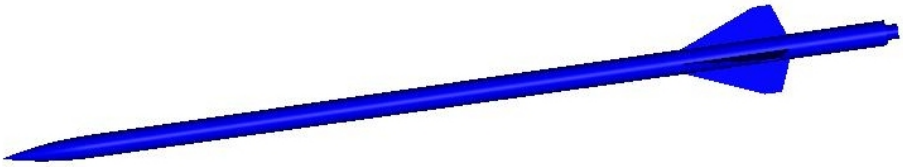
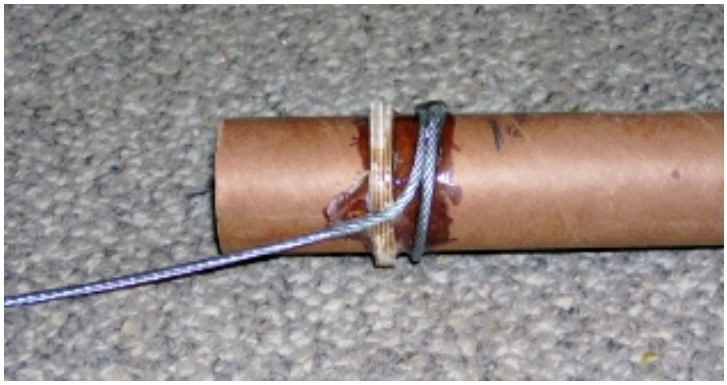
Building the Rapier

Builder: Ray Wilkinson



The Rapier is being scratch-built from tubes donated by one of our technicians, which were the cores of Hewlett Packard plotter paper. They are high-quality cardboard, and about 54mm outside diameter, 2 feet long. I wanted to build a rocket capable of taking a RATT I-80 hybrid motor, which is around 30 inches long, but also to be able to fly on a Pro38 solid motor. Thus, a 38mm motor tube was fitted, with through-wall fins, and a 29mm adaptor tube was also built to accommodate the RATT.

Because the tubes are not phenolic, the airframes were covered with 1.5oz glass cloth. Glass was also applied to the fins. The nose is of turned balsa, again glassed to make it more resistant to knocks on landing.



Forward centering ring with steel cable attached

The first step was to assemble the 38mm motor mount. After buying a 12-inch length of 38mm motor tube, it was decided this would be too short, as the fins have a long chord and are quite forward, so it was extended from some tube that was in stock. An external coupler was made for the motor tube, again from some scrap 38mm tube. The finished mount is about 20 inches long (500mm). Three ply centering rings, 6mm thick, were cut and sanded, and the forward ring epoxied to the motor tube, about 2 inches forward of the fin position. A stranded steel cable was to be used as the bottom section of the recovery harness, so this was epoxied below the centering ring, wrapped securely round the tube. Two more centering rings were fitted, but not until the mount was fitted to the tube, to allow the fins to be attached.

29mm motor adaptor and retainer

In parallel with the 38mm mount, a 29mm motor adaptor was made. This is a long tube to take the RATT I-80 hybrid, with two 6mm ply centering rings and a larger-diameter plate at the aft end. This larger plate transfers the thrust load into the aft centering ring. Behind this is a 29mm motor retainer made in-house from aluminium alloy. A vent hole is drilled at a suitable place in the tube, as the RATT's vent is on the forward closure plate. When the aft airframe is complete, a corresponding vent hole will be drilled in the airframe. More vent holes will be needed for any other hybrids fitted, but this is easy as the tube is removable.

Two sections of tube, each 2 feet long, were assembled together using a 5 inch length of coupler, made by splitting another piece of the same tube along its length and removing a suitable width of material. The tubes were assembled using epoxy - PVA glue would be strong enough for this joint, but it grabs and sets so quickly there's not enough time to slot everything together. Once assembled, the fin slots were marked on the tube and cut using a scalpel. It's important that these slots are absolutely parallel to the tube axis.

The 4-foot length of tube then had a thin coating of finishing resin applied all over the external surface, and two layers of glass cloth were smoothed onto it, and left to dry overnight. The resulting finish was not as good as hoped for, so another layer of finishing resin was applied, and the tubes then rolled in polythene to dry. Once completely dry, the tubes could be sanded smooth. This was a tedious job, but the final paint finish depends on the finish of the surface to which it's applied, so plenty of sanding was done until the whole surface was matt - all shiny spots indicated hollows, so they all needed to be sanded out. The aft airframe tube alone took around three hours to sand. Once finished, the glass was cut away from the fin slots, and they were adjusted for width so the fins would be a snug fit.

The four fins were cut to shape from ply, setting the major grain direction of the ply parallel to the leading edge. A template produced by Rocksim was used to mark them onto the ply, and they were individually cut out and sanded, then stacked together and sanded again to ensure they were identical - a disc sander speeds thing up here. Then the edges were hand-sanded to put an aerodynamic profile onto them. The disc sander definitely does NOT help here, as it's too fast and not controllable enough. The fins were to be glassed as well, as much to get a good finish as for strength, but it was decided that this would be done after fitting.

A fin jig was made from a piece of scrap ply. These jigs only take about ten minutes to make and are an easy way to make sure the fins are square to the airframe, so are worth the effort. A semi-circle the same diameter as the tube was marked onto the ply, and the exact centre was also marked. A straight line was marked through the centre point, and another line drawn on at right angles, also through the centre,

using a try-square - this line is then exactly radial to the semi-circle. Two lines were marked parallel to this radial, which were the same distance apart as the thickness of the fin. The semi-circle was then cut and sanded away (using a bobbin sander), and the fin slot cut. Cutting away a small triangle at each side of the base of the fin slot helps to avoid gluing the jig to the airframe, saving a lot of drag!

Using the fin jig

The motor mount was fitted to the airframe next. Since the fins are some way from the aft end, the motor mount was slid into the airframe until the forward centering ring was just aft of the front of the fin slots. Epoxy was then poured through the slots onto the forward face of the ring, and the mount slid forward into its final position. The aft centering ring was temporarily slid into place to line up the mount with the airframe, having been fitted with tape tabs to allow it to be pulled out again, and the assembly was stood with the forward end uppermost to allow the epoxy to spread evenly around the tube. Once dry, epoxy was again poured through the fin slots, this time onto the aft end of the forward ring, and allowed to dry. Finally, the fin slots were cleared of any epoxy.

Fins assembled to aft airframe

Each of the fins was fitted separately, as only one jig had been made, although 12-minute epoxy meant little delay. A small amount was mixed and applied to the base of each fin, which was then slotted firmly into place and held in position by the jig. Once dry, each remaining fin was fitted, in turn, ensuring they were fully seated into the slots.

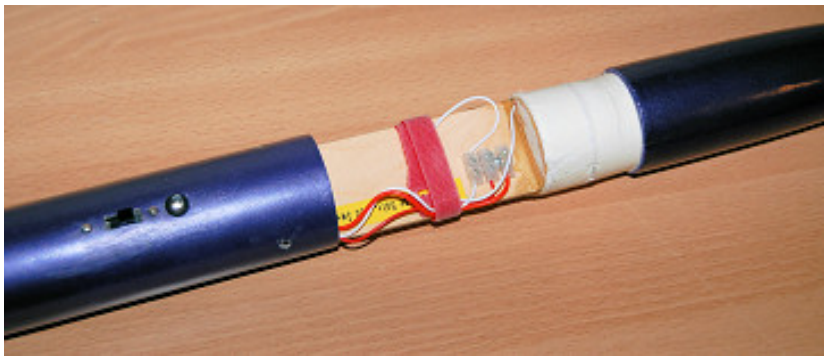
An epoxy fillet was to be applied to each side of the fin, between the airframe and

motor mount, but again the long chord and the distance of the fin from the aft end made this difficult. An experiment using a syringe and drinking straws to pipe the epoxy into place succeeded only in filling the straws with epoxy, so a small hole was drilled through the airframe at the base of each fin, both sides. Epoxy was then syringed through each hole and allowed to run down the fin root - relying on gravity meant this could only be done two fillets at a time. It proved impossible to see down the narrow gap between the tubes, so it was a matter of applying plenty of epoxy and an equal measure of hope. In any case, the fins seem secure.

Once all the internal fillets were applied, the middle centering ring could be fitted, just aft of the fin roots. The holes used for the fin fillets were also used to apply epoxy to the forward face of this ring. Before fitting the aft centering ring, the rail guides were fitted. These are PML moulded guides, as we usually use, and are epoxied in place with additional screws and nuts fitted through the airframe tubes, cropped to length and locked with epoxy. Finally, the aft ring was fitted, and again an epoxy fillet applied to the joint.

The fin roots were given an epoxy fillet on the outside, then the fins were covered with one layer of lightweight glassfibre, partly for strength but also to help get a smooth finish. Once completely cured, this was sanded to a smooth finish.

The only remaining job on the aft airframe was to finish off the shock cord. The steel cable used is quite stiff, and doesn't easily bend to pack into the airframe as hoped, so this was a problem, as the small diameter of the airframe tube made it impossible to create the loop and crimp a tube onto the cable without the cable being too long. The solution was to pull the cable through the tube and out through the motor tube, allowing it to be made up at a slightly shorter length. This will need careful covering to make sure the chute doesn't snag on ejection. On reflection, the steel cable was a bad idea, but there's no way of replacing it at this stage.



Altimeter mount and switch in forward airframe

The forward airframe was much more straightforward - just one length of tube, covered in glass cloth as before, sanded to a finish. The nose was turned from balsa and again glassed. It was quite tricky to get a good finish with the glass right to the nose, due to the taper, but several attempts eventually got it right. A slot was cut into the shoulder to hold an electronics platform, of 3mm ply, which carries the altimeter (not optional for hybrid flights) and its battery. The end of the platform was fitted with a bulkplate to support it in the tube. A piece of airframe tubing was split and reduced in diameter to make a coupler, and this was fitted to the aft end, together with a 3mm ply bulkplate. A strong eye bolt was fitted to take the shock cord, and the nut was epoxied in place to lock it. Holes were made in the forward end of the airframe and an LED and switch were fitted to allow the altimeter to be switched after closing the

rocket. Three small self-tapping screws hold the nose in place.

The final jobs were to fit the shock cord - 6 metres of 600lb flat Kevlar tape - and the 36-inch chute, which is a very thin ripstop material and packs away nicely into the tiny space. After a paint job and application of decals, it's ready to fly.

Unfortunately, its first flight did not go as planned. Ray didn't assemble the motor properly, and the rocket received extensive fire damage around the motor mounts, although the forward section was intact. The rocket has now been stripped down and is in the process of being rebuilt, with new airframe tubes and motor tube. The fins and centering rings have been re-used, and the steel cable was replaced by a flat Kevlar shock cord.