Geohazard risk assessment and asset management along railway corridors

BGC: Matt Lato, Pete Quinn, Mark Pritchard, Mike Porter and Sarah Newton
IOC: Dominique Sirois

bgcengineering.com
BGC supports risk-based geohazard management for linear and distributed infrastructure, including: pipelines, highways, railways, communities and mines.
Cambio\textsubscript{Pipeline} contains \textgreater135,000 documented geohazards along 300,000 km of pipeline for 18 operators.

Pipeline Team Goal #1: Efficiently reduce the global risk of pipeline incidents and failures caused by geohazards by \textgreater10\% by 2025
BGC’s geohazard management platforms

- Cambio: Geohazard Management for Pipelines
- River Network Tools
- Hazard Info Tool
- Vantage: Automated Instrumentation
- gINT: Requests
- IOC - GMS
- Proyecto Alturas
- Flin Flon Mobile
- Flin Flon Dam Monitoring
- Site C
- CN RGHRMS
Cambio Pipelines combines real-time monitoring, inspection and historical data with risk-based algorithms to help operators make decisions to prevent failures and reduce consequences.
The RNT is used to automate FFA calculation and support real-time flood monitoring for pipeline water crossings.
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The QNS&L railway line

- 420 km of track between Sept Iles and Labrador City
- Daily traffic
  - Ten to fifteen ore trains a day
  - Two fuel unit-trains per week
  - Multiple freight trains per week
  - Four passenger trains per week
  - Work trains
- Fibre-optic communication for Labrador City follows the corridor
Origins of Cambio\textsuperscript{Rail}
(IOC Geohazard Management System)

- At approximately 05:30 on November 6, 2014 a northbound (empty) ore train derailed into the Moisie River
  - One locomotive was completely submerged
  - One locomotive derailed onto the embankment
  - Nine empty ore cars derailed onto the embankment
# Geohazard risk management framework

<table>
<thead>
<tr>
<th>Assessment Type</th>
<th>Ongoing review of risk scenarios and risk management process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geohazard Risk Identification</td>
<td>Monitoring and Review</td>
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<tr>
<td>Geohazard Risk Analysis</td>
<td></td>
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<tr>
<td>Geohazard Risk Management</td>
<td></td>
</tr>
</tbody>
</table>

**1. Scope Definition**
- Recognize the potential hazard
- Define the study area and level of effort
- Define roles of the client, regulator, stakeholders, and Qualified Registered Professional (QRP)
- Identify ‘key’ consequences to be considered for risk estimation

**2. Geohazard Analysis**
- Identify the geohazard process, characterize the geohazard in terms of factors such as mechanism, causal factors, and trigger factors; estimate frequency and magnitude; develop geohazard scenarios; and estimate extent and intensity of geohazard scenarios.

**3. Elements at Risk Analysis**
- Identify elements at risk
- Characterize elements at risk with parameters that can be used to estimate vulnerability to geohazard impact.

**4. Geohazard Risk Estimation**
- Develop geohazard risk scenarios
- Determine geohazard risk parameters
- Estimate geohazard risk

**5. Geohazard Risk Evaluation**
- Compare the estimated risk against tolerance criteria
- Prioritize risks for risk control and monitoring

**6. Geohazard Risk Control**
- Identify options to reduce risks to levels considered tolerable by the client or governing jurisdiction
- Select option(s) with the greatest risk reduction at least cost
- Estimate residual risk for preferred option(s)

**7. Action**
- Implement chosen risk control options
- Define and document ongoing monitoring and maintenance requirements
Key assumptions

- Geohazards conform to a frequency-magnitude relationship, where larger events occur more rarely.
- Large events may be lower risk than a small event if the likelihood of unwanted outcome is sufficiently lower.
- Mitigation priorities depend on risk tolerance for specific consequences, not only event magnitude or frequency.
Cambio Rail

(IOC Geohazard Management System)

User Name: bgc
Password: ********

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This site is under development and decisions should not be based on data without checking with BGC.
### CambioRail: Tabular Database

- **Sortable and searchable table with filters for documented geohazards**
- **Links to photos, rating and inspection history, and planned mitigation**
- **Automatic assignment date of next inspection based on risk level**
- **Exportable data and reports**

<table>
<thead>
<tr>
<th>Subdivision</th>
<th>From Mile</th>
<th>To Mile</th>
<th>Track Side</th>
<th>HazID</th>
<th>Scenario Type</th>
<th>Photo$</th>
<th>Haz Rating</th>
<th>Consequence Rating</th>
<th>Risk Rating $</th>
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<td>18 Jun 2019</td>
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</table>

Showing 1 to 30 of 724 entries

Shift-click header to order by multiple columns

Selection Criteria
- Subdivisions [Washouga]
### CambioRail: documentation forms

**IOC-GMS Earth and Debris Landslide Site Characterization Form**

- **Location Information**
  - Date: 16-Jun-2016
  - Inspector: Marc-Andre Brideau
  - Subdivision: Wacouna
  - Mileage: 10.04 - 10.06
  - Track side: Right

- **Risk Matrix (field estimate)**
  - Annual Probability of Impassable Track
  - Consequence, given Impassable Track
  - Risk (expected loss)
  - Level 3

**IOC-GMS Washout Site Characterization Form**

- **Location Information**
  - Date: 18-May-2017
  - Inspector: Rebecca Lee
  - Subdivision: Wacouna
  - Mileage: 9.78 - 9.78
  - Track side: Right

- **Risk Matrix (field estimate)**
  - Annual Probability of Impassable Track
  - Consequence, given Impassable Track
  - Risk (expected loss)
  - Level 3

**IOC-GMS Bank Erosion Site Characterization Form**

- **Location Information**
  - Date: 22-Aug-2015
  - Inspector: Melissa Hairabedian
  - Subdivision: Wacouna
  - Mileage: 57.14 - 57.23
  - Track side: Left

- **Risk Matrix (field estimate)**
  - Annual Probability of Impassable Track
  - Consequence, given Impassable Track
  - Risk (expected loss)
  - Level 5

**IOC-GMS Rock Slope Site Characterization Form**

- **Location Information**
  - Date: 19-May-2017
  - Inspector: Marc-Andre Brideau
  - Subdivision: Wacouna
  - Mileage: 12.20 - 12.27
  - Track side: Right Side
  - Track speed (mph): 25

- **Risk Matrix (field estimate)**
  - Annual Probability of Impassable Track
  - Consequence, given Impassable Track
  - Risk (expected loss)
  - Level 5

### Effectiveness of Slope Mitigation with respect to rock fall reaching the railway

- Uphill of track
- At grade
- Downhill of track

**Slope Maintenance:**
- Scaling
- Bolts
- Mesh
CambioRail: spatial access to information
CambioRail: individual site risk estimation
# Cambio_Rail: TARP warning systems

**TARP for weather triggered shallow landslides**

IOC may escalate the TARP levels on any observed monitoring data, beyond that explicitly described in the TARP.

<table>
<thead>
<tr>
<th>Response Level</th>
<th>Weather Characteristics</th>
<th>Geohazard Activity</th>
<th>Operational Response</th>
<th>Management Response</th>
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<tbody>
<tr>
<td>1</td>
<td>Rainfall below Threshold 1-2&lt;br&gt;1-hr &lt; 7 mm&lt;br&gt;2-hr &lt; 9 mm&lt;br&gt;6-hr &lt; 12 mm&lt;br&gt;12-hr &lt; 15 mm&lt;br&gt;24-hr &lt; 19 mm&lt;br&gt;48-hr &lt; 23 mm&lt;br&gt;72-hr &lt; 25 mm&lt;br&gt;96-hr &lt; 27 mm</td>
<td>Shallow landslides very unlikely</td>
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<td>Sporadic shallow landslides unlikely</td>
<td>TBD by IOC</td>
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<td>3</td>
<td>Rainfall below Threshold 3-4&lt;br&gt;1-hr &lt; 27 mm&lt;br&gt;2-hr &lt; 33 mm&lt;br&gt;6-hr &lt; 46 mm&lt;br&gt;12-hr &lt; 57 mm&lt;br&gt;24-hr &lt; 70 mm&lt;br&gt;48-hr &lt; 86 mm&lt;br&gt;72-hr &lt; 97 mm&lt;br&gt;96-hr &lt; 106 mm</td>
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<td>Abundant shallow landslides likely</td>
<td>TBD by IOC</td>
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Cambio_Rail: geohazard event database

- Events are input into a webform with photos by track forces
- Events are sent to Engineering for review and approval
- Location of events are plotted on the map
- Data can be easily imported from existing records

Events per Mileage Interval

- Events are input into a webform with photos by track forces
- Events are sent to Engineering for review and approval
- Location of events are plotted on the map
- Data can be easily imported from existing records
Cambio_Rail strengths

- All geohazards and risk scenarios are assessed using a consistent framework to allow direct comparison between different asset and hazard types
- The IOC-GMS is used by maintenance workers, engineers, planners, and executives
- Information is easily accessible with minimal learning required
- Risk levels reflect corporate standards
- Real-time warning based on live weather data along the railway
- Ability to measure risk reduction versus dollar invested
Cambio_{Rail} outlook

- Expanding the capabilities to include culvert rating and management
- Integrating performance objectives and maintenance scheduling
- Working with Rio Tinto Iron Ore in Australia to implement Cambio_{Rail} for a 1,600 km rail network that connects 16 mines and two port facilities
Cambio_Rail outlook: beyond geohazards