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 because of the value that space programmes deliver back to public services, national security, science and innovation and the economy.

As a result, there is both government backing and private financial investment driving space sector growth. Currently Britain controls 5.1% of the global space economy with well developed upstream manufacturing and downstream services. UK Space Agency aims to help to grow this to 10% by 2030 [1]. However, the lack of a domestic launcher system fractures the supply chain allowing foreign influence vulnerability and bottlenecking downstream sector growth. The Space Industry Act 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 Galactic.

In 2014, the UK space sector directly contributed £11.8 billion to the economy and has consistently achieved annual growth of over 8.8% even during the recession. Considering the the services enabled by space infrastructure in sectors such as agri-tech, meteorology, energy, telecommunications, insurance, transport, maritime, aviation and urban development, the true economic value of space is significantly huge and the space sector is not only a growth sector itself, but is the vital future enabler of growth.

In addition to direct gross value added, activity in the space industry create indirect contributions. For example, satellite manufacturing necessitates electronic subsystems, which might not be produced in the absence of space industry demand. Furthermore, induced effects are created whereby employees in the space industry and supply chain spend their salaries in other sectors of the economy.

According the 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 [2].

A potential obstacle to this ambitious growth projection is the STEM skills gap in the UK. 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. According to a report by STEM Learning, there was a shortfall of 173,400 workers over 2017 and 2018, which costs STEM businesses an estimated £1.5 billion a year [3].

B. Aims and Objectives

The SSI aims to allow motivated University of Sheffield Students the opportunity to enhance their knowledge of space engineering and space 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, Sheffield Rover Robotics and Avtalon. 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 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. They experience all aspects of a science and engineering mission: from conception, to design, manufacture, integration, testing, and operation. They are also exposed to the financial and regulatory factors which are not encountered in normal curricular projects.

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 to 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 stands for 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 2017 on ESA's BEXUS program [4]. A second version was flown with NASA / LSU's High Altitude Student Payload. During both of these balloon flights, the tracking and pointing system was proven to be effective, although no scientific images were captured [5]. 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.

Fig 1. SunbYte I at Esrange Space Center

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 [6]. 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 build rocket altitude at 36,274 feet [7]. In addition to setting records, SunrIde also has concrete aims and timelines in relation to outreach and STEM engagement. This complements the UK Space Agency's goal of increasing the UK's space sector workforce from 40,000 to 100,000 by 2030 [8].

Fig 2. SunrIde at Spaceport America Cup

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 in 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 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's mini martian rover design was accepted to 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.

Fig 3. Marsworks at iForge makerspace

The Avalon ROV group was started in 2017 with the aim of creating an underwater ROV. Avalon was the first UK team ever to enter the MATE ROV competition in 2017. The Avalon ROV was entered into the MATE ROV competition in the USA in 2018 and again in 2019. This year the team were the top team from England, and 11th overall.

The newest SSI team is SunSat, which was set up in 2018. The concept 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 devices. It aims to simplify the process for payload developers by enabling rapid integration into a low-cost standardised satellite bus resulting in shorter time to launch. The team 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.

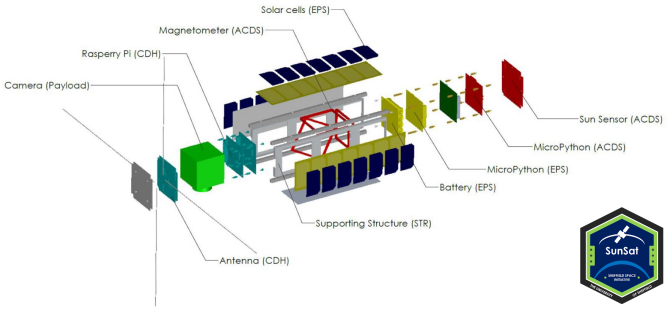

Fig 4. SunSat Computer Aided Design Satellite Architecture

III. Real-World Experience

In total the SSI group of 2018 / 2019 has 108 members across degree programs. A breakdown of members by gender, area of study, and degree type is shown in Fig. 5 and Fig. 6 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.

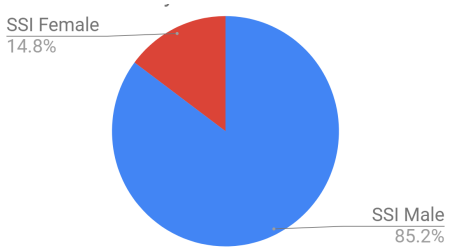

Figure 5. SSI Members by Gender

The diversity of academic backgrounds across the teams reflects real world workplaces by giving team members the experience of working in multi-disciplinary teams. 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.

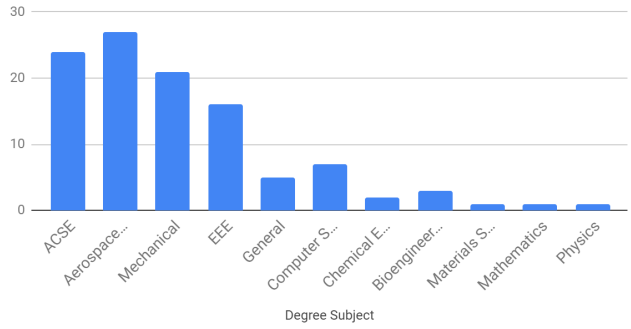

Figure 6. SSI Members by degree Subject

Student projects cannot survive without funding and online visibility, therefore in addition technical and scientific work, students can also learn soft skills such as communication and working as part of team, as well as managing finances and financial paperwork.

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 their final year studies. As they leave their knowledge of the unique design and coding 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. A positive knock-on effect of the SSI's outreach efforts is that there will be more STEM graduates available to fill the skills gap across the space and STEM industries.

Figure 7. SunSat Operations Manager at Pint Of Science event

VI. EVALUATION

An anonymous 5 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. It was discovered that the SSI is having a positive impact on their 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 ecosystem pioneering the latest student-led learning techniques to further enhance higher education. This paradigm shift will better equip learners for professional careers both in 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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