CENTRE D'INNOVATION CENTRE

Enabling Adaptation and Resilience in the Rail Sector

Innovation Centre Rail Program

UN Transport Committee's Working Party on Rail Transport

Matt Krech, P. Eng, Chief - Rail RD&D

November 2022

Transport Canada Transports Canada

Canada

CENTRE D'INNOVATION CENTRE

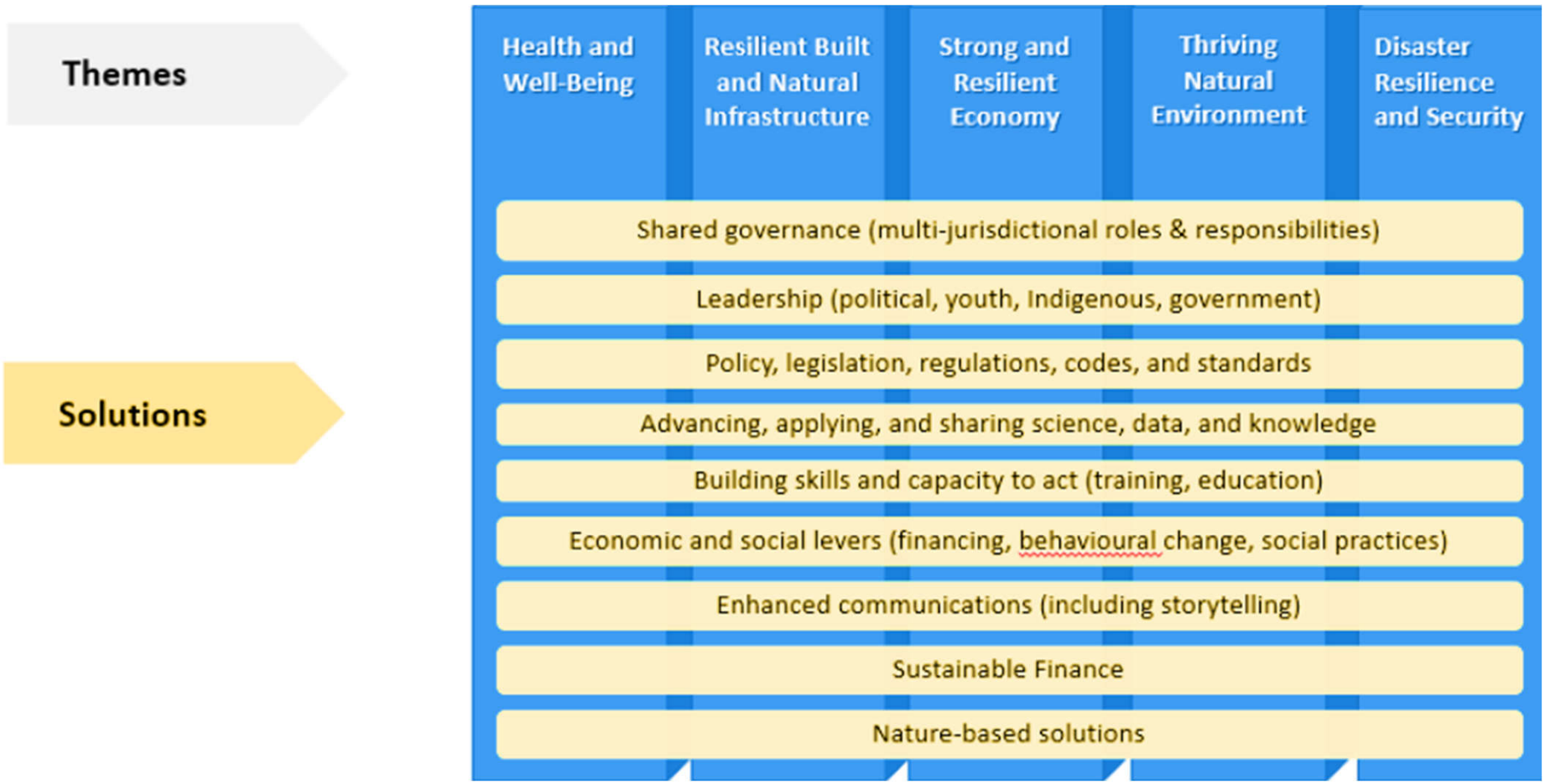
Context:

- With nearly 41,711 route-kilometers of track, Canada has the third-largest rail network in the world.
- 70 % of all intercity surface freight and 50% of Canada's exports are moved by rail; more than $320 billion worth of goods annually.
- Canada's climate is warming rapidly – two times faster than the global average and three times faster in the North. Canadians are already experiencing the impacts of climate change, like extreme weather, flooding, wildfires, and coastal erosion.
- **Lytton wildfires**: In July 2021, wildfires in Lytton blocked Class I railways' main lines leading to the Port of Vancouver. At the peak of the crisis, railways' capacity was reduced by 30% to 50%, generating significant congestion at the Port of Vancouver and severely impacting exports and imports of key commodities, i.e., grain, coal, forestry products, fertilizers, containerized goods.
- **British Colombia atmospheric river:** In November 2021, flooding in BC resulted in long lasting disruptions to the transportation system, including damage to 30 locations of the heavily-used rail corridor between Vancouver and Kamloops. This event incurred significant loss to Canadian GDP due to the loss of train capacity, increased congestion at the Port of Vancouver, and the loss of output for various sectors in the form of production cuts and lost imports / exports.

CENTRE D'INNOVATION CENTRE

National Adaptation Strategy:

- **Objective:** Establish a shared vision for climate resilience in Canada, identify key priorities for increased collaboration, establish a framework for measuring progress at the national level
- Innovation and research will be important in advancing solutions and contributing to overall federal efforts that are currently underway to develop Canada's National Adaptation Strategy.



CENTRE D'INNOVATION CENTRE

Importance of Collaborative Fora

1) Railway Ground Hazard Research Program (RGHRP)

- The Railway Ground Hazard Research Program (RGHRP) is a collaborative effort among industry, academic institutions and the federal government to develop and evaluate scientific and technical solutions to help railways manage the risks associated with ground hazards

- Sharing their resources has led to an innovative platform to advance scientific knowledge and develop industry standards. The RGHRP facilitates innovation in the transport sector and creates opportunities to train skilled workers and experts for the railway industry.

2) Rail Research Advisory Board (RRAB)

- The RRAB was created by Transport Canada in 1989 to optimize collaboration and create synergy in the railway R&D programs of industry, government, and academia

- Mobilizes resources and programs to address problem areas and issues of relevance in Canada and facilitates participation by industry and academia in the formulation and implementation of railway-oriented R&D programs by the federal government.

CENTRE D'INNOVATION CENTRE

WORKING WITH CANADIAN STAKEHOLDERS TO DEVELOP PROMISING TECHNOLOGIES

CENTRE D'INNOVATION CENTRE

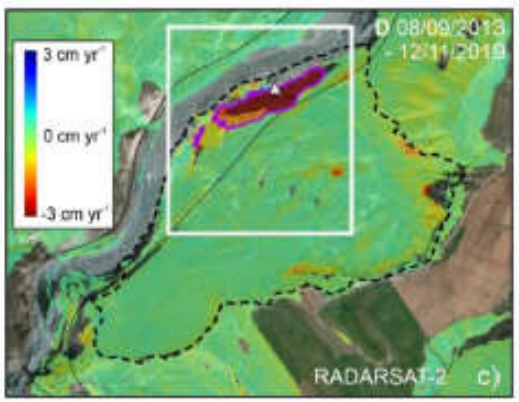
TECHNOLOGIES FOR MONITORING LANDSLIDES

1. Understanding plateau and prairie landslides: research in the Thompson River valley

Objective: Increases in magnitude and frequency of landslides are expected as a response to rising precipitation amounts (both rain and snow), greater seasonal ranges in temperature, and more extensive wildfires. This project aims to provide insight on the influence of climate through emerging monitoring technologies on strategically important sections of the Canadian railway network.

Key results:

- Our studies show that satellite InSAR platforms with repeat visit times of weeks provide effective landslide monitoring capability with cm-scale precision and accuracy when periodically benchmarked with ground-based RTK-GNSS measurements and UAV photogrammetry.
- This approach can be an effective tool to detect and monitor landslides across broad areas.
- InSAR does not perform well in snow and the quality of monitoring is subject to local weather conditions.
- This data has helped inform the railways' prioritization of mitigation measures for large slow-moving slopes, such as river berms, lock-block retaining walls, or engineered slopes.
- Monitoring and early warning for maintenance and cautionary speed enforcement can be effective strategies for management and mitigation of landslide hazard where the cost of slope mitigation is high.



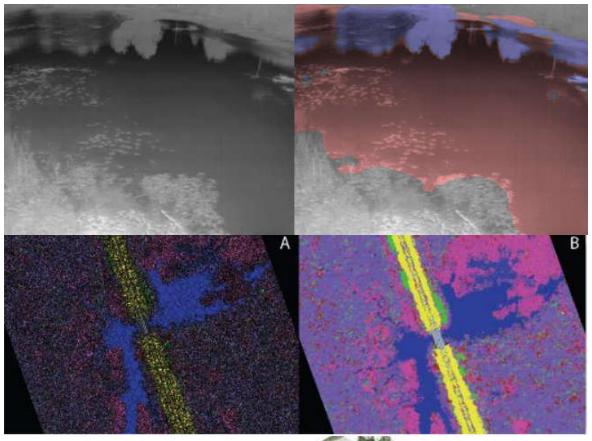
Next steps: Work with industry through RRAB and RGHRP to continuing optimizing the use of new technologies and supporting the development of industry guidelines.

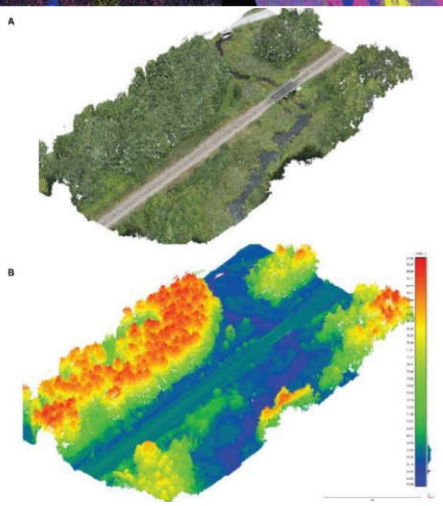
CENTRE D'INNOVATION CENTRE

TECHNOLOGIES FOR MONITORING WATER LEVELS

2. Emerging Technologies for Monitoring and Managing Water Levels around Railway Tracks

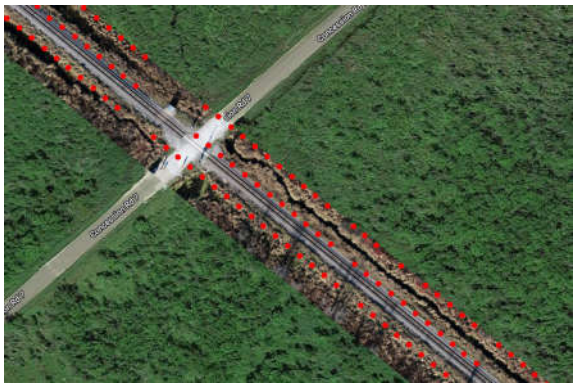
Objective: Prolonged periods of heavy rainfall, rapid snowmelt, flash flooding, river flooding, beaver dams, blocked culverts or poor drainage design can result in a rise in water levels. Risks to railways include washout, massive shear failure, and bridge foundation damage. The goal of this study was to collect data from three different platforms (satellite, UAV, and instrumented hi-rail truck) and different sensors (high-resolution camera and LiDAR) over several test sections and measure surface water near railway tracks.





Key results:

- These technologies offer an inexpensive and effective method that provides valuable data about the water issues and supplements the information from current visual inspection methods.
- Satellite monitoring features excellent visibility range and low cost but inadequate spatial and temporal resolution for water issues close to track.
- UAV monitoring offers moderate visibility range but higher spatial resolution.
- Instrumented hi-rail has limited visibility range but highest resolution that can be used to quantify water levels and measure distance to track.
- The combination of various sensors provides a wide range of complementary information with different spatial and temporal resolutions as well as field of view which may be helpful in monitoring flooding risk.



Next steps: Advance algorithms and data fusion techniques to combine data sets and advantages from various platforms as well as support the development of industry guidelines to augment current water inspection practices with new technologies.

CENTRE D'INNOVATION CENTRE

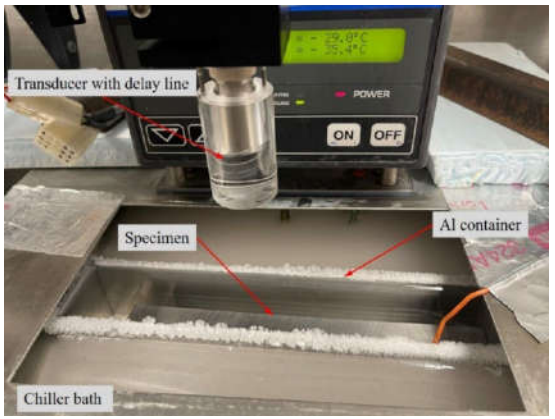
TECHNOLOGIES FOR COLD CLIMATE OPERATIONS

3. Investigating tie plate icing/ice jacking and ultrasonic flaw testing in extreme cold conditions

Objective: Warming temperatures are disrupting the polar vortex and pushing cold air into non-traditional areas causing increased occurrences of extreme cold. Canadian railways operate in temperatures up to 39°C in the summer and down to -60°C during winter with snow, ice, and high winds. The main goals of this study are to advance technologies that can help address cold weather performance challenges. Specifically, tie plate icing and ultrasonic testing were identified as initial priorities.

Key results:

- **Tie plate** icing is caused by a combined effect of track conditions (poor tie condition and fouled ballast) and weather conditions (snow accumulation or freeze thaw cycling)
- A finite element model was proposed to evaluate the track gage strength when tie plate icing occurs and assess when remediation measured are needed.
- Significant differences in **ultrasonic testing** wave properties (velocity, refraction, attenuation) were detected in temperatures from 0°C to -35° which may significantly impact flaw detection zones and test effectiveness.



Next steps:

- Model tie plate icing mechanisms, identify early warning signs and maintenance thresholds, and assess effective remediation measures.
- Collect additional ultrasonic testing date in field conditions, propose improvements to calibration and operation procedures to improve performance.
- Advance research on other cold weather challenges including frozen switches, broken rails, wheel shelling, air brake performance.

CENTRE D'INNOVATION CENTRE

DEVELOPING PROGRAMS TO SUPPORT TECHNOLOGY TRANSFER TO INDUSTRY AND LONGER-TERM DEPLOYMENT

CENTRE D'INNOVATION CENTRE

RAIL CLIMATE CHANGE ADAPTION PROGRAM (R-CCAP)

Program Objectives:

Transport Canada's will launch the R-CCAP program from 2022/23 to 2023/24 to support research, deployment, and implementation of innovative new technologies, tools, and approaches to help address the increasing risks and impacts of climate change on Canada's rail sector. In so doing, the program will also help enhance the safety and resilience of supply chains.

Program Launch
(Summer 2022)

Proposal Submissions
(Sep 2022)

Develop Contribution Agreements
(Fall 2022)

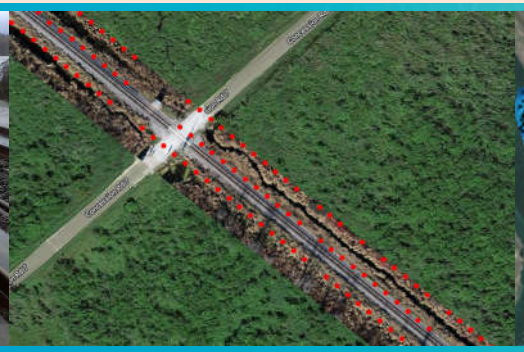
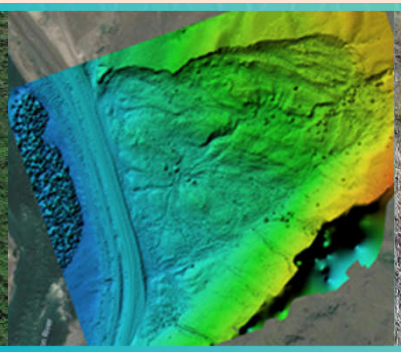
Project Execution
(Fall 2022 – Winter 2024)

Results Dissemination
(Ongoing)

Project Categories

Host call for proposals to support field trials and deployments of new approaches and technologies to address climate impacts on rail infrastructure across the following three project areas:

1) **Risk Assessments:** Research and engineering studies that help railways better understand the risks and impacts of climate change on their rail network and improve design, maintenance, training, and operational practices.
2) **Monitoring Technologies:** Testing, trialing, and implementing innovative technologies to enhance the inspection and monitoring of climate risks (e.g. fires, flooding, vegetation conditions, landslides) on the rail network.
3) **Mitigation Measures:** Evaluating new design or maintenance practices, technologies, or alternative materials to address adaption challenges (e.g. flooding, permafrost degradation, more extreme operational temperatures and temperature variations).


CENTRE D'INNOVATION CENTRE

Final Thoughts:

1. *Climate change is bringing an array of new challenges to the rail sector – **new challenges require new tools and solutions**.*
2. ***Academia, government, and industry working together** creates a powerful consortia that can take new ideas from theory to proof-of-concept testing to long-term deployment.*
3. ***Strengthening linkages with international counterparts** can help ensure maximum complementarity and optimum utilization of research resources.*
4. ***Standardization** can enable technologies developed to address a challenge in one country to be adapted and applied to similar challenges around the world and ensure interoperability with other technologies.*

CENTRE D'INNOVATION CENTRE

Additional references to rail innovation and adaptation RD&D in Canada

The Railway Ground Hazard Research Program (RGHRP) website contains a list of publications as well as YouTube links to project overviews presented at the annual RGHRP workshops from 2020-2022.

The Canadian Rail Research Laboratory (CaRRL) website contains links to recent publications along with links to YouTube presentations on research conducted over the past few years.

In 2021, CaRRL hosted the Canadian & Cold Regions Rail Research Conference which had sub themes of Climate Change and Environment, Innovations in Railway Engineering, and Risk and Reliability. The presentations can be found here:
https://www.youtube.com/playlist?list=PLf76HEiLxBxSTmJNchOOUyG5pdskkcosa

The Ingenium open science portal host publications from projects undertaken by TC's Innovation Center. A few relevant projects include:
Review of the Current State of Knowledge Regarding the Design, Construction, and Maintenance of Railway Lines over Permafrost
Understanding plateau and prairie landslides: annual report on landslide research in the Thompson River valley, British Columbia, and the Assiniboine River valley, Manitoba-Saskatchewan
Cold Climate Railway Technologies: Literature Review and Gap Analysis
Climate Change Adaptation by Canada's Northern Railways: Best Practices and Strategies
Emerging Technologies for Monitoring and Managing Water Levels around Railway Tracks, Phase II-Stage II

Transport Canada, in collaboration with the Innovative Solutions Canada fund, undertook a series of RPAS based rail projects including a 5km beyond visual line of sight (BVLOS) flight, 3D bridge mapping, and production of digital surface models for key measurements. An overview of the work conducted can be found in the two links below:

https://www.linkedin.com/posts/spexi-geospatial_beyond-visual-line-of-site-bvlos-trial-activity-6922637436598591488-nTaF?utm_source=linkedin_share&utm_medium=member_desktop_web

https://www.linkedin.com/posts/spexi-geospatial_were-working-to-bring-aerial-data-to-canadians-activity-6920137206493761536-LCng?utm_source=linkedin_share&utm_medium=member_desktop_web

CENTRE D'INNOVATION CENTRE

Additional Transport Canada Adaptation Programs

- **Northern Transportation Adaptation Initiative** – Enhanced northerners' capacity to adapt their transportation systems to climate change
- **Transportation Assets Risk Assessment Initiative** – Aims to better understand climate risks to federally-owned transportation infrastructure and potential adaptation solutions that could be employed
- **Rail Safety Improvement Program** – Aims to improve rail safety, contribute to increasing safety at grade crossings and along rail lines, address climate change resiliency, and increase public confidence in Canada's rail transportation system.
- **National Trade Corridors Fund** – Funding for infrastructure projects ($4.6B, competitive, merit-based program)
    - One of the four objectives is to "help the transportation system withstand the effects of climate change and make sure it is able to support new technologies and innovation"
    - Climate lens: All applicants are required, as part of their comprehensive project proposal, to provide information on the degree to which the proposal takes climate change impacts into account, and this information factors into the proposal evaluation process.