STRaND: Surrey Training Research and Nanosatellite Demonstrator

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Abstract

As pico and nanosatellites gain popularity with space educators and institutions, Surrey Space Centre (SSC) and Surrey Satellite Technology Ltd. (SSTL) have collaborated together to build STRaND-1, a nanosatellite based on the 3U-CubeSat standard. The aim of STRaND, or 'Surrey Training Research and Nanosatellite Demonstration' programme, is:

- *To provide rapid hands-on training experience for academics and less experienced engineers at both centres in designing and building new satellite technologies,*
- *To challenge the current industry standard development processes and discover new ways of managing developments, and*
- *To demonstrate novel space technologies or the use of existing but modern terrestrial commercial-off-the-shelf (COTS) technologies in space.*

This paper will outline the processes that Surrey, the collective team of SSC and SSTL engineers, went through to design STRaND-1's mission requirements, and through to the final system design. To cater for a range of new mission requirements, including a new high performance computer, a modern smart-phone with Android operating system, and a novel electric propulsion system. Many custom parts were designed to accommodate a new 3-axis stabilised attitude/orbit control system (AOCS) of micro-wheels, micro-magnetorquer rods, Sun/Earth sensors together with a bespoke payload bay for non-CubeSat standard boards.

1. Introduction

STRaND stands for Surrey Training, Research and Nanosatellite Demonstration, and the aims of the program are synonymous with the acronym. The programme was initiated out of a desire to:

- Give less-experienced Surrey Satellite Technology Ltd. (SSTL) engineers and Surrey Space Centre (SSC) researchers the chance to rapidly gain new skills.
- Develop new, innovative nanosatellite technologies with the possibility of commercialisation by SSTL
- Challenge the traditional SSTL approach and the processes that have developed in SSTL over the last 25 years, and perhaps most importantly
- To maintain the formal and informal links between SSTL and the Surrey Space Centre at all levels of both organisations.

The STRaND programme is intended to be a long-term arrangement between SSTL and the SSC, with STRaND-1 the first of a long line of STRaND nanosatellites. It builds upon a similar programme, a decade ago, which resulted in the highly successful SNAP-1 nanosatellite mission, launched in 2000 [1].

1.1. The STRaND Project and Goals

STRaND started out as a feasibility study and mission requirement exercise in the Mission Concepts team at SSTL, with the aim of answering the question: 'what could SSTL do to leverage the explosion in miniature consumer-level technology that has occurred in the last 10 years?'. At the same time, SSC were developing an advanced Cubesat bus, so with input from the advanced space system research at the Surrey Space Centre, the result of the feasibility study and requirements exercise was an initial mission concept for a rapid, low cost technology demonstrator and requirements list, including a list of payload candidates, a component make/buy list, high level concept of operations (CONOPS) and mass, power and budgets.

The goals set for STRaND were graduated into three levels of priority, and covered all aspects of the programme, including programmatic, management and technical goals, found in Tables 1 and 2. The three levels of programme goal priority were primary, secondary, and tertiary. Only the primary set of goals need to be achieved for the mission to be a success.

Table 1. Mission Requirements

Requirement Level	Mission Requirement
Primary	Gain engineering experience for SSTL staff
	Work closely with SSC to maintain ties with the university
	Fly *something* and demonstrate an operational telemetry link
Secondary	One or more of the payloads work
	Rapid development and build time
	Demonstrate the use of modern COTS for space applications by accepting an above-normal level of technical risk
Tertiary	Remote inspection of a rocket body
	Sustained outreach programme
	Gain heritage of STRaND components for use in commercial SSTL missions

Table 2. Subsystem Requirements

Requirement Level	Power Subsystem Requirements
Primary	Power core systems permanently
Secondary	Enable 1 operation per sunlit orbit section
Tertiary	Enable more operations per sunlit orbit section, or one operation during eclipse (implies successful deployment of solar arrays)
	Attitude control system Requirements
Primary	Detumble the satellite and point panels towards the sun
Secondary	Enable camera pointing for imaging the Earth and the rocket body
Tertiary	Detumble and achieve full 3-axis control within 1 hour
	Payload Requirements
Primary	Receive telemetry from a payload
Secondary	Take imagery from a payload and downlink it to a groundstation
Tertiary	Make use of all expected payload functions

1.2. Evolution of Team

The feasibility study phase of the STRaND programme was initiated in February 2010. At the time the team consisted of an SSTL Mission Concepts Engineer acting as lead system engineer, and SSC Academic acting as Principal Investigator and an SSC Research Assistant acting as a nanosatellite technology and payload consultant. The feasibility analysis was concluded in April 2010, as the task was considered a low priority compared to business oriented tasks. The study phase culminated in a mission concept design review with senior SSTL engineers and senior SSC academics given the chance to decide on whether to proceed with the programme. The results of the feasibility study were promising and exciting and the programme was finally given a 'go'.

Any SSTL employee wishing to be involved with the STRaND programme had to be a volunteer. It is a condition of the programme that volunteers from SSTL and SSC use their own, free time for STRaND activities (such as lunches and breaks). There is a budget for hardware but no budget for man-power. This condition made finding willing volunteers a difficult, however the first call for SSTL volunteers generated interest from at least 10% of the company, and a core team of six SSC academics and researchers.

Volunteers are expected to join the STRaND programme for their own benefit. In most cases, volunteers use STRaND-1 as an opportunity to learn new skills. Volunteer responses included information on which skills the volunteer wanted to develop and so this was mapped to roles on the STRaND-1 mission. The programme is intended to be as inclusive as possible to maximise the benefit to SSTL and SSC. No volunteer was turned away.

The organisation of the team follows the standard Surrey practise of grouping by subsystem. However as the programme has evolved, this organisation was found to be restrictive, e.g. attitude/orbit and the on-board computer software were found to have much in common and it was more pragmatic to merge the groups. Therefore a new arrangement organised along skill sets rather than subsystems is being considered. This is a lesson that was learnt recently on the Astrium UK LunchSat project [2] and STRaND may follow a similar organisational structure as evidence that this is a more efficient structure, in general, for combined industrial/academic CubeSat/nanosatellite projects where the technical complexity of the satellite is constrained enough to allow engineers to be involved with multiple subsystems.

A similar move is also being considered with work package management. The STRaND mission was originally scoped out with work packages, as is standard industry practice. However this method was found to be restrictive and inhibited engineers' innovation to solve problems. The STRaND team is currently transitioning to a more ownership-based system where engineers have the freedom to tackle tasks as they see fit, without being committed to a work package.

SSTL is a growing company, with a growing workload. It is inevitable that during the course of the mission timeline there would be cases where volunteers would have to drop out of the programme due to increased commitments on commercial SSTL projects, as the amount of free time they could spend diminished. It is interesting to note that the rate of volunteer erosion is not constant, and a peak in erosion was seen approximately 5 months in to the project, however the team has been stable for the last 3 months. This is analogous to the settling of a 'core team' which is standard SSTL procedure for satellite manufacture. The growth of the SSC STRaND team was more organic, and followed a more reactive process where volunteers were recruited as technical needs demanded. At the time of writing the ratio of SSTL engineers to SSC engineers involved on the project is approximately 3:2.

1.2.1. Stealth Reviewers and Mentors

The STRaND programme has been an opportunity to try a different approach to guidance and technical review than the standard SSTL (and indeed industry standard) approach of milestone reviews. The mission has a set of reviewers for each subsystem or volunteer, and the reviewers are expected to conduct reviews at random. This method was developed out of pragmatism as the reviewers are senior engineers with very little time availability. However, the system has additional benefits (one could say) in that volunteer engineers do not know when reviews will occur, so progressing the mission activities instead of preparing documents for review milestones. This also means that progress can be demonstrated regardless of when the next review takes place.

Stealth reviews have so far tended to be informal, irregular discussions. It is the close contact that enables the volunteers to avoid the need for formal review documentation, as the reviewer tends to be as up to date with recent events as the volunteer. This method of review is not designed or expected to be transferable to standard SSTL operation as it does not provide a satisfactory record of traceability. It is, however, ideal for the fast paced, innovation-rich and customer-less 'pathfinder' type missions that the STRaND programme is intended to produce.

1.2.2. Interteam Cooperation and Knowledge Transfer

The Surrey Space Centre has developed expertise in embedded and miniaturised CubeSat technologies and standards that SSTL does not currently utilise. The STRaND programme is an ideal vehicle to start the transfer of this expertise in to SSTL. SSTL benefits from increased understanding of very new technologies and how they can be incorporated in to existing SSTL heritage systems, and SSC benefits from greater visibility of their CubeSat projects within SSTL with the potential for industrialisation and commercialisation. On a related topic, SSC is a core participant of the amateur groundstation networking.

Although the transfer of knowledge is primarily from the University to Industry (as is expected), there are practical engineering skills that SSTL is helping SSC to gain. For example in SSTL solar array manufacturing expertise and antenna deployment mechanisms.

Some engineering aspects of STRaND-1 are true collaborations (i.e. neither SSC nor SSTL are the prime developer). These are areas of collaborative research and development where the experience gained is beneficial to both parties. Good examples of this collaboration on STRaND-1 include the development of bespoke Android software and the incorporation of AOCS, OBC and bus software on a single unit.

2. The STRaND-1 Nanosatellite

This section will discuss the STRaND-1 nanosatellite ideas and concepts and the hardware and software implementations that are currently based-lined. We will also discuss the launch and comment on the implementation of our programme as a whole.

2.1. Initial STRaND Concepts

STRaND-1 aims to combine both classical satellite design techniques from the microsatellite community with newer techniques and payloads towards an advanced concept nanosatellite. Challenging existing processes and traditional spacecraft design was also a key factor for both SSTL and SSC. The first STRaND satellite needed to be low cost, low mass, and high impact – as with the rest of Surrey's satellite programmes. Therefore, the CubeSat standard was chosen to work on with the existing experience within SSC with a smart-phone payload.

Classical CubeSat design methods include the use of several existing COTS subsystems and components utilising I^2C buses for satellite control. Purchased subsystems include the GomSpace on-board computer (OBC) or data handling (OBDH) unit utilising an ARM7 processor [3], the ClydeSpace electrical power system (EPS) [4] with 20 W/hr battery [5], and CubeSense [6] from the University of Stalenbosch.

New subsystems currently in development are a UHF/VHF transceiver (with the potential in later versions for S-Band with minimal redesign), deployable solar panels, power switches, nano-magnetorquers, nano-reaction wheels, a butane thruster, and a new CubeSat deployer called 'S-POD'. Further firsts will include the latest attitude and orbit control system (AOCS) software .

Figure 1. Media Concept Art

After an extensive trade study, an Android-based smart-phone payload was selected for this mission. A smart-phone was chosen as it was the most advanced commercially available electronics device that contains many highly miniaturised and integrated components. These include orientation and acceleration sensors, highly integrated computing and memory devices, and open source software tools. If a smart-phone can be qualified for space flight, the potential for many new COTS components and sub-systems, found commonly in terrestrial systems, could be used to reduce costs and mass in satellite and space missions.

2.2. The STRaND-1 Satellite

The satellite bus itself utilises the PC/104 connectors for mechanical and electrical conformity to other commercial CubeSat subsystems within a classical 3U CubeSat structure as shown in Figure 2 and 3 along with Table 3.

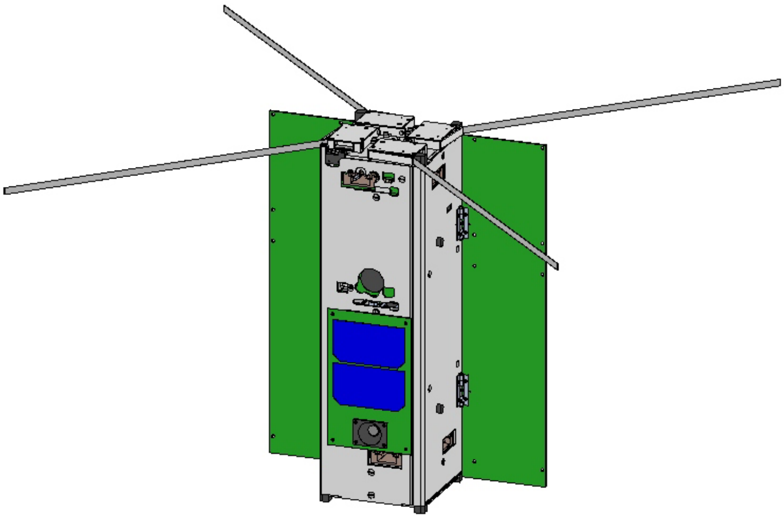

Figure 2. STRaND-1 (with solar panels and antenna deployed)

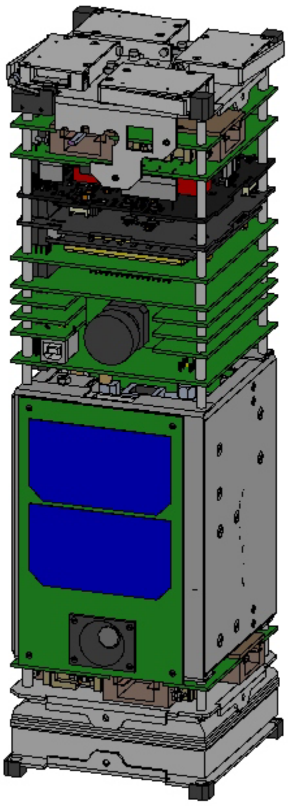

Figure 3. STRaND-1 CAD Drawing

Table 3. STRaND-1 PCB Subsystem Stack

PCB Layer	Developer
Custom VHF/UHF Antenna & Deploy Switches	SSTL
Pulse Plasma Thruster Board 1	SSC
Pulse Plasma Thruster High Voltage Board	SSC
Clyde Space EPS 3U Board	SSTL/SSC
Clyde Space Battery Board	SSTL/SSC
GomSpace NanoMind ARM7 OBC	SSC
CubeSense (Sun and nadir imagers)	Stallenbosch
Payload Power Switches	SSC
Custom VHF Up/UHF Down Transceiver	SSTL
Payload Bay:	SSC
Custom Magnetorquer x 3	SSC
Custom micro reaction wheels x 3	SSC
Digi Wi9C High Performance Computer	SSC
Android smart-phone	SSC/SSTL
Screen Imager	SSC
GPSR (SGR05)	SSTL
Pulse Plasma Thruster Board 2	SSC
Butane Thruster	SSTL

The key operations of each subsystem are operated using the I2C bus with the NanoMind ARM7 OBC acting as a master. The attitude and orbit control system (AOCS) contains a number of sensors and actuators including nano-reaction wheels, nano-magnetorquers, SSTL's SGR05 GPS receiver [7], 8 pulse plasma thrusters (PPTs), and a butane thruster. Except for the SGR05, each of these subsystems has been designed for STRaND and future CubeSat applications and missions within Surrey's activities. The custom transceiver provides a UHF downlink and VHF uplink at 9.6 kbps using frequency-shift-keying (FSK) modulation at 1.6 W RF output power. The nano-magnetorquer rods and nano-wheels are housed in the payload bay; and discussed in the next section. Pulse plasma thrusters developed through extensive research at Surrey Space Centre will also be flown in STRaND-1, and is discussed in detail in “Development of the μPPT propulsion module for STRaND a 3U CubeSat” presented at the 1st IAA Conference for University Missions and CubeSat Workshop (Rome, 2011).

2.2.1. Payload Subsystems

The payload bay houses a number of advanced AOCS payloads as well as a COTS high performance computer (HPC) based on the Digi Wi9C embedded system and the smart-phone. The payload bay not only provides further total-dose protection for these components but also provides rigid mounting points for the nano magnetorquers, nano reaction wheels, SGR05, and GPSR antenna. The magnetorquer rods are 85 x 6 mm and made from a custom metal alloy. The three reaction wheels provide full 3-axis control and are a development of the momentum wheel flown on SNAP-1. These are shown in Figure 4.

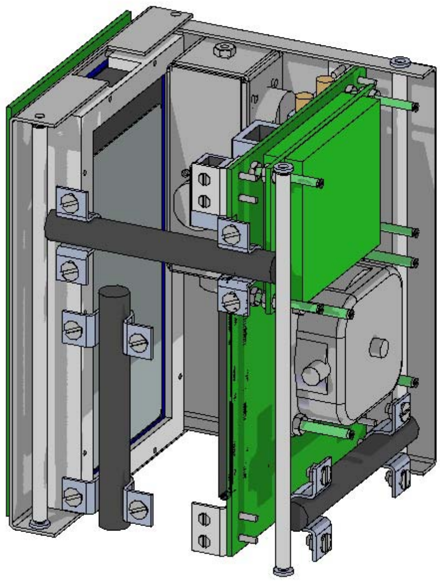

Figure 4. STRaND-1 Payload Bay

To control the high performance computer (HPC) and smart-phone using I^{2}C, an interface board is used to decode and command these payloads. The smart-phone is modified only at the power switch and uses a custom micro-USB connector which is soldered to the HPC. An additional C328A imager with lens is used to capture the phone screen and operations should further links fail. The smart-phone operates the Android 2.3 operating system (OS) which is primarily based on a modified Linux 2.6 kernel. The HPC also operates Linux 2.6 and can be connected via telnet and IP networking applications on both platforms. Other “apps” will include taking images/video footage, lossless compression algorithms, and operating the telemetry logging app (shown in Figure 5).

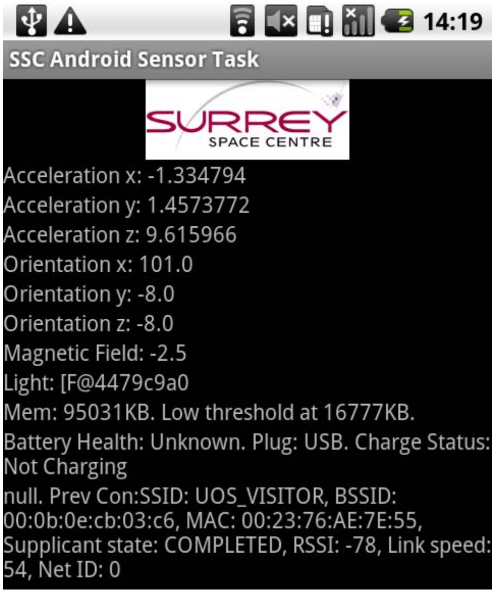

Figure 5. SSC Telemetry Logging App

The aim of these applications is to assess the state of various components on orbit, from the light, magnetic and acceleration sensors to computational loads, as well as providing compressed data to be downloaded. Other applications will look at fault detection and recovery from single event effects (SEEs) using autonomous software agent middleware from previous Surrey Space Centre research [8]. The same agent middleware is also under way for controlling and communicating with other satellite subsystems; shown in Figure 6 as IP-networked devices.

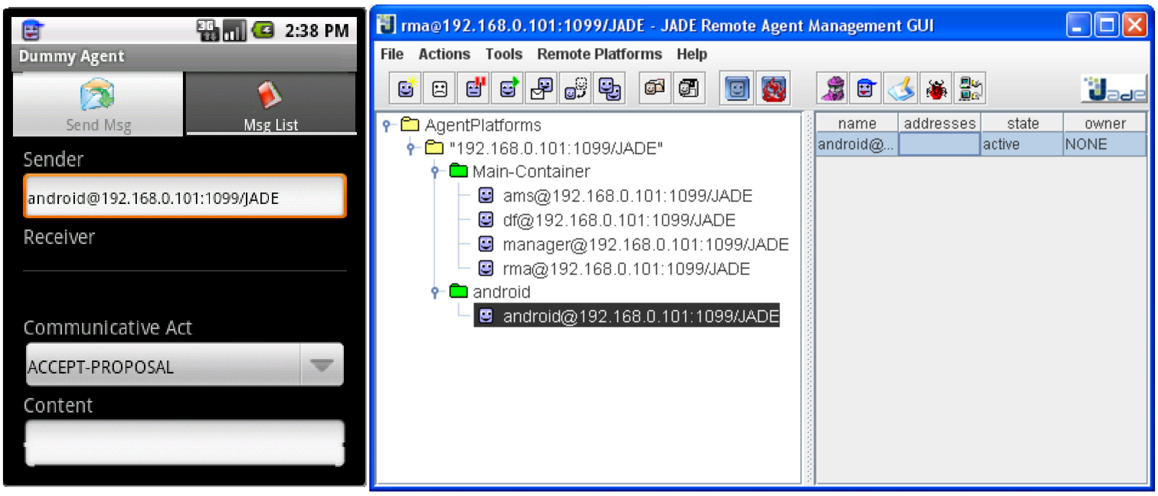

Figure 6. Agent Middleware Screenshots on the smart-phone & laptop

The smart-phone has already undergone thermal-vacuum, and total ionising dose experiments as part of the rigorous ground testing expected with such a high risk payload. Thermal ranges swept between -10 to 70 °C and vacuum tests were carried out at 10^{-4} mbar for 3 hours. Radiation results are currently underway and are being carried out at National Physics Laboratory (NPL), London, using a Cobalt-60 gamma-ray source. Further tests are planned in the coming months.

2.3. STRaND-1 Operations and Programmatics

Launch is a notoriously difficult segment of any CubeSat development, and STRaND-1 is no different. At the time of writing, no specific launch is officially planned for the satellite, although it is expected that a Q4 2011 launch is feasible. Subject to launch availability, the decision was made at the mission design phase that a circular orbit of 550km, sun synchronous inclination would be a reasonable assumption and any sizings or engineering trades would use this rule-of-thumb for the final orbit until a launch is secured. An early decision was made to only pursue low-Earth orbit (LEO) launch opportunities, due to radiation dose concerns in other orbits. Single-event effects (SEEs) will be mitigated using Surrey's normal methods of memory washing with error-detection and correction (EDAC) coding, and over-current protecting power switches to mitigate single-event latch-up (SEL).

The power budget analysis for STRaND-1 is also different to the standard process for SSTL. In SSTL it is standard practise to start with the mission requirements or any customer requirements in relation to payload duty cycle and to calculate from there the required power sizings necessary to meet the requirements. STRaND-1 benefits from not having a set of commercial payload operation requirements, and so the problem was inverted. The power budget is now approached from the starting point of available solar cell area and then the available duty cycle for payload operations for every subsystem and payload is calculated.

The ground segment to be used is based-lined on previous groundstation activities in the GENSO Project with the European Space Agency (ESA) and can be found in Figure 7.

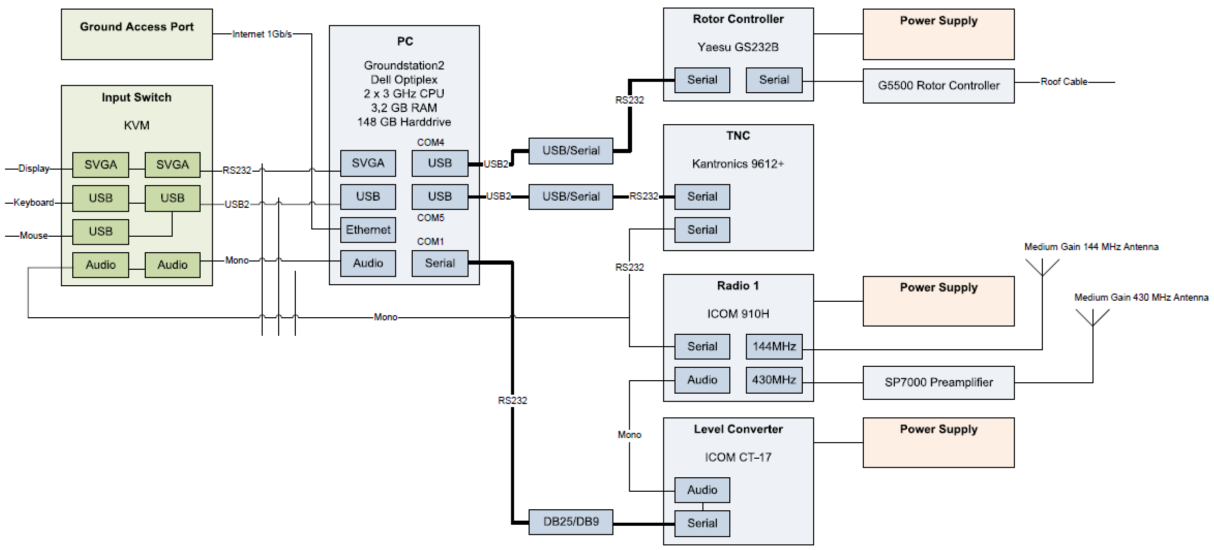

Figure 7. Surrey Space Centre Ground Segment

As the concept of operations for STRaND-1 is expected to be dynamic and reactive, flexibility in the operations schedule are key. There is no ‘nominal operations’ concept for STRaND-1 and so the power budget was calculated as a function of a set of core operations, ensuring that depths of discharge did not exceed 20% for any single operation per orbit. Additionally, none of STRaND-1’s payloads demand challenging pointing requirements, this allows the operator to control the attitude to maximise the power generation by ensuring that the angle between the sun angle and the solar panel normal vector is kept to a minimum.

Mentoring on STRaND-1 is another aspect where the process is experimental and part of the innovation of the programme. In this case, the onus is very much on the volunteer to initiate the mentoring process, and decide on the appropriate level of mentoring. Assessment of the stealth review method is ongoing. A key finding so far is that the engagement of the reviewer is strong indicator of the effectiveness of the stealth reviewing. Some stealth reviewers are highly engaged with the volunteers and when this is the case the volunteer benefits greatly from the review sessions. This implies that there is a profile for the ideal Stealth reviewer, and they must have the time flexibility to allow for unannounced reviews and passion to remain interested in the volunteer’s progress. Further observations and collation of anecdotal evidence will feed into a more thorough assessment of the Stealth review process at the end of the mission.

Both SSC and SSTL have capped budgets for STRaND-1. This cap forces the team to be careful with component purchase, and also prevents STRaND-1 from being a purely integration project only. Large expenditure decisions in SSTL on STRaND have followed a procedure that considers:

- Is the component mandatory for spaceflight?
- Can we build it ourselves?
    - Is the cost of building it ourselves comparative to purchasing one?
    - Is there the potential for commercialisation of a surrey-built alternative?
    - Can we build it better than what’s commercially available?
    - Can we develop it in time?

Following this process of considerations, it was deemed more suitable to develop the following sub-systems in-house: antenna assembly and deployment mechanism, VHF/UHF transceiver, solar arrays, butane propulsion system, and launch deployment mechanism (project called ‘S-POD’).

SSTL and SSC are now on separate sites. Unfortunately, this means that collocation of the STRaND-1 team is not possible, but also given that STRaND-1 is a free-time project all the volunteers have separate roles and are collated with their colleagues on work-time projects. The situation has led to reliance on conventional teleconference technologies, but also technologies that are still being rolled out in institutions such as Instant messaging, VoIP, and for more technical cooperation activities, virtual desktops. In some cases, even social networking websites such as Facebook and Twitter have helped communication during out-of-hours conferences. STRaND-1 has also attempted innovative information sharing techniques.

Online storage to share information between the two sites has been an experiment with varying results. Google Docs was assessed at the beginning of the project for the sharing of documents and imagery. However, the support for wider file formats such as CAD packages and diagram packages was not as mature as that for more common file types such as spreadsheets and text documents, and so an SSTL-hosted FTP site was set up instead.

Figure 8. S-Android Logo

The opposite finding was found for the sharing of software. STRaND software collaboration (non-Android) is hosted using GIT, a software revision control repository [9]. For wider collaborations with NASA and Google, Surrey Space Centre founded a Google Code project called ‘S-Android’ for the sharing of source code pertaining to the smart-phone [10].

3. Conclusion

This paper has discussed many of the processes that both Surrey Satellite Technology Ltd. and Surrey Space Centre have been implementing to train new engineers, lever off University research, help fly novel payloads, and challenge industry concepts in managing spacecraft missions.

Unlike other nanosatellite programmes, STRaND chose a CubeSat to leverage existing expertise at Surrey Space Centre, but also to provide a standard design compatible with commercially available CubeSat subsystems. Both teams successfully work closely together using a variety of online software tools which gains improved visibility with each organisation which led to knowledge transfer and the development of new skills.

Payloads include an advanced and capable attitude and orbit control system, a new high performance computer, a modern smart-phone with Android operating system, and a novel electric propulsion system and high performance AOCS – making this one of the most advanced CubeSat yet designed.

Acknowledgements

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4. References

[1] C. Underwood, G. Richardson, J. Savignol, "SNAP-1: A low cost modular COTS-based nano-satellite - Design, construction, launch and early operations phase" in Proc. for Fifteenth AIAA/USU Conference on Small Satellites, Logan, UT, 13-16 Aug. 2001

[2] N. Fishwick, "LunchSat, a training programme for young professionals in EADS Astrium to build a nano-satellite", in Proc. for the 61st International Astronautical Congress 2010, (IAC '10), October 2010, Prague, Czech Republic

[3] GomSpace, NanoMind A702 Datasheet, Online: http://www.gomspace.com/documents/GS-DS-NM702-1.5.pdf (last accessed 24.01.2011)

[4] Clyde Space, 3U CubeSat EPS, Online: http://www.clyde-space.com/cubesat_shop/eps/12_3u-cubesat-eps (last accessed 24.01.2011)

[5] Clyde Space, Integrated Battery Daughter Board 20Whr, Online: http://www.clyde-space.com/cubesat_shop/batteries/15_integrated-battery-daughter-board (last accessed 24.01.2011)

[6] University of Stellenbosch, CubeSense, Publication unavailable

[7] Surrey Satellite Technology Ltd., SGR-05U – Space GPS Receiver Datasheet, Online: http://www.sstl.co.uk/Downloads/Datasheets/SGR-05U-v1_13 (last accessed 24.01.2011)

[8] C. P. Bridges, "Agent Computing Platform for Distributed Satellite Systems", University of Surrey, PhD Thesis, November 2009

[9] GIT – Faster Version Control System, Website, Online: http://git-scm.com/ (last accessed 24.01.2011)

[10] Google Code, S-Android (Space Android: Android for Space Subsystems), Website, Online: http://code.google.com/p/s-android/ (last accessed 24.01.2011)

5. Biographies

Dr Christopher P. Bridges is a Research Fellow in the Astrodynamics Group at Surrey Space Centre. He gained his BEng in Electronic Engineering from the University of Greenwich and completed his PhD in 'Agent Computing for Distributed Satellite Systems' at the University of Surrey in 2009. He won the PhD+ scholarship to continue work on CubeSat computing payloads and Java technologies and has since started in the Astrodynamics Group on mission analysis and a visual inspection payload with EADS Astrium.

Shaun Kenyon is a Mission Concepts Engineer at SSTL specialising in feasibility analysis for future nanosatellite and microsatellite concepts, and enabling technologies. He graduated with an MEng in Aerospace Engineering from the University of Southampton in 2006, and has since worked on various projects including Space Situational Awareness, ORS, and Galileo.

Dr. Craig I. Underwood is Deputy Director of the Surrey Space Centre and is PI for the STRaND programme. As Chief Architect of SNAP-1, he brings unique experience of academic/industrial collaboration on rapid-development nano-satellite programmes and has over 25 years of space engineering experience. He is an expert on the space environment and space instrument design, and is responsible for the academic overview of STRaND.

Professor Sir Martin N. Sweeting, B.Sc.Hons., PhD (Surrey), FRS, FREng., FIEE, FRAeS, FBIS, SMIEEE, SMAIAA, MBIM, MIAA has pioneered the concept of advanced microsatellites utilizing modern commercial-off-the-shelf (COTS) devices for 'affordable access to space.' After completing BSc & PhD degrees at the University of Surrey, in 1985 he formed a spin-off University company (SSTL - Surrey Satellite Technology Ltd) which has designed, built, launched and operates in orbit nano, micro, and minisatellites - making SSTL the world's leading microsatellite company. He has been responsible for the leadership and management of the Company which by 2006 has grown to 300 commercial staff. Sir Martin is also Director of the Surrey Space Centre, leading a team of 90 faculty and doctoral researchers investigating advanced small satellite concepts and techniques. Sir Martin was knighted by HM The Queen in the 2002 British New Year Honours for services to the small satellite industry.