Space Universities Network
Supporting the Space Higher Education Community

Title:

Project SunrIde - University of Sheffield Nova Rocket Innovation Design Engineering

Summary

Project SunrIde was the first student-led rocket design engineering team from the U.K. to compete in the Spaceport America Cup (SAC) 2018, the 2nd annual rocket engineering conference and competition that takes place in New Mexico, USA. The team designed and constructed a rocket named 'AMY' to compete in the 10,000ft category. The team had a successful launch and earned the James Barrowman award for Best Flight Dynamics

Team SunrIde at Launch Site, New Mexico

Rocket Launch

Aims/Objectives

In the academic year of 2017-18, the main aim of team SunrIde was to compete in Spaceport America Cup 2018 in Las Cruces, New Mexico in the 10,000ft category solid propellant commercial off-the-shelf motor (COTS) competition. The team had to design and manufacture a sounding rocket, which they named ‘AMY’, after Britain’s first aviator and alumna of the university, Amy Johnson. The rocket had a non-functional, 4 kg boilerplate payload as per the competition regulations.

This academic year of 2018-19, the team’s target is to participate in Spaceport America Cup 2019 with two rockets. The first rocket will be ‘AMY II’, a modified and improved design of ‘AMY’, with the aim of competing in the category of 10,000ft COTS, carrying a non-functional payload. In addition, the team will participate in the 30,000ft COTS category, introducing a completely new design for a rocket named ‘HELEN’, inspired by Dr. Helen Sharman, Britain’s first astronaut and alumna of the University of Sheffield, which will incorporate the use of a functional scientific payload.

What was the context / background?

SunrIde is part of Sheffield Space Initiative (SSI). The SSI plays an important role at the University of Sheffield in providing STEM students with research-led teaching within a dynamic and vibrant community working together to deliver internationally inspiring achievements. The SSI also aims to create an innovative technology hub inside the University campus.

How was it organised and who was involved?

Since the project's inception in the academic year of 2017-18, SunrIde was formed by postgraduate students from the Automatic Controls and Systems Engineering (ACSE) department of the University of Sheffield. Its nature is very interdisciplinary and therefore students from various engineering departments and years were welcomed to work on and gain experience in rocketry. It involved students from the ACSE, Mechanical Engineering, Interdisciplinary Engineering Office (IPE) departments and the School of Mathematics and Statistics of the University of Sheffield.

In 2018-19, SunrIde consists of 15 Undergraduate and Masters students across the Faculty of Engineering (ACSE, MecEng, EEE, BioEng, Material Science, Aerospace) and the Faculty of Science (SoMaS). The team is composed of 5 research sub-teams: Design and Propulsion, Recovery Systems, Avionics, Payload, Structures and Manufacturing and 1 back-office sub-team on Media.

What resources did you need?

The resources needed were both financial and human. The rocket itself cost about 3,000 GBP including commercially bought body tubes, nosecone, motor and electronics associated with in-house made bulk-heads, motor retainer, and non-functional payload, Moreover, the team entered the Team Project Support (TPS) scheme provided by the UK Rocket Association, whose fees cost around 400 GBP. It exists to provide guidance and experience to those building rockets and was very helpful. Other expenses included the travel fares to and in the U.S. and accommodation for the team members for the duration of the competition. Furthermore, there is an entry fee for Spaceport America Cup of approximately 700 GBP for the rocket and 50 GBP for each team member to attend the competition onsite. As 8 people were sent to the competition, the SAC expenses were 1100 GBP. In terms of personnel, the team initially had more than 26 students involved but the main focused group of students was 10 people. The guidance and technical help of the university staff was needed and helpful.

Describe the activity

Without any prior experience in amateur rocketry, building a high-power rocket from scratch proved to be a daunting task. Initially, the team had to rely on solid communication skills in order to bring a team of students from different engineering backgrounds together. Establishing a network of experts in academia and industry in order to start developing some initial concepts and overall having some form of reliable support throughout, was the main part of the project's early stages. The team collaborated with Dr. Viktor Fedun from the Department of Automatic Control and Systems Engineering (ACSE) of the University of Sheffield and Charles Simpson from the UK Rocketry Association (UKRA) through their Team

Project Support (TPS) scheme. Both of them offering years of experience and knowledge from the field, they proved to be an integral part of the project throughout its run-time.

The objective was to research, design and construct a high-power rocket, fully recoverable and capable of carrying a non-functional payload of 4kg while reaching an apogee of 10,000ft. The team conducted a significant amount of research and finalised the design for 'AMY', which was a 2.68m tall rocket that weighed approximately 28kg. The rocket was powered by a Cesaroni P98-4G M3400-WT solid propellant motor providing a total impulse of 9994Ns. The payload was constricted to a 10cm x 10cm x 30cm container made out of 6mm plywood layers and weighed no more than 4kg. The mass was achieved through a concrete mixture confined within the container. The airframe was made out of fiberglass-coated kraft phenolic tubing having an outer diameter of 158mm, with an ogive-shaped, fiberglass reinforced nose cone, giving the rocket a smooth and aerodynamic exterior. An important aspect of the design were the fins, which were airfoiled delta-clipped shaped and were made out of two 3mm plywood layers laminated with a fiberglass cloth in between. The rocket consisted of four fins placed at 90o angles to promote overall stability and optimal flight performance and were mounted on a removable fin can. The fins were further reinforced with an additional layer of fiberglass over them to eliminate the risk of any destructive fin flutter caused due to transonic flight which occurs at around Ma = 0.96.

In order to fully recover the rocket post-flight, a dual deployment parachute system was utilized. The avionics bay provided the basic functionality of deploying the parachutes through implementing instrumentation capable of accurate altitude monitoring. For that purpose, two PerfectFlite StratoLoggerCF altimeter boards were used. Upon meeting the deployment conditions, the altimeter would detonate a small controlled black powder pyrotechnic explosion that would pressurize the tubes enough to cause different sections of the rocket to split. Upon splitting, the drogue or main parachutes would be deployed. Due to the dual deployment system, the rocket was split into 3 sections: the top, middle and bottom. The bottom section contained the motor and the drogue parachute, the middle section contained the payload and the avionics bay, while the main parachute resided at the top section. All three sections were linked by 26mm tubular polyamide webbing shock cords.

The rocket was launched on the 22nd of June, from a dedicated launch rail near the SAC competition site. Due to the hot weather and past incidents at the competition, the exterior of the rocket was painted with a white primer, to prevent the interior from overheating. This was done due to the SratologgerCF boards being sensitive to high ambient temperatures, and failing to function properly under them. Should this precautionary measure not have been taken, there could have been an incidence of early parachute deployment and potential failure and disqualification from the competition. The vehicle launched successfully, reaching an apogee of 10,017ft giving it a 17ft overshoot and a 99.83% accuracy of being close to the intended target of 10,000ft. Upon reaching apogee, the drogue parachute was deployed, slowing down the rocket at 37.59 m/s. Further down at 1500 ft, the main parachute deployed, allowing the rocket to land at 12.192 m/s. The rocket was recovered the next day, having received no significant structural damage and it was deemed capable of flying again by officials.

Has it been evaluated? What feedback have you had?

The team received positive feedback from the ESRA judges for work and effort and were acknowledged by large-scale, space-engineering companies' representatives and recruiters such as Virgin Galactic, The Spaceflight Company (TSC) and SpaceX.

Key Learning Points

Various learning outcomes were achieved by the team members. In addition to technical skills, SunrIde team members have the opportunity to develop their engineering skill-sets in the areas listed below:

- Propulsion: Control and optimization of engine characteristics (thrust, burn time, mass flow rates)
- Recovery: Landing control, parachute design, and manufacturing
- Electronics: Remote controls of electronic systems (GPS module, StratoLogger, Transmitter, Receiver)
- Testing, Ground Operations, and Safety: Responsible for safety, organize and secure launch sites, test, and maintain launch infrastructure.
- Construction: Design (using designing software such as Solidworks, OpenRocket, and others) and fabrication of structural components aiming to optimize manufacturability and reusability.
- Dynamics and Performance: Calculate and accurately predict the trajectory of the rocket through modeling, Stability control, Analyse performance of the rocket.

Interpersonal skills gained through participation:

- Professional: developing professional behaviors, providing training towards Chartership,
- Learning: experience of providing peer learning, experience of leadership,
- Management: experience of project and team working and management.
- Finance: Budget and cost control, funding, procurement.
- Documentation and Legal: Writing technical reports, registration forms.

- Publicity: Open days attendance, outreach activities, Flyers, and posters.
- Website, Facebook, social media management.
- Sponsorship: Finding and communicating with sponsors.
- Experience with real-world engineering applications
- Software knowledge (e.g. OpenRocket, Solidworks, Ansys)
- Exposure to the use of hand tools and various machinery (e.g. laser-cutters, bench-drills, sanding machines)
- Teamwork spirit and solid communication methods
- Project management tools and methods
- Experience in working to solve problems of interdisciplinary nature

Thematic Categories (tick any that apply to your case study)

Method		Topic	
Online Text and Notes	☒	Orbits and Trajectories	☒
Assessment Materials	☐	Rocket Propulsion	☒
Video and Audio Lectures	☒	AOCS/ADCS	☐
Lecture Slides	☐	Payloads	☒
Curricula	☒	Power	☐
Video and Audio Clips	☒	Communications	☐
Recommended textbooks	☒	On Board Data Handling	☒
Useful software	☒	Systems	☐
Worksheets and Projects	☒	Mechanical	☒
Simulations	☒	Thermal	☐
Tutors' Guides	☒	Astronomy	☐
	☐	Earth Observation	☐
	☐	History of Spaceflight	☐
	☐	Other	☐

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