Rider

A two-metre soarer

for slope, cliffs and bungee

(and probably a 4 metre thermal soarer later)

Table of Contents

Last edit 28 January 2021

The beautiful big skies of Norfolk just cry out for gliders. Up to now these have been electric thermal soarers. However I could use a bungee launcher for more purist soaring. However looking at the fragile foamie gliders I usually fly I realised the wings would fold under the stress of a tow. So I though that the answer is to use the excellent cliffs for slope soaring, when the wind is between north and east.

I thought it was time to build a tough but light glider for tow and slope, with room for ballast for windy days on the cliffs. I looked at published designs but didn't find anything I fancied. I read an article in RCM&E singing the praises of cheap CAD packages. There was no mention of how you print out plans. Presumably you have to gain access to a large plotter and the only one I could find was an HP inkjet T520 at just under £1000. So it was out with the drawing board and drafting pen

Two metres span seemed a good size with a wing area of about 40 dm^2 and aspect ratio of about ten. The next question was whether to have easy-to-build rectangular wings or to choose more fashionable attractive curves. The good stall behaviour of elliptical tips, even with modest washout, settled that. Keeping with fashion I decided on a low drag aerofoil similar to Clark Y with full-span ailerons and flaps. That would enable me to add undercamber for thermal soaring using flaps and flaperons. I would then probably steer with rudder to keep the wings level. When sloping I can use the same control surfaces for crow braking. Three cheers for Taranis flexibility. The code is towards the end.

As I might be flying out over the sea I decided that a modest motor with a folding propellor was needed for emergencies. Our field is shared with full-size aircraft so it will also be useful if being blown downwind towards the main runway after a bungee launch. I settled on a 2836 size 300W outrunner powered by a 1.3 Ah 3S graphene lipo. The battery would be more than big enough for a few minutes run, monitored with a lipo voltage sensor. It will be easy to find room for the small battery and cause very little weight gain.

I intend to learn how to use carbon skinned foam, but for this prototype I used semi-conventional rib and spar wing construction. The unconventional bit is the use of carbon fibre (CF) for the main spars (10 x 1mm) that will be part of a D box with vertical grain balsa webs and top and bottom balsa sheeting forward of the spars. Ribs will be capped with the same thickness of balsa as the sheeting.The only downside of CF is the need to use epoxy glue which is heavy and messy or cyano-acrylate which can cause a permanent human/model interface. In the end I decided to make this the first model on which I would use CA for most joints. I soon found out that I need some fine nozzles. There was a fair bit of runoff. I bought some 5ml luer lock syringes and blunt end needles with various bores, the most useful being 1.3mm for PVA.

Design data

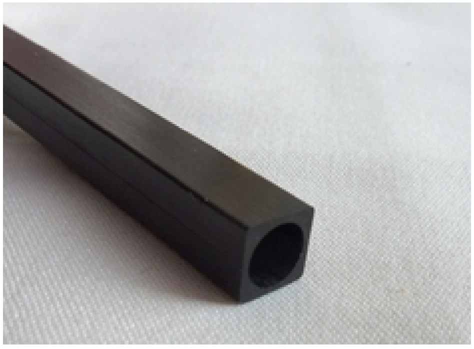
The wing area for the shape I finally decided on is about 35 dm^2. The tailplane has a symmetrical section so there is no lift there. For a sports aero machine the rule of thumb for lifting area is 21 – 30 g/dm^2. Using wing area alone this give a target all-up unballasted weight of 735 – 1050g. Using this weight I chose the motor. For a 1kg sport model, power needs to be 200 to 240W. I chose a 300W motor. Allowing for not achieving the specified power, this should give a decent speed and rate of climb. My estimate of the aspect ratio is about 10 allowing for the elliptical taper.

Wings

The wing has a flat bottom low drag aerofoil similar to a 10% Clark Y. Flaps and ailerons are almost full span. For sloping a crow braking system can be formed with down flaps and up flaperons allowing roll control. For thermal soaring a small and identical amount of down is used on both flaps and ailerons to give undercamber. Steering is then best done by yaw, using the rudder to keep the wings level for maximum lift.

For the future I can foresee building a 4 or 4.5 metre thermal glider using the 2m wings as the outboard panels plugged into some parallel inboard panels. The tail boom looks long enough. I might need to build a larger tailplane.

I used Hobby King 10mm square tube and 8mm round tube for the wing mount and main spar. The tube slides smoothly and has very little sideways movement. It is very strong but the tubes will give a little to absorb vertical shocks and the stresses of towing.



The elliptical shape of the wings required a laminated leading edge. The rear curves are produced by the shape of the ailerons and flaps, so the trailing edge struts are straight. I used the same method for the curved laminated edges of the ailerons, flaps, tailplane, elevator, fin and rudder. I cut the shapes out of 6mm liteply to make formers. I cut them oversize with a jigsaw then sanded to exact shape using a bench sander. I used multiple layers of 1.5mm balsa glued with white PVA. They did not need soaking as the PVA wetted them.The layers were squeezed onto the former with pinned balsa scraps and the result was strong and rigid. The glue added strength and toughness.

Because it was not a straight taper I couldn't use the usual sandwich method for the ribs. I cut the root rib former from 1mm aluminium. As the initial taper was small I left the first seven ribs full thickness and just trimmed their lengths. Taper increases rapidly towards the tip so I cut full size ribs then moved the former down progressively to reduce the thickness by trimming. Cut to the correct lengths any required further shaping was done with a sanding block after fitting.

Here is a picture of some of the formers, including wing, tailplane, rudder and fin.

I used a Slec balsa building board for the first time and was very impressed. Pins were easy to push in but held well. Bit like a bristle dart board.

Fuselage

The next design question was the fuselage. I toyed with using my skyscraper method but realised that I needed a slimmish fuselage for this model to give good slope penetration (on the slope not into it!). There would be no room for a carbon fibre tube going all the way to the nose. So it is a tapering CF tail boom with a ply and balsa planked front end, strengthened with 24 g/m^2 glass fibre cloth and Eze-Kote. The join between the front and the boom will be a weak spot so needed careful design. I was going to use 5 x 2.5 mm carbon fibre longerons but the laminate front end was so strong I saved weight by not using them. However there are shorter pieces of the strip across the join with the boom.

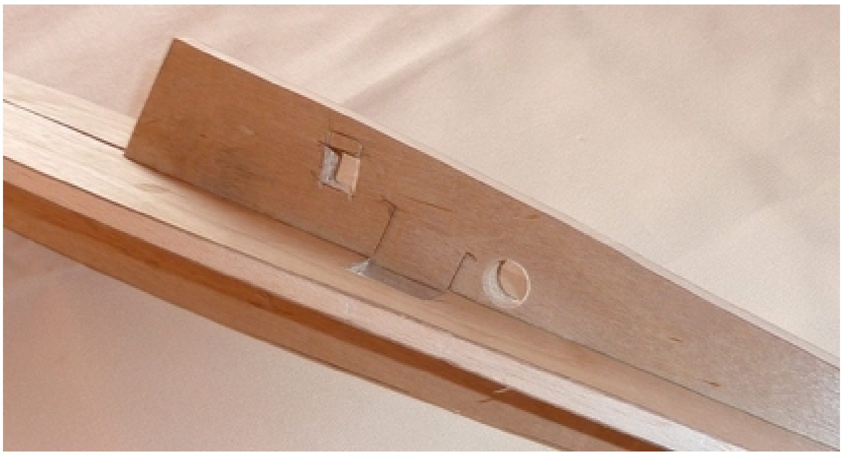
I laminated a vertical core plate out of 6mm soft balsa with 0.8mm birch ply on each side. I glued it with white PVA. Using this glue the laminate must be firmly clamped between two rigid flat boards to dry or it will warp.While I was at it I also made up some wing rib laminate from 3mm balsa with 0.4mm birch ply. I made single and double sided for different root ribs carrying the carbon fibre tube.

The tail boom tapers from 26 to 9mm with 0.5mm wall thickness. I trimmed it to length with a circular diamond cutter so the end diameter was about 15mm. As I was hand holding this and other pieces I cut them slightly oversize and sanded them to exact size on the side of the disk. I used a face mask of course.

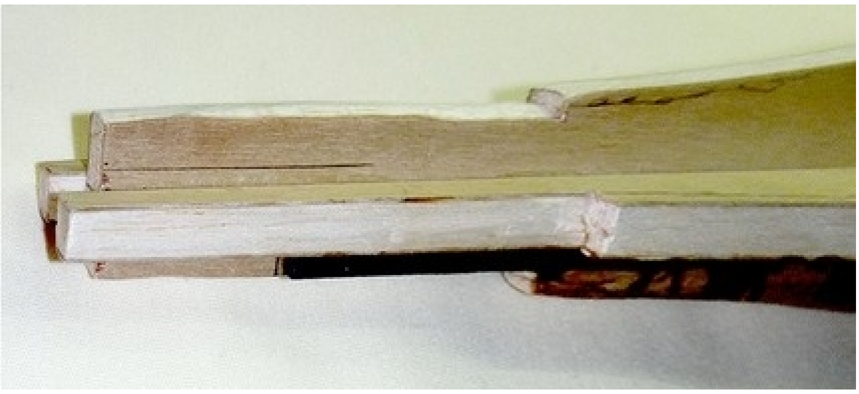
Wing incidence will be set at 3º. Having a tailplane and fin that bolt on from underneath on the prototype means I can make fine adjustments to the tailplane incidence using a wedge. A rear tab in the wing root will be bolted down to a bracket in the fuselage. Ply washers will allow fine adjustments to wing incidence.

The front of the fuselage is a tough cross shape core made from the laminate. It is a little heavy at 98g but it is immensely strong. The boom and planking won’t add much more weight so I expect it to finish at less than the maximum 250g.

This shows the cutouts for the wing spar box, the left-hand servo and the wire from the right-hand servo.



This picture shows how I shaped the fuselage rear end to fit the boom. I staggered the ends of the parts to avoid a single stress raiser. Getting a snug fit was easier than expected. Using a craft knife I shaped the end then slid the boom on till it jammed. A slight rotation then marked the wood black, rather like using engineer’s blue. Successive tries and trims allowed me to move the boom farther until it was fully on.



For the tailplane and fin mounting I used the good old principle of ‘simplicate and add more lightness’. There are lots of complicated moulded mountings that you can buy but I decided on two vertical 5mm carbon fibre tube stubs glued into the end of the boom. These take M3 nylon screws that go through the tailplane and screw into M3 brass inserts in the base of the fin. Very simple and light. As a bonus a pointed bamboo barbecue skewer fits into the stubs perfectly. This acts as a pointer on the jig centre line to ensure the vertical.

The boom end is shown here with the carbon fibre stubs.

This shows the 7mm brass tailplane bushes cut from tube. They are a loose fit over the stubs to allow incidence tweaking. I used a plumber’s copper pipe cutting tool and squared the tubes on a diamond wheel.

Here is the uncovered tailplane in place with the 6mm liteply fin base rib. This rib has M3 bushes glued in with epoxy. They are called ‘M3 threaded inserts for 3D printed parts – flanged’.The nylon M3 screws screw into these from below, locking down the fin and tailplane whilst giving a weak link break point in a poor landing. Nylon screws are about 0.3g, whilst steel ones are 2.1g. Wondering whether nylon would be strong enough, I tried steel but found the finished model tail heavy so went back to nylon to save on nose weight.

Talking of jigs, I had to build one as this is a circular fuselage. This is the jig on its own.

And here it is with the skeletal fuselage clamped onto it with a velcro strap after gluing. I set it so the top of the boom was horizontal thus making it simple to set tailplane incidence.

In this prototype version I glued and screwed a plate to the centre of the vertical plate to take a movable tow hook.The plate is 1mm titanium glued into the balsa part of the fuselage laminate and then fixed with M2 screws. I cut the shape with a metal cutting blade in my Makita jigsaw. I then cleaned up the edges and corners on a belt sander. There are several holes to enable the hook to be moved to find the optimal position. The hook will be made from bent piano wire. I found that thickish coolant oil made drilling the titanium much easier. Avoid over heating and drill breakage by not pushing too hard. A good deep centre pop is needed. Due to using a spring centre punch my drill wandered a bit as you see. Next time it will be back to a standard punch and hammer.

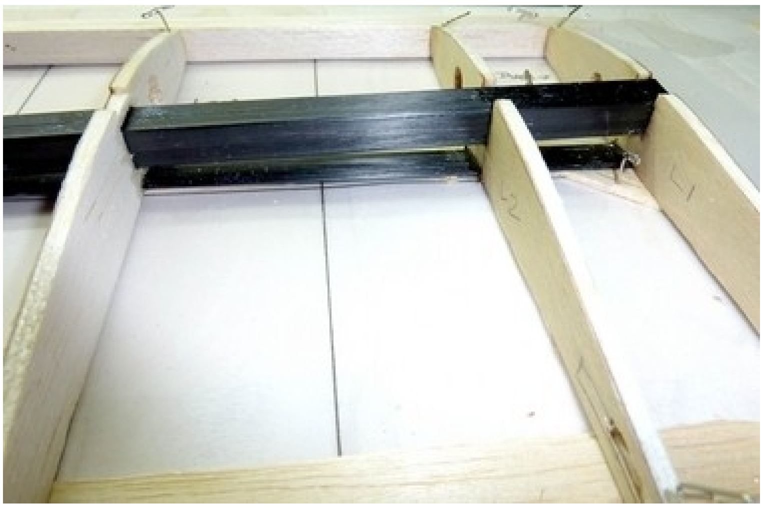
In a future version I will probably install a 10 x 10 x 100mm box at the bottom of the fuselage under the wing. This would accept ballast in the form of balsa, aluminium, steel, brass or lead bars for sloping in different wing conditions. For towing I would fit a piece of wood with a metal plate and an adjustable hook. I know it’s fashionable to put the ballast in wing boxes but I like the idea of it being lower down.

The rudder is turned by a wire that projects down through the elevator. To turn it I needed a horn that would clamp on to the wire. I couldn't find one anywhere so I had to make one from a brass wheel collet soft soldered onto a scrap of 0.7mm brass sheet using a gas flame. I shaped it using my trusty belt sander. Here it is before drilling the holes for the clevis.

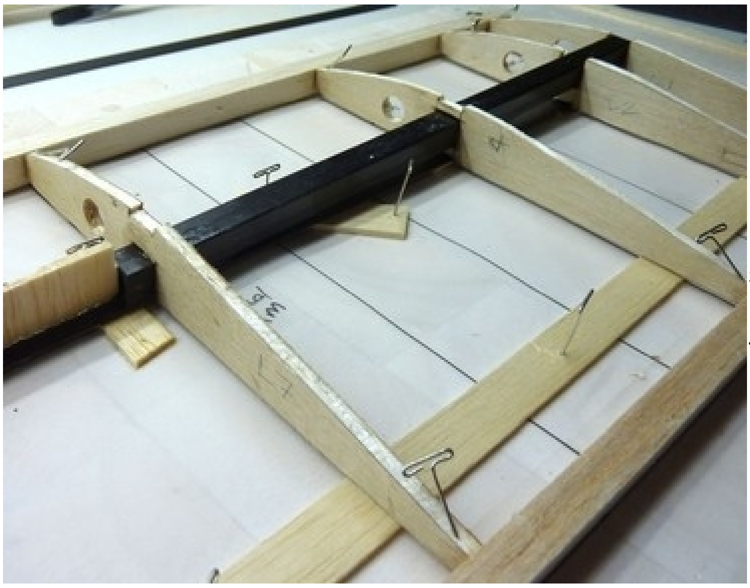
The wings

This is the nearly complete left wing before sheeting and capping. The ribs and lower spar are held up with scrap the same thickness as the sheet will be.

The wing root is a critical area as it has to take the loads from bungee tows and, on the cliffs, strong winds coupled with tight manoeuvres.



This shows the square tube and the lower carbon fibre spar



Here you see the packing under the spar and ribs to allow for the capping. I made the 10mm holes in the ribs for the servo wires using a diamond holesaw.

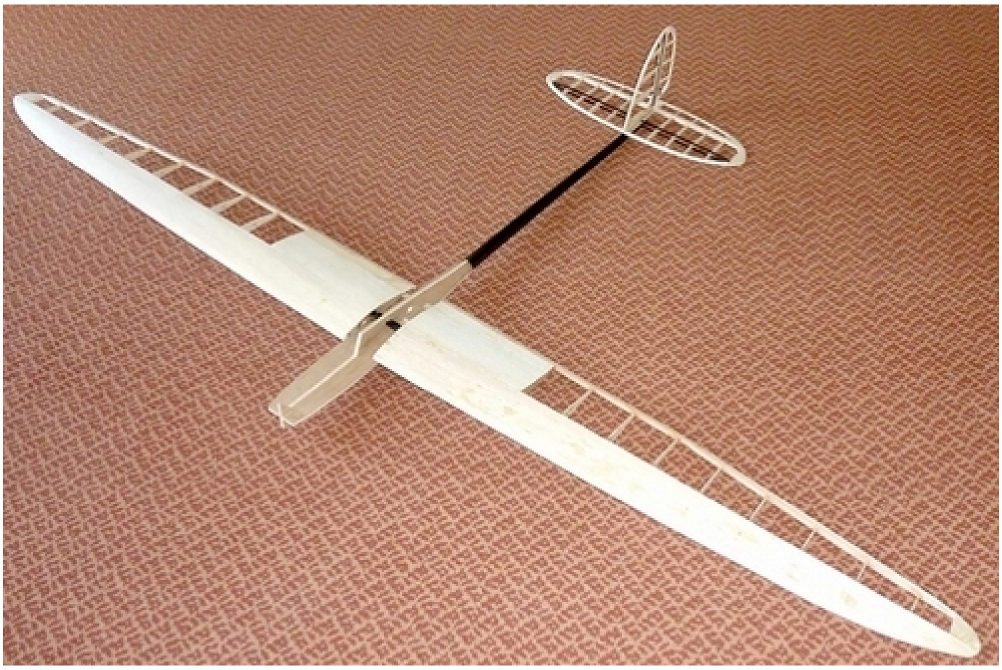
This underside view shows the packing around the tube.

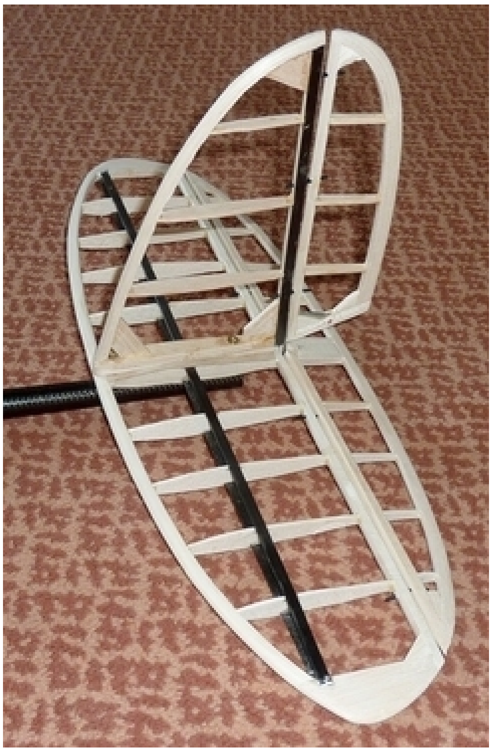
Wing servos

These are the slim versions designed for thin wings. I didn’t think ahead on this one. I fitted out wing bays to take the servos after building the wings. I future versions I will build servo boxes in advance and fit them while the wings are on the building board. An example is shown later. The current ones are a bit untidy as you can see in one of the photos below. I might solder and heatshrink sleeve the servo ends of the wires to save space and weight next time.

Airframe

Here are some pictures of the nearly complete airframe. There are no cap strips, servo boxes, flaps or ailerons on the wings yet. It was 460g at this point, so my 530g estimate might be about right.





Here is one wing with the woodwork complete and the flap and aileron loosely in place

Finishing the fuselage

I epoxied the square tube for the wing spar in place with rectangular 6 mm braces underneath. Once cured I slid the wings on and marked the places where the holes will go for the M4 threaded bushes that hold down the rears of the wings.

Then I shaped and glued 6 mm soft balsa formers for the planking on the underside. I also added soft blocks to fill the gap between the last former and the tail boom. This was my first attempt at planking so I read an excellent article titled “Strip-Plank like a Pro” by Henry Holcombe. I wrote my own account, which will soon be downloadable from my website, **peterscott.website**, under **Flying/Inventions/Construction** methods. It has more detailed pictures of the planking of this model and my Sirius glider.

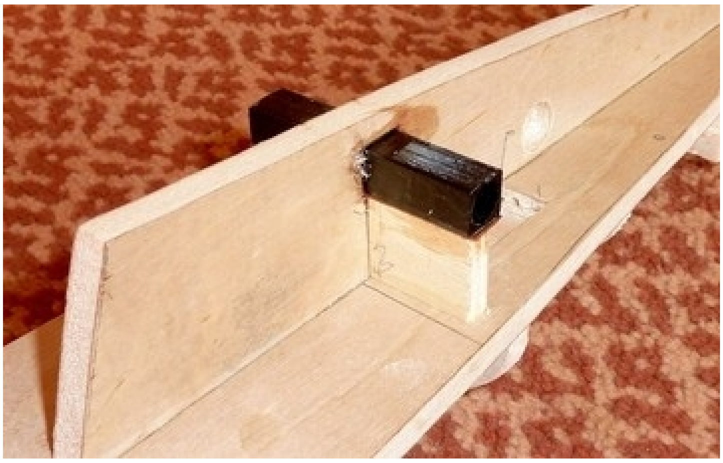
This shows the underside of the fuselage with the formers in place though not trimmed to exact shape. The blocks to the rear were shaped to match the taper and circular profile. I wrapped masking tape round the boom to protect it from damage.

Hingeing the control surfaces

The control surfaces are all built up and very light. Therefore the hinges needed to be light. I decided to use 2.5mm round pivot hinges for the rudder and elevator and 16x28mm flat nylon pinned hinges for the wing surfaces. The pivot hinges are pushed into round holes and glued. As the hinges are ridged I reasoned that white PVA would do the job. As a trial I put some on a hinge point because I suspected that, even if it spread on the hinge point, it would not lock up the plastic parts. That proved correct so it made the installation that much less risky. For the flat hinges I used a Dubro DB216 slotter tool and carefully applied thick CA. I have now changed to Super ‘Phatic.

Wing mount

This is the wing mount tube.



These pictures show one M4 bush in place and the 9mm packing added above the bush to give the correct incidence of about 3º. It was three layers of 3 mm liteply glued with white PVA.

To give 3° incidence the most forward part of the leading edge should be 10 mm higher above the horizontal plate than the underside of the trailing edge. Having the packing 9 mm on the prototype allowed for a small amount of downward and upward adjustment using washers or grinding away.

Tailplane support

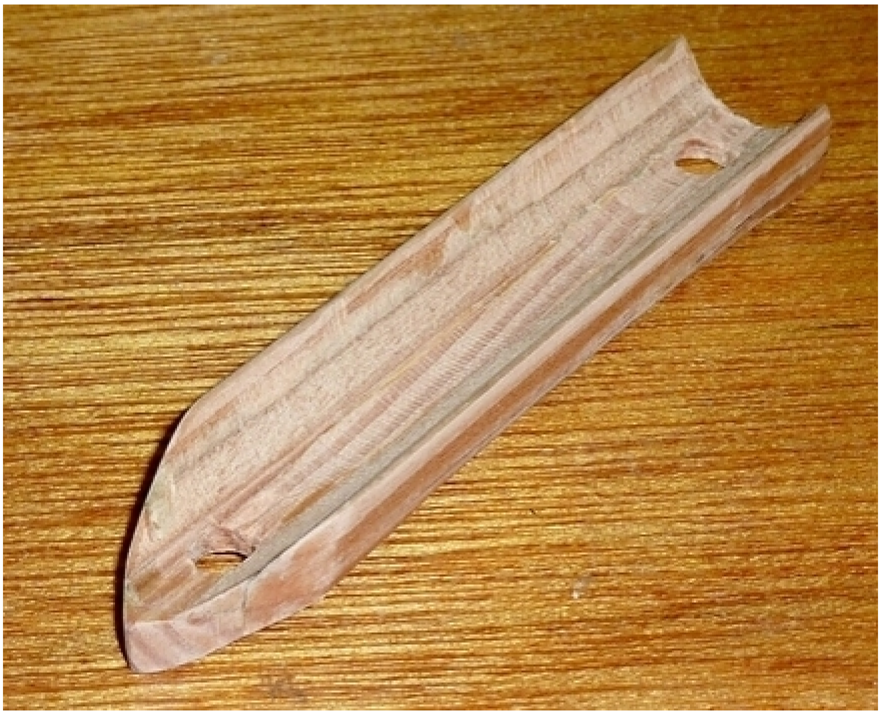
The tailplane has a symmetric airfoil so has a curved under surface. I had to make a support that the tailplane and fin can be clamped down on. I decided on a fabrication of three sizes of spruce.

This shows the blank before shaping using a bench sander, Dremel, files and sand paper. After sanding to the markings, I rounded the ends to a fairly streamlined shape. I then glued it onto the tail boom with epoxy, using the vertical tubes to ensure it was centred.

These show the shaped tailplane mount:

Top

Underside to fit round tail boom



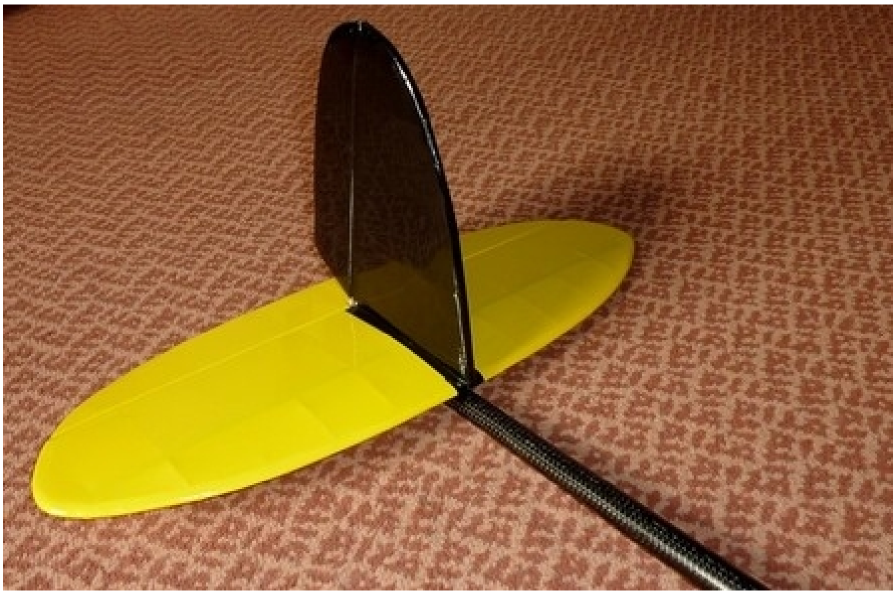
This shows the mount epoxied in place round the stubs, painted and varnished.

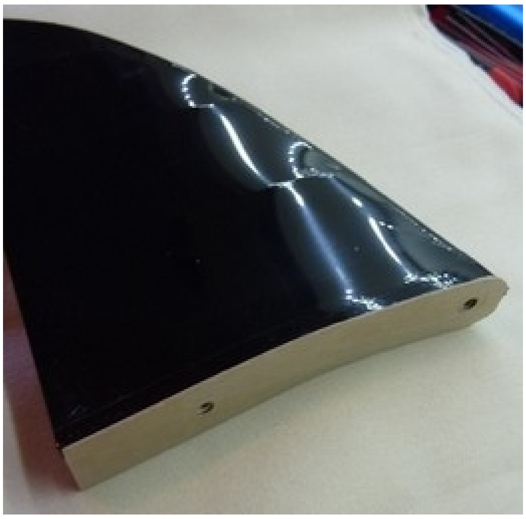
Fin, rudder, tailplane and elevator

Originally the control surfaces were going to be solid, soft balsa. I changed to built-up surfaces because they would be lighter and I did not know how light the tail end needed to be. I used 1x5 mm carbon fibre for the spars on the tailplane. The rear vertical post on the fin is a sandwich of the same fibre with a core of 3mm soft balsa. This proved very strong and made installing the hinges very easy.

The rudder and tailplane simply bolt on with M3 nylon screws as described above. The tailplane mount gives the correct zero incidence. I glued on a rectangle of 0.8mm ply to the bottom of the fin to ensure that it stayed upright under load. I glued the ply and lightly clamped the fin onto the tailplane until it was set, then covered it in black film to match the boom and fin.

Here are the completed components in position on the boom.



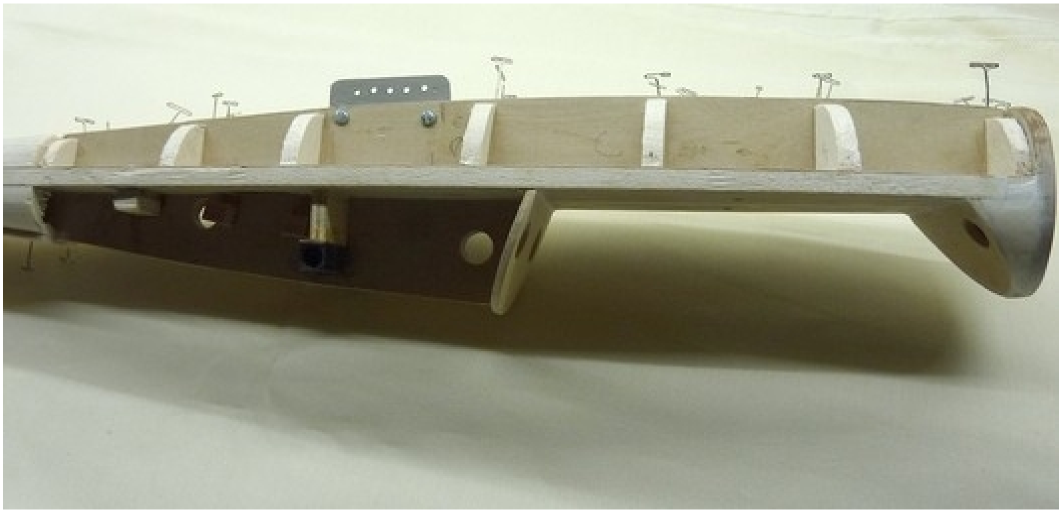


Slightly clumsy connections for elevator and rudder.
Must do better in mark 2.

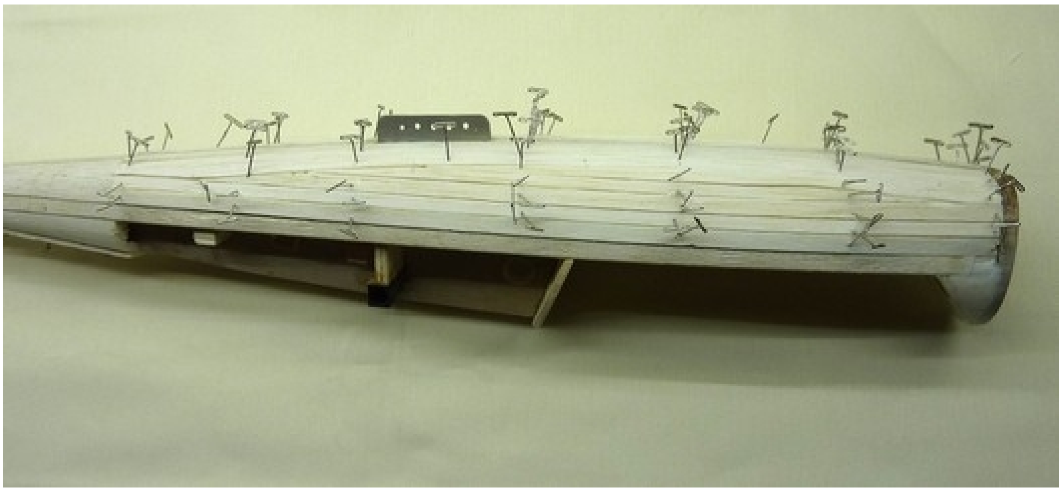
Planking the fuselage

I decided to use softish, light 3mm balsa for the planking with the edges bevelled as described in my guide to planking. My first attempt was unlikely to be brilliant and 3mm allowed for a fair bit of sanding to shape. The surface was toughened with 24g/m^2 glass fibre cloth and Eze-kote. For filling I used Supalite microballoon powder made into a paste with Eze-kote.

Ready to plank



Planked but before sanding

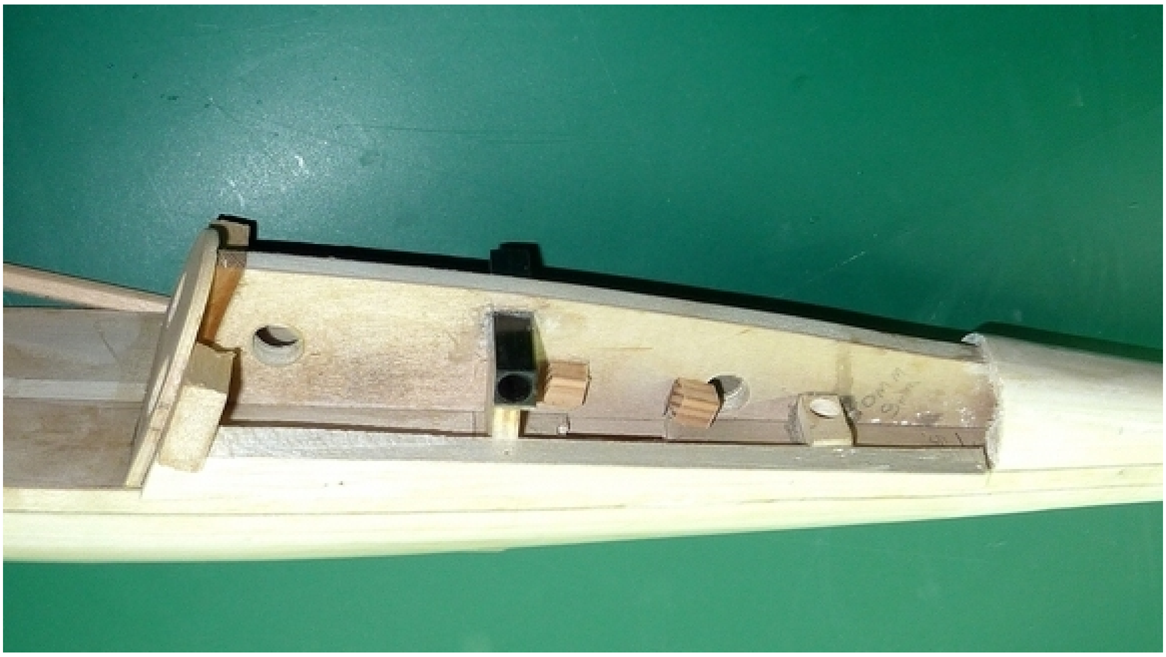


After sanding, filling and Eze-Kote

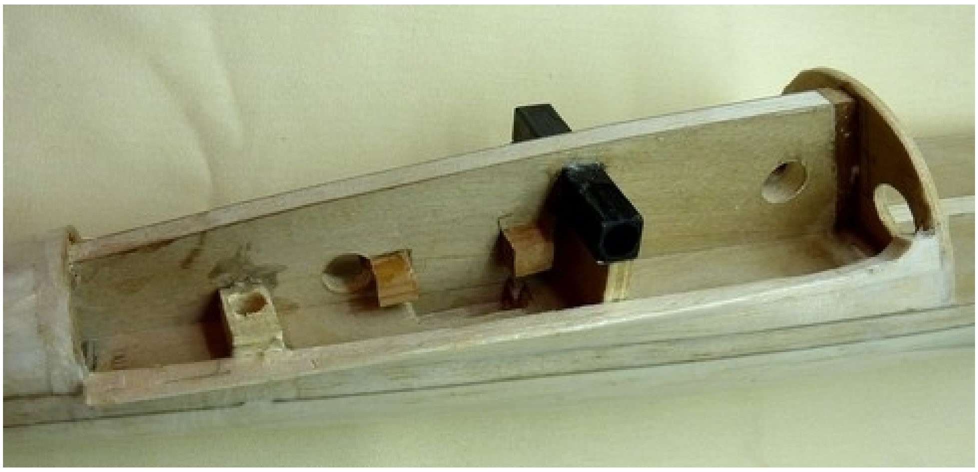
Building up the fuselage fairings and the cap required fitting the already covered wing roots. I thought that this might damage the wings so I made a balsa moulding, trimmed to shape with a plane and a bench sander.

This shows the shaped and Eze-Koted moulding. The stubs of 8mm carbon fibre tube fit into the wing mount tube.

This shows a fairing in rough form.



Finished fairing



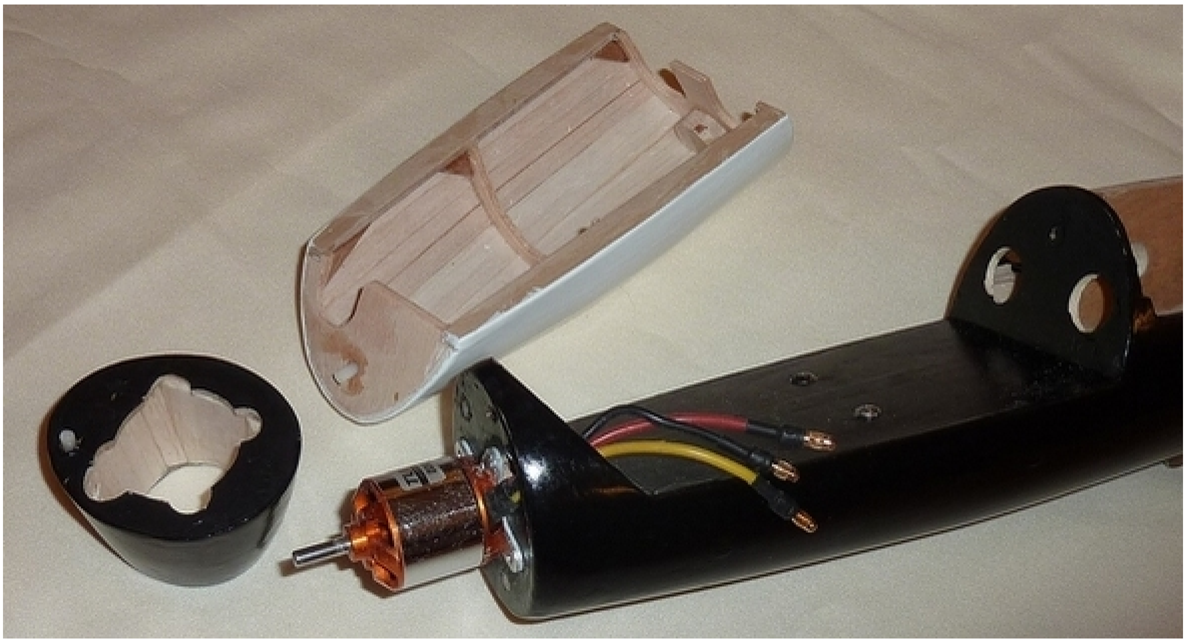
Canopy

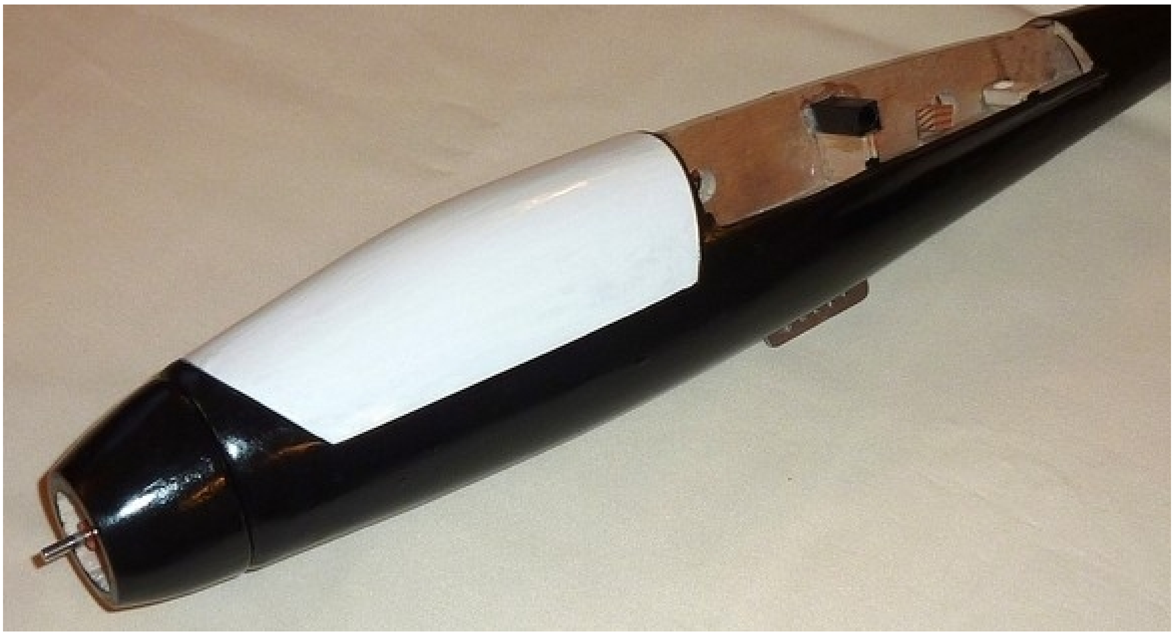
For speed I built this out of ply templates and 3mm balsa planking covered with 24 g/dm^2 glass cloth and Eze-Kote.

This is the bare structure before planking. I glued the parts whilst fixed in position, with clingfilm preventing the frame being glued to the fuselage.

Planked, glassed and sanded canopy in place

These show the painted and varnished fuselage together with the planked and glassed cowl and canopy separately and in position. This was my first attempt at this finish. It’s not bad but needed some more sanding and filling. As Pylonius once said in Model Aircraft magazine , ‘The experts told me that the difference between a beginner and an expert is sandpaper. I bought reams of the stuff and now I’m the shortest-fingered beginner in the business.’



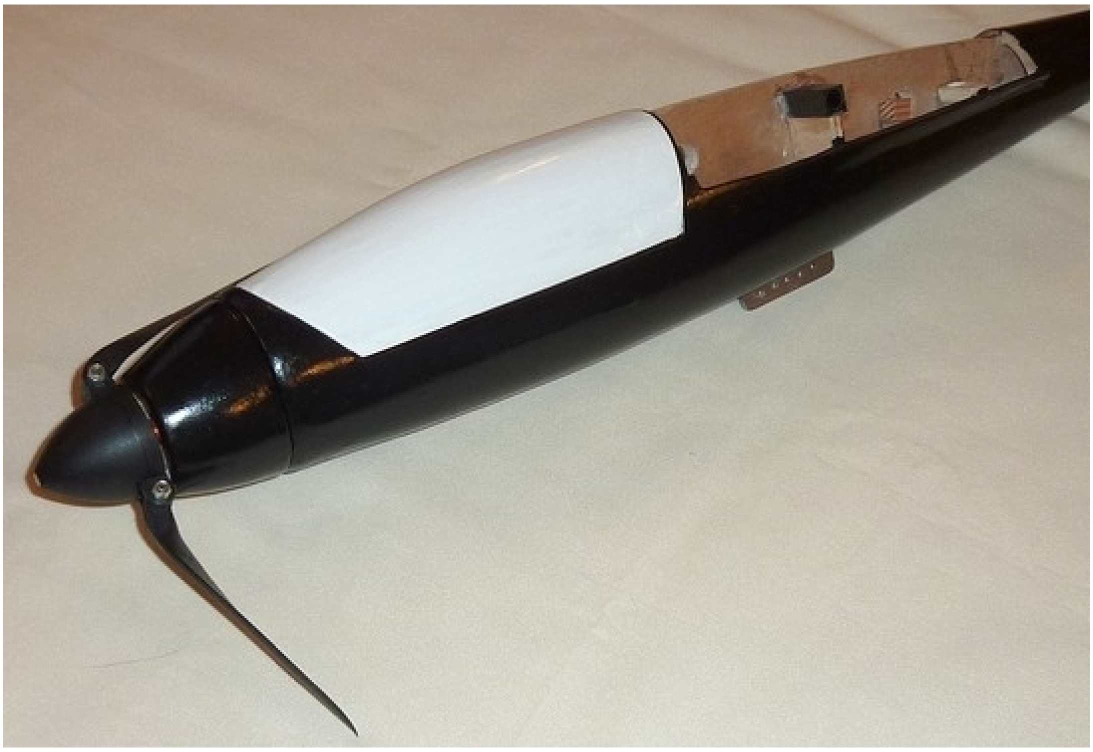


The cowl and canopy are held in place by 3mm nylon dowels and pairs of 6x6mm cylindrical neodymium magnets. You have to be careful to glue them so they attract rather than repel.

Propellor

This shows a folding propeller in place. This one has a 38mm spinner and has been replaced with an aluminium 40mm one with 9x5 blades.

Here is the completed fuselage without the yellow wing cap.



The cap proved to be one of the trickiest parts of the build. I had to form it out of pieces of thick balsa, then sand it on a bench sander, then add more pieces, and so on till it was right. I found a yellow acrylic paint from Vallejo that was a very close match with the wing covering. I was going to use magnets to hold it on but in the end glued M3 threaded bushes into the vertical spine and held the cap on with screws.

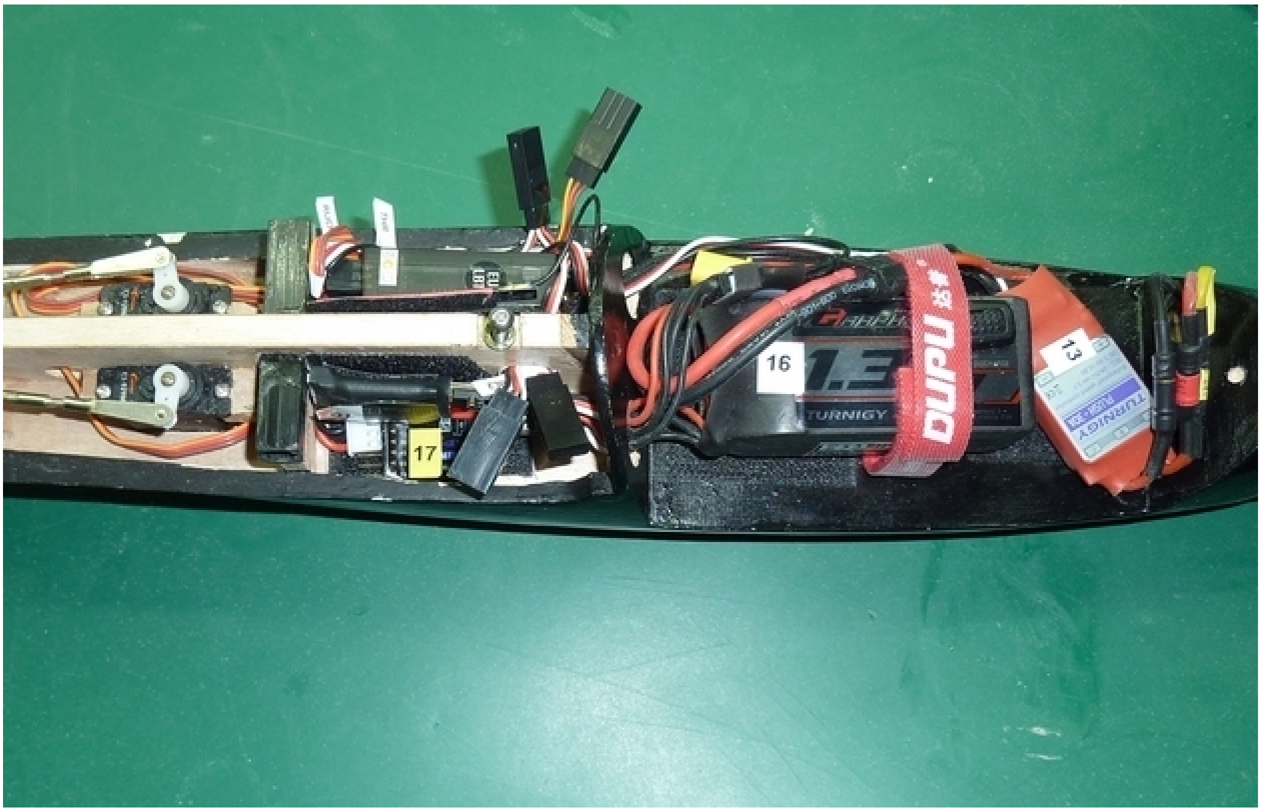
These pictures show the cap and how it fits. The shape is not exactly right but it is streamlined and mark 2 will have a different wing root layout.

Completed model

The canopy is now painted black to give a more sleek appearance.

Radio installation

This was tight! I had planned the spaces inside the fuselage carefully but the best laid plans of mice and men… In the end it all fitted exactly. This was another good reason for using FrSky, as the telemetry devices are very small and light. The servo connectors are almost as big.



Far left are the servos for the rudder and elevator. The snakes are inside the carbon fibre boom. Centre top is the X8R receiver. One aerial goes vertically down through a slot. The other can be seen as a red line going across. The red is shrink wrap to enable the velcro to stick. I wanted to keep the aerials away from the servos. The loose servo connectors are for the ailerons and flaps.

Bottom centre are a lipo voltage sensor (17) and a high-precision vario sensor. The latter uses air pressure and can sense height changes of much less than a metre. It must be zeroed before flying of course. I number all my devices and batteries so I can keep a record of their ages, uses and abuses.

Moving to the right there is a 3S Turnigy 1.3Ah graphene lipo (16) held on by velcro and a red hook and loop strap (for when I want to do bunts). It also clamps the loose leads. Far right is a Turnigy Plush 30A electronic speed controller with shortened leads. The motor, which is out of sight, is a Turnigy 2836/8 turning a 9x5 folding prop. I like the Plush ESCs as they are easily programmed using a card, in this case for motor braking. People using other makes seem to to spend a lot of time fiddling with their bleeping transmitters and cursing a great deal.

After plugging up, the wings push on and are screwed into place, allowing the loose servo leads to be shoved into place before the wing cap is screwed down. The Tx ‘full-house’ programming is described later.

Revised radio

During the building time FrSky introduced the Neuron 40S ESC. This is tiny and has telemetry built in. I decided to use one in this model and changed the receiver to a G-RX6 which has a vario built in. I was able to move to ESC from under the canopy into the space previously used for the vario and lipo voltage sensors. The extra space up front allowed me to change to a 2.2Ah 3S lipo. This gave me a much longer motor run time and, being heavier, avoided the need for nose weights.

This is what it now looks like inside:

Actual and estimated weights

Actual	**g**	**Revised g**
Motor Turnigy 2836 (300W)	137	137
Battery 1.3 Ah 3S graphene lipo	137	184
30 A Turnigy Plush ESC	25	32 (Neuron)
FrSky X8R receiver	17	2.6 (G-XR6)
FrSky lipo voltage telemetry	3	0
FrSky vario telemetry	18	0
Wing servos (4) Corona 293MG	88	88
Fuselage servos (2) Corona 929MG	25	25
Wires	15	10
Prop and spinner 9x5 blades / 40mm	32	32
Subtotal	468	510.6
This leaves 267 to 582 g for the airframe		or 227 to 542

	Estimated	**Actual**
Wings	250	435 + 20 + tube 11
Fuselage, fin and rudder	250	Fin/rudder 21 + 170 + canopy ???
Tailplane	30	42

Ballast weights for mark 2 fuselage
10 cm^3

Aluminium	27
Steel	79
Brass	85
Lead	113
Radium (for night flying)	141

Final all-up weight with a 2.2Ah 3Sbattery was ???g and wing loading 1???/?? or ?? g/dm^2

So the airframe finished up weighing 1300 – 468 which is 832g, rather more than the desired 582g maximum.

I might build two 1m parallel inner wings to increase the span to 4 m. This should increase the weight by about 400g and the area by about 45 dm^2. The wing loading would then be 1700/80 or 21 g/dm^2 and the aspect ratio about 19. That should float well for slope days when the wind is light.

Alternatively I might build a 1 m centre section and have a three piece wing of 3 m span. This will enable me to have a stronger centre section and to use wing ballast spread out to reduce centre load. I cound also use steel rods to join the wings in strong winds again spreading the ballast load. This will of course require modification to the fuselage but it will make it simpler as the cap can be on the wing. By then I will know the best incidence.

Lessons learned

1 The wings should be lighter. The target of 250g was over-optimistic but I think I could prune 100g off. I must absorb John O'Donnell's dictum of, 'Build it again, lighter'. I over-engineered the wing roots I think, but at least I know they won't fail under stress.
2 Bought-in tapered carbon fibre tail booms are excellent.
3 I will build servo boxes for mark 2 wings and fit them when installing ribs.
4 I must use fine nozzles for CA glue, use 'phatic or go back to balsa cement .
5 White PVA makes an excellent glue for hinges where there are ridges or holes in the hinge. Even if some gets on the hinge points it doesn't gum them up.
6 Balsa/ply laminate is light and very strong.
7 Planking is straightforward if a bit fiddly. Balsa cement is a good adhesive as it hardens quickly and sands well.

Wing servo box

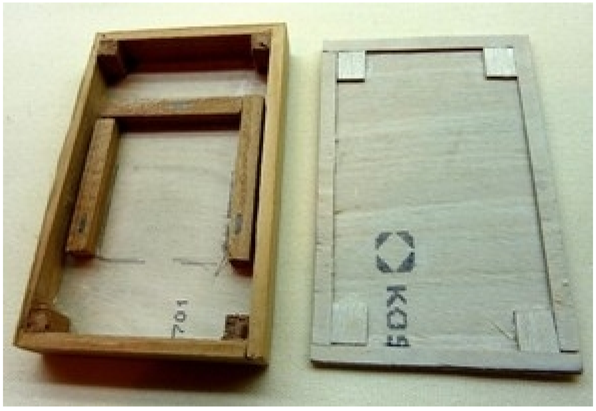
There are excellent slim servos available for wings, particularly the thinner wings used for gliders. Less well developed are the mounts for them. SLEC makes some good ones but only if the size is correct for your model and servo.

While developing Rider I made the mistake of leaving the servo mounts too late. The results worked but were untidy and clumsy, as you see.

So I decided to design a mounting box for future versions and other models. The boxes will be installed when fitting ribs rather than at the end.

The servos I use - Corona CS-239MG (£7.07 4.6kgcm analogue) are exactly 10mm thick. The bottom and lid are made of 1mm birch ply. The sides are 3 x 10mm spruce with corner pieces for the threaded bushes cut from 5mm square spruce. A slot will need to be cut in one side for the wire to exit, to suit the location.

I made the box 80mm wide only because that was the gap between the ribs. It could be made a lot narrower to suit the servo and model. The lid has a strip of 1mm birch ply around the edges of its underside and squares in the corners. These allow a little more thickness for countersinks for the M2 x 4 screws holding it down.
This shows the box with the servo frame and corner blocks glued in.

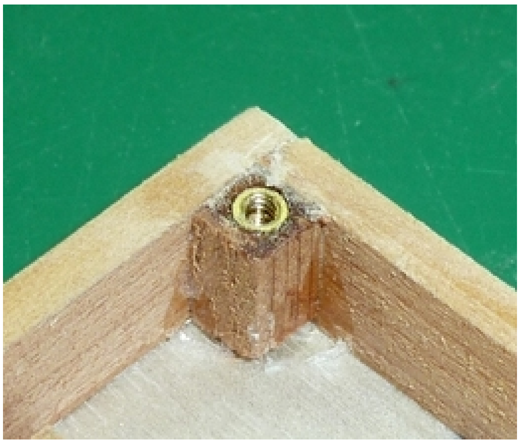


This shows the servo in position. 5mm square spruce was exactly the correct size to form the frame into which the servo fits. Short 2mm servo screws hold the servo down.

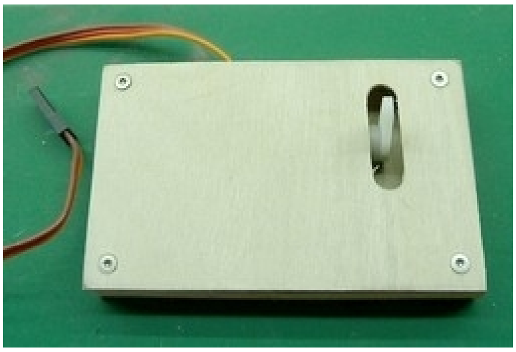
The lid is held down by M2 x 4mm allen head countersunk screws. The bushes for them are glued into 3mm holes drilled into the corner blocks using a diamond holesaw. They are sold for melting into plastic mouldings, for example those made with a 3D printer. They are called some combination of ‘brass knurled thread insert’. I got mine for £2.65 for a hundred on eBay. That is the ex-China price so allow for the delivery period,

usually about a month. A tiny drop of epoxy is all that is needed as there is almost no stress on them.

One insert glued in



The completed box



Total weight without the servo is 11.4g. I will probably do away with connectors to save space and weight by soldering the leads and using heat shrink. I also tested two other slim wing servos from Hobby King, the HK15322MG (£7.61 1.75 kgcm digital) and the Turnigy BMS-555MG (£16.36 4.2 kgcm analogue). These are reviewed next.

Comparison of three metal geared slim servos from Hobby King

The three are:

		Torque (kgcm)	Type	Weight (g)
Corona CS-239MG	£7.07	4.6 kgcm	analogue	22.6
HK15322MG	£7.61	1.75 kgcm	digital	19.6
Turnigy BMS-555MG	£16.36	4.2 kgcm	analogue	18.4

(Prices in August 2017)

The three are the same width and thickness (30 mm x 10 mm) The Turnigy and Hobby King are the same height (27 mm) and are 7 mm less than the Corona at 34 mm. All weigh about the same.

I tested the centring speed of the three simultaneously on a servo tester and, surprisingly, the digital 15322 was not noticeably faster. Its torque is less than half that of the other two. The Corona seemed more solid than the other two, having a metal case. The Turnigy 555 boasted a large boss and a well made metal horn where the others were plastic.

In future then, provided there is space for it, I will be buying the Corona servo. I have used them in the Rider. It has excellent torque and is less than half the price of the Turnigy. A larger horn boss and better horns would have been good but this is a minor point.

Radio setup for ‘full-house’

I decided to go for what is now known as a ‘full house’ glider setup. This means that the flaps and ailerons work differently for different flight modes. For normal flying the flaps are neutral and the ailerons work as usual with more up than down movement. For thermal soaring, flaps and ailerons are moved down by up to 10º using a rotary control to add undercamber. The ailerons become flaperons. For high speed aerobatics, flaps and ailerons are moved up a little to make the airfoil a bit more ‘slippery’. For landing on tight slopes the flaps go up and flaperons go down to create crow brakes.

This is relatively easy to do with the Taranis X9D transmitter that I use, as mixes are very flexible. There are four rotary controls and the code lines allow you to do almost anything. For more information download my Taranis manual.

Channels
This is how the channels are used:
1 Throttle with the ESC set to brake on zero setting to allow the propellors to fold.
2 Left aileron with up movement double that of down.
3 Elevator
4 Rudder
5 Right aileron with up movement double that of down.
6 Flaps using a Y-lead.

Controls
On the Taranis X9D plus transmitter I use the following switches and rotaries:
Three position switch SD: forward - vario tones, centre - sound off, back - height readout
Three position switch SC: forward motor on, other positions motor off, with voice confirmation
Rotary RS: voice and vario volume
Rotary S2: crow brake setting
Rotary S1: undercamber or slippery flap/flaperon settings
S1 and S2 will both be moved using my left hand on mode 2.
Two position switch SF: forward – normal rates, back – high rates
Three position switch SE: centre – reset vario data to zero field altitude

These are the lines of code used in the transmitter. The function numbers (GF, L and SF) can be different.

Functions

Global functions

GF1	ON	Volume	RS	☑	(allows the voice volume to be changed)

Logical switches

L1	a>x	Alt	122.0m	(switches on when Alt more than 122m)
L2	a>x	🕹Thr	-90	(reminds pilot about battery voltage when motor running)

Special functions

SF1	SD↑	Vario				
SF2	SD↓	PlayValue	Alt	10s		(says altitude every ten seconds)
SF3	L1	PlayValue	Alt	10s		(looks at logical switch L1)
SF4	SE-	Reset		Telemetry	☑	
SF5	SE-	Play Sound		ratata	1x	
SF6	SC-	OverrideCH1		-100	☑	
SF7	SC↓	OverrideCH1		-100	☑	
SF8	SC-	Play Track		engoff	1x	
SF9	SC↓	Play Track		engoff	1x	
SF10	L2	Play Value		Cels	1x	

Inputs, mixes and outputs

Note: the numbers in the following lines are not fixed. They were the ones I needed for my servo/control surface horn and linkage geometry.

Inputs

Switch SF gives the dual rates

I Thr	100	🕹	Thr		---
I Ail	50	🕹	Ail	E30	SF↑
	100	🕹	Ail		SF↓
I Ele	85	🕹	Ele	E30	SF↑
	100	🕹	Ele		SF↓
I Rud	100	🕹	Rud		---
I Flap	100	⊙	S1		---
I Crow	100	⊙	S2		---

Mixer

CH1	100	I	Thr
CH2	100	I	Ail
+=	60	I	Flap
+=	-80	I	Crow
CH3	100	I	Ele
CH4	100	I	Rud
CH5	100	I	Ail
+=	60	I	S2

+=	-80	I	Crow
CH6	20	I	S2
+=	-80	I	Crow

Outputs
These lines give the aileron differentials and reversal

CH2	0.0	—	-70	—	30	←	---	1500	▲
CH5	0.0	—	-70	—	30	→	---	1500	▲

Model setup

Model image	Fox glider		
Timer 1	Ths	03:00	Sets timer to 3 minutes of throttle open
Countdown	Voice		Voice reads out minutes then second in last minute

Notes for Rider mark 2

1 The wing/fuselage join area could be better. Instead of the wing being partially inserted into the fuselage I will make the fuselage wing tube longer and build out a fairing on each side so the wing halves are clear of the main fuselage curve. This will simplify building the wing cap.
2 Use pre-made servo boxes.
3 Reduce the length of the tubes in the wing and hence the amount of wing sheeting. This will save some weight.
4 Build two parallel 1m inner wings so the model can also be used for thermal soaring or light wind sloping. Some additional nose weight will possibly be needed, though maybe the forward part of the wing is heavier anyway. A thermal soarer will probably need a more rearward centre of gravity. Alternatively I might build a one metre centre section as described earlier.
5 After looking at high speed soarers I will move to an aerofoil closer to symmetrical.

Suppliers

Carbon fibre wing tubes	Hobby King
Carbon fibre flats for spars	LaptopConnections on eBay
Servos, ESC and motor	Hobby King
Tail boom	hyperflight.co.uk
Wood and snakes	www.slecuk.com
Threaded inserts	t7design on eBay
Plastic bits (hinges horns etc)	eBay, SLEC or Hobby King
FrSky radio kit	T9hobbysport.com
Covering film	Hobby King
Adhesives	www.slecuk.com or Hobby King
Propellor spinner and blades	banggood.com
Hinge tool	rcworld.co.uk

Wing building procedure

Laminate leading and trailing edges
Plane off surplus glue
Pin to building board
Cut tip block including recesses for spars
Make laminate for root ribs (single and double sided)
Cut out root ribs, both laminated and plain balsa
Drill holes for servo wires using 10mm diamond holesaw
For each laminated rib:
    Cut to length and trim training edge end
    Mark and cut out for spars and tube
For the two root ribs cut slot for rear mount
Cut tube to length
Cut lower spar to length
Place lower spar in position, packed up with thickness of sheeting
Glue in tip block
Slide laminated ribs onto tube
Position correctly
Glue tube and lower spar with epoxy or CA
Glue ribs onto leading and trailing edges with CA or cement
When dry, glue ply rear mount in first two ribs
When all thoroughly cured cut medium balsa packing to fill spaces over and under tube
Cut balsa root ribs, cut into halves to fit and install against tube packing
Cut remaining balsa ribs including servo wire holes where needed
Glue them in place
Glue in vertical grain 3mm light balsa webs to form I beam, with holes for servo wires
Cut top spar to length
Add top spar using epoxy or CA
Remove wing from board
Clean up any attached packing and glue drips
Shape leading edge with plane and sandpaper
Shape tip block and trailing edge for thickness and slight washout
Sheet top surface from spar forwards:
    CA sheet to top spar and fix using small clamps
    When dry, roughly trim sheet to shape
    Pin wing to board
    Cement and pin sheet onto leading edge checking that it is down on ribs by tapping
Glue in top cap strips
Remove from board
Install 400 and 700 mm servo wires after testing
Sheet bottom surface from spar forwards using the same method as for upper surface except:
    The rib edges must be glued at the same time as the leading edge
    Thicker packing will be needed when pinning to board
Add bottom cap strips
Sheet the root rib areas
Shape and glue a 1mm birch ply facing onto wing root
Shape all with plane and sandpaper
Add servo mounts
Fill all gaps with filler and give everything a final sanding
Cover with film

Flaps and ailerons
These are built up from laminated medium balsa using rib construction without cap strips
Aileron and flap leading edges are shaped into a ‘V’

Hinges
The ailerons and flaps are fitted with standard flat pinned hinges on the centre line.

Fuselage building procedure

Build a jig as shown in the photographs
Make the laminate out of 0.8 mm spruce ply and 7 or 8 mm light balsa
Cut out the vertical and horizontal keels including all holes except the rear wing mounting holes
Cut the tailboom to length
Cut the two tailplane and fin mounting stubs from 5 mm carbon fibre tube
Using a 5 mm diamond holesaw in a bench drill press, drill the two holes in the rear of the tube for the mounting tubes
Thread the stubs onto bamboo barbecue skewers
Glue the stubs into position using epoxy. Line them up by eye from side and rear using the bamboo skewers.
Trim the rear of the fuselage front to fit inside the tube. Trim the extreme end then gently press and turn the boom on it to mark how to trim the next part.
When the boom fits fully into place epoxy the lengths of 3 x 6 mm carbon fibre in place
Prepare the jig and check that the parts fit in it
Generously coat the mating parts of the wood part with epoxy
Mate the front and the boom and clamp into the jig
Insert a bamboo skewer into one stub and make sure it points to the centre line to ensure it is vertical
Make the towhook plate from titanium
Drill holes through the vertical keel to take the screws for the plate
Cut a slot in the balsa to take the plate
Glue it in place and fit the screws
Mark two lines across the horizontal at right angles to help lining up the main spar tube
Glue the tube for the main spar in place with the rectangular 6 mm liteply bracers.
Check the alignment with the drawn lines
Cut and glue snake tubes through the tail boom using soft balsa as infill

Cut out the 14 lower planking formers from soft 6 mm balsa noting grain orientation
Glue them in place using white PVA
Fill the space between the end of the boom and formers G with soft 10 mm balsa
When dry, plane and sand the infill to shape
Cut the wing boom to length from 8 mm carbon fibre
Mount the wings and mark the position of the rear mounting holes on the horizontal fuselage plate
Drill 5 mm holes and insert and glue M4 threaded inserts from below
Glue on hardwood blocks to mount the servos
Check fit the motor mount plate ensuring that the front of the fuselage plates fit it
Trim the front if they don’t fit exactly using a knife or sander block
Glue the motor plate in place using white PVA
Cut the formers for the front and rear of the canopy

Glue them to 15mm balsa
When dry shape to the correct angle using a bench sander or plane
Cut slots for the wires using holesaws and trim away to the bottom.
Glue into position
Sand to exact shape and fill
Plank the lower half of the front using 3mm soft balsa.
Add fairings to match the lower surfaces of the wings. It saves damage to the wings if you make up a moulding the same shape as the wing roots.
Shape and sand all of the planking and fairings until you are happy with the shape.
Apply two coats of Eze-Kote and sand.
Apply 24 g/cm^2 glass cloth.
Apply three or more coats of Eze-Kote, sanding between, until you are happy with the finish.
Cut three formers for the canopy and two bottom side pieces, all out of ply. The bottom pieces go the edge of the fuselage but the others are 3mm smaller to allow for the planking. Chamfer the edges to suit the flow of the curves.
Cover the canopy opening with cling-film.
Glue and clamp the formers to from a frame.
When dry, remove the frame and plank with 3mm soft balsa.
Coat and glass as you did for the fuselage.
Mask the boom and the wing openings and airbrush with acrylic primer, paint and varnish.
With the wings or moulding in position, shape block balsa to cover in the space above the wings. Coat and glass as you did for the fuselage.
Airbrush the canopy and wing cover with acrylic primer, paint and varnish.
The canopy is held in place by a 3mm plastic rod at the front and neodymium magnets at the rear. The wing cover is held in position by M3 screws that screw into M3 threaded sleeves in the vertical keel.