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Hazard ranking for railway transport of dangerous goods in Canada

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ABSTRACT

Transport Canada mandated in 2014 that Canadian railways conduct risk assessments for the transport of dangerous goods along corridors considered critical based on the type and quantities of dangerous goods transported (key routes). This regulation resulted from the public concern associated with recent rail incidents involving the release of dangerous goods and the increased amount of oil moving by rail. Part of a risk assessment involves the analysis and assessment of hazards, which allows the development of hazard management strategies and assessment of the resources required to mitigate them where necessary. This paper presents a hazard ranking tool for railway corridors that transport dangerous goods. This tool ranks hazard levels associated with the most common derailment causes and crossing accidents, recorded in Canada, based on train frequency, speed, track characteristics, the allocation of safety strategies, among other factors. The tool was reviewed by personnel of Canadian National Railway for relevancy and applicability to a Canadian Class I rail operation. This paper includes a detailed methodology and tables developed for the assignment of values to the hazard rankings. Two examples of the application of this tool to real track conditions are presented.

1. Introduction

The Canadian railway industry is vital for the Canadian economy, providing access to international markets and moving more than 70% of all intercity surface goods each year (RAC, 2011). The increased use of technology and safety management systems has allowed the industry to reduce the number of derailments and accidents despite large increases in the amount of goods being transported by rail (Leishman, 2016). The efforts of the industry to reduce all derailments has allowed for a 50% increase in the transportation of dangerous goods by rail without a corresponding increase in the number of derailments involving dangerous goods. (CAPP, 2014; Statistics Canada 2015; TSB 2008, 2015b).

Recent railway incidents involving the release of dangerous goods have shown the potential consequences of these events. This has resulted in public concern and an increased sensitivity to the risks of the transportation of dangerous goods by rail. (New regulations were implemented in 2014 and updated in 2015, requiring formal risk assessments to be conducted on railway corridors used to transport high-risk dangerous goods (with the potential of causing serious injuries due to inhalation) or large quantities (10 000 cars or more) of other dangerous goods (Minister of Transport, 2015).

There are risk analysis tools that have been developed for the railway industry. The Rail Corridor Risk Management System (RCRMS, www.railroadresearch.org) is currently used in the United States. The RCRMS is not applicable for Canadian railway operators as it compares the risk rankings of different route options, and in Canada there is rarely more than one route option. Other models have been developed at the University of Illinois (Kawprasert and Barkan 2009; Liu et al., 2011, 2013), and the Safety Risk Model (SRM) available from the Rail Safety and Standards Board (RSSB) in Great Britain (Muttram, 2002). These models are comprehensive and quantitative approaches that provide precedence for this application, but they do not reflect the characteristics of Canadian railway operations.

This paper presents a hazard ranking tool for Canadian railway corridors that transport dangerous goods that has been specifically developed for the operations, conditions, and characteristics of a Class I railway. The paper outlines the methods with examples of the tables used by the tool, with full disclosure of tables presented as Supplementary material to this paper. The tool takes on the authors' experience with other risk calculation methodologies used by other linear infrastructure operations (pipelines, highways) to tailor a methodology suited for a railway environment. The tool has been calibrated against a publicly available database of derailments and crossing

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accidents (TSB, 2015a, and Transport Canada: https://www.tc.gc.ca). The tool addresses the hazard component of the requirements of the risk assessment regulations for routes transporting dangerous goods, which specifies consideration of train speeds and frequencies, track gradients and curvature, rail types, safety strategies in place, among others (Minister of Transport, 2015). The tool provides a ranking of the hazard levels across the corridors analysed that will allow a Canadian railway to undertake assessment and decision-making regarding hazard control and mitigation requirements. The hazard ranking tool presented here further allows for evaluating of alternative mitigation strategies, with the flexibility for future implementation of a quantitative assessment.

2. Development of the hazard ranking tool

Risk is commonly understood as the combination of the magnitude and likelihood of potentially harmful events (hazard), and the severity of their consequences. In this context risk is estimated as the product of hazard and consequences:

$$Risk = Hazard \times Consequences \quad (1)$$

The tool developed here addresses the first component of this equation, the hazard component.

2.1. Conceptual model and considerations

This hazard ranking tool focuses on transportation operations and excludes yard operations and loading/unloading facilities. The tool also focuses on the potential for derailment occurrences and crossing accidents, which corresponds to the statistical database of train accidents involving dangerous goods. Between 2004 and 2013, over 70% of accidents involving dangerous goods on Class 1 railways (classification threshold based on operating revenue – over CAD 346.8 Million as of 2006) were derailments (main and non main-track) and crossing accidents, and 24% were attributed to collisions on non-main track (TSB, 2014). Non main-track includes customer tracks and yards, and according to the TSB (2015b), non main-track accidents are typically considered minor, occurring at speeds lower than 16 km/h. Considering that only 2% of accidents involving dangerous goods lead to a release of the product and that the tool focuses on routes transporting dangerous goods, we considered adequate to address only the potential for derailments and crossing accidents for hazard ranking purposes. The experience of Class 1 operators in Canada supported this conclusion. The development of the hazard ranking tool needed to balance a comprehensive treatment of hazard sources and the factors that affect the likelihood of these hazards with the flexibility required for it to be practical and applicable to differing track conditions on the Canadian network.

The conceptual model for the hazard ranking tool is shown in Fig. 1. This model is applicable for each derailment cause considered and for crossing accidents. The general process for developing the hazard ranking following the model in Fig. 1 considers the characteristics of railway operations, infrastructure and the environment along the corridor, as well as the safety systems in place, and how these influence the frequency of derailment causes and the likelihood of derailment occurrences. Derailment causes are then ranked based on their frequency and the likelihood of derailment given the cause is present. The hazard ranking tool divides the corridor into a unit length, this length then defines the resolution of the resulting hazard ranking. The unit length can be set as a fraction or a multiple of a kilometre or mile, this length can be chosen based on the resolution of the available information and the level of detail required. However, this length must be constant when comparing the hazard levels along the length of a corridor, or between multiple corridors. The details of the relative ranking equations and input values calibrated for a railway network are presented in following sections.

Table 1
Derailment causes considered and crossing accidents.

Code	Derailment Cause
C1	Equipment: Axle
C2	Equipment: Brakes
C3	Equipment: Draft System
C4	Equipment: Superstructure and Truck
C5	Equipment: Wheels
C6	Track: Geometry
C7	Track: Rail
C8	Track: Turnouts
C9	Track: Obstructions
C10	Ground hazards (including water and ice)
C11	Actions: non-deliberate
Others	
C12	Crossing accidents

2.2. Accident causes and factors

The accident causes (derailment causes and crossing accidents) considered within the hazard ranking are presented in Table 1. Table 1 is not a complete list of the accident causes that have been identified by the TSB, but these causes account for 96% of the primary causes of non-yard derailments between 2004 and 2014 (TSB 2008, 2015b) and were identified as priority. These causes are not listed in any specific order.

The term ‘ground hazards’ (C10, Table 1) has replaced ‘environmental’ from the TSB causes as it is more inclusive of the environmental conditions and ground-related phenomena (landslides, subgrade failures, washouts, snow avalanches, etc.). The specific ground hazards included in this cause are:

- Settlements in soft clay
- Settlements in muskeg
- Flooding
- Culvert failure
- Landslide
- Steep slope cut instability (including potential ice falls)
- Debris flow
- Avalanche area

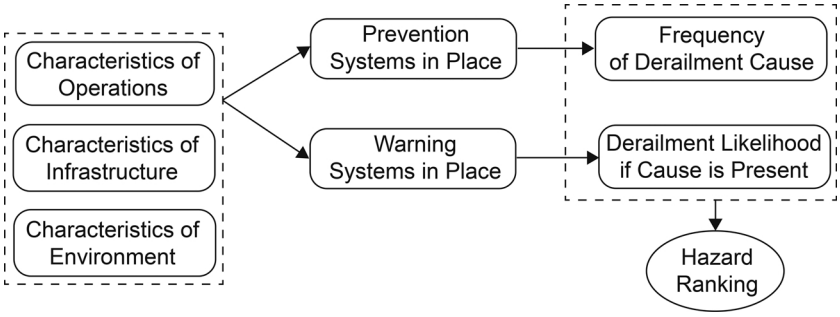

Fig. 1. Conceptual model for the hazard ranking tool.