completely unacceptable. Three previous owners have had their hands in this kit and I've come across many parts that were butchered by bad workmanship. A word to the wise – be careful if you're thinking of buying a used kit.

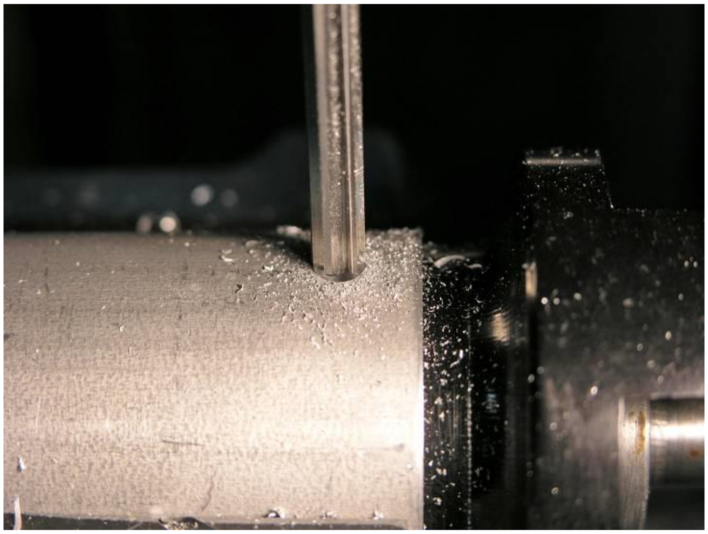
OK, back to business… The driveshaft is composed of three sections coupled together with bearing blocks, and at each end is a coupling. The first step is to cut one of the tubes to the approximate length. Last time I tried this I was using a belt sander. That was very crude. This time I used a ¾" end mill. It makes a perfectly square surface if you've lined up the vise. I support the tubing in the vise with a V-Block.



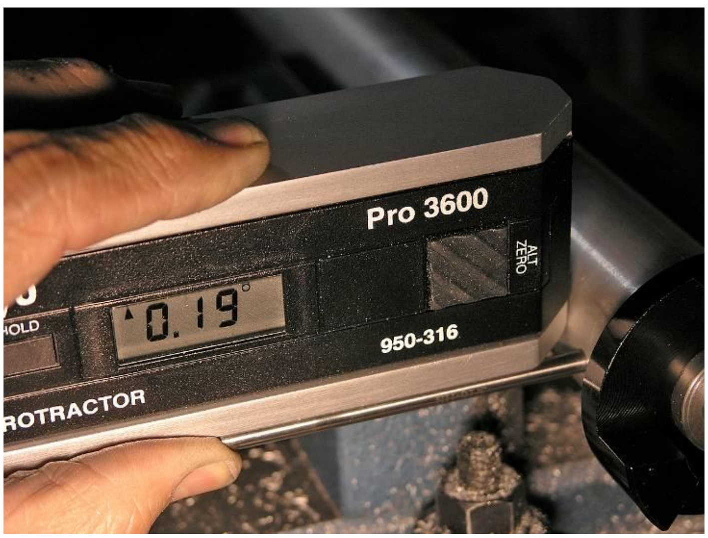
Once a tube is cut just slightly too long it's time to install either a bearing or a coupling, depending where you are. I started at the tail rotor and worked forward. The couplings and bearings are all mounted using two 3/16" AN bolts at right angles. Normally this wouldn't be too big a job but all of my bearings and couplings are already drilled with multiple cockeyed holes by a previous owner. By rotating the part 45 or 90 degrees I could drill a new set of holes, or I could try to match-drill the tubing to line up with previously drilled holes in the couplings or bearings. I did that a few times but it is very tricky since you have to take very precise measurements and hope you don't make a mistake. There is literally no room for error since the holes are supposed to be reamed and not drilled. This results in a very precise inside diameter. If everything goes the way it's supposed to the bolt will need to be tapped in with a mallet. Obviously the holes in the tubing have to line up with the bearings and couplings that fit inside.

My intent was to machine these two holes in the exact center of the tubing and have the two be exactly 90 degrees apart in rotation and one bolt diameter apart along the axis of the tube. The first step is to find the edge of the vise. I used a little gizmo called an edge finder. You chuck it in the mill and spin it. The bottom section is free to slide around as it is only attached with a spring. It wobbles around as you see in this picture until you come up against the edge. As you get closer and closer the edge of the vise slowly aligns the bottom part with the body. Eventually it is perfectly aligned and then… It pops off to the side! Don't ask why. I don't know. It's magic.

Juan Rivera



Once you've found the edge of the vise, and accounted for the thickness of the edge finder, you can move the mill's bed to position the tool directly over the center of the tube. Then I did the same thing for the other axis and started a hole 0.300" from the edge as you see. This only worked if I was not trying to match existing holes of course. I machined the holes in four steps – three drills of increasing size and then the reamer for a precise fit.



To align the second hole I placed the reamer in the first hole and rotated the tube until it was horizontal using my digital protractor to line it up. It was easy to get well within half a degree. Then I moved one bolt diameter up the tube and repeated the process. Once a bearing or coupling was installed on the end of a tube I could fit check it and mill the other end to the exact length I needed.

I took about a day and a half to complete this portion of the project. The tricky part is getting just the right amount of free play in the couplings at each end. I think I got close enough. Time will tell.

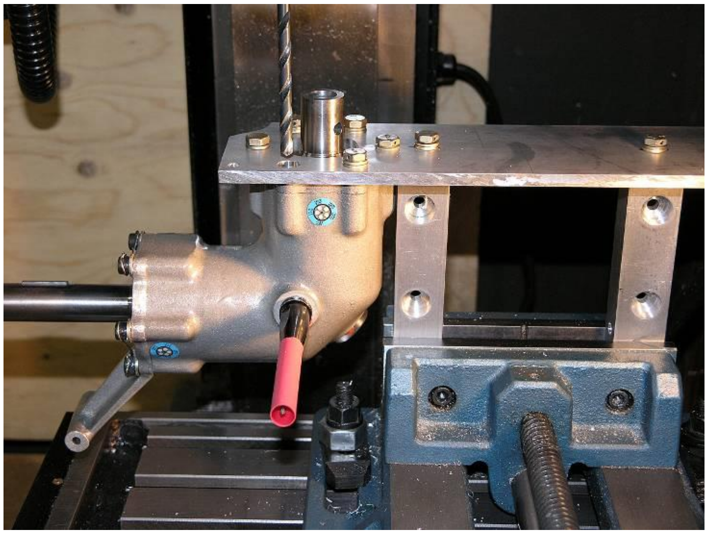
Here's a view looking forward showing the driveshaft. You can see the two bearing blocks. I'll have the bearings clamps chromed eventually. I also need to polish the tubing.

The next step is to check the alignment by stretching a string along the driveshaft and offsetting it at each end with spacers. Then the idea is to measure the distance to the string at each bearing and adjust their positioning to line the driveshaft up exactly. Once that's done I'll drill small alignment holes through the brackets and hangers so that I can always reinstall them precisely by lining up the small holes.

Now for a change of subject -- The picture below shows the VHF communications antenna ground plane. Now that it's painted I think it looks just fine. I am planning to attach it to the frame using 16 large tie-wraps. That should provide plenty of attachment redundancy and if a few break during flight and end up in the tail rotor they shouldn't do much damage.

I haven't been mentioning the date for a while. Today is April 12, 2009. I've been working on the project for slightly more than eight months now. I've probably averaged at least 20 hours a week which would put me at about 650 hours or so. That seems about right.

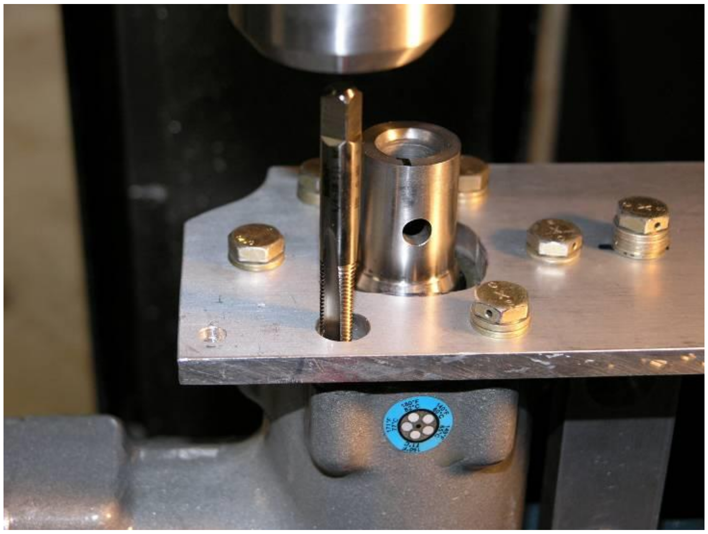
I almost forgot to mention that in the process of bolting and unbolting the tail rotor gearbox I managed to strip one of the bolt holes in the gearbox. I wasn't paying attention and I used one of the shorter bolts at the top where the shims were the thickest. Now I'll have to install a Heli-Coil in that spot. I may elect to install them in all six locations.



April 17 -- I put off tackling this stripped threads problem for a week because I didn't want to risk drilling out the threads using a hand drill, and I couldn't decide how to mount the gearbox on the mill. It's an awkward shape. This evening it came to me. I made this jig from scrap and clamped it into my vice. Now I can precisely locate the chuck over a hole, lock the bed in place and then all of my operations will be centered precisely. I stuck a small drill into the vent hole to prevent oil from leaking out and covered it with that red tubing so I'd remember it was there and not stab myself.

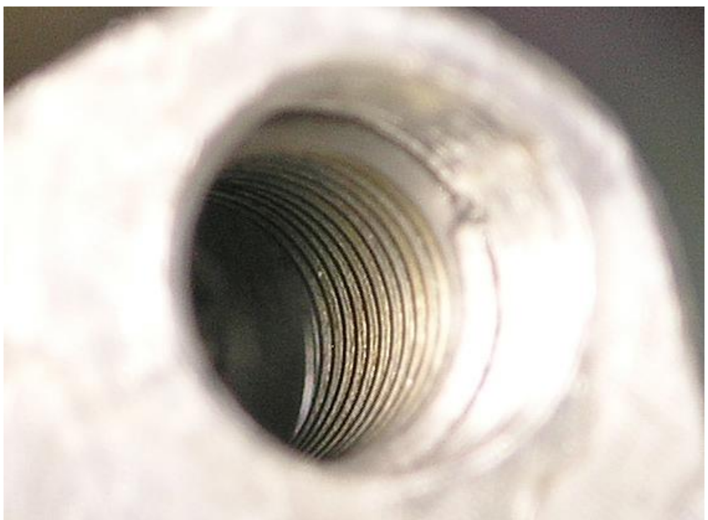
Here's the Heli-Coil kit I purchased. It has three different ½-28 insert lengths to choose from and includes a special drill and tap as well as the insertion tool and a rod to break off the tang.

The finished threads are superior to the original threads for a number of reasons. They're routinely used when screw threads are required in aluminum. For example, the Boeing 747 has over a quarter million inserts as original equipment. It's a very clever product.



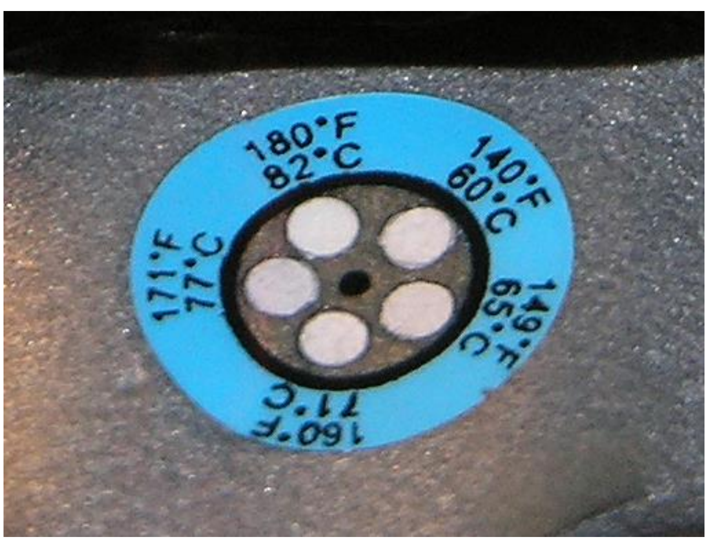
I first drilled out most of the threads using a ¼" drill, and then finish up the hole using the Heli-Coil drill. Next I chucked the Heli-Coil tap, lowered the speed way down and let the milling machine start the tap into the material. Once it was started I finished the tapping by hand so I could feel the bottom of the hole.

Don't be misled by the off-center hole in that jig. The tap is lined up exactly with the stripped threads. I just eye-balled those jig mounting holes and this one is off slightly.



Once the shavings were cleared from the tapped hole I selected the longest Heli-Coil length of the three choices and ran it down past the cover plate and into the housing using the installation tool.

Once in place the tang is broken off by inserting the rod and giving it a sharp tap. That's all there is to it.



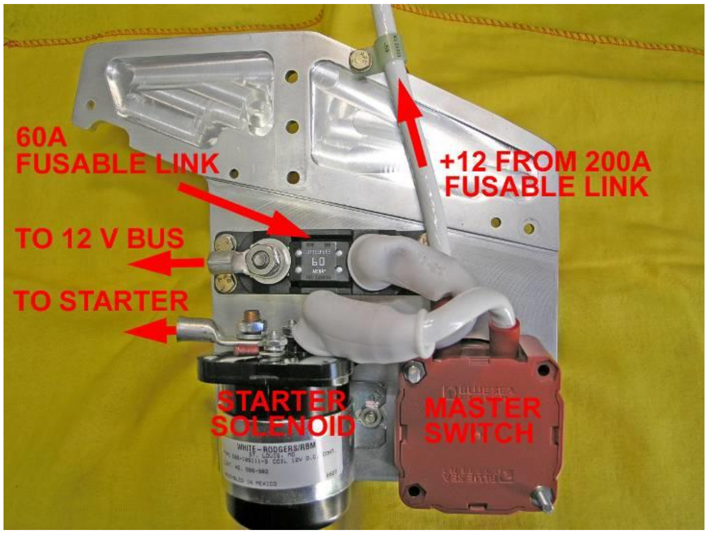
While I have the gearbox out, here's a close-up of one of the temperature indicating labels that I've placed over the bearings.

Once the temperature marked next to a dot is exceeded that dot will permanently turn black. This will allow me to keep an eye on the maximum temperature those bearings see.

April 17 -- I finished installing Heli-Coils in all six positions on the tail rotor gearbox. I set that aside while I wait for another shipment of bolts from Aircraft Spruce. While I wait I returned to the DC distribution and the battery box.

I borrowed a crimper from work that will handle #2 and #4 AWG terminals and I've been wiring the various components together using those two sizes of wire. The high current path through the starter circuit and back will be wired with #2 and the feed to the twelve volt bus will use #4 wire. There will only be one common ground point on the helicopter – at the starter. This should be the only chassis ground. All other ground return will go to an isolated ground bus in the instrument panel, and from the ground bus, via #4 wire it will return directly to the battery box. Using the frame as a ground return is now considered bad practice in military and jet transport aircraft.

My wiring is simple; the two batteries are paralleled and the +12 common goes directly to a 200 amp fuse. This is my ultimate protection against catastrophe should a major short develop such as a shorted starter motor. The link will protect all the wiring downstream from the battery.



This is the back side of the right hand battery box mounting bracket. The output of the 200 amp fuse feeds the master switch. The output of the master switch is fed to the starter solenoid and also to another 60 amp fuse. The output of the 60 amp fuse will feed my 12 volt bus in the instrument panel. Everything coming off of the bus will pass through a circuit breaker and then a switch.

I have preliminary drawings that are accessible from my main Helicycle menu. There will be a few changes but I think the basic configuration is still valid.

After weeks of working on this particular project I'm finally ready to fit check the assembly with the batteries included.

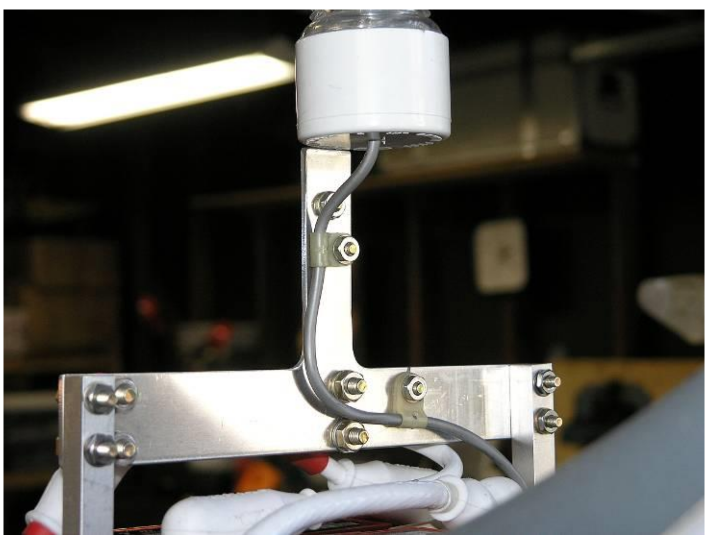
This assembly contains a lot of stored energy and it needs to be takes seriously, regardless of how many fuses I have. It's also too heavy to mount without some help. Fortunately my Genie-Lift came to the rescue again. I just clamp a 2x2 on the tray and hang the load at the end where I can move it over the center of the frame.

Here's the almost completed assembly finally sitting in the frame. I still have to cut off the two vertical rails to length and mount the top bracket that holds the 200 Amp fuse and the top strobe light. I also have to remember to fabricate one small piece. Then I'll take everything down to the plating shop and have it black anodized.

I've got twenty feet of #4 wire headed this way from Aircraft Spruce. That will be used for the hot and the ground return lines from the side panel to the +12 and ground buses that will be located in the instrument panel. The 2 gauge wire is about $5 a foot and I can't determine how much I need because I don't have my engine yet.

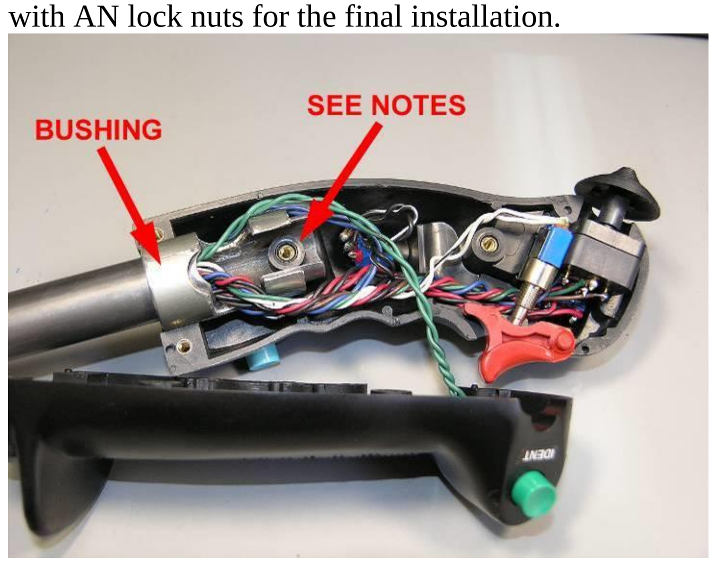
I'm planning on enclosing the cabling in a Nomex protective covering called Roundit.

Here's a picture of a sample of the Nomex version of Roundit. It comes in several sizes and it's manufactured to spring back into a tubular shape once you install the cables. It's manufactured by a company called Federal Mogul. Each size can be filled until the white tracer shows. When you see the tracer you know it's filled to capacity. Each size has an overlapping range it can handle. You can get the idea by seeing where the white tracer is in the empty closed portion as apposed to the open end I'm holding.



I'm slowly working my way up to the top plate. Here's a picture of the front side. I milled material off of the top of the two vertical rails and trimmed the top plate down close to size. A few last minute tweaks and everything will be ready to anodize. The top strobe light cable will be secured using MS25281 nylon cable clamps and all of the regular nuts will be replaced with AN lock nuts for the final installation.

April 19 -- I'm gathering up all of the items that I want to have chromed. I'm also ready to take all of the battery box pieces to have them black anodized.

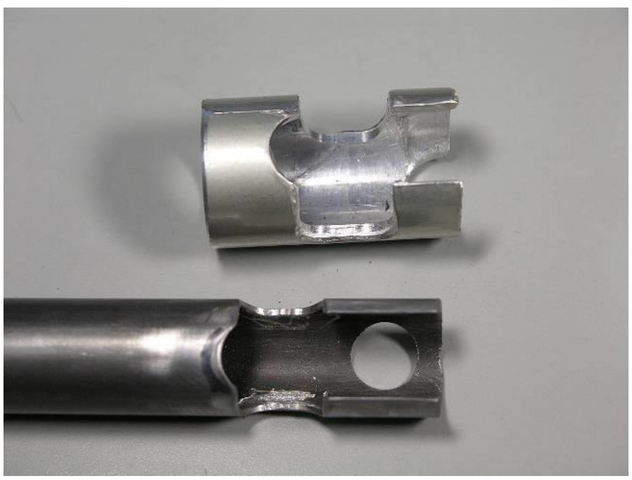


Juan Rivera

I need to cut the cyclic control tube to length before I make my run to the chrome shop. I'd already prepped the top end of the tube as you see here. I had to fabricate a complicated bushing. The first step was to cut the inner and outer diameters using a lathe. Then I used the mill to cut all of the slots you see. The two halves of the cyclic control are held together in four places where you see the threaded brass inserts. The second red arrow points to the piece that locks the grip to the tube. There is another identical stud on the other half of the grip and they come together to for a post that runs from side to side. The grip can't slide off the top because the two halves of that piece go through a hole in the tube. The two threaded inserts at the bottom of the grip squash the grip onto the bushing to secure it.

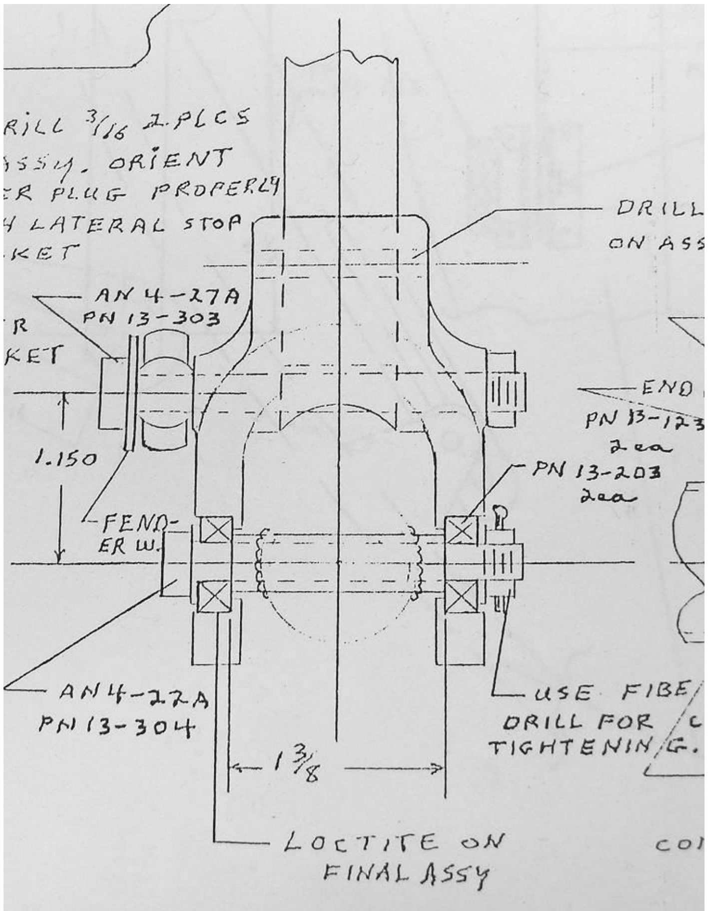
I mention all of this because the length and orientation of the cyclic grip is critical to flight. Most if not all helicopter pilots rest their right forearm on their thigh. Then you can move the cyclic very precisely by just moving your wrist. You don't normally yank and bank the cyclic like you might in an airplane, especially when you're doing precision maneuvering.

In addition to getting the length just right I need to get the angle of the grip correct. It will be rotated counterclockwise to line it up with the angle of my right arm while resting on my thigh. To get this right I'll have to take the grip off, cut the tube slightly longer than I think I need, reassemble it, install it in the Helicycle, and then sit in the seat and try it out. I'll have to repeat this process several times until I get it right (measure twice and cut once!) Once the length is correct then I can set the rotation and ream out the 3/16" and ¼" mounting holes. Once I have this piece completed I can toss it into the box of parts headed for the chrome shop.



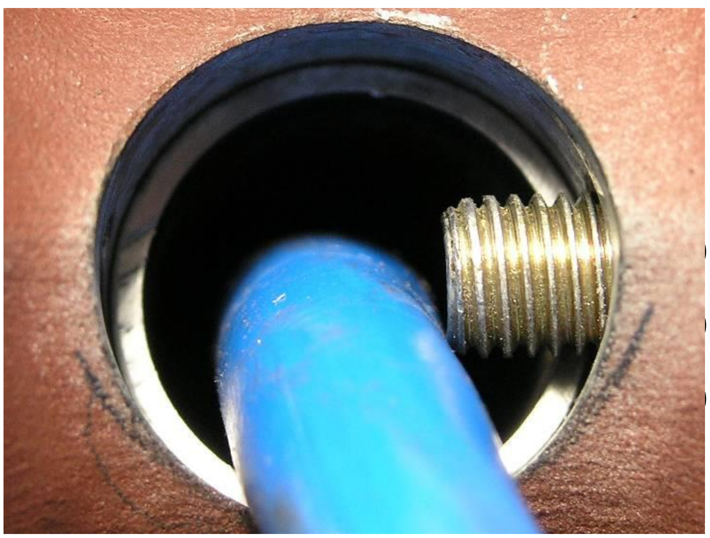
Here's another picture showing the top end of the cyclic tube and the bushing. You can see the hole in the top of the tube that prevents the grip from slipping off.

I've found that I get a better view of the small details when I look at a close-up like this. I didn't notice that I still have several edges that need to be deburred. I don't want to abrade the insulation on any of those wires.



Here's a detail from the drawing package. This is the casting that mounts on the bottom end of the cyclic tube. You see the tube coming down from the top. I cropped the drawing on the right a bit too much but at the top of the casting is a 3/16" bolt that you drill on assembly to secure the tube to the casting. Below that is a ¼" bolt that also crosses directly through the middle of the tube and attaches a control rod. Below that is a one inch tube that this whole assembly attaches to.

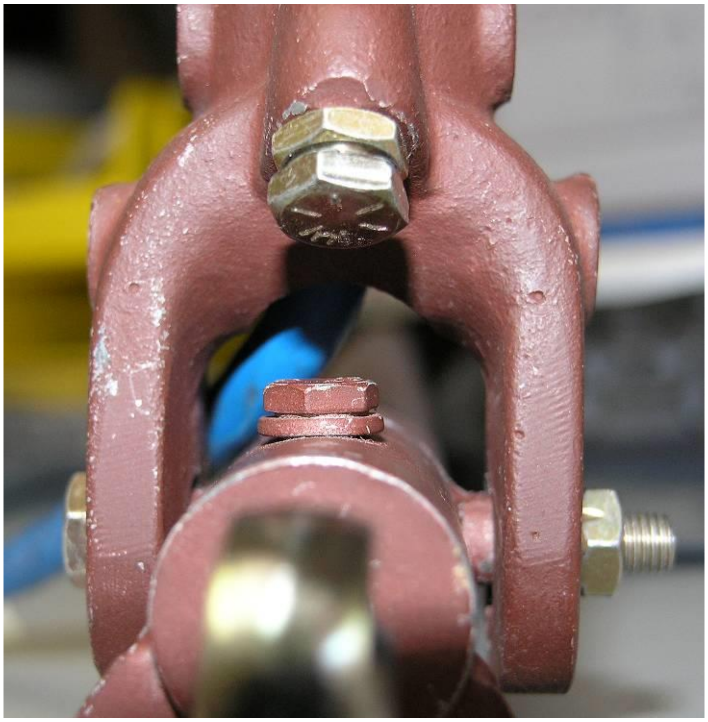
There's only one minor problem… The multi-conductor cable from the cyclic grip is too large to make it past the two bolts.



Here's a picture looking up the cyclic tube from the bottom, with the ¼" bolt pushed into its mounting hole.

It seems like I have several unappealing choices:

- Rewire the entire cyclic grip using smaller gauge wire (a smaller cable)
- Cut the jacket off of the cable and squash the wires around the two bolts
- Cut an oval slot in the cyclic tube before it reaches this piece and bring the cable out there, weakening the tube.



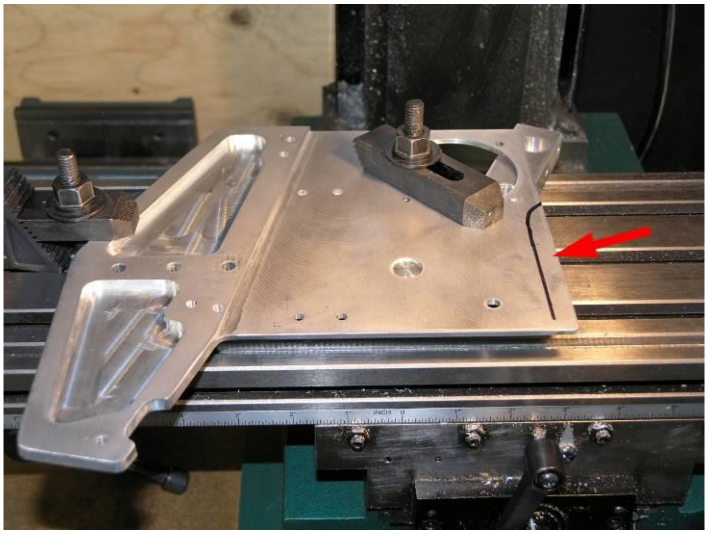
Here's a picture looking at the assembly from the front, with the tube and the cable coming down from the top. This piece rotates towards and away from the camera as you move the cyclic. Even if I get the cable past the two bolts (you can see the bosses where they mount towards the middle and top of the picture) the cable will be squashed in that confined space between the top piece and the tube it mounts to at the bottom of the picture.

It's time to ask the other builders who are using the Infinity grip what they did…

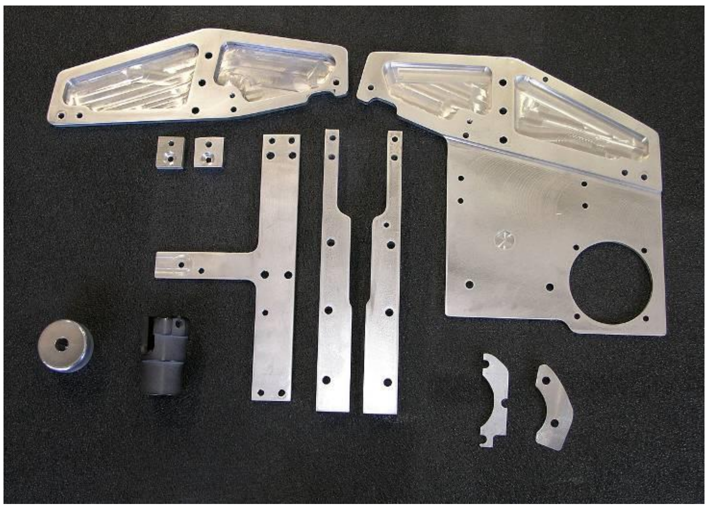
Hap cut the jacket back above the bolts and then sent half the wires down each side. I'd prefer not to remove the cable's outer jacket. I'll have to give this some thought.

Here's the 17 pieces I'll be taking to the plating shop tomorrow. Here's the list:

Rudder pedals and assembly
Tail rotor bearing brackets
Tail fin support tubes
Collective assembly
Collective friction slide
Swash plate bracket



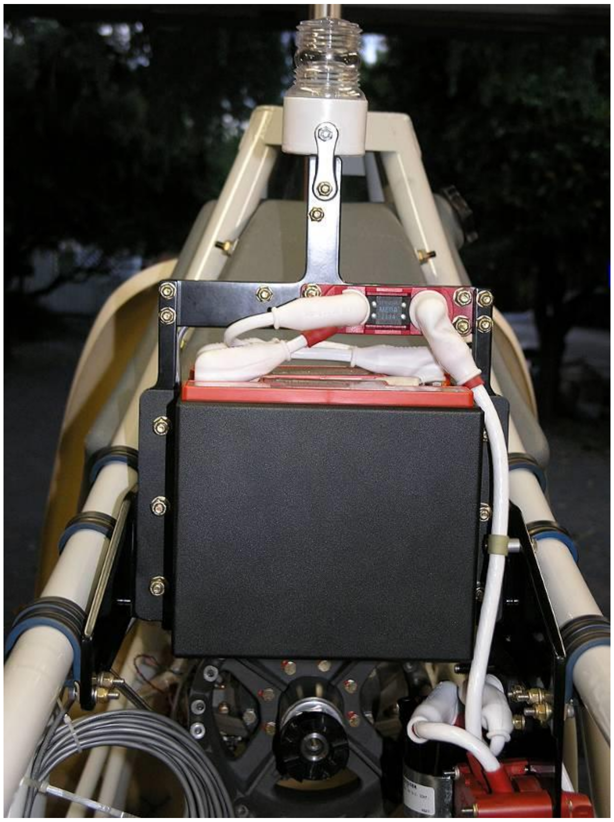
After comparing notes with Hap Miller I realize that the part of the left hand battery box plate that mounts the battery master switch, the starter solenoid, and the 60 Amp fuse is going to be very close to hitting the top of the engine gearbox housing. I pulled the plate back out of the pile of finished parts and milled this section off to add a bit more clearance. I had to modify the mounting bracket for the solenoid to move it up too. I hope this works. I have no way to know for sure because my engine has been sitting at the factory since last July waiting to get rebalanced.



Here are the battery box pieces after milling off that chunk at the last minute. I'm also going to include the two tail rotor gearbox shims, one part that needs to be stripped and re-anodized, and the friction knob for the collective.

Tomorrow I'll drop off both sets of parts. If all goes well I should get them back at the end of the week. In the meantime I'll polish my tail rotor driveshaft tubes.

April 21 – Change of plans… Gerry Nolan got me worrying about hydrogen embrittlement of 4130 chromoly if I chromed it. I had already taken that box of parts to the plating shop, but I started researching on the web and found that 4130 is about the most susceptible steel alloy there is. And the failure mode is catastrophic. The metal shatters because it looses it ductility and can't flex. After thinking about this overnight I went to the plating shop and recovered most of the parts. I'm still going to have the T/R driveshaft bearing clamps, the collective friction slider, and the pedals chromed since they are not subjected to much stress. I chickened out on the collective and the cyclic even though they aren't subjected to any appreciable stress either. Instead of chrome I'm having everything including the parts I was going to have anodized powder coated instead. It's much less expensive and I'll have those parts tomorrow afternoon.



Here’s the finished battery box. You can lift the helicopter up by this box. It isn’t going anywhere. It came out exactly as I had planned.

Powder coating turned out to be a good choice. The problem I ran into with attempting to anodize these parts is that I do not know with 100% certainty that every piece is 6061 alloy since I picked up scrap most of the time to save money. If you mix alloys some parts will take most of the current and you’ll end up with a bad batch of anodized parts.

Every bolt either screws into a locking nut, or I used Loctite 242, or in the case of the electrical components I used the lock washers that were supplied. Normally you don’t use lock washers in an aircraft, but these are COTS (Commercial Off-The-Shelf) non-aviation parts. If the bolts are not secured with a locking nut I added a dab of torque seal so I can notice any loosening during my preflight.

Here’s a view from the left side showing the 4 Adel clamps I use on each side to secure the battery box to the frame. They should give me the redundancy I’m after. Half of these clamps could fail in flight and the box would stay securely in place.

Now my only worry is what kind of clearance will I have between the bottom of the right hand plate and the top of the turbine gearbox housing? I have a plan if I need more clearance. I’ll make a new vertical support piece that angles the right hand plate outward instead of straight down as it is now.

Now that the battery box is installed it's time to reinstall the tail rotor gearbox with the Heli-Coils installed.

I splurged and bought this fantastic Snap-On digital torque wrench. It not only lights an LED when you reach the desired torque, it also beeps and vibrates! And it comes with a calibration certification directly traceable to the National Institute of Standards and Technology (NIST.) It's accurate to within 1% in the CW direction. That's extremely good.

I decided on a torque value of 60 in/lbs based on AC 43.13-1A recommendations. The recommended torque value needs interpretation since it assumes bolts threaded into a steel or aluminum AN lock nut and not into tapped threads or Heli-Coils. It also depends if the bolt is in sheer or tension. For an AN4 bolt in tension, and threaded into a steel nut, the minimum torque is 50 in/lbs and the max is 70 in/lbs. Since the Heli-Coil creates a stronger surface than the original tapped hole in the aluminum I feel secure slightly exceeding the aluminum nut max recommended value of 45 in/lbs. I'm backed by Heli-Coil's recommendation that I go with the maximum torque that the bolt could tolerate. Here's why -- The Heli-Coil not only presents steel threads to the bolt instead of soft aluminum, but it evenly distributes the loads over the entire coil. Consider a tapped hole where the thread count is very slightly off from the bolt. Most of the load is going to be concentrated in a few areas, greatly weakening that connection. The Heli-Coil is able to flex and even out the loads, and the Heli-Coil tap is a precision tap so the thread count is accurate.

Here's the final alignment check before safety wiring the bolts. That red dot on the side of the transmission shaft is the laser that's bore sighted down the axis of the tail rotor gearbox shaft – a distance of about twelve feet. I'm off about half an inch and the frame is going to twist more than that under power.

I know that laser looks like another blob of Torque Seal, but trust me, it's a red laser.

Juan Rivera

My order arrived for the two sizes of Roundit that I intend to use to bundle my cable harnesses. This little pile cost me $89.03. Ouch!

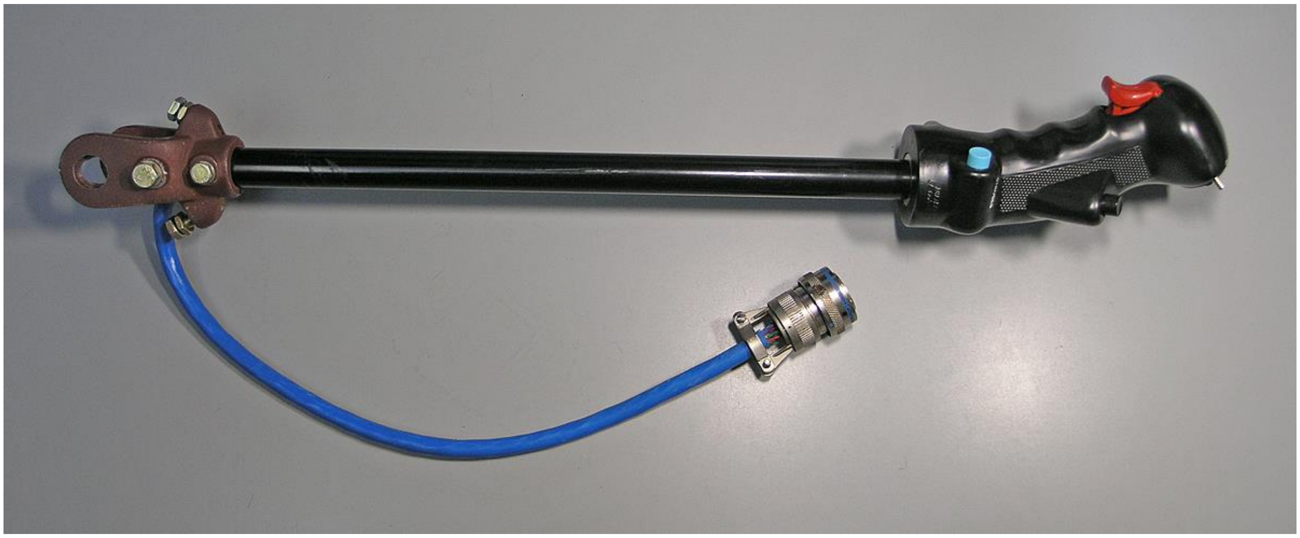
I forgot to mention that I now have my custom leather seat ready to install. I purchased half a cow hide of this gray aviation leather on eBay for forty dollars. I sent it along with a three-layer piece of Comfor Foam to Eagle R&D to have made into my seat. The Comfor Foam is in the seat cushion. I think the color looks great with the lighter gray of the frame and Eagle did a great job.

Right now it's just placed on the seat pan to take this picture. I need to pad the back with foam and then the back secures to the seat pan with snaps that I have to rivet into position. I'll do that after the seat pan is pained, so it won't happen for a few more months.

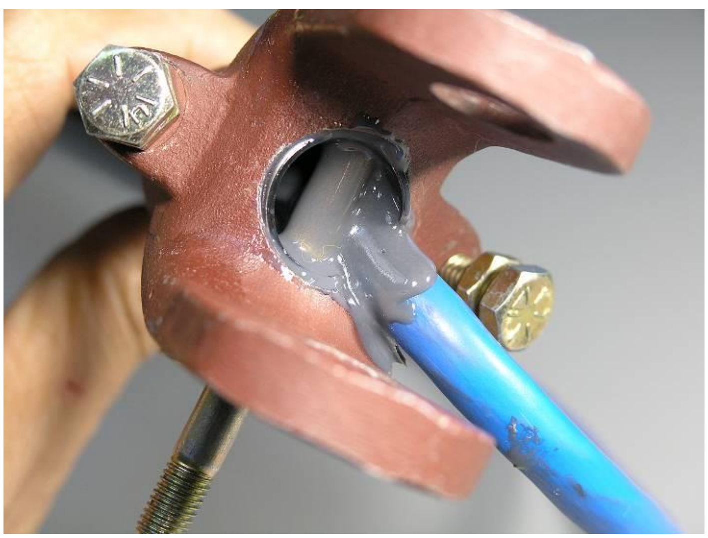
This weekend I plan to polish the tail rotor tubes and then corrosion proof the tubes, the skid end caps, and the transmission and tail rotor gearbox steel shafts with Evershield. In about three days when it dries I can install the tail rotor driveshaft.

While I'm waiting for the Evershield to dry I'll work on some of the other bits and pieces and then I'm planning to haul the ship up to Hap Miller's High Sierra Helicopter Fly-In next weekend.

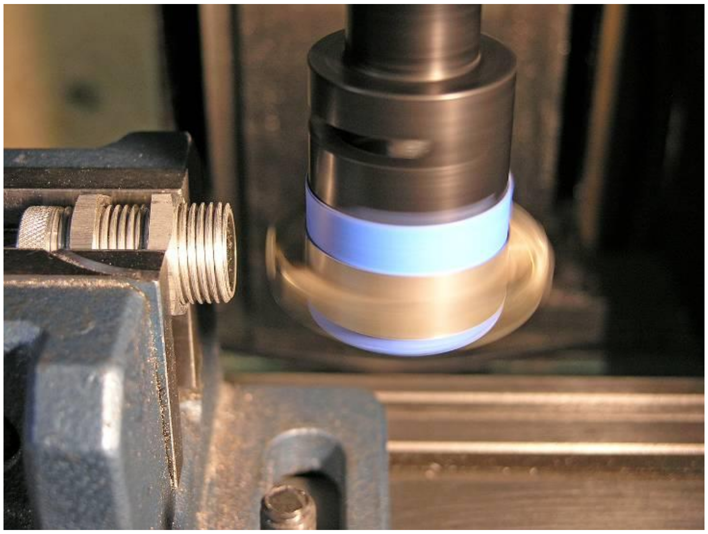
Juan Rivera



I finished the installation of the Infinity grip on the cyclic tube. Initially I was going to have the tube chromed but I was concerned with hydrogen embrittlement. 4130 chromoly steel is one of the most susceptible types of steel to this problem. The process of chroming the steel changes the structure so that it looses its ductility and behaves more like glass than steel. It can fracture catastrophically with no warning. This tube is .050" so even if it lost 80% of its strength it would probably be just fine, but why take a chance, especially when the chrome shop had a three-week turn around and the power coat shop was overnight and much less expensive?



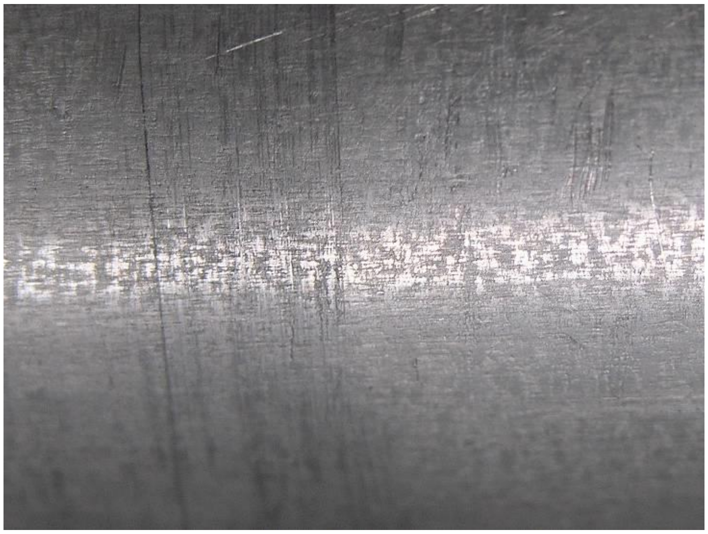
You can see from the picture above that the cable has to pass by a 3/16" and a ¼" bolt to exit the assembly. I ended up removing the cable jacket in the area around the 3/16" bolt and separating the wires so that half passed on each side. I milled out a slot in the bottom of the tube and in this aluminum piece to allow the cable to pass by the ¼" bolt, and then I filled the hole with 3M Scotch-Weld epoxy. This will secure the cable exiting the assembly at the angle that I want and prevent it from moving inside the tube.



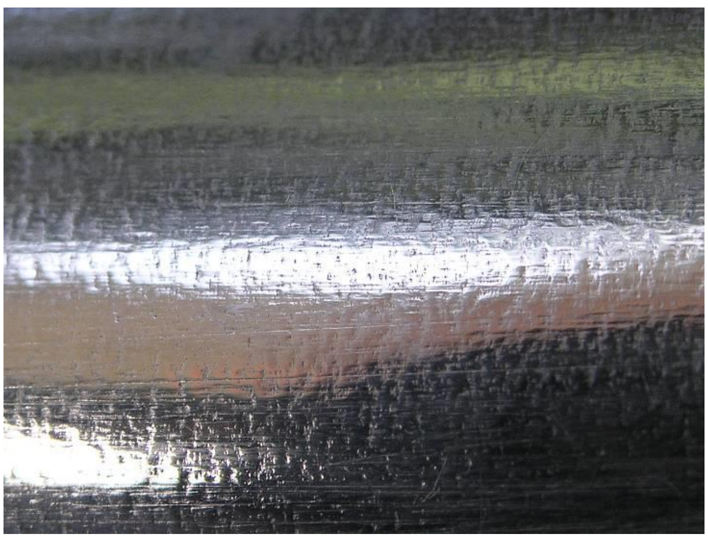
I've been thinking of taking a look at the rotor tachometer by spinning it with my mill and I finally got around to trying it yesterday. I stuck a bolt through the piece that holds the throttle pot and chucked the bolt into the mill. Then I wrapped some tape around the piece to get the diameter about right and attached the assembly that holds the four magnets. The magnetic pickoff is mounted in the vise on the mill's bed so I can vary the distance between the two very accurately.

The mill has an RPM readout but I have no easy way to determine its accuracy without tearing a frequency counter out of a rack in my shop. With the mill indicating 650 RPM the tack says 610. Here's what I can say:

- The meter draws nine milliamps
- The meter readout is stable down to an input voltage of 7.5 volts
- The pickup is stable up to a distance of 0.270" from the magnets



Getting back to my tail rotor driveshaft polishing project… The raw tubing looks like typical aluminum tubing when you get it. When you look closely you can see that it's covered with scratches and mill marks. In this picture the tube runs horizontally. You can see a row of circumferential scratches running from top to bottom that were caused by rough handling and then there is an underlying pattern of small short imperfections that run along the long axis of the tubing running left to right and cover the tube completely in this picture. These seem to be caused by the manufacturing process and they tend to run for the entire length of the tubes but often only cover one half or one third of the circumference.



This is what the tubing looks like using the same magnification, after hours of polishing. I'm using two separate methods; the first is a high-speed cotton polishing wheel using polishing rouge. Then I have multiple grades of Nuvite polish that I can apply with an auto buffer or by hand. These grades go from very rough to finish.

As you can see here, I've shined the surface to a high gloss and it looks great from a distance, but when you look closely I haven't moved enough metal to smooth out those fairly deep imperfections. According to Nuvite, polishing doesn't remove any metal - it simply moves it around. I have a large pile of black polishing rags that seem to contradict that statement, unless it's the polish that turns black and not the aluminum I'm removing.

The Nuvite process is to start with the very roughest grade of polish to get down into those deep scratches and imperfections and smooth them out. Then you follow up with progressively finer grades of polish to remove the smaller and smaller scratches that the previous grade of polish left. Finally you end up with a mirror-like finish. I've been able to do that with some of the 6061 components that I've made but this tubing is proving very difficult to finish properly.

On the left is my ¾ HP buffer with a deburring wheel on the far side and the buffing wheel nearest the camera. The Makita auto buffer is strapped to the table so I can hold the piece instead of trying to secure it in place and move the buffer. I have a separate lamb's wool buffing pad for each grade of polish.

I can lean into that buffing wheel until the motor slows and the tube gets too hot to handle and I still haven't been able to get those deep scratches and imperfections out.

I could dig down and remove those scratches by using the deburring wheel but then I am removing metal and weakening the tubing. I'm very hesitant to do that. I'll have to decide when these tubes are polished enough cosmetically to keep me happy.

Here you can see the five grades of Nuvite polish I have to work with and the difference between a unpolished piece of tubing at the right, and two of the three polished tubes.

Polishing is extremely dirty work. I picked up a box of fifty 5-mil Nitrile gloves. They keep the dirt off of my hands but it still spreads everywhere as you can see by looking at the top of this stool.

OK… I finally got my technique down after two days. I started again using the cotton buffing wheel and lightly applied rouge every inch as I worked my way along each tube from end to end. Once the rouge runs out or is throws off the polishing process seems to stop working. Getting just the correct amount of rouge and using just the right amount of force seems to be the secret to success.

After going over all three tubes with the buffing wheel I finished up by polishing them with the fine grade Nuvine polish and a very soft cloth. At that stage the cloth can scratch the metal so you have to be careful.

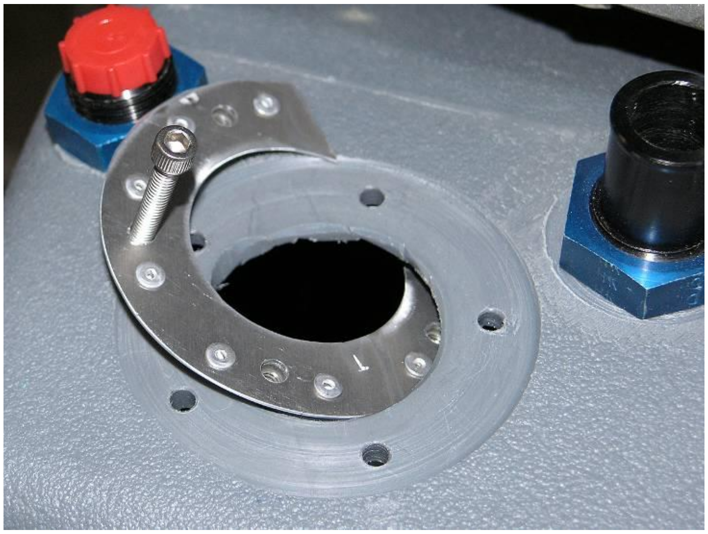
Here's a finished tube. It's almost impossible to take a good picture because there is nothing there for the camera to focus on. It looks for edges and the scratches worked well. Now they're gone. You really have to get into a very bright light and stare from a close range to see any imperfections.

I've decided not to coat these tubes with EverShield because I won't be able to polish them after that if I do. If I leave them uncoated then I can give them a touch up once in a while. I'll do the same with the rotor and main blades.

I found a loose fitting that I forgot to tighten. That should fix my transmission oil leak. I filled it to the middle of the sight gauge with 1800 ml of Pro Gear 21 ultra high-performance synthetic lubricant. BJ, the designer of the Helicycle insists on this brand. It cost over fifty dollars a gallon so it better be good!

Now I'm getting somewhere! I got the chrome pieces back, I have the painted tail fins and the powder coated support braces, and I finished polishing all of the tail rotor driveshaft tubes. Here's the result. Now the tail fins are almost completely installed. I have a few details to fix but this is how it will look. I also have the tail rotor driveshaft installed and it looks great. The chromed bearing clamps don't quite fit the same way they used to before chroming. There are two layers of copper and one layer of nickel plated under the chrome and I think it changed the fit. I'll have to deal with that too.

The next thing I want to do is to mount the two lower fuel tanks. This is the bottom of one of the caps that cover the big access hole in the top.



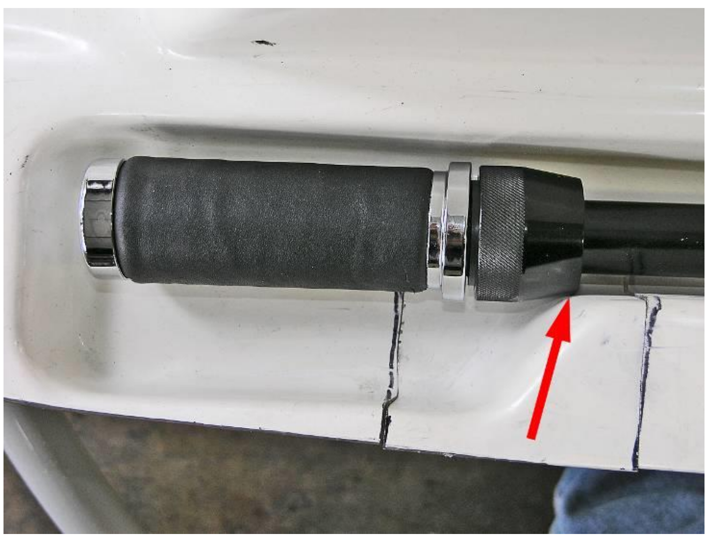
It’s a clever design. You fabricate this nut plate out of a small sheet of aluminum and then cut it as you see here. Next you “screw” it into the tank, taking care not to drop it.

Once the nut plate is inside the tank you thread a socket head cap screw through the cap, the tank, and into one of the captive nuts. Here you can see the nut plate inside the tank and prevented from falling by the one screw that I have loosely threaded into the nut plate.

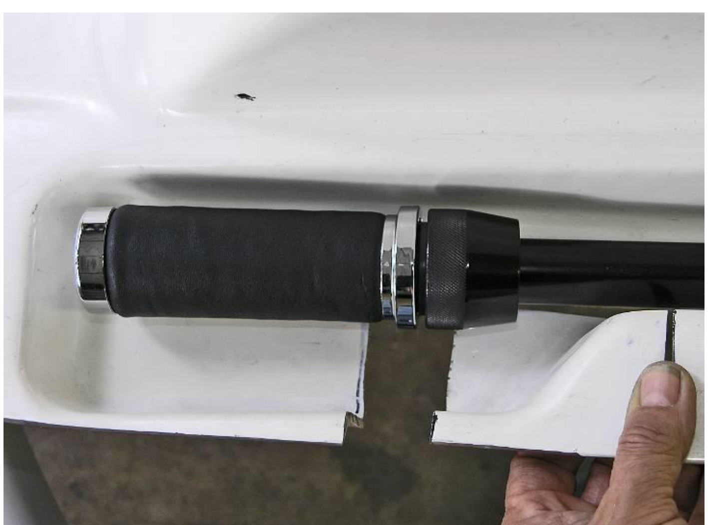
Next you rotate everything into alignment while keeping an eye on the o-ring as best you can to insure that it stays in its groove. I use a bit of grease to hold it in place.

Since fuel can leak out via the five screw holes they need to be sealed. I chose to use Permatex Aviation Form-A-Gasket sealant. I dabbed a blob on each screw and held it over the mounting hole and let it drip into the hole. Then I threaded the screw in and tightened it up. Once the sealant has cured I'll clean off the plate and polish it back up. I hope this doesn't leak! (This turned out to be bad idea #1 – see pg 125 for bad idea #2…)

Well, it probably won't leak but it is about as messy to work with as anything I've seen. It never quite dries out and it mixed with the polishing compound when I tried to buff out the cover. I've removed it and cleaned off all of the sealant. I'll have to come up with a better plan.

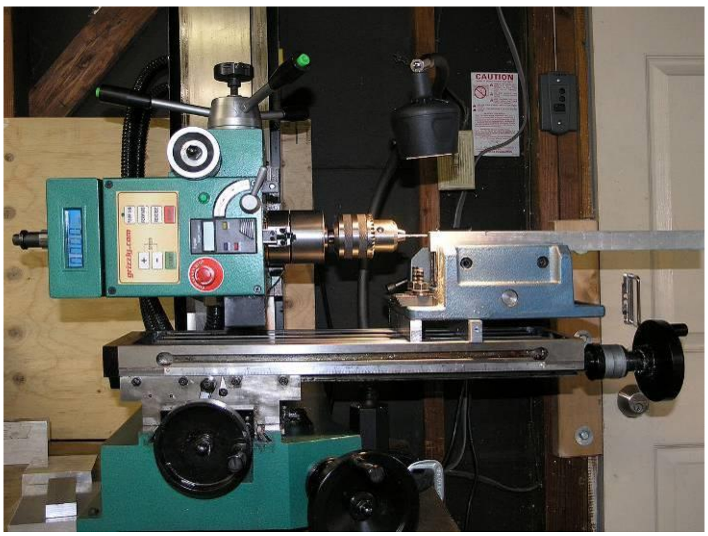


While I'm thinking about what to do to seal those screws and also be able to polish my cover plate, I decided to look at my seat pan. One of the issues I have to deal with is an interference issue with my collective grip. The factory supplies a sharp-looking rubber wheelbarrow grip but I decided to upgrade to a Harley Davidson grip. The area that's the problem is filled with curves and I've been scared off since I've never worked with fiberglass before. I picked up this tip from a fellow builder – cut that section out and move it back and then I'll be left with relatively simple flat areas to fill.

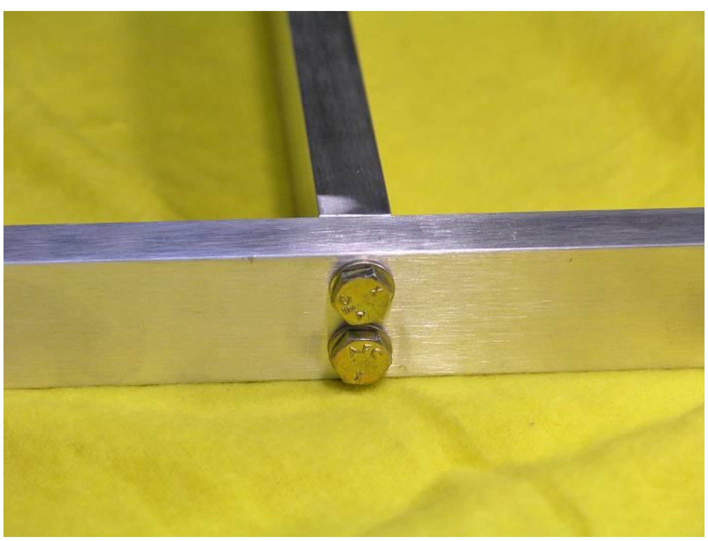


So here's the complex piece cut out and moved back out of the way. The next step will be to glass it into place and fill the holes which are relatively flat. A tip from a Lancair fixed wing owner at work sent me to Tap Plastics for my fiberglass materials. They have a very complete selection.

Tap Plastics has product bulletins for all of these items to help you made your selection. I have two widths of fiberglass tape, Microfibers to fill in small imperfections and chopped fiberglass to add structural reinforcement to the resin. I picked Four to One Super Hard Epoxy Resin after looking over their comparison chart. Shrinkage is less than one percent, its rigid, it will cure in cold weather, and it has excellent resistance to chemicals.

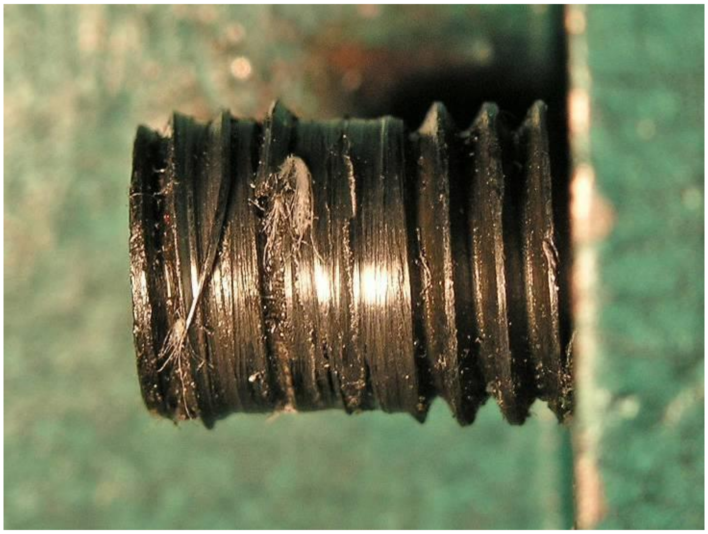


The fiberglass job is definitely a weekend project so I switched to one of the other projects I’m working on which is to make a plate that will live in the space under the seat and inside the cabin. I’ll use it for the ground plane for the transponder antenna and also to mount my fuel flow transducer and the strobe light electronics. I’m making a frame to support the plate out of ½” x 1” 6061 bar stock. In order to drill lengthwise down the ends of these pieces I turned the mill head 90 degrees on its side.



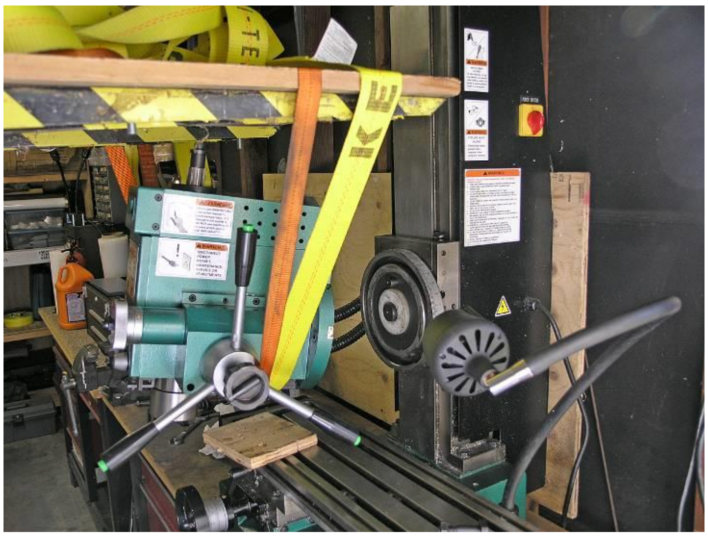
Here’s one of the intersections that required match-drilled holes. Trying to do this with a drill press is almost impossible. With the mill and the micrometer adjustments on all three axis it’s easy. I measured everything using a dial caliper (a very useful tool!), did some arithmetic, sketched it out, and then set up the mill using my digital protractor. It took me about 2 hours to set everything up and about ten minutes to drill and tap the two holes. This is about how far I usually get on a work night – two holes.

Juan Rivera



Well, when returning the mill head to the normal position I managed to strip this T-bolt using a small combination wrench and moderate torque. I should mention that the Grizzly mill is made in China and you do get what you pay for.

There's no way a good alloy bolt would have stripped. I'm going to have to tear the head off to access the bolt. This isn't going to be pretty…



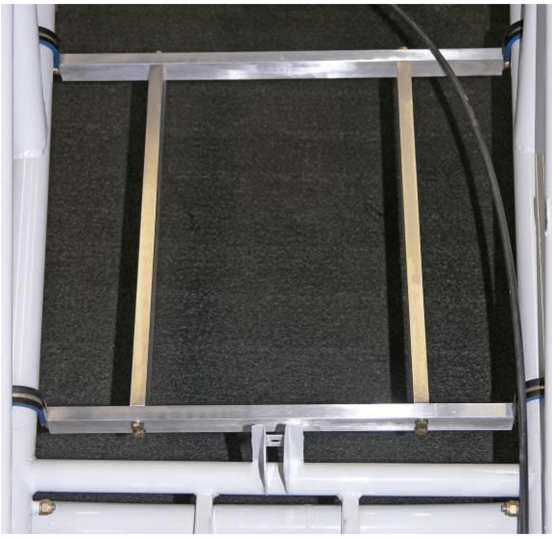
I can tell that I'm not going to make my normal work-day quota of drilling two holes today.

I've determined that the T-head isn't necessary so I'm off to the local Orchard Supply Hardware store to see what I can find in good alloy steel nuts and bolts. I'm going to replace both sides.

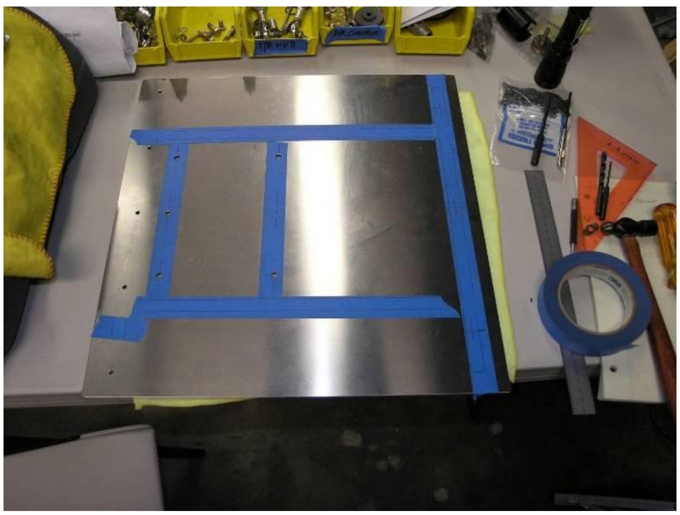
Did I mention how much I like my Genie Lift? I picked it up used on eBay for $500 and it's saved my back many times. It extends to a height of about ten feet.

That looks better, doesn't it? I found some class-8 nuts and bolts at the hardware store. I had to grind down both sides on the inside of the bolt heads so they would be captured by the slot they ride in and not turn when I tighten the nuts. It's crude, but it seems to be working just fine.

Now it's time to knock off for the evening. Tomorrow is another day…



Here's the roughed out frame. It's suspended from four Adel clamps and the top of the frame is even with the bottom of the aircraft's frame. A sheet of aluminum will attach to the bottom of the frame and the transponder antenna will mount right in the middle. The aluminum sheet will make a perfect ground plane and the antenna will end up inside the fiberglass cabin. I might also be able to stick the bottom strobe light on a stalk and protrude it through the bottom of the cabin. I'll have to think about that. I don't want any obstructions near the transponder antenna.



Laying this out was slightly tricky. I set the frame down on top of the bottom plate and marked out the location of the frame pieces. Then I hand drilled a few holes at the corners of the plate. Next I carefully lined up the plate on the frame and used the previously drilled holes in the plate to center punch the matching locations in the frame. Next I removed the top plate and drilled and tapped the holes I just located. Then I center punched the rest of the hole locations on the plate, mounted it to the frame with the locating holes I drilled and tapped, and then drilled through the plate and part way into the frame for each of the remaining holes (I used my drill press for this.) At that point I went back to the mill and carefully lined up the drill to exactly match the location of each partially drilled hole. I know this sounds complicated but it wasn't too bad. The result is that all 14 screws that secure the plate to the frame could be screwed in by hand without any binding. I must be getting better because there are no oval shaped holes that I needed to file to make this all fit. That's progress!

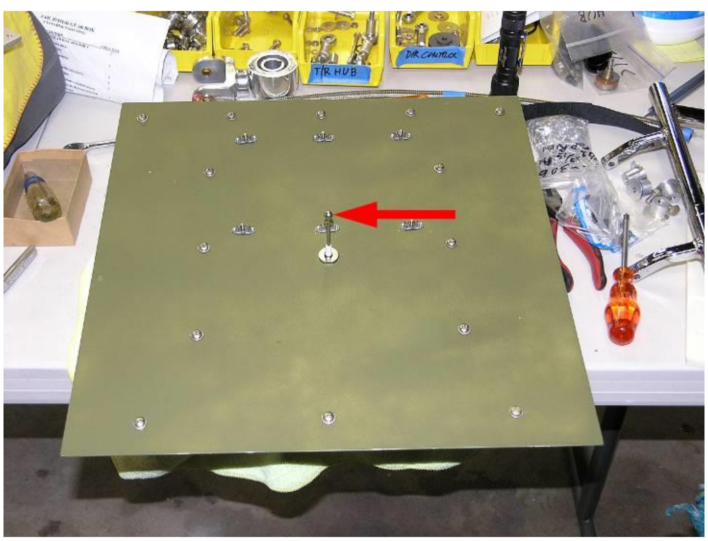
I was told that I was purchasing 6061-T6 aluminum alloy but I'm not sure what I actually have here. This bar stock was very soft and the bits clogged repeatedly. I drilled and tapped almost twenty 3/16" holes and I had to stop at least three times per hole to pick packed up aluminum out of the bits. This is a picture of a drill bit in case you couldn't tell. That's nasty.

Juan Rivera

The bar stock I picked is one inch thick and I used another slick feature on my mill to drill accurate ¾" deep holes so I wouldn't drill all the way through. You run the drill bit down until it touches the material and set the zero. Then the readout will tell you drill depth to the nearest 0.001". I'm not sure I'd trust all those decimal places but it worked for my application.

Once all the pieces were drilled and tapped I gave them a once-over with my palm sander and 800 grit wet and dry paper and then cleaned each one with acetone. After that I hung them up and sprayed them with a spray can of zinc chromate purchased from Aircraft Spruce.

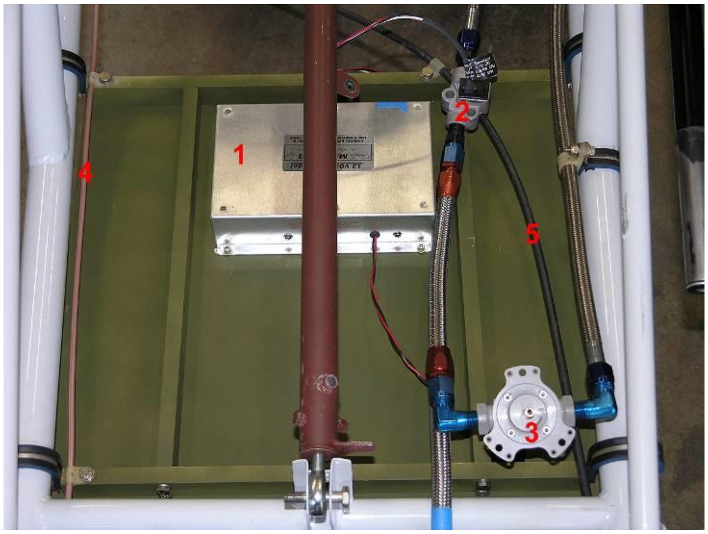
If I had to do this again I might leave it as bare aluminum, but since it already painted I'll leave it alone.



Here's a shot of the bottom side of the finished plate. The arrow points to the transponder antenna. This is a perfect place to mount it since the plate is huge in terms of the ground plane requirements for this antenna, and I'll end up with a very short coaxial cable to the transponder. This is important since cable losses go up with frequency.

The nut plates at the bock of the picture are to mount the strobe light electronics box.

The screws are all secured with 242 Loctite.

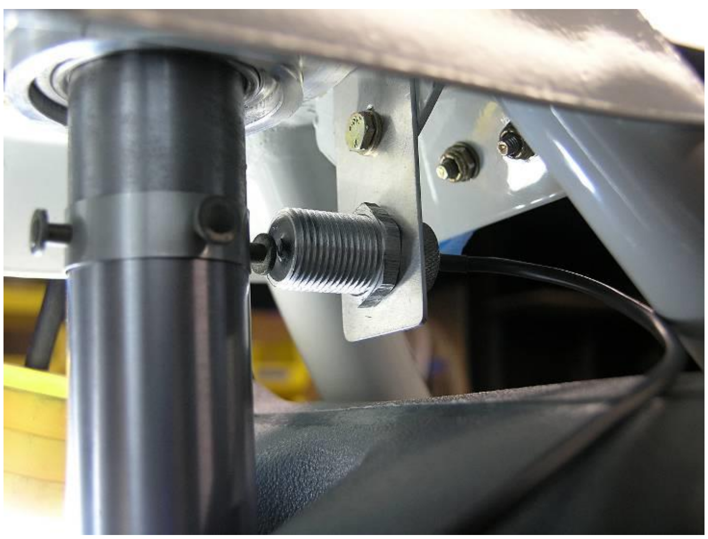


Here's the almost completed bottom plate assembly showing the following components:

1) Strobe light electronics
2) Fuel flow transducer (yet to be mounted)
3) Main fuel shutoff valve (mounts to underside of seat pan)
4) VHF Communications coaxial cable
5) Directional control cable

I've now reached the stage where I can start routing and securing some electrical, fuel, and control cables. I wish that I had thought to have tabs welded in strategic locations throughout the ship for the purpose, but I didn't and now the frame is powder coated.

I remove some of the rubber from the back side of an Adel clamp and then mount a MS25281 cable clamp facing as you see in the picture. It keeps whatever is secured in the clamp close to the frame.



This evening (May 9, 2009) I mounted the main rotor tachometer magnetic pickup. I'd suggest doing this before the top tank is mounted. There is no room to work. I installed the hardware by feel and I dropped washers and nuts many times in the process. I replaced the regular 4-40 nut that secures the magnets with a locking nut and used a chassis punch to make the pickup mounting hole. The mounting plate is secured with one 3/16" bolt. I cut a slotted hole for the mounting bolt so I could push the bracket all the way up against the bottom of the bonnet to prevent it from rotating.