National Research Council Canada

High Throughput & Secure Networks (HTSN) Challenge Program

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CELTIC-NEXT

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

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

Mission-oriented programs across industries

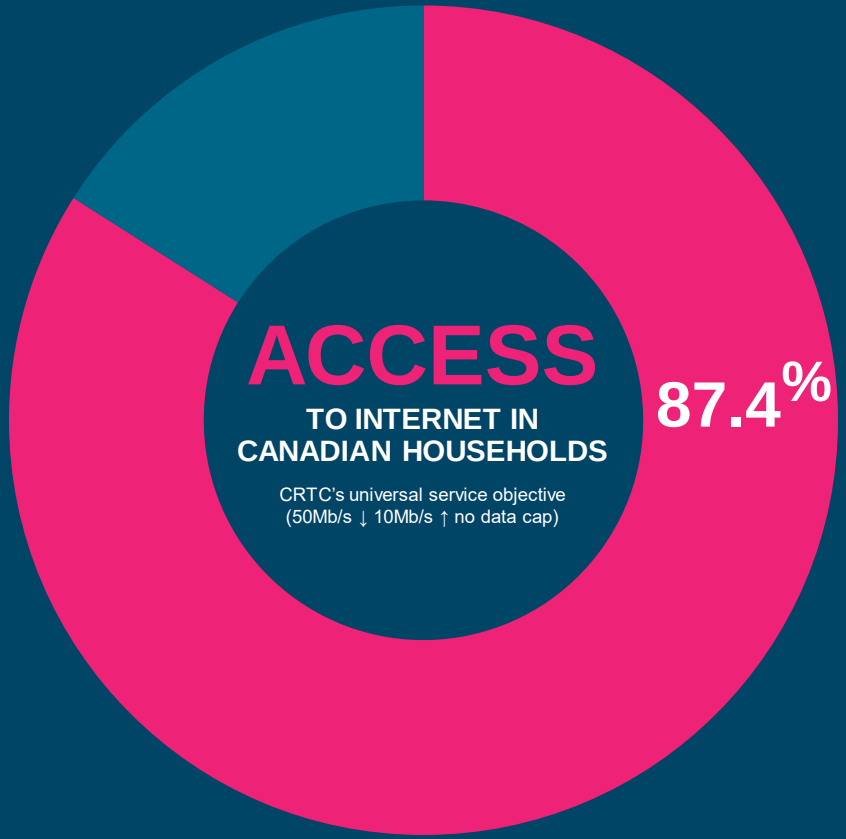
Outcome focused

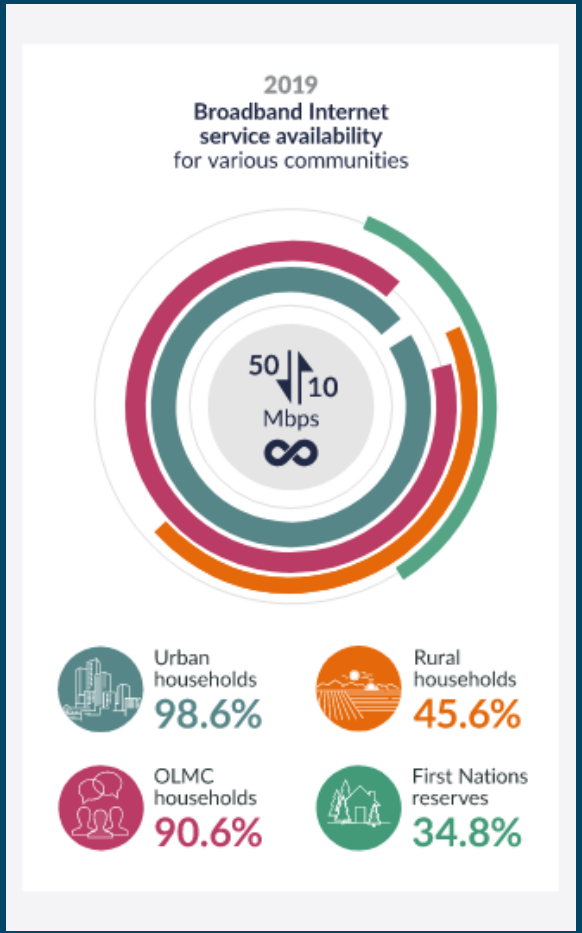
Multi-disciplinary

Up to 7 years in duration

Researchers and facilities from across 14 RCs with academic and industry partners

HTSN Challenge: Broadband Availability in Canada





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

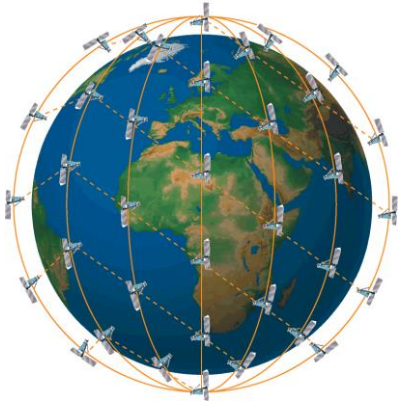
Goal is to develop disruptive technologies and technologies that improve the cost and performance of delivering 1 Gbps or faster connectivity to rural and remote communities

HTSN Research Themes

Theme	Objective
Optical Satellite Communications Lead: Dr. Sylvain Raymond	Develop optical satcom technologies for increased capacity of satellite-based communications
Photonics for Fiber and Fixed Wireless Access Lead: Dr. Boris Lamontagne	Develop photonics technologies to increase capacity and improve energy, volume, and cost per bit in fiber and fixed wireless access networks
Quantum Communications Lead: Dr. Aimee Gunther	Perform all aspects of research and development towards Canada-wide demonstrations of quantum-secured communications
Network Metrology and Timing Lead: Dr. Marina Gertsvolf	Develop methods and tools for improving current and future communication system performance via calibrated quantitative measurements

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

SATCAN

Level 1

MDA

Carleton UNIVERSITY

McMaster University

UNIVERSITY OF WATERLOO

National Research Council Canada / Conseil national de recherches Canada

LUMENTUM

Level 2

LEONARDO DRS

Optiwave

EXCELITAS TECHNOLOGIES

OZ OPTICS LIMITED

INO

LUNA

uOttawa

Defence Research and Development Canada
Recherche et développement pour la défense Canada

Level 3

BROADCOM

c-core

CSA ASC

Green Hexagon Inc.

NorthwesTel

IRIDIAN SPECTRAL TECHNOLOGIES

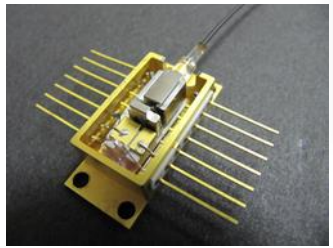
STRATOTEGIC

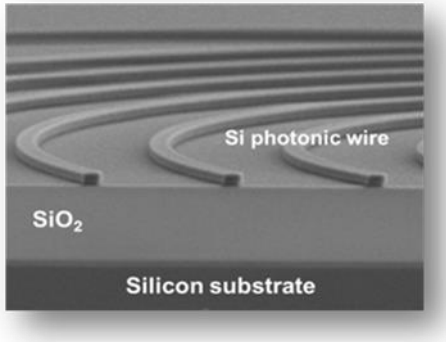
Mitacs

MAGNESTAR

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

“Alice” (generation)

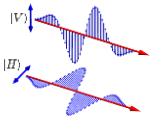
- Optical Quantum Ground Station for QEYSSat
- Single-photon sources, transducers, and other components

“Bob” (receiver)

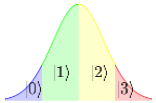
- Single-photon detectors
- Quantum memories
- Quantum repeaters

Qubits and beyond: NRC emphasis on high-dimensional photonic encodings

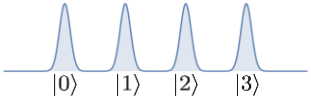
- Polarization



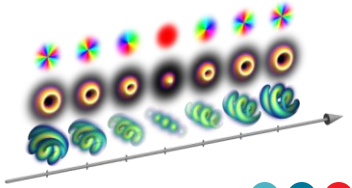
- Frequency-bins



- Time-bins



- Spatial mode



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

221 PEER REVIEWED PUBLICATIONS

18 INTELLECTUAL PROPERTY DECLARATION SUBMISSIONS

17 PATENTS FILED

PROJECT PARTNERS

14 UNIVERSITY (3 International)

6 INDUSTRY

6 GOVERNMENT

2 NOT FOR PROFIT

23 OPTICAL SATCOM CONSORTIUM (OSC) MEMBERS (including NRC)

>$3M 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

$1.96 M to uOttawa towards equipment for a **world-class, joint NRC-uOttawa quantum optics lab**

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

Questions?

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High Throughput and Secure Networks Challenge Program: https://nrc.canada.ca/en/research-development/research-collaboration/programs/high-throughput-secure-networks-challenge-program

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