Design Fabrication & Testing of Remotely Controlled Airship With Thrust Vectoring

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Background

This project was carried out during June-July 2004 under the aegis of *Kishore Vaigyanik Protsahan Yojana* (KVPY) of the Department of Science and Technology (DST), Government of India. The aim of KVPY is to identify and encourage talented students with an aptitude for research and development, and to provide them an opportunity to associate with working professionals to experience the R&D activities.

Introduction

An airship is a Lighter Than Air (LTA) vehicle that achieves lift primarily due to the buoyancy of a lighter than air gas (usually Helium or Hydrogen) enclosed in an envelope. Powered by IC engines or Electric motors for moderate cruising speeds, airships have a much lower fuel consumption compared to their Heavier Than Air (H-T-A) counterparts, thereby resulting in substantially lower operating costs. The attached empennage gives it a desired direction control. The naturally produced lift can be assisted by a thrust vectoring system. Airships are considered to be the vehicle of choice for long endurance operations at low/moderate speeds and low altitude. They are increasingly finding acceptance all over the world for niche applications such as aerial surveillance and photography, advertisement & product promotion, corporate hospitality and tourism.

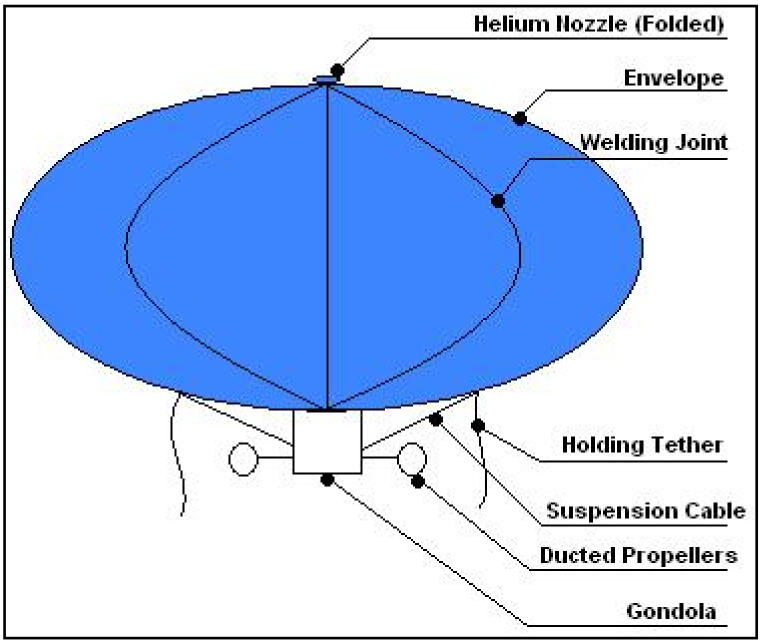
Project Description

The aim of project was to obtain a first hand exposure to the issues related to design and fabrication of a remotely controlled airship with thrust vectoring capability. The vehicle was desired to have good *station-keeping* capability in moderate wind conditions, and powered by indigenously available electrical motors and batteries.

The project was divided into three major sub-tasks as follows:

1. Arriving at a methodology for envelope sizing, design and fabrication
2. Fabrication of a Thrust Measurement Rig and selection of suitable electric motors, propellers and power packs.
3. Selection of Remote control system, and design of cost effective Thrust Vectoring system and attachment to the envelope

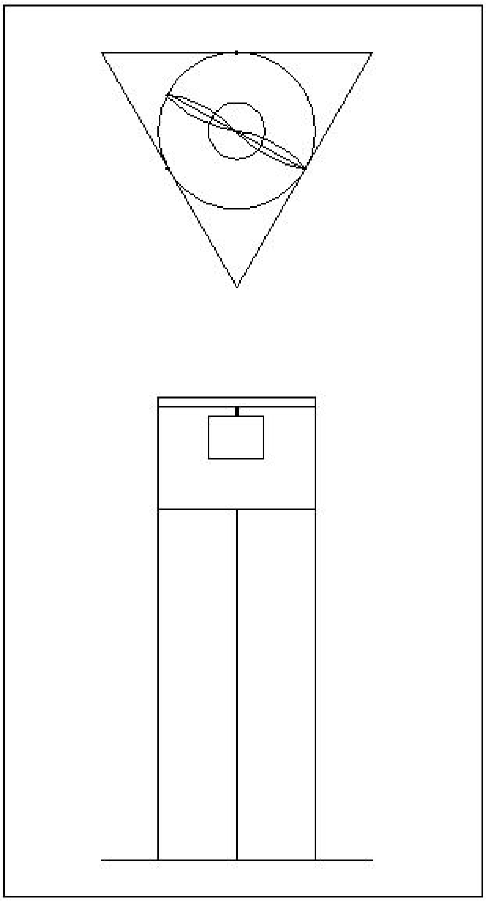
Envelope Design



Survey of available literature suggested that the most appropriate shape for airships with good *station keeping* feature is the *Lenticular* shape, which is similar to a flying saucer, i.e., two dishes kept upside down on each other. But lenticular shapes result in large surface area, and lateral dimensions, hence the shape that was finally chosen is an oblate spheroid, i.e. an ellipsoid obtained by revolving the ellipse about its minor axis, as shown in the figure.

A methodology for estimation of payload available as a function of envelope volume under various operating conditions (ambient temperature, and speed) was developed. It was decided that for ease in storage, the maximum diameter of the envelope should not exceed 2 m. The ratio of max. to min. diameter of the envelope was taken as 1.96, to obtain a significant positive net lift, with low drag.

After a detailed market survey, a blue-colored PVC fabric of 0.15 mm thickness and specific weight 202 g/sq. m. was chosen for the envelope. The envelope was fabricated by joining four petals, the coordinates of which were generated by a code using numerical integration method in Microsoft Excel. These coordinates were verified using graphical method of intersection of solids and planes in AutoCAD 2004. All petals with necessary hooks and nozzle for filling the LTA gas were joined using PVC sealing machine which uses a high radio frequency output applied to the die with shape according to the petal shape.



Fabrication of Thrust measurement test rig, and short listing of motors

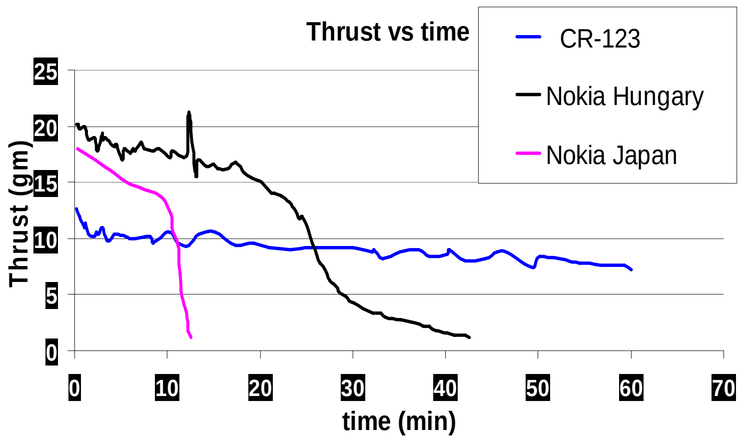
A thrust-measurement rig was fabricated, which estimates the thrust developed by an electric motor by measuring the reaction force created on an electronic weighing balance.

After a extensive market search, it was decided to employ the DC motors used in tape-recorders as the onboard power plant, as they were found to be light weight and inexpensive. Several plastic propellers used by aeromodellers were procured. Many experiments were carried out with several motor and propeller combinations to determine the ones, which generate the highest thrust. Model SR-200-3360 motor (cost = Rs. 30/-) with the following specifications was short listed.

Size		Weight	Voltage	No-Load		At Maximum Efficiency				
Diameter (mm)	Length l (mm)	W gms	V DC	Speed rpm	Current A	Speed rpm	Current A	Torque gm.cm	Power watts	Efficiency (%
23.8	**26.9**	**28**	**3.0**	**145.00**	**0.350**	**11540**	**1.210**	**14.0**	**1.6**	**44.0**

Selection of suitable power packs

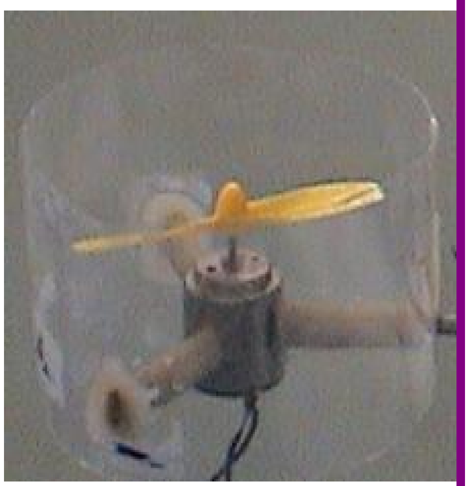
The desirable features of a power pack are ability to be recharged, high endurance, and low cost and weight. The thrust decay with time with SR-200-3360 motor were obtained using several batteries, such as CR123 Li-ion, Duracell 9V and various models of Nokia 3310 mobile phone batteries.



The Nokia 3310 battery of Hungary make exhibited the best characteristics, as shown in the figure

Thrust Vectoring system and Gondola

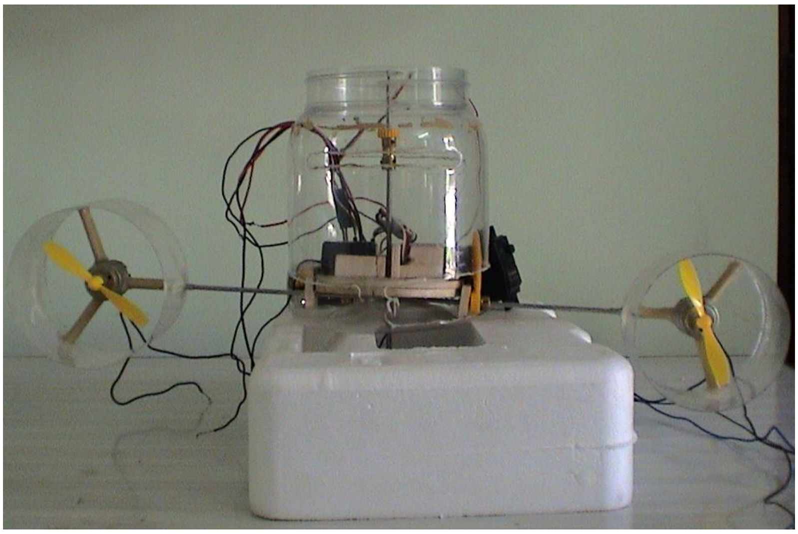
One of the perennial problems with airships is their lack of control while operating at low speeds, especially near the ground. In order to alleviate this problem and to provide good *station keeping* ability, it was decided to provide thrust vectoring.



The Gondola and thrust vectoring mechanism:

The thrust vectoring was decided to be carried out by swiveling the ducts housing the motors by 170 degrees in yaw and 180 degrees in pitch. Servo motors were used to swivel the ducts. A search was carried out to find light weight servos with maximum torque. The available servo had 60 degrees angular displacement. To obtain the required angular displacement, gears were used with reduction of 1:3

A prototype of the gondola and swiveling mechanism was made using thermo cole. After successful testing of the prototype, actual fabrication of gondola was started. The complete mechanism was housed in a plastic jar. Ducts were made from plastic bottle and the motor was attached to the duct centrally using plastic rods which were covered with molding strips to give them an having aerodynamic shape.



The motors were mounted in a pusher configuration for higher thrust. Balsa wood platform was made to support the receiver and servomotors. A four-channel receiver and transmitter kit (Futaba make) was obtained. Also a UHF Camera and Transmitter Set were attached to the gondola. Arrangement was made for easy replacement of the battery when the gondola is attached to the envelope.

Flight Testing and Demonstration:

A demonstration of the airship was carried out on 10th July 2004 in front of the Aerospace Engineering Department, some pictures of which are shown below.