CAUSES OF ACCIDENTS AND MITIGATION STRATEGIES

Prepared for
Railway Safety Act Review Secretariat

by

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Causes of Accidents and Mitigation Strategies

submitted to

Railway Safety Act Review Secretariat

by

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EXECUTIVE SUMMARY

The objective of this project were to:

- examine the Canadian railway accidents and incidents where equipment or track safety performance was an issue,
- examine the effectiveness of the mitigation strategies currently in use by the railway industry to respond to these issues,
- assess the current legislative criteria intended to provide minimum requirements for providing safe train operations, and
- identify any weaknesses and recommend improvements.

Trends

The number of derailments in the TSB database that were not coded with safety concerns was the most notable trend — growing from less than 10% in 1999 to representing close to 50% of the mainline derailments by 2006. The database (in its present state) limits insight and conclusions that can be drawn.

In comparing CN and CPR derailment rates, CPR showed little change in its mainline derailment rate over the period 1999 to 2006. CN’s rate was close to CPR’s rate on a train-km basis in 1999 and escalated at a higher rate by 2006. On a car-km basis CN started at a lower derailment rate than CPR but escalated to a higher rate by 2006. CN had acquired some shortlines over the interval which could have affected its safety performance — since derailment rates are higher on lower density lines and lower track classes. CN also has a more significant north-south operation than CPR, and could have had a higher exposure to problematic wheels from U.S. railway interchange.

Risk involves both frequency of occurrence and severity of consequences. The only measure of severity readily available from the RODS database is the number of cars involved in the derailment. On a train-km basis, CN’s rate was higher than CPR’s for every year and on average 1.68 times higher than CPR’s rate. On a car-km basis, CN’s rate was lower than CPR’s rate in 2000, 2001 and 2003, but higher for other years; on average its rate was 1.32 times CPR’s rate. Excluding the year 1999, which might have been an anomalous year, CN’s average derailment rate was 1.4 times CPR’s rate on a train-km basis and 1.1 on a car-km basis.

We believe that Transport Canada should take a more active role in trend analysis and benchmarking of railway performance. We also believe that the focus of these analyses should be at the highest level of safety performance measurement — the derailment rate. Benchmarking and trend analysis is not only vital to conducting its role of safety oversight but would provide a value added task to the railways.

We believe that the present paper-form reporting process is inefficient and prone to transcription errors. We recommend that each railway set up a secure database which contains all of the required fields outlined in TSB’s reporting forms, that the database be...
automatically updated as information becomes available, and that TC and TSB both have online access to the database.

We also recommend that the databases include all previous records back to 1999, when the proportion of blank fields in the database began to increase. If the development of the online database can not be accomplished within two years, we recommend that the missing data over the time period since 1999 be collected by existing manual procedures, either by TSB or Transport Canada field personnel.

We understand the recent passing of Bill C11 gives Transport Canada a vehicle to define new data reporting requirements. We recommend that Rail Safety Directorate include in those regulations a requirement for direct access to railway accident data that are reported to TSB and authority to follow up on any deficiencies in those data.

There are two data components required to assess derailment rates. The first is the safety deficiencies (or causes) of the derailment, and the second is the exposure or activity levels (train-miles and car-miles). Our analysis indicates there might be differences in both these areas. In cause assessment, CN and CPR might be assessing braking-related derailments differently. In activity levels, we were unable to determine if articulated five-pack container cars are counted as five cars or as one car, or if road switching trains were included in mainline train-mile aggregation or as yard switching activity. If Transport Canada does not already have the power within its scope of activities in auditing railway safety management systems, it should also make the necessary changes to include the following items, which are critical to accurate benchmarking:

- the guidelines used to assess safety deficiencies (or accident causes) and the actual conduct in practice at railway derailment investigations,
- the basis and consistency across railroads of activity-based data (car-miles and train-miles).

The above actions would provide a consistent set of data for trend analysis and benchmarking. However, research is required to develop accurate measures of performance, both for trend analysis and railway benchmarking. It is important to factor known environmental and operational influences into any trend or benchmarking analysis. These factors and other known influences need to be developed with a completed accident database and in a rigorous statistical process. We recommend that Transport Canada undertake or fund the research necessary to support an ongoing rigorous trend-and-benchmarking analysis of railway safety performance.

Mitigating Strategies
We believe the knowledge exists within the railway industry to develop strategies to mitigate safety concerns once they are identified. It is not clear that the industry has uniform ability to recognize at an early stage when safety concerns arise. We believe the TSB makes a value added contribution in identifying safety concerns through its investigation of selected derailments. We believe that Transport Canada could play an
important value added role through expanded research and an ongoing analysis of trends and benchmarking of railway safety performance.

Legislation
From the scope of work involved in this assignment, there are no other changes required to the Act itself. Desirable changes can be made in the regulations, and the industry and Transport Canada are progressing the regulations where needed. Changes to the Track Safety Rules (TSR) require the most attention.

It is beyond the scope/time-constraints of this exercise to make specific recommendations within the TSR. However, we believe that the TSR at the time of writing does detract from safety by forcing resources to be allocated to legally defined requirements, some of which, with present wording, have very little safety relevance; thereby leaving fewer resources to address safety concerns. We recommend that the required research and managerial resources be allocated to support the TSR change process.

In terms of overall approach to the TSR change process, we believe that where more prescriptive wording is used, care should be taken to ensure that the item being described does indeed represent a ‘safety minimum’ condition, and also permit scope to revise that definition as future knowledge/research warrants. Where performance measures are used, care should be taken to ensure that they reflect actual safety performance, are measurable and enforceable-or-punishable in a timely manner.

Whether a specific clause involves a prescriptive or performance related measure, the wording should recognize the risk attributes associated with the track location, including:

- overall traffic levels,
- volumes of specific classes of DGs carried on the line, and potential exposure to human or sensitive environmental areas, if a DG release occurs,
- proportion of passenger trains on the line,
- train operational characteristics (peak tractive effort, axle loads and speed variation),
- use of jointed rail or continuous welded rail,
- grade and curve severity, and
- maximum train speed.
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1 Introduction

1.1 Background
The Railway Safety Act, which came into effect in January 1989, was designed to advance rail safety in Canada by giving the Minister of Transport responsibility for rail safety regulation; providing a modern regulatory framework, together with a streamlined regulation development and approval process; and providing railway companies with greater freedom to manage their operations safely and efficiently.

Since 2002, there has been an increase in railway accidents and main-track train derailments in Canada. In addition, Transport Canada officials have identified deficiencies with the Act during their day-to-day administration of legislative provisions.

There is a view that the current regulatory framework does not provide the full set of tools to effectively deal with them. There is also a view that the current framework needs to be modernized and better aligned with safety legislation in place for other modes of transport in Canada.

Accordingly, in December 2006, the government announced the Railway Safety Act Review to further improve railway safety in Canada and promote a safety culture within the railway industry while preserving and strengthening the vital role this industry plays in the Canadian economy.

A four-member Railway Safety Act Advisory Panel (RSA Panel) was appointed by the Minister of Transport, Infrastructure and Communities to conduct independent study and analysis, undertake consultations, and prepare a report with findings and recommendations.

In support of the RSA Panel, various background studies and research were undertaken to help inform and provide them with additional information and analysis related to specific topics. This project, as the title implies deals with equipment and track safety performance.

1.2 Objectives
The objectives of the project were to:

- examine the Canadian railway accidents and incidents where equipment or track safety performance was an issue,
- examine the effectiveness of the mitigation strategies currently in use by the railway industry to respond to these issues,
- assess the current legislative criteria intended to provide minimum requirements for providing safe train operations, and
- identify any weaknesses and recommend improvements.

1.3 Report Layout
This report is presented in five chapters.
Chapter 2 assesses recent derailment trends and benchmarks the performance of the Canadian Class 1 railways.

Chapter 3 assesses the factors involved in mainline derailments and the strategies employed to mitigate those derailments.

Chapter 4 assesses the role of the Railway Safety Act and the regulations in place that address railway safety performance.

Chapter 5 presents the observations and recommendations resulting from this review.

2 Recent Trends in Railway Accidents

In this chapter we first discuss the basis of our approach to measuring trends, then look at the trends in mainline derailments and benchmarks the performance of the Canadian Class 1 railways, and finally discuss some factors that we believe Transport Canada should consider in its future assessments of safety performance trends and benchmarking.

2.1 Basis of Trend Measurement

2.1.1 Class-1 Railways Mainline Derailments

The TSB data structure and the Canadian accident reporting criteria limit the ability to answer some of the questions raised in the scope of work. The segmentation of shortline accident history is problematic because provincial railways are not required to report accidents to TSB. Also the transition to shortlines from Class 1 railways involves periods where they did report as part of a Class 1 to periods where they did not have to report as a provincial shortline.

Class 1 railways have a consistent reporting infrastructure for both derailments and operations activity and are thus selected for the trend and benchmarking comparisons made in this report. The criteria for reporting accidents in Canada leads to more low-consequence accidents being reported here than are reported in the U.S. under FRA reporting criteria. Due to the different reporting criteria and the different operating environments involved in the two countries, it was not possible to make a meaningful comparison of U.S. and Canadian railways safety performance. Thus the only comparisons made are between CN and CPR.

The derailment data are based on derailments occurring on CN or CP owned tracks and excluding VIA rail trains. There are some locations where CN and CP share tracks with each other or with other railroads. Thus, there are a few derailment records that involved non-CN freight trains on CN track that are only counted once as a CN derailment (and similarly non-CP trains on CP track that are counted as a CP derailment).

Railroad accidents involve either derailments or collisions. Collisions are usually tied to human factors issues, which are the focus of another study. Also, the focus of this study is
on equipment and infrastructure, which are usually contributing factors in derailments rather than collisions. For these reasons derailments are the focus of our analysis. Derailments can occur in yards or on mainlines. While the frequency of derailments is high in yards, they are usually low-speed occurrences and involve low consequences. Our interest is high risk events, and thus our analysis is focused on mainline derailments.

2.1.2 Timeframe
The last five years was requested for a trend analysis, but we believe that is too short an interval to assess any trend. However, there are limitations to how far back one can go to assess trends. The RSA Came into Effect in 1989, but many shortlines were spun off by the Class 1 railways up to 1998. As discussed later in Subsection 2.3.3, lower speed classes of track and low density traffic were found to be explanatory variables for mainline derailments (MLD) [TranSys Research Ltd., 2007]. Thus, shortline spin offs would improve the Class-1s derailment rates. Therefore, the interval 1999 to 2006 was selected for most of the trend analysis.

2.1.3 Exposure Measure
In assessing trends or benchmarking railway performance, one must recognize that underlying activity levels can change over time. It is not the number of derailments that is of interest but the derailment rate, as measured by the number of derailments per unit of underlying activity.

In selecting units of underlying activity we considered train-miles, car-miles, Net-ton-miles (NTM) \(^1\), and gross-ton-miles (GTM) \(^2\). One could argue that the net-ton-mile measure is the most basic underlying activity and therefore would be the most appropriate derailment-exposure measure. The advantage of the tonnage based measures is they capture changes in productivity — an increase in axle loads or a reduction in car tare weight that would allow more product to be carried will result in a higher activity value than if one used car-miles as the activity measure. Since the derailment rate is the number of derailments divided by the exposure measure, the derailment rate would be reduced by these productivity gains.

If one wanted to assess the safety performance trends or benchmark different operators in hauling the same commodity, the tonnage based measures would be the best choice. However, there are problems with applying the tonnage-based activity measures to benchmarking railways that carry a range of products and to trend analysis of railways whose distribution of products carried changes over time. The measures could show trends or benchmarks that are unfairly interpreted as safety performance changes when the true change is simply the weight of the type of product being carried. For example, the growth in

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\(^1\) Net weight is the weight of the product being carried (or payload) and excludes the weight of the car it is carried in and the locomotives that haul it. Net ton miles is the sum over all movements of the tons of payload multiplied by the distance each was carried.

\(^2\) Gross ton miles includes the payload and the weight of the car used to carry the payload and the locomotives used to haul it, as well as the weight of the car when traveling empty.
containerized shipments of light-weight cargo and fall off of bulk commodity shipments would lead to lower NTM and GTM activity levels. If the same number of car-miles are generated and the number of derailments remain the same, derailment rates would increase on either a NTM or GTM basis but remain the same on a car-mile basis.

If one were interested in assessing the safety impacts of raising axle loads on coal cars, the GTM activity measure over an interval that covers a significant period of prior and post heavy-axle-load activity would be the preferred approach. However, our focus is overall trends in accident rates and benchmarking of performance. We did not want unknown changes in operating practices or axle loads or empty return levels to influence the safety measures. Therefore, we selected the basic car-mile and train-mile activity measures as the denominators in our derailment rate assessment.

In using car-mile and train-mile measures of activity one must recognize that a move to longer trains (or more cars per train) would result in a lower train-mile measure for constant car-mile activity, or an increase in car-miles for constant train-miles. We present most of the data using both car-mile and train-mile data.

### 2.2 Mainline Derailment Trends

#### 2.2.1 Total Derailments for Class 1 Railways

The overall trend in the number of mainline derailments for Class 1 railways is illustrated in Figure 1. Four types of derailments are shown – those related to an equipment component (Eq), those related to track components (trk), those with no safety factor available in the data (N.A.), and all other derailments with a non-track, non-equipment factor cited (other).

One can see that track and equipment factors are the largest categories of derailments where a safety factor is cited. The largest increase is in those derailments where no cause or safety action is cited (N.A.); which goes from 9 in 1999 to 65 in 2006. In percentage terms, they have gone form less than 10 percent to almost 50 percent of the data. As discussed in more detail later, in most cases these N.A. records have known causes but are not in the database. The missing data makes it very difficult to draw conclusions about trends and relationships in the various types of derailments that occur.

For our purposes, we have assumed that the proportion of equipment and track derailments where the data are completed is the same for the data that have not been completed. Figure 2 illustrates the distribution of derailment causal factors on average over the entire 7 year interval. Equipment-related is highest at 34% and track-related next at 29% (equal to non-coded causes). If one assumes the same distribution of coded derailments to exist for the non-coded derailments then equipment and track factors clearly dominate, accounting for 89% of mainline derailments (i.e. (34+29) / (34+29+8)).
Figure 1 Trend in Number of Derailments for Class 1 Railways

Figure 2 Average Distribution of Causal Factors Cited (1999-2006)
2.2.2 Class 1 Railways Safety Performance Benchmarking

The trend in the mainline derailment rate for CPR is illustrated in Figure 3 and for CN in Figure 4. Both figures follow the same formatting. The solid light-blue line with diagonal symbols is the number of derailments per million train-km which is the vertical axis shown on the left side of the chart. The light-blue dashed line is the straight-line trend associated with the data points. The solid blue line with X symbols is the number of derailments per billion car-km which is the vertical axis shown on the right side of the chart. The blue dashed line is the straight-line trend associated with the data points.

The data point for the last year (2006-est) is shown as an estimate, because the activity data were not available from Statistics Canada. The 2006 activity levels were assumed to be the same as 2005; an assumption which was based on the fact that the monthly carload data (which was available) showed very little change from 2005 to 2006.

Looking at the dashed trend lines for CPR, one can see that on a train-km basis over the period 1999 to 2006, the derailment rate increased from 0.9 to 1.1 derailments per million train-km. However, on a car-km basis the derailment rate rose slightly from just below 15 to just above 15 derailments per billion car-km.

Looking at the dashed trend lines for CN, one can see that on a train-km basis over the period 1999 to 2006, the derailment rate increased from 0.9 to 1.5 derailments per million train-km. On a car-km basis the derailment rate rose from 12 to 17 derailments per billion car-km.

In comparison, CN’s derailment rate was close to CPR’s on a train-km basis in 1999 but escalated with a higher rate. On a car-km basis CN started a lower derailment rate than CPR but escalated to a higher rate by 2006. The differences in car-km versus train-km trends for the two railways indicate that CPR was increasing its average train length over the period while CN was not. CN had already increased its train lengths in earlier years and had acquired some shortlines over the interval which could have affected its average train length.

The other influence of acquiring shortlines is that the derailment rate on lower density lines and lower track classes is higher. This aspect is discussed in more detail in the next subsection. At this point, we simply note that it is very difficult to make comparisons without having a data base with significant level of detail on both the occurrence side and the exposure side.
Recent Mainline Derailment Trends
(CPR)

Figure 3 CPR's Derailment Rate Trends

Recent Mainline Derailment Trends
(CN, Excluding VIA)

Figure 4 CN's Derailment Rate Trend
The trend in number of derailments does not give a complete picture of safety trends. Risk involves both frequency of occurrence and severity of consequences. The only measure of severity readily available from the RODS database is the number of cars involved in the derailment. While media exposure to derailments leaves impressions of major pileups of many cars, many reported derailments involve only one car or one axle of the car coming off the rails. The distribution of cars involved in derailments in Canadian data is presented in Table 1. One can see that close to 38% of derailments involve only one car, and 66% involve five or less.

Table 1: Distribution of Number of Cars Involved in Canadian Mainline Derailments

<table>
<thead>
<tr>
<th>No. of Cars Derailed</th>
<th>Proportion of Derailments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>37.9%</td>
</tr>
<tr>
<td>2</td>
<td>14.2%</td>
</tr>
<tr>
<td>3 – 5</td>
<td>15.3%</td>
</tr>
<tr>
<td>6 – 10</td>
<td>13.6%</td>
</tr>
<tr>
<td>11 – 20</td>
<td>12.0%</td>
</tr>
<tr>
<td>21 – 30</td>
<td>5.0%</td>
</tr>
<tr>
<td>31 – 40</td>
<td>1.4%</td>
</tr>
<tr>
<td>&gt;40</td>
<td>0.6%</td>
</tr>
</tbody>
</table>

To make a better comparison of safety performance we looked at the total number of cars derailed by each railway each year. This measure is closer to the risk involved if interpreted as the number of derailments (frequency) times the number of cars derailed in each derailment (consequences). The resulting derailment rates expressed as cars derailed per billion car-km traveled are shown for each railway in Figure 5. CN’s rates are shown in the bars on the left side of each year, while CPR’s are shown on the right bars. The dashed lines represent the non-linear trend lines. By this measure CPR has a lower derailment rate than CN but a higher rate of increase over the interval — CPR’s trend line goes from 60 to 90 cars derailed per billion car-km, while CN’s trend line goes from 80 to 100 cars derailed per billion car-km.

The ratios of CN to CPR car-derailment rates are presented in Figure 6. The left column presents the ratio based on train-km exposure while the right column presents the ratio based on car-km exposure. The two ratios are presented for each year and the average for the period is shown at the right of the chart (Avg). If the railways had equal derailment rates the ratio would be 1.0 as highlighted by the horizontal line across the chart. On a train-km basis, CN’s rate was higher than CPR’s for every year and on average 1.68 times higher than CPR’s rate. On a car-km basis, CN’s rate was lower than CPR’s rate in 2000, 2001 and 2003, but higher for other years; on average its rate was 1.32 times CPR’s rate.

It should be noted that the average rate is influenced by what might have been an anomalous year in 1999. The previous train-derailment figures (Figure 3 and Figure 4) indicated that the two railways had similar derailment rates in 1999, but as seen in Figure 5, CPR had a very low number of cars involved in its derailments that year, while CN had a large number of cars involved in its derailments that year. Excluding the year 1999, CN’s
average derailment rate for the remaining years is 1.4 times CPR’s rate on a train-km basis and 1.1 on a car-km basis.

![Mainline Freight Cars Derailed Trend](image)

**Figure 5 Benchmarking of Total Cars Derailed**

![Mainline Annual Freight Cars Derailed Ratio](image)

**Figure 6 Car-Derailment Rate Ratio**
2.3 Considerations in Future Safety Analyses

2.3.1 A More Active Role for Transport Canada
We believe that Transport Canada should be taking a more active role in trend analysis and benchmarking of railway performance. We also believe that the focus of these analyses should be at the highest level of safety performance measurement — the derailment rate. Benchmarking and trend analysis is not only vital to conducting its role of safety oversight but would provide a value added task to the railways.

The present TC focus on making component inspections reinforces the misconception that safety performance is tied to activities at lower levels in the organization. We believe safety performance needs to be measured at a higher level (i.e. derailment rate) and addressed at a higher level (i.e. management). However, research is required before rigorous trend analysis or benchmarking can be undertaken.

Addressing Data deficiencies
With close to 50% of the derailments resulting from uncoded safety concerns, the TSB database (in its present state) limits the insight and conclusions that can be drawn. We were told that the TSB’s RODS database is mostly comprised of data sent to them by the railways (that are required to report the accident to the TSB). There are some fields in the accident report that get updated for those investigations the TSB conducts, but this is only a small proportion of the database.

When the railways first submit the data, the cause is not always known. Each railway conducts its own assessment of the factors that contributed to the derailment and updates the internal data when the investigation is complete. The initial accident reports are submitted on paper and manually transcribed to the TSB database. The TSB is in the practice of having its field investigators contact the railways to fill in the missing fields. They indicated that staffing reductions since 1999 have led to an increasing problem of staying current with data.

We were told that Transport Canada encountered problems accessing safety data directly from the railways because legally the data need only be provided to TSB. While the TSB in turn makes the accident data available to TC, its focus is more on individual accident investigations rather than railway safety performance. Contacting the railways in person to get manual updates of data fields within the reporting forms is allocated a lower priority.

Transport Canada has the role of safety oversight and should have the data to support the safety analysis that is inherent to assessing the industry’s performance. We believe that railway derailments are the most basic of safety performance measures and that Transport Canada should be directly involved with access and verification of the data.

We believe that the present paper form reporting process is inefficient and prone to transcription errors. We recommend that each railway set up a secure database which contains all of the required fields outlined in TSB’s reporting forms, and that the database be
automatically updated as information becomes available and that TC and TSB both have online access to the database.

We also recommend that the databases include all previous records back to 1999, when the proportion of blank fields in the database began to increase. If the development of the online database can not be accomplished within two years, we recommend that the missing data over the time period since 1999 be collected by existing manual procedures, either by TSB or TC field personnel.

We understand the recent passing of Bill C11 gives Transport Canada a mechanism to define new data reporting requirements. We recommend that Rail Safety Directorate include in those regulations a requirement for direct access to railway accident data that are reported to TSB and the authority to follow up on any deficiencies in those data.

There are two data components required to assess derailment rates. The first is the safety deficiencies (or causes) of the derailment, and the second is the exposure or activity levels (train-miles and car-miles). Our analysis indicates there might be differences in both these areas. In cause assessment, CN and CPR might be assessing braking-related derailments differently. In activity levels, we were unable to determine if articulated five-pack container cars are counted as five cars or as one car, or if road switching trains were included in mainline train-mile aggregation or as yard switching activity. If Transport Canada does not already have the power within its scope of activities in auditing railway safety management systems, it should also make the necessary changes to include the following items, which are critical to accurate benchmarking:

- the guidelines used to assess safety deficiencies (or accident causes) and the actual conduct in practice at railway derailment investigations,
- the basis and consistency across railroads of activity-based data (car-miles and train-miles).

The above actions would provide a consistent set of data for trend analysis and benchmarking. However, research is required to develop accurate measures of performance, both for trend analysis and railway benchmarking. Environmental factors can play a significant role in trends and if not reflected in the data can lead to erroneous conclusions about safety performance and also the effectiveness of mitigating actions. Also, differences in railway operations and types of track can present one railway with a more demanding safety environment than another. It is important to reflect these factors in any benchmarking. Some examples of each are presented in the following subsections.

### 2.3.2 Environmental Factors

While the timeframe and scope of this assignment did not permit an in depth assessment of causal factors in derailments, the large variations in annual derailment rates were reviewed in a cursory way. The two largest contributors to derailments are wheel failures within the equipment category and rail failures within the track category. Together they are responsible for about 35% of the classified derailments. There is a seasonal influence in
both of these failure rates. As illustrated in Figure 7, the winter months (December through March) have a much higher proportion of the wheel and rail (W&R) derailments. As indicated in the figure, January has 2.6 times the average monthly number of W&R derailments while July has only 0.25 times the average. Figure 8 overlays an indication of the winter low temperature on the estimated W&R derailment rates for each year from 1996 to 2006.

**Figure 7 Seasonality of wheel and mainline rail derailments**

**Figure 8 Winter low temperature's influence on annual derailment rate**
The winter low temperature is the average reported low temperature for the interval January to March, plus December as reported for Saskatoon, SK and Geraldton, ON. The negative of the low temperature in degrees centigrade is shown on the right side axis. Thus, the lowest average winter low-temperature was in 1996 at -22.4°C, and the highest average winter low-temperature was in 2006 at -15°C.

The total estimated W&R derailment rates (number of derailments/billion car-km) are in a stacked bar format on the left side axis. The lower segment of the bars is the wheel derailment rate, the second segment is the rail derailment rate and the top bar is an allocation of 35% of the uncoded derailments (NA). One can see that the very large swings in derailments rates between 1996 and on up to 2002 (and possibly 2003) are well aligned with the changes in low temperature. Temperature alone could be the explanatory parameter in variations in W&R derailment rates over this period. From 2002 to 2006 the W&R derailment rate grows beyond what would be expected from temperature variation. Also, it is possible that the reduction in the derailment rate between 2005 and 2006 is due to the significant change in winter-low temperature, rather than mitigating measures taken over that period.

2.3.3 Railway Operational Influences.

As discussed above, we believe that performance benchmarking and trend analysis are important roles for Transport Canada, and that this benchmarking should involve performance measures at a high level. However, there are a number of influences in a railways performance that need to be factored into the comparisons. It would not be reasonable to benchmark Canadian railway performance against U.S. railway performance in the areas of wheel and rail failures. Similarly, it would not be reasonable to assess the effectiveness of initiatives taken to mitigate wheel/rail failures without factoring temperature variations into the assessment.

In addition to environmental influences, there are railway operational differences that can influence the inherent derailment rate or the safety management task of one railway in comparison with another. Axle loads, car types and track characteristics all influence safety performance and would ideally be treated as independent variables in a statistical analysis. CPR has much more significant grades and curvature on its trunk mainline network than did CN, prior to its acquisition of BC Rail. The BC Rail terrain is more severe than CPR’s. CN has mixed passenger and freight traffic on much more of its network, which results in lower speed freight trains seeing over-elevation conditions in curves designed for higher speed passenger trains. Also, as discussed later in Section 3.1.3, wheel failures have been tied to interchange equipment from U.S. railways that do not experience our winter-low temperatures. CN, being more of a north-south railway than is CPR, could have a higher exposure to problematic wheels via interchange.

It is important to factor as many as possible of the known or potential influences into the safety performance benchmarking and trend analysis. A recent study undertaken for Transport Dangerous Goods, identified two explanatory variables. Since TranSys Research
2.3.3.1 Traffic Density Influence
One of the parameters found to differentiate derailment rates was the traffic density on the line. Traffic density was measured as the average combined number of freight and passenger trains traversing a subdivision each day, for every subdivision on CN’s and CPR’s networks. The overall derailment rate by traffic-density is compared with the corresponding train-mile exposure values in Figure 9. In the figure, the derailments on presently abandoned or transferred short lines are included in the density range “fewer than 5 trains per day”, such that the portion of derailments that occurred on low density rail lines is 31 percent. The same low-density lines accounted for 10 percent of the train-miles. Without the allocation of abandoned/transferred lines, 24 percent of the derailments occurred on low density rail lines.

![Figure 9 Freight train derailment and train-mile distribution by traffic density](image)

For passenger trains, the percentage of derailments on low density tracks was similar to freight trains — 24 percent of derailments happened on low-density lines, which accounted for 6 percent of the passenger train-miles. The proportion of derailments is 37 percent when abandoned/short lines derailments are assumed to have had fewer than 5 trains per day.

While there is a higher derailment rate on low-density lines, the absolute number of derailments will not necessarily be higher than on high-density lines. The derailment rate assessed above in terms of derailments/train-mile reflects the total number of expected derailments anywhere on the network that possesses the same characteristics. The expected frequency of derailment on a specific short segment of a low-density line inherently involves a low train-mile multiplier. Light density lines involve many more route miles than high density lines. Fifty percent of the route miles had traffic densities lower than
5 trains per day, while 16 percent had traffic densities greater than 20 trains per day. Thus, while the derailment rate is higher on low-density lines, the absolute number of derailments occurring at a specific siding location is generally lower for low-density lines.

2.3.3.2 Track Class Influence
Track class (as inferred from time-table speed limits) was the other parameter that was found to be statistically significant in the data. This is consistent with the findings of Anderson and Barkan [Anderson & Barkan, 2004] who found U.S. derailment rates to decrease with increasing track class.

Speed limits were used as a surrogate for track class. We believe that it is a surrogate for track geometry quality when located on low traffic-density lines. Track-class (or speed limit) is also a surrogate for curvature when located on high-density lines. We did not have a direct measure of curvature by line segment and our estimated curve index by region did not produce a statistically significant influence on derailments. Our estimated curve index was allocated at the full subdivision level in relation to our judgment of the severity and number of curves expected on that subdivision. Curvature at specific locations within a subdivision was not known, and while it is a field in the RODS accident database, the field is rarely populated with data.

While we know from an engineering viewpoint that curvature does have an influence on some types of train derailments, we were hesitant to impose a specific factor based on judgment since the track class measure used in the data did reflect curvature conditions in an indirect way — high degrees of curvature have lower speed limits.

The data exhibited variation in track classes across all traffic densities. Low density lines had segments of track with class 3 and class 4 speed limits. Similarly, high density lines had segments of track with class 2 and class 3 speed limits. As noted, we believe the measure reflects different underlying parameters when occurring in the different traffic densities but they have a similar influence on derailment rates — a lower track class either signifies a lower quality of track or a more complex track design due to high curvature, both of which are expected to elevate the probability of derailment.

Concluding comment
The data/discussion of the previous sections illustrates the importance of factoring known environmental and operational influences into any trend/benchmarking analysis. This factor and other known influences need to be developed with a completed database and in a rigorous statistical process. We recommend that TC/RSD undertake or fund the research necessary to support an ongoing rigorous trend-and-benchmarking analysis of railway safety performance.
3 Types of Derailments and Mitigating Strategies

In this chapter we explore derailment trends and mitigating strategies; first for equipment and then track. Within each category the trends, contributing factors and mitigation strategies are discussed. In the third subsection we explore contributing factors that are common to both track and equipment failures. In the forth subsection we address geotechnical failures, and in the last subsection we deal with other works, including signaling and bridges.

3.1 Equipment Failures;

3.1.1 Types of Equipment Failures

Figure 10 presents the proportional distribution of types of equipment failures on average over the interval 1999 to 2006 reported by CN (left pie chart) and by CPR (right pie chart). One can see that axles/wheels are the largest category in both cases, followed by body/coupler components.

The main difference between the two is the proportion of brake-related failures — CN reports about twice as many brake-component failures as a derailment factor than does CPR. The remaining categories are about 10% higher for CPR due to this difference. We were told that the difference is most likely a reporting difference rather than a causal factor — derailment site investigation is not an exact science, one is searching through the wreckage to find clues of the cause. One railway might conclude that brake rigging found on track was a causal factor more often than the other.

Nonetheless, if TC undertook a rigorous ongoing benchmarking which was supported by a completed database, differences such as these should be followed up with the reporting...
railways to see if accident investigation guidelines vary or if lessons in maintenance and/or inspection practices of one railway can be applied to another.

3.1.2 Trends in Equipment Failures

Figure 11 presents the annual variation in equipment factors cited by each railway for mainline derailments. The data are presented in a stacked bar format, so each component is additive in determining the total equipment-related derailment rate for the year. The top segment of each stacked bar is the allocated proportion of records without a causal factor cited. Since equipment factors were cited in 48% of the derailments where a cause was shown, 48% of the blank records were allocated to equipment as a blank cause. Thus for example in 1999, CN reported a total of 5 equipment related derailment factors per billion car-km. About 2.25 were axle or wheel related, an additional 0.45 were brake-related, 1.1 were truck-related and another 1.35 was body or coupler related. On top of the reported 5 derailment-conditions/billion car-km, an additional 1.1 resulted from the 48% allocated blank records, making the total estimated equipment derailments 6.2 per billion car-km. Since some derailments involve multiple unsafe-conditions, the cumulative rate for unsafe conditions cited exceeds the simple derailment rate based on number of occurrences.

![Figure 11: Equipment-related derailment unsafe-conditions trends for CN and CPR](image_url)

Since there was a growing proportion of derailments that were not coded in the data, one can not draw definite conclusions about trends. It would appear that there is a significant variation in equipment components cited from year to year. While CN and CPR had a similar average equipment failure rate in the first three years, CN’s rate exceeded CPR’s rate in the last four years.
3.1.3 Equipment Mitigating Strategies

3.1.3.1 Routine Inspection and Maintenance Procedures
Transport Canada has established a set of rules which require railways to routinely inspect and maintain their equipment. Fundamental to these are the safety inspections which must be performed by certified inspectors whenever locomotives, passenger or freight cars are placed into service. To facilitate this, the railways have established designated safety inspection locations across their networks. The certified inspectors verify proper operation of equipment and ensure that each vehicle’s components are maintained within industry accepted wear limits as specified in the AAR Interchange Rules. When a certified inspector identifies a safety defect on a car then it is either fixed immediately or becomes “bad ordered” and sent to a repair track. The AAR rules stipulate that roller bearings be lubricated at least every 18 months. Railways may also develop their own internal schedules and criteria for performing additional routine maintenance in accordance with the equipment manufacturer’s specifications.

Locomotives must receive a safety inspection by a certified locomotive inspector when placed on a train for freight service. For passenger trains, locomotives must also be safety inspected each time a train is laid over for more than eight hours. Locomotives used in yards or in “designated service” must be safety inspected at least every ten days when operating at a safety inspection location, otherwise they must receive a safety inspection at intervals not exceeding 45 days.

Safety inspections must be performed on passenger cars by a certified car inspector whenever trains are made up, laid over, or where cars are added to the train or interchanged. If a certified car inspector is not available at the location then a qualified person, such as the locomotive engineer, must perform a less extensive pre-departure inspection. Then, the train must receive a full safety inspection at the first designated safety inspection location encountered in the direction of travel.

Freight cars must be safety inspected by a certified car inspector when placed into a train at a safety inspection location. Otherwise, they must receive a pre-departure inspection by a qualified employee and then inspected by a certified car inspector when the train arrives at the nearest safety inspection location. Dangerous goods cars must receive full safety inspections at the nearest safety inspection location prior to being loaded and then must be safety inspected again when being received by the operating railroad after being loaded.

The Railway Freight and Passenger Train Brakes Rules define additional inspection procedures which must be followed to verify adequate functioning of the train’s brakes. For locomotives, brakes and related controlling equipment must be tested after being laid over or repaired. For trains departing a safety inspection location after being made up, a certified car inspector will perform a “No. 1” brake test to verify: the integrity of the brake pipe; the condition of the brake rigging on each car; application and release of each car brake; and that the brake cylinder piston travel on each care is within appropriate limits. Pull-by brake inspections which verify that the brakes on each car have released are acceptable for departures after a train has received a more complete brake test. Locomotive engineers
operating passenger trains use “running brake tests” where the brakes are applied while the train is moving to verify proper brake function. By regulation, trains are not permitted to depart a safety inspection location unless at least 95% of the brakes are operational. Departures from other locations are permitted provided that a minimum of 85% of brakes are operating.

A more extensive test called the “single car brake test” is performed on a scheduled basis to quantify the amount of air leakage from the brake pipe, air fittings and brake cylinders of a car. New cars must be sent for a single car brake test after 96 months from date of manufacture. All other cars must be given single car brake tests at intervals not exceeding 60 months.

U.S. DOT regulations (CFR49.180.509.g) specify pressure test intervals for tank cars. The most constrained is fusion welded tanks, which can not exceed 10 year test intervals; and if the tank car carries corrosive materials its service equipment (piping, valves, fittings) must be tested at no greater than 5 year intervals.

3.1.3.2 Wheel Strategies

Better Quality Wheel Supply

The railways recognized there was a problem with wheel failures and in particular one manufacturer’s wheels. Wheel failures similar to that shown in Figure 12 were frequently traced to one supplier’s wheels (Southern) made in the year 1995, which was the year it went bankrupt.

Figure 12 Picture of wheel failure involving a Southern wheel.

Source: Transportation Safety Board [TSB, 2004]

Wheel failures are much more pronounced in cold weather (see previous Figure 7) and as a result are more of a Canadian railway problem than an industry problem. U.S. railways can use the bankrupt supplier’s wheels and experience a much lower failure rate. Combined with the fact that the majority of wheel failures (75% for CN) are found by inspection before
they result in derailments, it was difficult for Canadian railways to get an industry wide agreement to phase out use of these wheels.

CN and CPR now change out the problematic wheels if found on their own cars when they are in their shops for inspection. However, while CN and CPR did not have large numbers of the failure-prone wheels on their equipment, U.S. and private cars are used on the Canadian rail system and Canadian owned cars can have these problematic wheels installed by other railways when wheels are changed out under industry equipment interchange agreements. Since CN has more north-south movements than CPR, it is possible that CN had a greater exposure to this problem than did CPR and contributed to the trend shown in Figure 11.

The natural attrition rate of these pre-1996 wheels continues to mitigate the problem and the industry has agreed to phase out the remaining wheels when removed for cause, rather than reconditioning for reuse. As reported by the TSB in its investigation report R04Q0047 [TSB, 2004]:

*The Association of American Railroads (AAR) has issued an instruction for the removal from service of all Southern wheels manufactured in 1995 when cars are in repair shops or tracks.*

*Canadian National and Canadian Pacific Railway have initiated programs that go beyond the requirements of the AAR. They are removing all Southern wheels from their equipment and have instructed their suppliers to not install Southern wheels on any cars owned or leased by them.*

*Transport Canada is monitoring the wheel failures on an ongoing basis by reviewing and analysing any reported failure with the railways to quickly identify any emerging trends and implement regulatory action should it be deemed necessary.*

The move to heavier axle loads and the problems with Southern’s wheels highlighted the benefits of a better quality steel. The Canadian railways are presently purchasing most new wheels from manufacturers that use a ‘Clean Steel’ process in which vacuum degassing mitigates the probability of internal occlusions (hydrogen bubbles) or micro-contaminants in the wheels.

**Wheel Impact Detectors/Preventative Thresholds for Owned-Equipment**

Wheel flats can lead to both wheel failure and rail failure in the winter months. While there is a gauge used to manually find wheel flat spots, the interchange criteria upon which the gauge is based and the detection probability by visual inspection have been found to miss many wheel conditions that impose significant impact forces. These impact forces are experienced by both wheel and rail. Wayside impact detectors have been used to detect problematic in-service wheel loads and the industry has agreed to a change-out threshold of 140,000 lb. under its interchange agreement. CN and CPR have been increasing the number of wheel impact detectors on their mainline systems (CN doubled the number of sites over the past five years). They also began using a threshold of 135,000 lb. in Northern
Ontario for owned-equipment during the summer months to prevent the escalation of the problem to higher impact loads from these wheels in the winter months.

**More Hot Wheel Detectors**

Braking problems can lead to two different safety concerns for wheels. First, stuck brakes prevent the wheel from turning and create a flat spot on the wheel. Second, poor distribution of brake forces among all wheels on a car can lead to overheating of some wheels. Wheels are manufactured to normally have residual compressive stresses in the rim, such that a crack, if initiated, sees closing forces. With overheating, the residual stress state can change to neutral or a tension state such that cracks are rapidly propagated.

The importance of maintaining good braking has been recognized. When wheel impact detectors were first installed, eighty percent of wheel flats were found to occur on the B end of the car, where the hand brake is located. Thus, early efforts focused on promoting better hand brake use by employees and customers. More recent recognition of the importance of thermal stresses in surface crack initiation and propagation has led to installation of more wayside hot wheel detectors (CN now has 25-30 mile spacing across the main line in Canada), and use of the detectors to assess brake force distribution via hot and cold wheel combinations on a truck.

The hot wheel sites do not provide car numbers but CN has built a “virtual automatic equipment identification system” to determine the car number involved. CN have also built a “hot wheel repeater” system to track cars with repeat hot/warm wheel events. Cars are flagged to receive a single car brake test. CN is working with other private car owners to have their hot wheel cars handled. CPR does not have the same interconnection of sites that CN has, but is working on central computer software to accomplish the same automated problem-car-tracking when the wayside system emails its report to the central office. A prototype system is presently installed on its heavy haul coal route.

**Abrasive brake shoes**

Another measure taken to mitigate the development of surface spalling/pitting is the use of an abrasive brake shoe — CN has installed 175,000 of these ‘tread-guard’ brake shoes. Surface spalls will not grow into a problem if the wheel surface is “dressed” with a material that is abrasive enough to condition the surface and gently remove the surface pitting as it develops. The brake shoes address problems of shells that develop from wheel-rail contact stresses as well as spalls that develop from braking forces.

**Wheel Impact Load Assessment**

In the same way that flat wheels can produce significant impact loads on rail, rail discontinuities can produce high impact loads on wheels. To assess the sources of potentially damaging impact loads seen by wheels, CN, CPR and Griffen Wheel Co. cooperated in a joint test program to monitor wheel loads of a car circulated across both railways’ systems. The results indicated that the highest impact loads occur at the gaps in rail that occur in diamond crossings. The test program produced a better understanding of the load environment; however, since diamond crossing are few in number and a necessary component where two rail lines intersect with each other, it did not result in mitigating action.
**Additional anti-spalling strategies**

Additional strategies include: more frequent light turning of wheel tread surfaces in a lathe, adopting conformal wheel/rail profiles to distribute the contact stresses, and use of improved steering trucks.

3.1.3.3 Axle Truck and Car body Strategies

**Over/Unbalanced-Load Detectors**

The wheel impact detectors measure average static load as well as impact loads. As a result the data interpretation software has been expanded to assess overload and unbalanced load conditions. Lateral unbalanced loads can lead to poor performance on track geometry that would otherwise be adequate, resulting in car-track interaction derailments. Endwise unbalance or overloading can lead to suspension component failure and in the extreme, full axle failure. These conditions are now monitored and if extreme conditions exist, immediate action is taken. Where repetitive problems develop, customers or car owners are advised of the problem loading history. If customers are involved they are slated for a visit under the industries education campaign which highlights the problems of not following recommended loading practices.

**Better Axle Materials and Maintenance Practices**

Axle problems can involve either an axle failure or a bearing failure. Axle failures are a relatively uncommon occurrence. When they do occur, the reason for the failure and correction of the underlying problem is addressed. VIA Rail experienced a few axle failures in its LRC equipment and found that the axles had been made in a cold – rolling process. They replaced all LRC axles of that type with forged steel axles, which was the more commonly used process for high speed passenger axles.

CPR had some axle failures that it traced to propagation of cracks that initiated as surface pitting due to rust development on inactive cars. The axle reconditioning guidelines used by the industry prior to CPR’s assessment allowed small surface pitting to be left in an axle. The guidelines were subsequently changed to insure that axles were turned down far enough to remove all signs of surface pitting.

**More and Improved Hot Box/Dragging Equipment Detectors**

Bearing failures usually develop over time into an overheated state and ultimately to axle failure at the wheel bearing. Locomotives also have suspension bearings that support the traction motors.

Passenger trains have electric cables interconnecting all cars and locomotives in the train. Thus it is possible to have onboard thermal detectors at every bearing to continuously monitor and display for the crew the status of all bearings. This capability is also possible for freight trains equipped with electric cables, as exists with electro-pneumatic brake systems (see the RSAR’s technology report).

Freight cars are now limited to wayside ‘hot box detectors’ (HBD), which are installed at regular intervals to detect hot bearings. CN’s core mainline system has an average spacing of 15 miles between HBDs.
These same sites usually have dragging equipment detectors to detect broken items like brake rigging before they fall off and have potential to derail a wheel. These dragging equipment detectors are now being improved to detect low-hanging equipment (brake hoses, or rigging) before it fails or catches on a track switch point.

**Wayside Acoustic Detectors**

CPR is testing the use of wayside acoustic detectors on its car route. The device was installed on CN’s subdivision which is used to transport both CN and CPR loaded cars in their joint-track usage agreement along the Fraser River. Both railways’ cars are monitored by the device. Acoustic detectors can detect roller bearing problems before they develop into an overheated state, whereas hotbox detectors can only detect the overheated bearing. Some initial bearing problems can go many thousands of miles before developing into an overheated state, whereas an overheated bearing’s condition can be exacerbated to the point of full failure within a few hundred miles. Thus, the acoustic bearing detectors have a predictive advantage, although reliably differentiating high risk conditions continues to be a development issue. Also, the Canadian railways have an existing network of hot box detectors (HBD), and the incremental benefit of acoustic detectors is lower than if there were no existing HBDs. There might still be a value in having a few strategically located acoustic detectors on the system, particularly when applied to monitoring of unit trains.

**Equipment Performance Measurement Devices**

The industry has been pursuing performance based measurement technologies for equipment inspection. In service detection of hunting, and truck alignment and curving performance problems is possible. In addition, digital imaging technologies are being developed to assess some component conditions. More details of these technologies is presented in a separate Technology Project being conducted for the Secretariat.

3.1.3.4 Specific Measures for Dangerous Goods Tank Cars

Risk by definition, involves both the frequency of occurrence and the severity of consequences resulting from that occurrence. Public safety with respect to railway freight transportation is largely tied to dangerous goods transport. When dangerous goods cars are involved in a railway derailment/collision, the consequences can be influenced by addressing the potential for release from those cars, and the possibility of human contact with released dangerous goods. The probability of release can be influenced by car design.

Dangerous goods (DG) transport involves common issues across all modes and is addressed by a separate Transport Dangerous Goods Act rather than the Railway Safety Act. Thus, while this subsection is relevant to railway safety it is not directly influenced by the RSA.

Not all DG cars that are involved in a derailment release contents. The proportion of DG cars releasing when involved in a derailment was recently reviewed by Treichel et al. [Treichel, 2006]. For mainline derailments, the proportion releasing varied by car type as indicated below:

<table>
<thead>
<tr>
<th>Car Type</th>
<th>Proportion Released</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 111, non-jacketed</td>
<td>35%</td>
</tr>
</tbody>
</table>

TranSys Research Ltd.
<table>
<thead>
<tr>
<th>Type</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 111, jacketed cars without bottom fittings</td>
<td>17%</td>
</tr>
<tr>
<td>Type 112J340W cars with 5/8&quot; shell thickness &amp; full-height head shields</td>
<td>7.9%</td>
</tr>
<tr>
<td>Type 105J500W, cars with ¾&quot; shell thickness &amp; full-height head shields</td>
<td>6.3%</td>
</tr>
</tbody>
</table>

Of those releasing product, the portion releasing over 80 percent of the capacity was 39 percent for non-pressure cars and 50 percent for pressure cars. Type 111 are non-pressure tank cars which are used to transport liquid commodities while types 112 and 105 are pressure tank cars used to transport commodities which are gases at normal atmospheric temperature and pressure. Compressing the gas greatly increases the amount of commodity which may be transported in a tank car. A non-pressure tank car is less likely to release large quantities of commodity if punctured than is a pressure tank car since the liquid will drain by gravity down to the height of the puncture. The contents of a pressure tank car, on the other hand, will be forced out of the tank by the high internal pressure.

The overall probability of a specific tank car type releasing 80 percent of its contents if involved in a derailment may be calculated by multiplying the car type-specific release probability by the appropriate 80 percent contents release probability. Thus, for a pressure 112J340W car the multiplier associated with release of 80 percent or more of its capacity is 0.079 * 0.5 = 0.039. For a non-jacketed type 111 car the probability of a release of 80 percent or more of its contents would be 0.35 * 0.39 = 0.136.

While many DGs that are toxic to humans if released in large quantity are carried in type 105 and 112 tank cars some toxins and many chemicals that can have an environmental impact are transported in type 111 cars, which have a higher probability of release in a derailment. The industry is taking action to mitigate the release probability of tank cars involved in a derailment. The Next-Generation Rail Tank Car Project is a joint industry-government initiative in the U.S. which aims to have a prototype next-generation car to carry Toxic Inhalation Hazards (TIH) developed by the spring of 2008 and with first introduction into service by 2010. The industry partners in this venture include DOW Chemical, Union Pacific Railroad and Union Tank Car. The design concepts being considered are discussed in the technology project being undertaken for the RSAR Secretariat.

This first generation car design is projected to exceed the current AAR Tank Car Committee Performance Specification to provide between 5 and 10 times the level of safety and security. Generation 2 and 3 tank cars will be subsequently developed to carry chlorine and other environmentally sensitive chemicals and DOW Chemical expects to have 50% of their fleet renewed by 2013 with the balance replaced by 2018. However, changeover of the overall North American fleet will take a significantly longer period of time in the absence of any regulatory inducement. A potential scenario is limiting older cars to low-level toxins, or by mandating the retrofit of some next-generation safety features to the older cars.

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3.2 Track Failures

3.2.1 Trends
Figure 13 presents the proportional distribution of types of track failures on average over the interval 1999 to 2006 reported by CN (left pie chart) and by CPR (right pie chart). One can see that geometry is the largest category in both cases, followed by rail failures.

![Figure 13 Distribution of Track Factors in Mainline Derailments](image)

Figure 14 presents the annual variation in track factors cited by each railway for mainline derailments. As with the equipment derailments presented earlier in Figure 11, the data are presented in a stacked bar format — each component is additive in determining the total track-related derailment rate for the year.

![Figure 14 Annual track-related derailment unsafe-conditions for CN and CPR](image)
The top segment of each stacked bar is the allocated proportion of records without a causal factor cited. Since track factors were cited in 41% of the derailments where a cause was shown, 41% of the blank records were allocated to track failures as a ‘blank’ track-related cause. Thus for example in 1999, CN reported a total of 4 track-related derailments per billion car-km. Two were geometry related, an additional one was rail related, 0.1 were switch-related and another 0.9 were various other track-related factors. On top of the reported 4 derailments/billion car-km, an additional 0.8 resulted from the 41% allocated blank records, making the total estimated track derailments 4.8 per billion car-km. Since some derailments involve multiple unsafe-conditions, the cumulative rate for unsafe conditions cited exceeds the simple derailment rate based on number of occurrences.

Again, while the growing proportion of derailments that were not coded in the data makes it difficult to draw definite conclusions about trends, it would appear that CN began with a lower number of track-related derailments than CPR, but grew to be close to CPR’s rate by 2005/2006. The biggest growth in allocated derailments was rail failures between 2003 and 2005.

3.2.2 Routine Inspection and Maintenance Procedures
The Rules Respecting Track Safety defines a minimum set of standards to which railways must adhere when designing and maintaining track. These rules establish the maximum deviations, for each track class, of: track gauge; alignment; curve elevation and runoff; and track surface. Trained railway employees are required to visually inspect track for defects either on foot or while traveling in a vehicle at a speed which permits adequate inspection. The rules allow, but do not require, railways to use other mechanical or electrical measuring devices to supplement the stipulated visual inspections and it is a standard practice for railways to inspect their track using track geometry measurement vehicles.

The track safety rules require class 4, 5 and 6 main track be inspected at least three times per week. The required inspection intervals are reduced to twice per week provided that the railway uses a geometry car to inspect their tracks at least twice a year. Sidings are to be inspected from the adjacent main track during main track inspections and must also be inspected at least once per month by actually traversing the siding. Class 1, 2 and 3 main track must be inspected twice weekly if traversed by passenger trains or once weekly otherwise.

3.2.3 Mitigating Strategies-Rail
Some of the strategies used to mitigate rail failures are the same as those used to mitigate wheel failures. The measure used to reduce wheel flats also addresses rail failures from impact loads. The wheel and rail surfaces see the same contact stresses, and both the resulting problems and mitigating strategies are common to both. The move to ‘clean steel’ manufacturing processes and use of higher hardness steels for heavy axle load territories are common to both. Use of better steering trucks to reduce curving forces, equally benefits wheel and rail. Conformal matching of wheel and rail profiles is an interactive strategy which recognizes both sides of the contact stress picture; and the counterpart of using abrasive
brake shoes to dress the wheel surface, is use of preventative grinding to frequently dress the rail surface before surface shells develop into cracks.

In addition to these common strategies, rail has some independent trackside strategies. These include the use of temporary slow orders placed on trains in cold weather — since lower speeds result in lower impact loads for a given wheel flat condition.

External cracks propagating from the bolt holes of rail joints or from rail welds have historically been detected by visual inspection. However, automated inspection techniques with digital imaging technology are being developed and assessed by the industry. In addition to surface cracks, digital imaging is being considered for tie condition, raised or missing spikes. These technologies are explored in RSAR’s technology study.

Rail failures can also result from internal defect development, which are not visible and can only be found by automated inspection systems, using ultrasonic and/or eddy current technologies. These devices put a signal into the rail while traveling at speeds of 20 mph and read the signal coming out of the rail. The task of interpreting the received signal is as much an art as it is a science. The signal can be influenced by many factors and it is common practice to flag suspect locations and then make a hand measurement at that location, either by stopping the test car or by a second follow-on vehicle.

Data reported for North American heavy haul railways indicate that automated inspections [International Heavy Haul Association, 2001]:

- detect an average of 0.4 defects per track km. (0.6 rail defects/mi) each year while inspecting at intervals of 18 mgt (20 mgt) and experience 0.06 service failures/km (0.1 service failures/mi.). One service defect in two hundred leads to a broken rail derailment. Rails are typically replaced when total defects are occurring at a sustained rate of 1-2/rail km (2-3/mi.).

Thus, for every six defects found by inspection, one broken rail occurs before it is found; and for every 200 broken rails that occur, one results in a derailment.

Both CN and CPR have adopted risk based scheduling of automated rail inspection equipment. The factors included in the scheduling equation include: proportion of dangerous goods traffic, number of passenger trains, proportion of heavy axle load traffic, train speed limit, and the recent defect detection rate.

In addition, some railways are assessing the trade offs of using higher frequency testing with fewer stops. Rather than flagging suspect conditions and hand testing, the location of uncertain signals is recorded and then reassessed in the subsequent test to determine if it still exists.

Defect detection is less accurate under some known track conditions. The IHHA’s recommended practices for these situations are [International Heavy Haul Association, 2001]:

In at-grade crossings, the fouling of the rail surface by road-borne materials, particularly salt, can obstruct a good ultrasonic indication. This can be overcome by sweeping out the crossing in advance, slowing down the test and reversing if an unusual indication is seen. Welds are another problem. Because of the change in grain structure and the fact that fractures can propagate rapidly from very small cracks or stress raisers, welds are very difficult to test either with ultrasonic or induction. One possibility is to have automated ultrasonic recognition of the weld upset, which could trigger a change in the signal gain and the use of tighter inspection tolerances. Most heavy haul railways ensure more careful testing through special track work.

Rail defect detection technology and the associated pattern recognition software have improved over recent decades. At present the industry is evaluating the effectiveness of a non-contact laser-based technology (see the RSAR’s technology study).

3.2.4 Mitigating Strategies-Geometry

Geometry failures include full buckling of track, as well as all other smaller geometric deviations that result in an inadequate surface condition for the weight and speed of the equipment it is meant to carry. Buckling is caused by thermal stresses which compress the rails with enough force to buckle the complete track in a lateral offset typically called a “sunkink”. When rail is originally installed, it is tensioned to provide a stressed state which is appropriate for the ambient temperature at the time of installation. The stress state is selected to accommodate winter low temperatures without pulling-apart and summer high temperatures without buckling. However, under operating conditions the rail can shift and become offset from its intended “neutral stress” temperature.

Track buckling is a lower frequency occurrence in Canada than in the hotter temperatures of the U.S. Even though buckling has a lower frequency than other geometry conditions, they often have more severe consequences, both in cost and potential involvement of the lead locomotive and crew. At present, determining the neutral stress state of rail is a laborious and intrusive process of removing rail anchors and spikes for a length of track and lifting the rail. The industry is assessing a prototype in-situ device that has potential to measure stress state without having to disturb the rail.

The other aspects of track geometry (vertical and lateral variations of rails) have already seen improvements in measurement technology. Inertial measurement systems, hi-rail and locomotive-mounted systems, and lateral restraint force measurement capabilities have evolved over the last 15 years.

As with rail defects, the frequency of automated inspections is a key ingredient in managing the risk associated with track geometry deterioration. CPR has two track geometry test vehicles, one with a lateral gauge restraint measurement system, deployed in dedicated work trains on its system. CN has one TEST car and contracts out additional geometry testing. It has recently been increasing its frequency of automated geometry testing with its owned car and has a second test car on order.
Recent advances in software tools, which interpret the geometry conditions to detect undesirable conditions may support a more performance based maintenance targeting strategy. Both CN and CPR in conjunction with Transport Canada have been evaluating a software tool (LVSafe) which takes the geometry measurements as input and calculates the Lateral/Vertical wheel force ratio in real time for a number of ‘bad actor’ freight cars. The track performance predictor has been configured to identify track conditions that result in high L/V wheel force ratios for one or more of the car types that are included in the model. Each car is modeled at several speeds. The lowest speed for each car type was selected to capture the most severe response for that car type while the higher speeds have been selected to represent track class speeds. The highest speed evaluated is capped by the applicable speed limit for the segment of track being tested. [TranSys Research Ltd., 2004, 2002]. Some U.S. railroads have also been assessing signal processing based software with the same objective.

The instrumented wheelset test programs that were undertaken to validate the models, and the model predictions themselves, indicate that fewer than 50% of high risk conditions are identified by existing regulatory measures; and similarly, the majority of regulatory defects do not present a high risk condition [TranSys Research Ltd. 2004, and TTCI, 2005].

These new software capabilities provide an opportunity to better target maintenance resources. CPR has integrated the LVSafe software system with its existing defect printout system, but has not yet been able to build a business case to go the next step of handing out the new defined defects to its field maintenance forces. CPR believes that to realize the benefits of the improved risk-targeting, it needs to transfer resources from low risk targets to high risk targets rather than just add more targets. It sought relief from Transport Canada for some of the existing regulatory defects that it considers to be of little relevance to safety performance in order to improve the business case.

**3.3 Train Operations Influencing Factors**

We have discussed some of the environmental and operational factors that influence safety performance (Section 2.3). Other changes in the Class 1 railways’ operating practices have raised the question of whether safety performance has been affected and/or the risks properly evaluated and mitigated. The changes include longer trains, heavier axle loads, high performance locomotives, energy saving train handling practices and destination-based train marshalling.

These changes have been pursued in advancing the efficiency and cost effectiveness of railway operations. In most cases the economic framework that is used in making these changes include safety performance. It can be considered as a direct cost component (e.g. the costs of derailments) and/or indirectly through cost elements that arise before safety is affected (e.g. rail/wheel and track maintenance costs).

The move to heavier axle loads involved significant research and testing by the industry prior to the decision. The International Heavy Haul Association (IHHA) presents the experience of railways around the world in its “Guidelines to Best Practices for Heavy Haul
Railway Operations: Wheel and Rail Interface Issues. The Guidelines have significant contributions from Canadian Railways – particularly CPR’s experience with its coal route through challenging mountainous terrain.

Advances in locomotive performance over recent decades have resulted in a higher ratio of tractive-effort to power than previously existed. This allows trains to be operated with less power and still be able to climb the steepest grade (hill) it encounters. The higher traction performance from the locomotive is present in both pulling (via traction motors) and stopping (via reverse powered traction motors with dynamic brakes). The lower powered trains generally have lower speeds than previously experienced and higher traction forces concentrated at the locomotives (both in pulling and braking).

The lower speeds combined with higher traction has led to isolated problems of “stringlining” derailments at low speeds in tight curves. Higher concentrated dynamic braking forces cumulated under the locomotive consist also exacerbates longitudinal forces and track buckling probability. Use of elastic fasteners in curves has helped mitigate these problems (see RSAR’s technology paper). Additional mitigating measures include, revising the superelevation in curves to best match the actual operating speeds of trains and distributing locomotive power at mid train so that the high traction forces are not cumulated at one location in the train. CPR has been assessing superelevation changes while CN has been equipping its locomotive fleet with remote control system to allow mid-train power, which results in a reduced concentration of locomotive traction/braking forces.

Higher power locomotives are one of the factors that made it more economical to operate longer trains. Longer trains can contribute to higher temperature rises in rails, can exacerbate the problems of managing in-train forces thorough proper train handling, and also make the train more sensitive to train marshalling practices in the event high in-train forces develop. Guidelines were developed in the 1970s for train marshalling that call for loaded cars to be placed in the front and empty cars in the rear of the train, and to avoid long-car/short-car combinations that are susceptible to high lateral forces when braking in curves [Government - Industry Research Program, 1973]. Economic principles can conflict with these guidelines and destination blocking of cars can save significant switching costs when cars are placed in the train according to their common destination, regardless of weight/car-type.

Like most guidelines, the marshaling guidelines are most applicable to trains that traverse severe terrain – tight curves and steep grades, but can also be relevant in less demanding terrain if a train has its emergency brakes applied. The optimal balance of economic and safety principles will vary by location and determining the various balances by location requires research. Transport Canada is planning to initiate a long-train research program that presumably will assess these issues as well as other influences of long trains such as elongated grade crossing occupancy times.
3.4 Geotechnical failures, such as slides and washouts;

3.4.1 Trends
Figure 15 presents the number of derailments in the TSB database attributed to slides or washouts. One can see that the frequency of occurrence is relatively low and the trend is decreasing. However, they represent a high potential of severe consequences to the railways, both in risk of employee involvement and cost of the derailment.

3.4.2 Mitigating Strategies
Mitigating strategies include:

- Aerial Surveys and Track-Based Patrols
- Fence Detectors for Rock-Slides and Avalanche Detection
- Cover-Over for Repetitive Slide Areas

In addition, the industry has researched this problems in the past and presently has a multifaceted Ground Hazards Research Program underway which is jointly funded by Transport Canada and the railways.

The reader is referred to the Technology Project being undertaken for the Secretariat for more details on these areas.

![Figure 15 Trends in geotechnical derailments](chart)

**CN + CPR Total**

**Derailments from Slides and Washouts**

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<th>Year</th>
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</thead>
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</tr>
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</tr>
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Figure 15 Trends in geotechnical derailments
3.5 Other Works

Human factors is an element in all derailments but operator error is a specific factor being addressed in a separate study for the Secretariat. Our scope included infrastructure and thus signaling hardware and bridges are involved.

Signal hardware failures are not an issue in rail systems. The signaling systems are designed to be fail-safe and thus, component failure leads to a ‘stop’ indication. As a result most signal-related accidents are human factors related rather than technology related. New technologies are being explored to mitigate the human dependency of existing technologies, and are part of another technology-based study.

Bridge failures are also a low frequency occurrence – so low that TSB does not have a code for it. The one bridge failure that did occur (failure of a timber bridge at McBride) is coded in the accident database as an Unsafe Track Condition. The TSB investigation of that occurrence raised a number of timber-bridge inspection/maintenance issues, and the railways have responded to the recommendations [TSB, R03V0083].

4 Role of Regulatory Standards

In this chapter we explore the role of regulatory standards in enhancing public safety – first with respect to equipment and then with respect to track.

4.1 Equipment

The Railway Freight Car Inspection & Safety Rules (equipment regulations) that came into effect in 1994 under the new RSA, cover the following items:

- safety appliances (e.g. ladders and hand rails),
- specific measurable conditions of freight car components (e.g. wheel flange thickness, wheel skid flat-length),
- actions taken when safety defects are found,
- qualifications of car inspectors,
- locations of car inspections, and
- reporting requirements when defects are found.

In the same year, the Railway Freight & Passenger Train Brakes Rules came into effect covering:

- Brake test requirements,
- Brake equipment condition requirements, and
- Filing requirements to identify locations and procedures for brake tests.

Equipment inspection and repair response have been in place within the interchange agreements of the North American railways for many decades. The safety-minimum
specifications identified in the regulations for measurable conditions of freight car components are based on the agreed interchange regulations. The safety regulation thresholds are set to a level where the component is expected to be identified for maintenance under the interchange agreement before the safety-minimum state is reached. None of the individuals interviewed questioned the relevance of the measurable equipment standards (although some such as friction bearings are obsolete and are being addressed in rules ‘housekeeping’).

There were some issues raised with respect to other parts of the equipment and train braking regulations. One issue related to training, the regulations call for ‘certified’ car inspectors, but have situations where ‘qualified’ individuals can make decisions in the absence of ‘certified’ inspectors. Both definitions/qualifications need to be better defined in the regulations. There is also a question of the amount of training required — Transport Canada felt that employees re-deployed during labor disruptions into other job functions had very little training (e.g. 4 days of training for a conductor).

Changes in operating practices that resulted in ‘block swapping’ of cars outside of major yards led to situations where cars that would previously have been inspected in the yard were no longer inspected. The industry and Transport Canada have explored changes to the regulations that address the issue, but a final rule is not yet been declared.

There is a concern that some existing regulatory standards are more relevant to public or employee safety than others. Some directly address derailment risk (e.g. wheel flats and suspension element wear), some regulations address only employee safety (e.g. hand rails), and some address underlying contributing factors (e.g. cracked vent protectors (a device meant originally to keep bees out of the brake system). The railways and TC are reviewing the equipment and braking regulations to prioritize the various components of the regulations and classify those that relate to risk of derailment and those that pose a risk to employees when undertaking specific duties.

Another issue is with respect to the way that automated inspection devices are viewed within the regulations. Recent wayside automated inspection devices can find problems that manual inspection can not, as well as problems that dictate action at thresholds below regulatory and interchange limits. Discussion of technology issues is included in the RSAR’s technology paper.

4.2 Track
Track’s regulatory history is different than equipment’s. While the industry had long experience with interchange and/or regulatory rules on the equipment side; prior to Transport Canada’s 1992 request under the Railway Safety Act, there were no regulatory Track Safety Rules in Canada. Each railway managed its track maintenance from its own perspective — its derailment history and shared experience among the North American railway industry influencing its own practices. CPR had more severe curvature and gradients on its mainline routes than did CN and had developed a number of threshold conditions that triggered action that CN did not use. Each railway had its own in-house
software installed on its geometry cars that reflected its own maintenance guidelines and repair thresholds. The state of technology at the time, focused on measures that had previously been made in the field with simple tools and gauges with deviations from design that were simple to understand and of sufficient magnitude to be found by visual inspection and verified by hand measurement.

The timeframe available for the development of new ‘performance standards’ for track proved inadequate for an industry that had not yet appreciated how a performance standard should be phrased or how it would be interpreted in the field. Neither Class 1 railway wished to adopt the other’s existing standard practices as the Canadian Track Safety Rules. Since the Class 1 railways had lower track-related derailment rates than the U.S. Class 1 railways and the industry was just beginning to see a shift to more north–south traffic and U.S. rail acquisitions, adoption of the FRA Track Standards was a compromise solution that each believed could be easily accommodated by their “better performing” track. Thus, the FRA track geometry rules and speed-related track classification system became a key component of the draft Canadian Track Safety Rules.

While the Railway Safety Act allowed performance measures, the compromise solution on the geometry side was for very prescriptive measures. For other areas where track supervisors had historically made subjective assessment of the maintenance condition and no defined quantitative action thresholds existed (e.g. ballast fouling/mud) similarly subjective wording such as ‘adequate’ was adopted. Experience with the TSR, has led Transport Canada to raise issue with how they are to assess conformance with those more subjective clauses.

The railways’ experience with the TSR found the prescriptive track geometry rules to be much more burdensome than anticipated. They initially found the new FRA track geometry rules to identify a very large number of conditions that had performed well without maintenance action prior to their adoption, as well as some that were interpreted by TC inspectors to exceed their original design condition. CPR with its much more severe terrain, retained its in-house safety thresholds in addition to the new FRA conditions. CN with much lower gradients and less severe curvature, adopted the FRA standards. BC Rail, which had gradients and curvature conditions that were more severe than CPR’s but not the staff capacity to formulate its own track maintenance standards found it had to take precautionary measures to operate safely within the FRA track geometry rules. It imposed slow orders on trains with certain car types and applied more rigorous maintenance standards to “troublesome” cars when inspected at interchange points. Its initial experience with the TSR led BC Rail to raise the question of whether track curvature should be a consideration in the tolerances allowed within the track geometry rules, rather than simply being speed based.

A more sophisticated approach to risk management and more sophisticated software capabilities for interpretation of the measured geometry has raised other issues and opportunities for enhanced safety management of track geometry. Transport Canada and the railways have had 15 years to experience the concept of performance measures and have been involved in technological developments that have potential to improve safety.
Both sides see the need to update the TSR from this perspective. Learning from the experience of the first TSR they have agreed to explore the issues together before formally drafting an updated TSR.

An initial workshop was held on 22 September 2006 to explore the issues involved in redrafting the CTSR. The workshop involved 5 sessions:

1. Impact of Track Safety Rules on Safety of Railway Operations
2. Intent of Track Safety Rules
3. Track Safety Monitoring and New Technology
4. Track Safety Rules: Prescriptive vs. Performance
5. Timely Changes and Revisions to Rules

While all participants praised the meeting, there has been some criticism of the lack of progress since then. Transport Canada has cited resource constraints as a factor in its unintended lag in its follow up, which it sees as the development of a strategy for the development process.

In our opinion the existing TSR detracts from safety by forcing resources to be allocated to legally defined requirements, some of which, with present wording, have very little safety relevance; thereby leaving fewer resources to address safety concerns. We recommend that the required research and managerial resources be allocated to support the TSR change process.

In terms of overall approach to the TSR change process, we believe that where more prescriptive wording is used, care should be taken to ensure that the item being described does indeed represent a ‘safety minimum’ condition and also permit scope to revise that definition as future knowledge/research warrants. Where performance measures are used care should be taken to ensure that they reflect actual safety performance, are measurable and either enforceable-or-punishable in a timely manner.

Whether a specific clause involves a prescriptive or performance related measure, the wording should recognize the risk attributes associated with the track location, including:

- overall traffic levels,
- volumes of specific classes of DGs carried on the line, and potential exposure to human or sensitive environmental areas, if a DG release occurs,
- proportion of passenger trains on the line,
- train operational characteristics (peak tractive effort, axle loads and speed variation),
- use of jointed rail or continuous welded rail,
- grade and curve severity, and
- maximum train speed.
5 Observations and Recommendations

In this section we summarize the observations and recommendations that have been made in previous chapters.

5.1 Trends

The number of derailments in the TSB database that were not coded with safety concerns was the most notable trend — growing from less than 10% to representing close to 50% of the mainline derailments by 2006. The database (in its present state) limits insight and conclusions that can be drawn.

Wheel and rail (W&R) derailments accounted for 35% of coded mainline derailments. The very large swings in wheel and rail derailments rates between 1996 and up to 2002 (and possibly 2003) are well aligned with the changes in winter-low temperatures. Temperature alone could be the explanatory parameter in variations in W&R derailment rates over this period. From 2002 to 2006 the W&R derailment rate grows beyond what would be expected from temperature variation. Also, it is possible that the reduction in the derailment rate between 2005 and 2006 is due to the significant change in winter-low temperature, rather than mitigating measures taken over that period.

In comparing CN and CPR derailment rates, CN was close to CPR on a train-km basis in 1999 and escalated at a higher rate by 2006. On a car-km basis CN started at a lower derailment rate than CPR but escalated to a higher rate by 2006. CN had acquired some shortlines over the interval which could have affected its safety performance. The derailment rate is higher on lower density lines and lower track classes. It is very difficult to make comparisons without having a data base with significant levels of detail on both the occurrence side and the exposure side.

Risk involves both frequency of occurrence and severity of consequences. The only measure of severity readily available for the RODS database is the number of cars involved in the derailment. On a train-km basis, CN’s rate was higher than CPR’s for every year and on average 1.68 times higher than CPR’s rate. On a car-km basis, CN’s rate was lower than CPR’s rate in 2000, 2001 and 2003, but higher for other years; on average its rate was 1.32 times CPR’s rate. Excluding the year 1999, which might have been an anomalous year, CN’s average derailment rate was 1.4 times CPR’s rate on a train-km basis and 1.1 on a car-km basis.

We believe that Transport Canada should be taking a more active role in trend analysis and benchmarking of railway performance. We also believe that the focus of these analyses should be at the highest level of safety performance measurement — the derailment rate. Benchmarking and trend analysis is not only vital to conducting its role of safety oversight but would provide a value added task to the railways. A published record of safety performance by Transport Canada would serve the industry and would also serve the public much better than leaving uncertainty, which encourages media conjecture and exaggeration of the relevance of individual occurrences.
The present TC focus on making component inspections reinforces the misconception that safety performance is tied to activities at lower levels in the organization. We believe safety performance needs to be measured at a higher level (i.e. derailment rate). However, research is required before rigorous trend analysis or benchmarking can be undertaken.

We believe that the present paper-form reporting process is inefficient and prone to transcription errors. We recommend that each railway set up a secure database which contains all of the required fields outlined in TSB’s reporting forms, that the database be automatically updated as information becomes available, and that TC and TSB both have online access to the database.

We also recommend that the databases include all previous records back to 1999, when the proportion of blank fields in the database began to increase. If the development of the online database cannot be accomplished within two years, we recommend that the missing data over the time period since 1999 be collected by existing manual procedures, either by TSB or TC field personnel.

We understand the recent passing of Bill C11 gives Transport Canada a mechanism to define new data reporting requirements. We recommend that Rail Safety Directorate include in those regulations a requirement for direct access to railway accident data that are reported to TSB and authority to follow up on any deficiencies in those data.

There are two data components required to assess derailment rates. The first is the safety deficiencies (or causes) of the derailment, and the second is the exposure or activity levels (train-miles and car-miles). Our analysis indicates there might be differences in both these areas. In cause assessment, CN and CPR might be assessing braking-related derailments differently. In activity levels, we were unable to determine if articulated five-pack container cars are counted as five cars or as one car, or if road switching trains were included in mainline train-mile aggregation or as yard switching activity. If Transport Canada does not already have the power within its scope of activities in auditing railway safety management systems, it should also make the necessary changes to include the following items, which are critical to accurate benchmarking:

- the guidelines used to assess safety deficiencies (or accident causes) and the actual conduct in practice at railway derailment investigations,
- the basis and consistency across railroads of activity-based data (car-miles and train-miles).

The above actions would provide a consistent set of data for trend analysis and benchmarking. However, research is required to develop accurate measures of performance, both for trend analysis and railway benchmarking. It is important to factor known environmental and operational influences into any trend or benchmarking analysis. This factor and other known influences need to be developed with a completed database and in a rigorous statistical process. We recommend that TC/RSD undertake or fund the
research necessary to support an ongoing rigorous trend-and-benchmarking analysis of railway safety performance.

5.2 Mitigating Strategies
The same data limitations that preclude definite conclusions about trends in safety performance, make it difficult to assess the effectiveness of mitigating strategies. We believe the knowledge exists within the railway industry to develop strategies to mitigate safety concerns once they are identified. It is not clear that the industry has uniform ability to recognize at an early stage when safety concerns arise. We believe the TSB makes a value added contribution in identifying safety concerns through its investigation of selected derailments. We believe that Transport Canada could play a more important value added role through expanded research and an ongoing analysis of trends and benchmarking of railway safety performance.

5.3 Legislation
If the above noted data access provisions are not attainable through the regulations that will be developed under Bill C11, we recommend that the appropriate changes be made to the Railway Safety Act.

From the scope of work involved in this assignment, there are no other changes required to the Act itself. Desirable changes can be made in the regulations, and the industry and Transport Canada are progressing the regulations where needed. Changes to the Track Safety Rules require the most attention.

It is beyond the scope/time-constraints of this exercise to make specific recommendations within the TSR. However, we believe that the existing TSR does detract from safety by forcing resources to be allocated to legally defined requirements, some of which, with present wording, have very little safety relevance; thereby leaving fewer resources to address safety concerns. We recommend that the required research and managerial resources be allocated to support the TSR change process.

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• train operational characteristics (peak tractive effort, axle loads and speed variation),
• use of jointed rail or continuous welded rail,
• grade and curve severity, and
• maximum train speed.

References:


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