Overview of CN’s Corridor Risk Assessment Process

Risk Ranking Tool for Railway Transport of Dangerous Goods In Canada

CSChE 2017 -- 24 October 2017
CN Corridor Risk Assessment - Background

• Launched August 2013 as a proactive CN initiative in the wake of the Lac-Mégantic incident:
  - Transport Canada (TC) establishes emergency order to conduct ‘key route’ assessments in 2014, finalizes regulation in 2015.
  - TC risk assessment requirements closely mirror CN’s model and methodology.
  - TC regulation does not describe ‘how’ to conduct the assessment

• CN internal process used to assess numerous risk drivers along a given rail corridor:
  - Existing models inadequate to analyze CN network.
  - Analysis of both discrete and overall risks required.
  - Risk mitigation strategies identified and implemented following completion of the assessment.
• What is a ‘key route’?
  ➢ Any rail line segment handling more than 10,000 carloads of dangerous goods per year

• How many miles of ‘key route’ on CN in Canada?
  a) 1,000
  b) 6,000
  c) 9,000
  d) 12,000
CN Corridor Risk Assessment - Process

• Two stage process to undertake an assessment:
  ➢ Initial work:
    ▪ Collect information on the 28 elements of corridor characteristics and hazards as defined by TC.
    ▪ Establish initial calculations of risk and vulnerability.
  ➢ Team assessment working session:
    ▪ Utilize the team’s collective experience to review the initial findings, identify risk mitigations, propose plan to introduce technology or revised practices.

• Continued evolution of process and methods:
  ➢ Engaged Canadian Rail Research Lab (University of Alberta) in 2015 to enhance the risk calculation process.
  ➢ Application of new calculation methodology started August 2016.
• Detailed review of vulnerabilities and hazards:
  ➢ Example from mapping review – what we are trying to quantify:
CN Corridor Risk Assessment – Initial Phase

- Master inventory table (front-end) prepared to account for:
  - vulnerable features
  - infrastructure data
  - existing mitigating technologies developed to initiate the hazard, vulnerability and risk calculations.

- Portion of a sample vulnerability features table:

<table>
<thead>
<tr>
<th>Milepost</th>
<th>Significant Wetland or Waterway</th>
<th>Population 1000-10000</th>
<th>Population 10000-100000</th>
<th>Population 100000+</th>
<th>Adjacent Highway</th>
<th>Adjacent Railway</th>
<th>No. of Significant Bridge Structure</th>
<th>Yes/No</th>
<th>Usage (&quot;High&quot;, &quot;Medium&quot;, &quot;Low&quot; or &quot;Unknown&quot;)</th>
<th>Adjacent Parkland</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
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<td>2 Yes</td>
<td>Yes</td>
<td>Low</td>
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<td>Low</td>
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<td>7</td>
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<td>8</td>
<td>Yes</td>
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<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>9</td>
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<td>Yes</td>
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<td>Yes</td>
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</tbody>
</table>
CN Corridor Risk Assessment – Risk Valuation

• Hazard, vulnerability and risk calculated using a mathematical approach developed with Canadian Rail Research Lab:
  
  ➢ Hazard = likelihood for occurrence of derailment on a discrete mile segment:
    ▪ based on incident history, infrastructure, operating practices
  
  ➢ Vulnerability = valuation of exposure to physical elements
  
  ➢ Risk = Hazard x Vulnerability
CN Corridor Risk Assessment – Hazard Ranking

• Graphical representation of the hazard quantification methodology:

```
Characteristics of Operations  Prevention Systems in Place  Frequency of Derailment Cause
Characteristics of Infrastructure  Warning Systems in Place  Derailment Likelihood if Cause is Present
Characteristics of Environment

H_{R} = \sum_{i=1}^{11} (h_{i} \times (n_{i} \times f_{i})) + (n_{12} \times f_{12})
```
Multi-year data pool of accidents used to develop a potential for a derailment occurrence based on presence / absence of various factors:

- Risk factors that influence derailment:
  - Trains per day, speed, track alignment, rail weight/type, public crossings, geotechnical features.

- Mitigation (safety measure) factors:
  - Wayside inspection systems, hazard detectors, signal systems, inspection types / frequency.

- 12 most frequent derailment causes evaluated against these factors ("i" in hazard equation)

Interactive – vary the safety measures to assess impact on hazard (and ultimately risk) valuation
CN Corridor Risk Assessment – Vulnerability Ranking

• Detailed inventory used to generate weighted vulnerability quantification for three main categories:
  ➢ Public / workers:
    ▪ Populated areas, passenger stations, parks, schools, etc.
    ▪ Weight associated to usage levels.
  ➢ Environment:
    ▪ Waterways, parklands, other special features.
  ➢ Infrastructure:
    ▪ Roads, bridges, other railways, yard facilities, etc.

• Results normalized to a basis of 100
CN Corridor Risk Assessment – Risk Ranking

- Numerical risk quantification generates tabular and graphical (visual) data presentation that pinpoints areas that may require focused mitigation efforts to reduce risk.

- Portion of a sample risk ranking chart:
CN Corridor Risk Assessment – Team Review

- Risk assessment session where practices and risk features are reviewed and mitigations are proposed:
  - Multi-functional review with Transportation, Engineering, Mechanical and Environmental perspectives included
  - Issues of concern tabulated, mitigation strategies identified
  - Mitigation strategies ranked

<table>
<thead>
<tr>
<th>Sample Sub (Station A to Station E)</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issues of Concern</td>
<td></td>
</tr>
<tr>
<td>1. DG volume:</td>
<td></td>
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<tr>
<td>- Station A to Station E = 10,001 loads in 2015 (various products)</td>
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<tr>
<td>2. Major population centres:</td>
<td></td>
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<tr>
<td>- City C</td>
<td></td>
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<tr>
<td>3. Major water resources in the vicinity:</td>
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<tr>
<td>- Big R. crossing</td>
<td></td>
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<tr>
<td>- numerous small ponds / lakes / wetlands in select areas</td>
<td></td>
</tr>
<tr>
<td>4. Branchline track conditions east of Station D</td>
<td></td>
</tr>
<tr>
<td>Existing WIS Sites</td>
<td></td>
</tr>
<tr>
<td>1. Existing DED sites = 2</td>
<td></td>
</tr>
<tr>
<td>2. Existing WILD sites = nil</td>
<td></td>
</tr>
<tr>
<td>3. Existing WIS sites = 6</td>
<td></td>
</tr>
<tr>
<td>Detection Enhancement</td>
<td>1</td>
</tr>
<tr>
<td>1. Add One DED Mile x (west of Station E)</td>
<td></td>
</tr>
<tr>
<td>2. Add One WIS Mile y (east of City C)</td>
<td></td>
</tr>
<tr>
<td>Track/Structures Inspection Enhancement</td>
<td></td>
</tr>
<tr>
<td>1. Rail Flaw Detection - at least 10 inspections annually</td>
<td></td>
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<tr>
<td>2. Track Geometry - 1-2 track geometry passes each year</td>
<td></td>
</tr>
<tr>
<td>Emergency Response</td>
<td></td>
</tr>
<tr>
<td>1. Contractor in Station A (Static Liquids and low hazard gases)</td>
<td></td>
</tr>
<tr>
<td>2. Closest DGO in Station D</td>
<td></td>
</tr>
<tr>
<td>3. Industrial fire teams deployed from Station B</td>
<td></td>
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<tr>
<td>4. Foam availability - CN Station A, other carrier Station E</td>
<td></td>
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<tr>
<td>5. High hazard transfer equipment must come from US</td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>1</td>
</tr>
<tr>
<td>1. Equipment Caches: Existing at Station A (53' trailer); Station D (20' container)</td>
<td></td>
</tr>
<tr>
<td>2. E2MS mapping; complete</td>
<td></td>
</tr>
<tr>
<td>3. Contractor coverage being reviewed</td>
<td></td>
</tr>
</tbody>
</table>
CN Corridor Risk Assessment – Implementation

• Projects prioritized over a multi-year time horizon.
• Continuous project tracking by Safety Leadership Team:
  ✓ proposal stage
  ✓ approval with regional management
  ✓ procurement
  ✓ installation
  ✓ commissioning
• Investments staged as the various CN corridor risk assessments are renewed on the mandated 3-year cycle.
CN Corridor Risk Assessment – Results

• CN’s corridor risk assessment process has proven to be highly valuable:
  ✓ **High resolution:** assessment is discrete and location-specific
  ✓ **Comprehensive:** assessment considers numerous risk drivers
  ✓ **Mathematical basis:** linear risk valuation based on practice used in other high risk industrial activities
  ✓ **Current:** connected with current traffic, municipalities and environment
  ✓ **Accountable:** recognizes strengths and opportunities of current risk mitigations
  ✓ **Pinpointed:** allow for specific risk reduction actions
  ✓ **Proactive:** mitigate risk before it becomes a serious challenge
CN Corridor Risk Assessment – Moving Forward

• Continuous improvement of the mathematical modeling for risk valuation:
  - Paper has been submitted for journal publication (Case Studies on Transport Policy) regarding the hazard calculation methodology for peer review.
  - Next step – integration with a corporate level risk management system.

• Opportunity to introduce new technologies to help mitigate risk as corridor characteristics change:
  - Assessment team has been challenged to consider new technologies as part of the review process.
  - Continued interaction with University of Alberta / Canadian Rail Research Laboratory.