



# Continental Defence S&T Initiatives

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Overall Classification: **UNCLASS**





# Context



## NORAD Modernization

- Current NORAD capabilities are not adequate to meet the changing Global security environment
- Defence Policy Our North, Strong and Free (ONSAF) reinforces previous commitments to science and technology development in support of the ongoing evolution of continental defence capabilities
- Treasury Board recently approved \$1.3B for NORAD Modernization Science and Technology

## ONSAF

*Future-proofing our capabilities to defend North America through investments in science and technology. Canada will support the ongoing evolution of continental defence capabilities with investments supporting researchers, innovators and entrepreneurs in assessing new and emerging threats, evolving research and development work, and co-developing innovative technological solutions ...*



# Continental Defence S&T delivered by DRDC



## All Domain Situational Awareness (ADSA) S&T

\$133M over 5 years  
Completed in 2020

## Baseline Defence & Security S&T (DSST) Program

Baseline R&D activities  
\$40-60M/yr

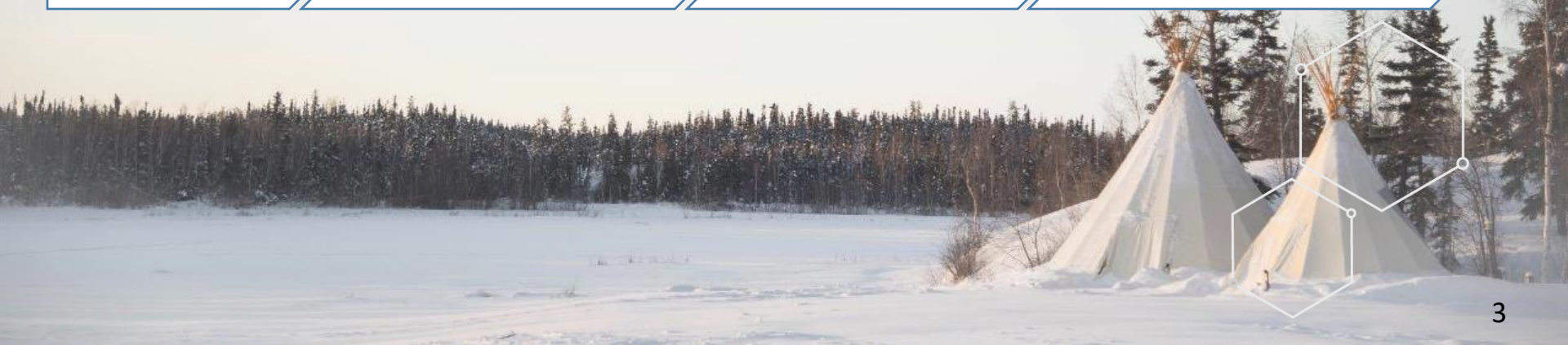
## NORAD Modernization R&D – Interim funding (Budget 2021)

Additional \$266M over 5 years

## Continental Defence Modernization R&D


\$4.2B over 20 yrs

R&D to detect, deny, defeat, and ultimately deter threats to Canada






# Continental Defence S&T Investment (ConDI) Initiatives




1. Over-the-Horizon Radar (OTHR)  
Range Enhancement



2. OTHR Capability Expansion




3. Space Low Earth Orbit (LEO)  
Architectures for Defence




4. Next-Generation Digital High-  
Resolution Space-Based Radar



5. Space Domain Awareness (SDA)




6. Semi-Autonomous Systems




7. Quantum-Enabled Defence Capabilities




8. Cyber Intelligence and Operations




9. Emerging Missile Threats



10. Counter-Uncrewed Aerial Systems (C-  
UAS)



11. Integrated Systems for All Domain  
Operations



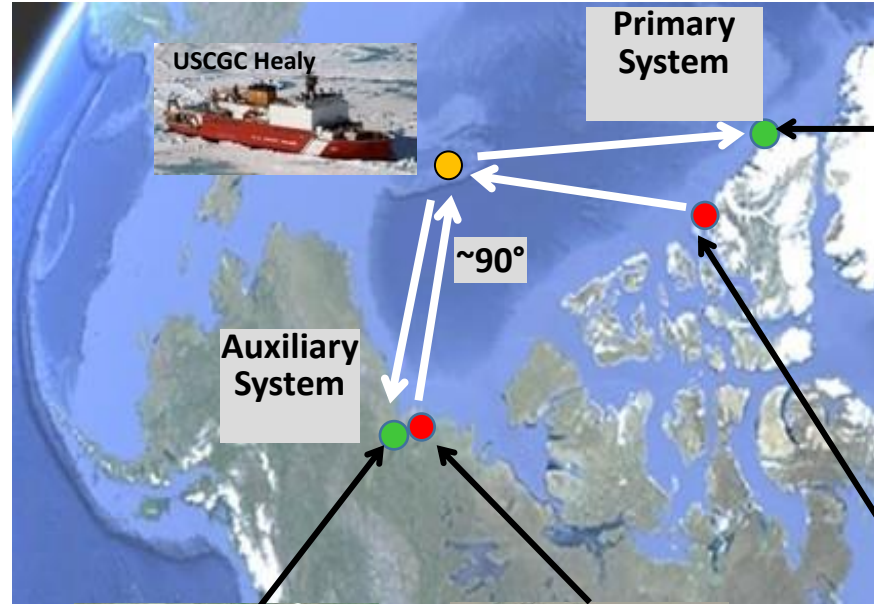
12. Enabling Arctic Defence Research and  
Development





# P-OTHR Range Enhancement Objective

- To test the hypothesis that detection range can be extended to 3,000 km using the less-stable polar ionosphere F-layer at 200-300 km altitude if one employs an “auxiliary” POTHR system to provide a second target observation from a different vantage point
- Tuk/Inuvik selected as they exhibit good view angles and provide existing government-owned land
- Partnering with RCAF to use BAR-3 NWS site at Tuk for transmit
- Partnering with NRCan to use Inuvik Satellite Station Facility for receive



Primary System

POTHR 3 Receive Site - CFS Alert



POTHR 3 Transmit Site - Eureka



Auxiliary System

~90°



ISSF

POTHR 4 Receive Site



NWS  
BAR-3  
(Tuk)

POTHR 4 Transmit Site



## OTHR Capability Expansion Objective

- Explore an integrated military radio frequency capability for surveillance, communication and electronic warfare using OTHR sites in support of DND/CAF Arctic and Polar operations.
  - Radar Embedded Comms
  - 27/28 start

This initiative will provide advice to decision makers on the technical feasibility and the potential operational performance that might be achieved by expanding the capability of Canada's OTHR sites





# Space LEO Architectures for Defence

“To explore the possibilities offered to defence by the new space-borne information ecosystem that is resilient to attacks and can support real-time C2 data sharing and communications”

**BL7B:** Evolve and demonstrate a proof-of-concept Low Earth Orbit (LEO) space architecture for polar communications and earth observation

**CONDI:** Provide key technologies and new knowledge to enable resilient, proliferated, and federated space information mobility\*

B21 v CONDI

BL7B - Explores the use of commercial satellite networks to provide backbone connectivity R&D

CONDI - Expands to hybrid networks of military and commercial assets, including those of Canada's Allies.

- Develop and analyze enabling technologies, including vulnerability assessment and threat reduction, and architecture trade-offs, risks and benefits
- Development, experimentation and demonstration of on-orbit capabilities exploiting RF and optical intersatellite links
- Evolving space architectures to integrate enabling technologies and intersatellite link capabilities to support mission assurance for complex operations involving multiple coalition and commercial space assets (i.e. Networking in Space)

Connect sensors and systems across land, sea, air and space for a resilient space-borne information ecosystem to support NORAD modernization



\*Space Information Mobility provides “timely, rapid, and reliable collection and transportation of data in support of tactical, operational, and strategic decision making across the competition continuum”

– USSF “Space Power: Doctrine for Space Forces”, USSF Space Capstone Publication, 2020)

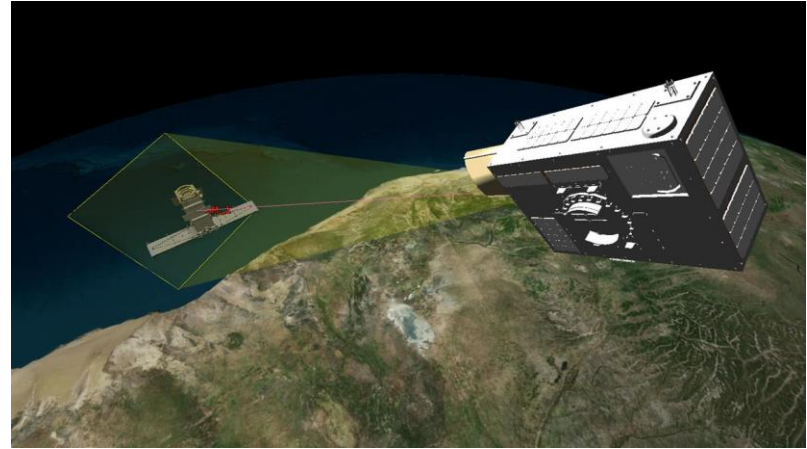


## Redwing Microsatellite SDA Mission

“To characterize suspicious activities in space in order to provide sufficient warning to protect our space critical infrastructure and promote responsible behaviour in space”

### • Overview

- Space Domain Awareness (SDA) R&D microsatellite capability for DRDC experimentation
- Cutting-edge R&D platform to inform Royal Canadian Air Force (RCAF) future program in space-based SDA
- **Redwing addresses SDA technology gaps identified in both Sapphire and NEOSat**
- Core mission - attribution and responsiveness to space events, space object sensing
- Target orbit: 615 km Sun-Sync (Similar to RCM)
- Government Owned – Contractor Operated acquisition model
- Unclassified architecture mission



### • Mission technical objectives

- **Persistent tracking and characterization**
- Extend SDA capabilities to **resolved imaging** of the Canadian RADARSAT Constellation Mission (RCM) satellites for High Value Asset monitoring
- **High performance attitude control** system for autonomous “closed-loop” tracking of space objects (both LEO and GEO)
- **Co-orbital proximity awareness** within 250 km for defensive assessment
- **Intersatellite link** TT&C demonstration using existing LEO connectivity
- **Cloud-based** tasking and data processing services and interfaces
- Nanosatellite drone (needs allied payload), Laser for downlink/debris ranging



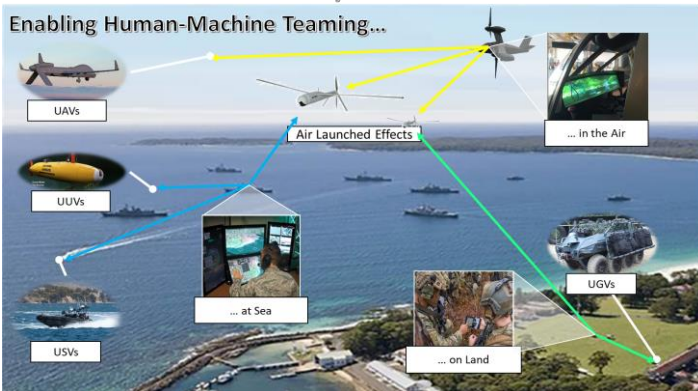


# Semi-Autonomous Systems

“Maximise the robustness and capability of unmanned systems in highly dynamic or communications limited environments, research investments are required in a set of scalable autonomy and artificial intelligence (AI) capabilities, ranging from advanced automation to semi-autonomous systems”

## Initiative 6 Semi-autonomous Systems

### Enabling Human-Machine Teaming...



### So What? - near term

- UAV/USV/UUV integration into River Class or AOPS.
- HAT UI Additions to Android Tactical Awareness Kit (ATAK).
- Cockpit/Autonomy upgrades to CH147 helicopters.
- UAV/UGV for rapid CASEVAC, Contested Logistics and last-mile resupply, Minefield breaching, and Route Clearance.

- **Tactical Aviation:** pilot-centred autonomy for crewed/uncrewed platforms, incl Air Launched Effects for persistence and resilience.
- **Maritime Systems:** integration of UxSs into maritime platform; autonomous surveillance of approaches, long endurance autonomous operations, and undersea infrastructure protection
- **Land Autonomy:** Autonomy Foundation framework; CONEMP development and demonstrations.
- **Human Autonomy Teaming:** Multi-vehicle mission management and situational awareness; optimization of human-autonomy interactions

### So What? - longer term

- Advice/recommendations for Uncrewed Maritime ASW force mix for River Class.
- Guidance on Launch and Recovery requirements for Canadian Patrol Submarine Program.
- Guidance/advice on requirements for EM-silent UAS platforms.
- Advice on requirements for Contested Logistics uncrewed cargo and/or tactical rotorwing for Future Tactical Helicopters.
- Advice on UI/Autonomy requirements for Future Tactical Helicopter and P8 ALE management.
- Advice on requirements for ACP/ALE from P8, CC-130J, or Future Tactical Helicopter.



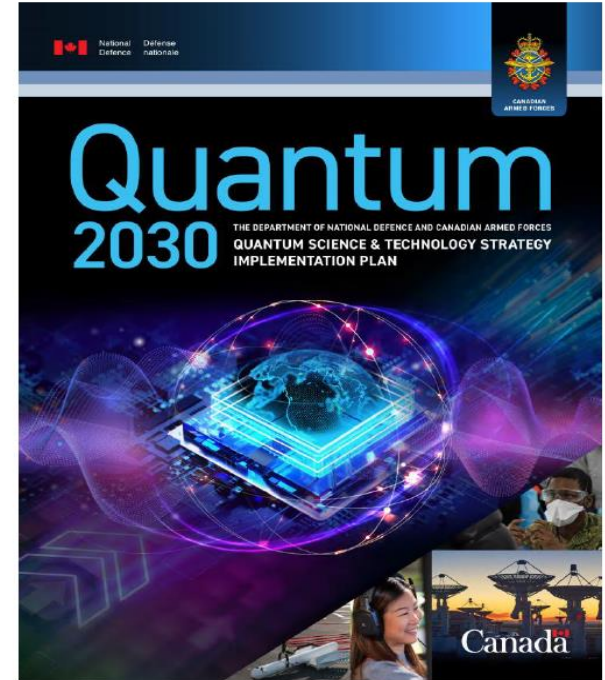
## Quantum

“Canada requires new quantum-enabled technologies to facilitate next-generation solutions to complex problems”

- Emerging quantum technologies promise to advance, disrupt, and enable new functionality for a variety of military, safety, and security applications.
  - Quantum-enabled sensing;
  - Quantum networking and communications;
  - Applications of quantum computing (e.g. Molecular biology);
  - Quantum-enabled alternative PNT.

### Exploitation Narrative:

Quantum technologies, a broad category of sensing, communication and computing technologies enhanced by exploiting the phenomena of quantum mechanics, are emerging rapidly and are at various levels of technological readiness today. Exploitation pathways are to be determined as the technologies continue to be developed. Through the Quantum-Enabled Defence Capabilities initiative, DRDC will play an active role in advancing quantum technologies towards operational readiness, including testing prototypes and exploring CAF use cases. Quantum-enabled position, navigation and timing systems, the quantum technology closest to full readiness, are expected to be integrated into existing platforms including ships and aircraft that must be able to navigate in GPS-denied environments.





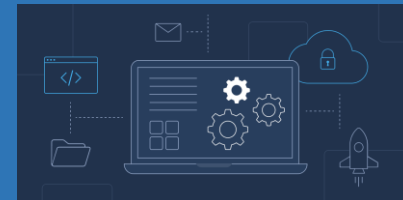
## Cyber

**Objectives:** To establish a robust Cyber R&D capability to support DND in defending Canadian and allied assets from cyber-attacks and to build a deterrence capability for Canada.

- Conduct vulnerability research to understand and anticipate potential disruptive cyber effects.
- Support to hardware forensics and counterfeit detection.
- Develop cyber defense systems for legacy platform technology.
- Develop cyber-resilient systems.
- Innovate in the field of automation technologies for cyber operations.



Counterfeit detection



Software vulnerability research



Cyber resilient systems



Automation technologies



# Hypersonic and Cruise Missile Defence

## Key deliverables and exploitation

- **Understand the Threat:** Scientific reports and virtual models will be produced to provide DND/CAF a better understanding of these emerging weapon systems. Results from this research will be applied to defeating the missile threat.
- **Defeat the Threat:** This research will explore ways to defeat the emerging threats for both active defence (kinetic and non-kinetic effects) as well as passive defence (resiliency and hardening) and produce associated reports to inform DND/CAF.
- Technical reports to inform DND/CAF on potential requirements and solutions to strengthen the development of a **Canadian IAMD concept**

### Intent for exploitation/transition

- **Including DND/CAF** (i.e. RCAF) during small-scale virtual/live experiments to, as early as possible, improve DND/CAF's understanding of the threat and potential countermeasures (to help inform development of DND/CAF IAMD concepts)
- **Sharing** potential IAMD solutions by conducting a large-scale simulation experiment with the DND/CAF, the US, NORAD and other allies such as Australia
- **Answering** DND/CAF questions relating to emerging missile threats (increase knowledge)
- **Preparing** Canadian industry and academia via the innovative network
- **Advising** DND/CAF capital projects as needed



**“To understand, detect and ultimately defeat this growing class of threat”**





## Counter Uncrewed Aerial Systems (C-UAS)

- The C-UAS Initiative will
  - Develop, implement, and integrate improved counter-UAS sensor and countermeasures technologies
  - Demonstrate a prototype system
    - Detect, track and identify individual UAS and UAS swarms in areas up to 10 x 10 km
    - Engage at ranges in excess of four (4) kilometers.
  - Develop methods and techniques for the management of multi-departmental situational awareness and response
- **Key Work Elements**
- Drone on drone interceptor
  - to seek and disable enemy drones, or to geo-locate the controllers/operators.
  - Leverage drone technology against drone. Seek technical and cost symmetry.
- Low-cost, distributed, networked active and passive sensors
  - cover wider areas to achieve persistent gapless coverage in all applicable environments
- Low-cost kinetic effectors with targeting support (radar, optical, etc) to attack single or swarms of UAS
  - Conventional, air-burst or directed energy.
- Networked fire control for light kinetic air defence weapons.
  - Networking light point defence weapons with early warning sensors to reduce sensor-to-shooter response time.





# Expansion of All Domain Situational Awareness

**“All-domain awareness, information dominance, and decision superiority to deter in competition, de-escalate in crisis, and deny/defeat in conflict”**



## Overview

- How a system-of-systems can be developed to provide effective, layered, and timely response to threats. Also includes deterrence and the strategic environment.
- The focus of this initiative is on the detection and mitigation of threats posed to Canada and North America in all domains by advanced weapons





## Enabling Arctic Defence R&D

**“To enable DRDC to conduct year-round Arctic R&D to enhance CAF/DND Arctic operations”**

### Overview

- Climate change is rapidly transforming the Arctic and Northern landscape, and foreign actors are increasing their activities in Canada’s North. This presents a very real threat to Canadian communities in the North, Canadian economic interests in the North, and the Northern natural environment.
- To address this rapidly evolving situation, R&D activities are needed to improve force readiness, forward presence, and situational awareness of Northern approaches. Canada must also explore ways of mitigating the environmental footprint of a larger military presence in the region and new investments in science infrastructure and staging stations in the region are also needed.





## Enabling Arctic Defence R&D - Objectives



12.1 Implications of climate change for military operations

### Objective

To prepare the Canadian Armed Forces (CAF) to face the challenges and operate successfully in an environment that has been, and continues to be transformed, by the effects of climate change (CC).



12.2 Development of Arctic research infrastructure

### Objective

To invest in DRDC's own infrastructure for operating in the Arctic which will enable us to improve our research capabilities at Gascoyne Inlet as well as our abilities to conduct field trials in the North.



12.3 Powering the North

### Objective

PTN is targeted towards solving the enduring challenge of providing scalable, energy-efficient and sustainable power and energy solutions for current and future DND/CAF arctic requirements, which is a key enabler to sustain personnel, operations and supporting infrastructure in arctic and sub-arctic regions.



12.4 Arctic Mobility

### Objective

"To increase the reach, flexibility, and capability of the CAF in the Arctic through enhancement of platform mobility, situational awareness, and performance in harsh conditions"



12.5 Human performance and protection in the Arctic

### Objective

To prepare aviators, sailors, and soldiers to operate safely in the harsh Arctic environment.





# Questions