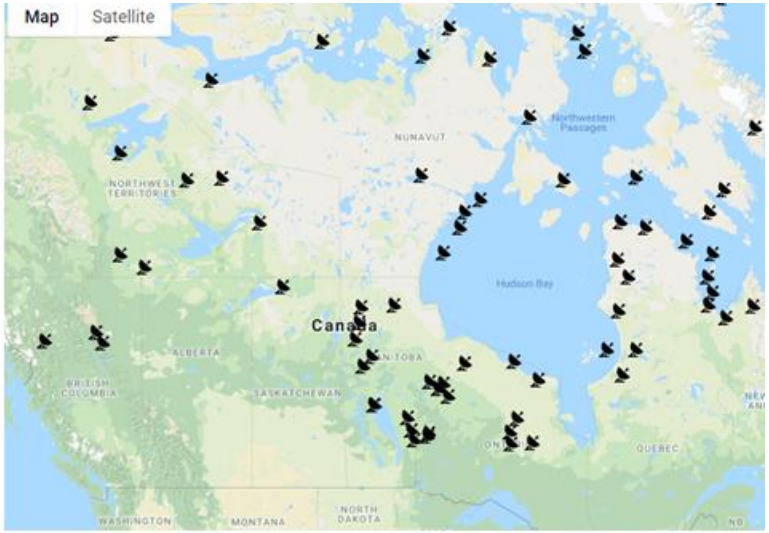
NRC Research Program: High Throughput and Secure Networks Réseaux Sécurisés à Haut Débit

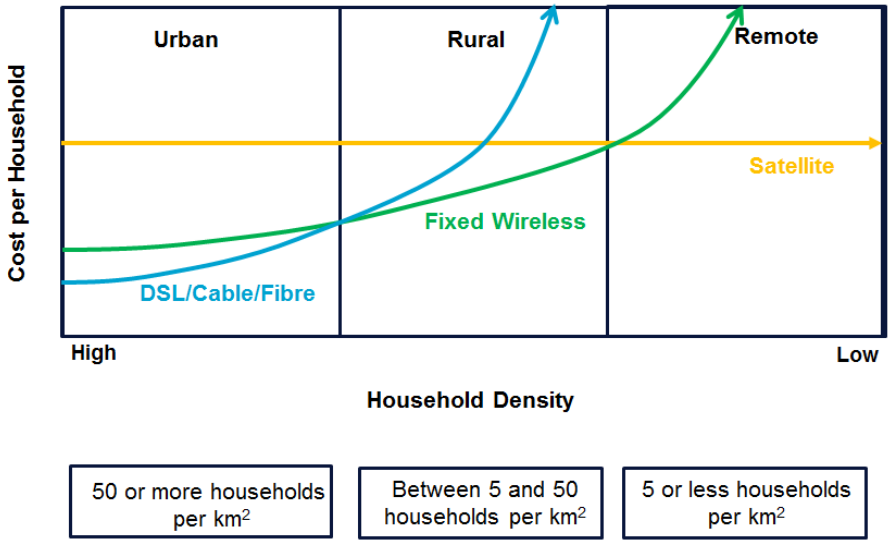
For rural and remote regions

June 9th 2020

Challenge: Geography and Demographics



Source: ISED National Broadband Internet Services Availability Map



Source: CRTC

- Canada: one of lowest population densities – 3.7 inhabitants per km^2
- Access to 'Broadband' service (50Mb/s down, 10 Mb/s up)
  97% urban vs 37% rural (2017)

R&R connectivity options

Connection	speeds	Pros	cons
DSL	5-35 Mb/s	Availability, reliability, cost	Slow, distance dependent
Cable	10-250 Mb/s	Availability	Variable speeds
Fiber	Up to 1 Gb/s	Speed, reliability	Availability, cost
Fixed Wireless	~100Mb/s	Cost, availability	Line of sight
satellite	Tens of Mb/s	availability	Speed, reliability

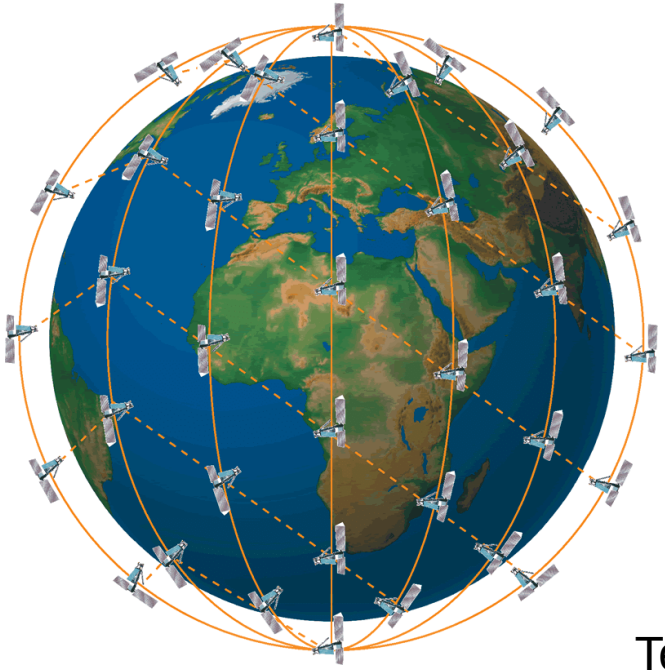
R&R connectivity options: promise of 5G and fixed wireless

Connection	Network	Carrier	speeds	Pros	cons
Fixed Wireless	4G (LTE)	600-700 MHz	~100Mb/s	Range	
	5G - low	600-700 MHz	30-250 Mb/s	Range	
	5G – FR1	2.5-3.7 GHz	100-900 Mb/s	speed	Range, line of sight, weather sensitive
	5G – FR2	25-39 GHz	Up to 1 Gb/s	Speed	Very short Range, line of sight, weather sensitive

- **Current carrier frequencies in use propagate far in the atmosphere, flows through walls and buildings, relatively unaffected by rain, snow, fog.**
- **5G and later networks: FR1 and FR2 carrier frequencies offer higher download speeds.**
- **FR2 carrier frequencies have much shorter range in atmosphere**
- **FR2 carrier is strongly attenuated/disrupted by foliage, rain, snow etc.**
- **Higher data input rates at antenna will require direct connections to fiber to achieve 5G benefits.**

R&R connectivity options – promise of LEO

Low Earth Orbit – LEO Satellite Networks

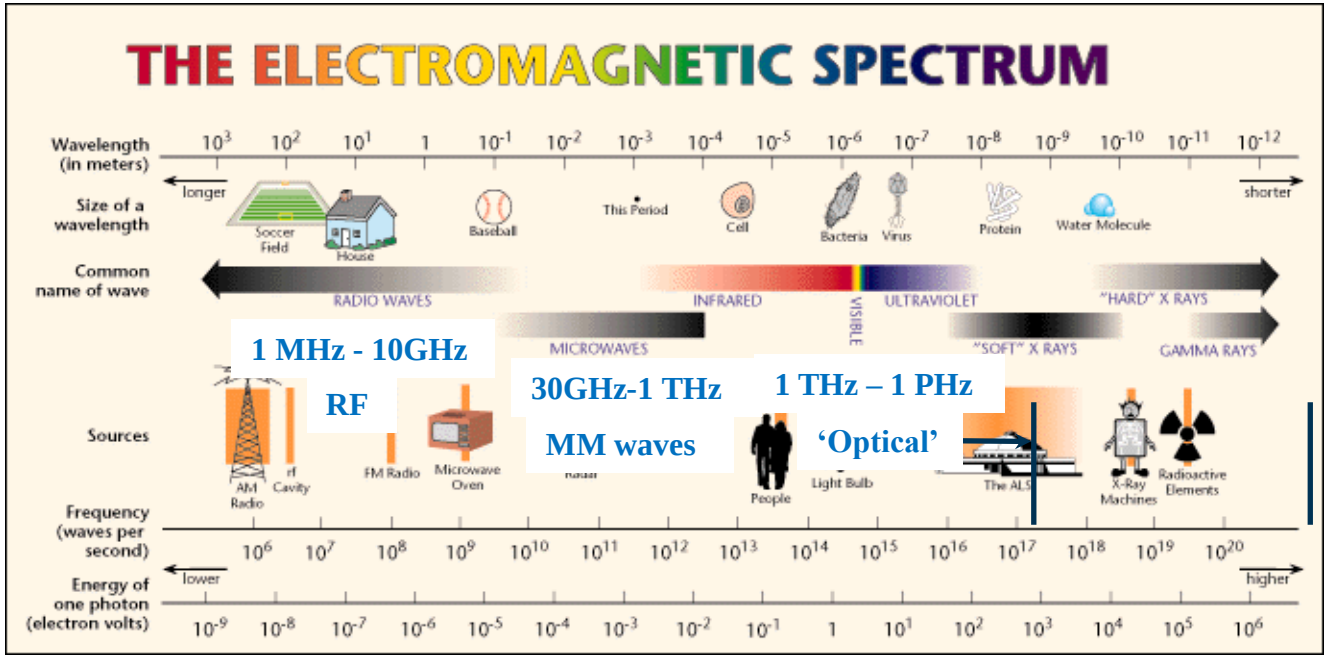


Satellite type	Orbit	Line of sight	Intersatellite links	Ground-Satellite link
GEO	36 000 km	Stable	N/A	SHF
MEO	2000-30,000 km	Moving	N/A	SHF
LEO	1000 km	Moving	RF or optical	SHF

- **LEO's will orbit directly above any point on the planet**
- **Lower orbit = lower latency**
- **LEO Still use the SHF band – no revolutionary increase in capacity**
- **COST for users ???**

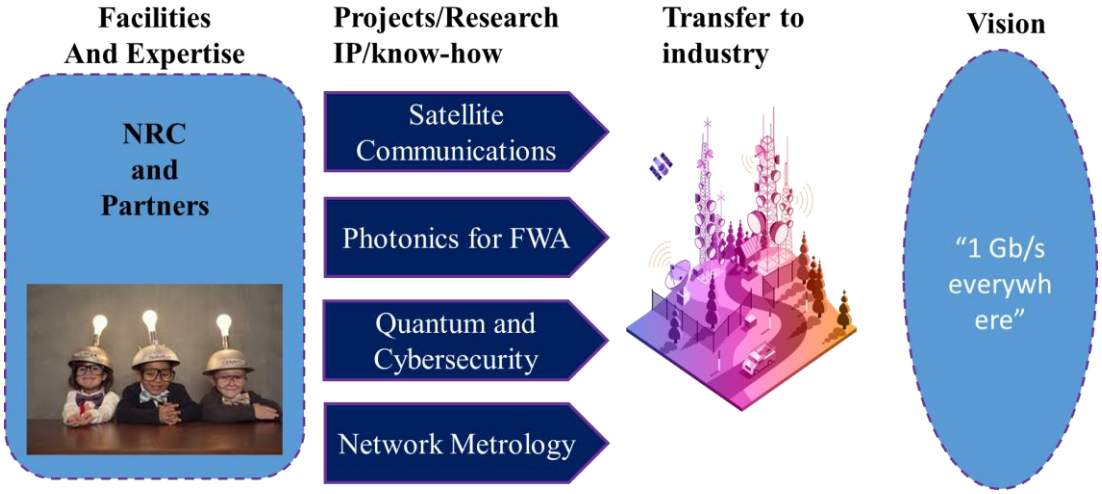
Telesat, OneWeb, Space X, Starlink, Amazon

Question: how to make a leap forward?



As we move from RF (Radio Waves) towards the right (microwaves, visible light), the data rates can go higher.

Government Mandate to NRC: Research Program ‘High Throughput and Secure Networks’ - HTSN



HTSN performs basic research with aim to transfer resulting innovations to industry that will enable service providers to offer secure and affordable extreme high speed broadband connections to users anywhere in Canada, including rural and remote regions.

7 years in duration

- ~$8-10M/year intramural research at NRC - Mostly labour & Facilities, but some O&M available from program.
- ~$2.5 M/year from partners supported through grants and contributions.
- Partner in-kind contributions

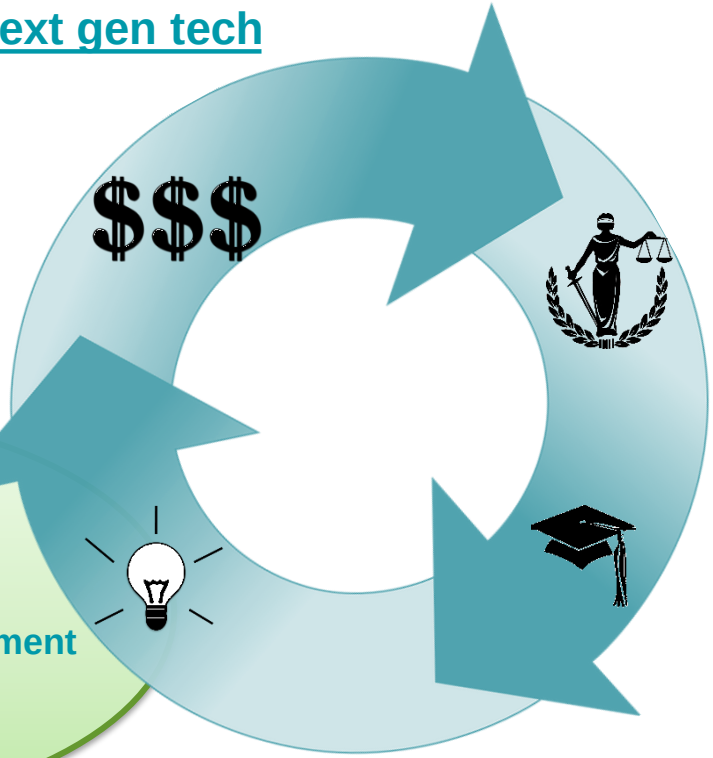
HTSN's part of the challenge

Investments: Current and next gen tech

Federal

- ISED Connect to Innovate : $500M
- Canada's connectivity strategy: $6B
- CRTC Broadband Fund : $750 M
- Canada Infrastructure Bank: $1B
- Canada Telesat: $600M

Provinces & Territories
Communities
PPP



NRC·CNRC

Innovation:

next-after-next gen tech

- Cost/performance improvement
- Disruptive technologies

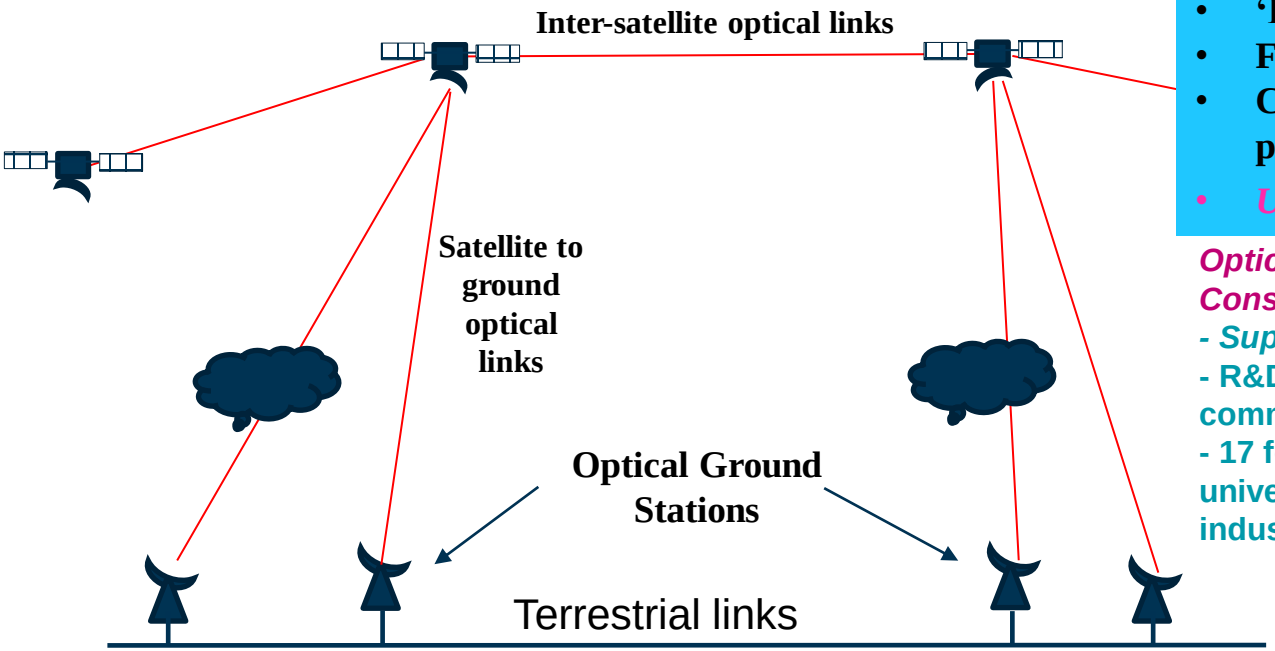
Regulation & market:

- Spectrum allocation & use
- Licenses
- Access to public infrastructure (poles)
- Competitive forces

Others:

- Digital literacy
- Market demand
- HQP training

Research Area #1: All-Optical LEO



- **'Fiber-in-the-sky'**
- **Fiber-like speeds – Tb/s links**
- **Connect any two points on the planet**
- ***Unknown: Cost, Reliability***

Optical Satellite Communication Consortium

- Supported by NRC, SatCan

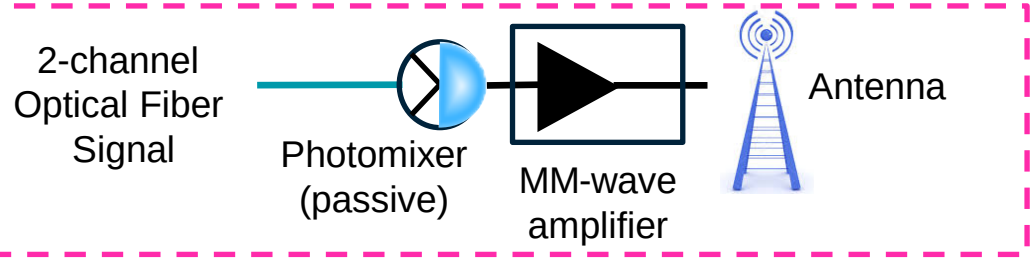
- R&D for next gen satellite communications

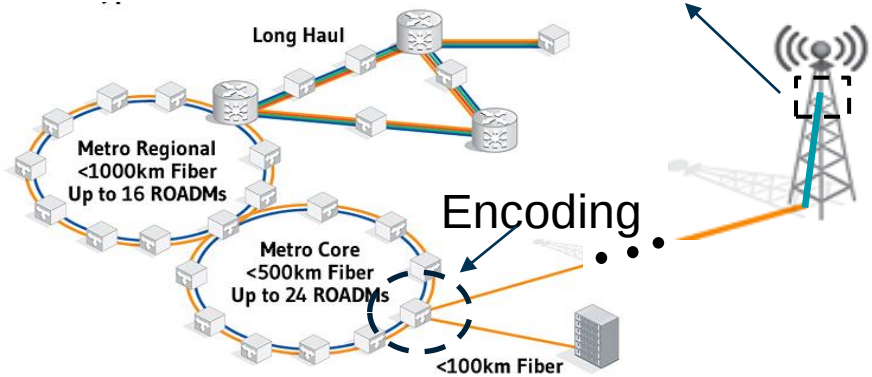
- 17 founding organizations – NRC, universities, not-for-profit, government, industry

Link to community

Research Area #2: Fixed Wireless Mitigate the MM-wave limitations

Radio-over-Fiber concept





- Millimeter waves – 30 to 300 GHz (5G - FR2 and higher)
- Support fast data rates
- Short reach – needs lots of antennas
- May well need a fiber to ‘feed the beast’.

Radio-over-Fiber Benefits:

- Cheaper - Remove cabinet for optical-electronic conversion
- Less power - Passive components.
- Connect to optical ground terminal to serve a community?

Research Area #2: Fixed Wireless Testbed for 5G applications

Ottawa L5 Testing Facility
Invest Ottawa

Test Tracks:

- Autonomous vehicles (private)
- Autonomous Vehicles (Public)
- Precision farming

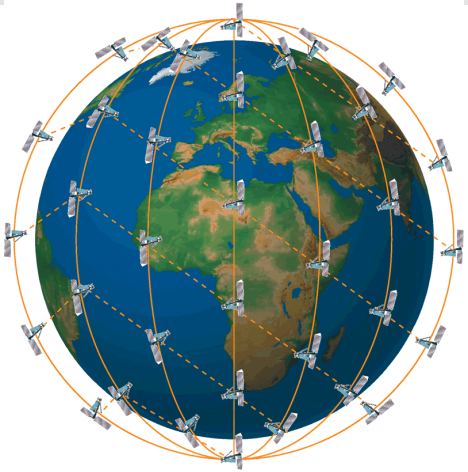
Networks:

- Dedicated 4G LTE, 5G
- GPS, Wi-Fi

https://www.investottawa.ca/ottawal5/

Summary

- ***Moving to MM-waves (5G-FR2 and up) and optical waves (light) is very beneficial for network speed.***
- ***Fixed wireless: moving to MM-waves (5G-FR2 and up) means more antennas (atmospheric absorption, signal blocked by walls etc). Mitigation: Radio-over-Fiber.***
- ***LEO: enabling free-space ground-satellite optical links would bring fiber-like capacity in the sky. Challenges: atmospheric disturbances, pointing and tracking…***



Search for HTSN, you will find our website

https://nrc.canada.ca/en/research-development/research-collaboration/programs/high-throughput-secure-networks-challenge-program

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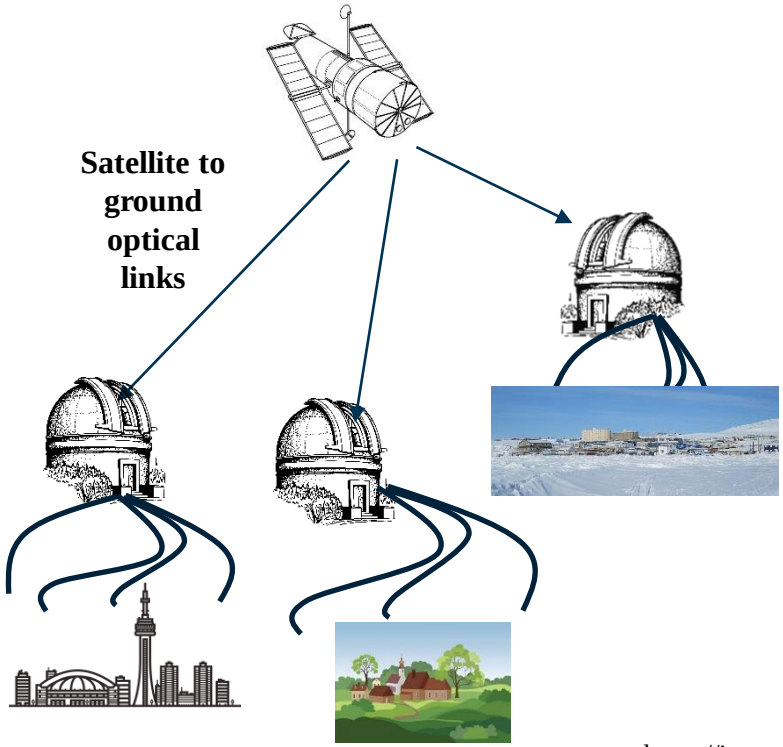
Thank you / Merci

HTSN : Role of Artificial Intelligence

- Help design new materials and devices
- Render networks more autonomous
- Help manage complexity of Data routing in dyamic networks
- Predict points of failure in advance – regulate maintenance
- Manage handover to backup networks when necessary

Research Area #3:
Quantum Resistant communication channels



Quantum Encryption

- Ultra secure communication channels
- Protection against quantum computer attacks
- Based on the quantum properties of light
- Very slow data transmission.
- Canadian demo ~2024 – QEYSsAT project (CSA-led)
- Still many, many years away from network implementation.

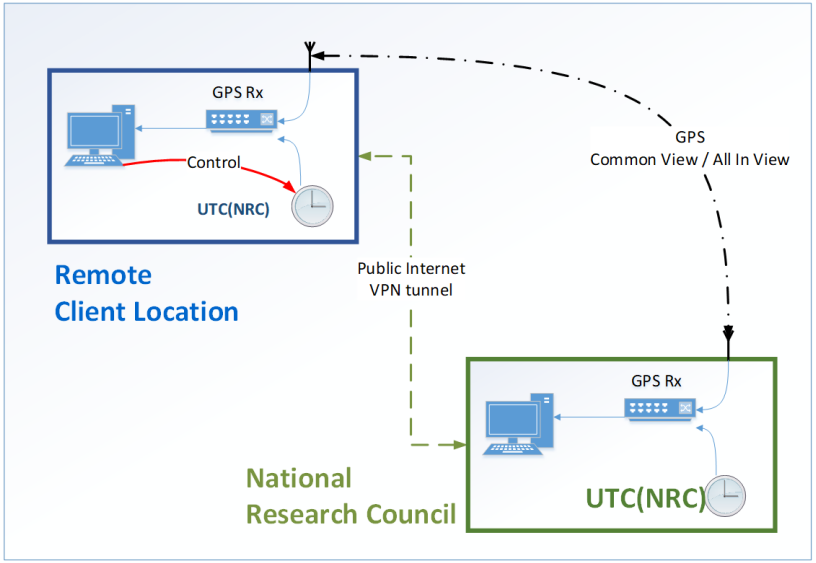
Advanced 'classical' cryptography

- Quantum Resistant Algorithms (QRA)
- QRA for imperfect networks
- Edge security for IoT networks

https://images.app.goo.gl/Uttt5hgWx6DtKwgU8

Research Area #4: Timing for remote networks

Distribution of precise, ‘validated’ time markers in R&R regions.



- Remote Control
- Secure Connection
- Long Holdover
- High Accuracy
- Network Segregation