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**:**

1. 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.

1. 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.

1. 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.