The Skyscraper Method for Fuselages

The conclusion of a two part series where the author breathes new life into some orphaned wings and tail feathers.

Peter Scott

The wings and tail are from a 40 year-old 3m Graupner Cirrus, and the new fuselage is the subject of these articles.

*For readers who would like to review the first part of this article, you can find it in **the July, 2021 issue** of the NEW R/C Soaring Digest.*

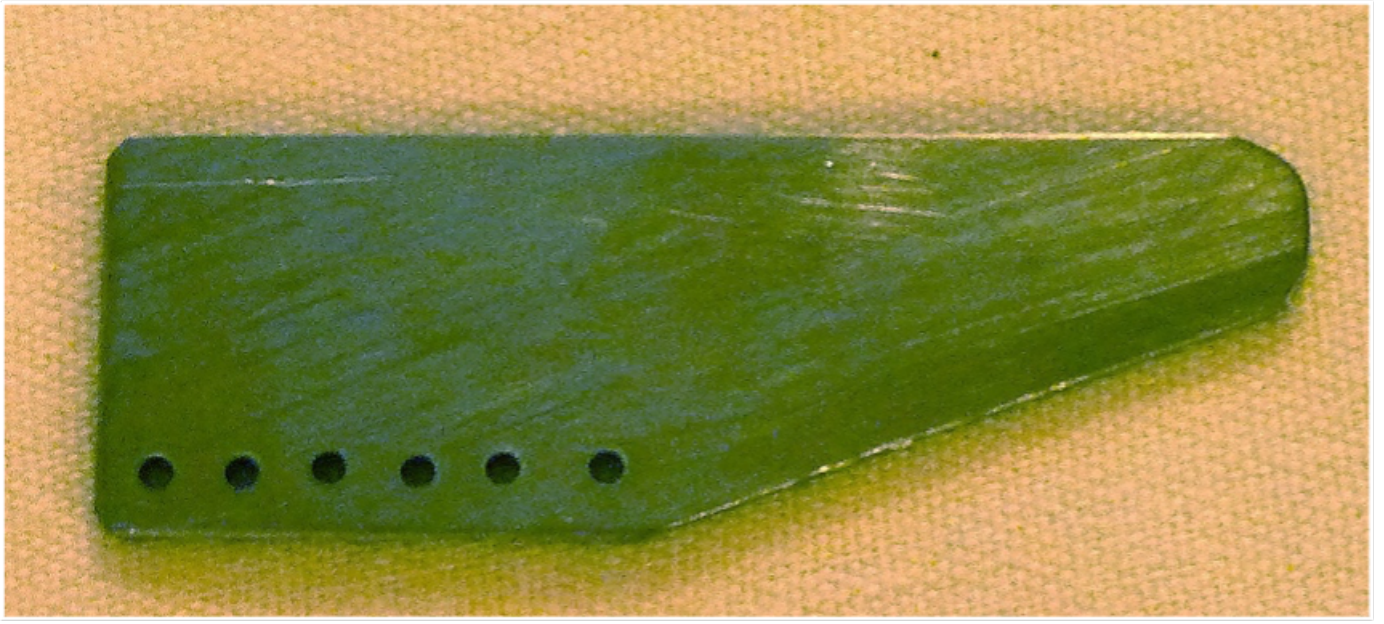
Skinning the Fuselage Pod

Last month, I left you at the stage where I was just about to give the fuselage pod a robust skin to absorb the rigours of future flying sessions. They say a picture (or four?) is worth a thousand words:

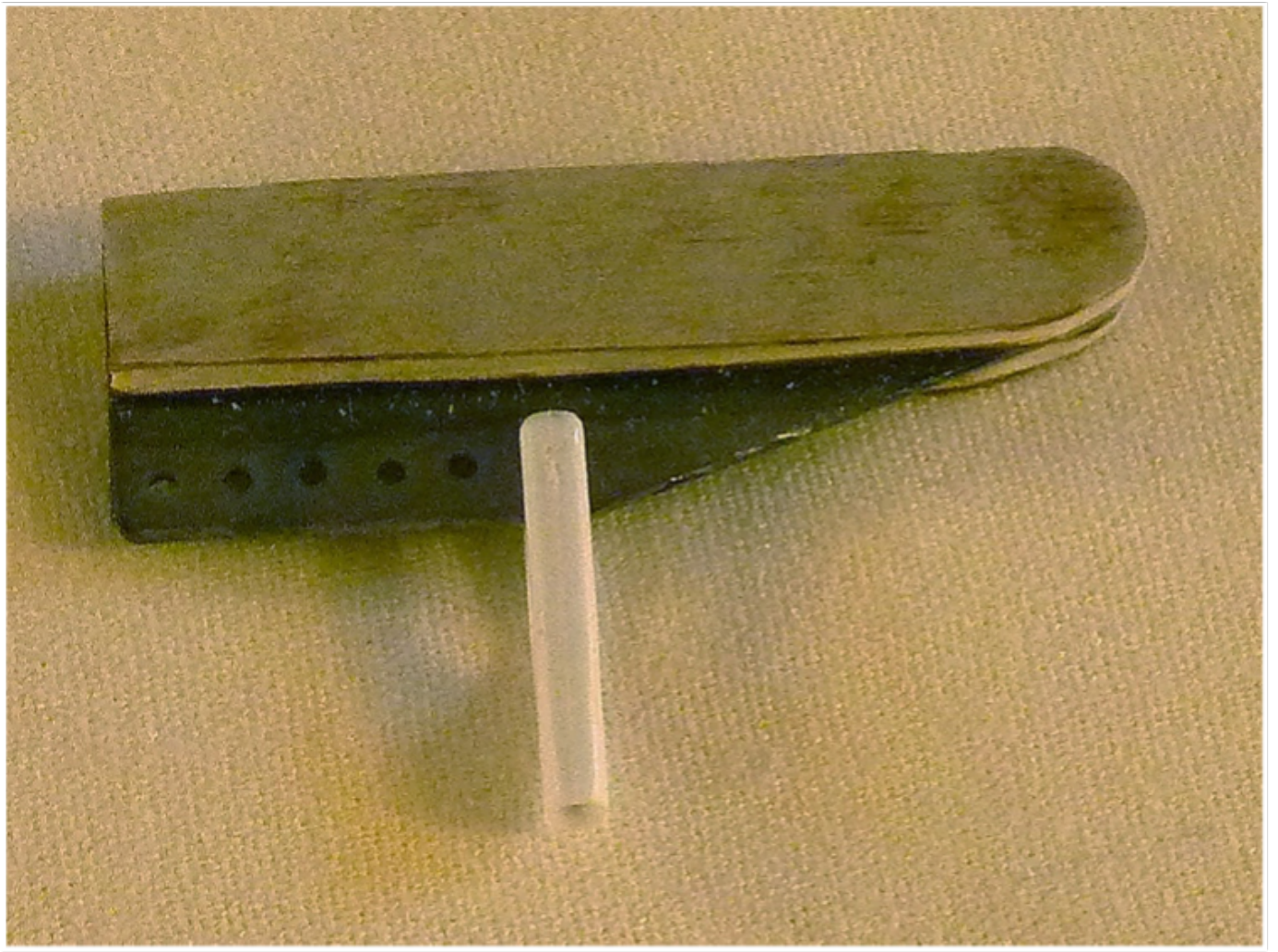
The All-Flying Tailplane Suspension

The *Sirius* — the name I had given this project — has all-flying tailplanes. This meant I had to find a way of mounting and pivotting them. I decided to install micro servos in the tail for the tailplanes and the rudder.

The bellcrank is the key component. I made it from 1mm titanium and it weighs 3.4g. It carries, in 3mm tubes, the two 2mm piano wires that plug into the tailplane halves. The holes for the 3mm brass tubes were drilled when the side cheeks were glued on. The row of 1mm holes is for the clevis on the end of the servo connection. This pushes it from below. I like titanium as it is only twice the density of aluminium but immensely tough and hard enough never to wear. It is about the same as mild steel for cutting and filing though drilling is slightly more difficult due to its springiness and poor conductivity causing heating. Apart from tiny holes, a bench drill press is required but these are cheap now.



I then laminated some strips for cheeks for the bellcrank and to form a box in which to mount it. I used 1mm ply on each side of some 2mm and 3mm balsa. This is the bellcrank with the thinner cheeks fitted. The cheeks were sanded, as were the inside surfaces of the box, so they rub smoothly. The rubbing area will give extra stability.



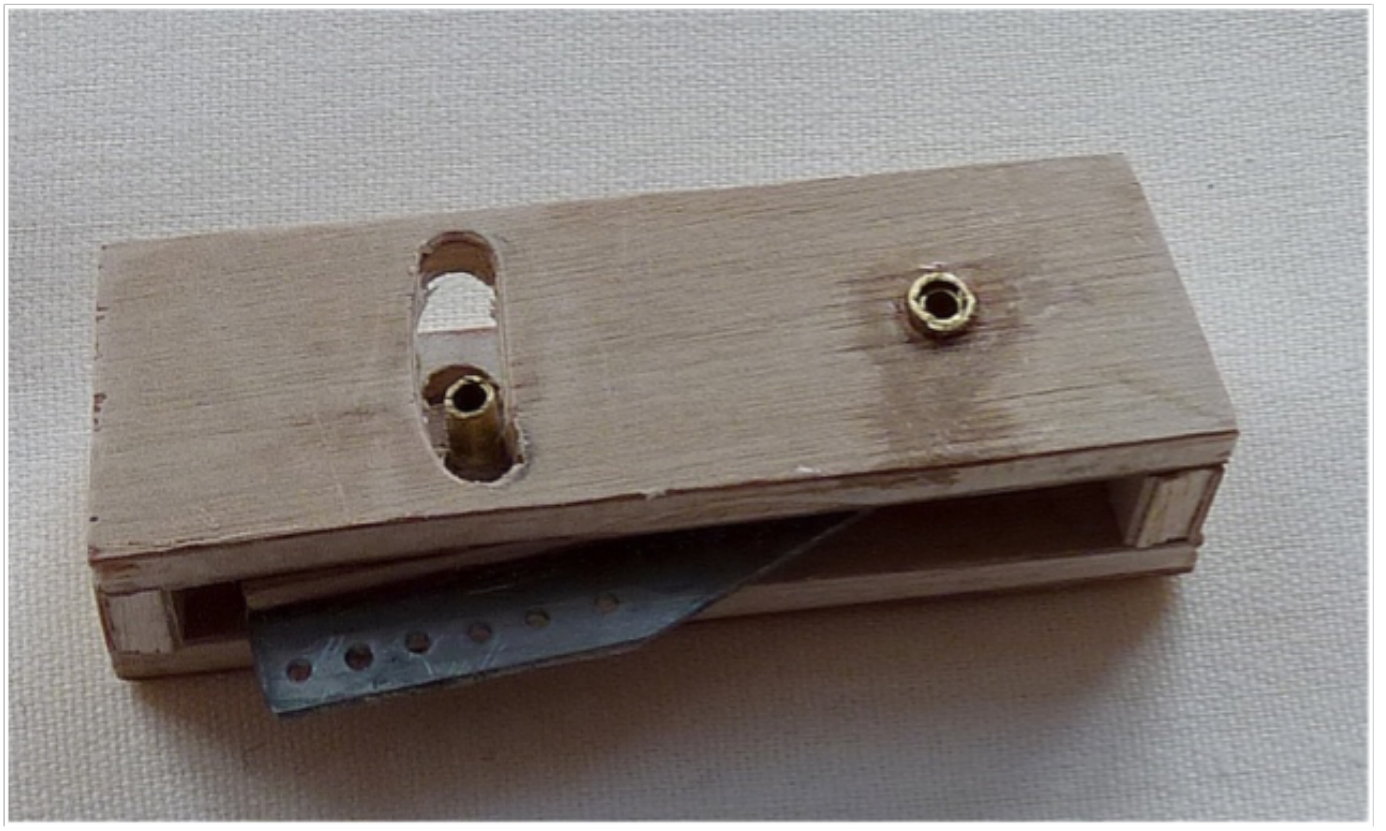
To form the bearings I used two sizes of brass tube. The smaller is 2mm bore for the tailplane mounting piano wires. This has an outside diameter of 3mm which is a perfect running fit in 4mm outside diameter tube. These were glued into the box to form bearings for the bellcrank to pivot. 2mm is a little small for the wires but this was the size in the original tailplanes. I imagine it was to keep the aft weight down. If I was building new ones I would use larger carbon fibre tubes.

The drilling and assembly order needed careful planning:

1. Mark and drill the positions of both bellcrank holes

using 3mm twist drill in a drill press.

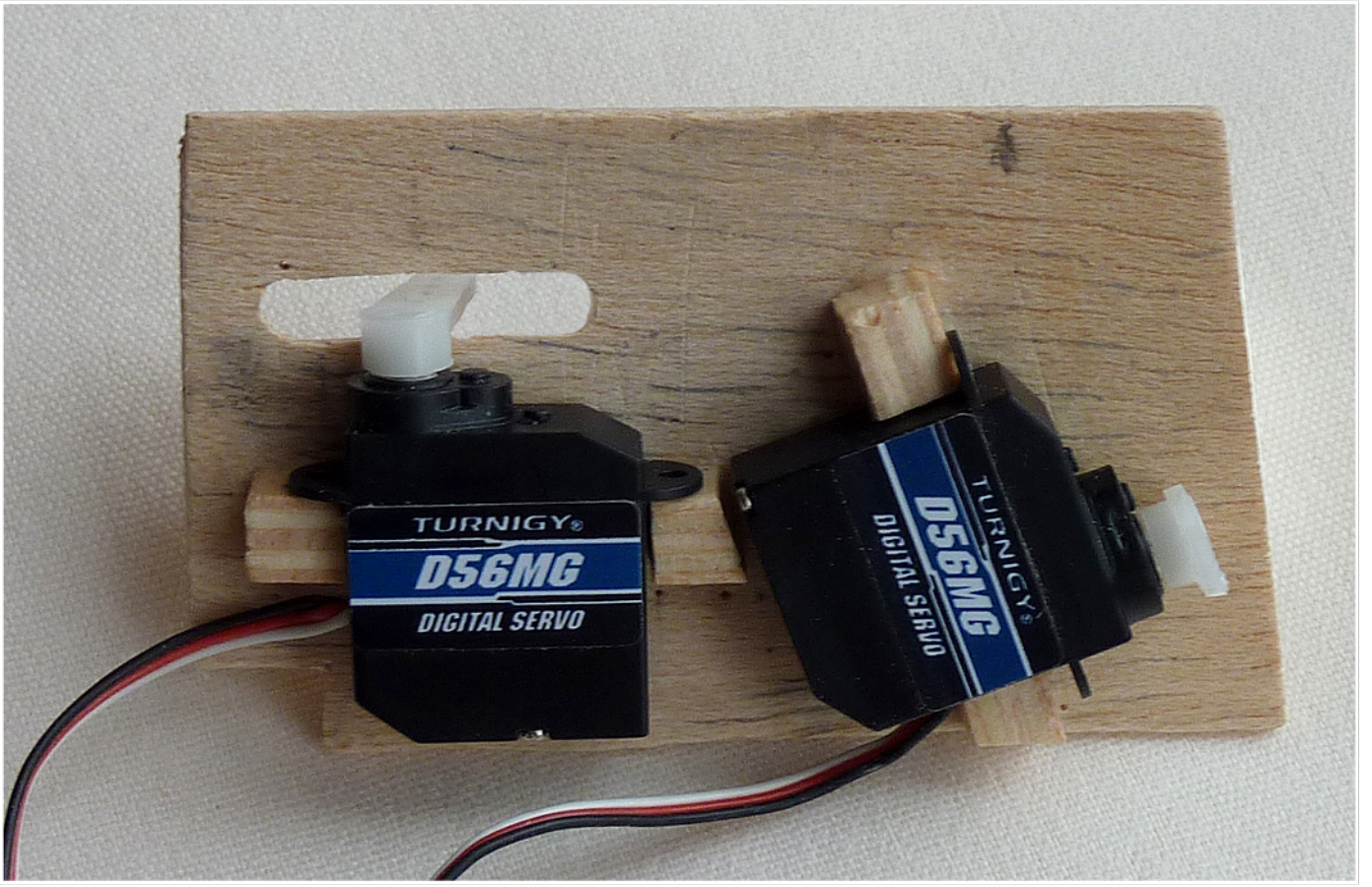
2. Connect a servo with a tester. Put the bellcrank on 3mm drill as pivot.
3. Find the servo horn and bellcrank holes to give ±15° on full servo deflection.
4. Make sure the chosen bellcrank hole suits the metal clevis. Open up if necessary.
5. Cut two pieces of 2mm piano wire of the correct length for tailplanes.
6. Glue 3mm tubes in front and rear bellcrank holes with these wires in and the tailplanes connected.
7. Measure the distance from the rear of the fin leading edge to the front bellcrank hole.
8. Drill front holes in box sides using 4mm holesaw using this dimension.
9. Glue in 4mm brass bushes with 3mm tube in place to line them up exactly.
10. Cut the rear arcs in the box sides using 5mm holesaw and a 3mm drill in the front holes as pivot.
11. Smooth bellcrank sides and relevant sides of box sides.
12. Cut front and rear box spacers out of laminate to give slight clearance.
13. Test clearance under pressure from clamps.
14. Assemble box around bellcrank.

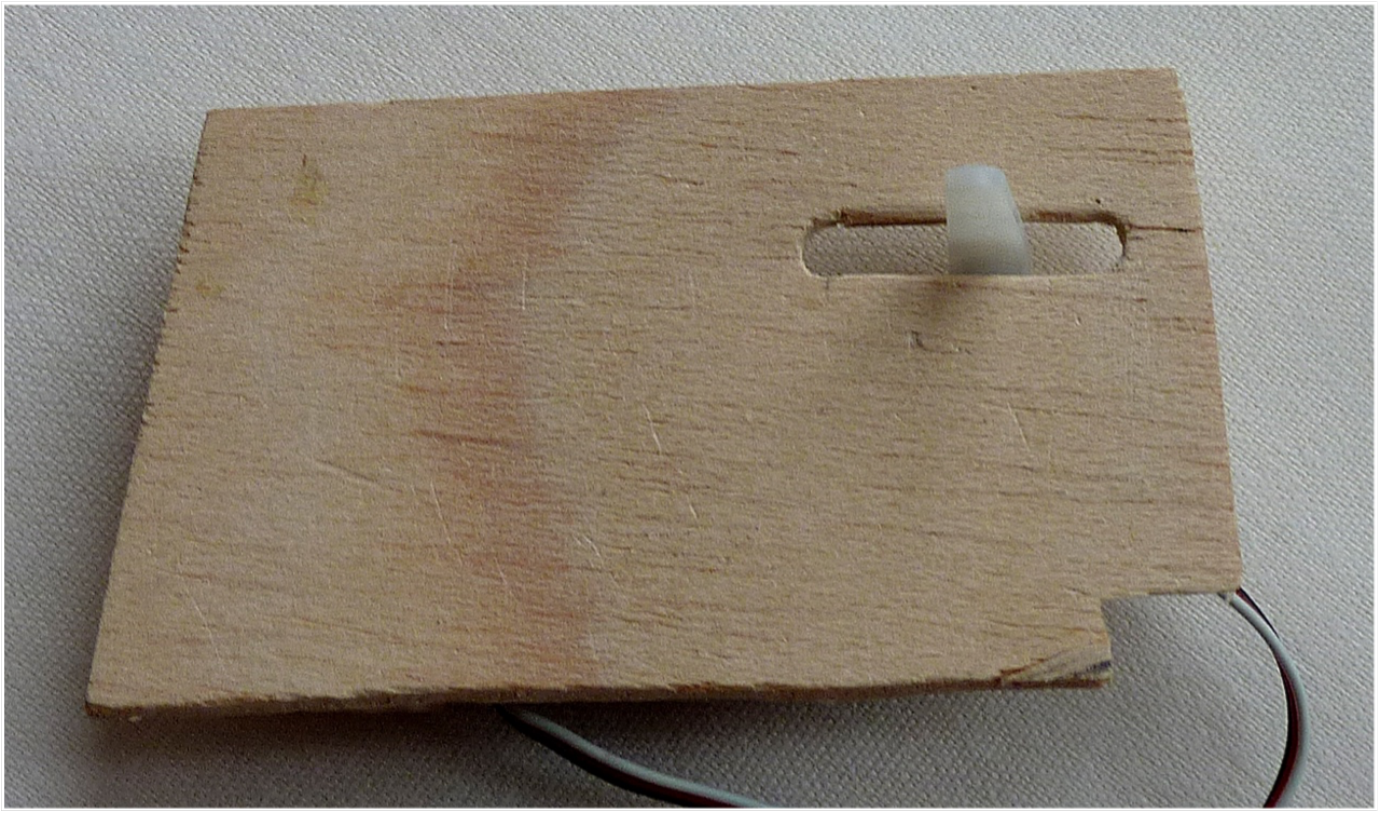


Left: Box complete. **Right**: Weight without clevis 11.9g.

Left: Box installed in fin with tailplanes. **Right**: The bosses for the sideplates screws have been added.

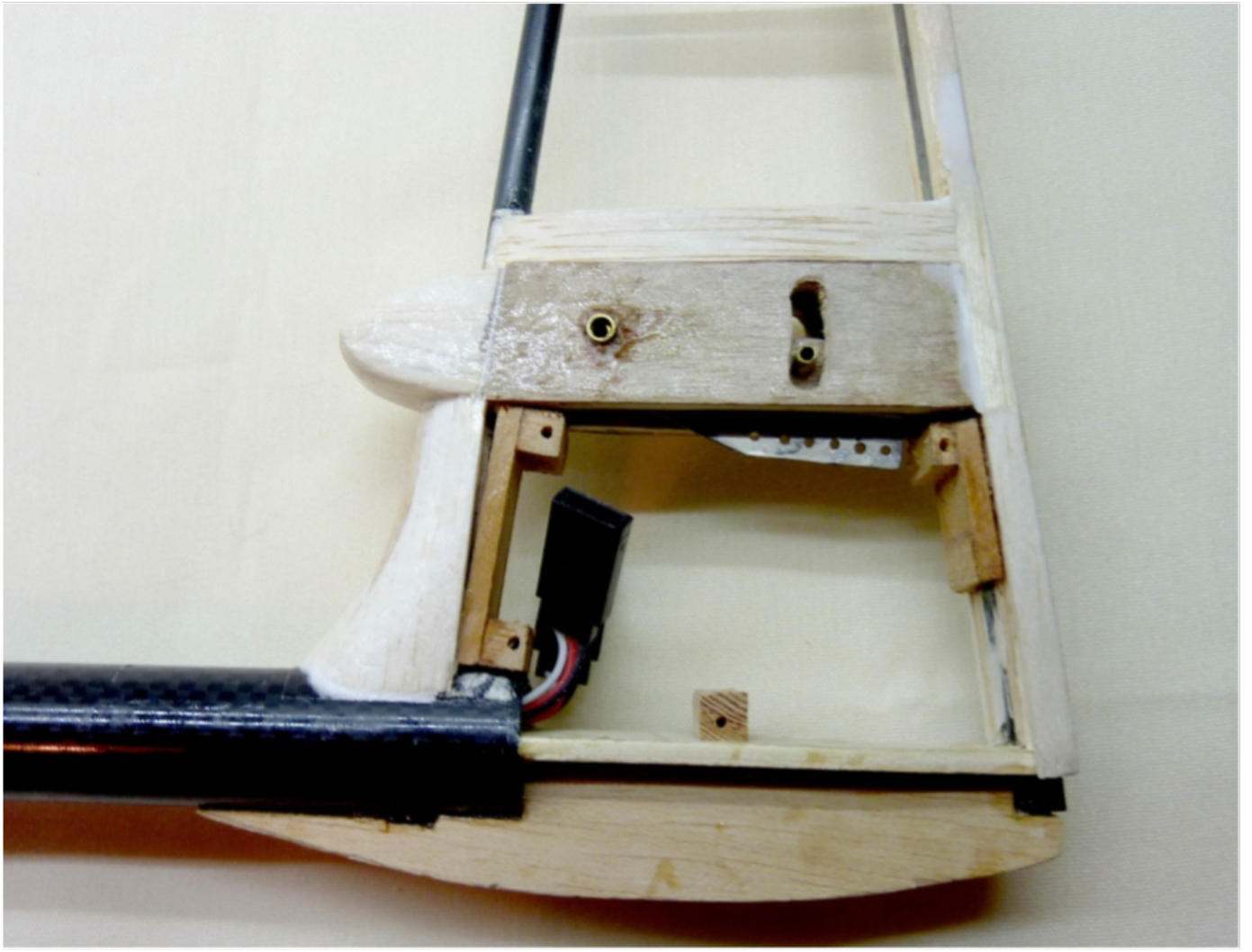
The two servos go into a box under the bellcrank box. Here is one side — the mounting plate. The servos are metal geared and quite powerful for their size. They are fixed with the normal screws. The deflection needed for the tailplanes will be small. Airspeeds will not be high so more important is the ability of the servo to hold the tailplanes steady, and the metal gears, and short, carefully drilled, connections should be more than good enough. After filing and sanding, the two sides are now covered with black Hobby King film.





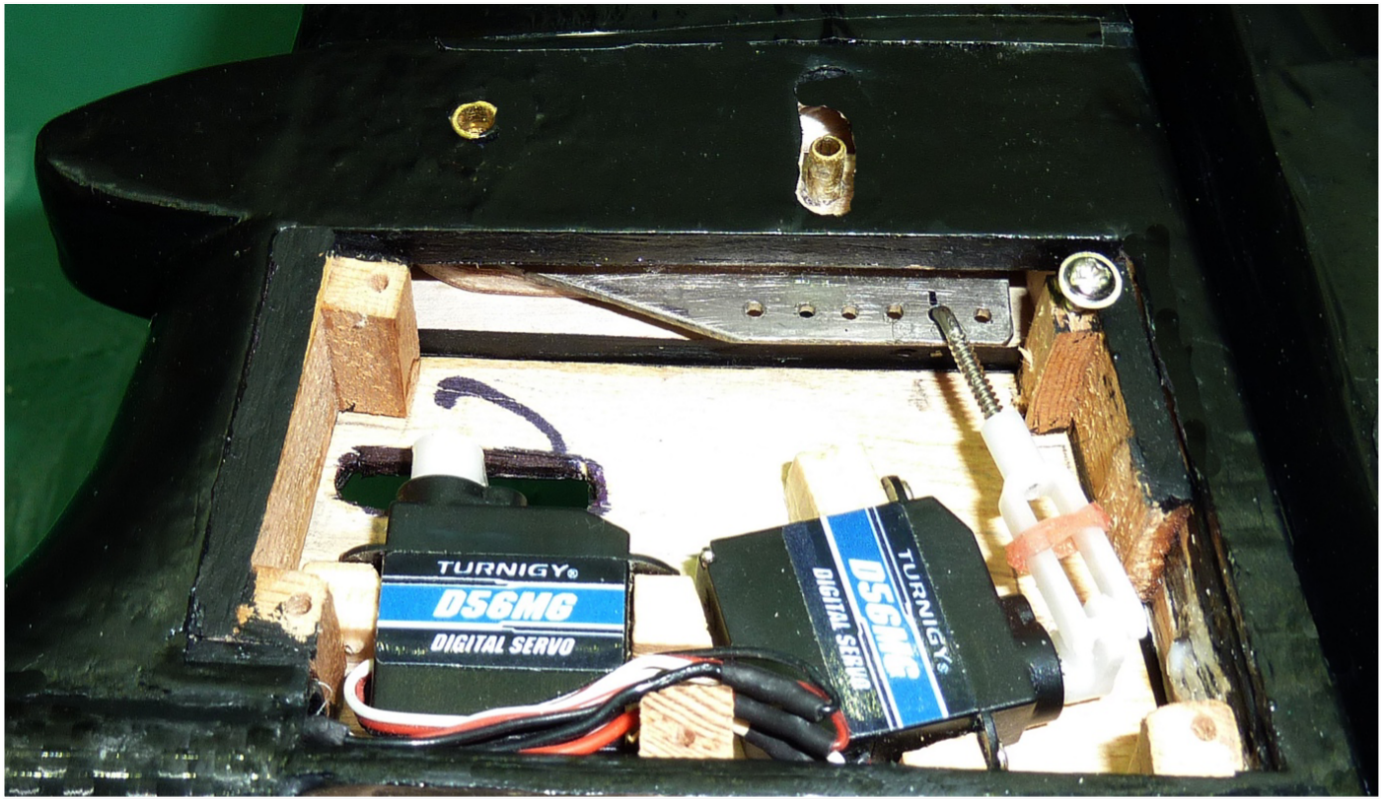
This is the fin with shaped fairings, filled, coated with Eze-Kote and sanded. The area under the fin will be left unfinished until the model is complete. Lead might need to

be added. A balsa fairing will then be added and painted.



Detail of the servo box and all-flying tail suspension.

This shows the servos fitted into place and connected up. I removed the connectors, soldered the wires, and covered them with heat shrink. This saved both space and weight. Connecting to the bellcrank was a tricky little job. I tried all combinations of clevis and rod and in the end settled for the KISS (Keep It Simple — Stupid) approach. The wire in the bellcrank has a double bend. The other end is a simple plastic clevis.



The geometry isn't perfect but I can adjust that with differential throws in the transmitter if needed. On the elevator servo horn I used the hole nearest the centre. I had to, as the full horn fouled the other sideplate and I had to trim it. Full throw, tested with the transmitter not the servo

tester, gave a linear movement of 5mm in each direction. On the second from last hole of the bellcrank this gave 6° movement (tan-1 (5/45)), which is just about right. If it proves not to be enough I can move to a bellcrank hole nearer the pivot.

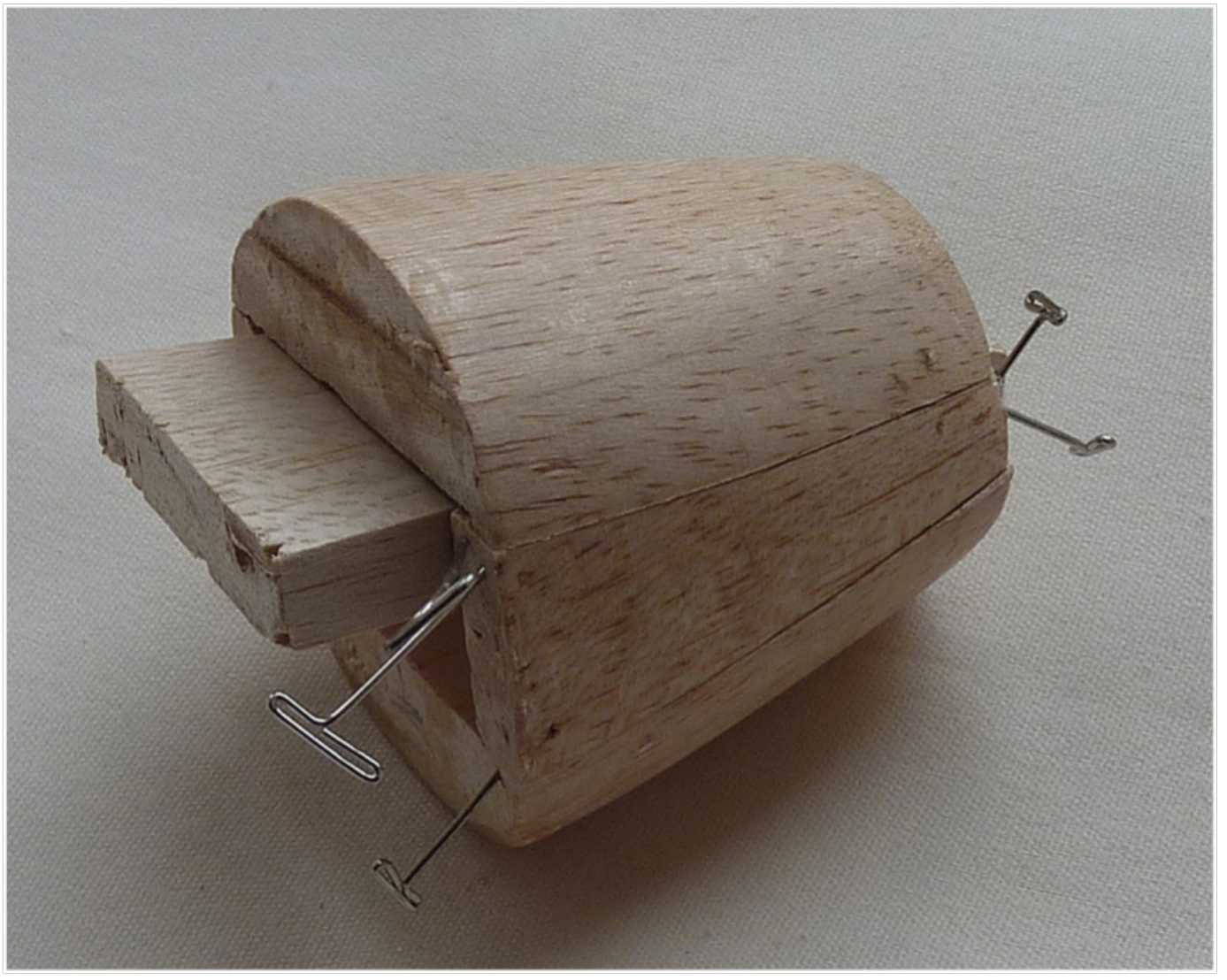
Making the Glass Fibre Cowl

The cowl needed to be elliptical tapering to circular at the spinner. I thought I would make a re-usable male mould out of balsa. The tapering sides would slide out releasing the tapering top and bottom parts. There would be a central key, which would push the parts outwards and would be removed first. I would shape the balsa mould then tightly cover it with cling film as a release agent. The cowl's inside finish wouldn't matter. If it went badly wrong and I couldn't slide the parts out I'd have to chew them out. However I hoped the mould would be re-usable.

The first question was a geometric one: for a given circle radius how thick would the sheet balsa have to be to allow the box shape to be trimmed into a circle? Dredging Euclid out of my brain I calculated the thickness to be 0.28 of the radius. If you calculate thickness using about a third of the radius then there would be margin for strength. Size the wood for the worst case which is the largest circular cross-section and the rest should be fine. Obviously square-ish shapes could make do with thinner wood. In the end,

however, I decided to have two layers of 10mm balsa top and bottom and a single layer for the sides. I made it several millimetres too long to allow for trimming rough edges.

All went to plan. I shaped the male mould and gave it two sanded coats of Eze-Kote to aid release. With a new scalpel blade I sliced the sides and tops apart. Note the taper to the back. I then pinned them back together with the key as shown here:



I stretched kitchen clingfilm over the mould with overlap at the edges to avoid sticking. I gave the clingfilm two sanded

coats of Eze-Kote, then one layer of 48 g/m² glass cloth. This was followed by two more sanded coats of Eze-Kote. I then trimmed the edges with the scalpel, pulled out the key and tried to spring the other parts apart. I only needed to prise one or two parts with a blade, otherwise it all fell apart easily.

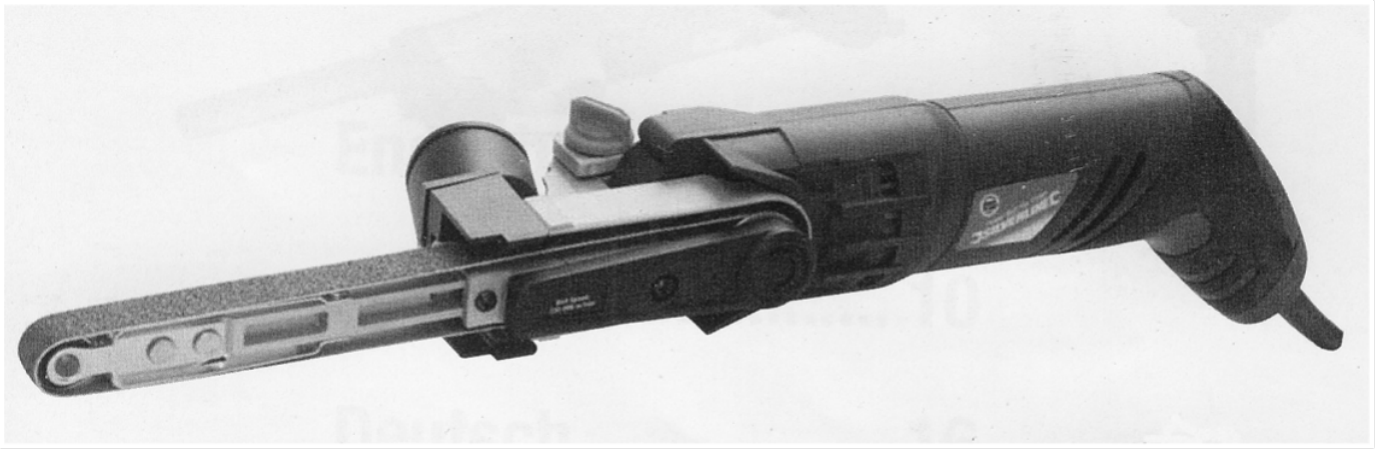
First layers of glass removed from the mould: the resulting moulded cowl was much too flexible. I think Eze-Kote, being a single-part polyester resin, is less rigid than epoxy when cured, so I reassembled the mould parts and wrapped them

in some more clingfilm to avoid adhesion at the edges. I applied two more layers of 48 g/m² glass with several more coats of Eze-Kote, sanded between. This felt rigid enough but I decided to glue in ply annular shapes to make the ends even more rigid and to aid mounting on the fuselage. I made the ply out of four cross-laminations of 1mm birch ply glued with PVA.

After sanding some more I felt the surface still wasn't

smooth enough. I decided to apply several coats of primer with the airbrush. Still not good enough

Then I bought a great new tool, called a belt file. It's a Silverline one and cost £28.50 on eBay. I gave the cowl a real bashing with it on the slowest speed setting using a 120 grit belt. Then when I was happy that it was reasonably flat I applied some more glass, 24 g/m² this time, and coats of Eze-Kote.



The belt file from Silverline. (photo: Silverline)

The next step was to glue in the ply end plates and trim the fibreglass to length. The plates made the whole thing very rigid. Here is the completed cowl prior to painting. The rear view shows that the cowl is locked in position by the cutouts for the motor mount. I used a diamond holesaw to cut the hole in the front as that would be visible when the spinner was off.

I puzzled over how to fix the cowl to the fuselage. I considered screws but access was difficult both from front

and back. I decided to go for two pairs of neodymium magnets.

Even after cellulose filler, sprayed primer and top coats of acrylic, the final result wasn't perfectly smooth. The next will be better after lessons learned. However I proved that the method worked.

Final weight before painting was 13.2g and 14.6g after.

Making the Glass Fibre Canopy

Having learned the techniques from the *Sirius* cowl it was time to make a canopy for the same model. As it is a scalish model the front pod, and hence canopy, is quite large.

This time I decided to use release wax and possibly release agent on a polished male mould rather than cling film. As the canopy is open at the bottom there was no need to make a collapsible mould.

The first step was to make the mould. I laminated a rectangular blank from several sheets of 10mm balsa glued with white PVA. I then sanded it to the correct length using a belt sander on its side. This was so I could fit it in place and mark the curved edges on three sides: bottom, front and back.

I then planed it down using a David razor plane. Once happy

with the overall shape, I switched to sandpaper. One critical matter was how much smaller to make the mould to allow for the thickness of the glass laminations. In the end I reasoned that it was not critical after all as the canopy would be flexible prior to framing and so could be trimmed to fit. Rough measurement on a cowl gave a thickness of a bit under 1mm so I made the mould this much smaller all round except the ends.

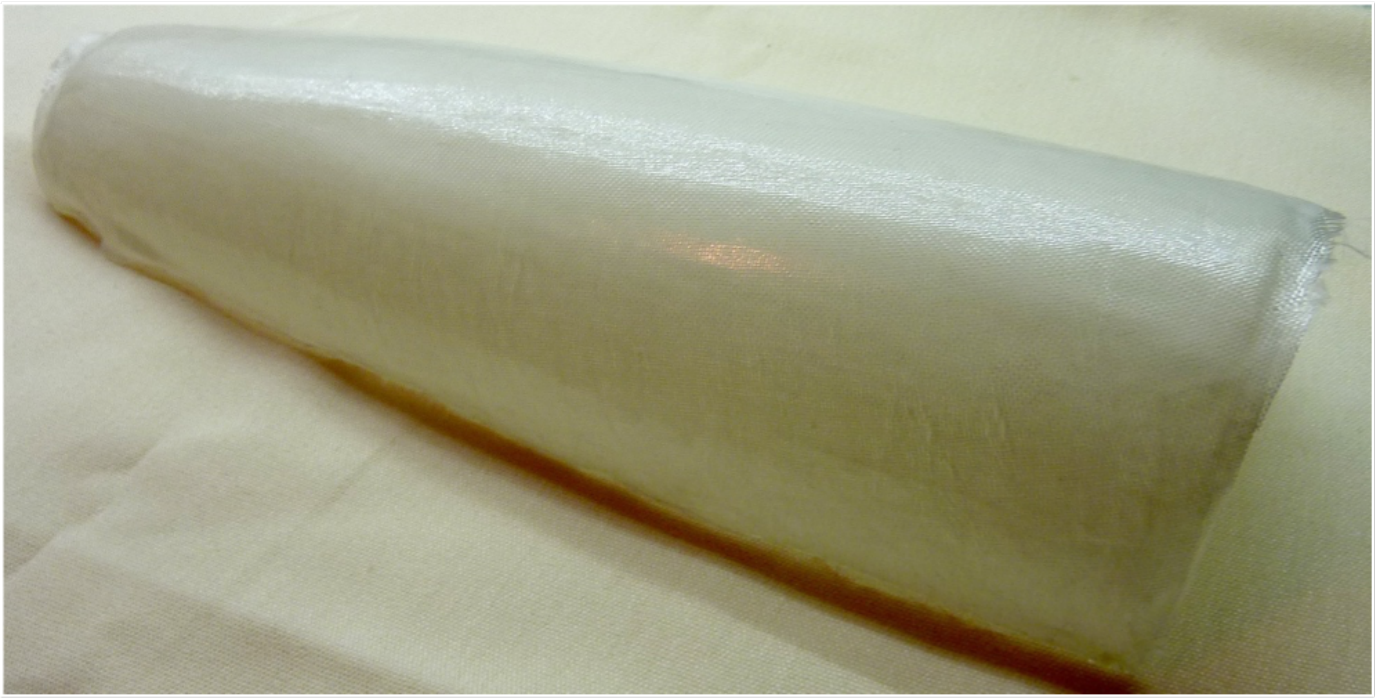
Here you can see the rough planed mould in position on the fuselage:

Here is the sanded mould coated with Eze-Kote and polished. Its outer surface will be on the inside of the canopy so a high polish wasn't needed. The Eze-Kote layers on the moulding will be sanded to give the outside finish.

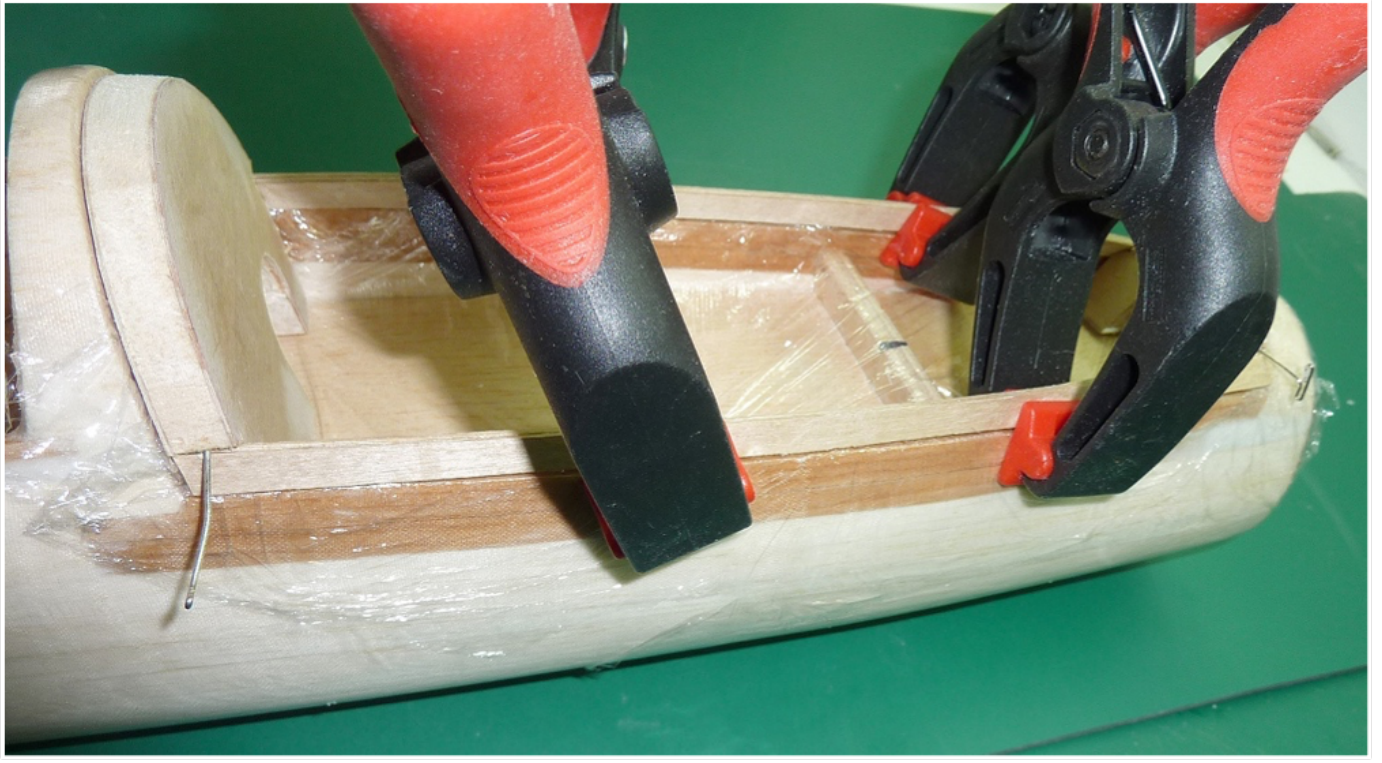
Before applying glass to the mould I experimented on some scraps of balsa to discover how many base layers of resin to use and how well the release agents work. I applied two layers of Eze-Kote to smooth the mould and three coats of mould release wax to each using a paper towel. You don't let the wax dry but clean each coat off with a cloth when wet. Then to one sample I added a single coat of PVA release agent using a soft brush. First time I didn't leave it long enough to dry. It takes an hour at room temperature (20 to 25°C). It seemed dry but the Eze-Kote dissolved it when I applied it. I found that wax on its own worked just as well as when I used PVA agent, so I didn't bother with PVA on the canopy mould.

I laminated three layers of 48 g/m² cloth with one of 24 g/m² cloth on the top to give a smooth surface. I lost count of the number of EzeKote coats but I'd guess about ten. Each dries quickly so delays are short. It popped off the waxed mould

very easily.



Eze-Kote is not as rigid as normal resin so, though this number of layers gives a fairly stiff shape, it could not be used as a structural component.To stiffen the canopy I framed it with ply and trimmed the ends of the canopy, which were moulded square, to give more realistic sloped ends.



The side frame parts both curve and twist. I tried to use spruce but it was too rigid. I cut strips of 1mm birch ply glued in threes with PVA and clamped in position. I covered the opening with cling film to prevent the new frame sticking.

I then air-brushed it with primer and white acrylic to contrast with the black fuselage.

I was pleased with my first major use of carbon fibre. It is light and stiff and does not change shape over time. One disadvantage is that all gluing must be done using epoxy, though possibly thick CA is an alternative. Not being water based, epoxy doesn't get lighter as it dries so you have to be as sparing as possible.

A cylindrical tube works well for a curved fuselage. I must try a square one for a square fuselage. It would make lining up

the formers and forming a balsa shell very easy.

Just a reminder from the first article as to why I call it the skyscraper method: such buildings now have a strong central core from which floors and walls are cantilevered. Then the glass is put on the outside. Apart from being rotated by 90 degrees my fuselage design is the same, as it has a very strong core with a light shell covered in glass (fibre).

The Wings and Tailplanes

Foolishly I didn't keep a photo record of doing the wings and tailplanes. I stripped off the old doped tissue covering using thinner and sanded and filled the frames. I could not get some patches off so relied on sanding those bits.

I modified the ends of the wings to take ailerons as the original was built with rudder and elevator only. I still had the original plans, though they needed some TLC with sellotape, so I made the ailerons the size shown on the plan. I used thin servos in the wings and cut slots in all of the ribs to run the wires through. I replaced the slightly corroded brass tubes in the roots with carbon fibre ones and generally strengthened the area without adding much weight. I installed boxes to take inboard airbrakes and fitted the servoless type as shown:

I used Hobby King shrink covering, which I find light, easy to use and a good shrinker. The low cost is a bonus. One aileron warped and I had to replace it with a laminated one.

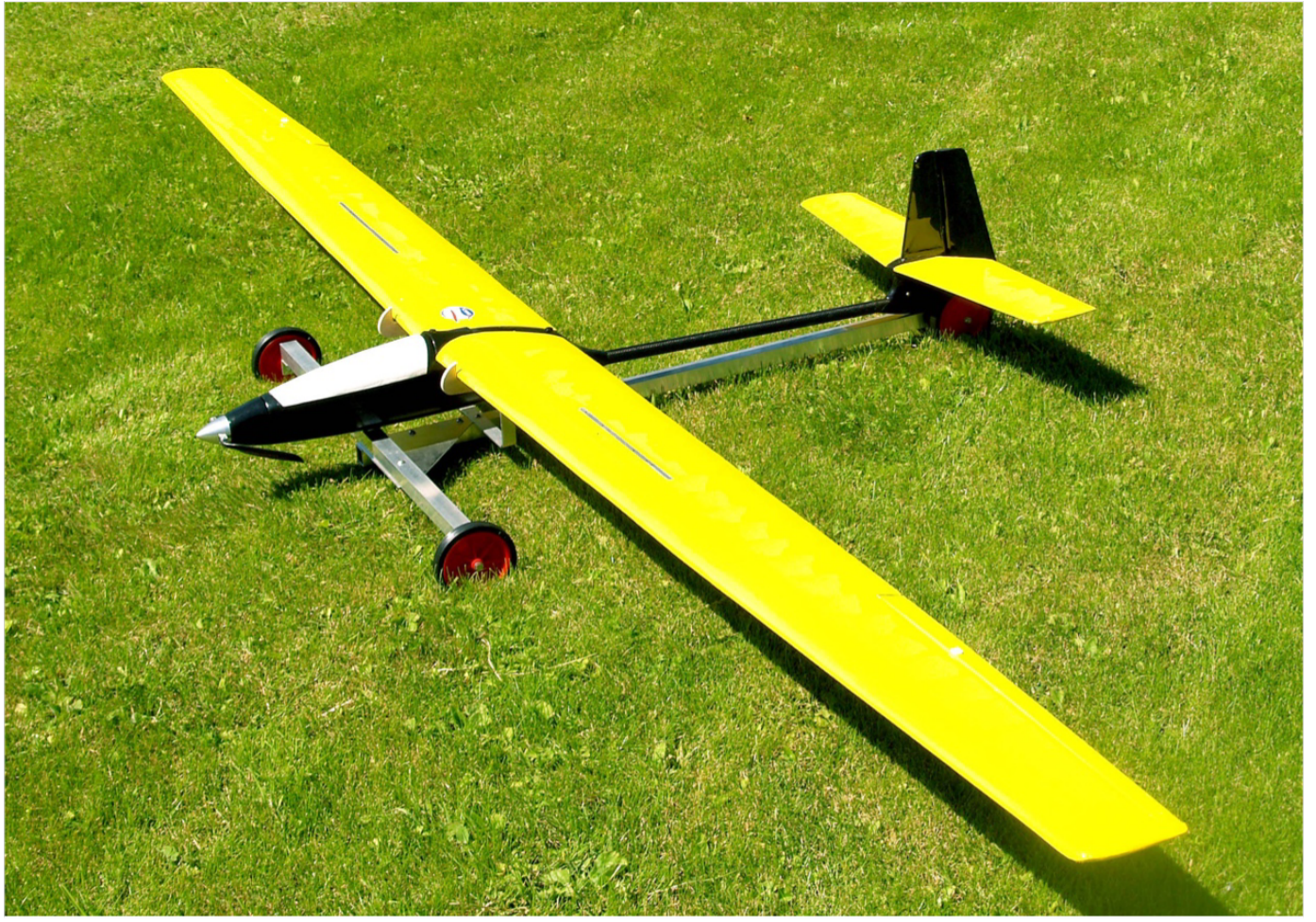
The tailplanes were an easy job. The plastic root ribs were pulled a little out of shape when the covering was heated and shrunk. I had to unstick it from the root ribs, add a filler of balsa and restick the covering. It's not perfect but looks reasonable.

Finished!

At last it's ready for a maiden flight. Ulp! I used to hurl it off hills and tug it into the air with a bungee but have never hand launched under power. Knee trembles.

Launch Dolly

I will possibly hand launch once I have the model stably trimmed and have a good idea of the required air speed. Until then I decided to use a lightweight dolly built out of aluminium with 100mm plastic wheels. The main tubes are 25mm square with 1.5mm walls. The front bracer is 1.5mm sheet. It is bolted together with M5 screws and the wheels run on M6 axles. The wings rest on some 6mm liteply supports bolted to 20x3mm aluminium U-shaped frame. I might add a rear support if it proves necessary.



Balancing

I got the balancing stand out. All it needed to be a tiny bit in front of the specified centre of gravity was 15g at the front of the cowl area. Looks like all my efforts to keep the tail light paid off. The servos being in the tail didn't cause a problem.

(More) Lessons Learned

1. Collapsible male moulds for fibreglass are quite easy to make out of balsa.
2. Cling film works as a release agent but it is difficult to get it really smooth. It might be easier on a larger or

flatter cowl. I experimented with wax release agent on scrap wood. It worked. I also tried adding a layer of PVA paint-on agent as well. It was no better. Provided the parts can be separated any small internal ridges won't matter. I have now tried coating the wood parts on a different mould with three coats of a wax release agent. It worked a treat. The moulded part sprung off easily.

3. It might be possible to achieve moulding rigidity with fewer coats of epoxy or polyester resin. However, making several lots of two-part for a small component would be wasteful. Eze-Kote seems fine on this smallish cowl though. You need to use more layers of glass and resin. I think that the convenience of Eze-Kote makes this worthwhile and the end-plates removed any doubts about rigidity.
4. Don't be afraid to sand fibreglass mouldings aggressively. You can reapply glass and resin. It weighs very little as long as its thin. Keep the sandings off your skin and out of your lungs.
5. Cover the exposed part of the tail boom with a removable film of some kind before starting to glue things. Despite the greatest of care I have put some glue smudges on the polished surface. Provided you are willing to do planking, this is an excellent method for building accurate circular cross-section fuselages, especially when strengthened with glass cloth.

Model Data

- **Weights**: fuselage with wing mount and radio, 847g; wings, 753g; tailplanes, 59g; battery, 229g; total weight with battery, 1888g. Incidentally, the original without motor was about 1500g.
- **Areas, Loadings, Centre of Gravity**: wing area 52dm²; total area, 60dm²; wing loading, 36.3g/dm²; area loading, 31.5g/dm²; centre of gravity, 78mm back from root leading edge.

Suppliers

- **eBay**: carbon fibre fuselage tube and other carbon fibre items, titanium, glass cloth.
- **SLEC**: wood (of course!), Eze-Kote.
- **Hobby King**: batteries, motor, covering film, servos, air brakes, paint and varnish.
- **RCLife**: radio gear.

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