

Fly a Rocket!

Agnieszka Katarzyna Polak
Department of Natural Sciences
University College London
London, United Kingdom
polak.agnieszka.99@gmail.com

Kim Regnery
Faculty of Aerospace Engineering
Delft University of Technology
Delft, the Netherlands
Kim.Regnery@gmail.com

Abstract— Over the course of one week at the Andøya Space Center, Norway, a university student team of 23 members of some 12 nationalities from across ESA member and associated states participated in a campaign to launch a Mongoose-98 sounding rocket with a suite of sensors with the intention of collecting data from the Earth's troposphere. The rocket itself achieved an apogee of 8.7km and enabled the team to collect data pertaining to parameters such as magnetic field strength, acceleration, light and temperature. The project allowed the students to expand their knowledge of rocketry and orbital mechanics. It gave them otherwise unattainable experience.

Keywords— *ESA Education; rocketry; sensor experiments; assembly process; educational process*

I. WHAT IS THE “FLY A ROCKET!” PRORGAM?

Fly a Rocket! campaign is organized by ESA Education, Norwegian Space Agency and NAROM. The program offers a chance to early university students to learn about rocket science and to assemble and launch their own rocket from Andøya Space Center in Norway. During the program, the students have to complete two assignments about rocket science in order to get ready for constructing and launching the rocket in Andøya. Fly a Rocket! gives a chance for students to work both individually and as a team. The campaign team consisted of four groups, each with specific roles:

- GPS and Simulations
- Telemetry and Data Readout
- Payload Group
- Sensor Experiment

II. ONLINE ASSIGNMENTS

As part of the project, the students have been given access to an online course that they could study and use to complete two assignments. In the online course one could read about rocket engines, satellite orbits, as well as the details about the NAROM student rocket. The first of the assignments was mostly about rocket engines and the second one had several questions about orbital mechanics. Both of the assignments helped tremendously with preparation for rocket launch and assembly.

The difficult assignments could only be solved thanks to cooperation between all the students.

III. ASSEMBLY PROCESS

The experimental set-up for the campaign consisted of two aspects: transmittance and reception. The transmittance was led by the Sensor Experiment Group, who created several sensors, along with the GPS and Simulations Group which, when installed by the Payload Group, sent data from the rocket. The group used a fully stocked workshop with specialized workbenches appropriate for building each sensor. In the room next door, the student telemetry station dealt with the reception of signals, led by the Telemetry and Data Readout Group. This group was tasked with the rigging and calibration of the telemetry station which used a horn antenna to receive signals from the rocket. These signals went through various steps and required the group to program decoders to interpret the signals into intelligible information.

IV. RESULTS

The rocket itself achieved an apogee of 8.7 km and enabled the team to collect data pertaining to parameters such as magnetic field strength, acceleration, light and temperature. The launch and flight phases were nominal even though the student-built GPS system failed to transmit any data to the telemetry station. Below, results from chosen sensors are outlined in detail.

A. Light Sensor

The light sensor was integrated in order to determine the direction and rotational velocity of the rocket. This was achieved by placing the light sensor directly beneath a hole in the rocket, close to the bottom of the payload. When the rocket was launched, depending on whether or not the light sensor had a large spike in voltage or a small spike in voltage first, it could be determined which hole the sun saw first, and therefore the direction of rotation can be determined.

As seen in figure 1, a graph comparing Time (s) and Voltage (V) from the light sensor, each spike represents when the side of the rocket with the holes turned back towards the sun. The time between each spike is about 0.05 seconds. This then totals to about 1000-1200 rotations per minute on average through the entire launch.

B. Pressure Sensor

The pressure sensor provided a reliable way of determining altitude of the rocket during flight. The sensor contains a piezoresistive transducer which responds to the pressure difference with respect to the internal reference pressure. The analog output voltage of the sensor is proportional to the applied pressure.

Using the sensor output value before launch as the ground pressure ensured the altitude information about the flight was calibrated. Data analysis showed the rocket reached the maximum altitude of 7985 m above the launchpad and the total flight time was 85 s.

C. Magnetic Field Sensor

A KMZ51 one axis magnetic field sensor was used to determine the rotational velocity of the rocket. To get usable data, steps were taken to ensure that the direction of the sensor was perpendicular to the rocket's travel-direction. The sensor did not measure the exact strength of the magnetic field, but it measured the differences in strength and displayed this in the output voltage as the field weakened and strengthened while the rocket was spinning.

The graph of the rocket spin (figure 2) reveals that while the rocket's engine is on, the rotational velocity increases rapidly (up to about 17 spins per second). When the thrust is stopped, it declines with the rocket's velocity until it reaches the max altitude. From there, the rotational velocity increases to what appears to be a somewhat stable velocity of 4-5 spins per second, until contact with the rocket is lost.

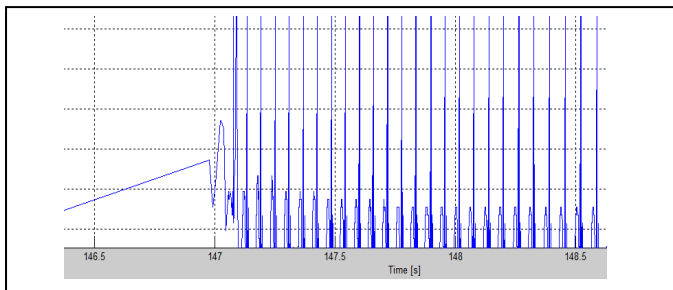


Fig. 1. Voltage vs Time graph

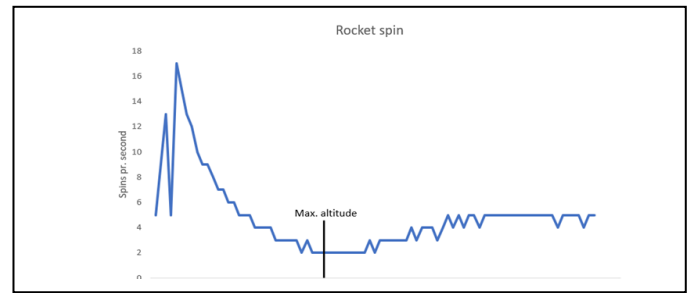


Fig. 2. Spins per second vs Time

V. EDUCATIONAL PROCESS

The students were able to experience almost every aspect of how a rocket is launched from the initial briefing and construction through to the launch and the post-launch data presentation. During the launch itself, the students assumed the roles of the rocket range staff. From the Principle Investigator, to Head of Operations, they got the chance to experience what it is like to work in a space center. During the week the students gained a lot of valuable insight they would not have been able to gain from any other program as this was a unique experience for everyone. The students were able to successfully obtain data from the rocket and the simulations.

The various lectures that the students attended throughout the week at the Andøya Space Center were a unique learning experience, as they were all led by scientists who work in the rocketry field on the daily basis. The knowledge gained from those lectures is one of the most beneficial aspects of the program.

ACKNOWLEDGMENT

The students would like to thank Alex Kinnaird of the ESA for his guidance and support and Christoffer Strausland from NAROM for leading the campaign.

Furthermore, they would like to acknowledge the hard work of other ESA Education and NAROM staff.

REFERENCES

Data sheet, NAROM, 2019

Fly a Rocket! Final Report, all Fly a Rocket! participants, 2019