Custom Speed Kit Installation

By Bud Yerly
Custom Flight Creations, Inc.
September 2020

Custom Flight Wheel Pants background:

Many Europa trigear owners were perplexed by the fact their aircraft was significantly slower than most others. I authored a number of emails which culminated in my paper Drag Reduction 103, which discusses techniques for reducing the drag of the Europa Aircraft (Trigear and Mono) that have worked for me and my customers. However, for the trigear owners, most folks detested the split or standard front and back half wheel pants and the many screws required to open or remove. Some chose to install aftermarket wheel pants these pants left the owner to make his own support brackets and there was too much fabrication. No matter whether owners installed after-market or Europa speed kit Pants, the installation was tedious to install, time consuming and tedious to remove for maintenance and frankly only added a few knots for most owners.

At Custom Flight Creations, it is my experience the time consuming multiple screw turning requirement necessary to remove split half wheel pants for filling tires, inspecting brakes, tire changes, and/or securing the aircraft for trailering meant proper maintenance and inspections were not accomplished.

In photo above, this pant takes 12 screws to remove for service and to fill the tire, it requires aligning the small hole to access the tire valve. A miserable morning exercise to fill a tire for sure.

A simple wheel pant removal system was needed. The tried and true method a fabricating and installing a one piece pant with a huge hole for the entire tire diameter in the bottom, such as in the Cessna Aircraft, has been done by the certified manufacturers for years but the huge hole made for higher drag and added no speed at all and only increased aircraft weight. These pants were molded in polyester so cracks were common, weight was significant, and to provide access to the tire valve, either doors were installed, a hole in the pant was drilled, or the pant was mounted far above the wheel rim increasing aerodynamic drag. Additionally, gear legs were normally not covered effectively with fairings, so wheel pants were suspended out in the breeze. Because of the very small improvement in speed, the heavy weight of the pants, and the increase in maintenance time, most civil light aircraft owners were forced to fly with no wheel pants as the aerodynamic efficiency considerations were not considered sufficient enough to justify the weight. As a result, many planes are flying with the three sticks in the air as servicing, inspection and maintenance was easy.

In the 1930s and 40s, streamlining techniques were tested by the NACA (National Advisory Council on Aeronautics now called NASA) in an effort to improve aircraft aerodynamics for introduction into military and civil production aircraft. (See References.) In a nutshell, the wheel needed to cover the tire and struts as much as possible. However, to achieve minimum drag, the wheel pant aerodynamics prevented easy maintenance, inspection, and on grass runways or northern environments the pants were easily filled with ice, snow and mud.

Some interesting ideas were tried and many of these ideas are still in use today.


In the photo above, not wheels were only half covered and the wheel "spats" were nothing more than mud flaps keeping the wing clean on muddy fields.

I attacked the problem by first assessing the best aerodynamic shape for the pants, gear legs and transitions, and then make the wheel and wing fairings kit that would be easy to remove or open for service and maintenance.

At CFC I decided on using the NACA series six airfoil of roughly 26 percent thickness. That allowed a low drag pressure recovery shape rather than the teardrop fairing common since NACA 485 was written in the 1930s. The teardrop shape ranging from 3-1 (length to width) to as high as 6-1 was common and was a compromise of surface/frontal area and weight. The original 3 (or 4)-1 teardrop was successfully used by Arnold in his AR-5 as the drag penalty vs weight in a hand laid up foam on glass pant was a good tradeoff in drag vs weight. In my case, aerodynamically, A 26 percent thickness airfoil (roughly 4-1 laminar flow pant shape) of about 30 inches long would cover the entire tire/wheel of a 5x5 tire and still be wide enough to cover the brake caliper, and be slightly better in drag performance and yet not add significant surface area drag or weight. To take advantage of this very low drag shape, it is imperative the angle of attack of the wheel pant has to be very close to zero at flight attitude. The wheel pant also needs to cover the tire and brake completely leaving only enough tire exposed to allow for normal operations, yet allow full aircraft rotation for takeoff and landing without dragging the rear of the pant.

Of course, there is a drawback to a low wheel pant, it requires a small wheel chock to be used under the pant for parking which many FBOs do not have. To cut drag, the gap in the bottom of the pant between the tire and pant needed to be as tight as possible. Normally a 5x5 tire will bulge outward or flatten out under a firm landing by nearly ¾ inch at 35 PSI. Therefore, a clearance of the tire to pant needs to be at least that distance or tire to pant wear will occur. The shape of the top and bottom was also important. Structurally, the taller the pant the compression and tension forces are smaller, so a thinner and lighter skin is possible reducing pant weight. To allow full stall landings without the pant impacting the surface, the bottom side of the pant had to be modified so that the back end of the pant allowed an angle from the tire to the rudder for rotation clearance.

In order to keep the construction of the pants lighter than the polyester types sold in the aftermarket, the CFC pant is only two layers of 8 oz. Rutan 7725 Bid using a laminating epoxy matrix and a very thin gelcoat. With this thin and flexible of a skin, the pant is sufficiently strong for flight loads but fiberglass moves due to heat and attachment stress points would not hold up, so bulkheads were needed, as well as reinforcements at each screw and hinge attachment point to distribute loads and hold the aerodynamic shape.

To allow access to the tire and brake for inspection and servicing, the pant must be easy to remove. That is easier said than done. The pant can be made so as to be hinged either vertically or horizontally but again the clearance for the full tire diameter and brake, requires a considerably sized hole either in the side or front and support brackets must be sized to secure the pant to take the normal air and ground loads. The curved top and side shape of the tear drop wheel pant makes for hinging problems, however the NACA series 6 airfoils are rather flat near the center of pressure which makes hinging and mechanical attachments to support the pant somewhat easier if the hinge on the inboard side is on the flattest side of the pant for easy hinging.

Mechanically, removing the pant had to be quick and easy. In order to quickly remove/swing the pant clear of the tire to allow inspection and maintenance, it must also use the fewest fasteners (three to four is the limit of my patience). I pioneered a horizontally hinged pant using a short horizontal hinge on the inboard side and three fasteners (one on the outboard side and two on the inner side) for the main pants. The nose pant front cap was hinged on one side and the other side heavily slanted to allow access to the air valve while allowing the aft portion of the pant and its supports to remain fixed.

Our final prototype main pant used an inverted horizontal T shaped metal support, attached to the inboard brake caliper support bracket (as is usually done) which attaches the inboard cover and pant to the metal bracket. The outboard axle end uses a threaded insert to provide lateral and horizontal support for the pant. The main pant inverted T is shaped and bent to clear the brake caliper, yet aligns with the pant sides. The hinge is attached at the top which allows for a flip up pant. The inboard fixed cover preserves the airfoil shape, and secures the gear leg fairing and transition. The metal support is sandwiched between inner cover and movable pant making a solid attachment. The main wheel pant is secured for flight with two #10 AN 525 screws on the inboard side through the inner cover and bracket to the pant flange (with one #10 on each end of the horizontal portion of the inverted T) and one ¼ inch screw through the outboard pant into a threaded insert on the outer axle end. This secures the inboard cover cleanly to the main flip up pant. However, after years of use and abuse, the leading edge may eventually bulge so and extra #6 screw keeps the cover to pant flange nice and tight.

Original prototype and additional screw location to keep the inboard cover tight on the leading edge.

The nose pant modifications I made are to allow a swing open of the nose pant, for access to the fill valve. To do this I raked the hinge line and screw line to allow just enough room to access the tire valve. The nose cap hinged side is simply riveted or bolted, and the free side is bolted with three small #6 screws to secure the other side of the cap.

Nose pant during installation. The nose cone opens to allow access to the nose wheel tire valve.

For both main and nose gear, when the three (or 4) screws are removed, the pants can be hinged upward (or sideward on the nose gear) to expose the tire, valve stem and brake for easy access. In the case of the main gear, the tire or brake disc to wheel gap can be secured by rope or protected cable to a trailer tie down in seconds without removing the wheel pant as they hinge up out of the way, or the hinge pin can be removed to remove the entire wheel pant for strapping the gear down for transport. Since the metal bracket is light weight metal and the open pant would flop around in transport at highway speeds, therefore I chose to make the hinge pin removable to allow the main pant to simply be removed for transport.

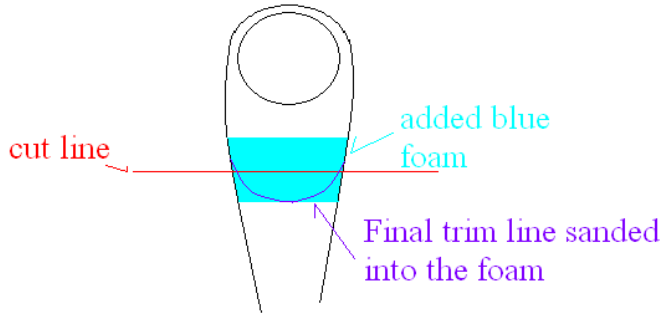
I couldn't stop with the wheel pants. The Europa highly angled main gear leg cover is a simple near airfoil shape to safe weight and make a simple trailing edge to mold and seal tight with a bit of glass. Europa's idea of just taping the gear leg on is nonsense. Worse yet, it is nonsense to use tape or omit a transition fairing leaving an open raw edge at a junction of the gear to fuselage or pant for the air to

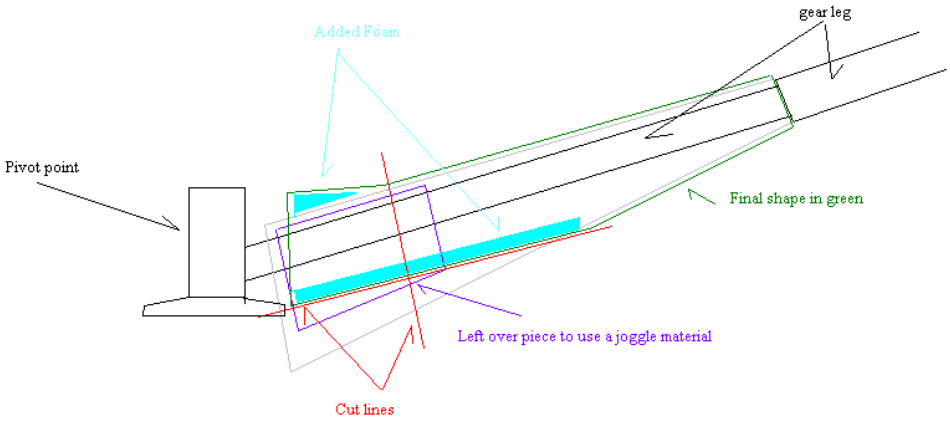
stumble and bumble about causing increased interference and parasite drag. In Europa's defense, because main gear steel legs bend and shake, tape was a cheap and fast solution. So if I were to build a gear leg cover, I needed to plan the transition area from the gear leg cover to fuselage as well as wheel pant to have not only smooth the airflow, they must be able to allow the gear to move, hold the gear leg fairing and be repairable. So, some sort of clearance gap or slip fit was necessary.

A basic 3 to one airfoil shape was created with a semi-blunt trailing edge that overlapped from bottom to top to either allow a hinge pin or simple screws to secure the trailing edge and allow removal of the gear leg cover for inspections if necessary. There would have to be some support to prevent flapping of the gear leg covers. Any movement of the gear leg cover would cause it to vibrate like a Venician Blind. I chose to make the skin thick at the leading edge and trailing edge and lock the gear leg cover in place with a transition fairing on the wheel and one on the fuselage to hold the gear leg fairing securely.

Insert photo of transition fairing from Brown's kit here.

The nose gear leg is fairly simple as the angle to the airstream (prop wash) is high enough, frankly my cover is a simple two piece cover to hide the humps and bumps.





I kept the nose cap cover as simple as I could so the shimmy dampener can be easily accessed. On N12AY I hand made a long cover and flared it to the pant, but that proved unworkable for many clients as the cover had to be filled and reinforced adding weight. My production nose leg cover is two pieces similar to the Europa cover and as shown in the drawing above, with some bits of foam and glue the rear leg cover can be hard glued to the leg if desired.

The gear leg nose cap comes off with two screws normally and exposes the bolt for the shimmy dampener. In my kit I wanted to have the nose pant to be able to transition right into the nose cap cover. It works out but it will take some fabrication work.

The nose gear pant has a simple near vertical hinge and a very raked port side for access to the air valve. The pant has the hinged area as far forward as possible so the simple V bracket can be used to bolt on the pant, yet the pant can be spread enough to clear the axle or even my towbar axle.

I did a bit of glass work to try to streamline the pant to leg as much as possible. But all the extra shaping and planning yielded less than a knot on speed runs. But it looks kind of cool.
Note the low wheel chock is 1/8 inch thick by 1.5 angle. About six inches long.

The wing outboard flap brackets are very draggy. Europa aircraft created a fairly simple to install cover for the mono wheel including the inboard brackets.

I experimented with a two-piece design hinged at the center as installed on many airliners like the Airbus and Boeing 737, but frankly, the weight and lack of an easy way to inspect the hinge points outweighed the negligible speed difference. I stole the basic shape of the wing covers from what Andy Draper did at Europa, but I fasten the fairings somewhat differently. I do use through bolts on the mid and inboard cover, and I install two nutplates in the outboard hinge to attach the wider cover. In my installations I use a #4 sized sheet metal screw to hold the forward end of the cover in alignment. Bath caulk is used to seal the flange to the painted skin.

This allows the maintainer an easy removal of the cover for maintenance and the bath caulk simply rolls off without damaging the painted wing. A single long screw and two short screws for the outer and flap arm using only a couple of screws and simple bath caulk to seal the gap and secure them. I do not use adhesive (such as 3M 5200) because it is in an area of little stress, and only a seal of the flange to the cover is necessary.

Custom Flight Trigear Wheel Pants Installation Kit:

The kit includes the following:
Two main pants
Two inner main pant covers
Two main gear leg covers
Two inboard and two outboard gear leg transitions.
One nose gear pant, usually with the nose cone taped on to it.
Nose gear leg cover and nose cap
Six wing hinge bracket covers. 4 for the inboard and center, and two for the standard outboard bracket.
Main and nose gear metal supports.
Four nylon spacers for the main gear hinge and pant supports
Three 4 inch hinges
Appropriate nuts, nutplates, bolts and screws.
No rivets, or decorative countersunk screws are included as your taste will determine which you want to use.

We molded all our components and covers with transparent gel coat. It may not look white and pretty as the glass overlaps and flox can be seen through them, but you can see where you are drilling and check clearances a lot easier for installation. Since you are going to paint and fill anyway, just scuff the gelcoat, fill any Oopses and get on with it. It's fiberglass, you have to paint it.

Custom Flight Creations Speed Kit Installation

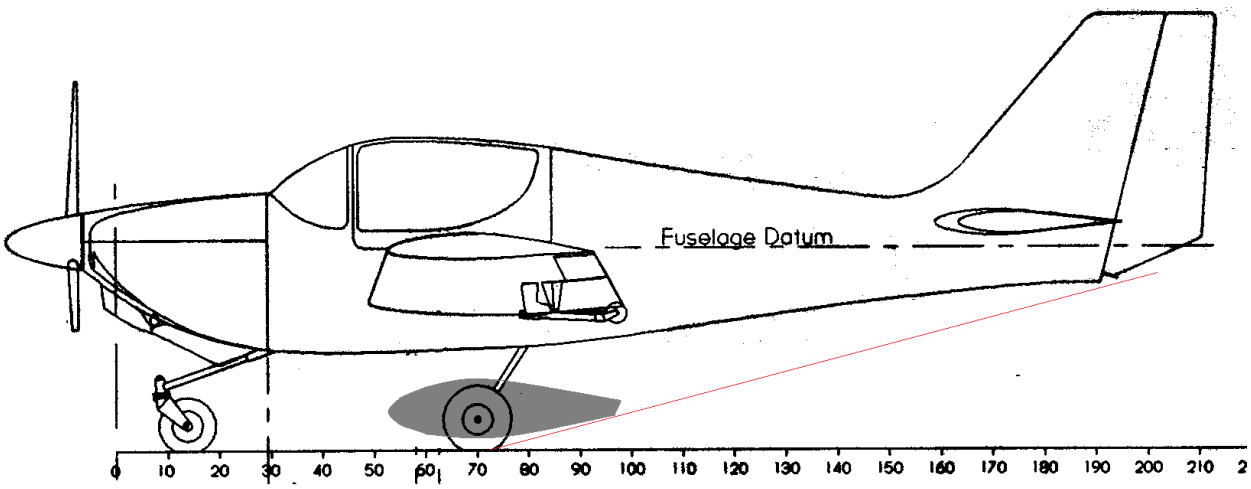
Wheel Pant Installation:

Preparation:
The main wheel pants need to be installed with the wheel pant level with the door sill or flight attitude and aligned with the centerline of the aircraft for acceptable results. This means the centerline of the aircraft must be marked, the aircraft leveled, and the weight removed from the wheels to remove bending forces on the gear allowing the wheel pants to be easily aligned in the shop.

Most builders are reluctant to jack the aircraft to level, align and relieve the gear in an installation, but it must be done. Start by simply removing the wings and tail planes for ease of moving about. Successful installations have been done by placing the unrefueled fuselage (wings and tail planes removed) on the flat hangar floor and simply lift the tail of the aircraft with a helper by the stab tubes until all the weight is off the mains, then, set the aircraft down on the mains slowly and hopefully there is sufficient floor friction to allow the tires to stay put. Note the gear barely moves. Sand paper glued to the floor is a way to keep the wheels and gear from sliding or springing outboard under the weight.

Next, find the centerline marks on the fuselage. If the aircraft centerline marks are no longer visible due to finishing activity, use the center of the tail post bottom. If a tie down was installed on the aft centerline, and is clearly centered that may be used also. Drop a plumb bob from the center of that point to the floor and mark it carefully. On the front of the aircraft, drop a plumb line from each side of the cowl line used in the weight and balance (vertical joggle line on the fuselage side for the cowl) and connect the points and find the midpoint. Again, successful installations have also used just the center point between the two foot wells marked on the engine/gear frame. Connect the front and rear marks for your centerline.

On the normal Europa XS or Classic, the pilot's side door sill is sufficient for determining the level flight attitude at an average gross weight. If being installed on the high top, use the lower fuselage bonding joggle if still visible. If not use the cockpit module top as it is as close as you will be able to get with the wings off.



Installing the wheel pants :
First prepare the moldings by light sanding with 180 grit. The gel coat is clear for easy viewing of internal components so drilling is quite easy. The wheel pants are only two layers of 8 oz. cloth so the edges may be a bit sharp. Lightly break the edges to make them more comfortable to handle. Each wheel pant must be reinforced after fitting with forward and rear bulkheads of two layers of 8 oz. glass(prevents mud and debris from filling the wheel pants) as well as the hinge attach point, screw holes and the lower opening edges. Once complete with the bulkheads, wheel pants are very light and quite strong. So make up some patterns and lay up flat two ply layers of 8 oz Rutan bid for the bulkheads and allow to cure at this time.

Note that there are two marks on each wheel pant which define the level aerodynamic minimum drag line. Use a flexible rule to connect the dots for alignment. The wheel pants are clearly left and right and the cutout has been made on the inboard side and just clears the standard 5x5 tires of the Europa. Check the fit if you wish at this time. Next, set the pants and the inner panel which should be taped to the inboard side on the bench and if necessary, sand or add a bit if heat to get the closeout to fit the main wheel pant recess well and allow to cool. When installing the transitions and flanges to the thin unreinforced glass, remember that applying glass to the outside, the epoxy/glass shrinks (as does filler) when curing, so these thin parts warp and care must be taken to assure the shape does not change.

Prepare the attachment brackets.
Included with your kit is a pair of T brackets (metal tees about 12 by 12) cut to fit the main gear brake bracket support. Two matching spacers made from nylon and 8 total AN-3-14 bolts are included to secure the bracket. This portion of the install can be accomplished easier if the wheels are removed and the mains supported on wood blocks as it is more convenient to drill and install the bolts, but not faster to install due to the reassembly of wheel and tires and the time to assure the brake caliper does not impact on the bracket. I leave the tire on and use a set of ignition wrenches, magnets etc. to secure the bolts.

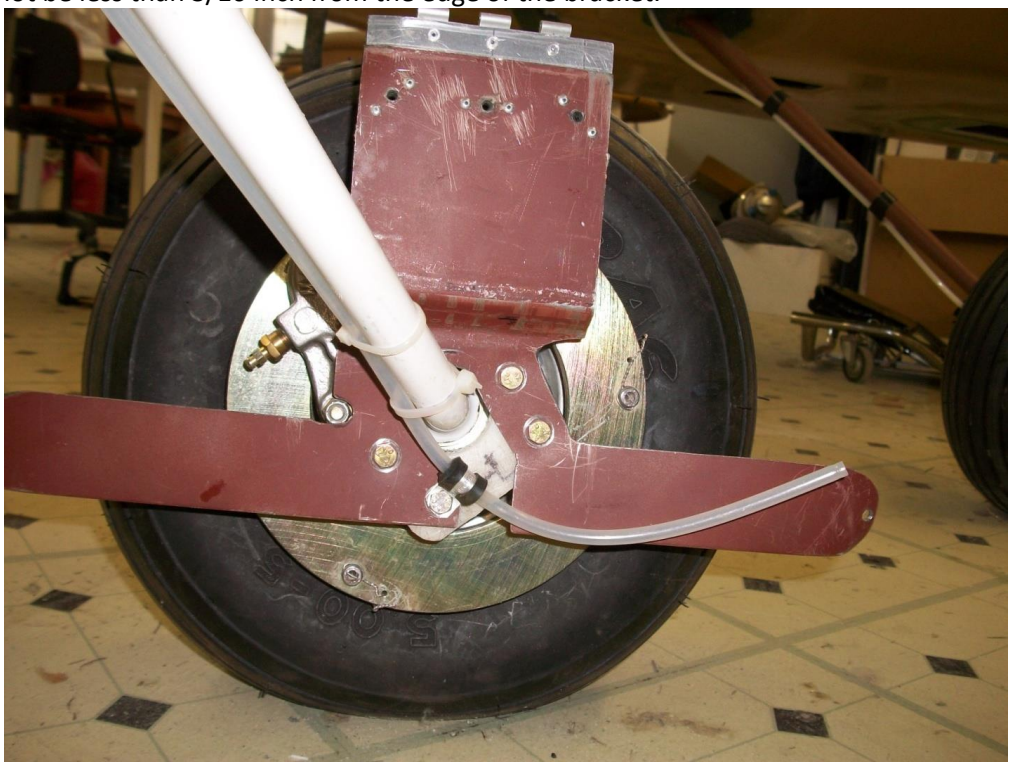
The wheels and brakes must be reattached at this step. The bracket must be attached and bent to clear your particular wheel brake caliper. IT IS IMPORTANT TO HAVE NEW BRAKE PADS INSTALLED OR ACCOUNT FOR THE PAD WEAR to position the brake caliper to bracket distance. It is easiest to install the nylon spacer(s) from the front inboard with the slot pointing upward and aft to align the predrilled

holes in the nylon spacers with the two existing holes in the brake caliper support. Fit the metal bracket by bringing it in from the aft inboard side and sliding the slot over gear leg and against the nylon spacer. Note that a bend must be made to the metal vertical support to clear your particular brake installation. Each plane is slightly different, so mark where the metal bracket touches the caliper and then note the amount of space the bracket must be bent for clearance. Mark the metal, remove and bend in the vice/brake or bench and reinstall to check the fit. The bracket is made from mild steel so if you have to hammer it a bit, it will still be bendable without cracking within reason.

Note: If the bracket is installed hard against the caliper the brakes will not release properly and drag, causing premature wear, and will feel spongy and cause ground steering problems due to unequal brake drag. Once the metal support bracket is temporarily installed actuate the brakes to check the bracket is clear of the caliper.

The picture below indicates the bend is normally a horizontal bend made in a vise or on a bending brake, of 45 degrees, for about ½ to 5/8 inch then bent back to vertical. The brake line does not have to be removed normally, but it must not rub against a metal edge and be secured properly when finished.

It is far easier to remove the wheel to attach the bracket bolts, but it is fairly easy if patience and a magnetic tool is available to retrieve the inevitable dropped nut into the wheel housing. Using the predrilled holes, it is easy to install the bracket with the first two lower bolts, but four bolts are needed so two additional upper bolt holes must be drilled. It is a bit of a pain to do these upper bolts holes and clear the axle brake support bolt. Now it is time to study and mark your wheel brake caliper support for drilling. Note that the hole must be placed so as the nut and wrench will clear the spindle and the hole edge will not be less than 3/16 inch from the edge of the bracket.



Once the bracket is bent to allow clearance, it is time to attach it. Note that the gear bracket is notched for the caliper bolts and the brake line.

Technique:

The gear brackets are vertical to the ground (or nearly) but the gear leg is at an angle as shown above, and at a camber so getting a precisely drilled set of holes to support the bracket can be a bit difficult. During the drilling, some have found it best to drill the nylon spacers to get things right, instead of drilling and bolting up the bracket and spacers hard for each hole. They will cut off the heads of a couple 3/16 bolts or use a 3/16 rod as an alignment pin to set the spacer position and make a template or drill through the 1/8 inch caliper bracket into the nylon spacer. Remove the newly drilled spacer to prep for the new holes through the other spacer and metal bracket. (It's an airplane, if you don't take it apart and put it together at least 5 times you're doing it wrong.)

Now it is time to mark your wheel brake caliper support. Note that the hole must be placed so as the nut and wrench will clear the spindle and the hole edge will not be less than 3/16 inch from the edge of the bracket.

If the wheel is removed, mark the hole position with a center punch and drill through the caliper support on the gear using a 1/8 drill bit to drill the first hole and deburr to serve as a pilot hole. Install the spacer and bracket. Then drill from the inboard side through the nylon spacer and metal bracket.

If the wheel is left on, it is best to measure, mark and drill the innermost nylon spacer first with a 1/8 hole then carefully match drill to that hole through the other nylon spacer. A premade template really comes in handy. Set the now drilled nylon spacer on the matched second ½ inch spacer (normally the nylon spacer is two ½ inch nylon blocks to allow some slop in drilling but some are 1 inch). It is then easy to use the two spacers to align your bit and drill the hole through the metal main gear bracket. Once the 1/8 inch holes are complete, drill them out final to 3/16. It is important to use the drifts, cut bolts or pins in the lower predrilled holes and simply ream the holes with the 3/16 bit for a good fit.

At this time, make sure the brake caliper, brake lines and brake line bends are clear and will not chafe. It is necessary to plan and fit an Adel cushion clamp to assure brake line security and hold the line so it cannot chafe against the bracket, the bolt heads or caliper to prevent a worn line and possible leak in the future. It may be necessary to make small cutouts for the caliper slide bolts by relieving part of the bracket as the photo depicts.

More than one Adel cushion clamp may be necessary to provide adequate clearance. If the brakes are worn, it is necessary to manually move the brake caliper out to its full compression to assure the metal bracket does not push against the caliper.

Prepare the bracket for wheel pant installation by touching up with primer and install with temporary nuts to allow easy install and removal. Have a magnet handy to pick up the pieces as they fall into the wheel and brake disk. Repeat install on the other gear leg.

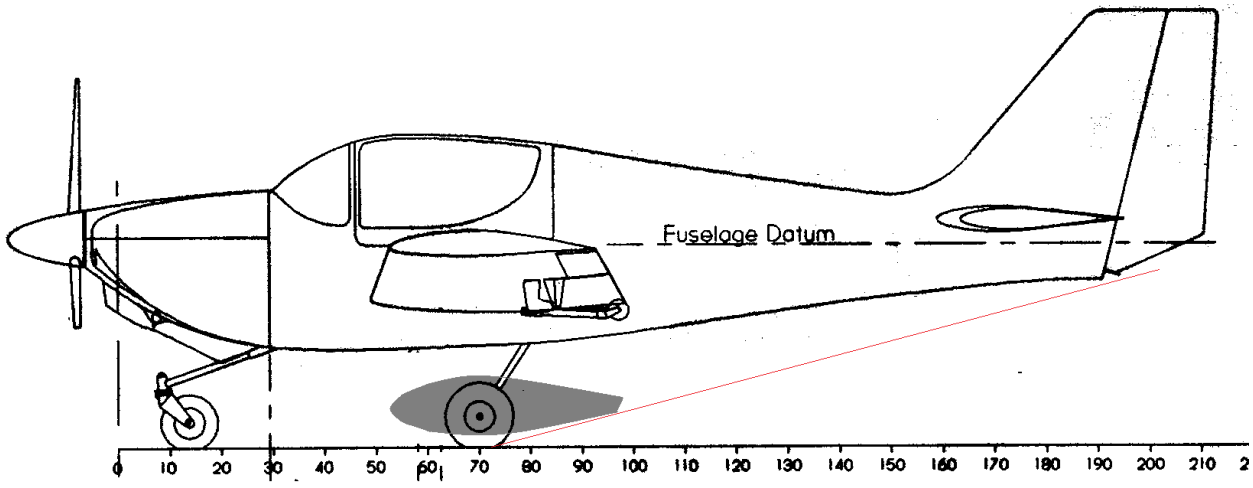
Note: The plastic lines used in most experimental aircraft will in extreme brake use get heat soaked and become brittle, or if the brakes get very hot like when taxiing in a strong cross wind for a mile, may even begin to bulge and burst. It is prudent to do one of the following:
Fabricate a small .016 stainless heat shield to fit between the spacers to reflect the heat from the disk away from the plastic brake line. Alternatively, metal or metal braded brake lines can be fabricated from the caliper to the gear leg then plastic the rest of the way are an excellent way to prevent the heat from damaging the brake lines. See photo below of a simple rectangular heat shield:

Installation of the wheel pant:
Pull the cotter pin out of the axle nut and install the supplied drilled nylon dowel. Many use the RV axle nut instead, but then a wood or similar dowel must be glassed on the pant to act as the spacer. Others have used their old T fitting from the original Europa pant kit for their outer support.

Place the wheel pant over the wheel and tire by rotating the pant on as if it were hinged to the upper bracket. Note how the wheel has outboard camber but the wheel pant must be placed nearly vertical as measured with a square from the floor for proper clearance all around. Place 2x4 lumber under the pant as blocking to hold it level with the floor. For vertical, use a brick or heavy square and check with a square.

The height of the wheel pant depends on the surface of your runway. For turf runways it is best to position the bottom of the aluminum wheel rim level with the bottom of the pant. For hard surfaced runways and for lower drag, lower the wheel pant to a point which allows 2.5 inches from the surface to the bottom of the wheel pant (with the tire inflated to 35 psi). The wheel pant bottom aft line is shaped to just clear the ground at full nose high on landing roll out as shown in the picture below.

We pull a string from under the wheel to the tail and clamp it in place to check that the back and bottom of the wheel pant clears the string by at least ½ inch. See drawing below:



The pant must clear the tire by a minimum ½ to ¾ inch all around the inside and top of the tire. The pant must be aligned with the flight path vertically and horizontally. Make longitudinal chalk lines parallel to the centerline of the aircraft to assure alignment. View from above from the nose to the tail of the pant that it is aligned properly. Once the basic position is set, note the horizontal arms of the bracket and where they rest on the pant. Note the position of the outboard center of the axle by looking through the pant (you may need to move the brick). Simply adjust the drilled nylon dowel in and out to just contact the inner skin of the pant for easy viewing.

Move the pant fore and aft to center it up on the approximate axle mark. The axle mark on the outside of the pant is not a vertical position, it is only for fore and aft positioning. Since the axle is not perfectly straight, the eyeball must be used to get the alignment set. Your vertical portion of the bracket arm

should be nearly centered in the slot at the top inboard section of the gear but still be aligned properly. It will be necessary to bend the top of the hinge inboard a bit to allow easy positioning of the pant. Once the vertical bracket arm of 4 inches is centered on the cutout, the two lower arms can be bent to allow them to rest on the outside of the pant rebate squarely. Simply use two small spring clamps to hold the horizontal portion of the bracket to the pant. The metal bracket must be trimmed off for a good fit into the pant rebate. Remember to account for your hole clearance from the bracket end. Clamp up the inner bracket arms and then mark the wheel pant inner and outer points where the nylon axle dowel and brackets touch the pant and re-check alignment.

Warning:

The wheel pant and its bracket cannot prevent the operation of the brake caliper. Installations on a brand new aircraft have full thickness brake pads. If installing on a flying aircraft, the pads may be worn down and when new pads are installed the caliper will be moved away from the wheel. One check is to activate the brake and ensure the movement of the brake caliper does not interfere with the brake support, inner pant cover, or brake line.

Next turn your attention to the top of the 4 inch arm of the metal bracket and note where it falls on the wheel pant. The metal bracket should be trimmed to 1/8 but no more than 3/8 inch below its hinge line point which is the slot cut in the wheel pant. Be sure the pant is at the proper height and alignment. Note the hinge is attached to the steel bracket and then is bonded to the wheel pant itself and riveted in place securely.

A photo below shows how the hinge is reinforced to the glass and bolted to the bracket at the attachment point. I prefer to pre-mark and drill my hinge for at least four 3/32 rivets to the pant and 4 #4 screws or three #6 screws for the metal bracket if you want the hinge removable from the metal bracket as I do.

Once the bracket is trimmed for vertical, position the hinge aligned nearly level to the floor so as to make sufficient contact with the pant and the metal bracket with the hinge barrel flush against the pant. Prepare to match drill to the bracket. Carefully bend the vertical metal support to be aligned just inside the pant, align the hinge and mark the hinge location. Carefully set the hinge on the outside of the pant top and drill two holes through the hinge into the wheel pant. Then move the hinge to the inside of the pant and cleco in place. Drill the other two holes.

Once the hinge is clecoed, check for level and tilt, then the ends of the metal tees can be final marked for trim and predrilled for attachment. Once trimmed, reclamp and check position, then drill through the wheel pant flange. Cleco it all together and check the position of the wheel pant. Once satisfied, remove the pant and prep for the fiberglass reinforcements.

Fiberglass Reinforcements:

The hinge is in the curved portion of the pant. This area is very weak and the flat hinge won't fit without filling and reinforcement. This hinge is not a structural support holding the pant on, but is necessary to keep the pant solid in the vertical and when open, and prevent fatigue of the three screw attachments when closed. This is a light wheel pant, it needs to be properly supported.

The hinge has to be supported with glass and flox by first scuffing the hinge area out about one inch past the hinge ends. Apply 4 layers of glass (6 inches by 2 inches) and floxing over the glass. This additional reinforcing is required for the hinge support and edges. Cover the hinge with release tape, open the

rivet holes and set the hinge into its place. Align the hinge with screws or hand clamp fixture holders similar to the European style clecos to just hold the hinge in place until the flox and glass cures. Spring type clecos apply excessive force that will bend and distort the pant. Allow to cure. Remove the screws and prep for attachment.

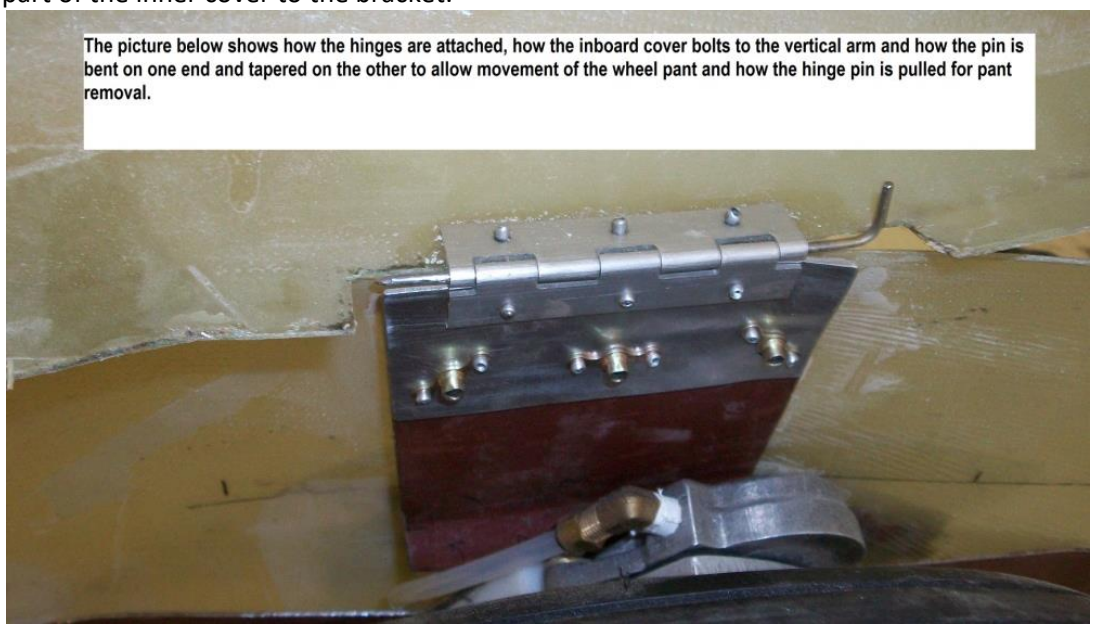
The attachment points for the three large bracket attachment screws must be reinforced also. The nutplate reinforcement for the inboard support requires 4 layers of glass measuring 1.5 by 4 inches. The outboard reinforcement is a 4 inch by 4 inch 4 layer bid reinforcement. Now, for those desiring a taper head screws without Tinnerman washers for the support screws , the thin outboard skin must be made thicker and stronger. If no Tinnerman washer is used on the outside, add a AN970-3 or 4 or similar washer to the inside and flox and glass into position. Countersink as desired.

Note, we use an AN4 screw for the outboard as it is stronger for grass operations and many prefer to use a Van's RV axle nut with a MS21042-4S nutplate in its center. It is a matter of taste.

Clearance the hinge line at the upper inboard area, this is so the hinge does not bind while opening the pant or it will scratch, tear or flex when against the skin. Clearance the wheel pant hinge using the same technique as on the aileron hinges. The lower bracket arm holes can be drilled at this time. Realign the pant as you did initially. Look through the pant inner cover and note where the axle hole is and mark where the axle hole goes through the inner cover and drill final.

Once all the reinforcements are cured, drill out the mounting holes from any flox or glass covering them and cleco in place again. Once satisfied, drill and countersink the hinge holes in the glass and drill out the bracket ends from 1/8 inch to the final 3/16 inch for the screws.

Inner cover installation:
The inner cover must be cut with a slot to allow it to slide over the gear leg and install the wheel pant for maintenance. Align the inner cover over the wheel bracket and trim to fit the rebate on the wheel pant. Once trimmed it is easy to see where the bracket holes are and install clecos to hold the inner cover to the two lower holes in the bracket. Now three #6 or 4 #4 holes must be drilled to secure the upper part of the inner cover to the bracket.



You may note the inner cover may be curved and not fit flat to the metal bracket. Scuff sand the inner cover and use expand cell or filler on the inner cover (cover the bracket with release tape and cover the brake caliper and slides) to make a spacer so the screws do not deflect the inner cover when tightened to the bracket vertical arm. We put the three upper bracket screws about ½ inch below the hinge flange to allow nut plates to be installed.

On some installations, the hinge is not riveted to the bracket but is secured using the riveted nutplates. This is a slick install also but more eyeball work is needed. See photo above.

After cure, it is prudent to smooth the filler and then add two layers of glass to the inside of the inner covers for a more ridged inner cover support. After the slot is cut, I like to add a full two layers of glass to the inside to stiffen this cover from distorting and allow rougher handling during filling operations.

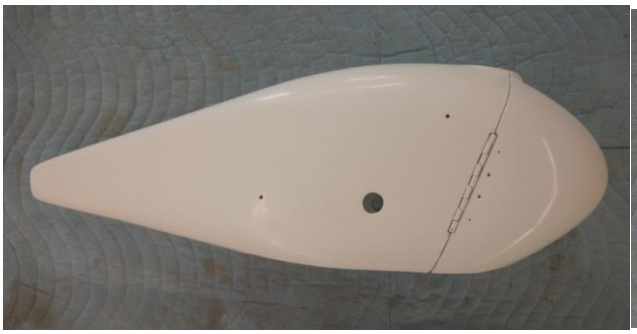
Finally, add nut plates to your holes drilled in your main pant arms to secure the inner cover to the pant and arm. The edge of the wheel cutout is to be reinforced by a 2 inch strip of two layer glass around the perimeter. Any debris or grass on the runway really cuts a low slung pant so be sure to reinforce this area. The Bulkheads are essential for strength of the wheel pant. Experience shows to prevent mud and debris from filling the pants properly fitted bulkheads assist in easy cleanout of the pant also.

Fashion the bulkheads as follows:
First mark the extreme forward and aft position of the tire in the wheel pant by simply looking through the opaque pant. I use a marker pen to roughly mark where the bulkhead will clear the tire and bracket attachment bolt points by at least an inch. Remove the pant and using ordinary paper and tape, make a template of the inner and outer bulkheads. Make them as near vertical as possible for ease of install, or if you wish, you may curve the bulkhead to allow debris not to accumulate in the bottom corners.

The bulkheads are made from one or two layers of bid and peel plied as stated above. Allow to cure, and trim to fit using your templates. Drill a hole for a cleco near the center to help hold the bulkhead in place. Once fitted, mark and then scuff the inside of the pant and apply a two inch wide 2 ply bid tape around the bulkhead and allow to cure. These bulkheads add a great deal of rigidity to the thin lightweight pant. I always make a hole in the bulkhead and use a centered cleco to help position the bulkheads and tack with thick super glue prior to applying tapes. Then remove the cleco so that as the tapes cure, the wheel pant does not distort. Allow to cure. Next comes the nose pant.

Nose Wheel Pant installation:

The Custom Flight Nose wheel pant is an exact duplicate of the Europa pant shape, well, nearly. It is slightly longer and it is a bit flatter on the bottom. Obviously it has a totally different nose cone shape. We also built it to accommodate our custom flight wheel axel shaft and tow bar.
One can see the right side has a cut from the pivot shaft opening to the bottom, sloping slightly aft and is hinged.




Fresh out of paint, one can see the shape is similar to the original Europa pant but the bracket is a bit different than stock and is set much more vertical. Large hole is for the tow bar.

On the left side one can see the nose cone cut is quite raked aft. It is raked to allow the nose cone to open via three screws and pivot to allow access to the valve stem. Be sure to install the tire with the valve stem on the left.

Begin the install by installing the two V shaped supports on the axle bolt. Trim the Europa supplied axle bolt to be just inside the pant. The nose gear brackets are only slightly different than the Europa ones. Note in the photos above, the axle shaft has a bolt head to allow for a tow bar to be attached. The tow bar axle bolt is not required. See CFC custom tow bar mod.

Caution: Support the nose of the aircraft with a hoist or weight on the tail to keep the nose wheel off the ground safely when removing the axle bolt and installing the V supports. Once the axle bolt is reinstalled lower the aircraft nose to the ground.

Do not tighten the axle bolt more than snug. Allow the V supports to move. With your hands, spread the open section of the aft wheel pant half to clear the axle bolt and position it temporarily over the axle shaft. The wheel pant hole at the top is undersized. Your task is to make the bottom of the wheel pant level with the flight path or door sill and as vertical as possible. (During shipment the pant may be out of alignment, so heat it, if it is “leaning”.) The wheel pant should be no lower than the bottom of the wheel rim lip or it won’t open properly. Trim the vertical pivot shaft hole to make that alignment happen. Mark the inside or outside of the wheel pant and make the axle access hole if you wish this to be open. Most guys do to check the axle shaft on 25 hour inspections or use our tow bar.
Remove, drill and reinstall.
Once satisfied with the fit, note the V shaped supports. They must be positioned to only hold the aft section at this time. Note that the front holes of the V are on the aft pant section but within 1/2 inch of the front.

From the outside, mark the forward and aft 3/16 inch holes for #10 525 10R8 screws. We cleco the pant on and check alignment again.
When satisfied with the alignment, tilt and pitch, install the nose cap. Again, some fitting may be required. Open the top pivot shaft hole to clear by at least 1/16 inch, and tape the cap in place.

Look over the alignment. Mark where the hinge will go (basically the middle of the starboard side), then mark where you want to drill the three holes for the port side. Drill 1/8 inch holes to start.
Carefully drill the port side holes. If you can, predrill your hinge with 3/32 inch holes. Align the hinge with the hinge line and place the hinge on the outside of the pant, drill two holes on the starboard aft side of the hinge and two on the forward side of the hinge using 3/32 inch clecos.

Check the pant alignment and fit. When satisfied, remove the nose cover and aft portion of the pant.

Install the nose cap AN -3 hinge. Trim the glass just as you would an aileron hinge using a 3mm rebate on each side of the hinge line. Attach the hinge using at least 3 4-40 screws or 4 3/32" rivets (TLPK 36 rivets work great). Remember, the hinge line is set so that the nose cap will pivot and clear the ground when the pant is set no lower than the wheel rim lip. It will look like this below when open.

When satisfied, open the nose cone and tighten the axle bolts with open end wrenches.

Finally, drill and cleco the wheel pant with the proper sized holes (3/16 or #10 for the aft pant and # 27 drill for the #6 screws.) The nose pant needs reinforcements just as the main pants. Apply the same sized 4 ply pads for the bolts and nut plates. For the hinge, reinforce front and aft with a 4 ply one inch by at least 6 inch tape. Many of our clients prefer Tinnerman washers and #6 screws for the hinge and port side, and #10 countersunk screws and Tinnerman washers for the pant supports. AN 525 work just as well.

Finishing and installing the gear leg covers.
One must make transition fairings for the nose and main. We supply gear leg covers of a simple airfoil shape for the main gear leg cover. However, the gear legs covers will all need some sort of support to affix the gear leg solidly. I have found that properly made transitions will support the gear leg cover and when shaped to suite your taste and planned for easy install are quite attractive, maintainable, and will be good looking for years. That is where the time can come in.

This is the prototype transition, but it had too many screws. We have found it is much easier and just as clean to make a short transition that only goes about 1.5 inches up the gear leg cover. I also find it much nicer to cut the side of the inner cover up to just short of the width of the gear leg cover.

You can see the wheel pant inner cover below is pretty simple and small. It has 4 screws to hold the bottom of the cover firmly, but more importantly, remember, you won't take this inner panel off to open your pants, and frankly only remove it for annual inspections requiring brake removal. Remove these 4 small screws and the entire cover comes off and remove the hinge upper support screws to pull the inner cover off when doing brake pad maintenance or during an annual inspection. One trick to making these transitions and cutous is to properly cut the gear leg cover for a good fit on the fuselage and on the inner pant. Once the gear leg is properly fitted, then the transition fairing can be installed.

The gear leg cover is split to slide over the landing gear. It normally is trimmed to fit but can slide forward and aft. To put the fairing in the place you desire, mark your inner pant and fuselage and make sure the gear leg cover is aligned precisely with the relative wind. Use a pair of squares parallel to the fuselage centerline and align the leading and trailing edge at the same distance. Then verify with your eyeball. Some will fill the gear leg cover with spray in expanding foam or use ply to make small ribs to glue to the gear leg. Either way works fine. Personally, I just use my marks for fore and aft and a couple of squares, then draw a line on my inner pant cover.

I then plan my cut in the inboard cover by pulling the inboard cover off, laying on the transition fairing supplied, and plan my cut lines on the inboard cover and fairing. I then hold my breath and cut.

Above is the pant in fill and prep for final finishing.

Final finish of the pant. It just takes time, technique and patience. See my tips on finishing on my website.

Normally the transitions for the CFC Speed kit are supplied. However, if you have modified your gear leg covers or are using another style gear leg cover below is the process in fabricating your own gear transition fairings.

Clay is normally used to get the shape of the transition from the pant inner cover to the leg. We prepare the cover with release tape. We then add clay and shape it. When satisfied with the shape, apply four layers of glass to make the transition shape. Since glass will shrink 1-2 percent and not leave sufficient space for paint and filler. We fill our gear legs and prime them first. Then add 4 layers of painters tape over our gear leg cover and release tape over that to assure the glass will not shrink and be too tight. (We fill the gap after cure with a thin piece of insulation foam tape as used for window gap insulation obtained at any hardware store.) With the cutout of the inner cover, one might ask how do you cut the clay and glass off after cure. First, drill a small hole in the front and aft layer of the transition as well as the cutout section to hold it in place during the next action. Then carefully, mark your cut lines. The front of the transition should be about ½ inch aft of the leading edge, and the aft about an inch. Using a fine Dremel diamond cutoff wheel and patience, cut the transition off. See the photo above for how the transition is cut up the leg. Once cut, remove the covers and clean up the clay.

These transitions are not for looks, but for aerodynamics and to hold the gear leg securely aligned with the airstream. They are not strong enough to do this task at this time. Scuff sand the inside and outside of the transition pieces. On the inside pant mark the gear leg Reinstall the transitions and the upper section to the inner pant cover. Fit the cut leg cutout portion in place and clearance as required. Remove them both. Cover the cutout cover with release tape and tape to the upper transition paying attention to alignment. Lay 4 layers of glass lapping the inside of the upper section by at least ¾ inch over the inside of the cutout cover (which is covered in release tape, and on to the other side of the upper section. Allow to cure. Once cured pull the cutout cover from the glass and trim for a ½ inch flange. Drill and prepare for clecos. #6 screws are fine.

Once cured and cleco'd, it is time to reinstall the flange to the inner gear cover permanently. They are removed prepped by sanding and floxed onto the inner cover and cleco as required. Allow to cure. The flox is fairly strong, but will crack under flexing so remove the clecos, scuff the glazed areas and apply 2 layers over the whole transition floxed area. This will be rugged and carefree.

The upper gear leg to fuselage transition setup is done as the inner cover but the trailing edge made in place and cut, or overlapped on the aft end to allow it to be stretched over the gear leg. Finish paint and cement in place with silicone. For the purist, you may want to glass the transition in place and make it so the gear leg slides under it but much fine cutting must be done to get the gear leg to slide on without having to pull the wheel assembly off to get the gear leg on. I prefer to use small attachment screws along with the caulk to hold the transition on.
Caution: Do not drill into the fuel tank!

Try to keep your transition fairing thin and with enough gap to allow the gear to flex. Any gap is best filled with a flexible sealant like white silicone. This cover has ¼ inch at the front and back (more important at the back) and 1/8 inch on the outer side for the gear to move and flex without cracking the gear leg transition. The plane fully loaded above shows the gear leg cover just touches the gear leg. You can also glass the transition to the fuselage, but the gear leg must be shaped to slide into it or if you decide to butt them together, a gap must be left for gear movement.

There are many ways to make transitions fairings. I have a mold but frankly every gear is installed at a slightly different angle. My transitions are thin with gelcoat (probably not a good idea) so that with a bit of heat and some clecos they can be installed and trimmed easily. But no premade fillet will be perfect as we all install our gear slightly different. I will often times just take modelling clay and make a pleasing shape or better fair in my transitions. Once I finish the basic shape or fit my molded transition, I split the rear of the glass fairing to allow me to install the fairing over the gear leg. Remember, it may fit well in the raw and distort after filling. Filler makes the fairing stiffer and distorts it. Hence some believe that the transition fairing at the fuselage should be glassed on. I disagree with this as the gear leg cover to the fairing will be difficult to slide inside when fitting, so the gear leg cover would have to be slid over the upper fairing making for more work to get a pleasing fit and hold the gear leg cover securely. I did this on 12AY and have not been terribly satisfied. I find making the fairing, finishing it and simply gluing it on with sealant to be acceptable. One problem is some want to put in screw fasteners, but the close proximity of the tank makes for dangerous drilling for screws. Use caution.

Nose Gear Leg Cover:
The nose gear leg cover is just a set and fit it on. If you don't glue the leg on, it can ride up and leave an unsightly gap between the pant and the gear leg cover as shown in the photo below. Normally I leave about 1/8 to ¼ inch gap between the cap and pant, to allow preflight inspection to make sure no grease is on the plastic disk. This can be unattractive. It can be a smaller gap of course, but secure the nose gear cover so the cap doesn't drag on the pant.

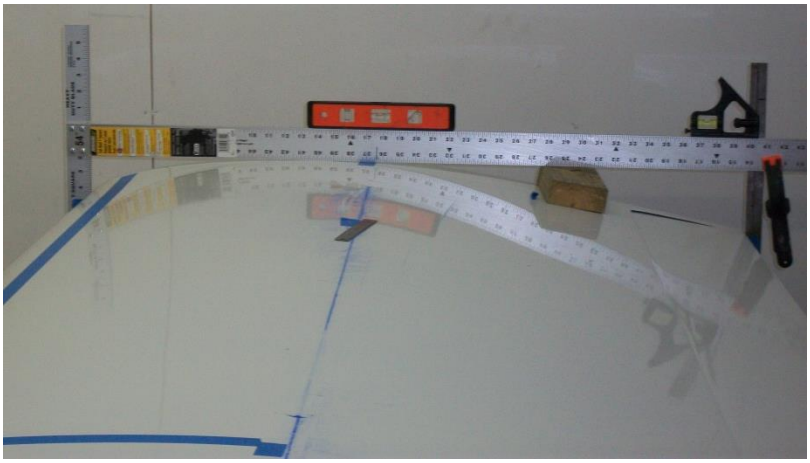
Apply a little release tape on the nose gear leg and using foam, filler and glass, make a transition lip to better clean up the flow around the leg cover and cap. Believe it or not, it not only looks better it cuts drag.

Wing Flap Bracket Cover Installation

The wing covers go on similar to the Europa kit. The only difference is in the attachment, and the width of the covers is slightly different. The CFC molded covers have a slight pressure recover taper for the inboard covers and the attachment method is slightly different. The flanges on the bottom are slightly recessed so filler can be added to get a very good fit to the wing.

Pay attention to your wing flap bracket aerodynamic covers. To help align them with the flight path, mark a line on the wing along the spar line with a chalk line to use as an alignment device to ensure the covers are dead on the zero sweep line and parallel to the slipstream or you will have six rudders out there slowing your plane down.

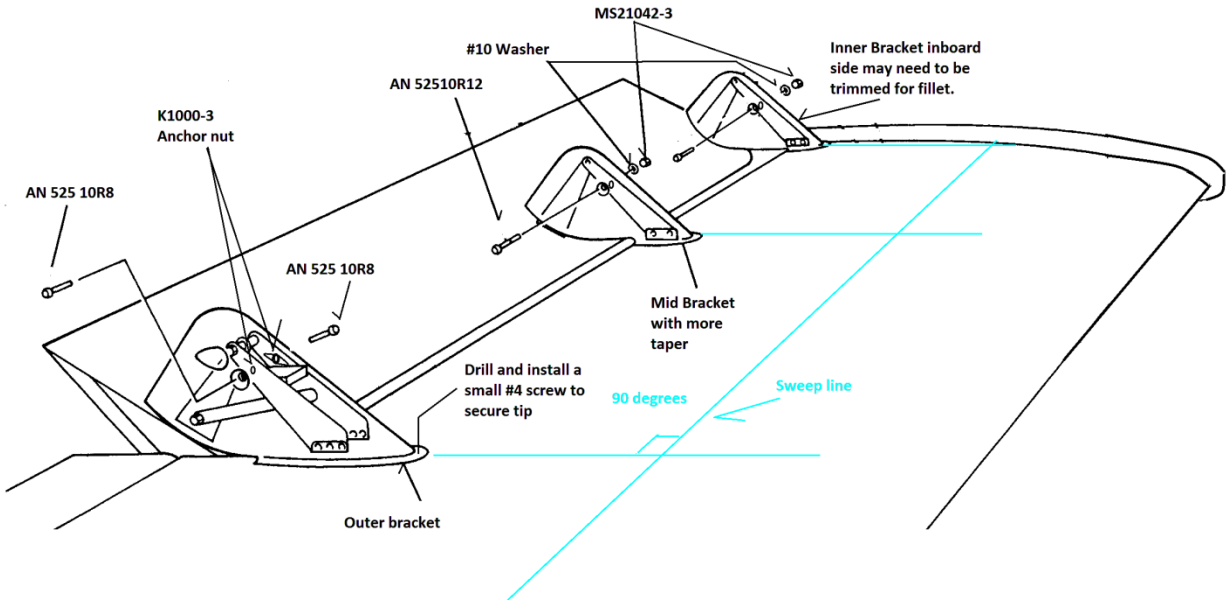
If you are a purist, and your wing sweep is not exactly zero, drop a line tip to tip at the spar line, (check your longitudinal axis to assure square) then mark the tips where your spar tips are (accounting for the overlapped spars) and snap a line tip to tip. This should be as close as you can get to your true flight path line.



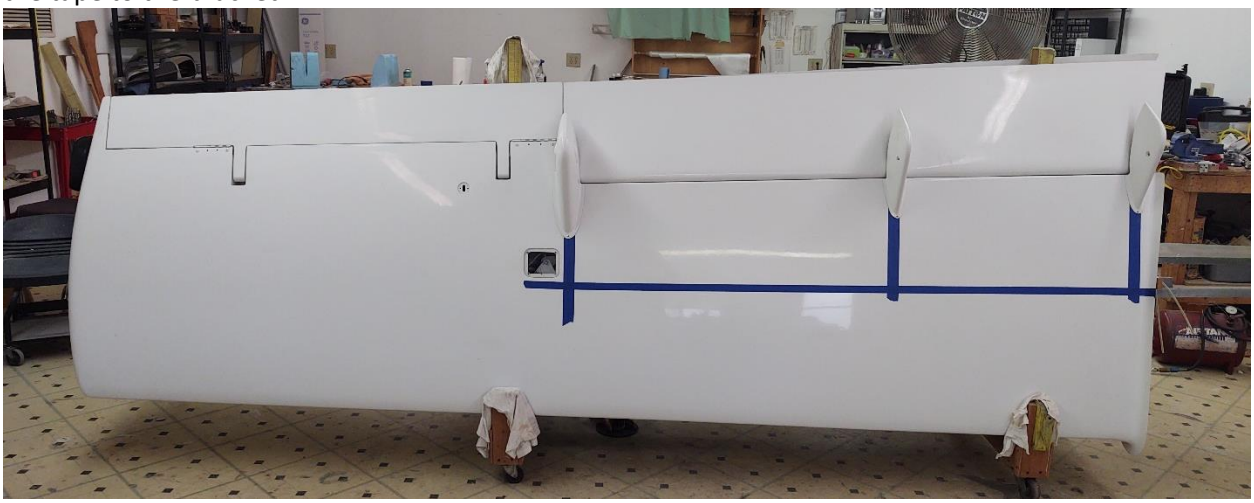
Normally Europa uses one screw and some caulking to attach your wing covers. This makes alignment and removal a pain as the single screw attachment does not assure proper alignment. The inboard cover is a cover to wing alignment problem. Note that the wing fillet may be smooth and angled or may be a joggle. The installation may or may not require additional trimming or depending on your preference, cut the existing flare and glass a smooth transition to suite your particular wing.

For a more secure installation, put two #10 nut plates in the outer flap bracket to hold the cover firm to the outboard bracket. The inner is marked, checked and a single 525 is drilled through with a #10 MS 21043 nut and washer. To assure alignment check the leading edge of the cover with your chalk line and a long square.

The flares at the wing may need filler to make a nice fit. Cover contact area with release tape and flox or fill in the flare inside to get a good fit. Trim and sand.



One easy way is to run a piece of tape parallel to the spar then up to the brackets. I still make a line on the tape to the bracket.



To hold your front edge of the cover in place and to assure alignment while the caulk cures on final assembly, we recommend that the installer drill the front flange of the cover and continue through the wing skin also. Install a small screw, such as a #4 x ½ inch taper head screw through the cover and into the skin. On an existing build with a finished wing, the skin is very thin and foam filled, so we recommend once the screw is located and tapped or screwed in the wing skin, then coat the screw with grease and install a small drop of super glue carefully in the hole to stiffen the foam core and secure the threads of the screw from pulling out. This hardening of the foam with the super glue greatly strengthens the screw threads now tapped into the skin, but caution is necessary to prevent stripping out the foam screw threads.

Note the bolts and brackets prevent the fairing from always being centered on the line you drew. Just make sure the fairing is parallel.

For a new build, we attach a #4 nut plate to a 970-3 washer or similar and glue it to the inside of the wing skin for a very secure cover attachment. Double check your alignment by installing the screws as the #10 screws in the side will flex the cover slightly. If the cover flexes too much, fill the space between the cover and the flap bracket with a spacer or stiff floxed mixture. Once assured of your alignment prior to final prep and paint, drill a least an 1/8 inch hole for drainage at the lowest point in the cover bottom. Finally, move the flap and check that the aft end of the cover does not rub on the flap before finish. Trim as required.

Once satisfied with the trim, fit and alignment, remove the flap bracket covers and paint. To install simply install a bead of caulk the covers on the wing with silicone or similar of your choice, and install the screws final. Bathroom caulk works fine and is recommended as it is easy to clean off. Marine sealants are slow to cure, and adhere so well, they are difficult to clean and on non Imron paint tend to damage the paint. Bath tub caulk only takes a razor blade and a few seconds to cut the soft sealant for maintenance. The wing covers only add a couple of knots in my testing on the inboard brackets for the Europa. The larger outboard flap bracket is a significant extra three knots.

Wing cover speed kit finish installed.

I typically take 40 hours to install a speed kit, and transitions. Filling, sanding and painting is extra...

Enjoy the ease of wheel service access and more importantly the speed increase and economy.

Our full speed kit took a Trigear fixed pitch Jabiru powered plane from 108 to 137 knots at the same power setting. It took a 912S Trigear from 117 to 134 at the same power setting and a 914 from 118 to 143 KTAS. Patience, proper alignment and clean transitions make a significant difference in cruise speed. Most importantly, preflight servicing is no longer a 4 hour task of pulling wheel pants, airing up the tires, finding all your screws, reinstalling the pants and then washing off the dirt from laying on the floor for an hour.

References:

NACA Test Reports: 485, 518, and 582.
Drag Reduction 103 by author.