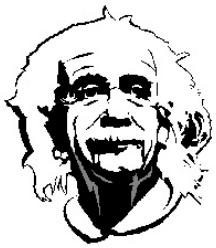
Einstein Centenary Project



The "ECP" rocket is my winter project for 2004/2005 and 2005/2006. I had to do something to celebrate the centenary of the publication of the Theory of Special Relativity in 1905. This magnificent piece of theoretical physics deserves to be remembered.

I chose to celebrate by designing and building a suitably large and complex rocket. This will be my most ambitious project to date.

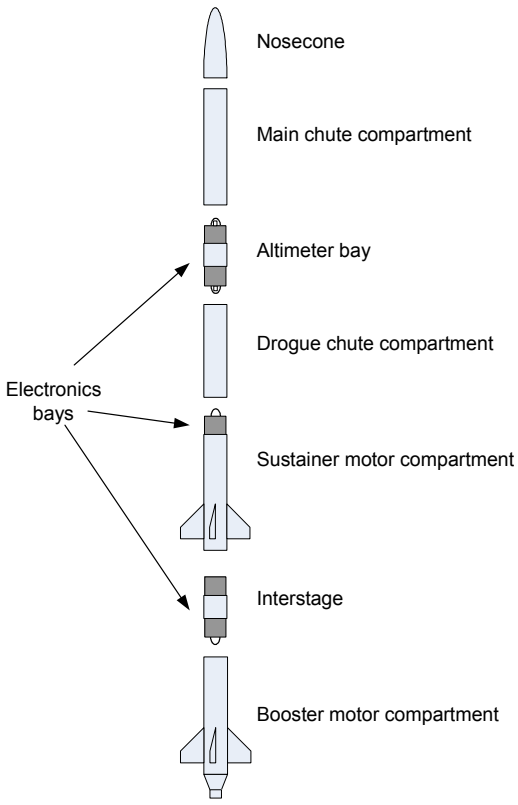
The Concept

The concept is to build a two-stage three-inch diameter HPR for experimenting with staging techniques. I'd like to get to understand staging before trying it with anything bigger. The booster and sustainer stages will be sized to take up to J impulse motors. The rocket will be modular so that, at a later date, a booster stage for K impulse motors could be constructed.

A typical test flight will take the rocket to between 5,000 and 10,000 ft altitude.

A rough-and-ready structural analysis suggests that the compressive and bending loads will not be too great above the motor compartments, reinforcing the view that the upper compartments needn't be glassed. As my glassing is not too brilliant I'm experimenting with the new glass socks from Aerosleeves.

A set of dimensioned layout drawings was done in Visio over Christmas 2004. A lot of 2005 was lost to work and family commitments so initial progress was slow. During 2005 I discussed ideas with other rocket fliers, and by Christmas 2005 I had produced a new set of drawings. The design was beginning to converge on its final form. The new drawings showed that the final rocket would be about 7ft 11in tall.



A general view if the rocket's construction can be seen in the diagram on the right. The booster compartment is 24 inches long, allowing for a 6 grain motor and a parachute.

The 2.5 inch long interstage contains a timer for staging, and is attached to the booster by a recovery harness. This could be used in a similar manner to the PML Quantum Leap where the igniter is fired by the interstage. There is the possibility of drag separation pulling the igniter out before sustainer ignition; in this case the motor would not fire but the recovery systems would operate normally.

A possible use of this interstage would be to fire a small charge forcing the booster and sustainer to separate. The sustainer could then be fires by an igniter triggered by the sustainer. To do this an additional electronics bay would be needed between the motor compartment and the drogue compartment, possibly housed in the coupling tube.

In April 2006 I initiated a discussion on The Rocketry Forum and realised that there would be benefits in putting an additional electronics bay in the sustainer motor compartment to allow experimentation with staging techniques. A pair of conduits ruin through the motor compartment would allow e-matches and igniters to be fired by a timer in this bay. The matches could fire small charges to separate the booster and sustainer, and the igniter could fire the sustainer motor. This added a number of new possibilities for staging, and enhanced the use of the rocket as a test bed.

This late decision to add an electronics bay after the tube had been glassed and cut resulted in some loss of internal length. It is possible to fit a 5 grain motor into this compartment but not a 6 grain.

The altimeter bay and parachute compartments form the heart of the sustainer recovery system. A PML nose cone tops off the rocket.

Construction of the Sustainer

The main components have been obtained from various suppliers. The majority of the structural components are from PML, including two sets of custom G10 fins, and parts for making the interstage and CPR. The Aerosleeves tubing arrived promptly (great service). Slimline retainers and an X-Par chute completed the components list.

The sustainer and interstage are the most complex parts of the rocket. For flexibility, the sustainer motor can be ignited by a timer in the interstage, or a timer in the sustainer itself. There is also the possibility of having black powder charges to actively separate the booster and sustainer, with the charge being ignited by the booster or sustainer electronics. Finally, there is an electronics bay in the sustainer for an altimeter to deploy the main and drogue parachutes. As a result there are three electronics bays and a pair of conduits running through the inside if the sustainer motor compartment.

AIRFRAME PREPARATION

The first part of the construction phase was to cut the tubes to length. This was a relatively quick job, with a little bit of squaring-off required where cuts had not been absolutely straight.

The next stage was to glass the tubes for the motor sections. Glassing with Aerosleeves is easy beyond words. The tube was scuffed with some coarse sandpaper to prepare the surface. I slid the tube onto an old piece of plastic pipe, slipped the sleeve over the tube and tensioned it with masking tape. Once tight, the resin was brushed on with some sponge and left to set. The end result was much better than my previous attempts at glassing, and took a lot less effort. I can't praise the Aerosleeves product enough.

The glassing in the sustainer was filled with Superfil, aka "Blue Goo". This stuff is a lot easier to sand and lighter than the other fillers I've played with. Thank you Mike Roberts for telling me about it.

ELECTRONICS BAYS

The interstage was a slightly modified version of a 3-inch PML design. I gave it a bit of extra length to allow for the motor retainer in the sustainer. The interstage was assembled on Boxing Day 2005.

The altimeter bay was more of a design problem as there was a lot to fit on the endplates. First there was the U-bolt, then two bits of M6 studding plus wing nuts, a terminal block, and the ejection charge holder. A bit of playing around in Visio resulted in a layout, and the whole thing was assembled in early 2006.

The other two electronics bays were built in April 2006. The three electronics bays can be seen in the picture on the left. They are, from left to right, the sustainer motor compartment bay, the altimeter bay, and the interstage.

A custom bay was designed to fit on the top of the sustainer motor section. This has the same faceplate design as the altimeter bay, but without the terminal block and ejection charge holders. The bay is designed to be epoxied into the top end of the motor compartment and has two aluminium conduits running through into its base, the inputs being sealed with epoxy.

The layout of the motor tube, conduit and sustainer electronics bay can be seen in the picture on the right. The approximate positions of the assembly can be seen from the airframe tube and the fin shown in the picture.

AIRFRAME CONSTRUCTION

Construction of the sustainer airframe started in April 2006. The most difficult part is the motor compartment as it contains a lot of components that have to be carefully aligned. This doesn't only include the fins, but also the alignment of the holed through the centering rings to allow the insertion of the conduit. At the time of writing this compartment has been assembled and the epoxy fillets are being applied to the fins.