Building the Sky Streak

Builder: Ray Wilkinson (updated March 2008)

Sky Streak tubes and nose in the lab

This is Ray's Level 3 certification rocket. Building is now approaching completion. It is around 12 feet long, 7.6" diameter and will be powered by a RATT L600/M900 combination hybrid motor. The motor is a long-burn motor with a mild (for an M) thrust curve. This means that super-strong is not so important as keeping the weight down.

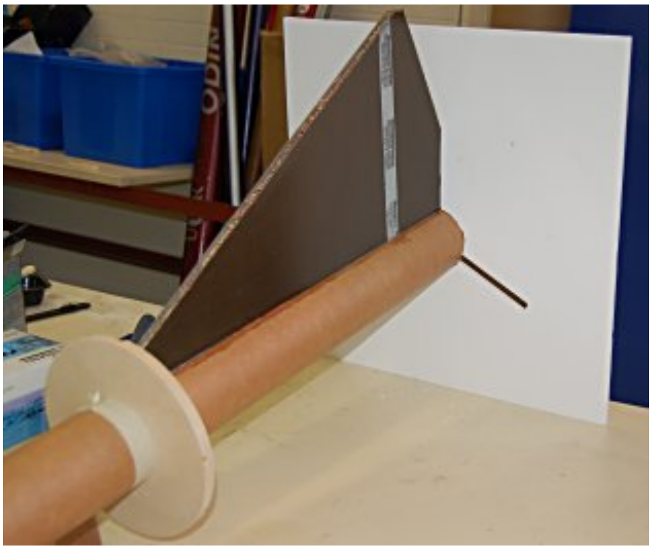
Ray decided to build the rocket so the fin/motor mount assembly can be removed*, which makes assembly slightly different from most rockets, but allows a really strong fin attachment to be made and allows access to the internals to replace the recovery harness. It also allows reinforcement of the launch lugs, and makes repairs easier if the worst happens. Otherwise, construction is quite straightforward, working on the KISS principle. Recovery will be dual-deploy - a drogue chute at apogee followed by main chute deployment at 800 feet. Recovery is controlled by fully dual-redundant altimeters with the superb GWiz 800 De Luxe on one channel and a HiAlt45K on the other. * This has now been changed - see below.

The removable fin can makes for an interesting situation with the centering rings, and also needs a bit of thought about how the thrust is transferred into the rocket airframe. It was decided that the forward ring would be full diameter and attached to the airframe tube. A corresponding thrust ring will be fitted to the motor tube so that it butts up against the centering ring when the tube is installed. For the middle centering ring, the full-diameter ring will be fitted to the motor tube, and a thrust ring will be fitted to the airframe. This will allow the forward thrust ring to slide through it on assembly. The aft centering ring will be fitted to the motor tube only, with no thrust ring. Connection to the airframe will be via a set of screws through the airframe at this point. It sounds complicated but a look at the pictures below will show how it works - we didn't want to design a ship in a bottle, and wanted a secure assembly.

Fins are made from Fibrelam composite board (because we CAN!), edged with wood and glassed over to keep it all together. The airframe tubes are glassed lightly - more to stand knocks during handling and transport than anything. The nose cone was to be borrowed from a LOC Warlock that we had, but was later procured as a fibreglass copy. The glass nose has space for a radio tracker, although it was later decided to fit the tracker into the electronics bay, with a switch on the outside tube, which is more convenient.

For recovery, a dual-redundant, dual-deploy system is used, due to the altitude predicted. Two independent channels are incorporated, each operating both drogue and main chutes, with separate switches, batteries, wiring and ejection charges. The drogue chute, deployed at apogee, is 5 feet diameter and will bring the rocket down at around 50mph to 800 feet, when the main chute, an X-type of 11 feet, will be deployed to slow descent down to round 18 feet per second.

Building



Fins being fitted, using a foamboard alignment jig

The first step was to complete the electronics section - a short length of tube over a 14-inch section of coupler, with a fixed bulkhead at the aft end. The forward bulkhead is removable and sits on a short piece of coupler. A pair of 6mm threaded rods keep it together. 6mm diameter U bolts are fitted to both bulkheads, along with the terminals for the ejection canisters and the canisters themselves. The holes for the switches were cut, together with holes to fit the power indication LEDs. The short external section (only about 2" long) was covered in a single wrap of fibreglass cloth. When fitted to the rocket, the electronics section looks very short. However, as it incorporates the coupler between the forward and aft sections of the airframe it is actually about 14 inches long, leaving plenty of space to fit the altimeters and radio tracker.

The fibrelam parts of the fins were cut out and grooved to take the hardwood leading and trailing edges. The middle centering ring has been notched to take the leading edge, providing a robust fin installation, and the three fins were then epoxied into place. The hardwood edges were cut to size and a shoulder cut to insert into the fibrelam. A foamboard jig was cut to allow easier alignment of the fins, as pictured. The hardwood leading and trailing edges were profiled and shouldered to fit the fin edges, and epoxied in place. The joint at the fin tip was sanded and shaped to create a smooth profile. The fins were fibreglassed on both sides, and also onto the motor mount tube. The leading edges are embedded in the middle centering ring, and the trailing edges into the aft ring.

Fin with hardwood edges and fibreglass reinforcement

Once the three fins were in place, it was possible to cut the fin slots in the aft airframe tube using an oscillating saw. The edges were a little bit ragged, and it became clear that it would be difficult to support the edges of the fin slots properly. Also, the entire aft end of the tube was reduced in strength, and a crack has appeared. So, it was decided that the fins would be permanently fixed into the airframe. One of the reasons for wanting removable fins was to make the rocket more transportable.

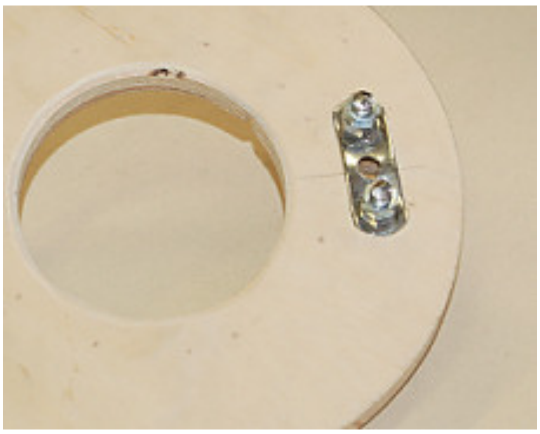
Sky Streak dry-assembled in the lab. The Cessna behind it is 8ft wingspan. The rocket's fins are just visible.

However, it was then decided that the joint between the aft and middle airframe tubes would be splittable instead. A concern was that the coupler, being unsupported by a glued joint, might collapse if high aerodynamic side loads occurred. The earlier plan involved making a full-diameter thrust ring, and this is now to be used to support the coupler, forward of the forward centering ring. This also gives two positions of attachment of the two airframe tubes, each of which will have six or nine woodscrews through the tube and into the rings. This also recovers one of the benefits of the previous arrangement - access to the recovery harness attachments, which would otherwise have needed a small child to crawl down the airframe tube to reach them...

It was now possible to assemble the rocket to see how it looks. Aside from the size, the impression that is made is that the fins, which look so big on the bench, look much smaller when fitted to the airframe, partly because much of the fin is inside the tube.

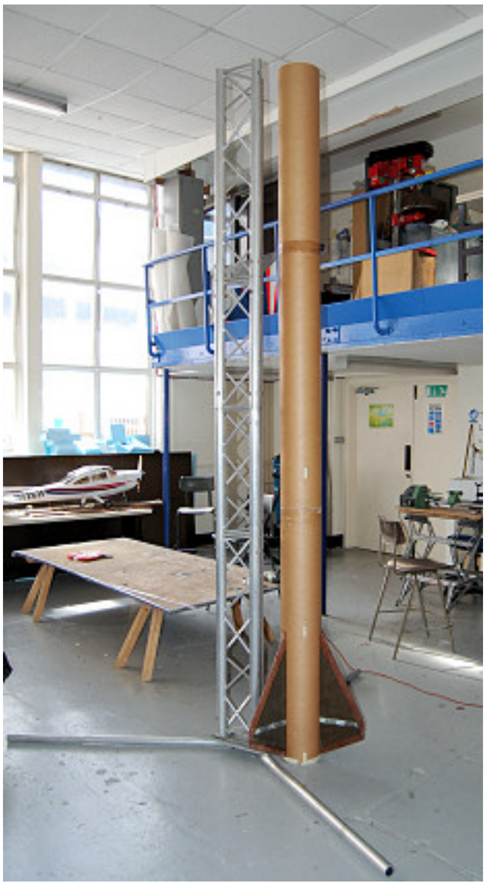
Threaded rod between centering rings. Note large washers. Middle ring is pictured.

All three fins are fibreglassed, and the extra centering rings needed for the modified fin attachment have been modified. Threaded rod has been fitted between the three centering rings, with most of the nuts doubled up to obtain the thread strength. Large washers have been fitted where possible to reinforce the plywood. The fin set has been epoxied into the aft airframe, and most of the external fin fillets have been applied. Three PML launch lugs have been fitted to the tube, including one on the middle airframe tube. These are epoxied in place and supported by two screws. One screw on each lug is a woodscrew, and the lugs have been positioned so these can go into the centering rings. This makes the spacing of the lugs slightly unequal, but will be strong as the lug fitting will not be accessible once the aft centering ring is fitted. The remaining screw in each of the aft and middle lugs is a countersunk M4 and has been fitted, backed up with a washer and nut and epoxied to lock it. The screw on the forward lug will be removed to allow removal of the tube, so is fitted into a T-nut epoxied into the tube.



Back of forward centering ring showing backing plate for U-bolt. Note hole in plate which will take the threaded rod. Thread ends are peened to lock nuts.

The next step was to fit the coupler for the joint between the aft and middle airframe tubes. The forward centering ring was epoxied into the coupler and filleted. The coupler was fitted into the aft tube with foaming polyurethane adhesive, which we find to be the most suitable for this joint, especially on large airframes. A lot of epoxy would be needed, and there would be problems with pot life, whereas the PU spreads well and fills the joint.



New launch pad under construction. Sky Streak less nose standing alongside for comparison. Main tower splits into two for transportation, and legs fold. Tilting the pad to load the rocket is also done by folding two of the legs.

At the same time, the centering ring was epoxied onto the small ring already fitted at the forward end of the motor tube, giving a strong joint with lots of glue area to support the thrust loads, and also the inertia loads during chute deployment. Fitting the forward ring was a little tricky as the threaded rod had already been cut to length, so aligning the ends of the rods to fit through the holes in the ring needed some planning. It has been arranged that these ends will be fitted into the middle of the two U-bolts that will take the recovery harness, so the load path is very short. The backs of the U-bolts have steel plates to reinforce the plywood of the centering ring. The ends of the U-bolt threads have been peened to lock the nuts.

Once the coupler was fitted and the fins are fully filleted, the aft centering ring was fitted. This completed the aft airframe assembly, and the rocket was ready for covering with fibreglass. A glassfibre nose was bought from Paul at Congreve, which completes the major component list. The nose is a copy of the plastic nose fitted to the Warlock, but is easier to finish and takes (and holds) paint better. We are still waiting for the motor, and need to complete the motor adaptor to fit the 3-inch tube fitted to the airframe (the motor is 64mm diameter).

Other progress made so far is that the launch rails (two 2-metre rails) have been collected, and a number of sections of triangular radio mast were picked up cheaply from eBay, which make up the main launch tower - the rails alone would not be stiff enough to support the rocket so they are bolted to the mast. A triangular base has been cut from 8mm aluminium plate, and the bottom section of mast is bolted to it. Three tubular legs brace the mast, and are pivoted at the bottom so they can fold for storage. Pivoting also allows two of the legs to be turned so the entire pad can be tipped over to install the rocket. Three pins, machined from M12 screws, hold them in position. Finally, a stainless steel blast shield (still to be made) will be fitted to protect the ground. Besides this, the final stage still to be completed is to fit the upper rail and its joint to the lower one.

Sky Streak at the UH Projects unveiling, along with the Formula Student race car.

The entire rocket was given 5-6 coats of grey high-build primer (after many hours of sanding down the finishing resin used with the fibreglass), followed by 5-6 coats of jet-black colour coat. Finally, four coats of clear lacquer were applied to achieve a deep finish, ending by spraying with pure thinners to gloss the surface. The paint used is two-part acrylic paint, which air-dries then cures, giving a very robust finish. Because it dries so quickly, it was possible to keep going around the tubes, hence the large number of paint coats applied. The lettering has also been added, made from cut vinyl, as were the alignment marks to ease assembly in the field.

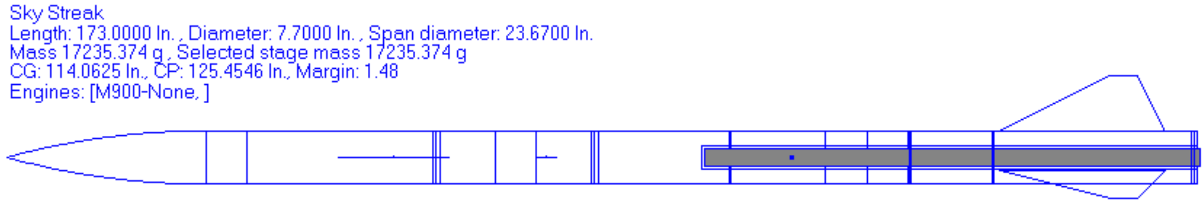
Sky Streak in the new Special Projects lab, next to the Odin, which is 'only' 9 feet long.

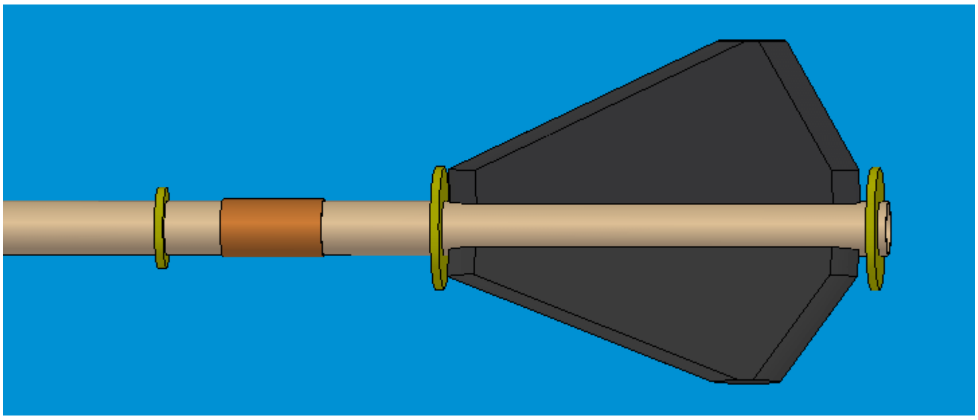
Section screws have been fitted, into screw-in captive nuts. The forward airframe section is attached to the front, detachable bulkplate in the electronics bay. This has the small advantage of reinforcing the attachment of the bulkplate to the electronics bay tube. Eight M5 screws are used, to spread the loads generated as the ejection charges fire, making sure the shear pins release the nose rather than pulling the forward airframe off the electronics bay.

The middle airframe tube is also attached, just forward of the front centering ring, using the same method, and the eight captive nuts are fitted into the ring that stiffens the coupler at this point. Again, it is important that the ejection charges separate the airframe at the correct point without damaging the tubes.

Final tasks still to be completed are the installation of all the electronics, including switches and wiring; internal fin fillets and the aft centering ring, and plastic rivets or shear pins. The shear pin size and quantity will depend on the results of the ejection tests, but with a 2.3kg parachute they will need to be strong enough to hold the inertia of the chute as the drogue deploys, but weak enough so we don't need charges to rival Guy Fawkes' to get the main out. It may be necessary to do some drop tests with the forward section to make sure the shear pins don't let go early. The motor adapter, from the installed 3-inch motor tube to the 2.5-inch tube for the RATT motor, also needs to be finished, along with a motor retainer. The tube is already joined but needs the various thrust rings and centering rings to turn it into an adaptor.

RockSim model with RATT M900 loaded





CAD model of motor mount/fin assembly