



DND/NSERC Discovery Grant Supplement Defence and Security Target Areas

Last Update – May 2025

- I. Autonomous Systems
 - II. Next Generation Systems
 - III. Infrastructure Resilience, Power, Arctic and Climate Change Implications
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I. Autonomous Systems

Context

This research challenge seeks to explore, enhance, develop, and deliver innovative autonomous system solutions and technologies to a vast range of applications providing reliable functionalities and decision-making abilities within complex environments in the context of defence, safety and security. Autonomous systems include the various levels of autonomy that are part of the continuum of interactions between environment, humans, and machines (from semi to full automation), as well as the various combinations of human-system interaction that could be required throughout mission duration. The focus is primarily on operational effectiveness and the optimization of capabilities through automation rather than developing robotic platforms.

Research Topics

1. Countering Autonomous Vehicles (AVs)

Projects under this research topic should focus on investigations of active, passive and other methods of detection of autonomous vehicles, including understanding how vehicle design, configuration, materials composition and operating state and environment affect their detectability. The focus may also be on tools and techniques to recognize the purpose and mission (e.g., scientific, industrial, or military) of detected AVs, and the targeted plans and activities carried out to achieve their mission. Research projects under this research topic may also address countermeasures that are technically proficient and cost effective against high volume / swarms.



II. Next Generation Systems

Context

This research challenge seeks to explore, enhance, develop, and deploy innovative, small footprint, low power, cost effective, robust, and potentially autonomous solutions of direct interest to defence and security applications within traditional and complex environments. Projects under this research theme focus on an opportunity for innovation in technologies, methodologies, architectures, tools and processes addressing resilient, self-aware, self-healing, energy efficient, secure and reliable cyber hardware/software networked systems. Specific topics of interest include trust-worthy, autonomous, self-aware, adaptive, fault-tolerant, and intrusion sensitive methodologies for wireless radio and sensor networks and highly networked systems; networked, distributed, and collaborative effects; efficient energy conservation in highly congested, faulty, and scalable networks; operations in spectral denied environments; and development and deployment of low-cost platform early warning systems within traditional and harsh environments including space. The second theme under this challenge is the development of next generation materials, cutting-edge experimental techniques and theoretical modeling tools to increase the understanding and development of next generation ballistic resistant and protective materials. The research could also focus on the design and development of next-generation systems and materials targeting a wide range of functional and structural applications underpinning current and future challenges in defence and security.

Research Topics

1. Electro-Optical (EO) Nano-Sensors

Projects under this research topic should focus on developing electro-optical (EO) sensors that extend present limits associated with sensitivities, response time, size, cooling, power consumption while capable of being tailored to wide or multiple wide spectral bands. Research themes could include but are not limited to the development of EO nanosensors that are of interest for defence applications and are usually structured solid materials capable of light-matter interactions on wavelength and subwavelength scales; nanosensors metamaterials having nano-scale structures capable of polarizing, filtering, tuning or focusing the light to enhance the detection signal-to-noise ratio in selected spectral bands of interest.

2. Active Optical Sensing

Projects under this research topic should focus on developing active detection and/or identification of targets of interest to defence and security. Research themes could include, but are not limited to: the use of active laser or single photon source, whose return signal is analyzed to extract useful information about the target while discriminating it from its background; the development of laser systems for standoff laser-based sensing and



characterization of a target object or the propagation medium; the use of nonlinear spectroscopy, or sources designed to allow spectral, temporal, or amplitude analysis of the return signal; the use of laser as a carrier wave in an acousto-optic or microwave photonic approach; the use of such systems in the detection and identification of explosives and energetic materials, chemical composition of targets, characterization of atmospheric or aquatic propagation, as well as the detection and identification of objects in a cluttered environment; quantum radar and remote sensing, including space-based, in the visible and microwave bands.

3. Compressive Sensing (CS)

Projects under this research topic should focus on combining compressive sensing, computational imaging and light-field imaging paradigms including quantum-based single photon schemes to achieve revolutionary enhancement of defence and security related imaging and sensing capacity with increased systems resolution, larger field of view, and imaging in complex environment (e.g., imaging around the corner). Research themes could include, but are not limited to, the use of radar, electro-optical and infrared (EO/IR) systems with active, passive, multiband and hyperspectral sensors for reduced CS sensed signal size, resulting in significantly smaller, cheaper, and lower bandwidth sensor devices with increased universality, security, and robustness with progressivity, and scalability; non-line-of-sight imaging; computational imaging; and the development of advanced image reconstruction codes for CS optimization techniques development.

4. Quantum-Enhanced RF Sensors and Signal Processing

Projects under this research topic should focus on developing novel active and/or passive quantum-enhanced RF sensors, and/or signal processing for such sensors. The projects should utilize hitherto unexploited possibilities allowed by quantum physics, such as quantization of electromagnetic signals (e.g., microwave, single photon sources) and quantum entanglement (e.g., quantum two-mode squeezing). Also relevant are novel approaches to generate quantum signals across the RF spectrum, such as via microwave-to-optical photon conversion or using Josephson parametric amplifiers/convertors, and novel approaches to RF signal detection (e.g., Rydberg atoms, NV-center in diamond). The development of quantum oscillators with substantially lower phase noise and the signal processing for such quantum-enabled radar and quantum enabled networked distributed radar as well as the signal processing are also in scope. The signal processing algorithms for the processing of quantum-enhanced RF sensor data, that account for real-world effects such as Gaussian and non-Gaussian noise and interferences (e.g., clutter and jammer), are also relevant. Applications could include active and passive radars.

5. Operating in a Spectrum-Denied Environment

Projects under this research topic should focus on developing new techniques and technologies that would enable robust military capabilities that currently require the use of



the electromagnetic spectrum (such as communications, command and control, threat detection, target detection, identification and localization, PNT (positioning, navigation, timing), etc.) to continue to be effective in the face of an increasingly congested, contested and competitive electromagnetic (EM) spectrum – this includes quantum PNT, quantum-enhanced gyroscopes, gravimeters, portable atomic clocks. Research themes could include, but are not limited to: addressing the accessibility and usage of the electromagnetic spectrum that becomes congested by the ever-increasing number of commercial and private users, and their increasing bandwidth requirements; ensuring military operational spectrum operations in the presence of jamming; addressing spectrum “ownership” that is also highly competitive in the sense that ever larger bandwidth allocations are being reserved for specific commercial or public use; exploitation of cooperative navigation concepts in networked, collaborative autonomy, and in swarms; and focusing on vulnerabilities of systems that depend on the use of spectrum, such as tactical radios, satellite communication links, Radar and GPS. Research themes should also include new technologies and approaches allowing various military functions to be performed with the use of significantly less spectrum or preferably without the use of EM transmission/ reception at all, or with the use of spectrum without interfering with or being interfered with by other users.

6. Space Domain Awareness

Projects under this research topic should focus on developing new technologies that enable space domain awareness. Awareness may be achieved through ground or space-based detection, tracking, and if possible, identification and characterization of objects in space considering signatures in both the RF and non-RF portions of the electromagnetic spectrum, particularly in or near-earth orbit, as well as characterizing the physical environment itself. Research themes could include, but are not limited to, characterization of natural/anthropogenic, active/inactive space objects as well as space debris, identification of potential space related risks and threats for enhanced capability, Cislunar space domain awareness, orbit determination, non-resolved object characterization, data interfacing standards for space domain awareness, and space assets management. Research themes could also include, but are not limited to, space operations vulnerabilities and resiliency to space hazards (space weather, debris, etc.), space assets vulnerability, collision risk prediction and avoidance, and protection against adversarial intent (cyber, kinetic, electromagnetic, etc.) and the safe and secure transfer of information in this environment.

7. Beyond-Line-of-Sight Communications

Research under this topic should address new and enhanced technologies for beyond-line-of-sight (BLOS) communications and advancing consumer technologies to provide secure networked military communications capability. Technologies of interest include: BLOS enablers such as meteor-scatter, troposcatter, high-altitude platform relay, and SATCOM;



secure radio networking; 5G/6G architectures for defence and security use; health monitoring of wireless networks; wireless ad hoc networks; and radio virtualization.

8. Hypersonic flow modeling and simulation

Projects under this research topic should focus on improving current computational fluid dynamics models to increase the fidelity level of flow predictions and their calculation speed. Example topics include hypersonic turbulence models, laminar transition models for hypersonic flows, non-equilibrium reactive flow modeling. Topics involving hypersonic multi-physics modeling such as ablation modeling, heat transfer to surface models should also be included. Additional topics covering modern computational fluid dynamics methods based on GPGPU architectures should also be included, such as Lattice Boltzmann methods and Physics Informed Neural Networks for hypersonic flows should be considered.

III. Infrastructure Resilience, Power, Arctic and Climate Change Implications

Context

Climate change is affecting the infrastructure in the Arctic. Melting permafrost disrupts the integrity of buildings, can cause damage to roads and runways, and the increased traffic can lead to increased burden on the northern communities. Furthermore, with the increased demand for the Internet as well as other information and surveillance technologies also comes a greater demand for power. Current reliance on diesel generators is environmentally unfriendly and can lead to damage to the sensitive Arctic ecosystems.

Research Topics

1. Implications of Climate Change for Defence and Security

Projects under this research topic will identify changes to the physical environment that are ongoing in the Arctic (atmosphere, land, ocean), including trends and uncertainties, that are relevant to Defence and Security (e.g., platform mobility and longevity, acoustic monitoring, etc.).

2. Defence Critical Minerals for Defence and Security

Defence critical minerals are an ever-growing critical component of many military capabilities. Projects under this research topic will help define the Canadian defence list and include enhancing our understanding of Canada's investments, reliance, and



dependence in the defence context, as well as Canada's positioning in NATO and Europe as a reliable, secure energy and resource supplier. Projects under this research topic will investigate options, methods, and/or processes to replace, or lessen, the use of critical minerals in materials, components, technologies, equipment, etc. relevant to defence, including dual-use technologies.