National Research Council Canada

High Throughput & Secure Networks (HTSN) Challenge Program

Lynne Genik, HTSN Director

CELTIC-NEXT

7 September 2022
WHAT NRC DOES

WE ADVANCE SCIENTIFIC AND TECHNICAL KNOWLEDGE

WE DELIVER POLICY SOLUTIONS FOR GOVERNMENT

WE SUPPORT BUSINESS INNOVATION

WE INNOVATE AND FIND SOLUTIONS TO SOCIETAL ISSUES
NRC Overview

- Canada's largest federal research and development organization
- **4,286** full-time equivalent staff
  - including **2,228** scientists, engineers, technicians
  - **262** small and medium size enterprise (SME) technology advisors
- **14** research centres, **24** laboratory locations, **106** Industrial Research Assistance Program (IRAP) points of service across Canada
- **$1.44B** annual expenditure including **$468M** in funding for SMEs through IRAP
- **$169.8M** revenue
- **1,187** peer-reviewed publications (2021)
- **1.21** citation score relative to world average (2019-2021)
- **270** patent applications, **1,855** active patents, **542** licensed active patents
Challenge Programs are part of NRC’s Collaborative Science, Technology & Innovation Program

EXISTING CHALLENGE PROGRAMS:

- High Throughput & Secure Networks
- Materials for Clean Fuels
- AI for Design
- Cell and Gene Therapy
- Aging in Place
- IoT - Quantum Sensors
- Arctic and Northern
- Applied Quantum Computing

NRC’s collaborative platform uses science excellence to tackle Canada’s most pressing challenges

Mission-oriented programs across industries

- Outcome focused
- Multi-disciplinary
- Up to 7 years in duration

Researchers and facilities from across 14 RCs with academic and industry partners
HTSN Challenge: Broadband Availability in Canada

ACCESS TO INTERNET IN CANADIAN HOUSEHOLDS

87.4%

CRTC’s universal service objective
(50Mb/s ↓ 10Mb/s ↑ no data cap)

Source: CRTC Communications Monitoring Report, 2019
HTSN 7-YEAR PROGRAM (2019-2026)

OBJECTIVE
HELP BRIDGE DIGITAL DIVIDE IN CANADA

4 RESEARCH THEMES

- OPTICAL SATELLITE COMMUNICATIONS
- PHOTONICS FOR FIBER AND FIXED WIRELESS
- QUANTUM COMMUNICATIONS
- NETWORK METROLOGY AND TIMING

~24M GRANTS + CONTRIBUTIONS

AVAILABLE TO FUND COLLABORATIONS
LEVERAGING REQUIRED

Goal is to develop disruptive technologies and technologies that improve the cost and performance of delivering 1 Gbps or faster connectivity to rural and remote communities.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Objective</th>
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<tbody>
<tr>
<td><strong>Optical Satellite Communications</strong></td>
<td>Develop optical satcom technologies for increased capacity of satellite-based communications</td>
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<tr>
<td>Lead: Dr. Sylvain Raymond</td>
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<tr>
<td><strong>Photonics for Fiber and Fixed Wireless Access</strong></td>
<td>Develop photonics technologies to increase capacity and improve energy, volume, and cost per bit in fiber and fixed wireless access networks</td>
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<td>Lead: Dr. Boris Lamontagne</td>
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<td><strong>Quantum Communications</strong></td>
<td>Perform all aspects of research and development towards Canada-wide demonstrations of quantum-secured communications</td>
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<td>Lead: Dr. Aimee Gunther</td>
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<tr>
<td><strong>Network Metrology and Timing</strong></td>
<td>Develop methods and tools for improving current and future communication system performance via calibrated quantitative measurements</td>
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<tr>
<td>Lead: Dr. Marina Gertsvolf</td>
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Optical Satellite Communications

- **Free space optical links**
  - Adaptive optics systems
  - Photonic phased arrays
  - High power / efficient amplifier systems
  - Emitters and receivers

- **On-board photonics**
  - Optical beamforming circuits
  - On-board photonics communications
  - Photonic power transport

- **Networking and system architectures**
  - AI-assisted data routing
  - Link handover management
  - Self-adjusting / self-configuring networks

Most collaborative projects are between NRC and members of the Optical Satcom Consortium (OSC):

- Led by HTSN, secretariat provided by SatCan
- R&D for next generation satellite communications
- Started October 2019, 5 year initial duration
- 23 current members, including universities, industry, not-for-profit, government
Optical Satcom Consortium (OSC) Members

www.opticalsatcom.com
Photonics for Fiber and Fixed Wireless Access

- Radio-over-fiber, microwave photonics
- Coherent optical networks using quantum dot multi-wavelength lasers
- Avalanche photo-diodes (high-speed, arrays)
- Short-wavelength infrared detectors for imaging
- Silicon photonics (sensors, couplers, multiplexers, etc.)
- Printed conformable antennas

Most collaborative projects are based on NRC’s unique photonics design and fabrication capabilities, and supported by NRC’s Canadian Photonics Fabrication Centre (CPFC) and Advanced Technology Fabrication (ATF) research facility.
Quantum Communications

HTSN has active collaborations on different aspects of long distance quantum communication

**Quantum channel**
- Free space
- Underwater
- Fiber
- High noise environments

**Qubits and beyond: NRC emphasis on high-dimensional photonic encodings**
- Polarization
- Frequency-bins
- Time-bins
- Spatial mode

“**Alice**” (generation)
- Optical Quantum Ground Station for QEYSSat
- Single-photon sources, transducers, and other components

“**Bob**” (receiver)
- Single-photon detectors
- Quantum memories
- Quantum repeaters
HIGH THROUGHPUT AND SECURE NETWORKS CHALLENGE PROGRAM
Progress as of 30 June 2022

46 G&Cs COMMITTED
$16.6M

19 G&C RECIPIENT ORGANIZATIONS

5 NRC RESEARCH CENTRES

PROJECT PARTNERS

- UNIVERSITY (3 International)
- INDUSTRY
- GOVERNMENT
- NOT FOR PROFIT

OPTICAL SATCOM CONSORTIUM (OSC) MEMBERS (including NRC)

- 23 OSC MEMBER IN-KIND (>$700k NRC)

COMMITTED IN MAJOR EQUIPMENT INVESTMENTS

- $3.6M to uOttawa towards equipment for world-class, metal organic chemical vapor deposition (MOCVD)
- $2.1M to the Canadian Space Agency for an Optical Quantum Ground Station for satellite communications
- $1.96M to uOttawa towards equipment for a world-class, joint NRC-uOttawa quantum optics lab

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$16.6M

PEER REVIEWED PUBLICATIONS
221

INTELLECTUAL PROPERTY DECLARATION SUBMISSIONS
18

PATENTS FILED
17

TECHNICAL AND SCIENTIFIC MILESTONES

- Functional integration of quantum key distribution (QKD) into evolutionQ’s Quantum Delivery Network software product
- Laboratory demonstrations of radio-over-fiber transmission
- Milestones towards low cost, compact, energy-efficient, free-space telecommunications systems

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Questions?

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Optical Satcom Consortium: https://www.opticalsatcom.com/