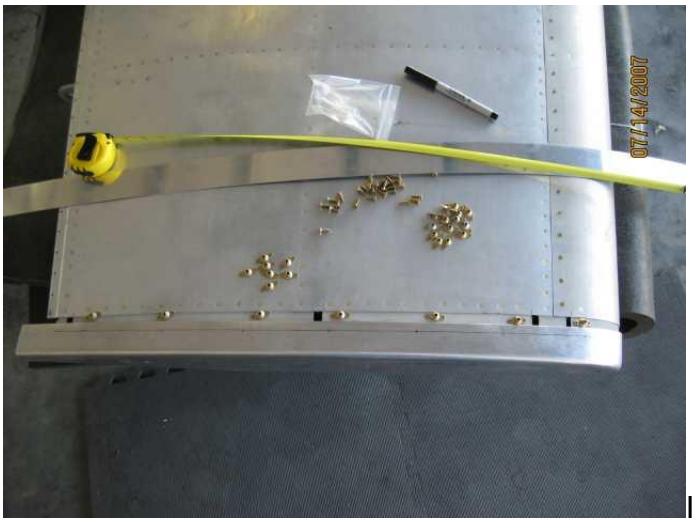
Wing Tips

I tried to talk Mark into swapping my aluminum hand hammered wing tips for a nice light pair of newer model fiberglass tips. Well initially he said he would, but later on, he talked me out of it. Something about possibly having to use pan head screws instead of countersinking the heads. No thanks.

The aluminum tips are actually quite nice. But they are hammered WAY out of dimension along the edge. Since I was working on the aileron gap seals, I just used the gap seal strip as a guide and marked a nice straight line along the bottom of each tip. 6 dremel discs later, I had some nice trimmed tips (on one side anyway). I used a hand file to fine tune them a little, but I won't do a whole lot more until I flip the wing over and do the gap seal on the top side.

Once the aileron gap seals were ready to rivet, I went ahead and trimmed the TE of the wing tip. The aileron tips (end caps) actually have to sit inside the wing tip and be free to move. Since I'm only working on the bottom of the wing right now, I only cut the bottom side of the wing tips.



I finally got a bunch of other stuff done on the bottom of the wings. Finally, I flipped the wings over and started working on the TOP side of the wing tips (and the rest of the stuff on the top). I used a dremel and many cut off wheels to cut down the wing tips untip they sat very nicely on the wing tip end flanges.

Mark said that the K1100 countersunk nutplates on the aluminum tips are spaced at 4 inches. That allows for exactly 7 nutplates on top and bottom. The first and second nutplates from the LE are not quite 4 inches apart, but otherwise the other 6 nutplates can be positined precisely at 4 inches.

A little marking and drilling and the wingtips are ready to get some permanent hardware!

I left the TE of the wingtip as is. I have to fabricate the top aileron gap seal and have it sized to fit before final trimming the TE of the wing tip. So I think I'll remove the tips and work on the gap seals, and perhaps go ahead and install the nav lights.

The 4 inch spread pattern for the screws and nutplates works very well. This was a fun little project. 14 nutplates in each wing. It had been a while since I had gone through the simple Zen process of match drilling and positioning nutplates, drilling, dimpling, and riveting on a series of nutplates. It was a fun way to kill an hour or two.

The aluminum wing tips were different to work with. Dimpling them is easy. Drilling them sorta sucks because the metal is so soft that it peels and leave a lot of flash. Clean up is a bear. And when I was trying to file them to shape the fit edges, it also peeled. Not safe to handle with bare hands due to the sharp edges. But all in all, a pretty good experience. Once the tips were ready to screw down, I needed to get the aileron caps on there, get those shaped and fitted and then trim the wing tip TEs to accommodate the aileron cap movement.

Picking a location for the GA-AIR Nav/Strobe assemblies was a little tricky. I wanted originally to put them on the top edge. In the end, I chose to locate the LE tip of the assy to the foward most point on the LE of the wing/wing tip. Also, I chose to put the lights slighlty back so that the entire Nav/Strobe would sit on flat surface. I merely drew a chord line through the tooling holes, assuming that was the chord, then offset another parallel line to the tip of the LE. The GS-Air instructions don't come with a template, but the measurements are provided and straight forward. Requires 4 holes to mount them. One of the holes is 1 1/8 in diameter. I should have used a spade bit instead of a step drill. I left

myself with a hole that needed wallering out to match the rubber socket of the strobe that has to insert through the wing tip.

Aileron End Caps (Tips)

Note: I didn't use the aluminum end caps. By the time I trimmed the trailing edges, I cut through the welded end and it left the ends open.

The wing tips also require you to set aileron tips in place. The ailerons are pre punched and dimpled so I'm going to have to work around that. And the aluminum aileron tips are going to have to have flanges added, too. But first, I decided to grind off the welds along the trailing edge.

The EVO wing (well, mine anyway) has several pre-drilled and dimpled holes. That unfortunately includes the outboard ends of the ailerons. Now adays, hopefully the "CZ Boys" are leaving the ends of the ailerons virgin and Mark is supplying fiberglass tips. I get to deal with predrilled and predimpled holes already in the ailerons for the caps. Evidently something really nice was supposed to be supplied for the ends of the ailerons. I just get to "make due" with the aluminum end caps that I got. No biggy, just more work.

I decided to test fab a strip of metal to make a bracket that mates the aileron to the aluminum caps. There's only 5 holes on the aileron on eac side that I'll probably use. If I was diligent and anal, I'd probably make ONE strip go around the inside of the aileron and make it so that I can rivet the end caps to just ONE strip using ALL the holes. I'm just going to get by with 10 holes and 2 strips in each cap (so far).

The ends of the ailerons are sort of compartmentalized into 3 separate areas and they are closed. The trailing edge is too narrow to utilize and the leading edge is very rounded (of course). The aileron LE is protected and the airflow doesn't really load the round part of the aileron or cap. But the flatter portions might take a LOT of load. Unfortunately the ends of the ailerons are not only closed, but they are rather shallow, too, so you can only use what you already got. I'm somewhat "factory limited". So I think the metal attach brackets are going to have to be pretty beefy. And it's going to require a spacer because there are three layers of metal in some places at the ends of the ailerons. Ok, now I know what I have to deal with. On to the fabbing.

I used a strip of .025 and bent it to shape on the bottom of the aileron. I marked the new piece to slot it to go around where two internal ribs close out the aileron. The strip is about 1.5 inches wide. It butts all the way inside the aileron end and nearly goes to the outer edge of the end cap. Once I had the slot the way I wanted it, I started match drilling and clekoing from the trailing edge, forward.

One thing worth noting on this pic is that one cleko is missing. Another is that you can see the amount of gap there is between the aileron and the aileron gap seal.

I might just have enough room on the strip I made to add another rivet or two when I get to installing the end cap.

The contours of the end cap are side specific and match the aileron quite nicely.

Of course once you close the aileron end cap with pull rivets, there's no going back. My plan is to squeeze hard rivets on the brackets and caps and then use counter sunk pull rivets in the aileron.

The depth of metal that I have to make up for to level the aileron skin with the cap is about .060.

After getting the first strip roughed in, time to do the other side (the upper side in this case). Or maybe I'll just wait until the wing is flipped over. I hate working on my back.

I didn't get very far with this project. I removed the ailerons in order to install the bottom gap seals.

While I had them off, I thought I'd snap another pic of the parts. This is sort of a proof of concept and may not be the actual parts.

The ailerons are deeply dimpled, but the bracket I fashioned is not. So I'm hoping that I can get by with some .040 instead of that wafer of .063 that sits on there now. But hopefully you get a better idea of where I'm going with the end caps.

Once I got the end caps to sit properly against the aileron body, I marked and trimmed the T E of the aluminum end cap. That ended up cutting completely though the welds on the ends. There's a little spacer set in between the top and bottom side of the cap. It fell out. So I epoxied it in to place and set the aluminum caps aside. ITMT, I grabbed up the fiberglass end caps that Mark sent me and dressed them down to fit. Shimming is definitely still required. But I think in the long run, the fiberglass caps are going to work out nicer than the aluminum caps.

The plan now is to put the brackets and shims into position on the ailerons, then set the fiberglass tips in place, then drill for NAS rivets. Then I will hard rivet the brackets and shims to the tips and finally blind rivet the bracket/cap assy to the aileron.

Heated Pitot

One of my Rocket bretheren was kind enough to sell me his Dynon heated pitot tube. He ordered the pitot before they were produced and got a substantial discount on the unit. It is not only heated, but if you use the Dynon unit (I don't), it has the ability to compensate for AOA.

The heated pitot comes with nice basic instructions, but no mounting hardware. I could have fabricated my own mast, but for $118 plus shipping, I decided to buy a Gretz CBK12 mounting kit. It comes with a mounting plate, doubler and a chrome mast. That will make my job a little easier. Time out called on the play while I wait for Aircraft Spruce to ship me the Gretz kit.

Mark sent me an email with three pics of his pitot install on the EVO wings. He said "put it here, this works best". So there you go.


FEB 14 2006

So here we go. Looks like Mark cut open the end rib foward of the wing spar, then made a plate to cover it. Fine. First order of business after locating the pitot is to cut out an opening large enough to ge a doubler, shim ("washer") and the pitot base inside

the wing.

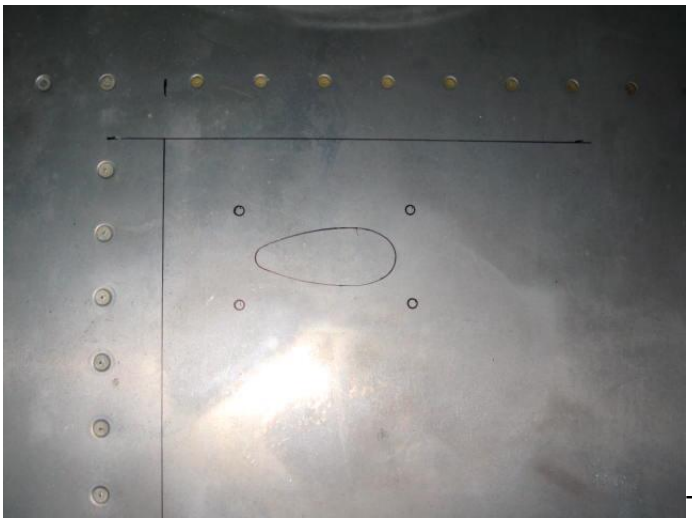
Note that I'm trying to use only part of the rib, not cutting out the entire thing (except for enough border to put some nutlpates on). I can get my "popeye" forarm in there pretty easy, and a doubler should go in there at an angle through the square opening (you know, that "hypotenuse thing").

Also note the vertical channel just behind the leading edge of the wing. Lots of room for wires and tubing to run along that baby. That rather large channel goes all the way through the wing. Nice!

Next step, fashion a cover plate for the big hole I dremelled out, and remake a doubler plate for the pitot base. I might just use the Gretz plate that came with the kit. It has a joggle in it made to locate on a flange. There isn't one in the EVO wing, so that joggle will just act as a stiffener. My cover plate will be at least 6 x4 3/4 inches. I think I'm going to add an inch and run it around the dimpled lightning hole at the forward end of the rib.

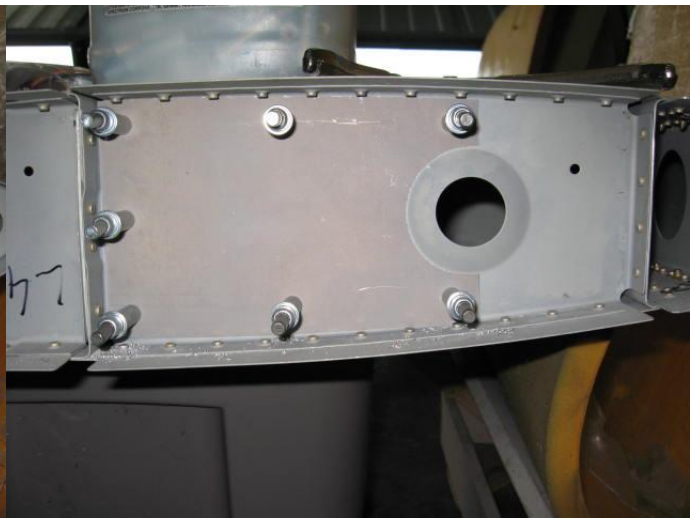
There's not much choice on where you locate the pitot base, really. It pretty much has to be forward of the spar, but very close to the spar to keep the pitot aligned with the wind. I guess practically the center of the pitot mast should be at the lowest point on the curvature of the wing in order to put the tube straight into the wind.

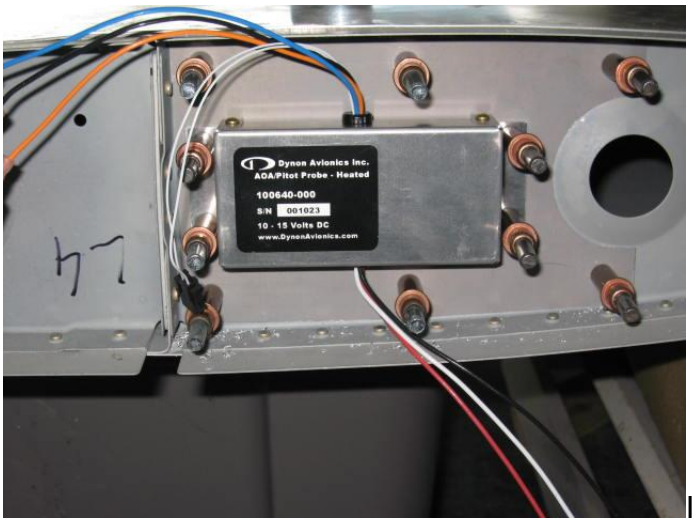
This pic shows the location of the mast and base. Once the thing is tightened down, the position will probably change slightly. But for the most part, this shows how the pitot tube will stick out under the wing, into the wind. If anything, I think the mast could go aft a tad. Once it's installed, if I think there's an alignment problem, I'll shim the base if necessary, but it shouldn't be.

 The markings for the pitot mast/base/doubler is a judggement call. No instructions provided on locating the thing from Team Rocket, other than the pics above. So I'm aligning it with the rivet row to keep the pitot tube aligned with the centerline of the ship. The rear portion of the pitot base has to be moved forward, not only to get the pitot tube aligned with the wind, but also to keep the doubler and mounting plates away from the spar.

The back end of the plate is 7/8 from the rivet line to clear the spar. BTW, there are NO flanges to clear in this mounting area. All the flanges are on the other side of the ribs and spar. I had to choose how to locate the base, and it turns out that symmetry just happens to work here. The inboard line is also 7/8 from the center of the rivet row.

Next step is to drill some holes and cut out for the pitot mast. After that, back drill the doubler and get it ready to rivet into place!

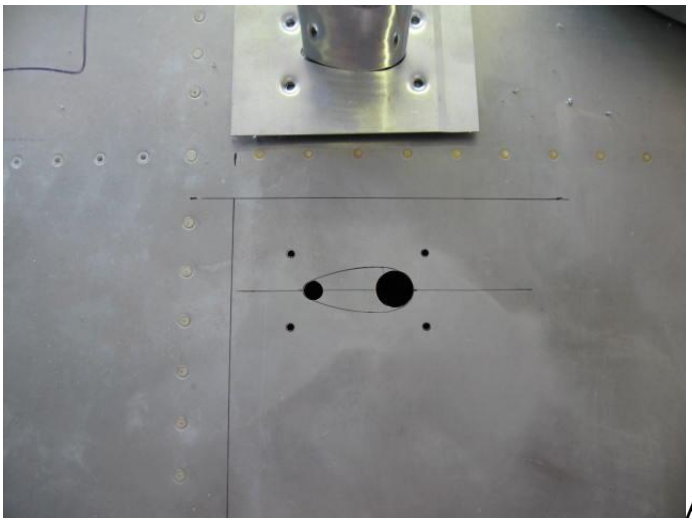





I decided to mount the Dynon AOA and heated pitot controller directly onto the outside of the end rib cover plate. I'll put a couple holes with bushings in the plate in order to run the wires into the wing.

I'll use #6 screws and nutplates behind the wing ribe to mount the plate.

The nice thing about this set up is that there is enough length on the stock Dynon harnessed to reach the pitot tube wires.


A step drill got me started on drilling the bottom skin for the pitot mast. A dremel with a cut off wheel then a large and small sanding drum finished the job.

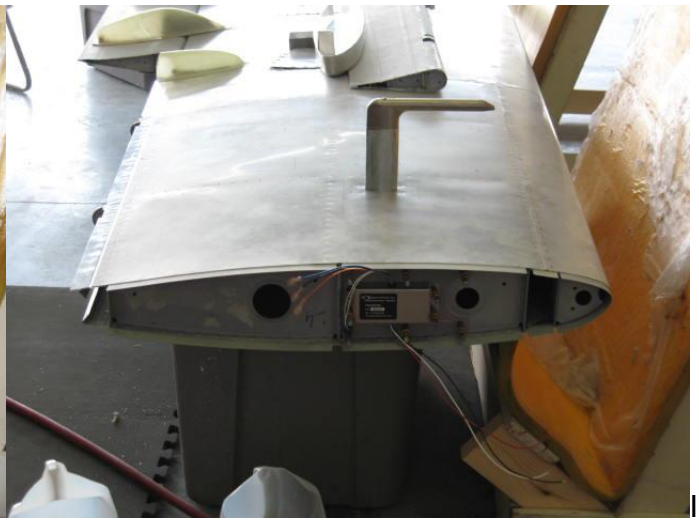
I went ahead and used the Gretz doubler that you see sitting around the pitot mast in the picture to the left. Note the joggle in the plate. Since there was no spar flange to lap that step in the doubler onto, I just cut a shim to go under that part. In that area I used 3-4 rivets,

I drilled #40 holes in the skin around the perimeter of the dounbler. The holes were 7/16 in from the edge. Then I ended up putting additional mounting holes at 1 inch intervals.

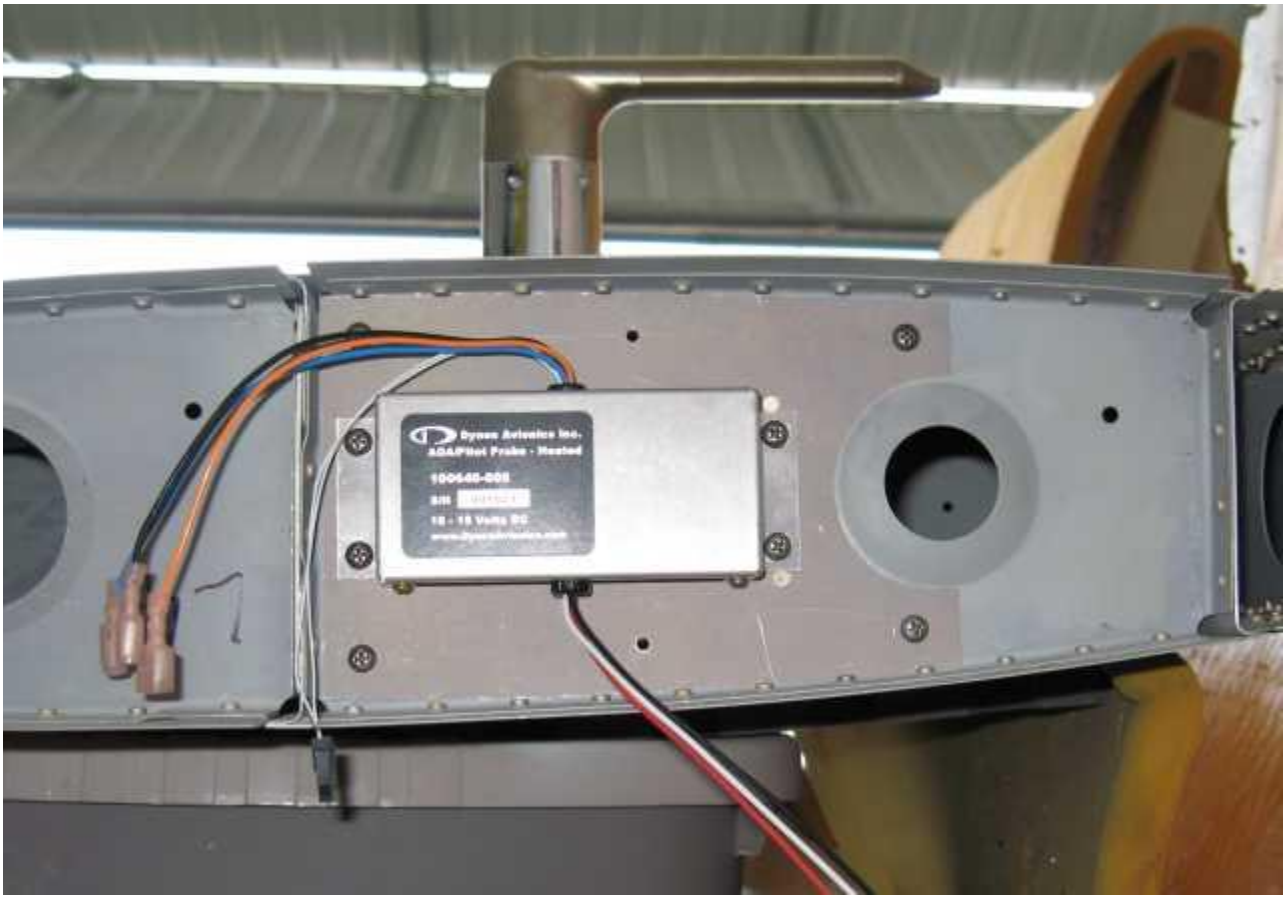
I wasn't able to effectively dimple the wing skin, so I machine counter sunk it. I would have preferred to dimple the skin for increased rigidity and resistance, but alas, I've never been able to master the "pop rivet dimpler".

During the match drilling process I was doing my best to keep the pitot/mast aligned with the chord

and centerline.

think that orientation of the pitot tube should be OK. Now to finish the wiring and get some #6 nutplates for that controller and cover!



I found a couple #6 nuplates and went to work. I decided to use two of the crews holding the pitot heat controller to also hold the cover plate in position. The two screws on the forward end of the controller (near the lightning hole) only hold the contoller to the plate.

The pic shows 6 of the 8 screws in place that hold the cover.

Next to drill a couple holes and run the wires to the pitot. I'll do that later "in final assembly", probably

after the wings are on the fuselage.

Ok, now you can see that at least I got the pitot in alignment with the centerline of the wing. (Note the rivet line to the left of the pitot.) That puts it straight into the airflow. The tough part is whether or not the pitot tube is offset with the direction of flight. It's hard to tell by the camber of the bottom of the wing, but I think I have it really close. You can get a better idea of the wing camber and pitot alignment in the picuture above.

Note the rivet pattern around the doubler and the 4 screws holding the pitot mast are machine countersunk.

Time to take the pitot back out and flip the wing over and get ready to install them on the plane! YIPPEE!!!!

Nav Lights

GS-Air makes a nice LED Nav/Strobe system that you can buy direct, or from other vendors. For about $400 it come with two complete wingtips modules with strobes, white tail lights and FAR compliant LED position lights. There's even nice teardrop shaped lenses for the lights and a strobe power unit with all the power cables for your wings. Nice. Whelen makes the same thing for over a grand. Well, I guess that's what you pay to have FAA/PMA stuff.

The F1 EVO wing has a nice "corridor" that runs the length of the wing just behind the leading edge skins. Good place to run wires and tubing.

My plan is to place this little gems at the very front of my wing tips. The control module will probably end up under the floor someplace where there is a little dead space. I hope I don't have to be too concerned about electrical noise and interference.

Since these little units have overkill with the rear facing white lights and strobes, you really don't need an actual tail light. I have an actual tail light. Now I think I'll just buy another strobe and run it from the XPAK604, which can handle up to 4 strobes. Nice.

I wasn't sure where to put the nav lights. So I put them as far forward as possible. They are lined up with the forward most point on the LE (not the "chord line" of the tooling holes), and hopefully aligned with the chord. Maybe I should have put them between 1/3 and half way back. Oh well, for now they

are at the front. Looks a little dorky to me, but these wing tips would probably look dorky with ANYTHING on them. They look nice flat and plain. Just doesn't look right to add anything at all to them. But I need nav lights and strobes.

I think I'll leave the tooling holes alone, and fly the plane before plugging them, just in case I decide to plug the present holes for the Nav/Strobes and move them aft.

The two small holes are bolt holes. The large hole is for the strobe "stopper". The medium sized hole is for the nav light wires. These rigs have two sets of wires and three sets of lights. There are not only superbright LEDs for colored nav lights, but superbright LED white lights facing rearward. Of course the strobes and LED lights conform to the FAA lighting standards, although they are not FAA/PMA'd.

One consideration for the light position is the amount of nuisance flash the pilot will get from the strobe. Hopefully the light is low enough on the tip that I won't get blinded by the flash, but hopefully I'll be able to tell that they are operating. Moving the lights aft would make the strobe a little less visible to me, but would also make the nav lights less visible up front. I have the strobe/nav rule covered either way you slice it, so it's just a matter of ergonimics (the wires go directly into the spar channel) and cosmetics (lights look dorky). They will be effective where they are on the wing tips.

Landing Lights

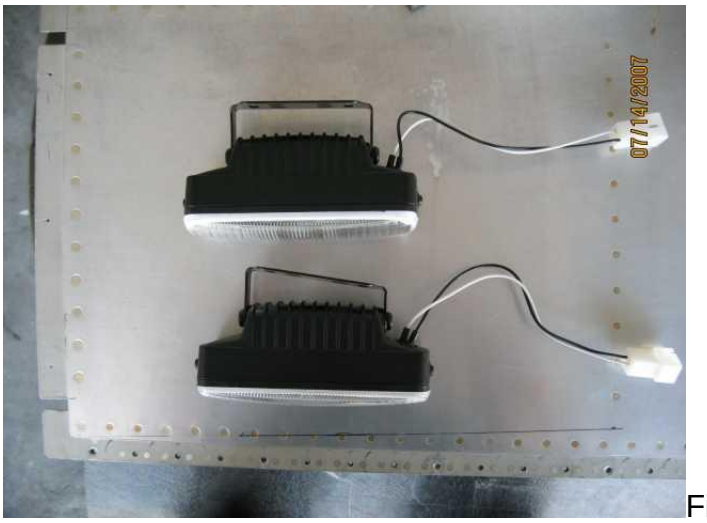
The original plan to install a pair of landing lights was to get some kind of reflector, install HID "bulbs" and insert the assembly into the leading edge of the wing, or better yet, inside the cowling or some other fiberglass area. The leading surface of the engine cowl really just doesn't lend iitself to pointing a beam in the right direction. For the most part, there just isn't room anywhere to stuff in a pair of headlights in anything fiberglass. So I'm back to the "driving light" plan.

I looked at the Hella FF75 for a housing and they were my first choice. Since the leading edge of the EVO wing is really space limited, a compact driving light would be the first choice. Hella makes a micro DE projector lamp that has a small footprint and puts out a lot of light. However, at about $700 - $800 a pair, I wasn't going to consider it. For that much money, I can buy a set of driving lights and buy an HID conversion hit and not have half the money invested.

Final decision on a light housing was the more expensive (than the FF75) PIAA 1500XT in driving light configuration. I think they come with hyperbright halogen bulbs.

The bulbs are H3 type, and certainly there are many HID kits available for that. But I will probably just install them "stock" and then upgrade to HID down the road some time. The first order of business is to get the lights shoehorned into the wing's leading edge. These lamps measure 2-1/16” high x 5-7/8” wide x 2-5/8” deep. What I'm hoping to do is find a place in the wing where there is enough room to STACK a pair of these. The top light will point out for landing and the other will point down more for taxiing. That's the plan anyway. The lights are on order. We'll see what we can figure out when they get here.

The PIAA 1500 XTs came from AutoAnything.com. I immediately took them to the airport and sized them up. Yep, they will fit. Nice thing was that I heard from Mark Frederick at Team Rocket and he said that he had strongly considered these lights for landing lights. Now I'm feeling REALLY good about putting them in the wing... at the outboard end of the Leading Edge (LE).



First order of business was to modify the brackets that hold the PIAAs to the spar. Remember that the EVO wing has a LOT of taper. And the lights normally just point straight ahead. Well for LE landing lights that are out near the wing tips, you need to really point those babies inboard so that the light is centered up (I hope) on your flightpath way downrange.

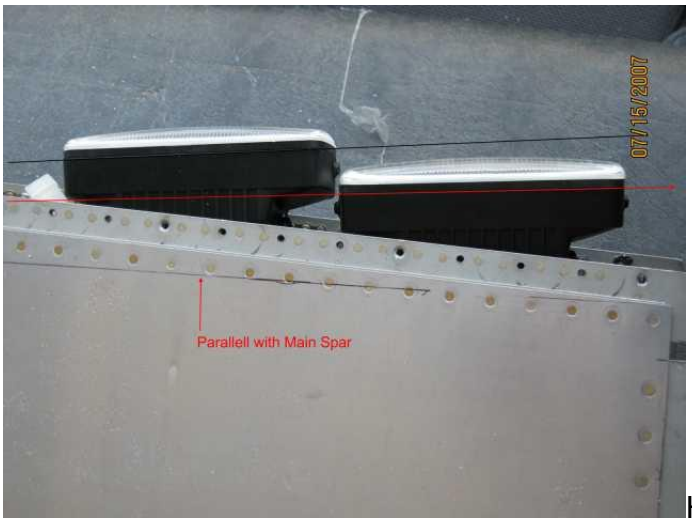
So here's what I'm looking for. The black line that you see is parallel to the wing's main spar. All I did to the bracket was cut one "loop" out for the hex bolt on the bracket. After I cut off the loop, I rounded it off and redrilled the hole for the bolt. Essentially the bolt mounting hole in the bracket was moved just one more hole shorter. I tried to remove as little material as possible when cutting off the loop, then drilled the new hole to give even edge distance around the bolt hole. Then I slightly bent the soft steel so that the bolt hole arms holding the light body would sit flat.

The forward wing spar out at the outermost position on the wing is pretty slim. And I had to work around the lightning holes. I was going to fab some doublers and use nutplates, blah blah blah... but I decided to KISS and just go with what was provided and some AN3 hardware. So I took off the brackets and used them as a template.

The holes around the lightning holes in the spar are really not kosher. However, I used a pair of BIG AN3 fender washers behind the holes to get more grab on the spar web.

Fortunately, those lightning holes are flat, not dimpled like some of them. That made mounting the very light, plastic bodied lights easy.

Each bracket is the same on the lights, but I mounted them upside down from one another. That actually gave me some orientation options. One light will point down at the taxi way and the other light will point way out in front of the plane. So mounting the brackets differently not only optimized the mounting position on the spar, but aids in how the lights are aimed!



Here's what I mean about the taper of the wing, the alignment of the main spar (perpendicular to the path of flight) and the aiming of the lights. I should have aligned the line parallel to the spar in the pic. That would have given you a better idea how offset the lights are to the LE of the wing.

I started cutting the wing LE in the back. I opened it first just enough for one light. I played with the lights a lot before cutting to make sure they would fit. Then I played with them inside the LE and re-mounted it on the wing. There was plenty of slop in there to allow for mounting the lights offset pointing amidships and for thickness of some Lexan.

After opening up for one light, I opened up for the other. Two PIAA 1500XTs can easily fit side by side in the end bay. And when I cut the back out of the LE, I still had enough room on either side of the lights that I have room that I could actuall install doublers and even an extra pair of ribs if I feel the LE needs the extra support. I don't think it does. I plan on using the Lexan lens to help the rigidity of the LE.

Once I hade the back cut out enough to allow me to leave the lights bolted to the spar and still get the LE off the ship, I started to contemplate cutting the actual LE out of the LE (to let the light out!). I ended up starting that cut 2 inches from the outermost end of the skin, and 2.5 inches down from the upper and lower edges.

Originally I was going to cut the opening at 2 inches from the top. I'm glad I left more meat in the skin. The more material you leave, of course the stronger the part will reamain. I think I got it just right top to bottom. But on the inboard cut, I think I'm going to have to remove about another 1.5 inches from the LE. The way these lights work, having part of the edge covered like that probably wouldn't effect the amount of light tremendously. However, since there might be some distortion and loss of light with the Lexan lens, I thought I'd better consider cutting that inboard area out a bunch more.

When you look at the landing lights from a distance and a different angle, the inboard light blockage of the LE skin isn't as apparent. But you can tell that there's a lot of room to cut more towards the rivet line. That's why I think I can take about another 1.5 inched out. That will make the opening about 12 inches and leave 3/4 inch minimum inside the skin at the rib ends. So there's plenty of room inside the LE to seat the Lexan behind the skin. Unfortunately, I don't think I'll be able to remove the Lexan without removing the 74 screws that hold the LE on the wing front spar.

I bought some Lexan sheet from USPlastics.com. The stuff is pretty flexible, and not too bad to work with. But it scratches VERY easily. Once I have a prototype lens fashioned (Approx 12 inches wide and 7 inches from top to bottom (across the leading edge), I may try to find some scratch resistant material and remake the lens. For now, I just want to close the hole and get flying!

Wing Insertion

Before installing the wings, I removed the temporary spacers that I had in the spar channel inside the fuselage. When you remove all the bolts through the spar carry through channel, the control system drops free in front of the main spar in the cabin.

The EVO wing comes from the factory with the rear spar attach plate and a front spar/gas tank attach plate already installed. On my ship, they are both appear to be about 1/2 inch too long. After slipping the wing into the spar channel, the laminated spar plates wouldn't go to the center of the ship. Therefore the bolt holes didn't line up either. Just to make sure, I asked if I was supposed to cut those spar mounting plates and sources confirm that they DO need to be trimmed to fit. Nothing in the plans about that. Ask twice, cut once.

I supported the wing in two places on the install. Left wing first, I put a large container with two used aircraft tires on it, centered on the spar and a rib. Then I used a pneumatic stool with another tire on the seat out at the end of the wing. The stool allowed some adjustibility of the wing height. Once the wings are in, 6 hardware bolts should be enough to stabilize the wings in position during setting of the incidence and the sweep. The wings will probably go in and out 1/2 dozen times before final assembly, with wiring and plumbing, etc..

NOTE: You probably only need to trim the FORWARD EVO wing attach plate to get the main spar fully inserted into the carry through. After I cut the left wing and got it all the way in, turns out that the forward plate needed trimmed about 5/8 and the aft attach plate (root end of aft spar) ended up being about 1/2 inch away from the fuselage skin. Now at this point the wing is NOT ALIGNED, so I may use up some of that excess gap I created. Also, there's plenty of meat on the aft attach plate and the angle bracket you fashion is plenty big to give you room for the single 5/16 bolt back there. But cut the FORWARD attach plate first, then see if you need to trim anything at all off of the aft plate.

The pic shows the gap between the aft wing mounting plate and the fuselage skin. This gap is with the wing in proper alingnment. Also note in the left pic how close the top wing skin flange is to the fuselage. I hope that fiberglass root fairing is nearly vertical in that area because is sure doesn't need to be very large there since there is virtually NO gap.

Now to get the right wing temporized in the carry through and get ready to position the wings.

Don't forget to level the plane before starting to finalize the wing position. My tail stand isn't sophisticated, but it works. Note the back up system, should the cinder blocks or plastic pales fail. Sure would hate to ding that rudder if it all dropped.

Wing Spar Aft Attach Angle Brackets

The main support of the wing is the laminated spar that bolts into the spar carry through built into the fuselage. Once the wings are in the carry through, you final position them by bolting the factory installed wing root spar plates on the forward and aft wing spars to angle brackets that you fabricate and bolt to the fuselage.

The forward angle bracket is only a single unit. 2 AN3 bolts go through longerons in the cabin to support this bracket. A single AN3 bolt holds the forward spar plate to the attach bracket. I decided to go ahead and use 4 AN3 bolts to hold the bracket to the fuse, but it isn't necessary.

The aft angle bracket is a double unit, sort of like book ends on either side of the aft spar attach plate. Each of those brackets require 5 AN3 bolts, one of which you try to instert through the floor rib longeron. Also, once these brackets are postioned, you want to rivet the perimeter around these two brackets in order to further strengthen the skin and doubler plate of the EVO fuselage. Only a single 5/16 bolt is used to attach the aft spar end plate to the pair of aft spar attach brackets.

Mark explains that there is a .125 doubler factory installed inside the EVO fuselage, inboard of where the 2x3x5 inch angle brackets will be bolted to the wing root spar mounting plates and the fuselage. He recommends those brackets go on with 5 AN3 bolts in each bracket, one of which should go through the "floor rib longeron". He also said that the bracket perimeter should be additionally riveted after final positioning of the wings and attach brackets. There's not much room for rivets in front of the brackets, but certainly there is room to rivet the aft side of the doubler. It pulled down a lot when the bolts went in, so it really needs reinforcement.

You cannot install the wings with BOTH of the aft brackets bolted in place. The front bracket has to be removed and reinstalled with the wing after insertion because the spar plate comes in at an angle. This also means you need to excersice care when drilling it to keep the bolt hole straight through the plates and brackets. Also, ED (edge distance) is CRITICAL on the bolt holes through the aft spar plates. Be VERY careful there.

One of the housekeeping chores with installing these brackets is to go ahead and complete the riveting in the area. Mark Frederick recommends a perimeter of rivets around the brackets. I decided to shoot a pair of rivets through the doubler and longeron in front of the brackets and several in back of the brackets. I should have used standard rivets, but prefer to CS or dimple and use flush rivets whenever practical... just because I do a better job on them. Perhaps they aren't as sturdy being flush, but shooting them through .040 skin using 4-8 rivets should be OK.

Note that I even put a nice row of three rivets between the brackets, two of which are 4-8s through the longerons.

Wing Sweep and Incidence

In order to position the wings, you get to check 3 things. You need the wings parallel to each other, you need the wings perpendicular to the centerline of the ship, and you need to set the incidence according to the plans. With the plane level and the wings pinned into the spar carry through, it's time to make some measurements to see where we stand.

First thing I'm going to do is make a mark directly over (or under) the spar at the tip end of each wing. I want a cross hash mark equidistant from the centerline of the ship on each wing. Next, from that point, measure back to the center of the tail spring swivel nut and bolt. If those measurements are equal, and the wings spars are parallel, we are good to go, The wings sit very stable in position being pinned in. Let's hope that they are where they should be and that no tweaking is necessary. (They were close, but it was easy to adjust them.)

Note that the main spar postitions the wing very closely and it's safe to position the aft angle attach brackets on the fuselage and clamp them down go ahead and bolt them in early in the wing installation process.

I bought some plumb bob string and 4 big steel nuts for the weights. I taped them to the either end along the tank skin seam under the wing. I let them swing free very close to the ground. What I found was that the left wing seemed to be just about correct in sweep and the right wing was cocked aft a couple inches.

I used a 4 inch C clamp to lock the right wing into position. It was farther out of whack than the left wing, so I started with the tough wing first. It wasn't tough. With the C clamp snug, I coaxed the wing forward until all 4 strings lined up.

Before going any farther, I needed to also set the incidence. I used a 1.9 inch piece of scrap and my digital level. I had to rack the LE of both wings down substantially to get the ZERO incidence (parallel to the "waterline" of the turtledeck lower rivet row). Again, the tail is up and the ship is level in two dimensions.

The incidence is set at "station 20". I measured the width of the cabin and boot cowl bays, divided in half (assumed that was REAL close to the centerline) and then did the math and extended out 20 inches from that mathmatical centerlin. I placed 3 marks on the wings. The incidence is set by using 2 rivets lines that are 22 inches apart (per plans). With one end of the level at the top most rivet line and the 1.9 inch spacer under the aft rivet line, I racked the wings until they were at ZERO incidence. Then I went back and checked the plumb lines (which did not change).

The right wing was locked down at the aft attach plates, I rechecked everything, then used a 12 inch drill bit to start the hole for the drilled 5/16 bolt that holds the aft end of the wing in postion. I drilled up to size and then inserted the bolt and snugged it up. Rechecked plumb and incidence and moved on to the left wing.

The left wing was clamped, racked and the plumb lines checked. Once the wing was in position (and at least three times before this point), I checked the sweep of the wings to see if it was even. The measurement from and equidistant mark near the outboard wing tip along the spar showed both wings were the same distance from the tailwheel nut.

Time to drill the left wing and lock it down. Once the drilled 5/16 bolt was snugged, I rechecked all my measurements and moved on to making the forward spar tank attach brackets.

I did notice that during drilling that the wings did slip a little bit, and that my final incidence measurements suffered about .1 degree. Oh the agony!

Forward Spar/Tank Attach Brackets

Now that the wing position is locked in (and the wings feel VERY rigid and fixed at the root), time to fabricate attach angle brackets for the front end of the wings. First you take another pair of 2x3x5 angle provided and open the angle in a vise. Not much, just about 1 thickness of the web is all that you have to bend it. The relationship to the forward attach plate on the wing to the fuselage is a little funky, so you have to bend the angle to sit flush and passively against both. It wasn't too hard to shape.

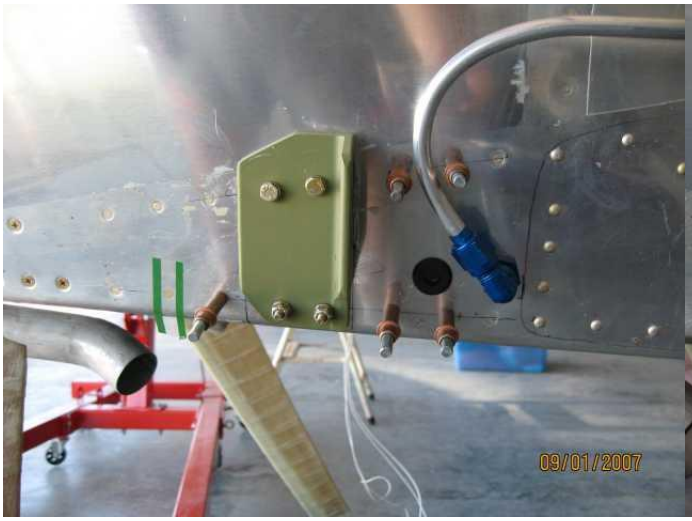
I didn't use the plans on the size and shape of this bracket. I just put them to position, marked the overlap points, and trimmed the angles down to size. Once I've flown and am confident that the wings are straight, I'll remove these brackets and cut them down to size. Also, I used FOUR AN3 bolts to attach the angle bracket to the fuselage and the plans only require two. Perhaps all I'm doing is

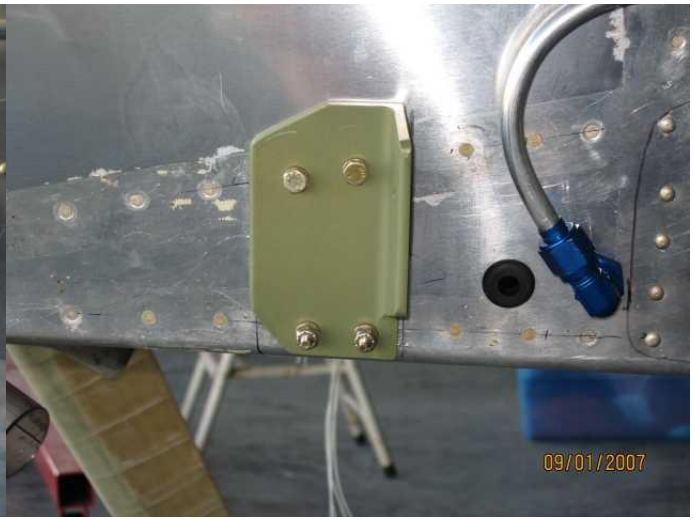
adding unnecessary weight, but I like a little more strength up front to suppliment the stress at the rear.

A single drilled AN4 bolt is all you use up front. A little smaller than at the rear of the wing root. There is much less stress up front.

Some more housekeeping rivets around the brackets is again in order.

These are 4-6 rivets.





Now that the wings are set in position, it's time to finish. I'll need to finalize the aileron push tubes, the flap push rods and wire up the wings. Still lots to do here, but it's terrific seeing the plane sitting with the wings and tail feathers in their final orientation!

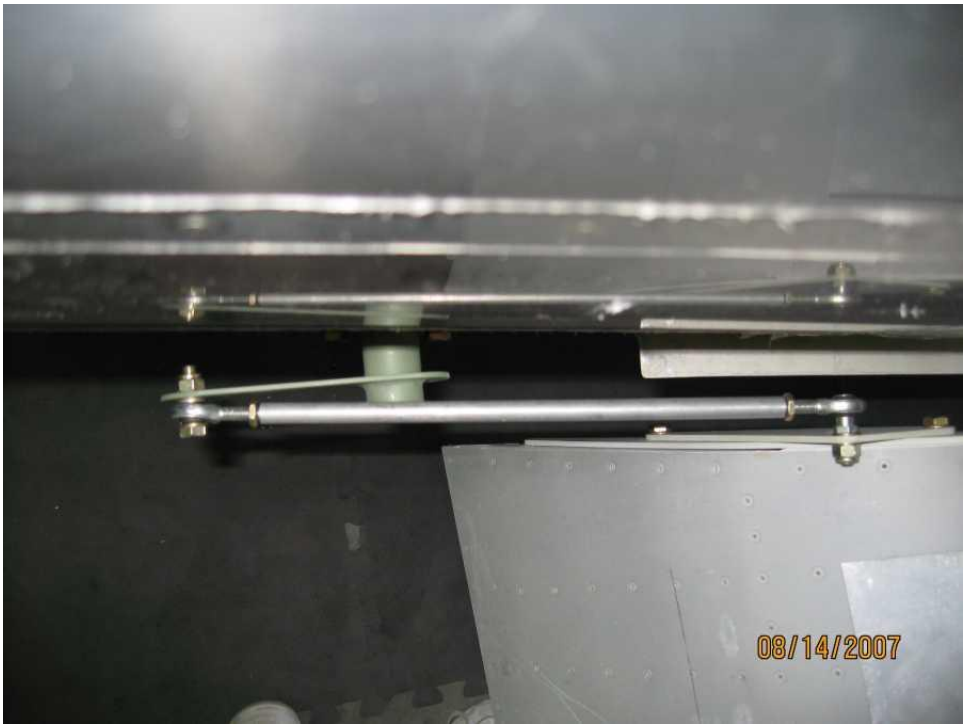
Flap Set Up

A little pleasant surpise: Current EVO production flaps have a premade (?) bracket for the push rod that makes them go up and down. My flaps didn't have that. A quick email to Mark, and I had the bracket in 3 days. Two AN4-7 bolts and washers in each bracket. Installe the bolt hole for the push rod on top of the flap and forward. Flap attach is good to go. It went so fast, I forgot to stop and take a pic.

Another surprise: The flap arm that gets screwed to the flap torque tube needs reinforcement. Evidently there has been some twisting of the steel in service, so the web of that arm needs to be reinforced. The current production arm has a small triangular truss welded between the tube sleeve and the web. Simple and effective. I don't weld, so I'll have to figure something else out. Yes, I could have just bought a set of "Mark II Flap Arms", but mine were already installed when the information became available. No biggy.

I rounded off the steel brackets provided by Team Rocket and then scotchbrited off as much RUST as I could remove. I primed the brackets and took them to the ship. Those steel brackets get drilled to the flap motor arm that goes through the fuselage. The bracket sits vertically on that arm. There is a push rod and threaded rod end bearing set with the kit too. Those rods are provided already to length.

It's just a matter of setting the flaps to neutral, then hooking up the pushrod/rod end bearing assy and hooking it up to the flap root bracket and the steel bracket. Once the fit is verified and the rod ends adjusted, drill the steel parts together to accept AN4 hardware. and bolt it up.



Once both sides are set, theorectically, the flaps should operate evenly. However if the rod ends are not adjusted the same, a turning tendency might be induced by the flaps. Best to check and make sure everything is bilaterally symmetrical. I had already marked the location on the flaps using the TE of the wings skin when the flaps were neutral. I simply adjusted both rods OUTWARD until the flaps got pushed against my wing skin enough to get back to neutral when retracted.

Couple things to look out for: Make sure you have adequate but minimal hardware. The wing root fairing doesn't allow any extra room for bolts and washers. You might have to grind off a couple threads of the AN4 bolt, depending on where you put your flap arm on the flap torque tube. So keep a close eye on the hardware combination and the clearance to the fuselage skin and wing root fairing. I started with the flap in the nutral position, and the flap motor arm fully extended and the rod end threads "centered", and didn't have any clearance issues.

Plumbing the Wings

Before installing the wings "permanently", some plumbing and wiring is necessary. I got some 3/4 ID corrugated conduit from my local Menards and ran it through the forward spar channel in my EVO wings. I'll run my strobe GR-400, the Nav/Strobe and landing light wires, Pitot Heat and AOA wires, and the pitot tubing through that channel. The conduit lays in the channel very nicely, not snug, but it sits there pretty well. I think I am just going to glue/bond the conduit into the lower aft corner of the channel. Less weight and less drilling of the spar that way.

Another wing wire that has to be attended to is the fuel level meter wire. This signal wire is merely ring terminated and attached to the screw in the meter, which is bonded into the fuel tank at the factory. The wire from this meter will snake around the fuel lines and enter the cabin with the other wires from the wing conduit.

The strobe cable will go into it's own hole into the fuselage. That will go below the longeron and along the floor, through the spar carry through and to the controller back as far away from other electrical stuff as I can get it, perhaps under the left rear floor. The other wires will go into a fuselage hole

above the angled longeron and then head up and over to the instrument panel where the EFIS, light switches and main electrical bus reside. The holes in the fuselage will of course have grommets or snap bushings to protect the wires from sharp edges. Those wings move a bunch, so the wires will no doubt be rubbing.

The wires and pitot tubing share the wing root with the fuel line and vent. The wires go under the tank/front spar attach plate and through the fuselage near the fuel lines. The fuel line is natural aluminum 3/8 tubing with -6 AD fittings, just like the rest of the fuel system behind the firewall. I ordered some fittings and tubing from Summit Racing. I fashioned a nice big loop from the 90 degree bulkhead fitting on the fuse and looped all the way up and over the tank vent fitting, then inserted the Summit Racing fuel filter at the bottom of the loop where I could get to it easily. From the forward side of the fuel filter, a short "S" curve of tubing will turn and connect to a 90 degree fitting on the -6 male fitting sticking out of the wing tank. Most other EVOs have a 90 degree bulkhead fitting on both tank fittings. I was SOL with mine and had to buy $60 worth of fittings.

There is also a mandatory tank vent that you have to plumb. That is the fitting near the top of the wing

skin. Tom Martin and others recommend a double loop before the aluminum tubing exits the bottom of the wing. The free end will stick out the bottom of the wing root. A bevel has to be cut in the tubing facing forward to aid in a "ram air" effect. The vent line is a -4 fitting and 1/4 inch tubing,a nd a snap bushing can be used where the tubing penetrates the lower wing root fairing.

The Jeg's filter is a nice compact little guy. Comes with -6 male ends. The filter is a stainless screen keeping debris larger that 40 microns out of the system. The Airflow Performance filter downline catches 10 micron particles. The Jeg's filter didn't come with any instructions, so I opened it to see how it was configured. The unscrewed end is the outlet and the barrel end is the reservoir... at least that's how I'm configuring it. I like the idea of the debris occupying the big area, not the small.

The rubber gasket around the neck of the filter is easy to botch when you try to reassemble the filter. Better keep a couple spare O rings and some "fuel lube" around.

"Final" Wing Install

Now that the wings are set up and plumbed, time to stick them back into the fuselage.With the wings disconnected from the attach plates but pinned in, I reamed the large bolt holes with the recommended reamers. Those bolts slip in the holes OH SO NICE after reaming! The AN3 bolts however wouldn't go in very well. I used a cheapo #12 bit and the bolts were still too tight. I was afraid I'd never be able to get them out if I had to "drive" them in. Turned out that the #12 was just worn out. A brand new 12 drill bit cleaned out the wing spar holes so that the AN3 bolts could be inserted and withdrawn by hand... but barely. Snug is OK. And this was dry. Putting the bolts in after lubing them with LP3 (for anti-corrosion) will make that job easier.

One of the tough parts of this project is reaming the lower bolt holes through the spar splice plates. The forward lower splice plate does not want to sit in place very well. The corner flange and rivest get in the way. But the splice plate will sit in there will a little coaxing (and a little filing of the "point"). Unfortunately, I have so much stuff in the stick bay, I had to disconnect a lot of adel clamps and brackets to get into the holes. I also had to cut the reamer shanks about in half just to be able to get the drill in there. I needed a VERY close order tight quarters right angle drill to finish the reaming job. Too bad I didn't have one. I ordered a Dewalt right angle drill after the fact just so I wouldn'g get stuck next time.

Putting the wing bolts is was a breeze. Some of the big bolts along the floor were a little tough, and some wires already go through the carry through, so working amoungst the spaghetti was a nuisance. All in all, though, it was pretty sweet to get the wings in "permanently". The bolt length and spar channel thickness is so close that one washer is barely enough, and two washers is about too much. Doesn't make sense, I know, but these wing spars are some precision made parts. And gladly so!

I put all of the top wing spar bolts through with the nuts forward and the head aft. The bolts on top are exposes and I'd rather have the heads (without washers) next to me where I'm sitting. On the lower spar plates, I reversed most of the bolts, but I don't think it much matters.

Wing Root Fairings

When I first got my fiberglass wing root fairings, I thought they were bulky, unwieldy pieces of work. Now that I have wings on the plane and put them into place, the wing root fairings are actually quite nice. They fit very well, and will actually be smaller in contour than you might expect. They should be a very nice adjunct to the airframe. I continue to be impressed on how nice this airframe comes together and how nice the form and function of the parts compliment the plane. Very nice!

In order to get them to fit, first thing is to trim the area at the TE of the flaps. This has to be done on the bottom side, trying to get the flap to be able to retract, yet fit into the fairing nicely. Once the fairing fits to place it's time to double check the flap actuator arm hardware to make sure it doesn't hit the fairing. Mine just barely touches, so I may need to use some thinner washers on the bolt, but I think it's good to go.

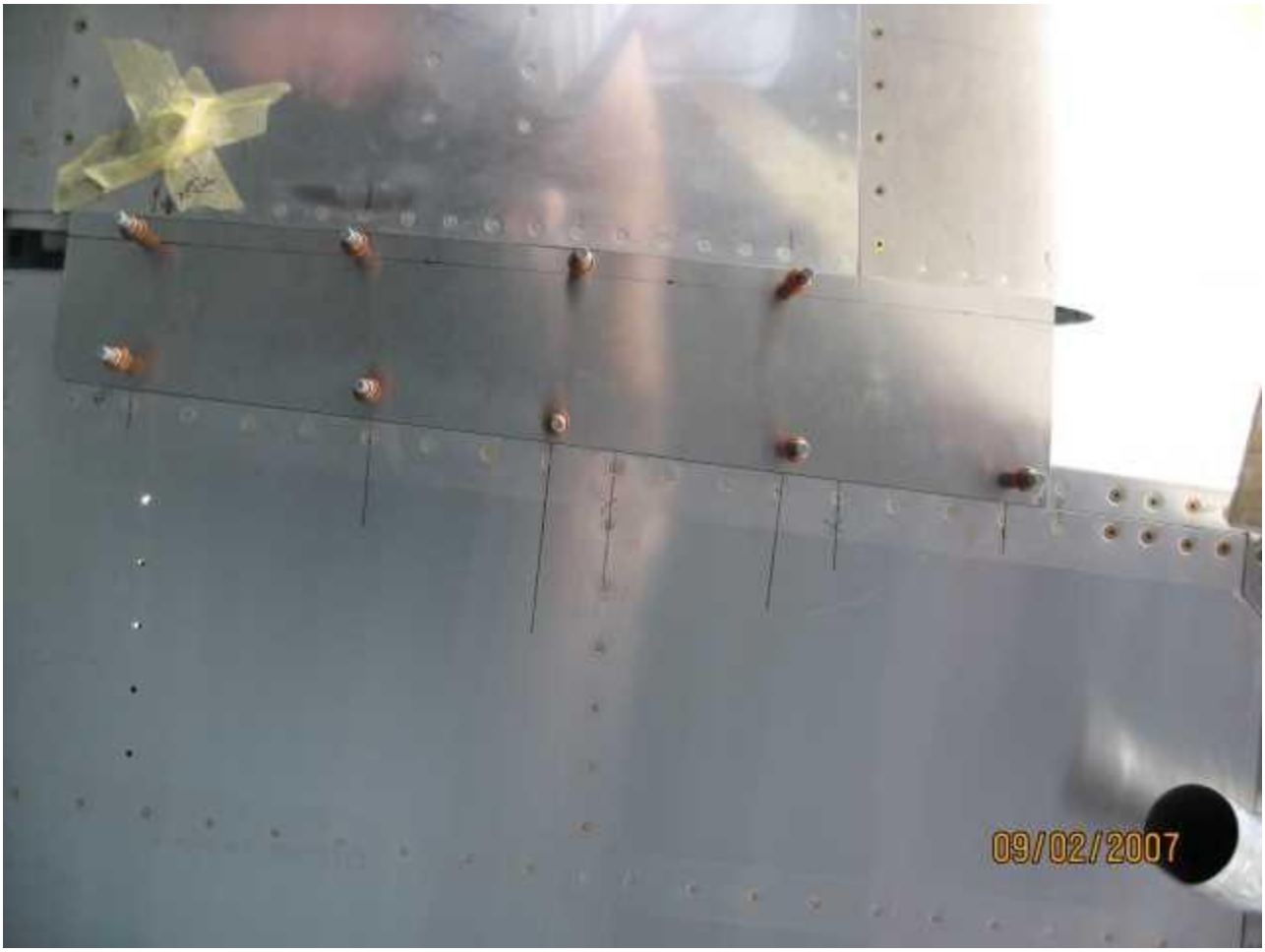
Word of caution here, the wing root fairing shouldn't be screwed to the top of the wing at all. The wing flexes a lot, so some freedom of movement needs to be accommodated. Also, there's that pesky 100LL under the skin in most of that area of the wing.

The lower wing root fairings are recommended to be in two pieces. Mine are 1 long one and a short one at the front. The EVO wing and the F1 fueslage are a mismatch, so there is quite a joggle that needs to be made on the aft piece.

First order of business on the lower fairings is to cut the belly skin extension (under the spar channel)

back to 7/8 inches along it's entire length. I did this with a dremel tool and the wing in place. Be careful not to cut through the main wing spar! The 7/8 inch of skin remaining will act as a nice flange for attaching a wing root cover with some nutplates.

Second order of business is to make a flange on the lower LE of the wing to attach the fiberglass root fairing and the metal lower wing root closure. I drilled all the rivets out of the rib flange and slipped a piece of .032 under there. Getting the rivets out was a little, uh, tough... so I ended up using NAS ("oops") rivets. Anytime those #3 rivet holes get even slightly wallered out, squeezing hard rivets nicely is nearly impossible. Those big NAS oops rivets work great!



Now that there is a flange on the LE to attach the fiberglass upper and/or lower forward Wing root fairing, we can procede with the lower fairings.

The forward lower root faring is pretty easy. Measure between the skin edge over the flange over to the ski edge on the belly, and cut a sheet to spec. I used .025 T6. This piece is just a cover, and although it is in a high pressure area, I don't think it will move with 8 or 9 screws in it. On the flange (wing) side I just spread the parttern of screw holes out as far as I could.

Note: Mark recommends AGAINST attaching the fairing this way. TR recommends just drilling between the rivets and tapping pan head screws into the longeron....

On the belly side, I chose to drill out existing rivet in order to install nutplates in their place. The belly side of the cover is just overlapped onto the belly. I was going to install nutplates with NAS rivets through the longeron. Mark's remark was that the extra holes in the longeron certainly don't help the overall structural strength. So I'm wondering if two little holes and removing rivets (to install nutplates and screw though the rivet hole) is better or worse than just drilling and tapping a #8 hole and putting in a sheet metal screw. That's a tough one. At any rate, I think I'll use pan head screws along the belly skin and not do any countersinking over there.

Once the cover is drilled and clekoed to place, time to remove it, then install nutplates, then dimple the wing flange surface and screw down the cover. I'll need 10 K1000 countersunk nutplates for the wing side. On the belly side, I think I'll use standard nuts or nutplates. I'm contemplating using the existing rivet holes and trying to figure out how to fix nuts there without drilling any extra holes.

The aft lower wing root fairing is another beast all together! That bitch has a curve on the belly side and a step to the wing. And the joggle isn't constant. At the forward end, there's NO bend at all, and at the aft end you have to joggle for a step up to the wing from the belly to the tune of about 2.5 inches. That's gonna be tough to do with aluminum and hand tools. For me, anyway...