SMARTSAT
COOPERATIVE RESEARCH CENTRE

SECTOR PRIORITIES

Defence and National Security

This report should be cited as:

SmartSat 2021, Defence and National Security Sector Priorities 2021, SmartSat CRC, Adelaide, Australia.

Disclaimer:

This publication is provided for the purpose of disseminating information relating to scientific and technical matters. Participating organisations of SmartSat do not accept liability for any loss and/or damage, including financial loss, resulting from the reliance upon any information, advice or recommendations contained in this publication. The contents of this publication should not necessarily be taken to represent the views of the participating organisations.

Acknowledgement:

The SmartSat is a collaborative consortium of industry and research organisations that are developing enhanced satellite connectivity, navigation and monitoring capability to propel Australia's space industry forward and generate transformative technologies to support sector needs. The technologies developed by SmartSat have the potential for application across a wide range of sectors.

As part of its planning, SmartSat had established three End User Boards to identify the challenges and needs of their sector and formed working groups to develop their respective Sector Priorities under the guidance of SmartSat's Industry and Deputy Industry Directors. Sector Priorities have been developed for: Agriculture and Natural Resources, Mining and Energy, Defence and National Security

These priorities 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 their technology and capability to service multiple sectors.

The priorities identified can be used by SmartSat partner organisations and the space community to help guide development of project proposals and identify priority areas for further research and development.

SmartSat would like to acknowledge the members of the Defence and National Security End User Advisory Board for their contributions:

Andrew Seedhouse (Chair)	Wayne Agutter
AIRCDRE Phil Gordon	Andrew Guidi
Rhys Goodwin	Martin Rowse
Nelson Bates	Brenton Whitington
Chris Brookes	Matt Tetlow

The following former members of the advisory board are also acknowledged for contributions to the development of this document:

- Luke Brown;
- Thomas Pfister;
- Bill Sowry; and
- GPCAPT Chris Robson

Table of Contents

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	**Need 1: Networked Capabilities** Create new ways to integrate and use capabilities through secure, resilient and adaptive communications networks	**Need 2: Situational Awareness** Using space to sense all of our operating environments to support agile C2 and multi-domain operations	**Need 3: Autonomous Space Operations** Trusted autonomous operations and responding to what is happening in space more rapidly than adversaries	**Need 4: Rapid Prototyping** Rapidly develop and deliver advanced technologies in space as a key enabler of responsive space capabilities
Priority Focus Areas	**F1.1 Resilient Tactical Comms** Offer robust, secure connectivity to highly mobile users through adaptive, power and bandwidth efficient data links and agile contention schemes. **F1.2 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. **F1.3 Cognitive Networks** Contribute to the ability to sense and respond autonomously to changes in network conditions in response to internal or external stimuli. **F1.4 Timing Signals** Access or extract high accuracy timing information to support synchronisation in contested environments.	**F2.1 Novel Sensors** Development of novel technologies and techniques, including distributed apertures and dynamic payloads, to create higher spectral, spatial and temporal resolution of earth. **F2.2 Multi-Sensor Integration** Combining sensor data capturing diverse phenomenology to enhance understanding of the operational environment including through intelligent fusion and change detection. **F2.3 Intelligent Processing** Exploiting Artificial Intelligence (Machine and Deep learning), including satellite processing, to enhance timely delivery & human understanding of all types of sensor data	**F3.1 Intelligent Constellations** Spacecraft/constellations that can autonomously operate, sense and react to their immediate environment and contribute to space domain awareness. **F3.2 Space Domain Understanding** Creating predictive tools that allow observations to become forecasts so response times to hazards can be reduced or eliminated. **F3.3 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.	**F4.1 Space Hardware** Ensure access to design, manufacturing and testing expertise including satellite mission system, C2 and payload development aligned with assured sovereign access. **F4.2 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.
Principles and Objectives	**Aligned:** Agile research that addresses opportunities identified in More Together, 2020 Defence Strategic Update, Force Structure Plan and broader national security needs. **Aware:** SmartSat remains aware of, and works to support, the differing needs of the Defence and National Security space R&D ecosystem. **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 out partner network. **Differentiated:** Internationally competitive with a focus on national strengths, including basic science and disruptive technologies, not playing catch-up **Digitally Engineered:** Use next generation "digital engineering" approaches to understand opportunities and evolve solutions more rapidly. **Dual-use (Commercial):** SmartSat will support programs which generate technology that can be adapted to other markets, and which has commercial applications which works to grow the viability of Australia's space industry. **Infrastructure:** Create R&D efficiencies through access to highly specialised space related infrastructure and personnel. **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. **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.			

1 Introduction

The SmartSat CRC (SmartSat) is a collaborative consortium of industry and research organisations that will propel Australia's space industry forward and generate transformative technologies to support sector needs. It will support the development of new capabilities that will position Australia as a leader in niche areas of intelligent satellite systems, advanced communications and earth observation driven data analytics.

The technologies developed by SmartSat are being targeted for their potential for multi-use application across a wide range of sectors, including Defence and National Security.

This document provides snapshot of key industry needs and research focus areas as well as a foundation for SmartSat to develop and implement solutions based on the principals and objectives. The priority areas identified in this document were developed by the SmartSat Defence and National Security End User Advisory Board (EUAB).

This document will be used by SmartSat to guide the development of a project focused sector plan and establish project priorities. The project plan will take into consideration the impact of projects, cross-sector collaboration, leverage other initiative and programs, returns on investments, and returns and benefits to project partners, industry and academia as a whole.

This document and the proceeding project plan may also be used by SmartSat partner organisations to help guide development of project proposals and identify priority areas for further research and development.

2 Background

The 2020 Defence Strategic Update[1] acknowledges the rapid changes to security within our immediate region and the pace of military modernisation across the Indo-Pacific that may challenge Australia's capability edge. Furthermore, the update refers to the impact of anti-access and area denial capabilities playing out as part of regional military capability investment and states an intent to enhance Australia's ability to independently shape actions through deterrence.

> *"Defence must develop new capabilities that can hold potential adversaries' forces and infrastructure at risk from a greater distance, and therefore influence their calculus of costs involved in threatening Australian interests. The Government's intent is that Australia take greater responsibility for our own security. It is therefore essential that the ADF grow its self-reliant ability to deliver deterrent effects"*

Space systems will play a critical role in delivering these "new capabilities" need due to unique characteristics of space-based systems and services in terms of coverage and connectivity. The Force Structure Plan[2] identifies a range of challenges for future space capabilities

> *"Australia is increasingly reliant on satellite-based capability and services, particularly where digital data and information drives decision-making. At the same time, low-Earth space orbits are becoming congested with increasing numbers of satellites being launched around the world every year. The combination of an increasing reliance on space capabilities with the capacity limitations of Australia's legacy systems must be addressed."*

A core outcome sought is higher levels of assured access to space as well as sovereign control of key elements within this space architecture, with satellite communication and geospatial intelligence capabilities specifically identified. It is recognised that while increased sovereignty is being sought, there remains a central role for partnership with allies across the space domain.

This recognises the enabling nature of space systems and services in delivery of improved situational awareness and enhanced command and control. The value of geospatial intelligence for tactical manoeuvre and support for precision targeting are examples of the critical enabling function provide by space systems. Further details concerning future plans for Australia's Geospatial Intelligence (GEOINT) capability is outlined in the "Defence GEOINT 2030" strategy[3].

Importantly, the Government recognises the opportunity and need to transform the way the ADF operates in space and that this is a national endeavour that requires alignment with Australian Space Agency initiatives and enhanced support from Australian industry and Academia. The inclusion of the

[1] "2020 Defence Strategic Update", July 2020, https://www.defence.gov.au/StrategicUpdate-2020/
[2] "2020 Force Structure Plan", July 2020, https://www.defence.gov.au/StrategicUpdate-2020/
[3] "Defence GEOINT 2030 – A Strategy for Defence's GEOINT Capability", July 2020, https://www.defence.gov.au/ago/library/Defence-GEOINT-2030.pdf

Defence Industry and the Space Industry as priority areas under the Modern Manufacturing Initiative highlights the national importance placed on both defence and space sectors by government.
Across the broader National Security community, the research and innovation needs are best captured in the 2020 National Security Science and Technology Priorities[4]. This identifies six priorities:

- Technology Foresight
- Intelligence
- Preparedness, Protection, Prevention and Incident Response
- Cyber Security
- Border Security and Identity Management
- Investigative Support and Forensic Science

The Intelligence priority specifically includes space technology as a research focus however there are relevant research themes captured through many of the other priorities. This includes application of artificial intelligence, machine learning and data analytics to understand sensor data, remote and/or stand-off sensing, secure communications and critical infrastructure risk analysis.
Research funding for programs such as NICSat[5] also highlight the interest from across the national security enterprise in understanding and experimenting with emerging space technology, in particular the opportunity to rapidly develop space-based systems featuring advanced sensors and on-board, intelligent processing.

3 Strategic Principles and Objectives

The Defence and National Security Sector Priorities are enabled by the following strategic foundations for the overall SmartSat research program which will be:

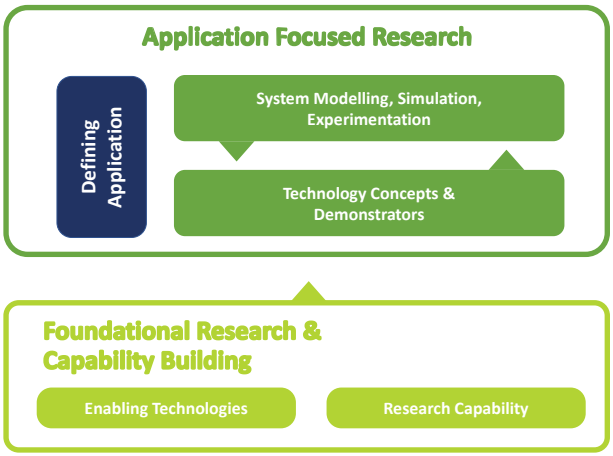
- **Aligned:** SmartSat CRC will support and conduct agile research that addresses opportunities identified in a range of key Defence documents including “More Together”, the Defence Science and Technology strategy, the 2020 Defence Strategic Update, the 2020 Force Structure Plan and broader Australian national security needs.
- **Aware:** The SmartSat CRC remains aware of, and will work to support the differing needs of the Defence and National Security space R&D ecosystem through our portfolio of research projects and activities This includes proactively identifying synergies across this portfolio to address more complex, national level needs.
- **Connected and Collaborative:** SmartSat CRC exists to connect people and facilitate collaborative and coordinated partnerships between academia and industry (including Australian and international defence industrial sectors) to further Defence and National Security Space Requirements. SmartSat CRC funded research activities should address high-risk/high-payoff opportunities that exploit synergistic strengths within our partner network.
- **Differentiated:** SmartSat CRC will support internationally competitive research and technology development with a focus on our national strengths, including basic science and disruptive technologies, not playing catch-up.
- **Digitally Engineered:** Use next generation “digital engineering” approaches to understand opportunities and evolve solutions more rapidly in order to support our industry partners to bring technology to market faster than our competitors.
- **Dual-use (Commercial):** The SmartSAT CRC will look to support programs which generate technology that can be adapted to other markets, and which has commercial applications which works to grow the viability of Australia's space industry. Exploitation of dual-use space technology can help build a sustainable industry base though diversity in market segments.
- **Supported by Infrastructure:** Create R&D efficiencies through access to highly specialised space related infrastructure and personnel. We will work with our research partners to identify research and development infrastructure gaps and help create solutions addressing the short, medium and long term needs for Australia. This may include supporting the development of proposals for extra funding through State or Commonwealth agencies.
- **STEM- Sustainable Workforce Generation:** The SmartSat CRC will work with academia to support and focus national STEM education and training goals. The CRC will lead by targeting and coordinating space research education and specialist skills development programs, pursuing where feasible the creation of centres of excellence, that enable the generation of space related programs that have the critical mass to be economical and sustainable.

[4] https://www.dst.defence.gov.au/nsstc
[5] https://www.defenceconnect.com.au/intel-cyber/6053-office-of-national-intelligence-seeks-smart-satellites

- **Value-for-Money (VFM):** The SmartSat CRC will endeavour to demonstrate effective and efficient implementation of the research program in order to demonstrate VFM to our partners in order to access ongoing lines of funding to secure and sustain Australia's space focused R&D supporting Defence and National Security sector needs.

4 Sector Needs and Research Focus Areas

The Defence and National Security End-User sector priorities include twelve research focus areas grouped under four broad sector needs.
These research focus areas include both application focused and enabling activities. This is consistent with the research program framework outlined in the SmartSat CRC Strategic Plan.



The first three needs roughly align to the three space related capability programs published in the 2020 Force Structure Plan. The research interests have been scoped to look beyond immediate capability needs and to focus on emerging technologies and novel applications.
The final need recognises that developing industry capability is an important outcome from the research program in order to increase access to nationally developed technologies. The ability to rapidly demonstrate space-based technologies can create opportunities for industry in both domestic and international markets.

Need 1: Networked Capabilities

The ability to manage information connectivity within a joint operating environment is critical to the defence and national security sector.

SmartSat CRC seeks research proposals that develop new technologies capable of operating in existing or new spectrum allocations, including free space optical communications. Such systems must offer game-changing capabilities (e.g. individual links > 100 Mbps) and identify and propose mitigations to known limitations such as low availability due to propagation impairment through the atmosphere.

The ability to secure these communications links against cyber-attacks is also important. Novel techniques such as quantum secured networks could position Australian to lead development of quantum safe network architectures.

The ability to develop advanced satellite communications ground segment technology will be critical to support unique Australian end-user needs, including for locally manufactured and foreign sourced platforms.

F1.1 Resilient Tactical Communications
Current technologies employed across the sector rely on dated technology and systems operating in ultra-high frequency (UHF) and L Band (1.5/1.6 GHz). This includes military specific solutions and commercial systems such as Inmarsat and Iridium.
SmartSat CRC research should look for advanced solutions that increase capacity, increase resilience and explore new service offerings including Internet of Things (IoT), safety of life messaging (e.g. extension to the fight recorder concept) and on-board demodulation and routing.

F1.2 High-Capacity Communications

Currently Defence and National Security organisations provide high-capacity communication to users in commercial and military bands including X band, Ku band, and Ka band. It is becoming increasing difficult to access sufficient spectrum in these existing bands to increase capacity, both per link and aggregate capacity which is likely to result in limitations on some aspect of usage, especially supporting mobile terminals. There is interest in research activities that explore higher frequency bands offering greater spectrum availability, or agile spectrum sharing techniques to more efficiently utilise existing spectrum in order to create alternate solutions for high capacity communication links. This focus area specifically includes research to understand how free space optical communication with higher availability might be employed.

F1.3 Cognitive Networks

Current generation military communications networks including satellite communications largely feature static planning approaches and require skilled personnel overseeing configuration and management. SmartSat CRC is interested in new approaches to network operation, including through distributed intelligence that is capable of sensing operating conditions and user communications needs and self-configuring autonomously. Such network can deliver greater spectral efficiency, higher availability, and greater resilience. Operating such networks over or through space-based nodes adds complexity due to the link characteristics such as latency and high path loss, especially to geostationary orbit. Research supporting development of advanced cognitive network technology optimised for satellite communication bearers is important more many elements of future capability across the defence and national security sector.

F1.4 Timing Signals

SmartSat CRC has no intention to directly fund research into Global Navigation Satellite System (GNSS) or Space Based Augmentation Systems (SBAS) as these are well covered by other programs. However, there may be opportunities to extract accurate timing signals from technical solutions developed for advanced communications, novel sensors or autonomous spacecraft operations. Defence acknowledges that timing is a critical service provided by GNSS and has a strong interest in alternate approaches to the provision of accurate timing information so support precision engagement, C2 and situational awareness for military operations, especially in contested environment when GNSS signals may not be available.

Need2: Situational Awareness

The advantage conferred by space-based platforms in providing surveillance and reconnaissance capabilities has been recognised since the beginning of the space era. Advances in space-based technology has created greater opportunities to exploit space to create enhanced situational awareness. SmartSat CRC is interested in technologies that use space to sense all defence and national security operating environments in order to better support agile command and control (C2) and multi-domain operations.

F2.1 Novel Sensors

Research activities that support development of novel technologies and techniques for sensing the earth, space and electro-magnetic environments are of interest. This may include the employment of distributed apertures and dynamic payloads, to create higher spectral, spatial and temporal sensing resolutions from small spacecraft. The ability to integrate and use such sensor within constrained size, weight and power to extract novel information types from sensor in space is of interest

F2.2 Multi-Sensor Integration

Combining sensor data capturing diverse phenomenology to enhance understanding of the operational environment including through intelligent fusion and change detection. The ability to integrate sensors supported on different spacecraft to enable novel concepts for improved temporal, spatial or spectral resolution is of interest.

F2.3 Intelligent Processing:

There is increasing interest and capability in deploying advanced computational capabilities on space-based platforms through programs such as the DARPA Blackjack[6]. SmartSat CRC will support research activities that develop Australian capabilities for intelligent processing and help understand applications that can accelerate delivery mission critical information to end-users to enhance situational awareness and decision making. Progress in intelligent processing, especially with on-board computational

[6] See for example https://www.darpa.mil/news-events/2020-05-11, accessed on 10th January 2021.

capabilities is critical in turning “smart systems” into “intelligent systems”. In potentially can provide a capability edge when using existing technologies and deliver high impact into defence and national security applications.

Need3: Autonomous Space Operations

The space domain is increasingly congested and contested leading to the need to identify new ways to manage spacecraft and constellations during launch, early operation and through life. We are interested in research that explore the use of intelligent and autonomous approaches to operations.

The ability to deliver novel services and effects in space from distributed payloads or larger constellations is driving considerable commercial investment. The defence and national security sector seeks to leverage this new approach to space operations but without increased operational and sustainment cost and without impacting system resilience.

F3.1 Intelligent Constellations

Current space services are provided through legacy constellation designs comprising low numbers of large, expensive satellites. SmartSat CRC seeks to develop technologies that support higher levels of sensing and autonomy in satellites forming the next generation constellation to provide enhanced space services. The ability to deploy larger constellations of smaller less expensive satellites in order to increase system performance without requiring additional operating overhead will be a key outcome.

F3.2 Space Domain Understanding

Space operations can create challenges in attributing cause and effect due to the need for remote operations. Research that aims to increase awareness of what is happening in space to support space operations is critical. This includes the application of Artificial Intelligence, Machine Learning, Deep Learning and Data Analytics in detecting anomalous behaviours, modelling system resilience and predictive management of complex systems to manage a range of hazards experienced in the space environment.

Creating predictive tools that allow observations to become forecasts so response times to hazards can be reduced or eliminated. The expanding use of space by government and the commercial sector requires new thinking on operating in the space domain as it becomes more congested and contested.

F3.3 Cyber Security

Higher degrees of autonomy in spacecraft operations may increase risks from cyber-attack. There is a need to ensure that effective cyber security is designed in and verified to facilitate high levels of trust in space systems.

Need 4: Rapid Prototyping

Defence and national security capabilities must be viewed within a geo-strategic context that is rapidly evolving. The Defence Strategy Update 2020 highlighted the high levels of investment being made in our region and the challenges this creates for Defence planners seeking an enduring capability advantage. The ability to develop and field capabilities faster than competitors is a strategic advantage. Rapid prototyping is one of the engineering responses to faster product development cycles.

F4.1 Space Hardware

Australia needs to ensure access to design, manufacturing and testing expertise including satellite mission systems, C2 and payload development aligned with assured sovereign access. The development of distributed and deployable sensor technologies where there is a high degree of integration with the satellite would fall within this category. This focus area will be critical in creating the ability to deploy space capabilities when needed and provide greater knowledge and certainty around space enabled or supported systems. The ability to grow industry capabilities and support NGTF goals of supporting high-risk/high-payoff capabilities might catalyse a change in national awareness of the need to invest in space technology demonstration.

F4.2 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. The development and access to high performance modelling and simulation capabilities to accelerate system definition and development and support operational concepts falls within this focus area.

5 Concluding Remarks

The Defence and National Security Sector Priorities were developed with the aim of identifying priority industry needs and associated research areas that can be targeted by the SmartSat space research community. They also work to inform academia about the role they play in core research and workforce generation.

The Agriculture and Natural Resources EUAB and Mining and Energy EUAB have conducted similar assessment resulting in Sector Priority documents being developed. Across each of these sectors, common problems have been identified which further highlight the need for strong and robust cross-sector collaboration and the need for the space industry to pivot their technology and capability to service multiple sectors.

The priority areas identified here and in other sectors lay the foundation for developing a research plans that will inform and shape the establishment of projects that provide maximum impact and benefit within the sector and enhance cross-sector collaboration to leverage capability and investment and avoid duplication.

SmartSat has established a number of research projects whilst the Sector Priorities are being finalised. As such, the priorities identified here should also be used by SmartSat partner organisations to help guide development of new project proposals and identify priority areas for further research and development and research education outcomes.

Annex A: Research Prioritisation and Pathways to Capability

It is anticipated that these priority focus areas will need to be adjusted over time as a result of evolving defence and national security end-user needs. In this sector it is typical for capability requirements to change due to the changing space domain operating environment and the threats it faces.
The primary pathway for utilisation of research outcomes in the defence and national security sector is through partnership with the Defence Science and Technology Group within the Resilient Multi-mission Space Science, Technology and Research Shot[7] (RMS STaR Shot).
This ambitious capability exploration program plans to deliver multiple missions over a ten-year period. Each mission is likely to deliver multiple space payloads, potentially on multiple spacecraft and creates numerous opportunities to showcase Australian technology to end-users across the defence and national security sector.
Detailed planning for these missions is still in progress and the intention is this annex, and potentially stand-alone documents will highlight technology pathways for industry and academia as the mission design matures.
This might include technology roadmaps along the lines of the exemplar shown below

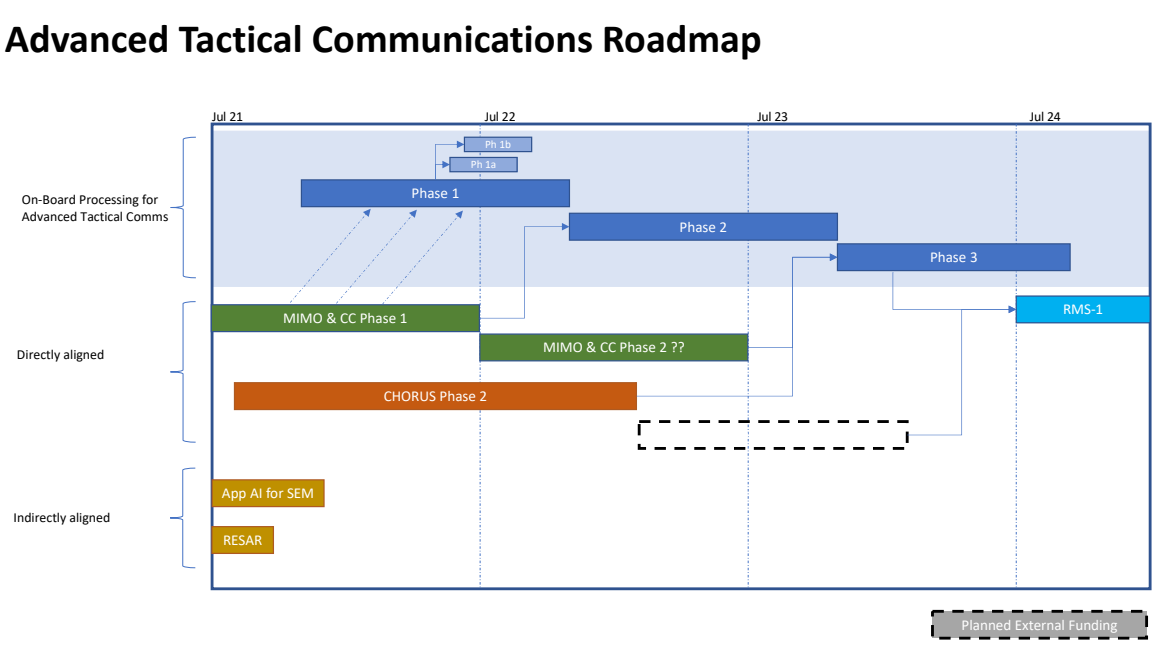


Figure 1: Indicative SmartSat CRC Research Project Roadmap showing possible pathway to RMS STaR Shot

SmartSat CRC will work with Defence RMS STaR Shot stakeholders to ensure funded research aligns with the Sector Priorities outlined in this document and that credible pathways to capability demonstration through initiatives such as the STaR Shots are developed.

[7] https://www.dst.defence.gov.au/strategy/star-shots/resilient-multi-mission-space

USER INFORMED INDUSTRY DRIVEN RESEARCH POWERED

SMARTSAT
COOPERATIVE RESEARCH CENTRE

Building Australia's Space Industry

Australian Government
Department of Industry, Science, Energy and Resources

AusIndustry
Cooperative Research Centres Program

SmartSat CRC Head Office:
Lot Fourteen, Level 3, McEwin Building
North Terrace, Adelaide, SA

info@smartsatcrc.com
smartsatcrc.com