VIKING ROCKET

The Project

The aim of the project is to have a first attempt at scratch building a scale model of a classic rocket. Researching and building the rocket would make a nice project for those winter evenings when the weather is unsuitable for anything else, and there's nothing on the telly. The Viking rocket was selected as it had an interesting history, and was not an over complicated shape to build.

Background to the Viking

The Viking rocket was an important milestone in America's space programme. Before Viking, the USA only had the stock of captured V2 rockets to use for high altitude research. To remain competitive in the emerging "space race" the USA needed to develop a rocket of its own. The US Navy funded the development of the Viking as a high altitude research rocket to replace their dwindling stocks of captured V2. Only 12 were built, and each one was different from its predecessors, due partly to the lessons learned from earlier flights and partly to accommodate the different mission payloads.

"The Viking Rocket Story" by Milton Rosen gives an enjoyable and informative account of the Viking programme. Rosen had the privilege of being involved in Viking throughout its life and being the controller of all 12 launches. His mixture of anecdote and informed technical commentary makes his book a good read for anyone interested in the early days of America's ventures into space.

Viking's 1-7 used a tall, thin, airframe. Viking's 8-12 were shorter, thicker, rockets with smaller, triangular, fins. Rosen explains the reason for this design change as being the desire to increase the volume of the airframe so that a greater fuel load could be carried. This permitted longer burns and thus the rocket could reach higher altitudes. Viking's 13 and 14 were built, but formed the first stages of the Vanguard launch vehicle.

Selecting a Rocket

As all the Viking rockets were different, it is important to select one rocket for a scale modelling project. The most important criterion was the availability of information on the rocket, in particular:

- Drawings, to give accurate dimensions.
- Photographs, for colour scheme and locating fittings.

- Text, to support the above.

A secondary consideration would be that the selected rocket had a story associated with it. Viking 4 was the first large rocket to be launched from a ship, whereas Viking 8 was never properly launched – it tore loose from the gantry during a ground test and flew to 6km. Viking 7 was initially chosen as it was the best photographed of all the Vikings, however it was eventually decided to build Viking 4. The main reason for this was that all the Vikings had very different nosecones due to their different payloads. The only drawing of a nosecone is a cutaway of Viking 4 in Rosen's book.

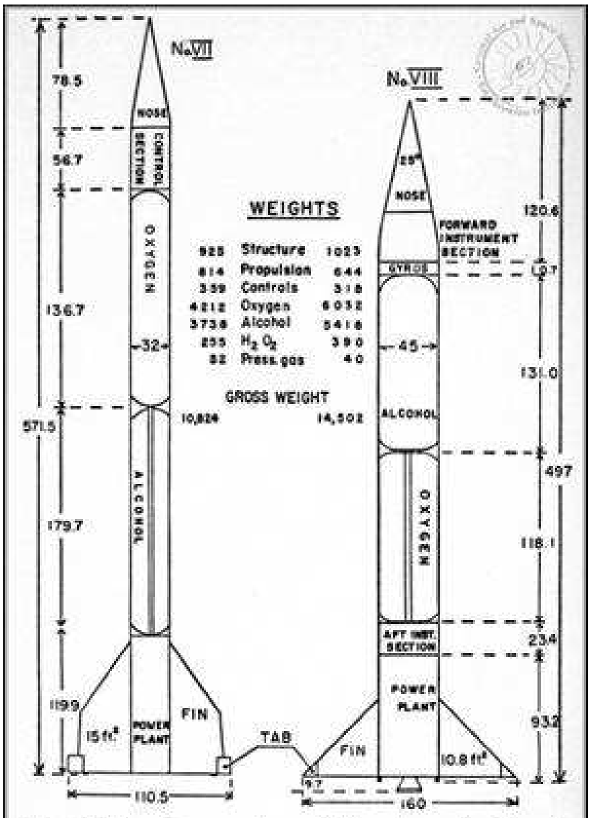


Fig. 47. Viking rockets VII and VIII. All dimensions are in inches; the weights for VIII are those planned for take-off.

Selecting a Scale

The choice of scale would be dictated by the difficulty of constructing an accurate model, the materials cost, the availability of motors, and the "wow" factor.

Building on a small scale (1:24), typically powered by Estes C or D motors, would be the cheapest option. The materials cost of such a rocket would be relatively small, but the construction and finishing would be tricky. It would also lack "wow".

On the medium scale (1:16), powered by 29mm F&G motors, it would be possible to build a rocket without too much fiddly detail. This would be the optimum scale, with a medium materials costs and a reasonable amount of "wow". The problem would be getting hold of motors, as the forecast for 29mm reloads in the UK is uncertain.

My inclination was to build something big, as I'd just had some success with my first scratch built HPR. Going for a large rocket (1:8 scale) would be costly, but reduces the constructional difficulties. It would need to be powered by H or I motors. The risks and cost of such a project would be considerable, compared to building something which could be powered on Estes Motors, nevertheless it would have masses of "wow" when it appeared on the launch site.

My wife, ever practical, raised another criteria: at 1:8 scale it will be 6ft tall. Where will it live? I reckon it will fit into my "den" if I make a wall bracket for it.

The decision was to go for 1:8 scale.

Reference Material

There are photographs and drawings of the Viking rockets available on the Web [1] [2] [3]. Rosen gives descriptions of some of the modifications made to the original Viking rocket design as the programme progressed. It also contains many useful photographs.

Model Dimensions

The first exercise was to get the dimensions of the rocket correct. The drawing (from the Smithsonian) shows the dimensions of Vikings 7 and 8, illustrating the difference in the design between the early and late Vikings.

At a scale of 1:8 the body tube will be 4 inches diameter, and 61.6 inches long. The nose cone will be a cone 4 inches diameter and 9.8 inches long.

The 4 fins are not adequately dimensions on this drawing, nevertheless the dimensions can be estimated from the drawing. Each can be cut from a piece of material 5 inches wide and 15 inches long, plus through-the–wall fin mounts. The thickness of the fins is also not detailed on the drawings.

Overall, this gives a rocket which will be 71.5 inches high, 4 inches diameter, with a fin span of 13.8 inches.

More Detailed Considerations

From the text in Rosen's book, and the photographs available, there are many detailed issues to be considered.

- Nose Cone. Photographs 34275 and 34279 show a nose cone which is not a pure cone, but which curves into the rocket body. This contradicts the drawing above. It is thought that the nose cone on the photograph looks more like an Ogive than a cone.
- Cable Conduits. According to Rosen, the cables were run in external conduits from Viking 3 onwards. This is because of problems with insulation materials in close proximity to the motor. These can clearly be seen on photographs 34277 and 34278 (Viking 7), as well as photographs 34265 and 34268 (Viking 5). Photographs in Rosen's boom give details of the length and position of the two conduits; one runs from the control section to the motor gimbals area, while the other bypasses the motor section. Other photographs in the book show a circular profile the longer conduit, which changes to a box profile around the bottom of the alcohol tank. If we assume that the conduits were unchanged between Vikings 3 and 7, we have enough photographic information to reproduce this feature on the model.
- Fin profiles. Photograph 34265 (Viking 5) shows that the leading edge of the fins was bevelled. Photograph 34277 (Viking 7) shows a rounded leading edge to the fin. It is unlikely that the fin profile was significantly changes between Vikings 5 and 7, so the information on photograph 34265 will be used to estimate the fin profile for the leading edge. There is no information available on the trailing edge.

- Colour Schemes. It is believed that the rockets had a conventional black and white scheme. The nose cone is believed to be silver, a view supported by the photograph in Rosen's book of a nose cone in the desert. The various photographs of Vikings 3 to 7 give a good indication of which bits of the rocket were black. The flight number appears on all of the tail fins in a font similar to "arial black". The covers for the roll thrusters are marked with "E" and "W" to reflect the orientation of those fins on the launch pad. If we number the fins clockwise, fin 1 is black and white, fins 2 and 4 are white, and fin 3 is black. There is a black band around the rocket just above the tail section. Photographs can be used to estimate the size of each of the black areas.
- Hatches and fittings. This is a real problem. Some of the close up photographs show hatches removes, and their size and relationship to other features such as the nosecone, conduits and fins can be estimated. Where there are no close-up shots it is impossible to guess where hatches are located. There are also some features which are visible on the distant views of the rocket but whose function is unknown. The approach here will be to look at their location in relation to other features (tanks, motors, fins etc) and try to estimate what the items would be.

First Simulations

Using the first estimates of model size, it is possible to have a go at producing a Rocksim model to get a first view of mass, stability and performance. The first attempt at a Rocksim model shows a rocket dry weight of about 83 oz, based on a 38mm motor tube and 48inch parachute. The rocket was stable on Pro38 2-grain to 4-grain motors, simulating between 1500 and 3000 feet.

Construction

Modifications have been made to the original design for the rocket. The first mod was to move away from PML tube to LOC tube because of its price, ease of filling the spiral groove, and the reduction in weight.

After 6 months of research, construction work started over Christmas 2003. Materials came manly from 3 sources: The LOC tube, nosecone and motor retainer came from "Rockets and Things", while the parachutes and swivel came from "Deepsky". The remaining items, including some plywood fin stock, were bought from Antics in Cardiff.

The first stage was to make the fins. The dimensions were marked out on the wood and rough cut with a saw. Five fins were made as a precaution against any workshop accidents. The fins were taped together and sanded to identical profiles.

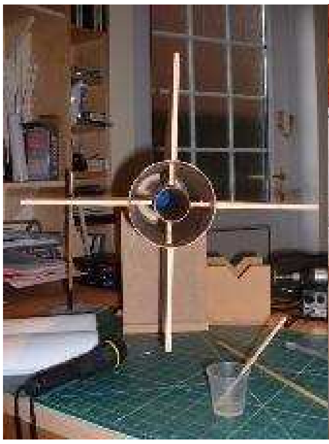
The five degree bevel on the leading edge was applied using a modified "shooting board". The fin was clamped to a board at five degrees off vertical, with the leading edge horizontal. A sharp number 5 plane was used to take thin layers off the leading edge. The picture shows the first fin on the jig.

The slots were marked out with some aluminium angle, and cut using the Minicraft disc cutter. Several cuts were required. When using LOC tube I found it useful to cut the slots slightly too narrow, then file them out to final size. This makes it easier to get a slot exactly the same width as the fin's thickness.

Final construction was fairly straightforward. The shock cord anchor (a retired eight foot rock climbing sling) was epoxied to the motor tube and a D ring sewn into the end. The front centering ring was fitted to the tube and the assembly inserted and epoxied into place. The rear centering ring was loosely taped in situ to allow rear access for filleting.

The fins were inserted and internally filleted, and then a second centering ring was epoxied in place immediately behind the fin tangs. The screw fittings for the motor retainer were fitted to the rear centering ring and the rear ring expoxied into place. UNU 30 minute epoxy was used throughout.

External filleting was done using a trick picked up from Rocketry Online. Two lines of masking tape were applied – each ¼ inch from the angle of the fillet. Slow cure epoxy was applied to the fillet, and after it had just started to harden the tape was removed. This gave a clean fillet, my best so far.




First Flight

The rocket's first flight was on 18 June 2004 at a Black Knights meeting. It was a moderate day with a slight chance of showers and a moderate wind. Given the conditions I decided to use a small motor, a 2-grain Pro 38.

Ignition and lift off went well, no signs of weather cocking. The flight was later described as “graceful”, as it lifted slowly, rose to around 1000 ft, and gently arced over. The selected 8 second delay was perfect; the rocket appeared to be horizontal and motionless as it ejected its 54 inch X-Par parachute. The wind took the rocket about 300 yards downwind where it soft landed on the edge of a field.

A year’s work, but was it worth it? Yes! I learned a lot about researching scale models and the difficulties and patience required to find all the information required. I made some mistakes, learned some new techniques, discovered LOC tubing, and in the end made a rocket with a fair amount of “wow” factor.