Observing Australia's space education: A mission to inspire the future of the industry

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Abstract: A solid academic and educational base for the Australian space industry will provide the expertise needed to support a domestic industry in the future. While the current education system involves some mentions of space activities, it is lacking the direct education and industry involvement that many other countries' curriculums offer. A small Earth observation satellite mission, MISTER Aussie (Mission to Inspire a Space Technology and Education Revolution in Australia), is proposed that will allow students at primary, secondary and tertiary levels to interact directly with a satellite system across a broad range of subject areas, including outside of typical STEM fields. A remotely accessible Mission Control will allow students to see and control the satellite within their own classrooms. The ground segment will be developed as a collaboration between multiple Australian universities to increase student and academic exposure to space communication systems. Alongside the mission itself, units and lesson plans will be written that conform to the Australian Curriculum and will be offered to schools taking part in the program. MISTER Aussie will also offer opportunities to develop the wider Australian space industry through local manufacturing and extra payload space.

1. INTRODUCTION

Although very experienced in the ground segment, Australia is one of the only developed nations in the world to not have an active government space flight program or agency. Consequently, there are very few established space companies working on space projects in Australia, and attempts to work in the country are met with confusion as to who to contact and a lack of coordinated incentive for growth [1]. In recent years, the commercial space sector has grown dramatically, with exponential growth predicted for the future [2]. While Australia may not have the financial ability to establish an extensive governmental space program, the Australian space industry currently forms only 0.8% of the global industry (compared to 1.8% of the general global economy); its experience with high-end technological research and manufacturing offers many opportunities for the support of the global commercial sector. Any technologically intense industry, however, requires solid academic partnerships to not only conduct research, but to also supply the industry with well-educated personnel. Currently, this is lacking in Australia, with very few dedicated tertiary space degrees offered, and only a limited number of supplementary workshops offered to students at a secondary school level [3,4].

This paper presents a satellite system, MISTER Aussie, intended to be used at primary, secondary, and tertiary educational institutions throughout Australia to foster student interest in continuing space-related studies by allowing students to interact directly with a satellite system. This system will contribute significantly towards "engag[ing] students and teachers in science, mathematics and engineering education" as one of the seven principles outlined by the Australian government in their Satellite Utilisation Policy [5]. Students will learn about space systems over the course of a term or learning period, culminating in an incursion activity where they can interact with MISTER Aussie from their own classroom. The satellite will carry two optical payloads allowing high resolution image capture of the surface of the Earth and real-time standard definition video streaming. It also provides a platform for universities and research institutes to develop and fly payloads, as well as establish a ground station network. While the technology involved is not new or unique, its direct application to education is.

In this paper, an overview of the mission architecture is given. The methods by which the satellite system will be used is then provided in terms of the larger project, followed by a short discussion on potential industry impacts and ways in which similar projects can be used as stepping stones to developing vital heritage for the Australian space industry.

2. OVERVIEW OF PROPOSED MISSION ARCHITECTURE

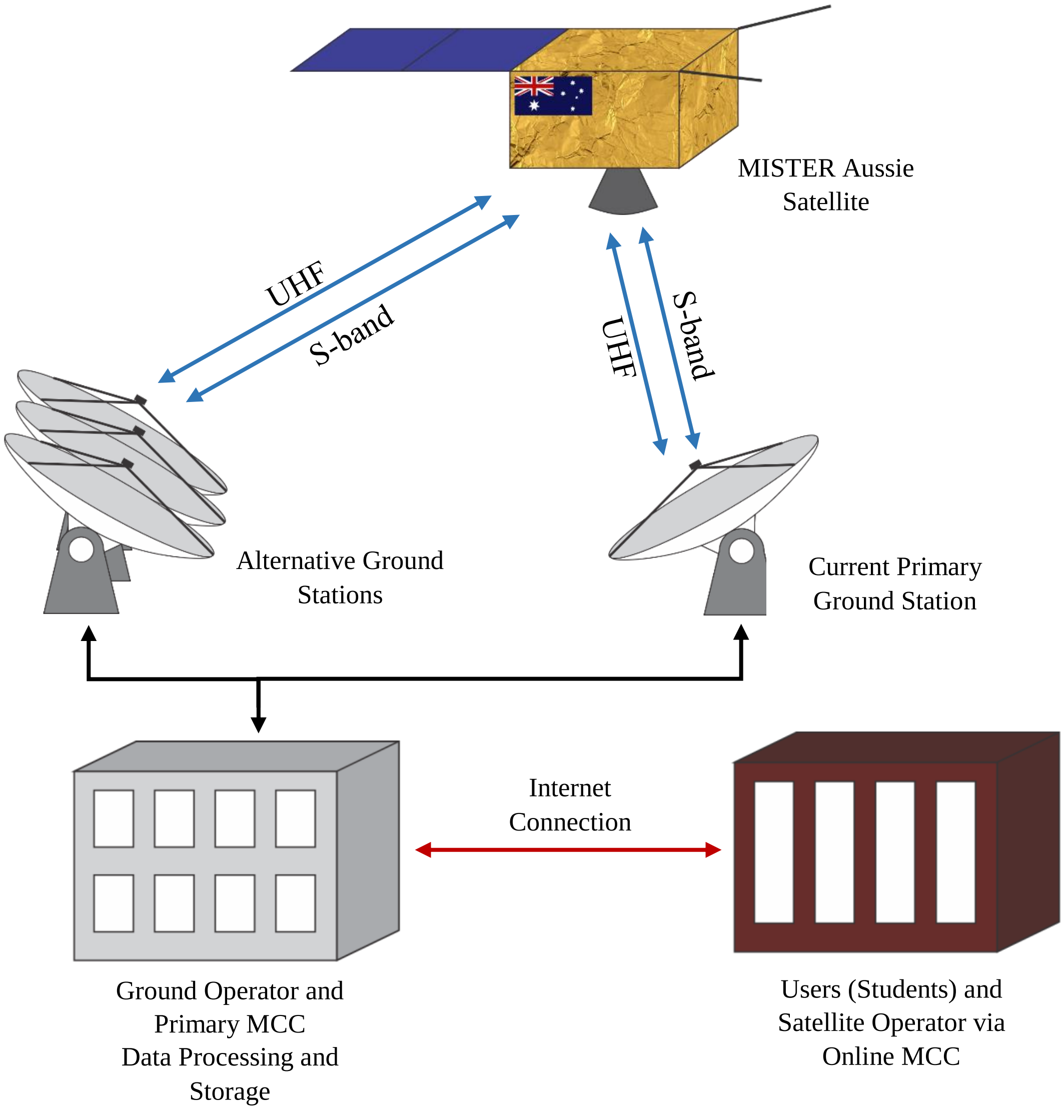

Figure 1: Schematic of MISTER Aussie system architecture

2.1 Ground Segment

It is envisioned that the Ground Segment will be established by a number of Australian universities spread across the continent. This will allow communication with MISTER Aussie throughout passes over Australia and surrounding regions. Each ground station would comprise of both S-band and UHF antennas. The S-band antennas will be used to receive captured payload data as well as allow real-time access and control of a standard definition video stream, similar to the system flown on the Lapan-Tubsat satellite [6]. The ground network must be capable of receiving, processing, and delivering captured images within two passes over Australia (the first pass including the capture of the image). The target of the images will be chosen and targeted by students in the classroom, and the images would then be made available to the students the same day. Spacing the ground stations across the continent (for example, having ground stations in Perth, Adelaide, Melbourne and Brisbane) will greatly extend the contact time. Ideally, Australian universities will establish collaborations with international universities to provide coverage for MISTER Aussie when it is not over Australia, with reciprocal coverage provided for the international universities' satellites. TTC communication will be conducted via UHF, a common communication band for CubeSats. Given the recent participation in the QB50 project by three Australian universities, it would allow them to share costs between MISTER Aussie and their own CubeSat projects [7].

The mission control centre will be an online-accessible interface, with varying skins applied appropriate to the level of the students involved. This will allow students to see and interact with the satellite directly from their own classrooms under the supervision of a project team member. Importantly, it will offer distance education and regional students access to the system and lessons easily, without necessarily requiring travel from remote areas. Remote students are often unintentionally excluded from educational activities due to prohibitive travel costs and resource limitations [8]. In offering 'direct' (although supervised) control of the system, protective control software must also be written to prevent students exceeding the system operating limits. While control software necessarily contains limitations, much more robust and intelligent control is required to facilitate this degree of inexperience of the intended users while still delivering a meaningful interaction to students.

2.2 Space Segment

2.2.1 Satellite Bus

It is intended to use a satellite bus similar to the LEOS-100 offered by Berlin Space Technologies [9]. Purchasing an existing bus reduces both program risk and cost, as well as shortening the development time required significantly. This low-cost bus has a nominal mass of 90kg, including 30kg for the payload, and is capable of transmitting in the S-band and UHF spectrums. This size of bus is chosen as it allows for imagers with up to 2m GSD, while remaining relatively low-cost. Importantly, the bus provides more than adequate resources for the primary payloads as discussed below. The excess initial resources can be either considered as an extension of the satellite operating life, or be used by secondary payloads.

2.2.2 Satellite Payload

The three primary payloads provide students with unique methods of direct interaction. The largest instrument will be an optical imager capable of at least 2m GSD. This system will be used to capture images of a target to be analysed in the classroom. For example, a class of young students can lay in a group in an open area of the school as the satellite flies overhead, and will then be able to see themselves from space; older mathematics students can use a colour-based analysis of the picture to calculate vegetation levels. Complementing the capture-and-store system is a video camera capable of real-time data transmission and control. Students will be able to manipulate the attitude of the satellite using a standard control interface such as a joystick while the satellite is in contact with a suitably close ground station. This system is highly dependent on the network latency and so may be restricted to lessons in or very nearby the ground stations and Primary MCC. A simulator may also be established so that student pilots can train before using the real system, making the most of the limited time they have at the controls. Finally, some form of system that allows students to observe the satellite at home without special equipment, such as a bright laser or sun reflector visible to the naked eye, will show students that space is not too far away. Any remaining payload space will be offered to Australian universities to conduct their own research or technology demonstration as part of the agreement in operating the ground stations.

2.2.3 Orbit

In order to maintain daylight operations over Australia, MISTER Aussie will be placed into a sun-synchronous orbit with an altitude of approximately 500km. Depending on the skew capabilities of the specific imager used, this should provide coverage of most of the Australian continent and surrounding waters over a reasonable period. A lower inclination orbit would provide significantly faster coverage of the entire continent; however the natural precession of a lower inclination orbit would mean the satellite would eventually not pass over Australia during school hours. If a suitable sun-synchronous orbit cannot be found (either for technical reasons, such as limited field of view of the cameras, or restrictions on launch opportunities), a lower inclination orbit could be used, with periods of students having to instead select targets outside of the geographical region of their school.

3. USE WITHIN THE AUSTRALIAN EDUCATION SYSTEM

It is envisioned that MISTER Aussie will consist not only of the satellite system itself, but will be complemented by complete curriculum packages that will be offered to schools participating in the program. Varying levels of detail will be provided, allowing teachers and curriculum coordinators to use as much or as little of the material as they would like. At the highest level, educators will be provided with a guide to achieving the goals set out in either the federal Australian Curriculum or their state-mandated curriculum using space as a theme. At the most detailed level, schools can purchase full lessons plans including suggested activities and material lists. In-classroom sessions with the MISTER Aussie satellite will require classes to complete a minimum instruction course dependent on the subject area, before the session takes place, to ensure the satellite's brief access time is used effectively. Given the aim is to have schools teaching complete units, careful scheduling will be required towards the end of school terms, as many classes will complete a unit in these periods. Alternatively, the incursion activity can also be delayed from the end of the unit to spread out demand for the satellite and reach more students.

In addition, the data products generated by the satellite (photos, videos, telemetry and housekeeping data, as well as two-line elements) will be provided to educators so that they can use them in their classes. All levels of data products, from Level 0 to Level 4, will allow teachers and students to perform their own experiments and analyses in ways tailored to their particular learning abilities and academic progression.

3.1 Effectiveness of Co-Curricular Activities

It is important to show that participation in co-curricular activities and exposure to a subject will positively influence student career and higher education decisions. This is the primary assumption behind the design of the MISTER Aussie mission. Student participation in co-curricular activities has been shown to increase student performance and engagement in a subject [10]. Here, Camp argues that participation in these activities results in increased academic achievement, no matter how academically strong or weak the student. MISTER Aussie is also not intended to only be offered to high performing students; rather, as many students as possible should have access to the system.

In investigating the driving factors behind tertiary course selection, Auyeung and Sands [11] discovered the major factor influencing Australian high school accounting students to continue studying accounting at university was "aptitude for subject matter". Generalising this statement to other subject areas, it can be seen that as co-curricular activities increase student engagement and performance, they likely also increase the number of students who pursue the relevant area of study in the future. This does not only apply to high school students transitioning to tertiary education, but also students at all levels making choices on project topics, subject selection, and major/minor sequences.

3.2 Primary Education

Units coherent with the Australian Curriculum will be written, with various levels of detail available to educators, ranging from general guides to including space, to complete lesson plans. Where states make use of their own curriculum (for example, The Victorian

Curriculum F-10 in Victoria), the relevant state curriculum will be used as the basis of the units. These units will encompass maths and science subject areas, as well as history and politics studies as they are taught at a primary level. Space may also be used as a link between these topics in a cross-curricular design.

It is important for young students to have visual interactions with MISTER Aussie; studies have shown that students are more engaged and perform stronger academically when visual technologies are incorporated into their classes [12]. For MISTER Aussie, this will comprise the live video feed, high resolution photos of their class or school, and the laser system, which will allow exciting, personal interactions with space technology. Older primary students may be able to make use of numerical data generated by the satellite. Programs may be run in conjunction with or to complement existing space education programs offered by institutions such as the Victorian Space Science Education Centre (VSSEC) [4].

3.3 Secondary Education

In their final year of secondary school, many students decide what career path to follow. Educating secondary-aged students about the role space plays in modern industries is therefore vital to achieving the goals of Australian-educated space professionals. The goal for secondary education is to seamlessly integrate space technology into as many subject areas as possible, highlighting to students the important and varied roles space technology plays. As for primary education, secondary units will be written in line with either the Australian Curriculum or the relevant state curriculums. In addition to complete unit outlines with lesson plans, teacher summaries and suggested integration topics into existing curriculum units inside and outside of STEM subjects will be provided to allow schools to decide how much of a focus to give to space. Cross-curriculum units that couple STEM subjects with topics such as history will encourage students' understanding of both the upstream and downstream aspects of space technology. At every level, though, the intention is not to drive students solely towards Space Science or Space Engineering courses; while these are required, MISTER Aussie also aims to establish a demand for space generated data and systems. Supplement sessions to penultimate-year Physics studies are provided by VSSEC in Victoria, demonstrating there is a current demand from students for space-specific studies [3].

3.4 Tertiary Education

Tertiary institutions will form a major base of support for MISTER Aussie. As mentioned above, universities across the country will provide an extensive ground station network. This will allow them to also establish academic collaborations with international universities who have more experience in space operations. The establishment of international collaborations is one of the major principles outlined by the Australian government [5]. Any remaining payload space will be made available to participating universities to conduct their own experiments or technology demonstrations. MISTER Aussie will be used to instruct tertiary students taking space-related units, ultimately aiming for more dedicated space science or engineering degrees being offered at

Australian universities. The project will provide access, information and expertise on the relevant topic area, and to some extent suggested subject summaries; however, universities will be expected to write their own units that can integrate the services offered by MISTER Aussie. In this way, academics will make full use of the system's capabilities and potentially contribute to the services and data analysis that can be offered to primary and secondary educators and students.

4. WIDER IMPACT FOR AUSTRALIAN SPACE INDUSTRY DEVELOPMENT

While the design and manufacture of the first MISTER Aussie satellite will most likely take place outside of Australia, there is a potential for some components to be manufactured domestically. Future satellite systems will be designed and built locally to further support the fledgling space industry and found partnerships with commercial space companies. Locally designed systems may begin smaller than the first satellite due to the increased approachability and lower cost of nano-satellites (i.e., CubeSats). Australian universities may also be involved in this design process, and a number of Australian institutions already have experience with their own CubeSat systems [7]. There is also the possibility of spin-off companies from university research taking place within space degrees inspired by the MISTER Aussie project.

Providing universities and research institutes with a flight platform on which they can gain experience and heritage will also be vital in developing commercially viable technologies. It may be possible to use data captured by MISTER Aussie and future missions to support downstream research programs and companies with regular, locally optimised data; access to some of which is currently considered at risk [13].

5. CONCLUSION

An Earth-observation satellite system to inspire Australian students to pursue a space-related career was presented. Research has shown the effectiveness of both the use of technology and co-curricular activities in the classroom to increase student engagement and academic achievement. These, in turn, lead to increasing student enrolments in the relevant subject area. By creating custom units for educators, the integration of space into most subject areas is simplified, and students' learning is reinforced through the end-of-unit incursion activity. The system does rely on strong support from tertiary institutions; however recent participation by Australian universities in other space programs suggests this is not an entirely unreasonable goal. Finally, the project has the ability for flow-on effects in the wider Australian space industry.

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