Annual Report

2020/21

SMARTSAT
COOPERATIVE RESEARCH CENTRE

Contents

Executive Summary

I am delighted to introduce SmartSat's 2020/2021 Annual Report. This has been a year unlike any other, and I would like to commend our entire community for continuing to deliver quality outcomes as we navigate the ongoing challenges presented by the global COVID-19 pandemic. Despite travel restrictions and limited face to face interactions, we have still managed to rapidly accelerate our strategic R&D activities which will put us on a path to success to shape the future of the space industry.

We have recently pivoted our research strategy to focus on conducting mission-oriented R&D that will develop and integrate technologies, subsystems and systems to demonstrate the utility and impact of these technologies. Three Capability Demonstrators (CDs) have been initiated to build capability and address Australia's national challenges. These CDs are: AquaWatch Australia (water quality monitoring), I-in-the-Sky (disaster management/climate change resilience) and the Indo-Pacific Connector (Defence & National Security).

The establishment of the SmartSat state nodes is ongoing. The NSW node has formally commenced operations and planning for the QLD, ACT, WA and VIC nodes is well underway. Our Education & Training program continues to grow, with a cohort of over 24 PhD students, and more in the pipeline. Having published Phase 1 of the Australian Space Industry Skills Gap Analysis we are now looking to commence Phase 2 to support the future needs of the Australian space sector.

Our other significant achievements for the year are outlined throughout this report. Of course, none of this would be possible without the ongoing support of our fantastic partner network. I would also like to thank the SmartSat Board of Directors and our team of dedicated staff for their ongoing efforts to ensure that we deliver on the SmartSat vision.

Prof Andy Koronios
Chief Executive Officer

Chair's Foreword

The 2020/21 year has been unlike any other, as our nation and the world continue to grapple with the ongoing impacts of the COVID-19 pandemic. Momentum in the space industry, however, continues to grow.

Other notable industry activities include the Parliamentary Inquiry into Developing Australia's Space Industry, the Australian Space Agency's Moon to Mars initiative and release of their Communications Technologies and Services Roadmap, the commencement of the 2030 Space and Spatial Industries Roadmap consultation and the announcement of the UK-Australia Space Bridge Framework. We are working hard to ensure that SmartSat is strategically aligned with these critical initiatives and will continue to work closely with our 100 partners, including 60 startups who joined our Aurora Space Cluster establishment phase, to contribute to the development of a fully functioning and thriving space ecosystem.

This year we have pivoted our research program towards mission-oriented R&D to address Australia's major challenges, such as water and land management and defence and national security. To do this, we will establish a portfolio of Capability Demonstrators that will develop and integrate technologies, systems and subsystems to demonstrate the utility and impact of these technologies.

On behalf of the Board, I would like to thank the Cooperative Research Centre Program for its ongoing guidance and support of SmartSat. I would also like to extend my thanks to the Board of Directors, SmartSat's CEO, Professor Andy Koronios, the management team, staff, and our participants for another significant year of progress. We remain committed to delivering high impact research and innovation to create opportunities for the nation and are excited to see what the next year holds.

Dr Peter Woodgate
Chair

Achievements

Governance

Dr Peter Woodgate	Chair
Prof Andy Koronios	CEO & Managing Director
Dr Michelle Allan	Director
Dr Jacqueline Craig	Director
Michael David AO	Director
Dr Rosalind Dubs	Director
Prof Margaret Harding	Director
Dr Danielle Wuchenich	Director
Kris Trott	Company Secretary

- Eighth Board member appointed (Dr Danielle Wuchenich)
- Additional members appointed to the Audit, Risk & Compliance, Research Investment and Diversity & Inclusion Committees
- Aurora Board of Directors appointed
- Strategic Plan approved

People & Operations

- Additional five staff recruited
  - Chief Research Officer
  - Two Research Program Managers
  - Administration Assistant
  - Marketing & Communications Officer
- New project management system implemented
- Staff Health & Wellbeing Program launched
- Diversity and Inclusive Leadership training for partners
- Stage 2 of the collaborative research study with the Inclusive Organisation

Education and Training

- 24 PhD scholarships allocated
- Completion of the Australian Space Industry Skills Gap Analysis
- Conducted a series of industry webinars to provide training supporting the Australian Space Agency's Demonstrator Program

Research & Industry

- Sector Priorities published in consultation with End-User Advisory Boards for:

Agriculture and Natural Resources

Defence and National Security

Mining and Energy

- Capability Demonstrator objectives developed and technology pathways drafted

- The Kanyini satellite mission (previously SASAT-1) funded by the SA Government

- 43 projects approved during the period

- Firefly Ideation Challenge launched with Trusted Autonomous Systems Defence CRC

- High-Altitude Pseudo Satellite (HAPS) Challenge launched in collaboration with Defence Air Warfare Centre, the TASD-CRC and RMIT

- AI4Space Research Network Steering Committee & Strategy established

Marketing & Communications

10
Media releases issued announcing projects, partnerships and appointments

5
Newsletters published providing update on research and industry activities

- Monthly Infocomms updates to all SmartSat participants and key stakeholders

- Kanyini (previously SASAT-1) project and naming competition launched by South Australian Premier Steven Marshall

- Appeared at the Commonwealth Parliamentary Inquiry into Developing Australia's Space Industry

- Exhibition Booth and Guest Speaker at the 11th and 12th Australian Space Forum

- Events and activities to share knowledge, learn from global experts and engage stakeholders

- Seven Distinguished Speaker events with over 550 attendees

- Demonstrator Webinar Series to support the ASA's Demonstrator Feasibility Grant

- NSW Node launch in partnership with NSW Government

Partnering with Industry

SmartSat's research is informed by end-users and driven by our partners. Over ninety percent of the research projects approved during the reporting period included at least one industry and one research provider, and several projects were established following an industry-led project call.

To achieve this outcome, SmartSat engaged with industry to ensure research aligns with sector needs. This included hosting several industry-led briefings with project partners and SmartSat team members to review outcomes of initial projects and concepts for the next stage. These briefings reviewed the viability of the research and commercial potential of the technology.

Key highlights of industry engagement this year include:

- Two projects with significant industry input and participation, Coherent Free Space Optical Comms and Compact Hybrid Optical/RF User Segment (CHORUS) have progressed into a second phase following further industry consultation on Phase1 outcomes.

- Undertaking a Partner Survey which provided valuable information allowing SmartSat to map partner capabilities, interests and needs so as to validate the technology roadmap and research strategy. This "SmartSat Ecosystem Map" will help bring industry and research partners together to build significant partnerships and projects. Feedback in the survey also helps SmartSat identify project opportunities, workforce development and PhD opportunities.

- SmartSat is one of the key stakeholders of the 2030 Space and Spatial Industry Growth Road Map initiative. This initiative aims to identify the drivers for industry growth, and develop a plan to deliver this growth to benefit Australia through better utilisation of space and spatial technologies and capabilities.
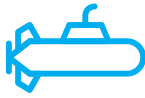
End-User Advisory Boards

Throughout the year, SmartSat's Industry team worked closely with its' three End-User Advisory Boards (EAUBs):

Agriculture and Natural Resources
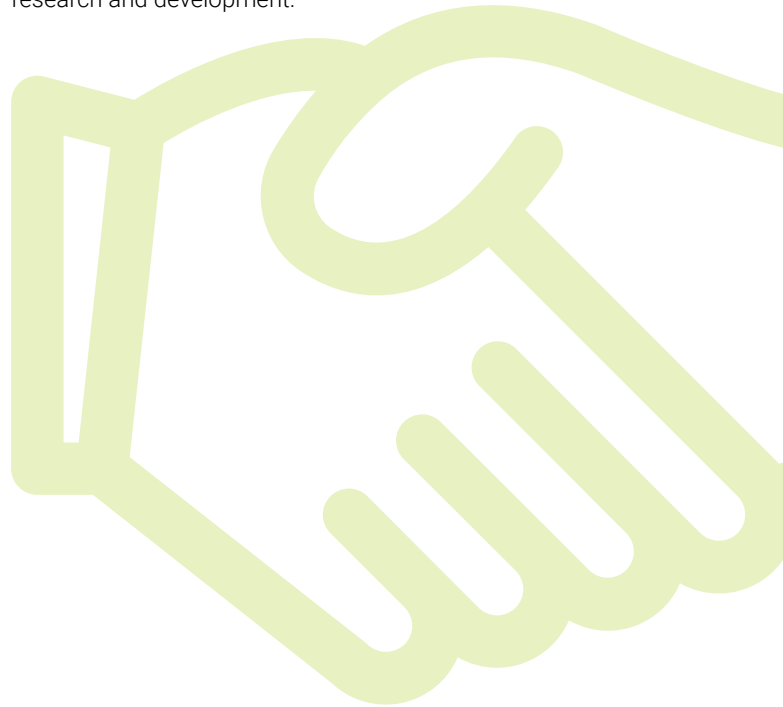
Defence and National Security

Mining and Energy

These Boards consult widely within their industry across Australia, and provide expert, balanced advice to the SmartSat Board to support effective decision making on behalf of their respective sector. An extensive consultation process through the End-User Advisory Boards as well as the Industry Advisory Board was undertaken to provide guidance to SmartSat's research and innovation activities during 2021-2022.

End-User Sector Priorities

Under the guidance of SmartSat's Industry and Deputy Industry Directors, the End-User Advisory Boards identified the challenges and needs of their sector and formed working groups to develop their respective Sector Priorities. Sector Priorities have been developed with the three EUABs and these will inform the SmartSat Research Program and help improve the sustainability and prosperity of critical sectors through harnessing transformative space industry technologies. Across each of the sectors, common problems have been identified which further highlighted the need for strong and robust cross-sector collaboration and the need for the space industry to leverage and pivot its technology and capability to service multiple sectors.

The priorities identified can be used by SmartSat partners and the space community to help guide the development of project proposals and identify priority areas for further research and development.
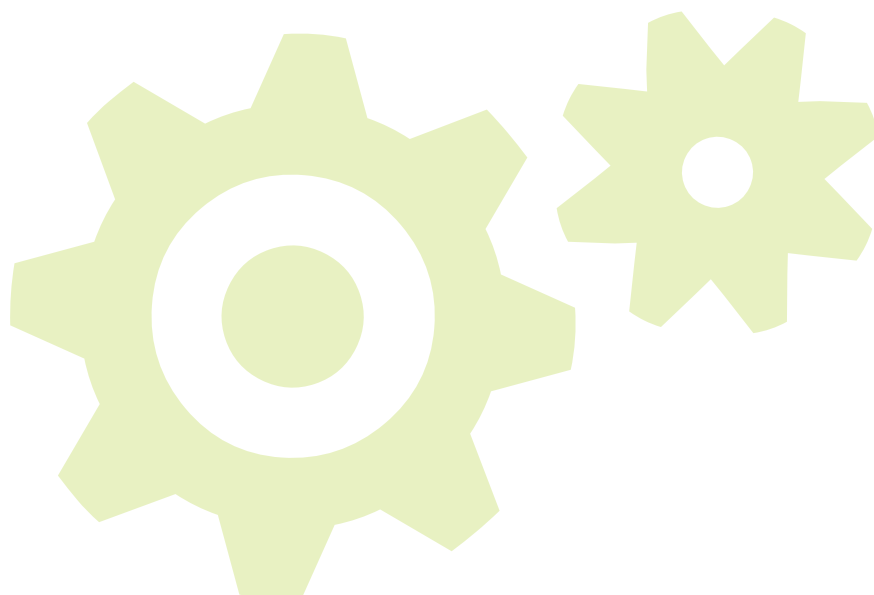
Agriculture and Natural Resources Sector Priorities 2021

Purpose	To improve the sustainability & prosperity of the Agriculture and Natural Resources sector through harnessing transformative space industry technologies

Summary	• The global space industry is growing at a rate of 9.5% compared to the global economy of 2.5% and it is expected to reach >$1 trillion in the next few years. • Transformative space technologies in the fields of connectivity, Earth Observation and positioning can help revolutionise the Agriculture and Natural Resources sector. • Optimising supply chains, managing risks and managing assets are key areas of the Agriculture and Natural Resources sector where space technologies can have significant impact.

Sector Needs	**Optimising Supply Chains** Enhancing supply chain profitability through better informed, accurate and timely decision making and reducing operational costs.	**Managing Risks** Better identification, monitoring, mitigation and reduction of costs associated with sector risks including environmental, fiscal and WHS.	**Managing Assets** Improved monitoring, management and utilisation of key infrastructure, plant and machinery, and labour.	**Sustainability** Improve sustainability of the agricultural industries and our natural resources consistent with societal expectations while maintaining financial outcomes.
Research Focus	**Enabling digitisation and data-driven decisions** Connectivity capability that enables the adoption of digital technologies and supports more data-driven decision making. The ability to monitor and predict production outcomes with an improved ability to make tactical decisions. **Improved supply demand forecasting** Scalable tools and analytics that provide better supply/demand forecasting (domestically and globally) and support both pre and post farmgate decision making, e.g. purchase and deployment of inputs, end-product sales or purchasing strategies etc. **More informed production tactics** Developing production tactics to maximise productivity and optimise returns from management of pastures, cropping, horticulture and livestock. New approaches to monitoring and maintaining livestock condition from paddock to processing and managing livestock yield, grazing, and watering.	**Planning and responding to threats** Monitoring, mapping, and modelling tools to help businesses better understand, plan for, and respond to key threats including biosecurity, drought, fires and floods and other threats across the supply chain. **Reducing the cost of uncertainty** New tools and analytics that reduce the costs and improve options relating to financial instruments, e.g. mortgage, insurance, investment. **Improving workplace safety** Farm owners and managers need to make sure that workers and other people on farms are not exposed to risks to their health and safety. Improved monitoring and handling of equipment and animals is important to reducing exposure to these risks.	**Managing Key infrastructure** Management and quality of key infrastructure is critical to the production and movement of agricultural products within and out of the country. Monitoring and control solutions that help track the status and support the operation of key physical infrastructure, e.g. roads, rail, ports, dams, irrigation etc. **Efficient use of plant, machinery and labour** Total management of machinery and labour is a significant cost component of agricultural production. There is an opportunity to optimise these costs through remote monitoring and analytics to improve utilisation. Transportation and logistical planning solutions that improve the utilisation efficiency of Total Plant, Machinery and Labour (TPML). **Supporting autonomous and remote operations** Autonomous and remote operations technologies that help reduce the costs and address shortfalls in labour and improve the timeliness and efficiency of key operations.	**Supporting natural assets** Monitoring and control solutions that support prosperity through sustainable practices, land use planning and the maintenance of high-quality natural assets e.g. waterways, soils and native flora and fauna etc. **Protecting animal welfare** Maintaining the welfare and health of livestock and native animals to meet standards consistent with sustainable production and societal expectations. **Addressing climate change threats** Programs to manage the impact of the agricultural industries on climate as well as their resilience with respect to the impact of climate change. Optimising carbon sequestration opportunities. **Drive environmental stewardship** Monitoring and assessing performance against the community's expectations with respect to sustainable agricultural businesses and management of natural resources.

Strategic Principles and Objectives	There is an overarching requirement to identify and define user needs and to enable adoption, reduce duplication and establish implementable solutions to needs and problems with potential for commercialisation sitting above five strategic pillars: 1. Delivery of RD&E projects that harness disruptive space industry technologies to help transform the Agriculture and Natural Resources sector. 2. Building cohesive critical mass that is focused on key Agriculture and Natural Resources sector needs. 3. Partner with the private sector to ensure path to market and adoption of SmartSat CRC outputs through to commercialisation. 4. Communication that fosters adoption of new technologies and promotes collaboration. 5. Assembling Data Analytics solutions that are FAIR (Findable, Accessible, Interoperable and Reuseable).

Mining and Energy Sector Priorities 2021

Purpose	**To improve the effectiveness and sustainability of the Mining & Energy sector through the enablement of transformative space technologies**
Summary	• Australia's challenging geography and limited built infrastructure create a need for integration of innovative technologies into operations to maintain viability. • Transformative technologies in the fields of automation, robotics and data analytics can help revolutionise the Mining & Energy sector with aid from SmartSat CRC's enabled satellite technology. • Maintaining operational viability, countering resource quality reductions and managing Social License to Operate are key issues facing the Mining & Energy sector.

Sector Needs	**Value Chain Optimisation** Optimising value chain efficiency, operability, and profitability through increased digitisation and data tracking.	**Reducing Sector Risks** Management of evolving risks and threats to maintain sector safety and combat the increasing complexity and scarcity of resources.	**Social License to Operate** Management of issues sensitive to Social License to Operate including transparency, social expectations and corporate social responsibility.
Research Focus	**Enhanced Digitisation Across the Entire Value Chain** Digitisation capability that supports collection and connectivity of data across the entire value chain enabling data-driven decision making through connection IoT and digital twins. **Communications and Data Transfer** Communication and data transfer capabilities that support full value chain responsiveness. **Automation, Robotics and Artificial Intelligence** Capability and technology development to support industry uptake in automation, robotics, AI, deep learning, machine learning and data analytics.	**Cybersecurity** Cybersecurity measures to manage the evolving threats introduced by increased digitisation. **Enhanced Remote Operations** Enhance remote operating capabilities through sophisticated technologies to safely manage the growing complexity of resource extraction. **Resource Identification** Broaden and sharpen methods to discover previously unidentified resources in both explored and unexplored geographies.	**Clean Energy Technology Integration** Clean technology integration into both existing and future operations to reduce reliance on fossil fuels and to ensure that environmental targets are met. **Environmental Threat Management and Rehabilitation Transparency** Management, monitoring and mitigation of environmental threats imposed by operations across the entire asset lifecycle to ensure environmental and personal safety through Earth Observation technologies. **Health and Safety** Technology development to ensure the continued safety and wellbeing of all people within the workforce.

Strategic Principles and Objectives	1. Delivery of R&D programs that harness automation, robotics and data analytics to assist in the transformation of the Mining & Energy sector. 2. Development of skills in both the current workforce and STEM students to meet the needs of the future in the Mining & Energy sector. 3. Creation of a diverse, ethical and multicultural workforce that has a focus on safety and wellbeing programs to support healthy and productive work environments. 4. Communications that foster the adoption of new technologies and promote both intra-sector and cross-sector collaboration. 5. Develop and assemble data analytics solutions that are FAIR (Findable, Accessible, Interoperable and Reusable).

Defence and National Security Sector Priorities 2021

Purpose	**To drive and support collaborative research and development for assured, sovereign access to space systems and services that safeguard Australia**
Summary	• Research proposals contribute to the development of resilient space systems and services to drive future national security capabilities. • Ongoing support for cutting edge S&T to understand and mitigate risk, characterise performance and demonstrate independent national space capabilities. • Australian Space Industry positioned for sustainable growth in a globally competitive market. • Commercially attractive systems and services, that also meet Australia's security needs have been developed. • Develop a trusted, secure and informed collaboration environment into which participants will bring their best people, capabilities and ideas.

Sector Needs	**Networked Capabilities** Create new ways to integrate and use capabilities through secure, resilient and adaptive communications networks.	**Situational Awareness** Using space to sense all of our operating environments to support agile C2 and multi-domain operations.	**Autonomous Space Operations** Trusted autonomous operations and responding to what is happening in space more rapidly than adversaries.	**Rapid Prototyping** Rapidly develop and deliver advanced technologies in space as a key enabler of responsive space capabilities.
Research Focus	**Resilient Tactical Comms** Offer robust, secure connectivity to highly mobile users through adaptive, power and bandwidth efficient data links and agile contention schemes. **High-Capacity Communications** Provide efficient and effective utilisation of available spectrum, including optical, to increase secure network capacity to all classes of users under all conditions. **Cognitive Networks** Contribute to the ability to sense and respond autonomously to changes in network conditions in response to internal or external stimuli. **Timing Signals** Access or extract high accuracy timing information to support synchronisation in contested environments.	**Novel Sensors** Development of novel technologies and techniques, including distributed apertures and dynamic payloads, to create higher spectral, spatial and temporal resolution of earth. **Multi-Sensor Integration** Combining sensor data capturing diverse phenomenology to enhance understanding of the operational environment including through intelligent fusion and change detection. **Intelligent Processing** Exploiting Artificial Intelligence (Machine and Deep learning), including satellite processing, to enhance timely delivery & human understanding of all types of sensor data.	**Intelligent Constellations** Spacecraft/constellations that can autonomously operate, sense and react to their immediate environment and contribute to space domain awareness. **Space Domain Understanding** Creating predictive tools that allow observations to become forecasts so response times to hazards can be reduced or eliminated. **Cyber Security** Ensure that effective cyber security is designed in and verified to facilitate high levels of trust in space systems, especially automated and autonomous implementations.	**Space Hardware** Ensure access to design, manufacturing and testing expertise including satellite mission system, C2 and payload development aligned with assured sovereign access. **Digital Twins** Development of skills, tools and infrastructure for cost effective digital engineering to reduce space system development time, risk, cost of ownership, improve agility and support autonomy.

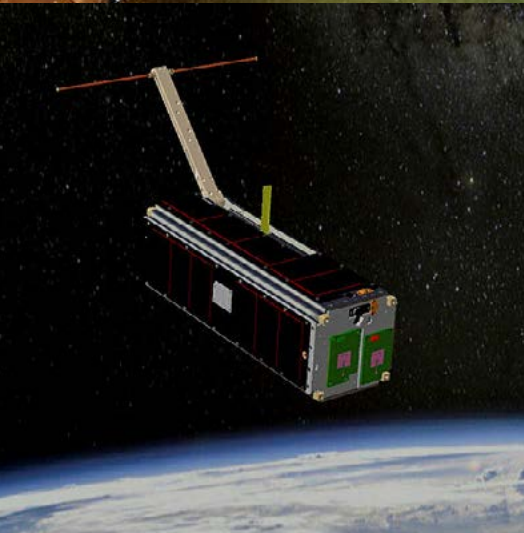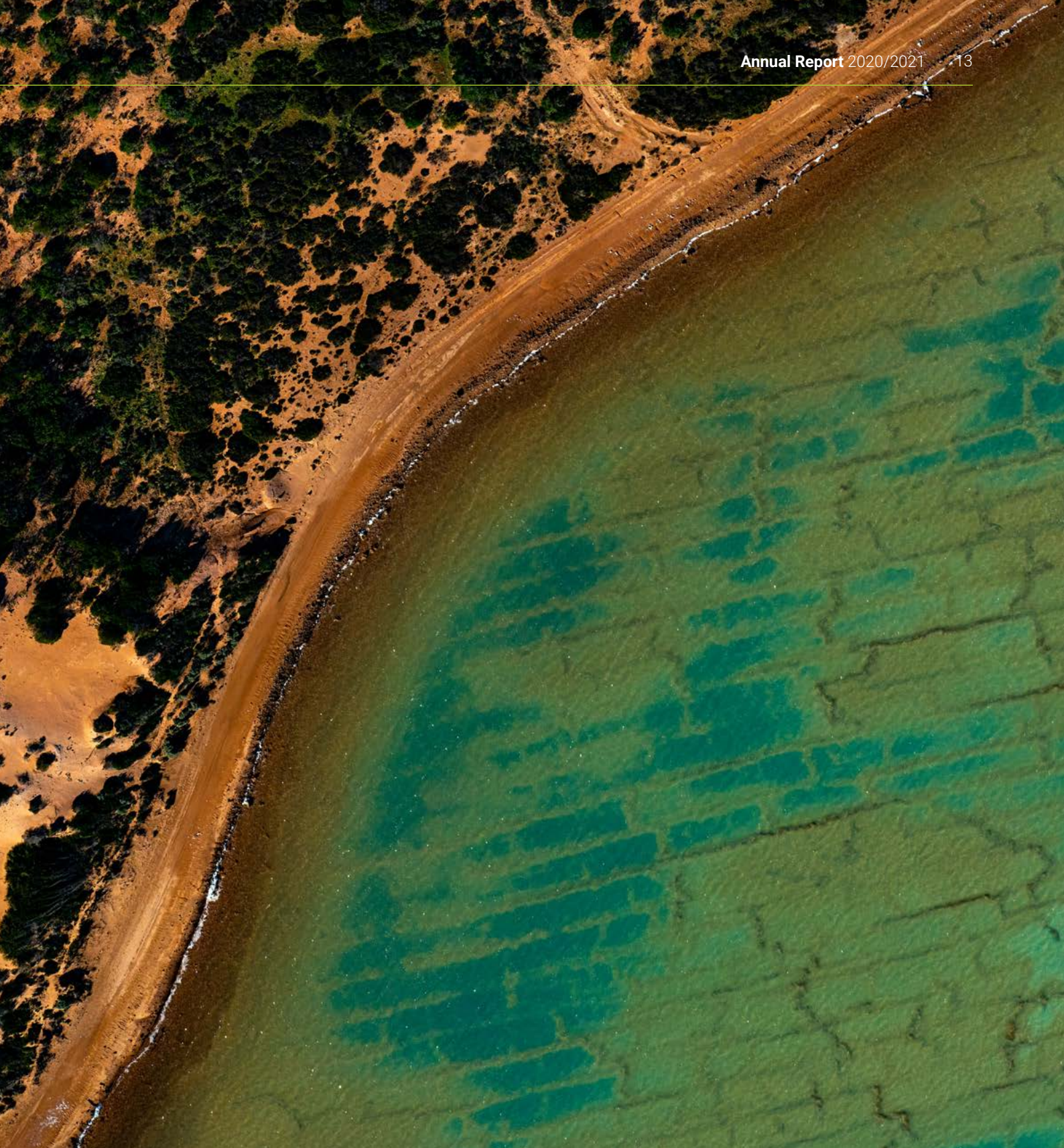| Strategic Principles and Objectives	1. **Aligned:** Agile research that addresses opportunities identified in More Together, 2020 Defence Strategic Update, Force Structure Plan and broader national security needs. 2. **Aware:** SmartSat remains aware of, and works to support, the differing needs of the Defence and National Security space R&D ecosystem. 3. **Connected and Collaborative:** Connect people and facilitate collaborative and coordinated partnerships between Academia and Industry (incl Defence and international) to further Defence and National Security Space Requirements. Should address high-risk/high-payload opportunities that exploit synergistic strengths within our partner network. 4. **Differentiated:** Internationally competitive with a focus on national strengths, including basic science and disruptive technologies, not playing catch-up. 5. **Digitally Engineered:** Use next generation "digital engineering" approaches to understand opportunities and evolve solutions more rapidly. 6. **Dual-use (Commercial):** SmartSat will support programs which generate technology that can be adapted to other markets, and which have commercial applications that work to grow the viability of Australia's space industry. 7. **Infrastructure:** Create R&D efficiencies through access to highly specialised space related infrastructure and personnel. 8. **STEM/Workforce:** SmartSat will work with Academia to support and focus national STEM education and training goals and leads on the targeting and coordination of space research education and specialist skills development programs, pursuing where feasible the creation of centres of excellence, that enables the generation of space related programs that have the critical mass to be economical and sustainable. 9. **Value-for-Money:** Access to ongoing lines of funding to secure and sustain Australia's space focused R&D supporting the Defence and National Security sector.

Image credit: Sage Swinton/
Australian Community Media

Supporting Industry Growth

State Nodes

To support the growth of the space sector nationally, SmartSat has established State Nodes in NSW, Victoria and Queensland, and will expand to South Australia, Western Australia and ACT in the next financial year.

SmartSat's NSW Node was launched in March 2021, as a joint project with the NSW Government's Space Office and the Office of the NSW Chief Scientist & Engineer, to support industry and research collaboration and commercialisation of space-related technologies. The NSW Node will run three separate grant programs and a regular events program to drive industry-research teaming and collaboration for space industry growth and R&D commercialisation impact.

The Victoria Node was launched in June as the RMIT Space Industry Hub. The investment in the Hub from SmartSat has been equally matched by the Victorian Higher Education State Investment Fund. Significant technical and training support will be provided by Amazon Web Services (AWS), as well as industry engagement backing from FrontierSI. Based at RMIT University, SmartSat's Victorian partners, including Deakin University, LaTrobe University, Swinburne University and RMIT University, will be able to participate in joint projects with Victorian industry. The Hub will provide affordable access to real-time satellite data for industry collaborators through AWS Ground Station.

SmartSat has signed an MOU with the Queensland Department of State Development, Infrastructure, Local Government and Planning to support the SmartSat Earth Observation Hub in Queensland. The Queensland Government's Queensland Space Industry Strategy 2020 – 2025 sets out key actions for strengthening Queensland space capability and growing the Queensland space industry. This strategy includes the development of a space-derived data analytics and commercialisation hub, based at the University of Queensland.

Aurora Space Start-Up Cluster

SmartSat is committed to supporting Australia's growing SME and startup space ecosystem and after twelve months of foundational work launched the Aurora Space Startup Cluster. Aurora aims to provide a framework for startups to grow together in commercial collaborations with one another, with research organisations, and with local and international primes, to win business, commercialise leapfrog R&D, and build world-class capabilities in ways that would otherwise be difficult by themselves.

In November 2020, an inaugural Board was voted in and shortly thereafter a brand identity for Aurora and a new website was launched. Aurora's establishing membership grew to over 60 member companies representing every part of the space supply chain – from rocket launch services, in-space computing, precision sensors, satellite digital twin technology, in-orbit and deep space operations, right through to ground station antennae development and Earth data applications for agriculture, resources and sustainability management.

Defence Industry Support

SmartSat seeks to help its industry participants engage successfully in the opportunities for Australia's space sector identified within the 2020 Defence Strategic Update. The Force Structure Plan, released with this update, included space as an operating domain and highlighted more than $7B of new capability acquisitions over the next 10 years allocated for space systems and services.

SmartSat is seeking to identify pathways for research projects to achieve impact in defence and national security through demonstration of advanced Australian developed technology. One such mechanism is the Defence Resilient Multi-mission Space Science and Technology Shot (RMS STaR Shot). In addition to the step-up in capability funding and the focus on space technology innovation, Defence has also recently added space as a Sovereign Industry Capability Priority area.

These collective changes within Defence have led to the establishment of the Indo-Pacific Connector Capability Demonstrator to accelerate research utilisation activities and ensure SmartSat resources are allocated to areas most likely to deliver outcomes for our industry partners.

ASA Moon to Mars Program Webinars

Following the Australian Space Agency's Moon to Mars Demonstrator Feasibility Grant, SmartSat offered a series of webinars to support organisations preparing for the challenges and requirements involved in developing space ready capabilities.

SmartSat CRC partners and the wider space industry supported these webinars by providing experienced personnel to prepare and present the webinar topics.

SmartSat CRC would like to thank all the presenters from the following organisations:

- The Australian Space Agency
- University of South Australia
- Myriota
- Nova Systems
- Fleet Technologies
- Airbus
- SSTL (Surry Satellite Technology Ltd)
- MSSL (Mullard Space Science Lab)
- Defence Science and Technology Group

As well as the presenters for upcoming seminars:

- Airbus
- Australian National University
- Shoal Group
- Sabre Astronautics
- Fugro
- Curtin University
- University of Western Australia
- Southern Launch

These webinars included the topics:

- Systems Engineering and the Project Life-Cycle overview;
- Introduction to Australian Space Regulation (e.g. licensing and spectrum allocation);
- Space Environmental Challenges (2-part series);

Further webinars are scheduled to take place in the 2021-22 period:

- Systems Engineering – NASA and ESA standards
- Spacecraft Operations
- Launch Licenses and Regulations

Research

As the suite of research projects expanded to forty-three, the project portfolio significantly increased in diversity in line with SmartSat's Technology Roadmap.
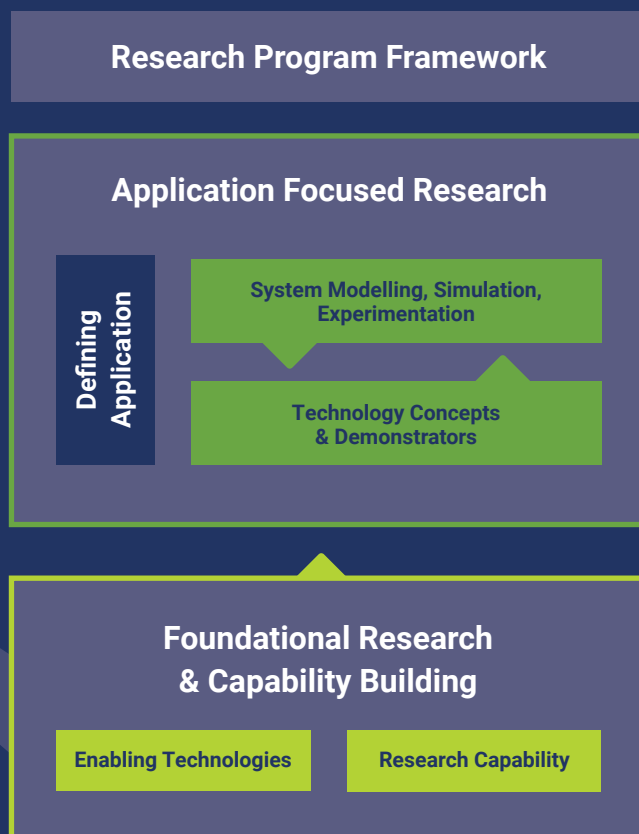
A number of research projects transitioned from a successful Phase 1 program of work to Phase 2. Additionally, the research portfolio progressed into new spaces including quantum, cybersecurity and Earth Observation flood mapping, ensuring SmartSat's research continues to lead developments in the space sector, and allowing a transition into key focus areas.

The SmartSat Research Framework

To ensure that SmartSat aligns with its guiding principles it is useful to place the research program within a strategic framework that supports a balance of investments inclusive of:

1. **Short, medium, and long term outcomes;**

2. **Foundation to applications research;**

3. **From commercial to national need;**

4. **From novel ideation to end-user driven; and**

5. **Research projects will be scalable and capitalise on the cross-cutting potential of space technologies across various industries.**

The central pillar of this framework is application focused research defined through the End-User Advisory Boards or by direct engagement with end-users in the primary sectors of application. Technology concept and demonstrator development is guided by system modelling, analysis and experimentation which places the technology within the context of the end capability requirements.

Research Program Framework

Application Focused Research

Defining Application

System Modelling, Simulation, Experimentation

Technology Concepts & Demonstrators

Foundational Research & Capability Building

Enabling Technologies

Research Capability

Research Leadership Team

SmartSat's objectives can only be met with an outstanding and collaborative team. During the 2020-21 year, the Research Program Manager team was expanded which accelerated R&D activity under the leadership of the Chief Research Officer (CRO), Dr Nick Stacy, seconded through the DST Group. With the increased R&D activity it was necessary to make a full-time appointment in this role and Dr Carl Seubert was appointed as a full-time CRO. Carl has ten years of experience in research and technology development and space system design from NASA JPL. SmartSat's research is driven by industry through the leadership of the Industry Director, Dr Sarah Cannard and powered through the leadership of three Professorial Chairs, who have formed a Research and Development advisory group.

SmartSat Professorial Chairs

Assoc Prof Tat-Jun Chin

Professorial Chair of Sentient Spacecraft, the University of Adelaide's **Assoc Prof Tat-Jun Chin** is building Australia's largest research group dedicated to AI and machine learning for space and actively seek to partner with industry to ensure timely transfer of the research outputs to industry.

Prof Christopher Fluke

Professorial Chair of Space System Data Fusion and Cognition, Swinburne University's **Prof Christopher Fluke** will further develop capabilities in real-time, data-driven discovery and decision-making, and form collaborations with experts in artificial intelligence and machine learning, skilled performance, human factors research, cognitive assessment, and user-centred design.

Prof Jill Slay

Professorial Chair of Cyber Security, University of South Australia's **Prof Jill Slay** brings expertise in cyber security and critical infrastructure protection teaching and research will strengthen links to leading international research centres and build capability in this critical area.

A further six professorial chairs will boost this first-of-its-kind space R&D initiative, with the Australian National University, Sydney University, and the University of NSW also taking part in this nation-building space capability development along with future appointments from the University of South Australia with additional professorial chair appointments well underway.

Capability Demonstrator Missions

To provide maximum research impact, SmartSat has established three Capability Demonstrator missions. This goal-orientated research and innovation aims to meet some of Australia's major challenges including water and land management (AquaWatch Australia), defence and national security (Indo-Pacific Connector), and response to increasing frequency of natural disasters (I-in-the-Sky). Research outputs from these CDs may be translated for operational adoption by end-users as fully-fledged missions.

SmartSat will, by design, integrate the required combination of capabilities from the 27 priority areas set out in SmartSat's technology roadmap across the three primary research program areas:

1	Advanced Communications, Connectivity & IoT Technologies
2	Advanced Satellite Systems, Sensors & Intelligence
3	Next Generation Earth Observation Data Services

Fundamentally, the role of the SmartSat Capability Demonstrators is to increase the research tasks through a more focused and applied approach. The CDs are intended to advance research and technologies into the utilisation domain with shorter timelines and lower budgets but a higher risk posture. This includes the systems, subsystems and technologies that build capability and deliver solutions. SmartSat has identified the first three CDs in its portfolio:

AquaWatch Australia

Knowledge of water quality information from inland rivers, reservoirs and coastal zones is a critical requirement for the effective monitoring and management of this essential resource.

Access to safe and clean freshwater impacts rural and urban communities, agriculture, livestock and wildlife. Freshwater quality can be adversely affected by natural or man-made low river flows, warm temperatures, toxic algae blooms, hypoxic blackwater from floodplain inundation, bushfires, sediment and nutrients transport. Recent events like the Menindee region fish deaths (>1 million fish died in 2019) led to major environmental, political, economic and community concerns as well as significant economic loss. Similarly, coastal water quality is a key factor for fishing, ecosystem health, aquaculture, recreation, and tourism.

Preventing poor water quality requires improved monitoring, forecasting and management responses. Australia needs a comprehensive and bespoke monitoring capability with in-situ measurement and Earth Observation platforms that can be used to provide timely and accurate information to support responsible management. The AquaWatch Australia mission is a partnership lead by CSIRO and SmartSat.

Indo-Pacific Connector

The Australian government has placed increased emphasis and priority on enhanced regional engagement covering disaster response, security and economic assistance for neighbouring nations across the Indo-Pacific.

In addition, the 2020 Defence Strategic Update notes the region is undergoing a strategic realignment, making the region more contested and apprehensive. Australian space capabilities across the three SmartSat research programs can contribute to regional diplomacy and security partnership through technology collaboration.

The Indo-Pacific Connector (IPC) mission provides a concept for integrating SmartSat technologies into an end-to-end system able to deliver advanced communications and situational awareness for Australia and our allies. This can be achieved through collaborative technology development aimed at capacity building with regional partners.

This is in part a regional security and diplomatic engagement concept, requiring Australian industry leadership enabled by advanced space technology. IPC aligns closely to the developments of the RMS StarShot program.
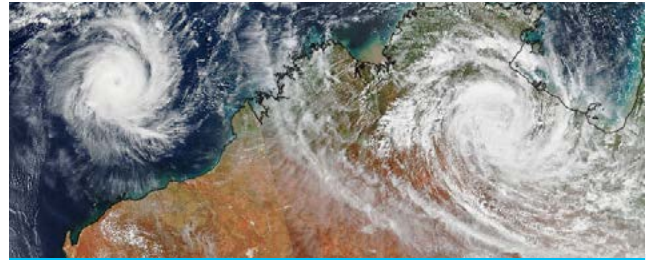
I-in-the-sky

Natural disasters have been part of the fabric of Australia's existence, with bushfires, floods, and droughts occurring with increasing frequency and severity. Such events can significantly impact national security, economic health and societal wellbeing and there is a strong national focus on improving disaster resilience.

The information age provides us with powerful tools to improve disaster resilience through the ability to collect, exploit and disseminate actionable information to a broad community of end users. This includes emerging space technology to augment emergency management contributing significantly to improving resilience.

Disasters can be segmented in phases covering prevent, prepare, respond, and recover where space technology can contribute to all four. Using bushfires as an example, earth observation and in-situ satellite communication connected sensors can contribute to managing forest fuel loads and the early detection of outbreaks. Additionally satellite communications and can support situational awareness and command and control in the respond phase, and both space technologies provide interim capability while ground infrastructure is under recovery.

The goal is to support Australia's efforts to be more resilient to disaster situations by developing capabilities and providing technologies for emergency management in the digital age.

The I (intelligence)-in-the Sky capability demonstrator seeks to develop an indicative architecture of an end-to-end, all source information broadcast system that will service the needs of planners, emergency services and the public now and into the future.

The approach is to start with simple use cases, develop concepts in partnership with end users and demonstrate practical and implementable capabilities.

SmartSat is working closely with the end-users including emergency management services to ensure research outcomes from the I-In-the-Sky mission are aligned with the needs of the sector.

Creating innovative R&D opportunities

Other innovative projects initiated during the year include:

• Project Calls on behalf of BAE Systems for two projects, which attracted strong proposals, with *Trusted AI Frameworks for Change and Anomaly Detection in Observed ISR Patterns* (The University of Adelaide, BAE Systems) and *Space Analytics Engine for On-Board Machine Learning and Multimodal Data Fusion* (The University of Adelaide, University of New South Wales, BAE Systems Australia Limited) being selected. Both of these build upon existing work at BAE Systems and the partner academic institutions and underpin an intrinsic development requirement needed for the Australian space environment. They enable future growth and development based upon not only the theoretical outcomes but also that of real-world tangible outcomes focused at capability driven need.

• *OysterQual: A Proof of Concept and feasibility study utilising space technologies to advance the aquaculture markets in Western Australia remote and regional areas* (P3-08) project, a collaborative project with Curtin University, Frontier SI, Myriota, Geoplex, GeoScience Australia, Maxima Rock Oyster Company, Western Australia Agriculture Authority. There is enormous opportunity to grow the market of the aquaculture sector in Western Australia, yet there are several challenges that need to be addressed for this to happen. To grow the sector, producers need to access data that can inform them of suitable shellfish growing sites and use this site characterisation to better assess stock carrying capacity and feasibility of farming. With this intelligence, producers can target suitable areas to develop with greatly reduced risk. This pilot project will prototype a software solution ingesting earth observation (EO), in-situ and model data, which can be trailed by our end-users to assess whether such a tool could assist them in determining the suitability of future sites. The prototype will focus on two sites, one in the Pilbara and one in the Kimberley, both remote areas of North West Australia. This solution will be designed so that it can also evolve towards an EO-based farm site monitoring tool.

• The *Compact Clock for Small Satellite Applications* project (P2-08) made good technical progress during the year and SmartSat is looking to set up follow-on projects that aim for an on-orbit demonstration of this unique and promising technology for precision timekeeping.

• In conjunction with the Aurora Space Cluster, a new project was initiated to explore *Distributed FlatSat* (P2-23). This project will engage Aurora members and other small satellite builders to provide their inputs into the technical requirements and business case options for a collaborative test support infrastructure that allows innovative projects to more rapidly climb the TRL scale.

• Two scoping projects related to resilience for satellite systems made strong progress and reached near-completion – P2-12 *LEO Constellation Resilience Technologies – Horizon Scan,* and P2-09 *Development of Taxonomy for Space System Resilience* (the latter focused on cyber resilience). These projects have set the scene for more targeted resilience research in the new year and beyond.

• The *HAPS (High Altitude Pseudo Satellite) Challenge* was a partnership with RMIT's Sir Lawrence Wackett Defence & Aerospace Centre, Australian Department of Defence, the Trusted Autonomous Systems Defence CRC and SmartSat. It aimed to energise local Australian development of key technologies and to ensure Australian sovereign HAPS that have accurate station-keeping capability or long endurance capacity needed to allow deployment over an area of operations for a period of days to weeks.

• The NSW Node issued an open call for project Expressions of Interest (EOI) in conjunction with NSW government, focused on Earth Observation-related analytics, sensor technologies, and other technologies related to creating commercial products and services for application areas.
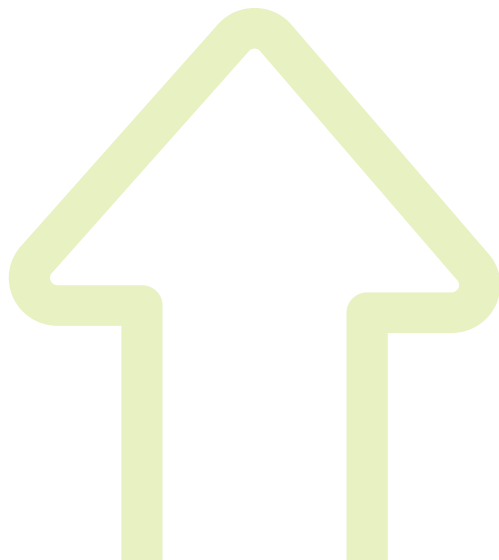
Engaging with SmartSat participants

Despite COVID limitations, there have been several successful workshops, employing a combination of in-person and virtual attendance. Workshops were held in:

Cyber and Resilience

Hosted by Professorial Chair Jill Slay, this workshop discussed the critical, cross-cutting aspect of cyber security and resilience that underpins all of our research programs.

Defence Resilience

Held in conjunction with DST Group to support planning for the Resilience Theme within the Resilient Multi-Mission Space STaR Shot, and assist SmartSat's strategy development and program definition for the Cyber and Resilience Cross-Cutting Research Theme.

Digital Twins

This webinar outlined the state-of-the-art in digital twin thinking, presenting concrete examples of digital twins and digital thread to motivate further innovation and creativity. In addition, industry experiences and needs were shared with the goal of identifying key research challenges and proposed future pathways.

Australian Concurrent Design Workshop (UNSW Canberra)

The Australian National Concurrent Design Facility (ANCDF), the only such facility in Australia, is an example of world-best-practice in applying concurrent engineering approaches to rapidly develop feasible space mission concepts that meet user requirements.

Bushfires

This workshop was held with support of the Bushfire Natural Hazards CRC to uncover current state of the art in bushfire management utilising satellite Earth Observation, collaboratively define the pressing problems and propose strategic areas of collaborative R&D.

In summary, during the 2020/2021 financial year, SmartSat completed its initial building phase and ramped up research activities, engagement, and impact. It has provided the platform to mature research projects and commence new synergistic programs which will deliver further impact and an enduring legacy for Australia.
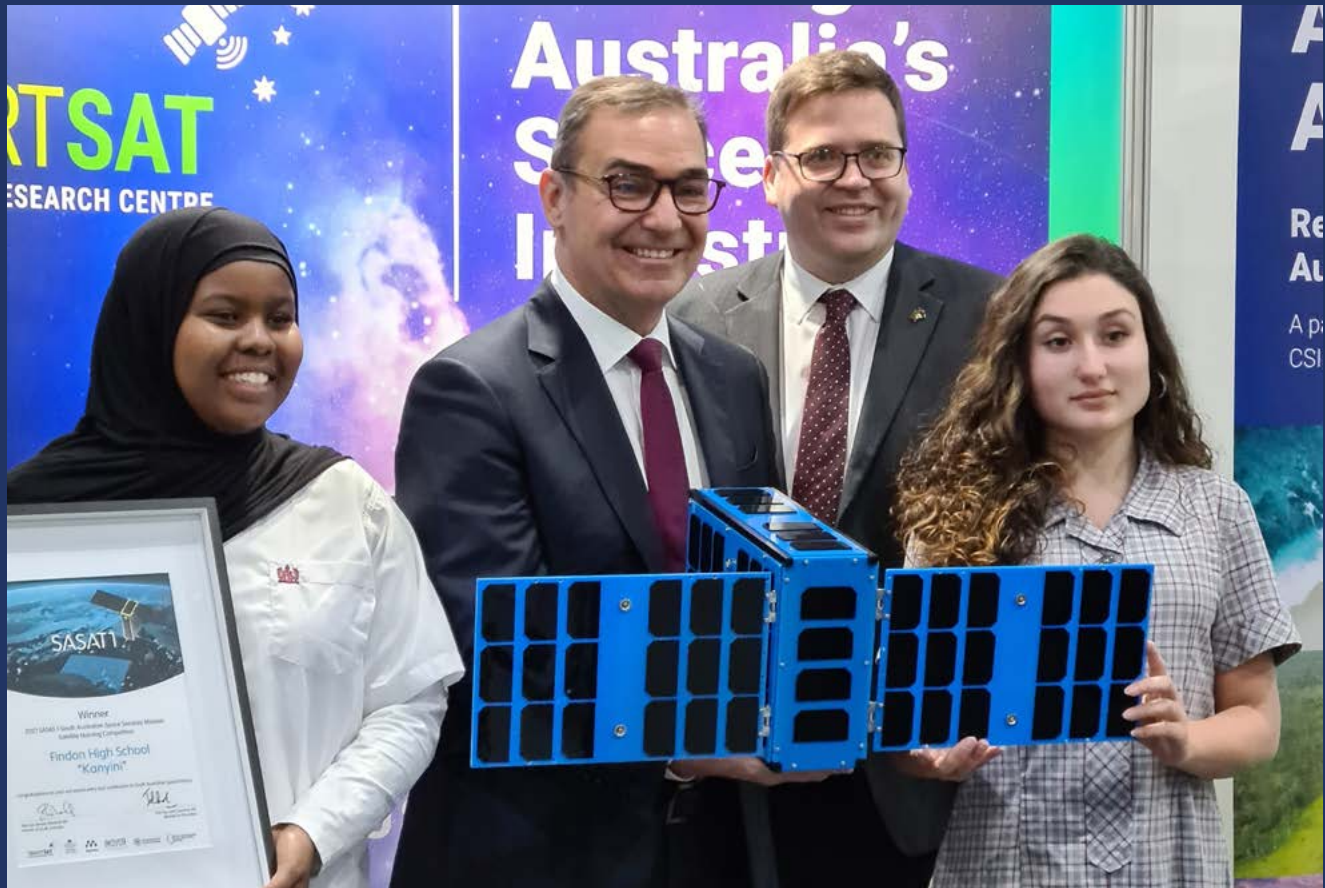
Kanyini
(SA Space Services Mission SASAT-1)

The SA Space Services Mission is a partnership with the South Australian Government, and South Australian companies Myriota and Inovor. SmartSat CRC is leading the mission and will manage application prototyping. Once launched, the planned three-year mission in Low Earth Orbit (LEO) provides opportunities to test and develop the capability and inform future missions. The satellite was named Kanyini by local school students, from Findon High School, after a state-wide naming competition aimed at engaging students in the project.

Inovor Technologies, Australia's only sovereign commercial satellite manufacturer, was selected to design, build, test and operate the satellite bus that will be launched into LEO. Myriota will provide the IoT space services for the mission; sending data from IoT devices and sensors on Earth's surface to the satellite.

Nova Systems is providing expert technical advice and support to the Kanyini team. This support includes providing a satellite engineer, project manager and software and systems engineer. This will build knowledge and offer expertise in operation and interface of the Earth Observation payload. Nova is also providing a software and systems engineer over the next 5 months to build knowledge and expertise in operation and interface of the Earth Observation payload. Kanyini is anticipated to be launched in early 2023.

List of approved projects

No.	Project Title	Lead Org	Project Parties Involved
P1-10	Lunar Ground Station Feasibility Study	The Australian National University	The Australian National University
P1-11	Q Pathfinder - Quantum Enhanced Secure Comms for Small Sats and IoT	The Australian National University	The Australian National University Airbus Defence and Space Limited (UK) Defence Science and Technology Group Quintessence Labs
P1-12	Hybrid terrestrial-satellite access system for IoT applications – Phase 1	RMIT	Fleet Space Technologies RMIT Macquarie University
P1-13	Anomaly Detection in IoT for Satellite Security Using Blockchain	La Trobe University	La Trobe University BAE Systems Australia Limited
P1-15	MIMO and Cooperative Communications for New Space – Phase1: Feasibility Study	Defence Science and Technology Group	Defence Science and Technology Group UniSA
P1-17	Evaluation of rare-earth quantum communication technology for space-based applications	The Australian National University	The Australian National University SmartSat CRC
P1-18	Coherent Free-Space Optical Communications (Phase 2)	The University of Western Australia	SmartSat CRC UniSA Thales Australia Limited The University of Western Australia Goonhilly Earth Station Ltd Defence Science and Technology Group
P1-19	Compact Hybrid Optical RF (CHORUS) (Phase 2)	Defence Science and Technology Group	Defence Science and Technology Group SmartSat CRC UniSA The Australian National University Lyrebird Antenna Research Shoal Engineering EM Solutions EOS Space Systems
P2-07	The Application of AI for Satellite Enterprise Management	Deakin University	Deakin University Nova Systems Defence Science and Technology Group
P2-08	Compact Clock for Small Satellite Applications	University of Adelaide	University of Adelaide CryoClock
P2-09	Development of Taxonomy for Space System Resilience	UniSA	UniSA
P2-10	Space Analytics Engine for On-Board Machine Learning and Multimodal Data Fusion	University of Adelaide	University of Adelaide UNSW BAE Systems Australia Limited
P2-11	Trusted AI Frameworks for Change Detection in Observed ISR Patterns	University of Adelaide	University of Adelaide BAE Systems Australia Limited
P2-12	LEO Constellation Technology Horizon Scan	Shoal Engineering	Shoal Engineering Deakin University
P2-14	Development of an Evil Digital Twin Framework	UniSA	UniSA Cygence
P2-15	Autonomous Vision-based Space Objects Detection and Tracking in Orbit	University of Sydney	University of Sydney High Earth Orbit Robotics Thales Australia Limited
P2-20	Decentralised Cognitive Systems for Radar Signal Recognition	DEWC Systems	DEWC Systems Deakin University

List of approved projects (continued)

No.	Project Title	Lead Org	Project Parties Involved
P2-21	Precision Timing for Space Based Applications – Utilisation Study	Frontier SI	Frontier SI Positioning Insights RMIT
P2-22	Super resolution Mosaic Infrared Focal (SMIRF) Sensor	Sitael Australia	Sitael Australia University of Adelaide
P2-23	Distributed Flatsat Phase 1	UNSW	Aurora University of Sydney UNSW
P2-24	GNSS-Reflectometry for Maritime Surveillance PHASE 1	UNSW	UNSW BAE Systems Australia Limited
P2-25	AI Architectures for On-board Processing	Queensland University of Technology	Swinburne University of Technology The University of Queensland Queensland University of Technology
P3-08	A Proof of Concept and feasibility study utilising space technologies to advance the aquaculture markets in Western Australia remote and regional areas (OysterQual)	Curtin University	GeoScience Australia Western Australia Agriculture Authority Myriota Geoplex Frontier SI Curtin University Maxima Rock Oyster Company
P3-09	Knowledge gaps and opportunities of earth observation tools for mine-rehabilitation at the property scale	The University of Queensland	The University of Queensland Frontier SI
P3-10	Enhancing Earth Observation for Maritime Domain Awareness (EO4MDA)	Leonardo Australia	Leonardo Australia Deakin University
P3-11	Next Generation Testbed Design for Earth Observation	Frontier SI	Frontier SI
P3-12	Development of novel methods to utilise space-based SAR measurements to create and maintain a State-wide surface deformation model	Curtin University	GeoScience Australia Curtin University NSW Department of Customer Service VIC Department of Land Water and Planning Frontier SI MDA Corporation
P3-13	Aquawatch Pathfinders: Earth Observation Sensor Design Testbed (End to End Simulator)	SatDek	SatDek Curtin University The Australian National University CSIRO The University of Queensland
P4-04	Business-as-usual Inclusion	The Inclusive Organisation	The Inclusive Organisation
P4-05	SmartSat Ideation Challenge 01: Firefly	SmartSat CRC	Lookinglass Rice Satcom Beings Systems Nova Systems Melbourne Space Program Lux Aerobot Spiral Blue RMIT Picosat Systems
P4-15	First Nations Earth Observation	Frontier SI	Frontier SI Winyama
P4-16	HAPS Challenge Phase 2	SmartSat CRC	Lux Aerobot GaiaPOD

Compact Hybrid Optical/ RF User Segment (CHORUS) Phase 2

Project Case Study

Project Partners

Defence Science and Technology Group, EOS Space Systems, EM Solutions, Shoal Group, Australian National University, University of South Australia, Lyrebird Antenna Research

Project Overview

Satellite optical communications is an emerging capability that potentially offers significantly higher communications bandwidths and lower probability of intercept when compared with standard civilian and military satellite communications. There remains however, some significant limitations to the technology that have and continue to create barriers to the widespread uptake (commercialisation) of the technology.

The CHORUS Project aims to address some of these limitations by using an RF beacon to establish an optical link, re-use existing RF terminal infrastructure and improve availability by using a hybrid optical/RF system. The research will significantly mature the technology and open the way to mainstream take-up of the capability. The project aims to develop an integrated satellite ground terminal that exploits diversity within RF and optical communications bearers, enabling the development of an entirely new class of satellite communications terminal.

In the first phase, the project team delivered a range of design options and are now proceeding to build a full-scale engineering model of the preferred option. The ability to get to this point within 12 months while working through the COVID-19 pandemic shows the benefits of having a strong, multi-disciplinary team with a range of complementary skills and enthusiasm for collaborative research. The research builds on long standing investment in Australia by Defence and industry in both small tactical SATCOM on the move terminals and laser communications.

A novel part of Project CHORUS has been the application of Model-based Systems Engineering (MBSE) methods and tools since the beginning of the project. Shoal Group has helped guide and expedite the R&D effort by capturing the system design, improving design analysis and supporting decision making. This MBSE model is a reusable template for specifying future iterations and variants of the CHORUS terminal, as well as a specification for interfacing systems including the modems and satellite terminals.

Utilisation

Current generation military communications from "disadvantaged platforms" are highly vulnerable to electronic warfare (jamming, geo-location and interception) and this is likely to get worse in the future unless new approaches to the provision of communications are developed.

Optical communications and E-Band (73/83 GHz) /Terahertz (>100 GHz) frequencies have potential to overcome some of these limitations and vulnerabilities, but questions remain about their suitability to meet commercial quality of service requirements and military reliability/ survivability requirements.

The research program aims to prove the technical viability of a small aperture, hybrid Optical-RF terminal that exploits diversity in electromagnetic wave propagation to provide high data rate and high availability from a single low-cost terminal.

Successful delivery of this project would create impact by enabling Australian developed technology solutions to provide a viable acquisition pathway for new SATCOM capabilities. If successful, CHORUS will position Australian industry to lead in the development and delivery of an entirely new class of military satellite communications service for the Australian Defence Force and its allies, including the ability to develop optical comms to provide higher bandwidth, lower observability and more secure communications than current RF technologies for tactical communications between ships, aircraft and even ground vehicles. It is believed there are additional commercial applications of this technology as well, e.g., for commercial shipping and cruise liners.

Members of the project team are well positioned to support the path to adoption of the outcomes of the project and the team has become a significant participant in the Defence, Government and Commercial satellite communications sector.
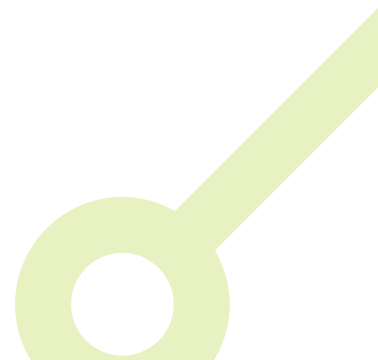
For Australian military communications satellites the nearest opportunity to place optical transponders on orbit rest in the Defence project JP9102 (Next Generation Defence Satellite Communications). SmartSat does not have the resources to progress this technology to TRL-8/9. The plan is to partner with Defence and demonstrate a viable hybrid RF/Optical SATCOM link through the Resilient Multi-mission Space STaR Shot mission series. SmartSat is working with DST Group to help define a potential "Advanced Communications Experimentation" mission supporting demonstration, experimentation and concept development for a number of SmartSat projects including CHORUS.

Collaboration

The cross-disciplinary team is drawn from across Australia and includes EOS, EM Solutions, Shoal Group, Lyrebird Antenna Research, Defence Science and Technology Group (DSTG), the Australian National University and the University of South Australia. The team were employed to create innovative technology options to address Australia's need for sovereign space capabilities to provide a secure, high data rate and high availability satellite link from a single low-cost terminal.
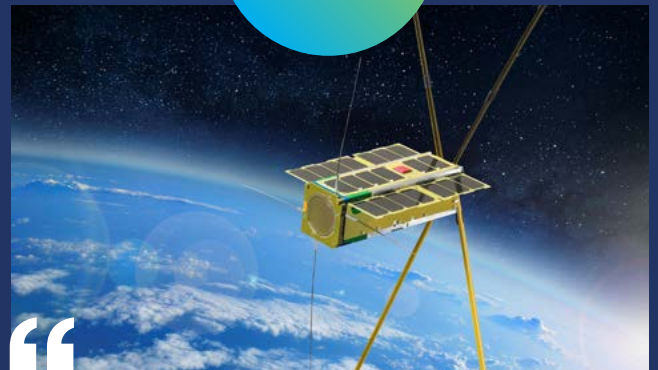
SmartSat is playing a key role in overcoming the 'risk hump' for potentially game-changing technologies such as free space optical communications. The ability of SmartSat to rapidly deliver a phased approach to research has helped manage risks and deliver outcomes. We are also keen to try new approaches to risk mitigation including model-based systems engineering (MBSE) in order to focus research efforts on the project elements that should deliver the best results.

Dr Gerald Bolding, DST Group

Project CHORUS is a great example of a true collaboration between Defence, industry and academia. This isn't a project the industry partners would have contemplated alone, and the leadership provided by Defence and SmartSat have been a critical element in the success to date. Bringing together the RF and optical communities has been eye-opening to see what can be achieved when all partners adopt a truly collaborative approach.

Prof Craig Smith, CEO of EOS Space Systems
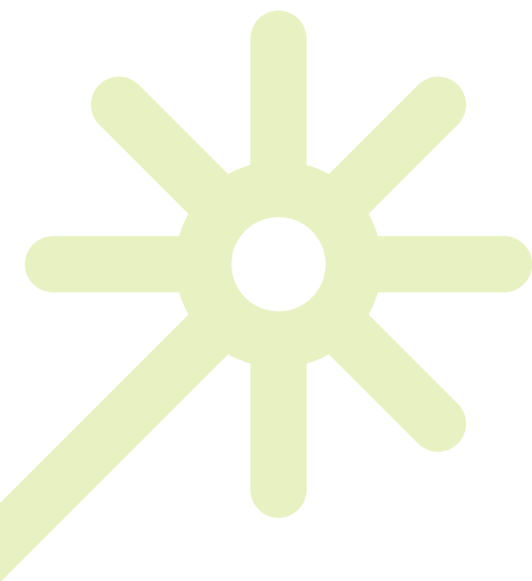
Resilient Emergency and Search and Rescue Communications (RESARC)

Project Case Study

Project Partners

University of South Australia (UniSA), Flinders University, Safety from Space, Black Art Technologies (BAT), Myriota, Australian Maritime Safety Authority (AMSA), NASA Search and Rescue Office, Defence Science and Technology Group (DSTG)

Project Overview

Emergency services require reliable, ubiquitous, and seamless communication systems to ensure rescue efforts and disaster response capabilities are effective and prevent loss of life. Significant gaps in emergency management exist that can be filled by new generation space-based technologies working in tandem with current ground-based emergency management systems. Coordination between multiple agencies in a timely manner is often critical but is seriously compromised by use of stand-alone communications systems which are not easily integrated. In this project, working with emergency services and technology developers, the information needs of first responders were considered and it was explored how this could be addressed by next generation satellite systems.

Extensive consultation with emergency services was undertaken within Australia and project stakeholders AMSA and NASA. Specific functional requirements apply to raising alarms (avoiding false alarms), broadcasting alerts to users within a geographical region, providing adequate command and control (C2), and sending incident reports both manually and automatically generated. Key challenges are created when there is poor coverage from 4G services in remote areas, damage to vulnerable cellular infrastructure (e.g. bush fire, earthquake, flood) and terrain dependent transmission limits the range of conventional VHF/UHF radios. Current commercial satellite services are generally too expensive to be widely deployed and typically are only available for a handful of crew members. Based on initial operating concepts and use cases, the first phase of the project has developed a set of enhanced system requirements and resilient architectures to enable a data-centric approach. This presents automation opportunities through use of data analytics and Artificial Intelligence (AI) techniques.

The project team is preparing to demonstrate a satellite-based proof-of-concept radio device. This will provide valuable reference data for development of a commercial product, designed for high volume manufacture with low Size Weight and Power (SWaP) to send and receive sensor data from vehicle or personal platforms. The demonstration will operate over an existing constellation of high availability Medium Earth Orbiting satellites, as an overlay to the current EPIRB/PLB beacon systems. This will allow collection and dissemination of situational awareness to those needing the information in real time. Technologies to be showcased include an enhanced highly robust waveform, secure two-way messaging protocol, a novel dual band antenna and transmitter geolocation. Combined, these significantly increase functionality and reliability of operation to support new and effective use cases based on resilient and secure bi-directional communications.

Due to close engagement with NASA, a related opportunity has also been identified to apply the same core technology for the safety of astronauts operating on the surface of the moon. The solution could, for example, provide astronauts with advanced warning of dangerous solar activity and real-time alarms for other safety critical information.

Utilisation

The technologies demonstrated by this project are:

- Enablers for resilient communications to maintain contact with distributed teams of emergency crews operating in dangerous environments with damaged or poor terrestrial communications infrastructure.

- Enablers for enhanced communications for astronauts and safety related sensors operating in the lunar environment.

In both applications, the priorities are instant distress alerting to and from a beacon, distribution of critical data for situational awareness and transmission of safety incident reports. The technology is scalable to support the operating constraints and requirements

Collaboration

AMSA and NASA both supported the investigation of existing spectrum allocation and space segment to support enhanced resilient communications. AMSA supported the project's successful application for a scientific spectrum licence to run experiments, and NASA has shared insights into its LunaSAR program and suggested potential use cases for future Moon to Mars missions.

DST Group has provided subject matter expert input and review of technologies under development. Investigation of a highly robust waveform together with dual band antenna was led by Safety from Space with technology contributions from UniSA, Flinders University and BAT. In addition, Myriota provided a unique and complimentary sensor to satellite service for non-real time tracking assets before and during an incident.

SmartSat supported the project R&D team, facilitated discussions with key stakeholders AMSA and NASA, and a Memorandum of Agreement with NASA is being finalised. This will formalise cooperation for search and rescue, as well as astronaut safety in the Moon to Mars program and help guide future directions.

"

The technologies demonstrated by this project are enablers for a nationwide resilient emergency communications capability, specifically tailored to the needs of Australia's many emergency services organisations, as well as further potential to extend for worldwide coverage. In addition, it presents a new opportunity for Australia to participate in the Artemis mission for astronaut safety in lunar operations.

Mark Rice, Safety in Space

We're proud to lend the engineering expertise of our Search and Rescue office as SmartSat CRC works on next-generation rescue technologies. Goddard is excited about this new partnership and the new capabilities that it will foster.

Christyl Johnson, Goddard Deputy Director for Research and Technology Investments

SmartSat's research could result in enormous benefits to the global search and rescue effort. This collaboration has the chance to further revolutionise beacon technology and may pursue bold future augmentations of the search and rescue network.

Lisa Mazzuca, NASA Search and Rescue Mission Manager

"

Coherent Free-Space Optical Communications

Project Case Study

Project Partners

University of Western Australia, Defence Science and Technology Group, University of South Australia (UniSA), Thales Australia, Goonhilly Earth Station

Project Overview

This project aims to demonstrate a system that will enable optical fibre-like data transfer rates for atmospheric free-space communication links.

Free-space optical communication links have several advantages over traditional radio-frequency links for ground-to-ground, space-to-ground, and inter-satellite communication, including the potential for much greater data rates. However, due to atmospheric turbulence, space-to-ground optical communications missions have so far only demonstrated data rates that are on par with the current best radio-frequency links.

The project will develop an advanced optical communications system that has been shown to support data transfer over atmospheric free-space communication links at rates several orders of magnitude greater than is possible with radio-frequency links. This will be achieved using a unique combination of adaptive optics and coherent phase-stabilisation technologies. This will allow the deployment of coherent optical communications system that is able to support modern, higher order combined phase and amplitude modulation schemes such as quadrature amplitude modulation (QAM) with high spectral efficiency.

The project's main aims are to investigate and quantify the effects of the atmosphere on Earth-Satellite-Earth laser communication links. In particular, to develop methods to stabilise the carrier phase and phase noise to permit the use of coherent high-order amplitude/phase modulation to facilitate the reception of extremely high data rates. The project will focus on deploying this system over vertical free-space communications links through Earth's turbulent atmosphere, starting with low-altitude targets, progressing to light aircraft and stratospheric vehicles. Preliminary work has already demonstrated successful communication over 2.4 km and 10 km horizontal free-space links.

In addition, the project team aims to extend the project to test ground station acquisition and tracking concepts using a space-based optical terminal deployed by the industry partners.

Utilisation

Coherent free-space optical communication links can provide the high data transfer rates required for relaying information captured by modern hyperspectral imaging instruments and other data intensive activities. High data rates are critical for spacecraft with short-duration orbital transits over critical ground stations. In addition, high data rates also remove latency bottlenecks for time-critical information. This is important for disaster management (tracking of wildfires, storms, sea ice, and flooding), and for national defence and security. Optical transceivers can be much more compact in size compared to RF link antennas. This results in a drastic reduction in the required weight and power consumption, critical factors for the spacecraft, and for any potential mobile optical ground stations.

Optical communication links also enhance communication security and resilience, as their highly directional nature make them much more robust against detection, eavesdropping, jamming and spoofing. In addition, phase-stable coherent optical detection is required for advanced data encryption techniques such as quantum key distribution. Optical communication links also avoid the issue of spectrum management, as they are highly directional.

Collaboration

Goonhilly intends to make use of the project intellectual property (IP) as part of its ongoing development of niche ground station products in the RF and free-space optical domains. Such products will be sold or licensed on a global basis.

Thales Alenia Space (TAS) is a global supplier of satellite payloads, across many applications from Earth Observation to civilian and military communication systems. TAS has an existing product range and future roadmap in the optical communications sector.

In parallel, the project team will also investigate opportunities to further qualify the system through testing with optical payloads on-orbit and at the Western Australian Optical Ground Station. The optical payloads could include the industry partners Optel-µ terminal, and Defence's Buccaneer satellite. The outcome of these investigations could also form the basis of an extension of the work in collaboration with the SmartSat CHORUS project team for a 'full' systems demonstration and deployment.

"

The project aims to develop the next generation of ultra-high-speed space-to-ground optical communications technology and demonstrate this using laser links between an advanced Australian optical ground station and airborne vehicles.

**Dr Sascha Schediwy, Project Lead,
University of Western Australia**

Goonhilly Earth Station is a world-class facility at the forefront of both satellite and deep space communications. Goonhilly's future ground terminals in the UK and overseas will incorporate free-space coherent optical communications capabilities and this aligns perfectly with the strategic objectives of Thales.

**Dr Bob Gough, Head of Business Development,
Australia & APAC, Goonhilly Earth Station**

Thales Australia is a local business with a global reach and significant credentials in the space sector. This project is an important step towards the ultimate objective of achieving high data rate satellite-to-ground optical communications and is a great example of how large organisations like Thales can work in partnership with the Australian research community to develop the next generation of space technologies, while also generating opportunities for local manufactures to feed into our global product supply chain.

**Michael Clark, Director Technical Strategy,
Thales Australia**

"

SatCom IoT-enabled Automatic Ground Water Collection and Aggregation Pilot (SIG Water)

Project Case Study

Project Partners

FrontierSI, South Australian Department for Environment and Water (DEW), Myriota, University of South Australia (UniSA), NGIS

Project Overview

Like other state and territory authorities, the South Australian Department for Environment and Water (DEW) is responsible for the operation and management of an extensive network of groundwater monitoring bores. Currently, only 6% of DEW's 3500 bores are instrumented and bore observation information is generally collected infrequently by field visits, often only a few times a year. There is a need to increase the frequency and spatial distribution of monitoring and provide automated data collection to service the growing data needs for effective groundwater resource management, whilst remaining within realistic budgets for monitoring related costs overall.

This project is developing a pilot system to demonstrate the use of an Internet-of-Things (IoT) and low-cost nano-satellite telecommunications (nano-satcoms) as an end-to-end means to transmit and aggregate, in near real time, automatically collected information from groundwater bores. These bores, often located in remote and harsh environments, will be fitted with sensors to measure water levels and other water parameters with a focus on groundwater resource monitoring.

The project will test the technical feasibility, reliability and cost-effectiveness of deploying an end-to-end IoT nano-satcoms solution in typical operational environments. This includes evaluating, procuring, integrating and deploying both sensors and telemetry transmission devices in experimental sites in the field and operating these for a period of around a year. During this time, various aspects of the system will be evaluated, ranging from the equipment deployed and its robustness, to the evaluation of the resulting data outputs. The aim is to assess the feasibility and cost of operating such devices autonomously for extensive periods of time. In addition, the project will develop a prototype capability to enable the end-to-end transmission of data from in situ devices via satellite to end users via the internet.

The SIG Water approach will be compared to current groundwater monitoring scenarios where information is either collected manually and sparsely in time or via costly telemetry systems. The system will be evaluated in conjunction with DEW as a representative end user and will provide results covering 60 to 80 sites across South Australia, including the Southeast region of the state, the Great Artesian Basin and the Eyre Peninsula. Although the focus of the project is on the system as a means for data collection, the data results themselves will also provide insight into how the information can be used in the groundwater management context.

The project also involves a specification of requirements for an 'ideal' monitoring system. This is being achieved through stakeholder consultation both with DEW and with several other jurisdictional water regulators and interested parties such as groundwater consultants, water utilities and national groundwater data curators such as the Bureau of Meteorology. A consultation process is underway that includes developing a better understanding of current practices for groundwater monitoring nationally, the gaps and unmet needs of these and how space-based communications solutions like SIG Water can be used to fill those gaps.

Utilisation

In Australia, groundwater is an important natural resource, accounting for around one-third of water use nationally and almost two-thirds in south-western Australia. Much of Australia's groundwater use is consumed by agriculture but it is also a significant component of the mining and energy sectors, as well as being a source for drinking water for many communities and sustaining dependent ecosystems. Balancing outcomes through government groundwater management frameworks is complex and is often hindered by incomplete and untimely delivery of data. Groundwater resources are many and varied and abstractions can occur many thousands of kilometres and hundreds of years from where inputs originate. Groundwater systems are complex and spread over wide areas, presenting considerable challenges in their monitoring and understanding. Australia has the opportunity to establish itself as a world leader in technology development and application for improved groundwater monitoring systems.

The outcomes of this project can have an impact on groundwater management in Australia and can also have broad global applications and present international opportunities. Satellite and Internet-of-Things (IoT) approaches, capable of providing increased volume and variety of monitoring data, more frequently with greater spatial density, less time-lag for collection and at a lower-cost than equivalent current approaches, can be central to this.

Collaboration

FrontierSI is leading the project and an advisory group with representatives from the DEW are involved in the project at all stages.

Myriota are supporting the system development to demonstrate how IoT and nanosatellite technology can be used to transmit and aggregate groundwater bore data.

In addition, the project takes advice and guidance from the SmartSat Water End-User Advisory Board.

"

The strong collaboration on the SIG Water project shows just how powerful Myriota's IoT nanosatellite technology is for effective water regulation in Australia. By removing the need for manual monitoring across multiple sites, water managers are seeing greater accuracy and richer data across their water assets, while saving money and reducing the number of hours spent travelling long distances to inspect water sites.

Alex Grant, Co-founder & CEO, Myriota

SmartSat is dedicated to developing satellite IoT connectivity technologies that help solve some of the biggest challenges facing Australian industries, and that includes water conservation. The outcome of this project will improve groundwater management and help safeguard our shared resource, water, for future generations. The project will put Australia in pole position to be a global leader in groundwater management and apply the solution locally and abroad.

Prof. Andy Koronios, CEO & Managing Director, SmartSat

"

Autonomous Vision-based Space Objects Detection and Tracking in Orbit

Project Case Study

Project Partners

Thales Australia, University of Sydney, HEO Robotics

Project Overview

This project is undertaking a comparison study of different sensor technologies, including ground and space-based optical, radar and RF sensors for space objects detection and tracking. In addition, it is investigating efficient machine learning algorithms and hardware architectures based on modern FPGA technologies for onboard data processing. The feasibility of the selected approaches will be demonstrated using existing sensor technology (telescope, hyperspectral imager and star tracker).

Space debris has become a concern in recent years due to increased traffic in low earth orbit. This has created a congested and contaminated environment with the proliferation of orbital debris. With the development and commercialisation of small satellites, the small satellite market is expected to reach $15,686.3 million by 2026. Any impact or collision of space debris with the operational satellites can jeopardise or even end their life, yield significant loss to the space economy, and trigger the so-called Kessler Syndrome which refers to the possibility that collisions will create more debris collisions.

To avoid potential traffic problems in orbit, at the same time the number of sensors of all types—primarily optical, but also radar, and active and passive Radio Frequency (RF) both ground- and space-based—being used for Space Situational Awareness (SSA) has been growing. Space-based optical systems have a few advantages over ground-based optical data collection in that challenges with time-of-day lighting are somewhat mitigated, and weather/atmospheric conditions are not an issue. Sensors in space are also more sensitive and allow for the detection of dimmer objects including space debris. Space-based SSA assets are typically a single satellite or a constellation of satellites conducting SSA on space objects using optical sensors.

This scoping study is:

- Undertaking a literature survey of existing space surveillance technologies with a focus on in-orbit sensors and monitoring systems;

- Investigating a constellation approach offering the potential to track and monitor objects in low earth orbit (LEO) by using onboard optical cameras and related innovative sensor types;

- Exploring gaps in currently available products and technology and to identify and recommend concepts and technologies for detailed research that have the potential to improve system performance and provide a sovereign capability for Australia;

- Examining the feasibility of different constellation configurations and assess their coverage of the celestial sphere and their suitability for Australian surveillance objectives;

- Developing machine learning algorithms to analyse the data and perform studies on hardware implementation of machine learning algorithms onboard satellites, which will enable the space traffic monitoring system in orbit and improve the downlink efficiency.

The outcomes of this proposal will inform a larger phase 2 activity, will which propose a space traffic monitoring system via satellite constellation in orbit. By constructing such a constellation system in space, onboard optical sensors can track and monitor objects in LEO. This will give much more detailed information about the Earth orbiting objects and can be further extended to build space traffic management capabilities.

Utilisation

This project will contribute to the sustainable exploitation of the LEO traffic for future space missions. This project has the potential to boost Australia's SSA market and space industry by pursuing commercialisation of space tracking services and SSA hardware and software packages. Dealing with space debris is a national security issue. This project will strengthen Australia's competencies and capabilities in detection and tracking of unknown space objects, in fusion of Australia's ground-based tracking facilities.

Collaboration

This project will allow an Australian SME to benefit from collaboration with an existing global player in the space business to facilitate access to global market opportunities, and work with a leading Australian research organisation.

Thales Australia has an interest in Space Situational Awareness (SSA), and is currently seeking market opportunities to deliver capabilities to the Australian Department of Defence. The strategy is to leverage technologies from the Thales Alenia Space global product portfolio, while also developing research relationships with Australian entities and researchers able to offer unique and innovative new components and subsystems in support of their solutions.

The study activity is a great facilitator to help grow the knowledge and understanding of Thales Australia staff in this area of technology that is relatively new to Thales' Australian operations. The literature survey of existing space surveillance technologies and the associated scoping study are identifying gaps and opportunities and will help guide Thales as to where best to focus efforts in this SSA domain.

Collaboration with The University of Sydney is also enabling the broader objective of creating true sovereign capability for Australia, at both the industrial and research levels.

HEO Robotics provides on-demand analytics for in-orbit asset management. HEO uses space-based cameras to capture high quality imagery of LEO and GEO assets, and its own suite of analytics software to provide valuable insights on the assets. The outcomes of this project will help HEO scale current Space Domain Awareness capabilities.

"

Thales is a large prime with global credentials in the space sector, and this activity is an important step in building knowledge and capability in the Australian part of our organisation.

Michael Clark, Director Technical Strategy, Thales Australia

The University of Sydney offers Space Engineering education and research program to the talented students since 2001. This project shows an example of knowledge transfer in the university-industry collaboration project and helps build Australian space industry capabilities in the domain.

Xiaofeng Wu, Senior Lecturer in Space Engineering, University of Sydney

HEO Robotics values the opportunity to collaborate with Thales and the University of Sydney in this project.

Dr. William Crowe, Co-founder and CEO, HEO Robotics

"

Compact Clock for Small Satellite Applications

Project Case Study

Project Partners

University of Adelaide and QuantX Labs Pty Ltd

Project Overview

The value that precision timing onboard Global Navigation Satellite Systems (GNSS) enables such as GPS and Galileo, cannot be understated; it is used by hundreds of millions of people around the globe and generates trillions of dollars of economic benefits every year. GNSS is now used in a range of applications including navigation, defence, coordinating complex logistics, electricity supply, finance, and telecommunications. Although such innovations have led to enormous gains in productivity and efficiency, modern society is now heavily reliant on the provision of precision time via satellite, of which Australia does not have any sovereign capability.

This project addresses one of the key hurdles to achieving an alternate Positioning, Navigation and Timing capability for Australia through the development of space-qualified, compact clocks.

Over the last 5 years, the University of Adelaide has been developing a new optical atomic clock technology that uses small glass cells containing rubidium vapour. The new optical approach allows significant reductions in size and weight, while opening avenues to higher performance.

The University of Adelaide team has already demonstrated timing stabilities comparable to the very best Global Navigation Satellite Systems (GNSS) clocks in a system that is at Technology Readiness Level (TRL) 4. A technical pathway has been identified to improve this performance tenfold whilst at the same time reducing size, weight and power metrics. A "frequency comb" will also be developed that can take the output of the optical clock and deliver a Radio Frequency (RF) signal with the same superb timing stability – but which can be interfaced with traditional electronics.

To make the clock more suitable for space-based applications, the high-power consumption and heavy components need to be replaced with small, low-power alternatives. Under this project, a new laser interrogation and detection system will be built and much of the existing electronics will be replaced with compact digital versions.

In collaboration with QuantX Labs, a sovereign, premier provider of high precision timing and sensor products, this project will address these challenges and mature the compact clock technology to the point where it can be developed into an Engineering Model in a second phase suitable for functional testing and space qualification of components.

Utilisation

High precision timing is an underlying technology for distributed systems and systems resilience. As such, the space-based compact clock will feed into a multitude of different technologies, including:

- Defence seeks to incorporate the clock technology in Resilient Multi-mission Space STaR Shot missions for application in Position, Navigation and Timing. If it can outperform the clocks currently used onboard GNSS satellites, it will not only provide Australia with a sovereign GNSS capability, but it will also be more resilient to jamming or spoofing than current state-of-the-art;

- Secure communications networks whereby encoding could be achieved in time delays that require precise timing to decode;

- The technology is of interest to NASA for accurate clocks for deep-space and solar system navigation and timing information is essential to synchronise each satellite's observations.

Collaboration

QuantX Labs have provided invaluable engineering support and commercial know-how which has helped guide the development of a solution that will be manufacturable and deployable at the next stage of the project. This collaboration demonstrates the value of academia and industry working together to accelerate product development.

"

This project has been a true collaboration between SmartSat, the University and QuantX Labs. The project team have delivered a manufacturable design through the invaluable input provided by the international space eco-system that has been created by SmartSat.

Prof Andre Luiten, University of Adelaide

"

A Decentralised Cognitive System for Radar Signal Recognition

Project Case Study

Project Partners

DEWC Systems and the Institute for Intelligent Systems Research and Innovation (IISRII), Deakin University.

Project Overview

Project P2-20 is a collaboration between DEWC Systems and the Institute for Intelligent Systems Research and Innovation (IISRII), Deakin University.

The project has been established to leverage artificial intelligence (AI) advancements to develop cutting edge radar monitoring capabilities in Australia. This initial collaboration is part of a multi-phase AI-driven RF monitoring system roadmap led by DEWC Systems to advance sovereign Australian RF technologies and capabilities, along with support from SmartSat CRC.

AI algorithms and in particular deep learning (DL) have shown promising capabilities for large data-driven analysis but there is a lack of AI research applied to RF spectrum analysis. This collaboration aims to fill this research gap by exploring state-of-the-art DL models such as convolutional neural networks (CNNs) to effectively detect and classify conventional and low-probability-of-intercept (LPI) radar signals.

The eight-month duration Phase 1 of the project has resulted in a proof-of-concept DL-based framework capable of detecting and classifying synthetic RF signals tested in a lab environment with simulated input noise.

This collaboration has yielded exceptional initial results, as shown in the graph. Initial CNN models have been evaluated with varying signal-to-noise ratios (SNR) to mimic the detection and classification of radar signals in synthetic noisy environments. The obtained accuracy for all different scenarios is very close to perfect accuracy, demonstrating the competency of the proposed RF detection framework.

The research team plans to extend the research in a future phase using real-time RF data sources in conjunction with satellite prototypes and technologies under-development at DEWC systems.

Utilisation

The full commercialisation of the project-derived technology will require additional phases, however, DEWC Systems already intends to use the research outputs to inform the development of the radio frequency (RF) sensor in the Miniaturised Orbital Electronic Warfare Sensor Systems (MOESS), a Defence Innovation Hub funded project. MOESS is a space-based tactical sensor system to provide persistent, resilient and adaptable situational awareness.

In the longer term DEWC Systems intends to integrate the AI system as a radar classification tool for a new satellite constellation that acts as a distributed system for sensing radar signals.

Collaboration

The project concept was developed by industry partner DEWC Systems, together with the SmartSat CRC's Theme Leader for AI, professor Clinton Fookes. The concept was made available to SmartSat researchers for a response, and Deakin University were selected as the academic partner. They were assessed to be a strong team with expertise in the Machine Learning area.

The research is being conducted by a team from IISRII at Deakin University. DEWC Systems is providing industry input and guidance to the researchers, management of the project milestones, as well as review/evaluation and feedback on reports, software and Machine Learning models.

"

Thanks to the assistance of the SmartSat CRC we were able to identify the IISRII at Deakin University as an academic partner for this important research. Working with IISRII has been pleasure and the collaborative approached displayed by both teams has been beneficial.

Graham Priestnall, General Manager, DEWC Systems

It is exciting to see how the close collaboration between academia and industry can lead to the development of novel and solid intelligent solutions for undertaking challenging real-world problems that will bring tangible benefits to advance the space industry of Australia.

Abbas Khosravi, Associate Professor, Project Lead at Deakin University

"

Australian Space Industry Skills Gap Analysis

Project Case Study

Project Partners

Western Sydney University (WSU), Asia Pacific Aerospace Consultants (APAC)

Project Overview

The Space Industry Skills Gap Analysis study established a space-related skills taxonomy specific to Australia, comprising 319 individual skills, encompassing Australia's space industry current and future needs. This study was commissioned by SmartSat with support from the Australian Space Agency as an initial step to understanding the skills needs of the national space workforce. The study provides a detailed assessment of Australian space-related skills.

Development of an Australian Space Skills Taxonomy

Without an existing job skills taxonomy from which to begin, the study team set about developing an Australian Space Skills Taxonomy (ASST). The ASST is based on a three-tier hierarchical structure; with 12 Tier One Skills categories, 56 Tier Two Skills Groups and 319 specific Tier Three Skills covering technical, business, management, and governance skills. Analysis of the responses identified key current and future skills needs across the Australian space industry.

The study revealed some interesting and unexpected information about current job skills, and current and future needs for the Australian space industry:

- Current skills exist within Australia's space industry for virtually all the 319 Tier Three space-related skills in the ASST (317 skills indicated as currently employed within organisations surveyed);

- Current skills shortages exist in virtually all the 319 Tier Three space-related skills in the ASST (310 current skills shortages indicated within organisations surveyed);

- Future skills requirements exist in all 319 Tier Three skills in the ASST;

- Sensitivity analyses identified 86 Tier Three skills of high intensity based on current and future skills demand versus currently available skills and training providers able to train to the specific skills. These were identified in two groups with many overlaps.

Training providers

This study also explored providers who might be able to deliver training and skills development for space-related skills needs. A range of training options to build skills capability were explored, such as tertiary education, in house training, professional development and bespoke training programs. Some of the key findings on training providers include:

- Of the 90 survey respondent organisations, 46 organisations (51%), spread across Australia, indicated they could provide some form of training for space-related skills development, training, or education;

- The largest number of training provider respondent organisations were from the private sector (46%), with 39% from the university sector, 9% from the not-for-profit sector and 7% from the government sector;

- Providers of university undergraduate or postgraduate programs were the most frequently referred to training activity (37%), while in-house training comprised 33%, bespoke training programs 22% and industry training programs 7% of training providers. No training providers from the TAFE or vocational sector participated in the survey.

- Of the 86 high intensity Tier Three skills, 67% have one or no training providers identified in the survey (20 have no training provider identified, 38 have one training provider identified).

- Only 28% of the training providers (13) have identified any ability to deliver training for the 86 high intensity Tier Three skills, resulting in a number of training gaps.

- There are 25 high intensity skills that might be needed for SmartSat research programs that have only one or no training provider.

The data indicates there are some potential gaps in training providers for space-related skills. In addition, the training needs for such a large skills-set seems to rest with a handful of training providers, and often relies on in-house training programs.

The burden of training for the current skills shortages and future demand may lead to additional training provider shortages or gaps, and may require:

• more training programs, and
• more training provider capacity

Utilisation

The premise for the study was that there are discrete key gaps in the Australian space sector. The fact that current skills and shortages exist for almost every skill is an unexpected finding. The data indicates that all 319 Tier Three skills will be required in the future. This suggests an industry poised for growth that cannot keep up with skills demand. It also suggests there may be potential imbalances between skills capability and shortages across the Australian space industry. It further suggests there is a likely need for training and other strategies such as outsourcing and skilled migration to address current shortages and future requirements.

The study also identified that Australia's space industry is heavily engaged in outreach activities to attract new people as an important long-term strategy towards building a sizeable, suitably trained workforce.

Collaboration

A survey was distributed widely throughout the Australian space community and training providers to capture demographic data, organisational information, areas of space activity and skills shortages, in order to build upon previous findings and emerging trends.

"

The SmartSat analysis is the only space industry job skills taxonomy in existence globally.

Office of the Australian Chief Scientist

The nature of space activity globally and the shape of national space industries have been changing with technological advances and will continue to evolve into the future. As we see in other countries, new capabilities, services and fields of endeavour are emerging, and the Australian space community must be prepared to take advantage of its unique capabilities and technical expertise to maximise the opportunities that will arise.

Emeritus Law Professor Steven Freeland from Western Sydney University (co-author)

"

Aurora Space Cluster

In 2020-21, the SmartSat Aurora Space Cluster continued to complete foundational activities including completion of corporate setup, incorporation, constitution, member rules and policies for membership, communication and delegation. Completion of the membership application and approval process, as well as set up of an Aurora member portal and payment gateway on the Aurora website allowed annual membership fees to commence online in the 2021-22 financial year.

With Aurora foundational activities complete, the first ecosystem value-adding project, the Aurora Distributed Flatsat, commenced, with SmartSat funding for hardwire requirements gathering and POC development.

Direct promotion of SmartSat project calls to the Aurora Space Cluster lead to Aurora members successfully partnering with SmartSat R&D partners on successful EOI responses to a range of SmartSat funded projects.

Initial, Member and Supporting-Member Companies

Between 2019 and the end of 2020, over 60 start-up companies completed one of our paper-based application forms for our initial 'free' membership tier:

AICRAFT Pty Ltd	Hypersonix Pty Ltd	Saber Astronautics Australia Pty Ltd
Airborne Logic Pty Ltd	Infinity Avionics	SatDek Pty Ltd
Altum RF	Jarmyn Enterprise Space	Seaskip
Amentum Aerospace	LatConnect 60	Skykraft
AMTD Electronics	Lookinglass	SmartSat Services Pty Ltd
Arlula	LUX Aerobot	Southern Launch
Astrogate Labs Private Limited	Lyrebird Antenna Research Pty Ltd	Space-BD
Atmoscience	Mapizy	Space Machines Company Pty Ltd
Beings Systems	Melbourne Space Program Ltd	Space Ops Australia
Black Art Technologies	Moonshot	Spectral Aerospace
Buchan	Nano Thermal Technologies	Sperospace
Cybermerc Pty Ltd	Nomad Atomics	Spiral Blue Pty Ltd
CyberOps Pty Ltd	Office of Planetary Observations P/L	Starmaster Technologies Pty Ltd
Dandelion	Orbit Australia Innovations P/L	SuperSky Engineering
Delta-V Newspace Alliance	PhosEnergy Limited	Symbios Communications Pty Ltd
Equatorial Launch Australia	Ping Services Pty Ltd	Terra Digitalis Pty Ltd
Esper Industries Pty Ltd	Predict	Terra Schwartz Pty Ltd
Fireball International	QuantX	Tyvak Nano-Satellite Systems Inc.
Flawless Photonics Inc.	Quintessence Labs	Valiant Space
Gilmour Space Technologies Pty Ltd	Rayar Systems	Venture Catalyst Space
High Earth Orbit Robotics	Regrow Ag	Xerra
Hydrix Pty Ltd	ResearchSat	
HyImpulse Technologies GmbH	Romar Engineering	

Aurora Distributed Flatsat Initiative

This project is the first to be conceived, proposed, and successfully funded within the Aurora framework, and we hope it will set the pattern for future projects. It aims to accelerate, and lower costs and risks of, pre-flight qualification of small satellites and payloads with the intent of accelerating Aurora cluster members' abilities to gain space flight heritage.

Connection with SmartSat Core Activities

The following Aurora early member start-up companies were also successful in joining SmartSat project calls:

Company Name	SmartSat Project
Arlula Pty Ltd	P3-18
Black Art Technologies	P1-07
Extraterrestrial Power	P2-29
Fireball International	P2-19
HEO Robotics	P2-15; P2-26
Lookinglass	P4-05
Lyrebird Antennas	P1-05
LUX Aerobot	P4-05; P4-16
Orbit Australia	P3-14
Picosat Systems	P4-05
QuantX	P2-08
Seaskip	P2-24
Skykraft	P2-14
Space Ops	P2-27
Sperospace	P2-32s
Spiral Blue	P4-05
Terra Schwartz	P2-14

Looking ahead to 2021-22

As Australia comes out of rolling lockdowns, Aurora is keen to continue fostering connections, creating meaningful commercial demonstration and partnership opportunities across the Aurora network

Nationally, and unlocking R&D infrastructure, talent and IP for members. The Aurora Board is particularly keen for members to take leadership positions within the Aurora Space Cluster and this will be a focus for 2021-22 to ensure we are supporting, collaborating and working on the right things to develop this stage of Australia's space industry growth.

Aurora Board Members

Dr Tim Parsons (Chair) – DeltaV
Troy McCann (Deputy Chair) – Moonshot
Anastasia Volkova – Regrow
Conrad Pires – Picosat Systems
Professor Andy Koronios – SmartSat
Dr Andrew Barton – SmartSat
Peter Nikoloff – SmartSat

Aurora is an opportunity to connect budding space startups into the CRC model in a way that will help grow new businesses as well as jobs. Accelerate your satellite sector startup's tech growth by joining R&D activity fuelled by a national network of members and partners of SmartSat.

**Troy McCann, Moonshot
(Inaugural Deputy-Chair Aurora Space Cluster**

Education and Training

Higher Degree by Research

SmartSat's Education and Training College meets on a regular basis to discuss matters relating to the recruitment, assessment, and training of PhD students. SmartSat also has a PhD Scholarship Committee which assesses all PhD scholarship applications.

In the 2020/2021 financial year, SmartSat has undertaken a number of initiatives with the objectives of recruiting more high-quality PhD applicants and engaging more closely with current SmartSat PhD students, including:

- Updated the priority areas for HDR scholarship applications in accordance with the overall priority areas of the SmartSat research programs;

- Developed a HDR Recruitment Strategy Paper;

- Conducted a PhD Welcome Seminar as an induction and training session for all students;

- Formed a LinkedIn group for SmartSat PhD students to engage with each other;

- Presented at two SmartSat PhD recruitment seminars, one to Curtin researchers on 3 June 2021 and one to La Trobe researchers on 29 July 2021;

- Commenced a new initiative to work with SmartSat industry partners on industry proposed PhD research projects. The HDR Director has been working with the BOM and Leonardo Australia Pty Ltd in implementing this new initiative.

Australian Space Industry Skills Gap Analysis Report

The Space Industry Skills Gap Analysis study established a space-related skills taxonomy specific to Australia, comprising 319 individual skills, encompassing Australia's space industry current and future needs. The study identified key current and future skills needs across the Australian space industry in a first of it's kind study in the world.

Andy Thomas Space Foundation

The Andy Thomas Space Foundation runs the bi-annual Australian Space Forum, one of Australia's premier space industry events. SmartSat is a major sponsor of this event and is an active partner within the exhibition booth area to promote SmartSat's activities and initiatives. In addition, SmartSat research and industry participants also feature as speakers in the Forum program.

The Andy Thomas Space Foundation supports space education and inspires youth to pursue careers in the space sector. The Foundation has committed to use the funding to work alongside the Australian Space Discovery Centre to inspire the next generation of the space workforce, as well as to provide scholarships and in-kind support to increase resources for space education and outreach.

Other initiatives:

- Support of the Swinburne Youth Space Innovation Challenge, an initiative which allows secondary students to pitch microgravity experiments and then see one of these experiments fly aboard the International Space Station. The sponsorship will see this initiative widened to allow school children from all states and territories to take part.

- Sponsorship of a space-themed challenge for the South Australian Premier's Reading Challenge. In 2021 there was a record number of entries with 2049 students entering the STEM challenge.

PhD Scholarships

By the conclusion of 2020-21, SmartSat had offered 24 PhD scholarships (full or top-up). Three SmartSat PhD students are profiled on the following pages.
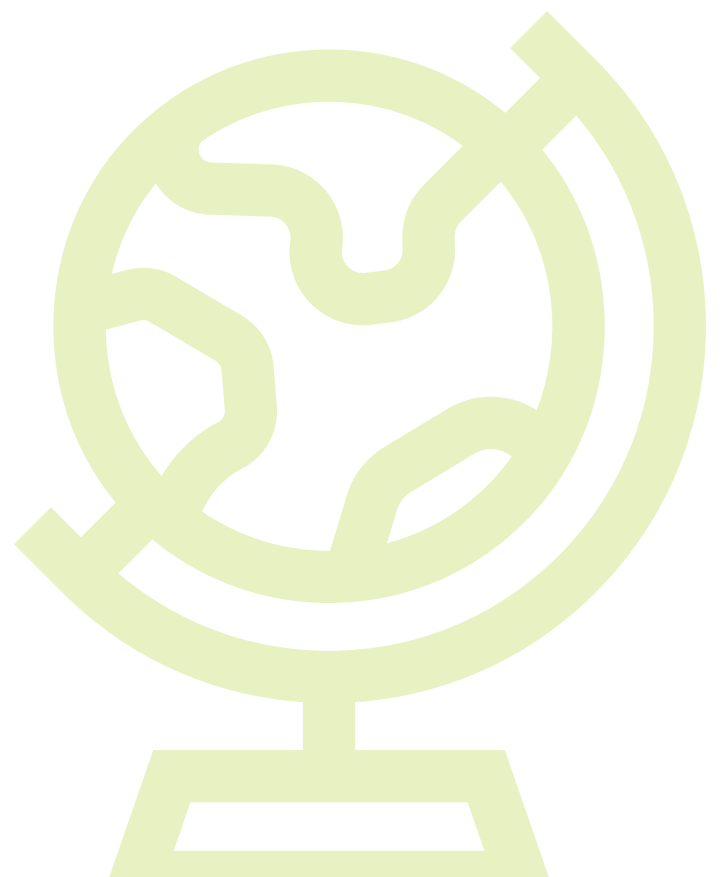
Emily Ahern
University of Adelaide

Emily Ahern is a PhD candidate at the University of Adelaide, working on a compact optical clock for small satellite applications. Her research is focused on increasing the stability of the clock by investigating novel light-atom interaction schemes. This research finds uses in global positioning systems and future space timing applications, such as synchronising constellations of small satellites.

Emily completed her Bachelor of Science with majors in Experimental and Theoretical Physics (Hons.) at the University of Adelaide, developing a novel dual-wavelength acousto-optically tuned laser.

Project: Compact Clock for Small Satellite Applications

Precision timing is of vital importance to our modern society. Its most high-profile application is seen in daily use by most of the world's population though Global Navigation Satellite Systems (e.g. GPS, Galileo), which generate trillions of dollars each year in economic benefits around the globe.

Other applications for precision timing are emerging within satellite constellations where highly accurate satellite position and timing information may be required. Such information is crucial for: intelligent space systems that aim to produce high-resolution monitoring of Earth by combining data from multiple low-resolution sensors, or next-generation GNSS and satellite communication constellations which are more immune to spoofing, offer higher accuracy, and could lead to a sovereign capability for Australia.

This project aims to demonstrate a next generation timing reference for spaced-based applications. The project will focus on design optimisation for small satellites (typically about 1m3, 100-200kg) as well as initiating an understanding of the trade-space between performance and SWaP for satellite clock designs.

Anne Bettens
University of Sydney

Anne Bettens holds her professional master's degree in Aerospace Engineering from the University of Sydney and is currently pursuing a PhD there in this field. Her present research focus is on Vision-based Autonomous Navigation of Robotic Craft for Space Exploration. Anne earned her undergraduate degree in Mechanical Engineering at the University of Western Australia and since then has worked as a consultant for many research projects and hopes to achieve her commercial pilot's licence.

Project: Autonomous navigation of satellites for space exploration

Intelligent autonomous navigation capability for space exploration includes autonomous approaches to small bodies, rendezvous, landing and surface operations such as surveying and sampling. These manoeuvres and scientific experiments will be performed by robotic craft such as satellites. The proposed area of research intends to investigate vision-based navigation on a satellite to assess the prospective autonomy for space exploration.

Liang Zhao
University of South Australia

Liang Zhao is a current PhD student at the University of South Australia (UniSA) in the STEM section. Being enthusiastic about data science and machine learning, he completed study for his honours degree at UniSA in 2020, which applied transfer learning techniques for modelling forest yield with multi-temporal remotely sensed data. His research was inspiring and received high praise from both his supervisors and the industry partner. Because of his outstanding performance for the research of his honours program, he was employed as a research assistant in the Forest Research Mount Gambier project group led by UniSA and the National Institute for Forest Products Innovation (NIFPI). Focusing on forestry data solution, he delivered a comprehensive review on possible data solutions for the forestry industry and gave insights on how to decide proper options based on various scenarios. He now carries his passion in machine learning and remote sensing to his PhD study, aiming to combine these two advanced technologies to combat more complicated environmental issues in real life.

Project: Satellite image-based smoke detection for bush fire detection

Early detection of wildfires is vital to reduce fire caused deaths and property loss, and to prevent disastrous impact on wildlife and the environment, as well as to minimise the economic loss by the government on firefighting. In recent years, more satellite data on earth surface observation become available to assist in firefighting, however, the current satellite image-based detection methods are still ineffective for early fire detection due to low spatial or temporal resolution of the sensors.

Instead of direct fire detection, smoke detection is expected to become an alternative method since smoke disperses very fast into the air and can be visibly detected by the satellites quicker than fire. However, there remains many challenges with smoke detection, such as smoke having similar characteristics to cloud, dust and haze, which are difficult to be visually distinguished most of the time. This project aims to develop practical machine learning technologies which can address the challenges for smoke detection based on satellite imagery. The technologies are expected to become a new way to address the fire detection problems in remote areas. The application of the technologies is hoped to reduce the cost of running remote fire towers, to mitigate the risks on people working at the towers, and to shorten the decision time between the start of the fire and proper reactions taken.

PhD Students

Project no.	Student's Name	Research Program	Project Title	University	Country	Date Commenced	Completion Due
1-01	Benjamin Dix-Mathews	RP 1	Phase- and spatial-stabilisation system development *	The University of Western Australia	Australia	2020	2022
1-01	Skevos Karpathakis	RP 1	Phase- and spatial-stabilisation system development *	The University of Western Australia	Australia	2021	2024
1.06	TBC*	RP 1	Chip Laser Combs for Free Space Optical Comms	UniSA	TBC*	2021	2024
1-08s	Duaa Fatima	RP 1	Physical Layer Security for Satellite based IoT Edge Services with Deep Reinforcement Learning for Energy Efficiency	La Trobe University	Australia	2020	2023
1-09s	Zachary Aul	RP 1	Anomaly Detection in IoT for Satellite Security Using Blockchain	La Trobe University	Australia	2020	2022
1-14s	Mohamed Sheta	RP 1	Potentials and Limitations of the IEEE 802.15.3d Standard for Terahertz Satellite Communications	University of Adelaide	International	2021	2024
1-16s	Ahsan Waqas	RP 1	Distributed Beamforimng for Satellite Applications	UniSA	Australia	2021	2024
2.18s	Brandon Victor	RP 3	Using Satellite Data to Locate and Phenotype Plants from Space	La Trobe	Australia	2021	2024
2.19s	Harikesh*	RP 3	An empirical and dynamic tool for prediction of forest fire spread using remote sensing and machine learning techniques	USQ	International	2021	2024

Project no.	Student's Name	Research Program	Project Title	University	Country	Date Commenced	Completion Due
2-01	Ziwei Wang	RP 2	Event-based attitude estimation for space applications	The Australian National University	Australia	2021	2024
2-02s	Anne Bettens	RP 2	Autonomous navigation of satellites for space exploration	University of Sydney	Australia	2020	2022
2-03s	Sam Hilton	RP 2	Human-Autonomy teaming for intelligent Distributed Satellite Operations	RMIT	Australia	2020	2022
2-04s	Jordan Plotnek	RP 2	Measuring Control System Resilience to Cyber-Physical Threat in a Satellite Context	University of South Australia	Australia	2020	2022
2-05s	Thomas Graham	RP 2	Responsible AI in Space	Swinburne University	Australia	2021	2024
2-06s	Sabrina Slimani	RP 2	Using quantum entanglement to remotely synchronise clocks	University of Adelaide	Australia	2021	2024
2-08	Emily Ahern	RP 2	Compact Clock for Small Satellite Applications: Protocol Development for Increased Stability	University of Adelaide	Australia	2021	2024
2-13s	Kathiravan Thangavel	RP 2	Artificial Intelligence for Distributed Satellite Systems Autonomous Operations: An Integrated Approach to Space and Control Segments Co-Evolution	RMIT	International	2021	2024
2-16s	Sai Vallapureddy	RP 2	A machine learning based solution for Space Situational Awareness and Space sustainability	RMIT	International	2021	2024

Project no.	Student's Name	Research Program	Project Title	University	Country	Date Commenced	Completion Due
2-17s	Artur Medon	RP 2	Small satellite thermal management with 3D printed metal heat sinks containing phase change material thermal storage	UniSA	Australia	2021	2024
3-04	TBC*	RP 3	Develop AI analytics for FRP combing geostationary and LEO platformed sensors	RMIT	TBC*	2021	2024
3-04	TBC*	RP 3	Develop AI analytics for combustion completeness combing geostationary and LEO platformed sensors	RMIT	TBC*	2021	2024
3-04	TBC*	RP 3	Develop AI analytics for fire persistence combing geostationary and LEO platformed sensors	RMIT	TBC*	2021	2024
3-06s	Jason Dail*	RP 3	Towards effective adaptive monitoring of UN SDG #15 Protect and Sustain Terrestrial Ecosystems using EO Data, Products and Services	The University of Queensland	USA	2021	2024
3-07s	Liang Zhao	RP 3	Satellite image-based smoke detection for bush fire detection	UniSA	Australia	2021	2024

Diversity & Inclusion (D&I)

SmartSat is committed to Diversity and Inclusion and progressed several collaborative initiatives with The Inclusive Organisation. This included offering 16 representatives from partner organisations the opportunity to participate in an Inclusive Leader Training Program to equip them with the knowledge, tools, and behaviours to drive inclusion in their own organisations. Phase Three of the joint project has commenced, which aims to measure the state of inclusion across the SmartSat partner network.

During the year, a review of all SmartSat policies and procedures was conducted to ensure they reflect our commitment to D&I. Guidance for researchers has also been developed and is available on the SmartSat website to assist partners in developing the D&I section of their research project proposals.

The first Annual Staff Survey was undertaken to obtain a more detailed staff demographic profile and measure performance across 12 key areas of inclusion. This information will be used to benchmark and measure improvement over the years to come. All staff were invited to attend a townhall meeting to review and discuss the results and the recommendations from the survey report have been incorporated into the 2021-22 D&I Action Plan.

The Health & Wellbeing Program remains under development with several initiatives introduced over recent months. These include staff flu shots, celebratory events such as International Women's Day, an office recycling program at SmartSat HQ and the establishment of an Employee Assist Program to support staff and promote mental health initiatives.

D&I Action Plan

The 2021-22 D&I Action Plan outlines a series of actions and success measures to progress our D&I activities across six priority areas listed below. Progress against the Action Plan will be closely monitored and reported quarterly to the D&I Committee.

Inclusive behaviours

Performance and career

Communications and marketing

Inclusive planning and action

Recruitment, training and development

SmartSat strives to build an inclusive culture which embraces people's individual differences and inspires people to reach their full potential. We are working hard to ensure our workplace and the broader space industry support a diverse range of voices which reflect the communities in which we live, work and represent.

Professor Andy Koronios
CEO, SmartSat

D&I Committee

The SmartSat D&I Committee has been established, as a sub-committee of the Board, to guide and progress our D&I program. The committee is comprised of internal representatives as well as members from partner organisations. The current committee is comprised of the following members:

Prof. Andy Koronios, Chair, SmartSat
Andrew Beveridge, SmartSat
Prof. Margaret Harding, SmartSat
Peter Nikoloff, SmartSat, Nova Group
Dr Sarah Pearce, Square KM Array Observatory*
Tim Roberts, Australian Space Agency
Eva Rodriguez Rodriguez, FrontierSI
Emily White, SmartSat

Our Staff

44% of our workforce are multilingual

11 11 languages are spoken

38% of our staff are women

50% of our workforce are bi-cultural
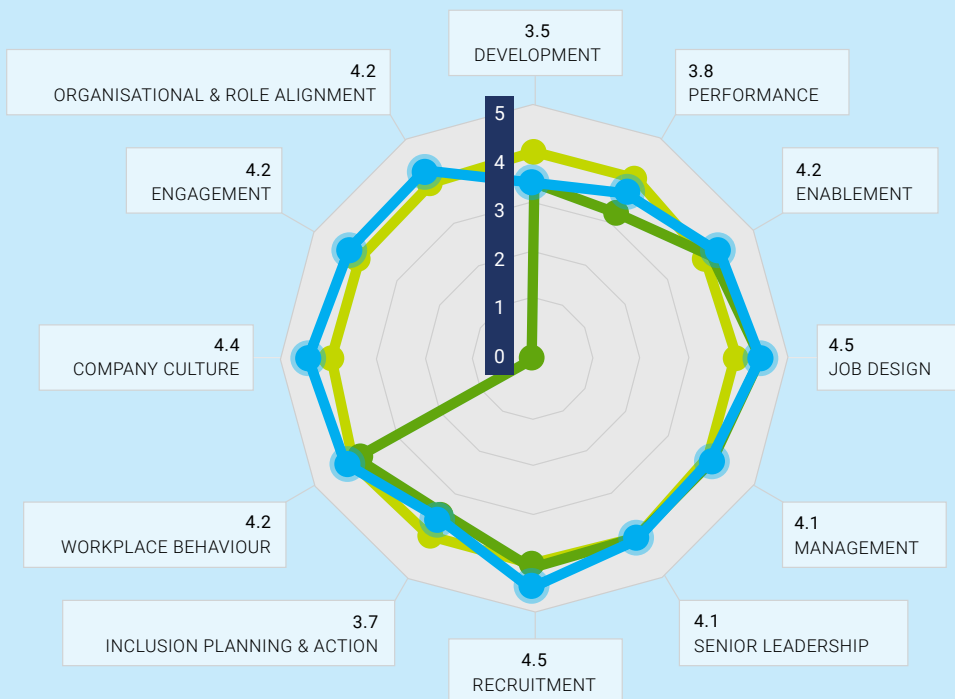
1. Does not demonstrate inclusion
2. Inconsistently demonstrates inclusion
3. Somewhat demonstrates inclusion
4. Demonstrates inclusion
5. Exceptionally demonstrates inclusion

● Target
● Score at Apr 2021
● Score at Oct 2020

3.5 DEVELOPMENT
3.8 PERFORMANCE
4.2 ORGANISATIONAL & ROLE ALIGNMENT
4.2 ENGAGEMENT
4.2 ENABLEMENT
4.4 COMPANY CULTURE
4.5 JOB DESIGN
4.2 WORKPLACE BEHAVIOUR
4.1 MANAGEMENT
3.7 INCLUSION PLANNING & ACTION
4.1 SENIOR LEADERSHIP
4.5 RECRUITMENT

5
4
3
2
1
0

Risks and Impediments

The SmartSat Audit, Risk and Compliance Committee (ARCC) actively uses a Risk Register for the management and reporting of risks which is reviewed quarterly by management, the ARCC and the Board. While SmartSat is progressing well with all critical governance and management systems in place, it is recognised that the identification and management of the following risks is critical to success:

IT and Cyber Security

Cyber Security remains a standing agenda item on the SmartSat board agenda such that during the year SmartSat has been able to develop a comprehensive Security Framework, inclusive of Information Technology (IT) and Cyber Security. During the reporting period SmartSat completed two assessments of SmartSat's maturity against the Australian Cyber Security Centre (ACSC) Essential Eight. The first was undertaken by the external IT service provider (Chamonix) in July 2020, and then a series of actions were implemented to uplift the SmartSat cyber measures to fully align with the intent of the mitigation strategies outlined by the ACSC. The second was undertaken by CyberCx to as an audit to the work implemented by the IT consultant and provide additional guidance relating to implementation of controls and remediation activities following the assessment. The findings of both reviews found SmartSat is well placed with its Cyber and IT policies and environment. It is intended that SmartSat will continue to educate staff and the network, and look to implement to recommendations of the review by CyberCx.

COVID-19

The wide-ranging impacts of COVID-19 have been well reported and have been a particular focus for SmartSat across the past 12 months. While SmartSat has been fortunate to retain its partners during this difficult period, and partner cash commitments have largely not been impacted, some partners have approached SmartSat to seek to negotiate arrangements, following COVID-related impacts to their organisation, including: re-profiled budgets, staff restructures and employment freezes, remote working activities, and supply chain difficulties. The impact on SmartSat has been seen in the form of reduced partner in-kind contributions, project initiations, the re-directing of some university research staff to teaching duties, resulting in some delays on project progress and partner engagement. The success of the SmartSat Tactical Research Fund, reported last year, saw over 20 short (12-month) projects approved and initiated. A number of these have been successful in accelerating the research program and increasing engagement with partners. It is expected that some of these will transition into larger projects in the coming reporting period. SmartSat management and Board continue to monitor the impacts of COVID-19 and work with partners to minimise any significant impact.

Participant Engagement

On balance, when comparing against some other CRCs, SmartSat has a large partner base. SmartSat therefore has identified a number of risks relevant to partner engagement and retention, including areas relevant to finance, strategy, and communication and outreach. During the term the ARCC undertook a deep dive into partner engagement within SmartSat. It noted that during its first two years SmartSat has had a focus on providing a balanced level of engagement and support to all partners, while also acknowledging that the majority of funding is coming from a small cohort of partners and this group have needed additional attention. SmartSat also laid the foundation for a number of initiatives to build deeper relationships with individual partners, support partner engagement and retention, and provide greater analysis of how partners are engaging with SmartSat, including:

- The early establishment of State Nodes are expected to be a proactive and positive partner engagement tool, for both SmartSat Participants, and third parties;

- Alignment of key staff to act as partner relationship managers to individual Participants;

- Development of a bespoke Customer Relationship Management (CRM) System, that will provide partner engagement dashboards and support the monitoring of engagement, and return on investments of partners, across SmartSat activities.

While SmartSat has laid substantial groundwork on partner engagement and retention, there remains work to be done, including:

- Engaging the remainder of partners on projects, and building the number of projects in Core Partner portfolios;

- More focussed one-on-one discussions with partners on projects, and on opportunities for utilisation of project IP where partners may not have been directly involved in projects; and

- Expanding some of the engagement mechanisms to ensure SmartSat is seen to be operating on a national level.

In considering the challenging year presented for SmartSat and many of its partners, it is noteworthy that since its establishment in January 2020, SmartSat has only had one partner (D-CAT) formally request to exit from being a partner. While a number of partners may still be considered at risk, the strategies outlined above have played a substantial part in partner retention.

Project Progress

With issues linked to COVID-19, a key risk for SmartSat has been the activation of its research program. SmartSat has made significant progress in the development and approval of projects in its second year. It has now commenced 43 projects with partners, plus a number of PhD projects. Through this, SmartSat has refined its reporting and monitoring to ensure project progress is tracked and issues resolved, and items such as intellectual property carefully monitored. The pivoting of the research program to now align with the three Capability Demonstrators has provided greater focus for project initiation and discussion with partners. SmartSat now has a growing portfolio of projects and a number of proposals in its development pipeline. It is expected that this effort in the past 12 months to actively pursue project development opportunities will support performance against activities and create opportunities to transition project into future phases of work and into industry adoption. Any items that we have noted have been related to projects that were designed with significant consultation and/or face-to-face workshops have needed to be re-designed or modified due to the limits of COVID-19. This has impacted both progress and the breadth of feedback in some instances; however, the majority of projects have not faced significant delays.

Achievement of Commonwealth Milestones

Of the first two years of milestones, 60% are completed or near complete. Milestones that are currently behind schedule are largely associated with the Earth Observation program, where the establishment of key activities and cross-program teams have been delayed. It is not considered that this is a material delay to SmartSat activities, and Earth Observation projects aligned to the Capability Demonstrators and those initiated from open calls will support the uplift of these milestones. Further, the agreement between SmartSat and the Queensland Government to establish an Earth Observation Hub in Queensland will provide significant support to deliver future milestones in that program. Fundamentally, the SmartSat milestones remain relevant and, while there has been some delay, SmartSat is on track to achieve milestones outlined within the Commonwealth Agreement.

HDR Student Recruitment

SmartSat has engaged with university partners to promote opportunities and secure students for its PhD program. SmartSat has continued to have a focus towards identifying areas for recruitment of local students to build domestic capacity and mitigate the impact of reduced international student numbers and the associated delays with their commencement. SmartSat now has a number of students within its program and has built good lines of communication with the network to this point. In moving forward, SmartSat builds on this foundation of work with its partners to create, and invest in, capacity aligned to its Capability Demonstrators. This will create some areas of focus and allow partners greater opportunity to build capacity in areas of mutual interest. While our target number of students expected to be enrolled with SmartSat at this time is slightly lower than expected, an ongoing push to engage with students with the assistance of partners should see numbers align with our targets and minimise any impact on the research program.

Intellectual Property (IP) Management

As outlined under the SmartSat Core Participants Agreement, the SmartSat Board will be responsible for determining protocols relating to the ownership of project IP, and utilisation of project IP, which will be agreed in Project Agreements by SmartSat on a fair and consistent basis.

The ownership of intellectual property (IP) is a key consideration for all participants in a project. In certain circumstances, it may be appropriate for SmartSat to depart from the position that it will own the project IP. While this will ultimately depend on the circumstances of each project, SmartSat has an approach to allow consideration on when it may be appropriate to alter the starting position. If a participant is seeking ownership of project IP (for whatever reason), SmartSat ensures that all project participants are involved in the decision as all participants will ultimately need to agree and sign the Project Agreement. To date, this process is working well, and the flexibility has provided for various project IP ownership positions that are fit for purpose of the project and partners' interests.

In our second year of operation, SmartSat has further refined its processes around its IP Utilisation Protocol that, as previously reported, would be guided by two principles, namely:

• Preference for utilisation rights to be given to those (Core and Supporting) participants who have played a lead role in the research and development phase, and

• The flow of benefits from outcomes of utilisation must be in the overall best interests of all SmartSat participants, including the immediate and long-term national interest.

In establishing all of its projects, SmartSat undertakes to identify all background IP, and third party IP, being brought to a project, along a Utilisation Agent on each Project Agreement where provisional utilisation rights and intended fields of use are identified. All of this is completed for each project and the details are established in the Project Agreement prior to signoff. This is in addition to documenting the agreed position on IP ownership.

In most instances, the development of a detailed Utilisation Plan, which will include the strategy of IP protection, and commercial terms for utilisation, are not fully developed at the commencement of the project. The review and monitoring of project allows SmartSat, and the project partners, to commence the project and take some additional time consider what IP will be developed from the project, and the time to develop a more mature commercial utilisation strategies for its exploitation.

To that end, SmartSat projects are required to report on a quarterly basis. The management and monitoring of project IP is a key element of this, including consideration of project IP that may be released in any publications. Quarterly progress reports that are submitted by project teams are reviewed by SmartSat management, which create opportunities to discuss IP with the teams as items arise. For all projects that complete, a summary report detaining IP and publications is required, to allow a fulsome review of the project outcomes, and consideration of any IP issues or IP utilisation strategies.

During the term, SmartSat established a process to allow project partners, once greater clarity on the project IP has been realised, to apply to become a Utilisation Agent and secure agreed utilisation rights that are approved by the SmartSat Board. This process has allowed the Board to consider applications and consider their alignment to the IP Utilisation Protocol, and the two aforementioned principles, and to ensure project IP will be exploited to maximise value and national benefit.

During the term, the Board and management considered a number of projects that resulted in several agreed outcomes, including:

• Utilisation rights for the exploitation of project IP being approved and agreed with a SmartSat industry partners for different projects;

• An agreement on the engagement of an independent reviewer to undertake a review of an approved project, at a critical decision point in the project timeline, to consider difference between background IP and project IP created during the project; and

• The release of information and project IP to the public in the form of technical reports that have been published by SmartSat.

Given the complexity of some of these arrangements SmartSat will, on a case-by-case basis, enter into separate agreements with Utilisation Agents to ensure the rights and requirements for the utilisation of project IP are documents and adhered to.

SmartSat continues to monitor projects and consider the IP arising from projects with its partners. As the portfolio grows and project matures, the Board and management will continue to work with partners in this area.

CRC Future Plans and Transition Arrangements

In its second year of operation, SmartSat has continued to focus on partner engagement, project development, student recruitment, and building on the strong governance and operations of the centre established during its first year.

SmartSat Participants have agreed in principle to work towards the establishment of a permanent space research entity at the completion of the seven-year term.

During the term, the SmartSat Board and management completed a strategic planning day and confirmed the focus of the SmartSat Strategic Plan. The vision of this plan outlined that SmartSat aims to be *'globally respected as an innovator in space technology and valued as an enduring, trusted and leading contributor in transforming Australia's space research and innovation ecosystem'*.

Through successful delivery against the Strategic Plan, SmartSat will aim to create a sustainable presence of a national, collaborative, innovation driven, research and development organisation, that will succeed through its enduring partnerships.

With the above setting the vision, SmartSat has commenced early planning and discussion with the Board about its future post the CRC Program Grant, including consideration for future models.
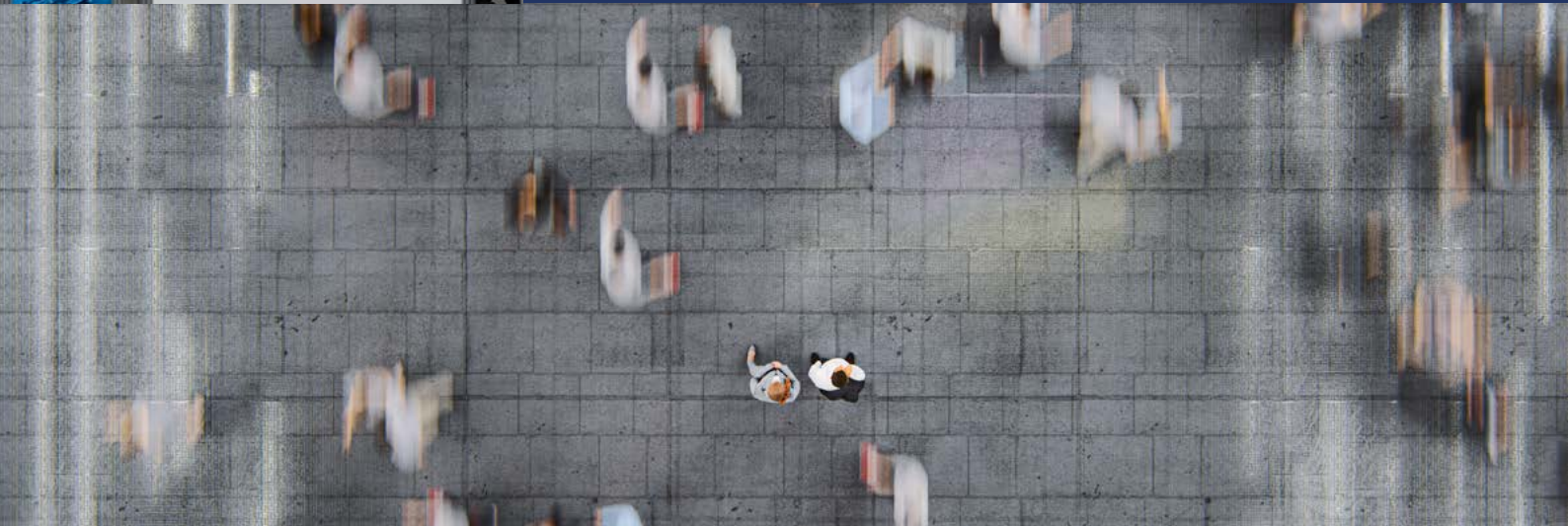
Financial Statements

SmartSat CRC Ltd

ABN 63 633 923 949
ACN 633 923 949
For the year ended 30 June 2021

Contents

Directors' Report

SmartSat CRC Ltd
For the year ended 30 June 2021

Directors' Report

The directors present their report on SmartSat CRC Ltd (SmartSat) for the year ended 30 June 2021.

Information on directors

The names of each person who has been a director during the year and to the date of this report are:

Directors	Position	Date appointed
Dr Peter Woodgate	Chair	05/08/2019
Prof. Andy Koronios	CEO & Managing Director	05/08/2019
Prof. Jacqueline Craig AM	Director	27/11/2019
Mr. Michael Davis AO	Director	27/11/2019
Dr. Rosalind Dubs	Director	27/11/2019
Prof. Margaret Harding	Director	27/11/2019
Dr. Michele Allan	Director	27/11/2019
Dr. Danielle Wuchenich	Director	31/01/2021

Principal Activities

The principal activities of SmartSat during the financial period were to conduct translational research which creates game-changing technologies, generate know-how that will make Australian industries more competitive, and future-proof jobs for the Australian population.

SmartSat is a consortium of universities and other research organisations, partnered with industry that has been funded by the Australian Government to develop know-how and technologies in advanced telecommunications and IoT connectivity, intelligent satellite systems and Earth observation next generation data services. The impact of this research will be to develop intellectual property and a specialist space industry expertise that will spawn new businesses, create export economic value and generate new high-tech jobs for all Australians.

Short and long term objectives of the Group

SmartSat was established to tackle three major challenges:

1.   Lack of universal digital connectivity; (communications and connectivity)

2.   Fragmented space ecosystem; (creation of an integrated space R&D ecosystem)

3.   Technology-limited earth observation; (earth observation from space)

Directors' Report

The strategic objectives of SmartSat are to:

·   Forge space systems research

·   Drive innovation and transformation

·   Develop a space industry

·   Foster a space smart nation

·   Position Australia as a global player in the space sector

The Group's strategy for achieving its objectives

SmartSat has developed strategic and operations plans that underpin the achievement of its strategic objectives.

These include:

·   Seeking peer review of SmartSat projects and outcomes from world leaders in space research and development

·   Developing a continuous review approach

·   Identifying areas of high impact applications in which to develop research programmes relevant to EU needs

·   Developing a technology roadmap to align research projects and technology development to selected applications

·   Identifying higher degree research (HDR) topics that support and augment the research programme

·   Conducting a space industry skill needs analysis

·   Collaborating with educational providers in mapping all available relevant training programmes

·   Developing partnerships to share expertise, capabilities and strategies

·   Using media tracking services to track media reporting on SmartSat activities and outputs

Key performance indicators used by the group

Key performance indicators have been developed for each of the Group's strategic objectives including:

·   Partners contributing additional funding to CRC approved research projects

·   Recognition of excellence in national and international events and activities

·   External benchmarking of research projects

·   Successful completion of at least 70 HDR students

·   A percentage of SmartSat students will be employed by the Australian space industry

The Group's key performance measures used are the milestones that are set up in the CRC Commonwealth Agreement and SmartSat is required to report against those milestones on a quarterly basis. SmartSat is also required to submit an annual report to the Commonwealth.

Significant Changes

There were no significant changes to the operations of the Group.

Directors' Report

Operating Result

A review of the operations of the Group during the year and the results of those operations, the Group was engaged in its principal activities, the results of which are disclosed in the attached financial statements.

The profit of the Group for the year amounted to $2,534,619. (Prior period: $11,652,883)

Dividends

The Group is limited by guarantee and has no share capital. No dividends were paid or declared by SmartSat for the period.

Events after the reporting date

No matters or circumstances have arisen since the end of the financial year which significantly affected or may significantly affect the operations of the Group, the results of those operations or the state of affairs of the Group in future financial years.

Future developments and results

As the Group continues its activities, further expenditure will be incurred on research, educational and other activities and projects established by SmartSat.

Environmental issues

The Group's operations are not regulated by any significant environmental regulations under a law of the Commonwealth or of a state or territory of Australia.

Information on directors

The information on directors is as follows:

	Qualifications
Dr. Peter Woodgate	DBA, M App Sci (Remote Sensing), B For Sci, Dip For, GAICD, FSSSI (Hon)
Prof. Andy Koronios	PhD, MLitt (Comp), GradDip Ed, BE, FACS, FISEAM, GAICD
Prof. Jacqueline Craig AM	BSc, MSc, PhD, FTSE
Mr. Michael Davis AO	LLB, MSc (Space Studies)
Dr. Rosalind Dubs	BSc, Dr ès Sc (Lausanne), FTSE, FAICD
Prof. Margaret Harding	BSc (Hons, Chemistry), PhD (Chemistry), DSc (Chemistry), FRACI, MAICD
Dr. Michele Allan	B App Sc (Biomedical), DBA, M Mgmt Tech, M Com Law, FAICD, FTSE
Dr. Danielle Wuchenich	PhD (Physics), BSc (Physics and Mathematical Studies), BA (Spanish Studies)

Directors' Report

Meetings of directors

Directors	Number eligible to attend	Number attended
Dr. Peter Woodgate	8	8
Prof. Andy Koronios	7	7
Prof. Jacqueline Craig AM	8	8
Mr. Michael Davis AO	8	8
Dr. Rosalind Dubs	8	8
Prof. Margaret Harding	8	8
Dr. Michele Allan	8	8
Dr. Danielle Wuchenich	3	3

Indemnification and insurance of officers and auditors

The directors and officers of the Group are covered by a directors and officers insurance policy, paid for by the Group.

No other indemnities have been given during or since the end of the year for any person who is or has been an officer or auditor of the Group.

Proceedings on behalf of the Group

No proceedings have been entered into on behalf of the Group.

Members' guarantee

SmartSat CRC Ltd is a company limited by guarantee. In the event of, and for the purpose of winding up of the company, the amount capable of being called up from each member and any person or association who ceased to be a member in the year prior to the winding up, is limited to $100 for members that are corporations and for all other members, subject to the provisions of the company's constitution.

At 30 June 2021 the collective liability of members was $800. (2020: $900)

Auditor's independence declaration

The lead auditor's independence declaration in accordance with section 60-40 of the Australian Charities and Not-for-profits Commission (ACNC) Act 2012, for the year ended 30 June 2021, has been received and can be found on the following page.

Signed in accordance with a resolution of the Board of Directors:

Dr. Peter Woodgate
Director

Prof. Andy Koronios
Director

30th September 2021

BDO

Tel: +61 8 7324 6000
Fax: +61 8 7324 6111
www.bdo.com.au

BDO Centre
Level 7, 420 King William Street
Adelaide SA 5000
GPO Box 2018 Adelaide SA 5001
Australia

DECLARATION OF INDEPENDENCE
BY ANDREW TICKLE
TO THE DIRECTORS OF SMARTSAT CRC LTD

As lead auditor of SmartSat CRC Ltd for the year ended 30 June 2021, I declare that, to the best of my knowledge and belief, there have been:

1. No contraventions of the auditor independence requirements of section 60-40 of the *Australian Charities and Not-for-profit Commission Act 2012* in relation to the audit; and
2. No contraventions of any applicable code of professional conduct in relation to the audit.

This declaration is in respect of Company Name and the entities it controlled during the period.

Andrew Tickle
Director

BDO Audit (SA) Pty Ltd

Adelaide, 7 October 2021

Consolidated Statement of Profit or Loss and Other Comprehensive Income

SmartSat CRC Ltd

For the year ended 30 June 2021

	NOTES	2021	5 AUG 2019-30 JUN 2020
Revenue			
Contributions from Participants		5,155,305	8,567,141
Government Grants		7,065,312	4,956,066
Third Party Contributions		550,000	180,000
Total Revenue		12,770,617	13,703,207
Other Income			
Other Income	5	615,301	294,791
Total Other Income		615,301	294,791
Total Revenue and Other Income		13,385,918	13,997,998
Programme Costs			
Education Expenditure		440,234	-
Outreach		142,525	117,359
Research Expenditure		8,099,495	530,261
Total Programme Costs		8,682,254	647,620
Expenses			
Business Development		126,304	153,752
Conferences & Seminars		(11,136)	30,264
Administration Expenses	6	988,429	706,727
Governance		330,841	216,572
Information Technology		216,516	133,069
Marketing & Promotion		157,792	207,932
Office Operations		199,038	120,857
Other Expenses		161,261	128,322
Total Expenses		2,169,045	1,697,495
Profit/(Loss)		2,534,619	11,652,883
Other Comprehensive Income			
Other Comprehensive Income		-	-
Total Other Comprehensive Income		-	-
Total Comprehensive Income		2,534,619	11,652,883

The accompanying notes form part of these financial statements.

Consolidated Statement of Financial Position

SmartSat CRC Ltd
As at 30 June 2021

	NOTES	30 JUN 2021	30 JUN 2020
Assets			
Current Assets			
Cash at Bank	7	18,320,643	11,087,716
Trade and Other Receivables	8	704,213	1,211,364
Prepayments		23,430	19,091
Other Current Assets		522	522
Income Receivable		-	50,000
Total Current Assets		19,048,808	12,368,692
Non-Current Assets			
Right-of-use Asset	9	274,920	353,468
Total Non-Current Assets		274,920	353,468
Total Assets		19,323,728	12,722,160
Liabilities			
Current Liabilities			
Trade and Other Payables	10	4,735,756	683,103
Employee Benefit Liabilities	11	100,543	24,480
Lease Liabilities	12	76,262	54,785
Total Current Liabilities		4,912,561	762,368
Non-Current Liabilities			
Lease Liabilities	12	217,192	306,264
Employee Benefit Liabilities	11	6,473	645
Total Non-Current Liabilities		223,665	306,909
Total Liabilities		5,136,226	1,069,277
Net Assets		14,187,502	11,652,883
Equity			
Reserves		7,726,416	4,321,500
Retained Earnings		6,461,086	7,331,383
Total Equity		14,187,502	11,652,883

The accompanying notes form part of these financial statements.

Consolidated Statement of Changes in Equity

SmartSat CRC Ltd
For the year ended 30 June 2021

Equity

	Research Chairs Reserve	Scholarships Reserve	Retained Earnings	Total Equity
	Note 17	Note 17		
Balance at 5 August 2019	-	-	-	-
Net Profit for the Period	-	-	11,652,883	**11,652,883**
Other Comprehensive Income for the Period	-	-	-	-
Total Comprehensive Income for the Period	**-**	**-**	**11,652,883**	**11,652,883**
Transfers to Reserves	-	4,321,500	(4,321,500)	-
Balance at 30 June 2020	**-**	**4,321,500**	**7,331,383**	**11,652,883**
Balance at 1 July 2020	**-**	**4,321,500**	**7,331,383**	**11,652,883**
Net Profit for the Period	-	-	2,534,619	2,534,619
Other Comprehensive Income for the Period	-	-	-	-
Total Comprehensive Income for the Period	**-**	**-**	**2,534,619**	**2,534,619**
Transfers to/(from) Reserves	3,600,000	(195,084)	(3,404,916)	-
Balance at 30 June 2021	**3,600,000**	**4,126,416**	**6,461,086**	**14,187,502**

The accompanying notes form part of these financial statements.

Consolidated Statement of Cash Flows

SmartSat CRC Ltd
For the year ended 30 June 2021

	NOTES	2021	5 AUG 2019-30 JUN 2020
Statement of Cash Flows			
Cash flows from operating activities			
Receipts from Grants		7,821,843	5,451,673
Receipts from Participants		6,424,049	7,625,676
Receipts from Other Operating Activities		985,930	146,093
Payments to Suppliers and Employees		(7,957,724)	(2,101,925)
Interest Received		45,307	8,799
Interest Paid	15	(18,883)	(10,907)
Net Cash flows from operating activities		7,300,522	11,119,408
Net cash flows used in financing activities			
Repayment of lease liabilities (principal)	13	(67,595)	(31,693)
Net Cash flows from financing activities		(67,595)	(31,693)
Net increase in cash and cash equivalents		7,232,927	11,087,716
Cash and Cash Equivalents at the beginning of the period		11,087,716	-
Cash and Cash Equivalents at the end of the period	7	18,320,643	11,087,716

The accompanying notes form part of these financial statements.

Notes to the Financial Statements

SmartSat CRC Ltd
For the year ended 30 June 2021

The consolidated financial statements and notes represent those of SmartSat CRC Ltd & Controlled Entities. SmartSat CRC Ltd is a Company limited by guarantee, incorporated and domiciled in Australia. Aurora Space Cluster Pty Ltd (formerly Australian Space Industry Start-up Company Pty Ltd) is a wholly owned subsidiary of SmartSat CRC Ltd.

SmartSat is a not-for-profit entity for the purpose of preparing the financial statements. The functional and presentation currency of SmartSat is Australian dollars.

The financial report was authorized for issue by the Directors on 30 September 2021. The directors have the power to amend and reissue the financial statements.

Principles of Consolidation

The consolidated financial statements incorporate the assets and liabilities of all subsidiaries of SmartSat CRC Ltd ('company') as at 30 June 2021 and the results of all subsidiaries for the year then ended. SmartSat CRC Ltd and its subsidiaries together are referred to in these financial statements as the 'Group."

1. Basis of Preparation

The financial statements are general purpose financial statements that have been prepared in accordance with the Australian Accounting Standards   Reduced Disclosure Requirements and the *Australian Charities and Not-for-Profits Commission Act 2012.*

The company was incorporated on 5th August 2019 and consequently the comparatives in the financial report reflect the results of the period 5 August 2019 to 30 June 2020.

The financial report has been prepared on an accrual basis, and is based on the historical cost method unless otherwise stated.

The Company is an entity to which ASIC Corporations (Rounding in Financial/Directors' Reports) Instrument 2016/191 applies and, accordingly amounts in the financial statements and Directors' Report have been rounded to the nearest dollar.

2. New Australian Accounting Standards

The Company has adopted all of the new or amended Accounting Standards and Interpretations issued by the Australian Accounting Standards Board ('AASB') that are mandatory for the current reporting period.

Any new or amended Accounting Standards or Interpretations that are not yet mandatory have not been early adopted.

3. Statement of Significant Accounting Policies

The accounting policies that have been adopted in the preparation of these statements are as follows:

Revenue Recognition

Income for Not-for-Profit Entities

The Group applies AASB 1058 Income of Not-for-Profit Entities. The timing of income recognition under AASB 1058 is dependent upon whether the transaction gives rise to a liability or other performance obligation at the time of receipt. Income under the standard is recognised where: an asset is received in a transaction, such as by way of grant, bequest or donation; there has either been no consideration transferred, or the consideration paid is significantly less than the asset's fair value; and where the intention is to principally enable the entity to further its objectives. For transfers of financial assets to the entity which enable it to acquire or construct a recognisable non-financial asset, the entity must recognise a liability amounting to the excess of the fair value of the transfer received over any related amounts recognised. Related amounts recognised may relate to contributions by owners, AASB 15 revenue or contract liability recognised, lease liabilities in accordance with AASB 16, financial instruments in accordance with AASB 9, or provisions in accordance with AASB 137.

Notes to the Financial Statements

Income of Not-for-Profit Entities (continued)

The liability is brought to account as income over the period in which the entity satisfies its performance obligation. If the transaction does not enable the entity to acquire or construct a recognisable non-financial asset to be controlled by the entity, then any excess of the initial carrying amount of the recognised asset over the related amounts is recognised as income immediately. Where the fair value of volunteer services received can be measured, a private sector not-for-profit entity can elect to recognise the value of those services as an asset where asset recognition criteria are met or otherwise recognise the value as an expense.

For the below listed revenue streams, the Group recognises revenue as follows:

Contributions from Participants

Contributions from Participants are recognised as revenue in the Statement of Profit or Loss and Other Comprehensive Income as they are received, or when the Group has an unconditional right to receive payment.

Government Grants

Government Grants (including non-monetary grants at fair value) are recognised as revenue in the Statement of Profit or Loss and Other Comprehensive Income as they are received, or when the Group has an unconditional right to receive payment. If conditions are attached to the grant which must be satisfied before the Group is eligible to retain the contribution, the grant will be recognised in the statement of financial position as a liability until those conditions are satisfied.

Third Party Contributions

Contributions from other third parties are assessed on a case by case basis, with the Group evaluating whether sufficiently specific performance obligations are attached to the funding. Where sufficiently specific performance obligations are determined to exist, revenue is recognised in profit or loss when the Group satisfies the performance obligations. When the Group determines there are no sufficiently specific performance obligations, contributions are recognised as revenue in the Statement of Profit or Loss and Other Comprehensive Income as they are received, or when the Group has an unconditional right to receive payment.

Interest

Interest revenue is recognised as interest accrues using the effective interest method. This is a method of calculating the amortised cost of a financial asset and allocating the interest income over the relevant period using the effective interest rate, which is the rate that exactly discounts estimated future cash receipts through the expected life of the financial asset to the net carrying amount of the financial asset.

Other revenue

Other revenue is recognised when it is received or when the right to receive payment is established.

Volunteer services and other in-kind contributions

The Group has elected not to recognise volunteer services as either revenue or other form of contribution received in line with AASB 1058. As such, any related consumption or capitalisation of such resources received is also not recognised.

Financial Instruments

Financial instruments are recognised initially on the date that the Group becomes party to the contractual provisions of the instrument.

On initial recognition, all financial instruments are measured at fair value plus transaction costs (except for instruments measured at fair value through profit or loss where transaction costs are expensed as incurred).

Financial Assets

All recognised financial assets are subsequently measured in their entirety at either amortised cost or fair value, depending on the classification of the financial assets.

Notes to the Financial Statements

Classification

On initial recognition, the Group classifies its financial assets into the following categories, those measured at:

* amortised cost
* fair value through profit or loss   FVTPL
* fair value through other comprehensive income   equity instrument (FVOCI   equity)
* fair value through other comprehensive income   debt investments (FVOCI   debt)

Financial assets are not reclassified subsequent to their initial recognition unless the Group changes its business model for managing financial assets.

Amortised Cost

Assets measured at amortised cost are financial assets where:

* the business model is to hold assets to collect contractual cash flows; and
* the contractual terms give rise on specified dates to cash flows that are solely payments of principal and interest on the principal amount outstanding.

The Group's financial assets measured at amortised cost comprise trade and other receivables and cash and cash equivalents in the Statement of Financial Position.

Subsequent to initial recognition, these assets are carried at amortised cost using the effective interest rate method less provision for impairment.

Interest income, foreign exchange gains or losses and impairment are recognised in the Statement of Profit or Loss and Other Comprehensive Income. Gain or loss on derecognition is recognised in the Statement of Profit or Loss and Other Comprehensive Income.

Plant and Equipment

Minor asset purchases of less than $3,000 are expensed when incurred.

Impairment of financial assets

Impairment of financial assets measured at amortised cost is calculated using an expected credit loss (ECL) approach which requires lifetime expected credit losses to be recognised from initial recognition of the financial assets.

When determining whether the credit risk of a financial asset has increased significantly since initial recognition and when estimating ECL, the Group considers reasonable and supportable information that is relevant and available without undue cost or effort. This includes both quantitative and qualitative information and analysis based on the Group's historical experience and informed credit assessment and including forward looking information.

The Group uses the presumption that an asset which is more than 90 days past due has seen a significant increase in credit risk.

The Group uses the presumption that a financial asset is in default when:

* the other party is unlikely to pay its credit obligations to the Group in full, without recourse to the Group to actions such as realising security (if any is held); or
* the financial assets is more than 120 days past due date.

Credit losses are measured as the present value of the difference between the cash flows due to the Group in accordance with the contract and the cash flows expected to be received. This is applied using a probability weighted approach.

Notes to the Financial Statements

Trade Receivables

Impairment of trade receivables and contract assets have been determined using the simplified approach in AASB 9 which uses an estimation of lifetime expected credit losses. The Group has determined the probability of non payment of the receivable and contract asset and multiplied this by the amount of the expected loss arising from default.

The amount of the impairment is recorded in a separate allowance account with the loss being recognised in Other Expenses. Once the receivable is determined to be uncollectable then the gross carrying amount is written off against the associated allowance.

Where the Group renegotiates the terms of trade receivables due from certain customers, the new expected cash flows are discounted at the original effective interest rate and any resulting difference to the carrying value is recognised in the Statement of Profit or Loss and Other Comprehensive Income.

Other Financial Assets Measured at Amortised Cost

Impairment of other financial assets measured at amortised cost are determined using the expected credit loss model in AASB 9. On initial recognition of the asset, an estimate of the expected credit losses for the next 12 months is recognised. Where the asset has experienced a significant increase in credit risk then the lifetime losses are estimated and recognised.

Financial Liabilities

The Group measures all financial liabilities initially at fair value less transaction costs, subsequently financial liabilities are measured at amortised cost using the effective interest rate (EIR) method. Gains and losses are recognised in the Statement of Profit or Loss and Other Comprehensive Income when the liabilities are derecognised as well as through the effective interest rate amortisation process.

Amortised cost is calculated by taking into account any discount or premium on acquisition and fees or costs that are an integral part of the EIR. The EIR amortisation is included as finance costs in the Statement of Profit or Loss and Other Comprehensive Income.

The financial liabilities of the Group comprise trade and other payables.

Impairment of non-financial assets

At the end of each reporting period the Group determines whether there is an evidence of an impairment indicator for non financial assets.

Where an indicator exists and regardless for indefinite life intangible assets and intangible assets not yet available for use, the recoverable amount of the asset is estimated.

Where assets do not operate independently of other assets, the recoverable amount of the relevant cash-generating unit (CGU) is estimated.

The recoverable amount of an asset or CGU is the higher of the fair value less costs of disposal and the value in use. Value in use is the present value of the future cash flows expected to be derived from an asset or cash-generating unit.

Where the recoverable amount is less than the carrying amount, an impairment loss is recognised in the Statement of Profit or Loss and Other Comprehensive Income.

Reversal indicators are considered in subsequent periods for all assets which have suffered an impairment loss.

Cash and Cash Equivalents

Cash and cash equivalents include cash on hand, deposits held on call with banks, other short-term highly liquid investments with original maturities of three months or less, and bank overdrafts.

Provisions

Provisions are recognised when the Group has a legal or constructive obligation resulting from past events, for which it is probable that there will be an outflow of economic benefits and that outflow can be reliably measured. Provisions are measured using the best estimate available of the amounts required to settle the obligation at the end of the reporting period.

Notes to the Financial Statements

Employee Benefits

Provision is made for the liability for employee entitlements arising from services rendered by employees to 30 June 2021. Provision in respect of wages and salaries, annual leave and long service leave is recognised when it is probable that settlement will be required and they are capable of being measured reliably.

Provisions made in respect of employee benefits expected to be settled within 12 months are measured at their nominal values using the remuneration rate expected to apply at the time of settlement.

Provisions made in respect of employee benefits which are not expected to be settled within 12 months are measured at the present value of the estimated future cash outflows to be made by the Group in respect of services provided by employees up to reporting date.

Leases

Finance leases are leases of fixed assets where substantially all of the risks and benefits incidental to the ownership of the asset are transferred to the Group, but the legal ownership is not transferred to the Group.

Finance leases are capitalised by recording a right-of-use asset and a corresponding liability at the lower of the amounts equal to the fair value of the leased asset, or the minimum lease payments measured at present value including any residual values.

Leased assets are depreciated on a straight-line basis over the shorter of their estimated useful lives or the lease term.

Short-term leases (remaining lease term of 12 months or less) or low value leases are charged to the Statement of Profit or Loss and Other Comprehensive Income on a straight-line basis over the term of the lease.

The Group has recognised a right-of-use asset of $392,742 upon the commencement of the lease on 1 January 2020. The lease liability was recognised of the equal value of $392,742. The weighted average incremental borrowing rate applied to lease liability was 6%.

The Group has tested the right-of-use asset for impairment on the date of application and has concluded that there is no indication that the right-of-use asset is impaired.

Goods and Services Tax (GST)

Revenue, expenses and assets are recognised net of the amount of goods and services tax (GST), except where the amount of GST incurred is not recoverable from the Australian Taxation Office (ATO).

Receivables and payable are stated inclusive of GST.

Cashflows in the statement of cash flows are included on a gross basis and the GST component of cash flows arising from investing and financing activities which is recoverable from, or payable to, the ATO is classified as operating cash flows.

Income Tax

Aurora Space Cluster Pty Ltd is a for profit company and liable for income tax. SmartSat CRC Ltd is income tax exempt under Subsection 50-5 of the Income Tax Assessment Act 1997.

4. Critical Accounting Estimates and Judgements

When determining the nature, timing and amount of revenue to be recognised, the following critical estimates and judgements were applied and are considered to be those that have the most significant effect on revenue recognition.

The directors make estimates and judgements during the preparation of these financial statements regarding assumptions about current and future events affecting transactions and balances. These estimates and judgements are based on the best information available at the time of preparing the financial statements, however, as additional information is known then the actual results may differ from the estimates.

The significant estimates and judgements made have been described below.

Notes to the Financial Statements

Key estimates - revenue recognition

The Group was required to assess whether government grants and contributions from participants fell under the scope of AASB 15 or AASB 1058. Specifically, the Group had to determine whether the Agreements contained performance obligations that meet the 'sufficiently specific' criteria in sections F20-F26 of AASB 15. Judgement is necessary to assess whether a promise is 'sufficiently specific', which takes into account any conditions specified in the Agreements regarding the following aspects:

a) the nature or type of the goods or services;

b) the cost or value of the goods or services;

c) the quantity of the goods or services; and

d) the period over which goods or services must be transferred.

No specific number or combination of the conditions noted above needs to be specified in an agreement for the promise to be 'sufficiently specific'. There may be other conditions that need to be taken into account in applying the judgement that may indicate the promise is 'sufficiently specific'.

A condition that a not-for-profit entity must transfer unspecified goods or services within a particular period does not, of itself, meet the 'sufficiently specific' criterion.

Where entities receive a transfer to be used over a particular time period for specified services, such a transfer could meet the 'sufficiently specific' criterion. It is unlikely that transfers directed at promoting or progressing an entity's charter or stated objectives alone would be specific enough. If the transfer does not specify measurable services to be provided, the entity would not meet the 'sufficiently specific' criterion because it would be unable to determine when it meets the performance obligations.

The directors have determined that the Commonwealth and participant agreements in place do not contain performance obligations that meet the 'sufficiently specific' criteria as per sections F20-F26 of the AASB 15. Therefore, Grant Income has been recognised in accordance with AASB 1058: in full upon receipt or when the Group has the unconditional right to receive the contribution, and it is probable that the economic benefits comprising the contribution will flow to the Group.

5. Other Income

	2021	5 AUG 2019-30 JUN 2020
Other Income		
Cash Flow Boost	-	100,000
Consultancy Work	93,750	-
Interest Income	45,307	8,798
Office Space	19,880	25,560
Space and Spatial Industry Road Map	40,000	89,000
Space Services Mission -SASAT1	416,364	-
Sponsorship	-	51,433
Skills Gap Analysis	-	20,000
Total Other Income	615,301	294,791

6. Administration Expenses

	2021	5 AUG 2019-30 JUN 2020
Depreciation Expenses		
Depreciation Expense – Right of use assets	78,548	39,274
Total Depreciation Expenses	78,548	39,274
Employee Expenses		
Wages & Salaries	743,170	608,320
Superannuation	83,714	31,533
Workcover	1,106	2,476

Notes to the Financial Statements

6. Administration Expenses (continued)

	2021	5 AUG 2019-30 JUN 2020
Annual Leave Expense	76,063	24,480
Long Service Leave Expense	5,828	645
Total Employee Expenses	909,881	667,453
Total Administration Expenses	988,429	706,727

7. Cash and Cash Equivalents

Cash at Bank

	2021	2020
Aurora Space Cluster Pty Ltd	11,000	-
SmartSat CRC Ltd	9,792,695	11,087,716
Smartsat CRC Ltd (NAB TD #10713840)	3,507,331	-
Smartsat CRC Ltd (MyStateBank TD1)	1,505,071	-
SmartSat CRC Ltd (MyStateBank TD2)	3,504,546	-
Total Cash at Bank	18,320,643	11,087,716
Total Cash and Cash Equivalents	18,320,643	11,087,716

Reconciliation of Cash

Cash and Cash equivalents reported in the statement of cash flows are reconciled to the equivalent items in the statement of financial position as follows:

	2021	2020
Balance as per Statement of Cash Flows		
Cash and Cash Equivalents	18,320,643	11,087,716
Balance as per Statement of Cash Flows	18,320,643	11,087,716

8. Trade and Other Receivables

	2021	2020
Accounts Receivable	704,213	1,211,364
Total Trade and Other Receivables	704,213	1,211,364

The carrying value of trade receivables is considered a reasonable approximation of fair value due to the short term nature of the balances.

The maximum exposure to credit risk at the reporting date is the fair value of each class of receivable in the financial statements.

Notes to the Financial Statements

	2021	2020
9. Right of Use Asset		
Office Lease	392,742	392,742
Accumulated Depreciation	(117,822)	(39,274)
Total Right of Use Asset	274,920	353,468

	2021	2020
10. Trade and Other Payables		
Current		
Accounts Payable	642,435	119,957
Accrued Expenses	3,876,132	6,336
Credit Card	1,962	5,984
GST	149,156	502,207
Income Tax Payable	2,600	-
PAYG Withholdings Payable	45,257	48,619
Superannuation Payable	18,214	-
Total Current	4,735,756	683,103
Total Trade and Other Payables	4,735,756	683,103

Trade and other payables are unsecured, non interest bearing and are normally settled within 30 days. The carrying value of trade and other payables is considered a reasonable approximation of fair value due to the short term nature of the balances.

	2021	2020
11. Employee Benefit Liabilities		
Provision for Annual Leave	100,543	24,480
Provision for Long Service Leave	6,473	645
Total Employee Benefit Liabilities	107,016	25,125

	2021	2020
12. Lease Liabilities		
Lease Liability Current	76,262	54,785
Lease Liability Non-Current	217,192	306,264
Total Lease Liabilities	293,454	361,049

SmartSat CRC Ltd has one finance lease with the duration of 5 years. The lease has terms to extend the period of use past the end date but no purchase option or escalation clauses.

Notes to the Financial Statements

13. Reconciliation of liabilities arising from financing activities

The changes in the Group's liabilities arising from financing activities can be classified as follows:

	Lease Liability
Balance at 5 August 2019	-
Acquisitions	392,742
- Repayments	(42,600)
- Interest	10,907
Balance at 30 June 2020	**361,049**
Balance at 1 July 2020	361,049
- Repayments	(86,478)
- Interest	18,883
Balance at 30 June 2021	**293,454**

14. Contingencies

In the opinion of the Directors, the Group did not have any contingencies at 30 June 2021 (2020: none).

15. Cash Flow Information

Reconciliation of results for the period to cashflows from operating activities

	1 July 2020 - 30 June 2021	**5 August 2019 - 30 June 2020**
Surplus for the period	$2,534,619	$11,652,884
Depreciation	$78,548	$39,274
(Increase) / decrease in trade and other receivables	$557,151	($1,261,364)
(Increase) / decrease in prepayments and other assets	($4,339)	($19,091)
Increase / (decrease) in trade and other payables	$4,052,652	$682,581
Increase / (decrease) in provisions	$81,891	$25,125
Cashflow from operations	$7,300,522	$11,119,409

16. Related Parties

The Group's main related parties are as follows:

• Key management personnel   refer to Note 18.
• Other related parties include close family members of key management personnel and entities that are controlled or significantly influenced by those key management personnel or their close family members.

Transactions between related parties are on normal commercial terms and conditions no more favourable than those available to other parties unless otherwise stated.

Notes to the Financial Statements

	2021	2020
17. Reserves		
Research Chairs Reserve	3,600,000	-
Scholarships Reserve	4,126,416	4,321,500
Total Reserves	7,726,416	4,321,500

The research chairs reserve has been set up for the specific purpose of quarantining future commitments for the payment of Research Chairs during the term of SmartSat. The amount has been identified through the budgeting process and ensures that sufficient funds are available to meet these obligations once the positions have been recruited. A statement of movement and balances will be provided for monthly financial reporting to the Executive and Board.

The scholarships reserve has been set up for the specific purpose of quarantining future commitments for the payment of PhD scholarships during the term of SmartSat. The amount has been identified through the budgeting process and ensures that sufficient funds are available to meet these obligations. Supporting the PhD programme is considered a high priority and is a commitment in the education and training milestones in the Commonwealth agreement. A statement of movement and balances will be provided for monthly financial reporting to the Executive and Board.

18. Key Management Personnel Remuneration

The totals of remuneration paid to the key management personnel of SmartSat during the year are as follows:

The total remuneration paid to key management personnel of the Group is $810,399 (2020: $698,898). Key management positions included in this value are the Chair, Non-Executive Directors, CEO, and COO.

19. Events after the end of the Reporting Period

The financial report was authorised for issue on 17 September 2021 by the Board of Directors.

No matters or circumstances have arisen since the end of the financial year which significantly affected or may significantly affect the operations of the Company, the results of those operations or the state of affairs of the Company in future financial years.

20. Statutory Information

The registered office and principal place of the Company is:

SmartSat CRC Ltd

Level 3, McEwin Building

Lot Fourteen, Frome Rd

ADELAIDE SA 5000

Directors' Declaration

SmartSat CRC Ltd
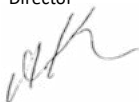## For the year ended 30 June 2021

The directors of the Group declare that:

1.   The financial statements and notes, as set out on pages 8 to 21, are in accordance with the *Australian Charities and Not-for-Profit Commissions Act 2012* and:

a.   comply with Australian Accounting Standards   Reduced Disclosure Requirements; Australian Charities and Not-for-profits Commission Regulation 2013 and other mandatory professional reporting requirements, and

b.   give a true and fair view of the financial position of the Group as at 30 June 2021 and of the performance for the year ended on that date.

2.   In the Directors' opinion, there are reasonable grounds to believe that the Group will be able to pay its debts as and when they become due and payable.

This declaration is made in accordance with a resolution of the Board of Directors.

Dr. Peter Woodgate
Director

Prof. Andy Koronios
Director

30th September 2021

BDO

Tel: +61 8 7324 6000
Fax: +61 8 7324 6111
www.bdo.com.au

BDO Centre
Level 7, 420 King William Street
Adelaide SA 5000
GPO Box 2018 Adelaide SA 5001
Australia

INDEPENDENT AUDITOR'S REPORT
TO THE MEMBERS OF SMARTSAT CRC LTD

Report on the Audit of the Financial Report

Opinion

We have audited the financial report of SmartSat CRC Ltd (the registered entity) and its subsidiaries (the Group), which comprises the consolidated statement of financial position as at 30 June 2021, the consolidated statement of profit or loss and other comprehensive income, the consolidated statement of changes in equity and the consolidated statement of cash flows for the year then ended, and notes to the financial report, including a summary of significant accounting policies, and the responsible entities' declaration.

In our opinion the accompanying financial report of SmartSat CRC Ltd, is in accordance with Division 60 of the *Australian Charities and Not-for-profits Commission Act 2012*, including:

(i)   Giving a true and fair view of the Group's financial position as at 30 June 2021 and of its financial performance for the year then ended; and

(ii)   Complying with Australian Accounting Standards – Reduced Disclosure Requirements and Division 60 of the *Australian Charities and Not-for-profits Commission Regulation 2013*.

Basis for opinion

We conducted our audit in accordance with Australian Auditing Standards. Our responsibilities under those standards are further described in the *Auditor's responsibilities for the audit of the Financial Report* section of our report. We are independent of the Group in accordance with the auditor independence requirements of the *Australian Charities and Not-for-profits Commission Act 2012* (ACNC Act) and the ethical requirements of the Accounting Professional and Ethical Standards Board's APES 110 *Code of Ethics for Professional Accountants (including Independence Standards)* (the Code) that are relevant to our audit of the financial report in Australia. We have also fulfilled our other ethical responsibilities in accordance with the Code.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Other information

Those charged with governance are responsible for the other information. The other information obtained at the date of this auditor's report is information included in the registered entity's annual report, but does not include the financial report and our auditor's report thereon.

Our opinion on the financial report does not cover the other information and accordingly we do not express any form of assurance conclusion thereon.

In connection with our audit of the financial report, our responsibility is to read the other information and, in doing so, consider whether the other information is materially inconsistent with the financial report or our knowledge obtained in the audit or otherwise appears to be materially misstated.

BDO

If, based on the work we have performed on the other information obtained prior to the date of this auditor's report, we conclude that there is a material misstatement of this other information, we are required to report that fact. We have nothing to report in this regard.

Responsibilities of responsible entities for the Financial Report

The responsible entities of the registered entity are responsible for the preparation and fair presentation of the financial report in accordance with Australian Accounting Standards – Reduced Disclosure Requirements and the ACNC Act, and for such internal control as the responsible entities determine is necessary to enable the preparation of the financial report that is free from material misstatement, whether due to fraud or error.

In preparing the financial report, responsible entities are responsible for assessing the Group's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless the responsible entities either intends to liquidate the Group or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the registered entity's financial reporting process.

Auditor's responsibilities for the audit of the Financial Report

Our objectives are to obtain reasonable assurance about whether the financial report as a whole is free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with the Australian Auditing Standards will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of this financial report.

A further description of our responsibilities for the audit of the financial report is located at the Auditing and Assurance Standards Board website (http://www.auasb.gov.au/Home.aspx) at: http://www.auasb.gov.au/auditors_responsibilities/ar3.pdf

This description forms part of our auditor's report.

BDO Audit (SA) Pty Ltd

Andrew Tickle
Director

Adelaide, 7 October 2021