iCERA Small Business Initiative Tier Priorities

Tier 1 Priority: Cyber

Defence is seeking to advance new science, technology, methods and concepts to support operations in cyberspace. This includes advanced capabilities to support Defence requirements in:

- cyber security
- defensive cyber operations
- intelligence
- effects

Conducted through research in:

- trustworthy and resilient systems
- situational awareness
- mission assurance
- threat countermeasures and effects
- cyber artificial intelligence and autonomy
- human element

The Cyber theme is interested in proposals that address the following problem statements:

A. Information Warfare

In support of the Information Warfare Science, Technology and Research (STaR) Shot, research is required into the application of artificial intelligence and machine learning (ML) techniques to cyber security. High priority applications include the discovery of vulnerabilities in cyber systems, software, networking protocols and the discovery of anomalous behaviours in military and enterprise cyber systems. Research is also needed into vulnerabilities of AI-based cyber defences, including mitigation against adversary use of data-driven attacks on ML-based cyber defences.

B. Operating in Chemical, Biological, Radiological and Nuclear (CBRN) Environments

Research is required into Operating in CBRN Environment's STaR Shot, particularly in relation to the management of vulnerabilities around large-scale sensor networks comprising sensors that might be low in cost and with small

size, weight and power characteristics. The research could consider such factors as:

- the identification of security vulnerabilities in individual sensors and solutions to improve trust in these devices
- concepts for developing and maintaining cyber situational awareness of these distributed sensor networks
- the autonomous management of cyber defences

C. Agile Command and Control

Agile military Command and Control requires decision makers at all levels to have an appropriate level of understanding of all factors that impact on decisions. With military systems now almost completely dependent on digital information systems, cyber security is emerging as a critical element of full spectrum military situational awareness. Research is required into technologies to support cyber situational awareness, including the ability to provide a level of abstraction suited to the needs of the military decision maker and the integration of cyber into full spectrum situational awareness.

Tier 2 Priority: Medical Countermeasure Products ─ Operating in CBRN Environments STaR Shot Problem Statements

Medical countermeasures are a priority theme of the Next Generation Technologies Fund (NGTF). In this call for proposals from Australian Small or Medium Size Enterprises (SME), the NGTF is seeking concept demonstrators, technology demonstrators and game-changing innovations that increase a warfighter's awareness and understanding of the chemical and biological agents they may be exposed to when operating in Chemical, Biological, Radiological and Nuclear (CBRN) threat environments. While all proposals that promise to enhance the warfighter's CBRN threat awareness will be considered, there is particular interest in receiving proposals that address the following challenges.

A. Human-operator functional state monitoring that is holistic, i.e. integrated from sensor network through analytics to user interfaces, and realistic, i.e. fit for a well-defined mission profile. Proposals that are well-grounded in human science and medical research are preferred. They would clearly identify the target/criterion for monitoring (alertness, stress, attentional focus, spare capacity, etc); employ validated and robust signal processing and inference algorithms leading to end-user-relevant decision points; and make an informed choice of which sensors and data to use based on estimates of relative utility. Ideally, functional elements of extant warfighter equipment are utilised or repurposed.

B. Data analytics for human health and functional state monitoring that is able to issue alerts to the individual warfighter based on the individual's cognitive, physiological and/or physical performance

thresholds and health indicators. Such personalised thresholds will need to be derived from the data collected through a network of wearable and environmental monitoring and sensor devices.

C. Near real-time detection and identification of biological agents. Detection and identification can be through direct measurement of microbes or derived indirectly, e.g. through the monitoring of biomarkers in a population or through other diagnostics tools. Whatever detection and identification method is proposed, estimates of its effectiveness, its accuracy and time of detection and identification will need to be provided as part of the proposal.

Tier 2 Priority: Enhanced Human Performance ─ Operating in CBRN Environments
STaR Shot Problem Statements

Enhancing Human Performance (EHP) is a high priority objective of the Science and Technology (S&T) efforts sponsored under the Next Generation Technologies Fund (NGTF). In this call for proposals the NGTF EHP theme is seeking concept demonstrators, and innovations from Australian Small or Medium Size Enterprises (SME) that enhance a warfighter's resilience to chemical, biological, radiological and nuclear (CBRN) warfare agents. This resilience may be achieved through superior training and preparation of the human for the strenuous cognitive and physical tasks associated with operations in CBRN environments, or through significant improvements to the human's cognition, endurance and protection whilst operating in CBRN environments. All proposals to enhance a warfighter's resilience in CBRN environments will be considered. However, preference will be given to proposals that may lead to the development of:

A. Field-deployable training devices or personal device-deployable protocols targeting cognitive and or physical readiness – backed by evidence of validity and/ or with built-in efficacy assessment. What novel methods can be used and demonstrated to assess an individual's readiness for a CBRN mission?

B. Significant enhancements to the "under-suit environment" (temperature, humidity, airflow, etc.) to enable warfighters who wear MOPP-4 individual protection equipment to stay and work for several hours in high-temperature and high-humidity environments.

C. Recovery-enhancing wearable or ambient technologies such as adaptive lighting, stress-reduction/calm-induction and personalised sleep management technologies.

D. Countermeasures to acute and chronic fatigue such as biomarkers of alertness (including metabolomics) and personalised circadian scheduling tools.

E. Novel tools and methods that can reliably, safely and effectively enhance a warfighter's resilience and endurance during operations in CBRN environments. These tools and methods need to be either demonstrable with regard to their reliability, safety and effectiveness or underpinned by credible evidence.

F. Studies on how immersive simulation technology can be used to provide realistic training for personnel required to operate in CBRN environments. Any claims regarding training efficacy will need to be substantiated by credible research pertinent to the study's topic.

Tier 2 Priority: Integrated Intelligence, Surveillance and Reconnaissance

Integrated Intelligence, Surveillance and Reconnaissance (ISR) is a priority theme of the Next Generation Technologies Fund, aimed at achieving the integration of information from ISR sources and tactical systems in real or near real time to support decision making. It is a key contributor to many of the Science, Technology and Research (STaR) Shots, as presented in the "More, Together: Defence Science and Technology Strategy 2030." Of particular relevance are the Agile Command and Control, Operations in a Chemical Biological Radiological and Nuclear (CBRN) Environment, and Information Warfare STaR Shots. Current priorities under the ISR theme are:

- Automated information processing and reasoning
- Distributed multi-domain networks
- Human and Artificial Intelligence (AI) interaction

Automated information processing and reasoning is imperative to help analysts, operators and decision-makers deal with the overwhelming volume, velocity, variety and uncertain veracity of available ISR information. Specific areas of interest are multi-intelligence content analytics (extracting increased information from images and video, and reasoning from multiple content types) and cognitive information fusion (combining low- and high-level fusion and answering "why" questions).

The information obtained from ISR sources and real-time tactical systems must be able to be utilised by human decision makers in the context of broader knowledge and tasking that will employ many different complex systems. As the complexity of AI increases, it is imperative to design these systems to collaborate with humans as a member of the team, as opposed to undertaking discrete activities in isolation as is the case with much automation today. Specific areas of interest are the design of AI systems to collaborate with human decision makers, design of exploratory AI systems for interactive sense-making, and design of distributed human and AI teams.

To effectively and efficiently process and integrate the information, and support real-time or near real-time decision superiority, it is expected the information integration architectures will need to be distributed, resilient and agile. Information architectures that integrate ISR systems and bring together feeds across the enterprise will underpin automated information processing and reasoning. Specific areas of interest are self-aware and self-integrating software systems, distributed edge-hosting and processing, and distributed applications over programmable networks.

The Defence Science and Technology Group (DST) is seeking research and development proposals from Australian small to medium enterprises. It is envisaged that a successful project will culminate in the demonstration of concepts or prototypes that contribute to the development of solutions for the above topics in general and more specifically as they align and address the below problems**:**

A. Scalable Heterogeneous Sensor Networks

Networks of heterogeneous sensors (i.e. networks that comprise sensors of more than one type) provide important services to both military and civilian applications, such as infrastructure surveillance, detection and characterisation of threats, or health monitoring of patients in populations. Scalable sensor networks are networks in which the number of sensors vary over time. This variation may be caused by growth of the network, rapid deployment of additional sensors, or a merger of networks (e.g. the merger of civilian and military surveillance networks during a whole-of government response to a bushfire disaster). Of importance is that (1) sensing applications are not disrupted by the scaling of networks, (2) human administrative efforts associated with network scaling are minimised, and (3) resources (to process or fuse data, to route information, etc.) are utilised effectively and most efficiently.

We are interested in demonstrators of concepts and technology that enable or enhance the scalability of heterogeneous sensor networks, i.e. specifically address one or more of challenges (1) to (3) above. The concepts and/or technologies in support of sensor network scalability must be novel to make the proposal eligible for Next-Generation Technology funding under the ICERA.

B. Self-integrating sensors

Many military intelligence, surveillance and reconnaissance applications are enhanced when new sensors are added to existing sensor networks. However, the integration of such new sensors often demands human effort and is laborious and resource-intensive. We are interested in the demonstration of concepts and technologies that facilitate the autonomous integration of new sensors into existing sensor networks. Here, autonomous integration means that the need for human integration efforts is eliminated. Ideally, these new concepts and technologies are fast with regard to the time it takes to complete integration, and highly efficient with regard to the performance of the network (network speed,

resource utilisation for networking functions, etc.) after self-integration takes place.

C. Autonomous data processing at the network edge

In distributed and large scale networks, it quickly becomes impractical to communicate all of the sensor data to a common data processing centre. Instead, it is necessary to do as much data processing as possible at the edge of the network and only use the limited resources to communicate important information. However, there are challenges with limited local computation, intermittent and unreliable communication links, and trust, when reduced data is available to verify local decisions. Similar limitations can be experienced if the control of sensors within the network is driven by centralised decision making; in scalable sensor networks timely decisions about sensor control may need to be dispersed. We are interested in demonstrations of autonomous data processing that makes use of innovative algorithms across a distributed sensing network to provide trustworthy information to support decision making and sensor control.

D. Scalable distributed sensing and control model

The behaviour of complex systems of systems is difficult to predict and it is often important to model the environment and system to explore early concepts and demonstrate subsystem interactions before building physical prototypes of all of the network components. These models can be highly detailed when the subject is a single sensor or a multi-sensor platform, but across a large distributed network it becomes necessary to reduce fidelity to allow scalability. We are interested in virtual models that are capable of scaling to very large complex situations with numerous actors and sensors observing their actions. These models should be able to represent such an interaction without too much loss of fidelity so they can be used to demonstrate potential advantages of new approaches within a particular subsystem.

E. Document Corpus Analysis

The challenge is to build up an application that takes, as input, a set of one or more keywords from a user and searches a set of documents to locate material related to those keywords. Once a set of documents/texts related to the topic are found, the application is to provide analysis in an easily-digestible manner, focused on the sentiment, range of perspectives and context of the information. The precise way that material is grouped and presented is open to the participant but the intent is to use automated sentiment analysis and related natural-language processing techniques on the material to display helpful information for a decision-maker interested in the keywords with the focus on

highlighting the range of perspectives and sentiments expressed in the source material. The challenge is to develop some novel ways of classifying and/or visualising this kind of information, to help a decision-maker better explore the range of perspectives that might be expressed in any large corpus of documents. In addition to including techniques such as sentiment analysis to explore the range of sentiments being expressed, this challenge might include representations of other information that might be useful, such as alternative meanings or definitions of keywords, or highlighting areas of ambiguity or disagreements in various source material. This task is deliberately open-ended to encourage novel ideas in this space and could include new ways of displaying or representing source material as well as searching through, analysing and summarising it. The specific context (document corpus and domain) is not important for this work, we would encourage submissions to specify a corpus of documents they intend to work on. This need not be Defence-related.

The overall intent is to demonstrate one or more ways of searching through any large corpus of documents and displaying a subset of material with a varied set of perspectives to help a decision maker get a better sense of the range of perspectives, meanings and sentiments present, without necessarily reviewing all of the material.

F. Machine Learning for Narrative Generation

The paths taken by an entity or object in the environment provide analysts and decision makers with an important clue to their intent and potential future actions. But, a decision maker does not think of a path as a time-series of geospatial coordinates, but in terms of higher-level narrative descriptions such as 'aircraft A circled the tower twice and then flew north', or 'vessel A followed vessel B along the coast'. Describing the path in a narrative form in this way allows the decision maker to understand what the situation may be. This is particularly useful when trying to make sense of a cluttered environment with multiple actors. Machine learning techniques have been used to describe static 2D scenes as textual descriptions, and early work by DST has shown that machine learning approaches can be used to generate narrative descriptions of the paths of a single object in a similar way. A more interesting, and challenging problem is to apply machine learning techniques to describe the behaviour of one or more objects in relation to other objects, features in the environment, or dynamic events. These techniques could be developed and applied in a variety of domains using freely available data sets such the OpenSky network (https://opensky-network.org/) tracking commercial aircraft, or the Australia Maritime Safety Authority (AMSA) data on commercial shipping (https://www.operations.amsa.gov.au/Spatial/DataServices/DigitalData), or indeed, any tracking data.

G. Designing Technologies for Agility in Complex Socio-technical Settings

This task explores the design of technologies for facilitating agility in individual, team, and organisational performance in fast pace, high-risk, and high-stakes environments. Sociotechnical workplaces are systems with psychological, social, cultural, and technological dimensions. Humans bring cognitive, social, and cultural dimensions to the performance of complex activities, and their work is carried out in interaction with the technological dimension. It is widely recognised that individual, teams, and organisations must be flexible, adaptive, and proactive to deal with change, uncertainty, and unpredictability in their work demands. However, technologies are usually designed to support standardised, routine, or typical work practices. For this initiative, we invite proposals concerned with exploring and demonstrating how emerging technologies can be designed deliberately to support flexibility, adaptability, and proactivity in work practices, including individual problem-solving, collaborative activities, and rapid transitions in roles and authority in organisations. Relevant technologies include, but are not limited to information displays, decision-support systems, workspace layouts, collaboration technologies, training systems, and human-machine teaming.

Tier 2 Priority: Trusted Autonomous Systems

The development and application of Trusted Autonomous Systems (TAS) for ADF operations will enable increased situational awareness and persistent surveillance solutions, supporting enhanced decision making abilities in complex highly contested environments with the ability to deliver disruptive effects; all the while reducing the risk to personnel and expensive platforms. The focus here is on the ability to sense and understand the environment from uninhabited platforms across all domains, processing information in real time, to detect, classify and localise objects and situations of interest, to enable new actions to be planned and executed, to develop support systems that enable the human operator to manage the capability and decisions with minimum supervisory control; to develop and evolve behaviours within the autonomous systems; including distributed decision making and task allocation; reasoning and negotiating over competing objectives (across single and multiple platforms); and communications protocols to support distributed or collaborative autonomy.

This opportunity is seeking submissions to advance TAS capabilities to support one or more of the following operational areas:

- **Operating in a CBRN Environment:** Enabling the joint force to operate safely and effectively in contested chemical, biological, radiological and nuclear (CBRN) threat environments.

- **Agile Command and Control:** Redefining the way the ADF conducts command and control across all operations in order to deliver a warfighting edge.

- **Information Warfare:** Delivering information warfare capabilities that are integrated across human, information and physical dimensions to allow the Australian Defence Force to fight in and through contested information environments.

A. Operating in CBRN Environments

The threat of CBRN attack against military and civilian populations is growing. State and non-state actors are increasingly willing to resort to indiscriminate methods and the proliferation of CBR agent synthesis manufacturing processes is increasing accessibility. The ADF has the ability to survive the surprise created by CBRN weapons, but there is a need to do more by being able to continue with operations and manoeuvres safely and effectively within contaminated environments for prolonged periods of time. This requires new advanced and integrated capabilities for detecting, identifying and monitoring CBRN threats as well as for warning and reporting, containment, protection against and managing CBRN hazards, mitigating health risks and improving human resilience to exposure and exhaustion.

B. Agile Command and Control

Prevailing in future complex and contested environments requires the ADF to bring together capabilities from across all domains of warfare to achieve complementary and coordinated effects. Future multi-domain operations will be high-velocity and high-manoeuvre with the aim of presenting multiple dilemmas to any adversary at an unmatched operational tempo. The ADF already conducts multi-domain operations; however, the command and control (C2) is human intensive and cognitively complex. Greater agility is needed to deliver real operational advantage across the continuum of conflict. The future Agile C2 must be robust, resilient, responsive, flexible, adaptive and reconfigurable and must be able to deal with many concurrent operations.

C. Information Warfare

Information environments are ubiquitous and they pervade all aspects of life. We depend on them for our social, commercial, civilian and military systems. Being globally connected and with a low cost-of-entry, information environments are not benign and are highly contested by a range of actors from criminals to nation states. Furthermore, the nature of strategic contests have changed with many

nations now using information warfare to achieve their objectives without ever exceeding the threshold of war. The information domain is a critical theatre of warfare. The success of future ADF operations will depend on our ability to fight in and through contested information environments. This will require innovative information warfare capabilities that enable the ADF to manoeuvre in the information domain.

Tier 3 Priority: Advanced Sensors

Advances in defence sensor technologies are being driven by the need to increase availability (reliability, persistence, cost), and reduce Space, Weight and Power (SWP) within an increasingly constrained SWP budget. The Advanced Sensors program aims to develop sovereign capability in next generation precision sensor technologies - devices capable of detecting minute physical, chemical, or biological influences - that will provide Defence with the capability to see further, deeper and for longer.

The advanced sensors program has a particular interest in sensor technologies that may enable enhanced undersea surveillance capability including:

- advanced acoustic sensing materials and transducers;
- advanced magnetic sensor technologies and;
- Single photon imaging and detection.

Tier 3 Priority: Directed Energy Systems

Directed Energy (DE) is a new disruptive capability, not currently operational in the Defence and National Security domains, which is likely to proliferate over the next decade.

Some of the specific challenges and priorities, include, but are not limited to:

- Reducing size, weight, and power (SWaP)
- Increasing output power/energy for both Continuous Wave (CW) and pulsed electromagnetic energy
- Thermal management of high temperature
- Radiation and beam delivery
- Targeting and Tracking
- Hardening/protection mitigations for electronics/ systems and bioeffects

Tier 3 Priority: Multidisciplinary Material Sciences

Advances in materials technologies are on the critical path to the delivery of many new and potentially disruptive Defence capabilities. The MMS theme will develop new capability through materials design and this opportunity will focus on proposals that look at advanced materials that may be used to support the prototyping of space structures and sub systems. This could include antennas,

thermal management materials, lightweight and deployable structures, protection of electronics and resilient structures that can withstand space impact. The scope of application would involve structures from CubeSat's to larger space systems.

Tier 3 Priority: Quantum Technologies

We are in the midst of the second quantum revolution, which will see the transition from the science of quantum mechanics to the engineering of quantum technologies. This will enable the development of new quantum sensor and quantum communications technologies that deliver unprecedented sensor performance and communications security. Australia has significant quantum technology capabilities and capacity in the academic sector. The Quantum Technologies Theme would now like to further explore the capability and capacity in the small business sector.

The Theme addresses two critical requirements of the Future Force, namely:

- The ability to fight through Global Navigation Satellite System (GNSS) constrained (e.g. underground or underwater) or degraded (e.g. jammed etc.) environments by using quantum technologies to provide Assured Position Navigation and Timing (APNT); and
- The ability to maintain effective communications and battlespace networking in contested environments.

Tier 3 Priority: Space Capability

The space domain is becoming increasingly contested with threats to the current generation of space systems. At the same time New Space commercial developments are revolutionising cost, capability and ability to rapidly deliver space systems. The ADF increasingly needs access to more capable and timely space services to prevail in future war fighting operations.

Australia has insufficient space research and industry capacity for the assured access and sovereign space aspirations of the Defence White Paper 2016 and subsequent 2020 Defence Strategic Update.

The Space Capabilities theme will lift the nation's capacity in the research, development and demonstration of innovative and resilient space constellation technologies across communications, Position, Navigation and Timing (PNT) and Intelligence, Surveillance and Reconnaissance (ISR) for Defence and National Security. There is a particular emphasis on assured, trusted and agile space services for deployed forces with a focus on technologies that improve resilience, support the end user (automation) and reduce the cost of ownership (autonomy).

The initial research and development focus is on:

- Resilient communications using non-geostationary systems
- Advanced payloads for persistent Maritime Domain Awareness

- Space-based space domain awareness sensors

Autonomous constellation technologies that can underpin the Defence S&T Strategy goal of Resilient Affordable Multi-Mission Space Systems.