

The Sheffield Space Initiative - Introduction, Motivation, and Impact Assessment

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Abstract—In the rapidly changing landscape of ‘New Space’ and ‘disruptive innovation’, the University of Sheffield has identified the need for bespoke and focused training for students wishing to enter the space industry. The Sheffield Space Initiative (SSI) is a group of student-led projects at the University of Sheffield. Its purpose is to provide highly motivated and passionate students with the opportunity to participate in space related projects and work within multidisciplinary teams to address real-world challenges in space engineering.

Keywords—Education; student-led learning; STEM; University of Sheffield; Sheffield Space Initiative

I. INTRODUCTION

A. Background

The UK is currently experiencing a period of great optimism and activity in the space sector which is being driven by both government backing and private financial investment. Currently Britain controls 5.1% of the global space economy with well developed upstream manufacturing and downstream services. The UK Space Agency aims to help to grow this to 10% by 2030 [1]. The UK Space Industry also impacts positively on public services, national security, science, and innovation [2].

A potential obstacle to this could be a lack of domestic launcher systems which can fracture the supply chain, allowing vulnerability to foreign influence, and bottlenecking of downstream sector growth [2]. The Space Industry Act of 2018 is paving the way for a spaceport and commercial space launches on UK soil, with horizontal launch facilities currently being developed in Cornwall for Virgin Orbit [3]. In terms of private investment, based on the Seraphim Space Index, venture capitalists injected approximately £150 million of funding into 20 UK space companies in the period of September 2017 to September 2018 [4]. The space industry can also contribute wealth to the economy directly and

indirectly. In 2017 to 2018, the UK space industry’s income grew to £14.8 billion and contributed £5.7 billion to the UK’s economic output, representing 0.29% of UK GDP [5].

The ‘Size & Health of the UK Space Industry 2018’ report clearly identifies that the space industry is not only a growth sector, but also an enabler of growth in other industries such as telecommunication, transport and meteorology [5]. In addition, the space industry’s workforce is “exceptionally highly-skilled”, with 3 out of 4 workers holding a primary degree. A potential obstacle to the UK’s ambitious growth targets is the STEM skills gap. According to Professor Martin Barstow, Pro-Vice-Chancellor of Strategic Science Projects at the University of Leicester, the UK is currently unable to produce enough STEM graduates for the space agency, and it will be necessary to reskill non-STEM graduates. A report by STEM Learning indicated a shortfall of 173,400 workers over 2017 and 2018, which costs STEM businesses an estimated £1.5 billion a year [6].

B. Aims and Objectives

The SSI aims to allow motivated University of Sheffield Students the opportunity to enhance their knowledge of space engineering and project management, and to develop the technical skills and experience that are vital to the industry.

There are currently five active projects within the Sheffield Space Initiative (SSI): SunbYte, SunrIde, SunSat, MarsWorks and Avalon. The projects cover a broad range of upstream and downstream applications, from pushing the boundaries of scientific discovery with SunbYte’s solar telescope, to SunrIde’s new launch capabilities, exploration vehicles like Marsworks and Avalon, and flexible satellite platforms as with SunSat. Over the course of these projects students work as part of a team to apply the knowledge from their degree programs and acquire new skills. Team members can experience all aspects of a science and engineering mission from conception

to design, manufacture, integration, testing, and operation. Students can also be exposed to financial and regulatory aspects of engineering projects which are not encountered in normal curricula.

This feeds into SSI's secondary goals, which are to help address the widely reported skills gap in engineering and space engineering in the UK, and to encourage school students to study STEM subjects. Each SSI project dedicates a significant amount of time and resources to outreach and educational activities, in order to inspire and train the next generation of engineers to continue and build on the successes of the projects, and to prepare them for careers within the space industry. To help achieve this SSI members have created the 'SSI Academy', which delivers a series of lectures and workshops at the beginning of each academic year, in which experienced SSI students share their knowledge and experiences with students and members of the public that are interested in space. SSI projects have had engagement with international space agencies like ESA and NASA, as well as major industrial companies, which presents unique advantages and employment opportunities for the members. This paper will assess the impact that the SSI has on former students as well as the wider outreach impact. It will present the lessons learned, and explore its potential use as a model for other institutions to follow.

II. THE PROJECTS

SunbYte was the first project of the Sheffield Space Initiative. It stands for the "Sheffield University Nova Balloon Telescope", and is a project which aims to create a robotic solar telescope capable of being lifted by high altitude balloon to an altitude of 30 to 40 km. The purpose of launching the telescope by weather balloon is to lift the telescope above the majority of the atmosphere which can distort the images, i.e. the 'seeing' will be improved. The first version of SunbYte was developed over 2016 and 2017, and was launched in October 2017 on ESA's BEXUS program [7]. A second version was flown with NASA / LSU's High Altitude Student Payload program. During both of these balloon flights, the tracking and pointing system was proven to be effective, although no scientific images were captured [8]. SunbYte III will fly on HASP in early September 2019, and it is hoped that images of the Sun will be captured in the Hydrogen Alpha wavelength of 656.28 nm. This project exposes students to physics, engineering, and project management concepts. The payload must also operate in almost space like conditions of -60 degrees Celsius and near total vacuum pressure. This provides students with a unique opportunity within the SSI to participate in the creation of a payload that operates in near space-like conditions. The next iteration of SunbYte will be one of five payloads to fly on the HEMERA 2020 scientific balloon flight.



Figure 1. SunbYte III at NASA's Columbia Scientific Balloon Facility July 2019

SunrIde is a project to build and launch a rocket. A team of students designed, manufactured, and launched a payload-capable high-power rocket at Spaceport America Cup (SAC) in New Mexico, USA in June 2018. This rocket was entered into the '10,000 feet' category and won, overshooting the target altitude by just 17 feet [9]. A second SunrIde team created a rocket over 2018 and 2019, which was entered in the 2019 SAC in the '30,000 feet' category. The team's rocket was named HELEN after Sheffield Alumni and the first Briton in space Helen Sharman. This rocket set a new UK national record for a student built rocket altitude at 36,274 feet [10]. In addition to setting records, SunrIde also has concrete goals and timelines in relation to outreach and STEM engagement, for instance SunrIde aims to create 200 new rocket engineers by 2024. This complements the UK Space Agency's goal of increasing the UK's space sector workforce from 40,000 to 100,000 by 2030 [11].



Figure 2. SunrIde at Spaceport America Cup 2019

MarsWorks, formerly MoonWorks, is a project to manufacture and operate a rover capable of traversing simulated lunar and martian surfaces, perform tasks, and retrieve regolith samples. The MoonWorks rover was developed over 2017 and 2018 and was entered into the UKSEDS Lunar Rover Challenge, where the team beat 14

other universities across the UK to claim the Best Innovation Prize, and came 2nd in the Outreach and Critical Design Review categories. Over the course of 2018 and 2019 the project was transformed into MarsWorks, and the team was accepted into the European Rover Challenge which will take place in Poland in September 2019. The initial motivation for MoonWorks was to create a mini rover capable of retrieving ice samples from the lunar surface, as it is anticipated that ice will be an important component of fuel and sustenance if the Moon were to become terraformed. The Mars rover designed by the team will compete in 4 field trials: science; maintenance; collection; and traverse. In addition to these, the team is required to prepare a preliminary and final report, as well as a promotional video and presentation.



Figure 3. Marsworks at The University of Sheffield's iForge makerspace

The Avalon ROV group was started in 2017 with the aim of creating an underwater ROV - Remotely Operated Vehicle - to participate in the MATE ROV Competition. Avalon was the first English team ever to enter the MATE ROV competition. The competition challenges teams to solve real-life underwater problems such as exploring Europe's oceans and installing turbines underwater for power generation. The project allows members to learn robotics, electronic and mechanical design, and computer vision. Avalon qualified for the international competition in the USA in 2017, 2018 and again in 2019. This year Avalon was the top team from the UK, 11th overall, and 9th in the product demonstration at the international finals.



Figure 4. Avalon at the 2019 international competition in Kingsport, Tennessee, USA

The newest SSI team is SunSat, which was set up in 2018. The purpose of Sunsat is to create a cubesat service module which will provide a standard interface for ADCS, power, and telemetry for small scientific and technology demonstration payloads. The team aims to simplify the process for payload development by enabling rapid integration into a low-cost standardised satellite bus resulting in shorter time to launch. The team also aims to work closely with the European Space Agency through its various educational programmes and startup opportunities to take this concept into the commercial market.

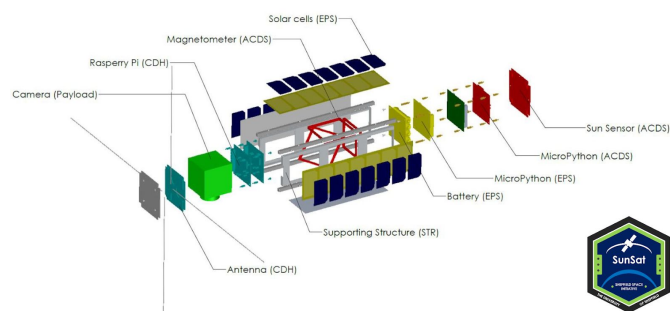


Figure 5. SunSat Computer Aided Design Satellite Architecture

III. REAL-WORLD EXPERIENCE

In total the SSI group of 2018 / 2019 has 108 members across several degree programs. A breakdown of members by gender, area of study, and degree type is shown in Fig. 6 and Fig. 7 below. The SSI project groups place a particular emphasis on STEM outreach for female students, for instance all projects display their payloads at the University of Sheffield's STEM For Girls fair every year.

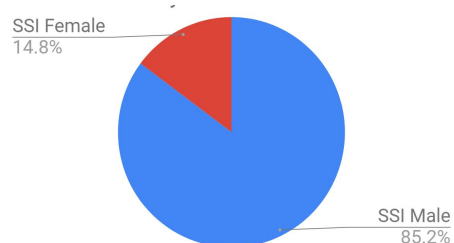


Figure 6. SSI Members by Gender

The diversity of academic backgrounds across the teams reflects real world workplaces by giving team members the experience of working in multi-disciplinary teams. Students can also learn soft skills such as communication, teamwork, and flexibility, as well as managing finances and financial paperwork. Student projects cannot survive without funding and online visibility, therefore in addition to engineering and science backgrounds, each project needs students from humanities backgrounds to assist in the vital tasks of management of social media and applications for funding and competitions.

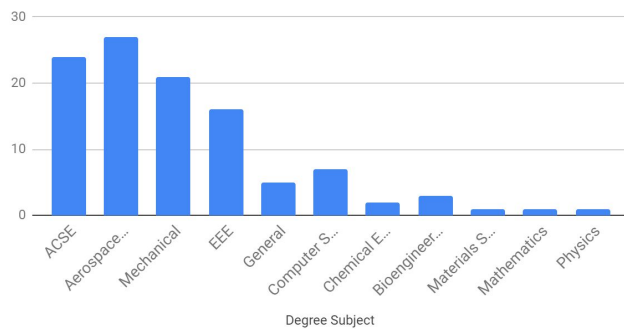


Figure 7. SSI Members by degree Subject

IV. SSI ACADEMY - KNOWLEDGE TRANSFER

The idea of an ‘SSI Academy’ was suggested by one of the student members, and was set up in early 2018. Typically, the team members of each project change year to year, as people leave the university or prioritise final year studies. As they leave, their knowledge of the unique designs is lost, and must be re-taught or re-learned over the next academic year. There are skills which are common to all of the SSI projects, including computer aided design, coding, team management, and electronic / electrical engineering, which may not be familiar to everyone due to their year of study or the focus of their degree subject. It was recognised that there was an opportunity to teach new entrants to the projects all of the skills that they might need or were interested in at the beginning of the academic year, which maximises the time available to work effectively on the project. This knowledge is passed on in the form of extracurricular lectures and workshops with academic staff and experienced team members.

V. OUTREACH

Outreach is important to each of the projects, and to SSI in general. All of the team members recognise that the projects need enthusiastic students to take over the projects to continue and improve them when they leave the University of Sheffield. To make sure that there will always be skilled and motivated students available to take over the projects the University of Sheffield needs good quality STEM students and school students that enjoy STEM subjects. The projects regularly apply to attend STEM education events and open days for primary and secondary school students, and bring their payloads and several team members in order to pique interest and ensure that any questions that curious students may have can be answered. It is hoped that SSI’s outreach efforts will result in more STEM graduates available to continue the projects and fill the skills gap across the space and STEM industries.



Figure 8. SunSat Operations Manager at Pint Of Science event



Figure 9. Avalon in the 2018 Maker Fair in Newcastle

VI. EVALUATION

An anonymous five question multiple choice survey was sent to all SSI project members, to assess the impact of their involvement in their project on their career and future career. The survey suggested that the SSI has a very positive impact on participants. The majority (about 70%) of SSI are members are undergraduate students, and 50% reported that their involvement in their project has already helped them secure a job or internship. All respondents also felt that their involvement enhanced their knowledge and understanding of space engineering, and 75% felt that their experience of their project has influenced their career path in the direction of engineering in the space sector.

VII. CONCLUSION

In conclusion, the University of Sheffield has managed to build up a thriving and dynamic group, which uses student-led learning techniques to enhance higher education. It is hoped that these projects and experiences will help to equip the students for professional careers in both research and industry. Students from other universities wishing to increase their knowledge of space engineering and augment their CV whilst studying for their degree could, with the assistance of an academic, search for student space engineering competitions and begin their own projects. As the project work must be done alongside normal study, it is recommended that as with the SSI academy, all team members should be trained as early as possible in the academic year to increase the amount of

time available to design, build, test, and acquire funding. For more information, please visit: <http://ssi.group.shef.ac.uk>

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