# SUITABILITY AND LIMITATIONS OF USING AN OPEN SOURCE VIDEO DATA APPROACH TO UNDERSTAND HAZARDOUS GOODS MOVEMENT BY RAIL

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## 1 Introduction

The safe and secure transportation of dangerous goods throughout Canada has faced increased scrutiny in recent years, due to the increase in dangerous goods being transported by rail and several high profile derailments. Following the Lac Mégantic tragedy in July 2013, Transport Canada issued Protective Direction (PD) 32, which has since been replaced by PD 36, to facilitate the sharing of rail cargo data between railway companies and emergency organizations within communities. The reports provided by the railway companies have the data aggregated on a quarterly level, which makes it difficult to determine any shorter term trends in the movement of dangerous goods. The results from a survey of select emergency officials in New Brunswick indicated that there was general satisfaction with the current reports they are receiving through PD36, although there was a desire for more detailed data to be presented on a lower level of aggregation (Hanson & McPhee, 2016). This paper presents the results of a study to determine the suitability and limitations of using a digital video camera to understand the movement of hazardous goods by rail through a municipality within New Brunswick.

## 2 Background

The number of carloadings of dangerous goods transported by rail have been on a general increase in Canada, increasing from 406,425 in 2006, to 491,802 in 2015, with a noticeable spike of 576,226 in 2014 (Railway Association of Canada, 2016). Similar trends have also been observed in the United States, with 9,000 carloadings of crude oil originated by Class 1 railroads in 2008, increasing to 493,146 in 2014 (Association of American Railroads, 2015). The variability in the volume of dangerous goods being shipped by rail throughout North America can lead to changes in risk, and the challenge is that current data sources represent a lagging indicator on the movement of dangerous goods through communities.

Presently, emergency organizations are reliant on railway companies to provide data which are lagging at varying frequencies. The two primary sources of data currently available to emergency organizations in Canada are aggregated reports from railways through PD36 and a smartphone application called “AskRail”. Emergency officials registered with the Canadian Transport Emergency Centre (CANUTEC) have access to the confidential dangerous goods reports made available through PD 36. PD36 requires Class 1 railways to provide reports to emergency organizations, incrementally increasing from one report in 2016, two in 2017, three in 2018, to four reports in 2019, summarized by type and volume of dangerous goods transported through their community, with volumes aggregated quarterly (Transport Canada, 2016). Class 1 railways are also required to provide select information regarding dangerous goods movement through each province in which they operate, available on their website. Class 3 railways, along with any other person who transports dangerous goods by railway car, are only required to provide an annual report aggregated annually, with no additional data required to be released (Transport Canada, 2016).

The Canadian Association of Fire Chiefs has recently partnered with railway companies to promote the AskRail application which is available to qualified first responders with proper training (Canadian Association of Fire Chiefs, 2016). AskRail currently only represents Class 1 railways in North America, and can provide single-car data, as well as data for the entire train, that can be provided to first responders if the conductor or train consist is not readily available. This query based application allows the users to search for individual railcar container codes to determine whether it is loaded with dangerous goods (Association of American Railroads, 2015). Despite these data being available in real-time, it does not appear to allow for historical data to be retrieved by the users to determine daily or weekly trends in rail activity or variation in cargoes.

The ubiquity of the use of video technology in transportation monitoring applications raises questions about the potential for use in real-time monitoring of hazardous goods by rail to fill a gap between data from AskRail and reports through PD36. A week-long pilot study by Hanson (Hanson, 2014) found that it was possible to transcribe information from digital video on the time of day of the train crossing, direction of travel, type of rail car, and whether a dangerous goods placard was present, though this was too short a timeframe to make conclusions regarding suitability and limitations of the method.

## 3 Study methodology

This study explored the use of using off-the-shelf video camera technology to monitor the movements of a Class 1 railway through a community in New Brunswick to support local emergency organizations with an enhanced source of data regarding the movement of dangerous goods by rail through their community. The camera was installed on municipal infrastructure in Sussex, New Brunswick, where access to electricity and internet were provided. The motion-activated camera collected video of all train activity 24-hours a day, from July 1, 2016, until January of 2017. The first three months of the collected video data were transcribed for analysis to obtain the information posted on the side of passing rail cars, which included container code, weight limits, and placard, as well as date, time of day and direction (Figure 1).

**Figure 1 Cargo text, tank car type, and dangerous goods placard legible from the side of passing tank car**

## 4. Results

A total of 199 trains were observed within the three-month study period, which included 17,864 rail cars. The video camera was able to collect video of trains at a sufficient quality to transcribe the vast majority of the information posted on the side of the observed rail cars. The container code and weight limits were legible 94% and 87% of the time, respectively, whereas dangerous goods placards were identifiable 99.97% of the time. “Secondary source” refers to relying on cargo information text posted on the side of a rail car, or from a previously transcribed rail car being referenced, to identify a dangerous good placard.

**Table 1 Effectiveness of the transcription process from the collected train video**

| | Count | Labeled Dangerous good | | Other | |
|---|---|---|---|---|---|
| | | Day | Night | Day | Night |
| Total railcars observed | 17,864 | 10,274 | 62 | 6,432 | 1,096 |
| Container code legible | 16,832 | 10,273 | 62 | 6,254 | 243 |
| Weight limits legible | 15,845 | 10,236 | 62 | 5,531 | 16 |
| Dangerous goods confirmed by placard | 10,313 | 10,251 | 62 | - | - |
| Dangerous goods confirmed by secondary source | 23 | 23 | 0 | - | - |
| Dangerous goods unconfirmed | 3 | 3 | 0 | - | - |
| Maintenance Vehicles | 62 | - | - | 48 | 14 |

Manually transcribing the video data required considerable time. Approximately 280 person-hours were required to transcribe the three months of video data collected (Table 2).

**Table 2 Level of effort required for video transcription process**

| | Value | Units |
|---|---|---|
| Total files | 267 | files |
| Total hours of video | 13:47:12 | (hr/min/sec) |
| Video transcription rate (approx.) | 20 | min/min of video |
| Estimated person-hours | 280 | hours |

There were 11 types of rail cars observed to travel through the subdivision. Tank cars were the most frequently observed rail car, accounting for 62.1% of the total observed rail cars (Table 3).

**Table 3 Total of rail cars observed during study period**

| Car Type | July | August | September | Total | % |
|---|---|---|---|---|---|
| Tanker | 3,545 | 3,709 | 3,839 | 11,093 | 62.1% |
| Hopper | 1,019 | 98 | 689 | 1806 | 10.1% |
| Gondola | 624 | 564 | 509 | 1697 | 9.5% |
| Box car | 413 | 514 | 465 | 1392 | 7.8% |
| Flatbed intermodal | 339 | 302 | 349 | 990 | 5.5% |
| All others (incl. locomotive) | 260 | 338 | 288 | 886 | 4.9% |
| **Total** | **6200** | **5525** | **6139** | **17864** | **100%** |

A total of 10,339 dangerous goods placards were identified over the three-month study. Carloadings identified as transporting petroleum crude oil and Liquefied Petroleum Gas (LPG) accounted for nearly 80% of the total dangerous goods cars observed, with crude oil accounting for nearly half (47.6%) and LPG accounting for 30.0%.

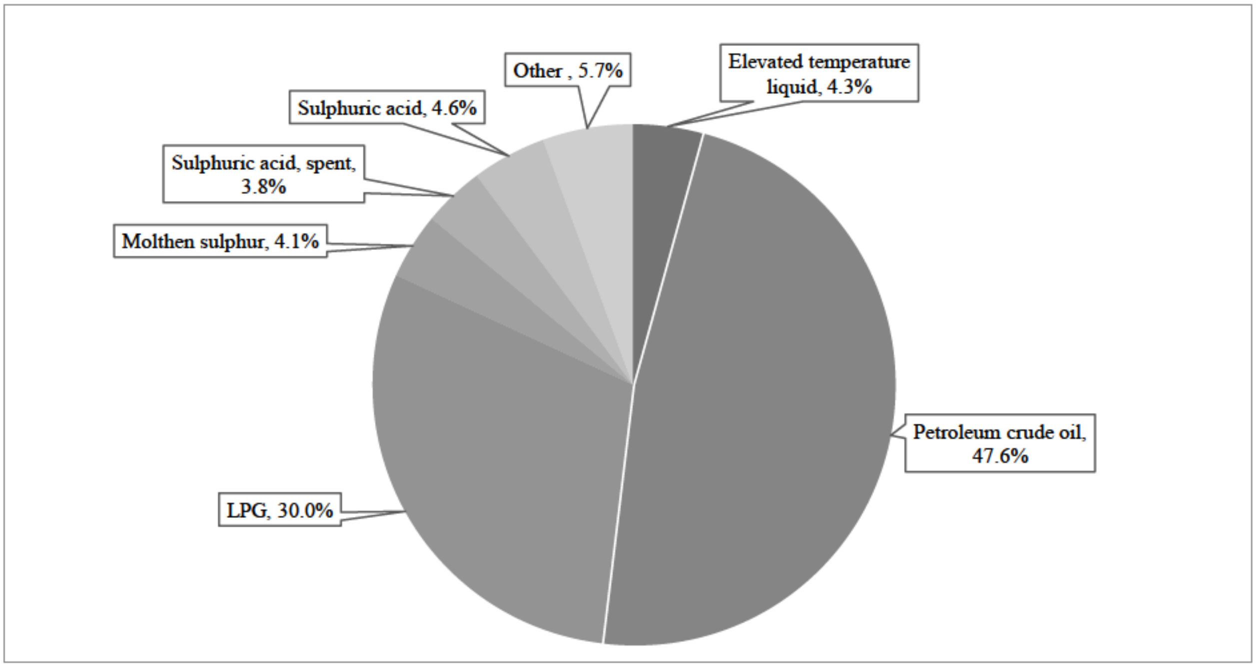

**Figure 2 Proportion of dangerous goods placards observed over study period**

Possessing data on individual rail car type and movements allowed for the data to be aggregated at varying levels, including monthly, weekly, and daily, as well on a per train basis. The monthly carloadings totals identified as transporting dangerous goods were within the similar magnitudes throughout the study (Table 4).

**Table 4 Summary of dangerous goods placards observed over study period**

| Dangerous goods type | July | August | September | Total |
|---|---|---|---|---|
| Petroleum crude oil | 1,601 | 1,666 | 1,650 | 4,917 |
| LPG | 992 | 895 | 1,209 | 3,096 |
| Sulphuric acid | 91 | 218 | 167 | 476 |
| Elevated temperature liquid | 194 | 112 | 136 | 442 |
| Molten sulphur | 132 | 164 | 126 | 422 |
| Sulphuric acid, spent | 112 | 164 | 116 | 392 |
| Others | 169 | 199 | 223 | 591 |
| **Total** | **3,291** | **3,418** | **3,627** | **10,336** |

Examining the data at a weekly level of aggregation, the identified dangerous goods carloading totals appeared to have greater variability than compared to the monthly totals, especially for crude oil and LPG carloadings (Figure 3).

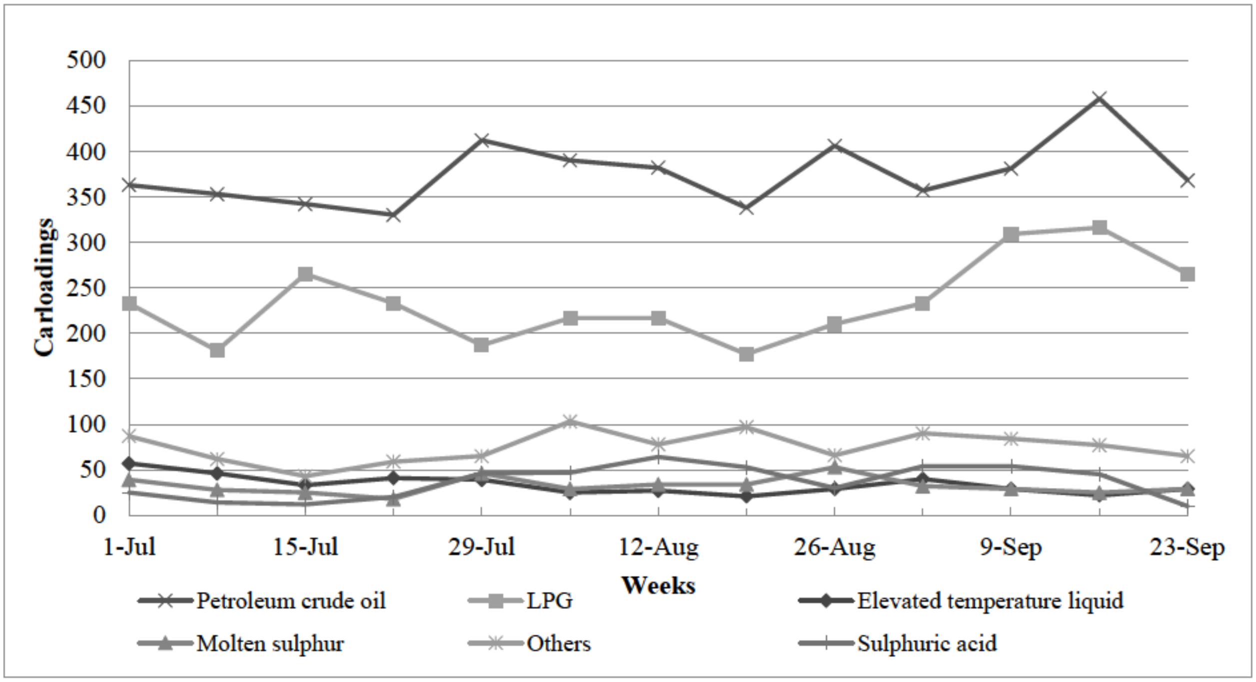

**Figure 3 Weekly observed carloadings of dangerous goods**

Daily levels of aggregation had the greatest variability in the carloadings of dangerous goods transported between days, with July 2016 shown (Figure 4).

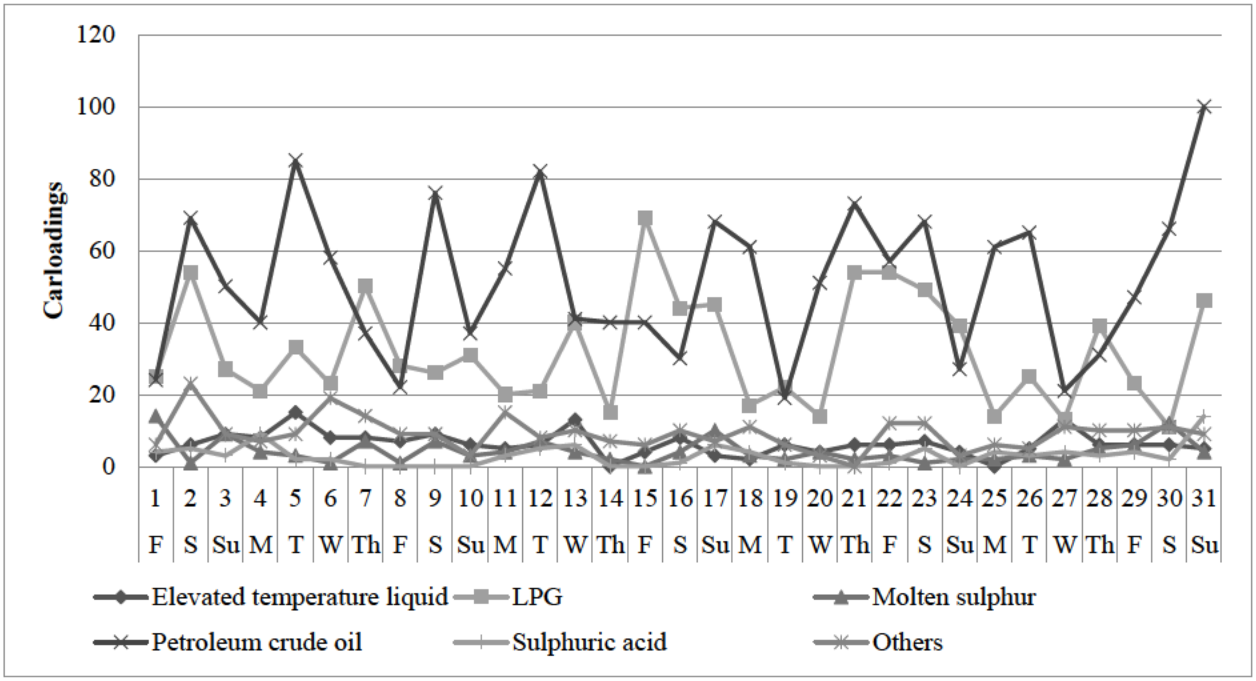

**Figure 4 Daily observed carloadings of dangerous goods for July**

It was also possible to organize the observed carload data by time of day and direction (Figure 5). Dangerous goods were most often observed at 2:30 pm (westbound) and 7:00 pm (eastbound), with a spread of arrival times approximating a normal distribution in each direction.

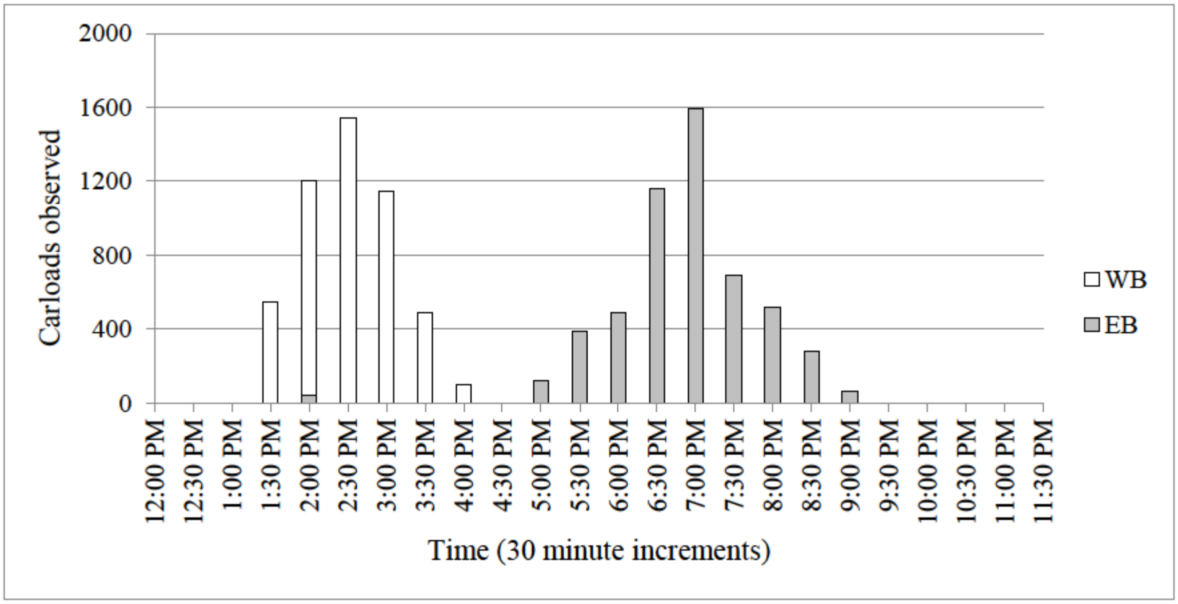

**Figure 5 Direction of dangerous goods carloads observed by time of day**

The frequencies of the observed train lengths were examined, and plotted in a histogram as seen in Figure 6. The figure resembles a bimodal distribution, as there are two distinct peaks in the train lengths. The two train length bins with the most frequent number of trains are between [70,75] and [105,110].

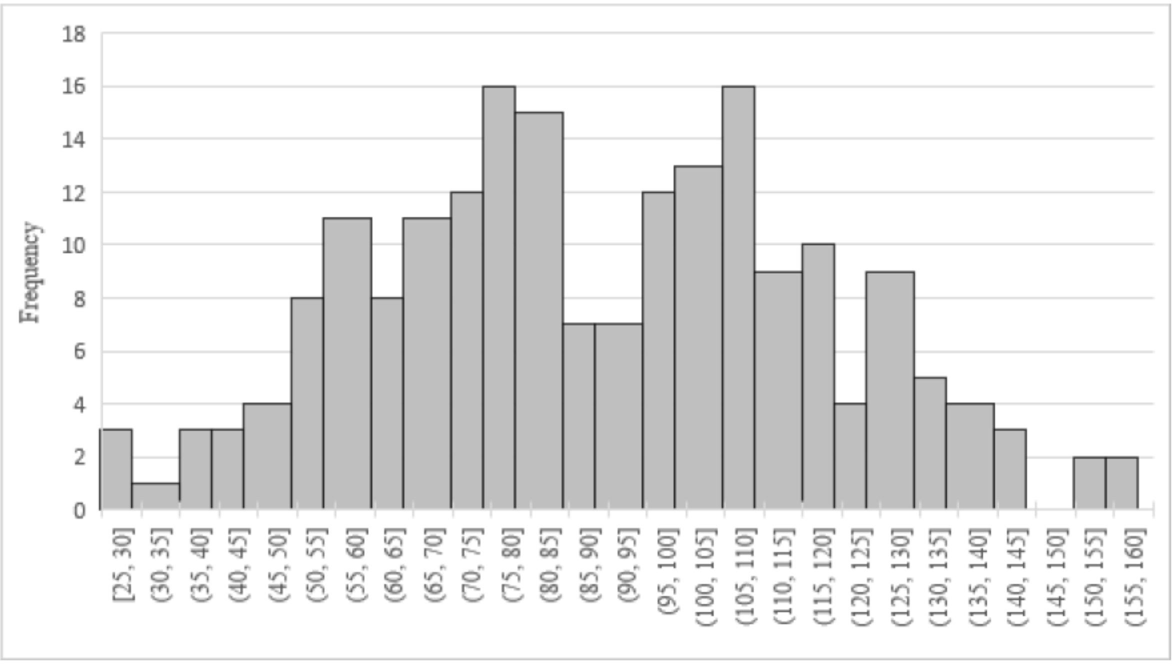

**Figure 6 Frequency of train lengths observed (bin ranges of 5 cars)**

## 5 Discussion of suitability and limitations

The data transcribed through the use of video provided an enhanced level of detail on the movement of rail cars through the observed rail subdivision when compared to existing sources, in particular for time of day, direction, daily, weekly and monthly totals. Rail cars with dangerous good placards were observed 10,339 times, with only three placards to be unidentifiable during the transcription process. It is not possible to determine whether a car is empty or full, though it may be possible to infer this from its location within the consist and the direction of travel (e.g. crude oil cars would likely be full travelling in the direction of the refinery).

The video camera was found to collect sufficient quality of video to allow each rail car’s container code and weight limits to be transcribed 94% and 87% of the time, respectively during the three months of observation. This could permit an inventory of rail car attributes to be maintained and queried if a system were developed to monitor movements. Weight limits could be useful in quantifying risk, in particular in looking at accidents per Gross Ton Mile, with upper and lower bounds on estimates determined from values of car capacities and tare weights. The observed frequency distributions of arrival times and train lengths could be useful for modelling the probability side of the risk equation, and the detailed inventory of cars and estimated contents could be useful for understanding consequence.

The main factors influencing the lack of legibility included car-based issues (e.g. obscured by graffiti/dirt) and camera location issue (e.g. 3.3 m elevation of camera made some numbers difficult to identify if located on lower part of rail car). The location of the camera, within a lighted area of municipal infrastructure, meant that rail cars could be observed at night. The time period of observation that was transcribed (July – September) would not have permitted evaluation of the method during inclement winter weather, though non-transcribed video data exist for October through December. Manual transcription was estimated to take 2.5 weeks per month (36.25 hours per work week) for two trains per day as observed; this makes manual transcription unrealistic for busier lines and nearly a full-time job if it were continued at the line under study. Automating this transcription though video processing is the next step.

The most appropriate use of these data seems to be for longer term emergency planning and preparedness, as well as for risk assessment, filling in a data gap between AskRail and carrier reports. A video-based system that would provide real-time updates on train movements to emergency officials remains a possibility, but would be contingent on being able to process the data with minimal error and still may need human oversight. Introducing a historical and temporal analysis component to AskRail would be preferable to the video data option since it is sourced directly from the railways. Since Class 3 railways do not participate in AskRail, there would still be value in using the video data approach for more timely Class 3 cargo data for emergency officials in those communities.

## 6 Conclusions

This paper details the results of a three-month study of mainline train movements in a New Brunswick community to determine suitability and limitations of using digital video for monitoring hazardous goods movement by rail. Movements were monitored 24 hours a day by a motion-detecting camera mounted on a municipal structure, resulting in nearly 14 hours of video. Each train movement was date and time stamped, and all identifying text manually transcribed taking approximately 20 minutes for every minute of video. A total of 17,864 railcars were observed; 94% had legible container codes, 89% had legible weight limits, 58% had dangerous goods placards. Three hazardous goods railcars could not be identified. The average train contained over 50% hazardous goods by labelled carload, had normally distributed arrival times, and bi-modal distribution of train lengths. The laden status of cars could only be inferred by train direction, though knowledge of car capacities permits an estimation of upper bounds of commodity values. While there have been considerable advancements in data sharing practices since the Lac-Mégantic disaster, there are still opportunities to enhance the resolution of train movement data for emergency management. The rail data using this technology have the potential to be collected and transcribed on a more frequent basis compared to the current reporting from railways, and at an enhanced resolution of rail cargo data, especially dangerous goods movements. Future research could further explore the use of video camera technology on a Class 3 railway line where reporting requirements for communities are less stringent than Class 1 railways.

## 7 Acknowledgements

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