Building the Odin

Builder: Ray Wilkinson

This was originally going to be a kit of the BSD Thor, but for reasons of supply it was built from similar components sourced from elsewhere. It was supplied as a couple of 4-inch tubes, one of which was already slotted, an altimeter bay comprising a short piece of tube and a pair of couplers, a bag of pre-cut fins (2 sets of 3 due to the tandem-fin design), a piece of 54mm motor tube, 3 centering rings, plastic nose and sundry hardware.

Bulkplate ring fitted to forward end of altimeter bay

It was decided to build the altimeter bay first. This was very straightforward - one of the couplers was slid into the short piece of body tube, and marked. Epoxy was applied to the coupler and it was glued into place, making sure the epoxy was applied to the whole joint area. The process was repeated for the other coupler, so they met inside.

One of the bulkplates was drilled to take a U-bolt, which was fitted. The nuts were locked in place using epoxy. The bulkplate was then epoxied into one end of the bay, taking it about 5-6mm inside the tube to allow room for a glue fillet. Once dry, a generous epoxy fillet was applied to both sides of the joint - this joint takes the main loads into the forward airframe when the parachute opens, so it needs to be strong.

At the other end of the section, a 6mm ply ring was made and epoxied in. This ring forms a stop that the other bulkplate will sit on, and allows an O-ring to be seated to seal against ejection gases if a dual-deploy arrangement is used. The remaining bulkplate was sanded down slightly to form a gentle push-fit into the tube, then 6mm U bolts were fitted to each bulkplate.

Shock cord and front centering ring epoxied to motor tube (note generous fillets)

The next step was to assemble the motor mount. Because of the split-fin design, there were 2 options here. One was to build a fin set comprising the motor tube, fins and centering rings, and then to extend the fin slots to the end of the airframe tube, slot the assembly in and then make good the airframe. This has the advantage that the assembly is easier to access and the quality of the fillets can be seen, but has the drawback that not all the usual fillets can be included, as there would be no access to the inside of the tube forward of the middle ring. Also, the repair to the airframe tube would be difficult to conceal.

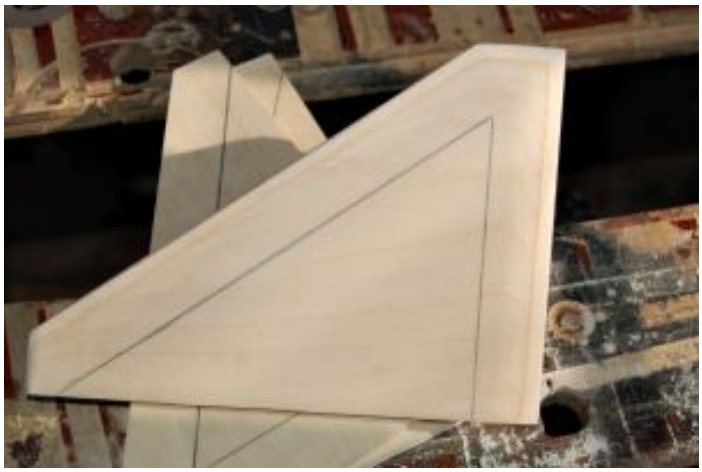
The alternative, chosen here, was to build the assembly inside the tube, as would be the case for normal fins, but to use the aft fin slots to get epoxy into the forward end before inserting the middle centering ring. So, the 54mm tube was cut to length and marked for the positions of the centering rings. The middle ring fits between the 2 fin sets, so this needs a bit of thought before assembly. An 8m length of 0.75-inch PML tubular nylon was obtained, and one end epoxied securely to the tube. One of the centering rings was cut to fit over the shock cord, and epoxied in place. More epoxy was applied to the shock cord, and a generous fillet was applied to each side of the ring - this ring is going to carry the majority of the loads into the aft airframe from the chute opening.

Aft centering ring dry fitted to airframe with tape tags to allow removal

Two tags of masking tape were added to the aft centering ring - these would allow it

to be pushed into place temporarily and then removed. The motor mount assembly was then epoxied into the aft airframe, gluing only at the front ring, but using the aft ring dry fitted to align it correctly. When it was dry, more epoxy was added at the forward end to make a good fillet between the centering ring and the airframe. Epoxy was poured through each forward fin slot in turn and allowed to run around the back of the forward ring to make a fillet on the other side.

When all the epoxy was dry, some polyurethane adhesive was added at the forward face as well. PU foams as it dries and forms a strong, light bond with a large surface area. The 8 metres of harness were a real pain during this process, as they were always in the way. The strap was dropped through the motor tube and allowed to hang out of the aft end while the mount was installed, but at this stage it was pulled through again, gathered up and taped into a bundle, and pushed into the forward end of the aft airframe.



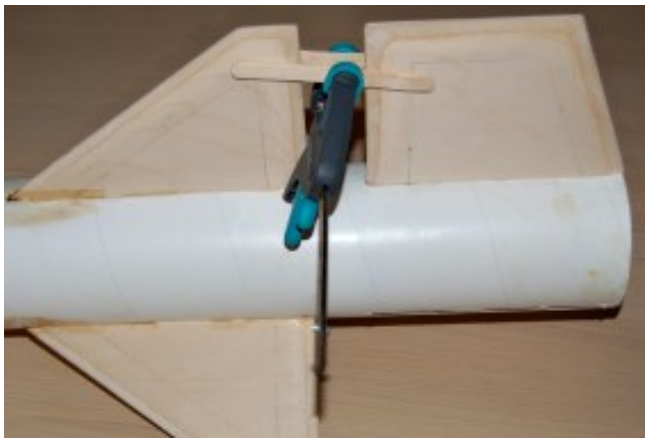
First fin sanded - note guidelines; the contour line in the ply is just visible near the edges

The fins were already cut to shape, but were just flat 6mm ply. Each fin was marked with reference lines about 25mm from the leading and trailing edges and tip. An orbital sander was used to taper the edges and give the fins some semblance of aerodynamic shape. No attempt to make a complete aerofoil was made, just a symmetrical taper all round. The 'contour line' effect of ply was very helpful here, as the top ply was sanded away. The fins were sanded all over to get them as smooth as possible. This would save time when preparing for a paint finish and it was easier to do here than when the airframe was complete.

Before fitting the fins, a fin guide was made. This only takes about 10 minutes and makes it easy to ensure the fins are fitted square to the airframe. A half-circle is marked onto a piece of ply to match the radius of the airframe tube. A line is drawn across the middle and the centre point marked. A line is drawn from this point at an exact right angle to the first line - this line is exactly radial to the circle. Two parallel lines are then drawn to allow for the thickness of the fin. The template is then cut out, using large Forstner bits (that cut large circles without splitting the wood) and a drum sander to get the exact profile. Saw cuts will remove the fin slot. The whole process is quick and the template can be used for any number of rockets of the same diameter.

Using the fin-alignment jig

The next step was to bond in the forward fins. The first fin had a layer of epoxy coated onto the root face, and it was slid into place. Using a torch, a careful examination was made to ensure it was fully seated onto the motor tube, then the alignment jig was slotted into place and the assembly set aside to cure. This was repeated for the other 2 forward fins. Now for the tricky bit - filleting inside the tube. With the airframe tube tilted forward end down, epoxy was dribbled through the forward end of an aft fin slot, then the tube was turned so that the glue would run down one side of the fin, making a generous fillet between the fin root and the motor tube. Again, a good torch is essential here. This was repeated for each side of each fin. It was a time-consuming and messy job, and quite a bit of the epoxy went astray, so the method was changed slightly. Three lolly sticks were epoxied together to make one long stick, which was then used to spoon epoxy into place to make the fillets. This proved more accurate, and eventually there were good fillets either side of each fin. This was repeated for the fillets between the fins and the inside of the airframe tube - same job, different angles to hold the tube.



Fitting aft fins, clamping to ensure alignment

Once the fillets were complete, some more PU adhesive was poured onto the back face of the forward centering ring, then the middle ring was epoxied in, and epoxy fillets added to its aft face. Once this was dry, the aft fins were added. This was easier than the forward fins, as the jig was not required. Each fin was seated

carefully in its slot then clamped to its corresponding forward fin to ensure it was aligned. Again, fillets were applied to every joint then some PU adhesive was added to the back of the middle ring and to the fillets to help keep everything secure. Filleting was easier here, as the fins were not as deep inside the tube.

Before closing up the final section, the launch lugs were added. PML rail lugs were used - these are nice lugs, shaped to fit tubes of various diameters and with countersunk holes for reinforcing screws. A line was marked on the airframe, and the positions of the lugs determined and marked. Holes were drilled for the screws. The back of each lug was coated with epoxy and applied, then M4 screws, cut as short as possible, were fitted through the holes, with nuts on the inside. This was quite tricky for the aft lug, as there wasn't much room to reach inside. In the end, nuts were attached to lolly sticks with a small amount of epoxy, which held them just long enough to let the screws pick up the threads. The nuts were then coated with epoxy, both to secure them and to make them as smooth as possible to help prevent the chute hanging up on them.

PML launch lug fitted

Once all the fillets and the launch lugs were in place, the aft centering ring was sanded to ensure a good fit - some epoxy inevitably finds its way onto the inside of the airframe tube, and it's not always possible to remove it all. The aft ring was epoxied into place, and fillets added between the ring and motor tube, and between the ring and the airframe tube.

Epoxy fillets were then added to the fin roots on the outside. This could have been done earlier, but was left until the inside was finished. The aft airframe was now ready for sanding and painting.

An electronics tray was cut from Fibrelam - a composite panel used in aircraft. It consists of 2 skins of fibreglass with a resin-impregnated paper honeycomb core, in this case about 8mm thick. It's very light but extremely strong. Because the avionics bay has an M6 stud running through it, a 6mm hole was drilled down the centre of the tray, which is used to secure it in place. Holes were drilled for the mounting screws for the altimeter, in this case a GWiz LC Deluxe 800, and a PP3 battery tray, as well as a short piece of connector block to make the connections. The altimeter is not an optional extra here, as the rocket will fly on a hybrid motor - a Pentamax 54mm J motor, which has no ejection charge. A hole was cut into the bay's external wall for a slide switch, and another one for a hyper-bright LED to show everything is switched on. It's easy to forget to switch the electronics on, so the switch was drilled for a Remove Before Flight flag. The switch and LED were wired up before fitting. It

would have been sensible to remove these again before painting, but sense doesn't always prevail. However, the masking worked okay. Finally, all the wiring was connected, and block connectors were attached to each bulkplate to allow connection of the ejection canisters. The holes for the wiring were sealed with epoxy to prevent ejection-gas gas leakage reaching the altimeter.

Aft airframe being painted

The nose cone will be ejected when the rocket is used with a large hybrid, as there's not enough room in the aft section to house the parachute when the Pentamax is used, so it needs an eye bolt to attach the shock cord to. The flimsy loops that are always moulded into noses are never up to the job, so a hole was drilled in the side of the cone (on the shoulder) to allow access inside. An eye bolt was added, with a nut on the inside, all embedded in epoxy to make sure it stays there. The nose cone was fitted to the forward tube, and 3 holes drilled through both for plastic rivets, which will shear when the ejection canister fires.

Finally, all the joints were drilled to have screws fitted (optionally, depending on the separation arrangements for each flight), and vent holes drilled for the altimeter and in each bay to prevent separation at altitude. A hole was also drilled for the vent tube of the Pentamax hybrid motor. All holes, and the bare edges of tubes and couplers, were treated with a small amount of cyanoacrylate to prevent fraying. After a thorough sanding with 280-grade wet-and-dry paper, used dry, the rocket was now ready for painting.

Paint consisted of 3 coats of high-build 'spray putty' high-build primer, 2 coats of grey primer, 3 coats of colour, then 2 coats of gloss acrylic varnish. The high-build primer was not required for the nose cone, and all lettering and other decoration was added before varnishing. Small alignment marks were added across the tube interfaces after varnishing. The final jobs were to fit shock cords and fire blankets, the chute - a 48" Tac-1 - and motor retainer.

First flight took place at **K-LOB** in September 2006, for Ray's Level 2 certification flight, on a 5-grain Pro38 solid motor. The flight went completely to plan. Since then, it has flown several times on our Pentamax 54mm hybrid motor in its J and K configurations. After a heavy landing and some tearing of the tubes due to plastic rivets not shearing, it has been rebuilt, slightly longer, to allow plenty of room for a

drogue chute in front of the Pentamax. We have yet to have a successful launch with dual-deployment, but it's only a matter of time once the winter shutdown comes to an end.