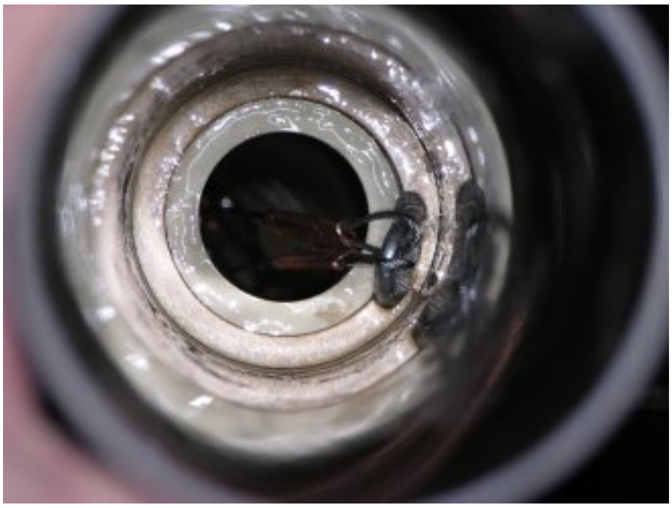
Building the Ariel

Builder: Ray Wilkinson

This is Ray Wilkinson's own rocket, but will mostly reside at UH, and will be used for display purposes as well as being flown. It's built from a kit made by PML (Public Missiles Limited), a Canadian company. The kit is good quality, quite straightforward to put together, and has a number of really nice features, like their Kwik-Switch interchangeable motor mount arrangement and pre-slotted airframe tubing.

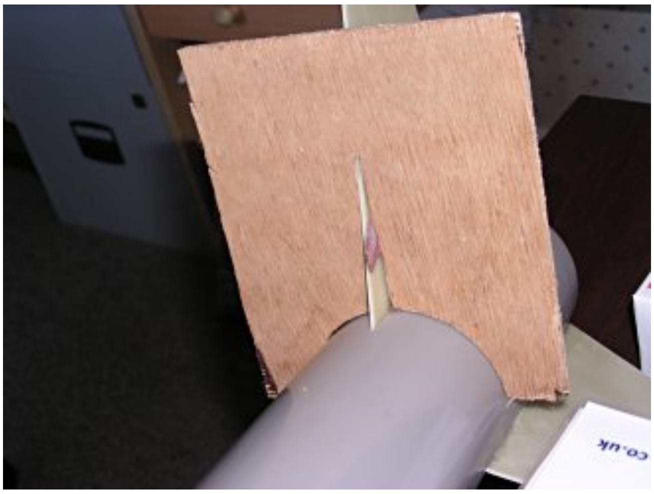
As it's a high-performance rocket, the glass-fibre fins are fitted through the body tube and onto the motor mount (hence the slotted airframe), and it uses a piston ejection system for reliability. The piston pushes the forward section off the rocket and also deploys the parachute, powered by the ejection charge in the motor. Some details were modified during the build, including setting up the piston so that it did not fully leave the tube, and venting it to allow the remaining ejection gases to escape. This modification reduces the chance of a 'zipper', where an early separation can pull the shock cord through the side of the airframe tube.

Construction starts with assembling the motor mounts. There are three - a 54mm mount which is permanently attached to the airframe, then 29mm and 38mm adapters, each of which can be screwed into the 54mm mount to take the smaller diameter motors. The 54 mm mount was assembled and then fitted with the forward centering ring, which fits snugly into the airframe tube. Before fitting this to the tube, conformal launch-rail guides (another modification) were screwed and epoxied in place, as this wouldn't be possible once the mount was fitted. The 54mm mount assembly was then firmly glued into the aft end of the tube and carefully centred. Strong is the order of the day here, as the centering rings are the only link carrying the thrust into the airframe. The inside of the tube was roughened to provide a key, and the forward ring was epoxied into the tube. Then a generous fillet of epoxy was added on both sides.



Modified shock-cord mount and cables (cables are shown pushed into motor mount here)

The Ariel uses a piston-eject system, which saves messing around with wadding to protect the parachute. However, the piston is attached to the motor mount with a black nylon strap. This means the strap is vulnerable to melting by the ejection charge and the colour makes it difficult to see the damage. The top centering ring on the motor mount was modified to incorporate a steel lug, of 5mm bar, embedded in a thick fillet of epoxy. Two 1.5mm stranded-steel cables (for redundancy and security) were fitted instead of the strap, using crimped-on copper tube and a Quicklink. (This turned out to be a very bad idea - see below.) The piston was also modified as already stated - the anti-zipper protection was incorporated by using a shorter cable and venting the piston skirt to release the ejection gases. The vents were punched using a leather punch, and consisted of three rows of eight holes, about 5mm in diameter. The cable length allows about two-thirds of the piston to leave the tube, so that any side loads are supported by the entire diameter, rather than the cable being pulled against the inside of the tube. To allow for inspection, a removable piston crown was fitted, using three long M3 screws through alloy tubes and into captive nuts on a ring lower down the skirt.



Fitting the fins using home-built alignment template

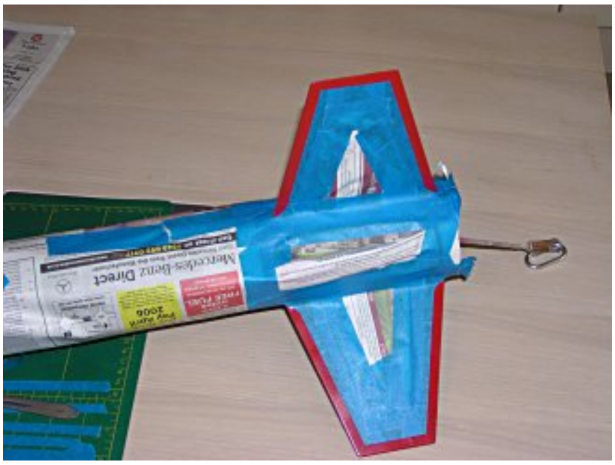
Next step was to prepare and fit the fins. They are fibreglass and quite thin, so it was not worth trying to sand a profile on them. They were simply rounded on the external edges and then sanded all over to provide a key for gluing and painting. The slots provide alignment fore-and-aft, and also the 120 degree angle around the airframe. The only remaining direction was to ensure the fins were at right-angles to the tube. A plywood jig was made, with a cut-out to match the curve of the tube and a perpendicular slot to align the fin. This took about ten minutes, and can be used again, so was a worthwhile exercise. Each fin then needs to be epoxied through the tube and onto the motor mount, using the template to hold it in position while the glue sets. Once they were all done, epoxy fillets were applied to each side of the tube (inside and out), and the fin/motor mount joint - 6 fillets per fin. This is time consuming, but not as much as rebuilding the rocket if they fall off in flight.

Fillets on some of the fin joints. Note also the nuts to retain the conformal rail lug

Once all the fins were fitted, generous fillets of epoxy were added to each side of the fin/tube joint and to the fin/motor-mount joint. This took some time, as the epoxy runs unless it is left flat, so each fillet must be left until the glue is almost set before the next can be added. Now, the forward end can be started. On the standard rocket, this would simply be a case of epoxying the coupler and bulkhead into the forward airframe tube, but in this case a switch and indicator LED for the electronics were then added. Long leads were fitted to allow for connection, and a fibrelam tray was made to fit snugly inside the electronic bay. This material is a sandwich of carbon-fibre skins on a paper honeycomb inner sandwich, and is light, stiff and non-metallic so it doesn't interfere with electronics such as the Flux Capaciter, which use the Earth's magnetic field to detect apogee. The nose was sanded to remove mould flash and fitted using three small self-tapping screws, for access to the electronics bay, and vent holes were drilled to allow pressure equalisation to ensure the altimeter readings are accurate. Finally, a strong, closed eye-bolt was fitted to the electronics bay bulkhead, with a large washer to spread the load.

For flights on G and H motors, the motor's own ejection charge alone can be used, so the altimeter isn't necessary for recovery, but flying on a J motor would make dual-stage recovery more attractive to reduce drift, so this needs an altimeter like the GWiz 800, which can provide the extra output for a main chute deployment at 800 feet. The main charge will then be used to deploy a drogue, allowing fast descent.

The rocket came together very quickly from this point. The nose was fitted to the forward tube and holes drilled for small self-tapping screws to retain it. Vent holes were drilled in the electronics bay (forward airframe tube) to allow the pressure to balance during flight, otherwise the altimeter would not read correctly. Three holes were drilled around the tube, offset from the three nose-retaining screws. Also vent holes were drilled in the lower airframe tube to allow pressure equalisation - this is to avoid premature separation of the airframes during high-altitude flights, as air pressure falls.



The fins and airframe masked for the chrome trim, applied over the main colour of red. The stranded steel shock cord (right) was pulled down through the motor tube to hang the rocket for painting

Next, the rocket was lightly sanded all over to provide a key for the paint, and the launch lugs were masked off. A coat of primer was sprayed all over. When this was thoroughly dry, three coats of red spray paint were applied and allowed to dry for a couple of days. This is important, as masking tape was to be applied to this coat. The 'Ariel' lettering was made by printing directly onto low-tack masking tape, then carefully cutting the lettering out with a scalpel - what was left was the mask, which was then applied to the tube. Other lettering, such as the location of the centre of pressure and the Safe and Arm logos for the electronics switch, were added using peel-off letters - again, the letters were removed and the surrounding paper becomes the mask. The fin decoration was also masked, and the rest of the rocket thoroughly covered with newspaper and masking tape. It's important to take great care masking everything - even the holes in the tubes were taped on the inside. Spray paint is amazing in its ability to find gaps in the masking. Three coats of chrome spray paint were applied, and the masking tape was carefully removed when the final coat was just dry - leaving it too long tends to cause the paint to chip at the edges, and too soon can let the paint run. There were one or two spots that needed touching in, then a name and phone number label was added (just in case), and the whole rocket was given three coats of clear varnish. Again, a little sorting out was required, as over-zealous application caused a run, which dragged some of the pigment with it. Finally, the masking was removed from the lugs, and the rocket is almost ready to fly.

One thing not included in the kit is a motor retainer. It is possible to retain the motor by adding masking tape until the case is a tight fit into the motor mount. But, as the chute deployment comes from the ejection charge of the motor, it means relying on a friction fit to avoid turning the rocket into a lawn dart. A Rowes alloy retainer was obtained - this is held in, and hence holds the motor in, by two screws attached to the aft centering ring.

The rocket flew at EARS on 4 March for a Level 1 certification flight. It was quite windy, so it was decided not to fly it on a G motor first, but to go straight to an H. The take-off and flight were good, and the chute deployment appeared to be good, but the aft tube detached from the recovery harness. Result: failed L1 and a core-sampled rocket, wrecked motor mount and a long walk to get the nose back from where it drifted to on the (now oversized) parachute.

The Ariel has now been repaired, and also extended to accept a RATT I-80 hybrid motor. At the same time, the opportunity was taken to incorporate a forward parachute bay to equip the rocket for dual deployment, looking forward to a Level 2 flight. This takes the form of an extra bay, forward of the electronics bay, attached by three small screws to the altimeter. The nose is then retained by three plastic rivets, which will be sheared by a separation charge when used in the dual-deployment configuration. The original nylon strap was reintroduced - attached to the motor tube and slotted and epoxied through a new forward centering ring, and protected by a Nomex sleeve. The piston is no longer used - instead, the end of the strap has been formed into a loop, using Kevlar binding and more epoxy, and this is now attached directly to the main shock cord using a good knot (a bowline). A large square of Nomex is also attached to the nylon strap to protect the parachute.

Update:

A flying attempt was made at Spring Thing (Tripoli English Midlands), but an error in assembling the motor caused a fire on the pad. It looked bad, but on closer inspection the damage was not as extensive as it looked. The aft airframe tube had melted forward of the fins, but when it was cut open the 38mm motor adapter had protected the 54mm motor mount that forms the centre of the fin mountings. The forward centering ring had gone, along with the recovery harness and parachute.

The tube internals were cleaned up and a tube coupler and a new length of airframe tube acquired. 8m of 1000lb strength Kevlar strap was attached to the 54mm tube, and a centering ring was made to fit between the 54mm tube and the coupler. The end of the airframe tube was squared up, and everything epoxied into place, ensuring generous epoxy fillets for strength. Before attaching the tube, a new launch lug was epoxied and screwed into place - it was easier to do that at this stage, as access to the inside of the tube is better, and the ends of the threads were covered in epoxy to prevent snagging. All that remains is to smooth the joint and apply some paint. A replacement 38mm adapter completes the job. The next flights were at Milson Park on 14 May 2006.

May 2006: The rebuild is complete, and the Ariel made four successful flights at Milson, every one a perfect flight. The rocket was also flown for the filming of the first episode of Mission Implausible, shown on Sky 1 in 2007, and was used in the studio. It has now been retired.