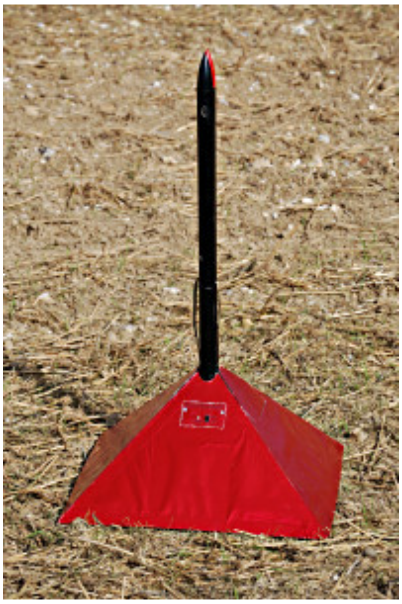
Building the Double Trouble

Builder: Ray Wilkinson

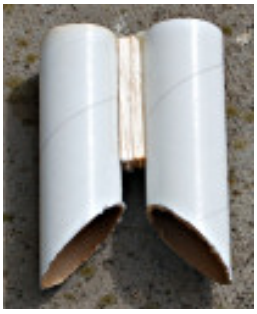


This is an unusual rocket in many ways. Ray wanted to build a clustered hybrid, just to make life interesting. Another RATT I-80 was bought, as it's such a nice motor with a long burn time - almost 5 seconds. It's also a handy size - 29mm I class. After a chat with Damian Hall about this it was clear that 2 tanks of nitrous oxide are needed as connecting 2 motors to one tank would mean that when one motor lights and the fill pipe falls away it would empty the tank of the second motor, unless non-return valves were fitted.

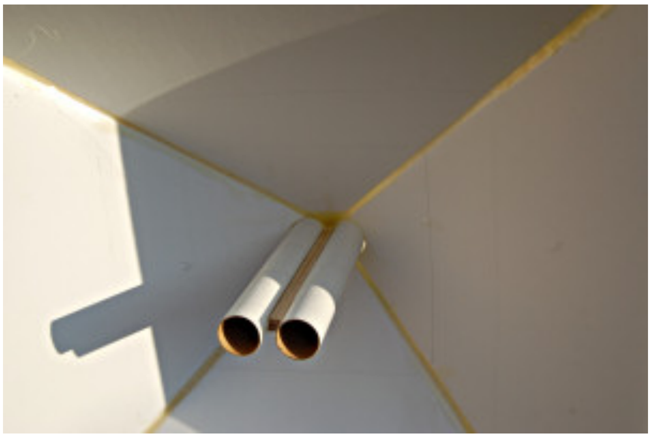
Flying a J-class rocket would limit the places it could be flown if it were a conventional design, so it was decided that a tetrahedron would be built. We can then fly this at Benington, near Stevenage, where we are limited to just 2400 feet. The motors are very long, so they would inevitably stick out of the front. This added the need to fit a recovery device rather than just have drag recovery, and the need for symmetry on a tetrahedron really points towards 2 parachutes.

One extra issue is that the rocket must not be allowed to take off with only one motor lit, and hybrids are less reliable and more variable on ignition than solid motors. This becomes a complex project, both in design and build, and will be a challenge to fly as well.

Unlike most projects, this one starts with the airframe, rather than the motor mounts. This is built from 5mm foam board, but the class of motors mean that plenty of internal support is needed to stop the whole thing collapsing at flight speed. Two motors, each with a peak thrust of around 150N means a maximum force of around 30kg on the airframe, although much of that is dissipated internally, and the motors are by far the heaviest components. Four triangular sides were cut from large sheets of board, their size really being dictated by what would fit the boards without too much waste. The bottom bulkhead was also cut at this point, as a square. The mating edges were cut at an angle, and taped together before gluing. Then all 4 panels were glued together in one operation, using the bulkhead to hold everything true, using foaming PU adhesive. Once dry, more PU was added into the joints to make sure everything is strong. Sprinkling water onto the wet glue helps it to set, and makes it foam to fill the joints.



Motor tube template

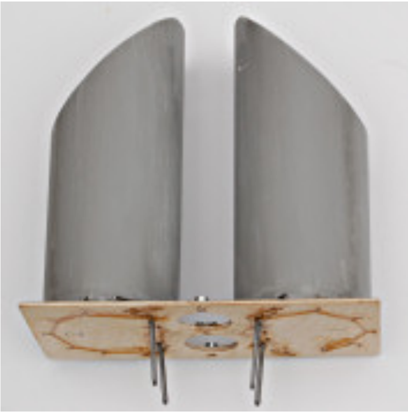


Motor tubes fitted to airframe

The next step was to fit the nose cones and join the motor mounts. The cones were quite flimsy, but noses to fit 29mm tubes are not easy to come by. They were filled with layers of epoxy and PU glue to reinforce them, and were epoxied into place as they would not be ejected. The tubes were then cut to length - slightly longer than the motors. A strip of balsa was epoxied to each tube then the 2 strips were epoxied to each other to join the tubes with a gap of about 6mm between them to allow for motor retention. The 2 offcuts from the tubes were also joined with similar balsa strips - these would be used as templates for cutting the holes in the tetrahedron and bulkheads.

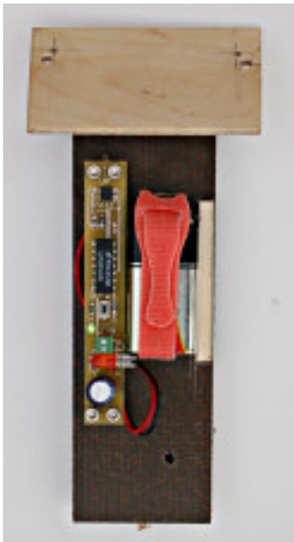
Once dry, the template was marked and cut to match the angle of the airframe's sides, and used to mark up the sides. The holes were cut in the airframe to clear the motor tubes, using a scalpel. The centre of the bottom bulkhead was marked (where diagonals cross), and 2 holes were made, again with the template, to accommodate the bottom of the motor tubes. The tubes were then epoxied into the airframe, using the bottom bulkhead (dry fitted) to hold them at the correct angle. Once set, more epoxy was added to strengthen the apex and make a secure joint. The bottom bulkhead was then removed. Two more bulkheads, of different sizes, were also cut to fit at various points inside the airframe, but no holes were made at this stage.

Because of the need for symmetry, this design uses 2 parachutes, forward ejected from a pair of chute cannons. A piece of 3" Quantum tube was cut approximately to length for each cannon. Balsa strips were added to the motor mount tubes to stand the cannons off a small distance, and hatches were cut in the pyramid. The tops of the chute cannons were cut to a matching angle, and cut to length. A foam board doubler was added to the airframe at each side, with holes cut to match the ends of the chute cannons.



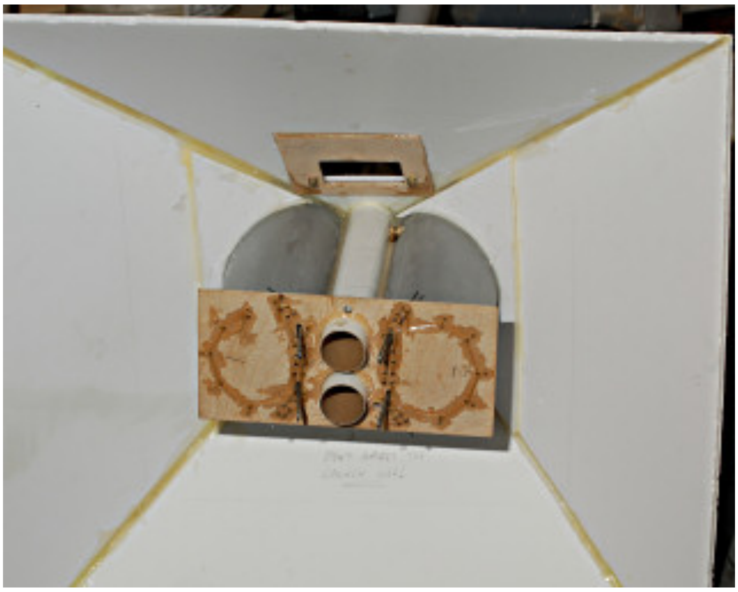
Chute cannon assembly. Note Kevlar stitching and retainer wires

The base of the chute cannons was made up by a sheet of 3mm plywood. To ensure it isn't broken away when the ejection charges fire, especially as Quantum tube doesn't take epoxy that well, it was drilled and stitched with 150lb Kevlar, epoxied to seal it. Three captive M3 nuts were added for motor retention. The method of holding the rocket on the pad was built in at this stage - 2 lengths of piano wire were bent to make loops either side of each motor. These loops would be used to attach the rocket to the launch pad with tie-wraps or similar devices, which pass across each motor nozzle. As each motor lights, the retention will burn through - only when both retainers have broken will the rocket be free to leave the pad. A slot was cut near the top of each cannon for the shock cords - of 70lb flat Kevlar woven tape. The shock cords are quite short, around 8 feet each, to reduce tangling and keep the volume down as the chute cannons are quite short.



Completed electronics tray with Velcro battery retainer

The next step was to make up the electronics tray - necessary of course as the motors are hybrids, so don't have built-in ejection charges. A simple magnetic apogee detector was used, attached to a piece of Fibrelam (aviation composite board), although plywood could have been used. A top plate of plywood was attached at an angle to match the slope of the airframe sides, and a matching slot cut in the airframe. A plywood plate was cut out and epoxied to the inside of the airframe. Two M4 screw inserts were fitted, and the Fibrelam plate will also be supported at the bottom, by slotting into the bottom bulkhead. A battery box could have been fitted, but this would have been too tall and the MAD was fitted with a PP3 battery clip anyway, so the battery is retained by the MAD itself on one side, a balsa strip on the other, and a Velcro strap, holding the battery to the board and the clip onto the battery terminals. An on-off switch and power LED have been spliced into the line - there's no launch detect on this MAD, so it's live as soon as it's powered. This means that if the rocket is tilted too far once the battery is connected the ejection charges will fire. The switch is therefore needed for safety. The switch lever has been drilled for a Remove Before Flight flag as a reminder.



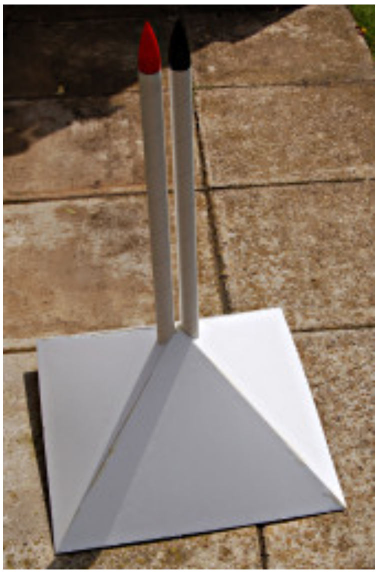
Chute cannon assembly fitted to airframe. Plenty of epoxy around the top to seal to the airframe and onto the motor tubes for strength. Note also the slot for the electronics tray. Rings around the plywood base are the Kevlar stitching to the chute cannons.

The shock cords were fitted as a continuous length, slotted through the balsa between the motor tubes. The strap was knotted either side, so an asymmetric deployment would not pull the shock cord through. The chute cannon assembly was then fitted to the inside of the airframe, by epoxying to the motor tubes. Extra epoxy was added around the tops of the cannons to seal them to the airframe. The shock cord was threaded through the slots in the cannons, ensuring it was kept free of epoxy. As the centre of gravity will be forward of the shock cord attachment points the cords will need to be attached to the motor tubes forward of the tetrahedron so it hangs base down. This is a shame, as it means the shock cords will be partially outside the rocket at launch, but there's little option. Before going any further, the tube for the launch rod was fitted, with a balsa strip to set it away from the motor tube a little. A hole was drilled in the plywood plate seen in the photo, and a drill bit was used to make sure the tube lined up while the epoxy dried. The final hole at the top can be made later, as it's only in foam board.

The first of the bulkheads - the upper one - was then fitted. It had to be cut around the motor tubes and chute cannons and, like the second one, had to be cut in half to allow it to be fitted. A generous amount of wetted PU adhesive makes sure it is well secured and all the gaps are filled. Once the glue has dried, a hole was cut to clear the electronics tray. Fitting the second bulkhead was exactly the same.

The bottom bulkhead is fitted in one piece, because it doesn't need to clear the chute cannons. A template was made up from scrap foam board to mark the places where the wire retainers fit, and this was transferred to the bulkhead. The launch tube hole was also transferred. Before fitting the bulkhead, a small foam board patch was made to support the bottom of the electronics tray - a slot in this patch stops the end of the tray from waggling around. The tray was fitted and screwed into place, and the patch was slotted onto the end. A couple of pieces of double-sided tape on the bottom of the patch then pick up on the bottom bulkhead when it is dry-fitted. The plan was to mark around the patch and re-fit it with a generous helping of tape, but the first pieces held it so securely this wasn't necessary or possible. The wiring for the chute cannons was also added - a T-piece of wire connected the 2 cannons to a single lead to fit the electronics. The leads were pushed through holes drilled into the bases of the cannons, and the bare ends tinned. The ejection canisters are then fitted before each flight, with the wires just twisted onto the leads and wrapped with PVC tape.

Finally, the bulkhead had plenty of PU adhesive, again wetted to make it foam, and was dropped into place. It was weighted down and left to dry.



To secure the covers of the chute cannons, 2 ellipses of foam were fitted to the underside of each. Again, double-sided tape on the inserts holds them in the correct position, and they attach securely when the cover is pushed into place. The covers should be held by the airflow over the tetrahedron anyway during flight. An eye bolt was epoxied into the underside of each cover, which attaches to the end of each shock cord. All that remained was to decorate the whole thing, and test the deployment.

The motor tubes and the underside of the tetrahedron were sprayed with gloss black car paint. The rest of the tetrahedron, including the 2 chute covers and the electronics tray, was covered in red aluminium foil, bought from a craft shop. It was attached with double-sided tape all round. This proved very tricky to make a neat job of, but the end result doesn't look to bad, given that the foam board had become quite heavily marked during construction.

The parachute deployment has been tested, to make sure the canisters eject the parachutes and the electronics can fire 2 canisters. The former was important because the chutes are tightly packed into the cannons, which are very short. The latter was also found to be a useful part of the test, as the first electronics tested - a magnetic apogee detector bought from someone on eBay, wasn't capable of firing both canisters. A Flux Capaciter was substituted, and this worked fine. However, these devices are very sensitive to having too much metal around, and this took some sorting out.