Causal Analysis of Passenger Train Accident on Shared-Use Rail Corridors

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ABSTRACT

A number of economic, technical and political factors have limited the development of new, dedicated, very-high-speed rail systems in North America. Consequently, most, proposed, near-term development of improved or expanded passenger rail service in the U.S. will involve use of existing railroad infrastructure or rights of way. Comprehensive understanding of train accidents on shared-use corridors is important for rational allocation of resources to reduce train accident risk. Nevertheless, little research has been undertaken to quantify the risk of a passenger train operating on or next to a freight train in a shared track or shared-use corridor setting. Train accident data from the Federal Railroad Administration (FRA) Rail Equipment Accident database were analyzed to examine the effects of different accident causes on the risk of passenger train accidents on shared rail corridor. Derailments and collisions were identified as the most potentially significant train accident types while human factors accidents and track failures were the primary causes of those accidents. Comparisons of freight and passenger train accidents show that some causes related to human factors are relatively more frequent for passenger trains, while infrastructure-related causes are relatively more prevalent for freight trains. The research described in this paper presents the initial results of a study intended to understand and quantify the most important contributors to the risk of train accidents on shared-use rail corridors. This work can be used to better understand how to most efficiently and effectively manage the risk on shared-use rail corridors.

INTRODUCTION

Shared-Use Corridors

Demand for regional and intercity passenger transport in the United States is increasing, resulting in the need to expand transportation network capacity. For the past half century most of this demand has been met by highway and air transportation systems; however, these are becoming increasingly congested and adding capacity is more and more constrained. Furthermore, rising fuel costs have added further pressure to both of these modes because of their relatively high energy intensity. Railroads are being viewed as a promising alternative because of their ability to provide safe, economical, comfortable, and reliable passenger transport *(1, 2)*. A number of economic, technical and political factors have limited the development of new, dedicated, very-high-speed rail systems in North America. Consequently, most, proposed, near-term development of improved or expanded passenger rail service in the U.S. will involve use of existing railroad infrastructure or rights of way (*3-7*).

Shared or mixed use corridors refer to different types of passenger and/or freight trains using common infrastructure in one way or another. The U.S. Department of Transportation, Federal Railroad Administration (FRA) defines three types of shared use: shared track, shared right-of-way (ROW), and shared corridor *(8)* (Figure 1).

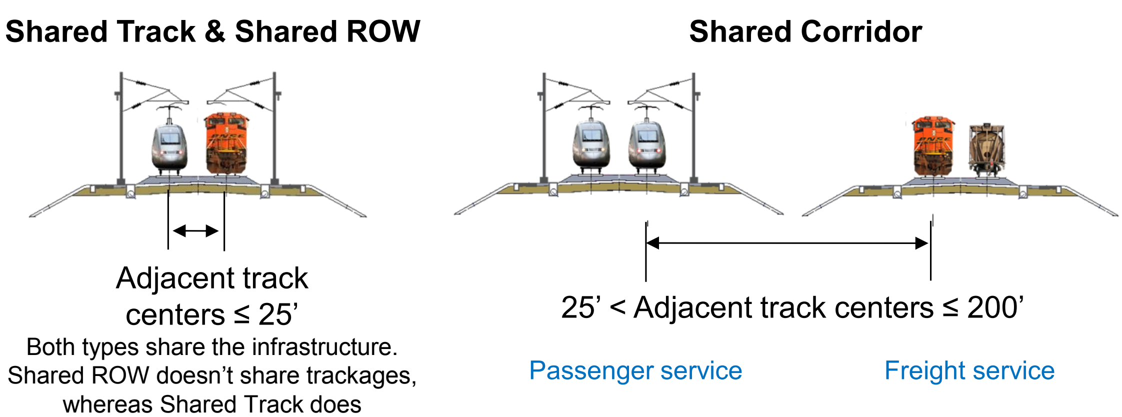


FIGURE 1 Definition of Share Use Corridor *(9)*

Shared-use as compared to the dedicated system has associated advantages and disadvantages. Among the advantages are potentially lower capital costs, less environmental impact, and easier access to urban cores. Among the potential disadvantages include: safety and risk concerns due to more frequent, higher speed operation of passenger trains in close proximity to freight trains and maintenance of way personnel, reduced line capacity due to more heterogeneous operating characteristics, longer travel time compared to very-high-speed rail, tradeoffs in infrastructure and vehicle designs due to differing characteristics of passenger and freight trains as well as other technical and institutional challenges *(1, 9)*.

A high priority for any rail system is operating safety, and there are several concerns associated with operating more frequent, higher-speed passenger trains on shared-use corridors (*9*). Among these are the consequences of a collision between a passenger train and derailed equipment from an adjacent track. Higher passenger train operating speed increases the likely severity of an accident if another train derails and fouls the track on which a passenger train is operating, or alternatively, if a passenger train derails and collides with a freight train on a nearby track (*9*). One approach to this has been to develop robust crash-worthiness standards for passenger equipment that operate in mixed-used circumstances *(10)*. An alternative approach used in most other countries has been to invest heavily in prevention of such accidents. Both approaches are beneficial, but although the U.S. railroad accident rate has been declining for decades, reaching its lowest level ever in 2012 *(11)*, the latter approach is more difficult in the heavy-haul, freight environment because of the 1.5 million railcars owned by hundreds of owners operating over hundreds of thousands of miles throughout the continent. Under a system such as this, optimized for highly efficient freight transport, it is difficult to maintain all these railcars in a sufficiently high condition such that components never fail and cause a derailment. Furthermore, the very high axle loads, commonly ranging from 32 to 40 tons put enormous stress on the infrastructure. Although the infrastructure is designed for these heavy loads, components occasionally develop problems that go undetected until they fail and cause an accident. Besides mechanical and infrastructure related causes, a third major cause of accidents are those due to human factors, in which an individual involved in operating or controlling a train's movement makes an error. Although not necessarily related to heavy-axle-load freight, these accidents also contribute to the risk of shared corridor operations. Another important factor is grade or level crossing accidents. Although nearly all of the world's dedicated HSR lines have complete grade separation between rail and highway lines, shared uses of existing freight infrastructure make the elimination of all grade crossings infeasible.

Literature Review

Despite considerable research on train accident causes, relatively little has focused on passenger train accidents on shared-use corridors. Ullman and Bing *(12)* conducted a general analysis of both freight and passenger train accidents on shared-use corridors in terms of different accident scenarios over the interval 1986 to 1993. However, the number of passenger train accidents was too few to conduct further analysis due to the short time period. The results may be different today due to improvements in railroad technologies and operating practices in the past decades. Barkan et al (*13*) identified major causes of mainline freight train derailments. Anderson *(14)* analyzed freight train derailment probability and severity. He conducted quantitative analyses and developed models to address the effect of freight train accident causes and other factors on position-dependent derailment probabilities of freight cars in a derailed train consist. Schafer and Barkan (*15*) analyzed freight train accident causes and their statistical relationship with train miles versus car miles. Liu et al (*16*) developed models to account for cause-specific-derailment rate and evaluate track improvement strategies. Liu et al (*17*) further conducted accident cause analysis on mainline freight train derailments and analyzed the factors affecting the severity of derailments *(18)*. Their work has contributed to our understanding of freight train accident causes. However, passenger train operations differ from freight train operations in various aspects, including maximum operating speed, train consist, braking ability, crashworthiness, and so forth. Furthermore, in shared trackage and right-of-way operations, passenger train safety may also be affected by freight train safety on the same or adjacent tracks on which passenger trains operate. Therefore, it is important to analyze both passenger and freight train accidents to understand the major factors affecting the safety of shared-use rail corridors.

There are also studies addressing the issue of shared-use rail corridor in other countries, such as in Germany (*19-21*), Japan (*19-21*), South Korea (*19, 20*), Taiwan (*7*), France (*7*) and United Kingdom (*7*). However, most of the studies focused on the interaction among high-speed rail trains, conventional passenger trains, rapid transit rolling stock, and light rail vehicles (LRVs) rather than the interaction between freight trains and passenger trains. One reason might be the proportion of freight train operation is small in other countries as compared to their passenger train network, whereas the situation is the other way around in the U.S. Another reason might be the different physical characteristics of rolling stock, regulatory conditions, railroad cultures and different philosophies in operational practices between the U.S. and elsewhere in the world.

Research Objective

The research described in this paper presents the initial results of a study intended to understand and quantify the most important contributors to the risk of train accidents on shared-used rail corridors. The larger vision of this work is to understand and quantify the most effective means of preventing accidents, and reduce the risk associated with shared-used corridors.

MAINLINE PASSENGER TRAIN ACCIDENT CAUSE ANALYSIS

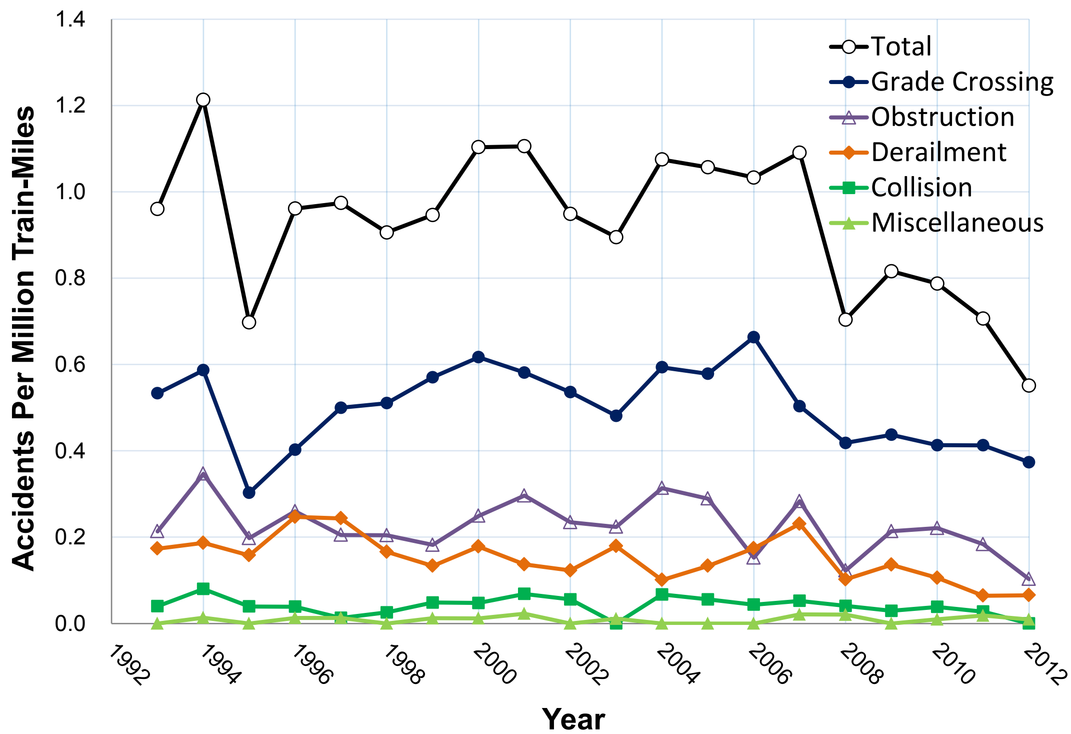
Train accident data from the FRA Rail Equipment Accident database were analyzed to examine the effects of different accident causes on the risk of passenger train accidents. The FRA publishes annual train accident statistic summaries *(22)* but the results are presented at a highly aggregated level *(17)*. More in-depth insights can be found by analyzing these data in more detail and considering other statistical approaches.

The FRA database we analyzed includes all mainline freight and passenger train accidents. These records, however, did not distinguish between accidents occurred on shared or non-shared-use corridors. The FRA database do not have sufficient information regarding accident locations to identify shared-use corridors. However, the majority of passenger trains run on freight owned infrastructures, and most of them are on shared trackage. Therefore, it is reasonable to assume that all the mainline passenger train accidents are on shared-rail corridors. For consistency, we also use all mainline freight train accidents in shared or non-shared-use corridors to conduct the comparison.

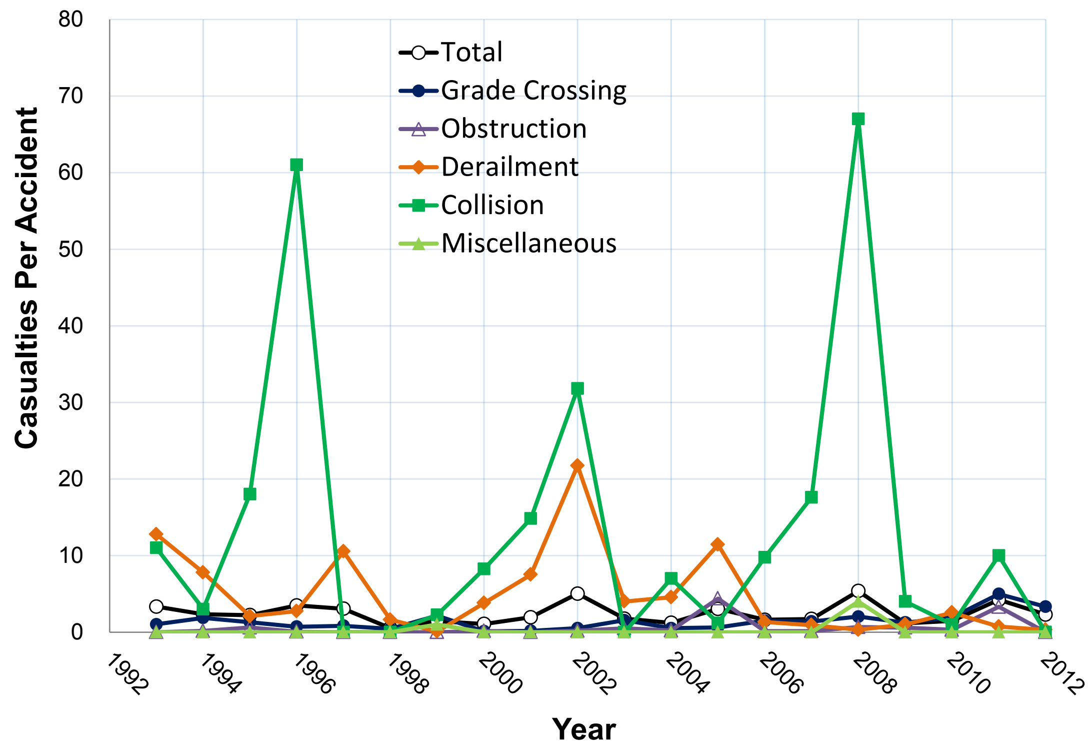
Over the 20-year interval from 1993 to 2012, there were 1,631 mainline passenger train accidents, including 886 grade crossing accidents, 395 obstruction accidents, 263 derailments, 71 collisions, and 16 miscellaneous accidents. Figure 2a shows mainline passenger train accident rate over the 20-year interval sorted by five types of accidents: grade crossing, derailment, collision, obstruction, and miscellaneous. The overall passenger train accident rate has decreased since 1993. Over this period, grade crossing accidents have been the most frequent type of passenger train accident, followed by obstructions and then derailments.

Both the probability of an event and the consequence of the event affect risk. The rate of accident was calculated as accidents per unit distance traveled (Figure 2a). Several different indices were considered to measure consequence (referred to as severity indicators). These included the cost of damage to rolling stock and infrastructure (referred to as damage), number of railcars derailed, and casualties. The average number of rail cars derailed was used as a proxy variable to measure accident severity *(13-17)*. Average casualties is also used because this study is specifically focused on the safety of rail passengers. Casualties, defined as the total number of passenger injuries and fatalities, were chosen as the primary severity indicator, but other severity indicators will also be discussed. These casualties only include passenger injuries and fatalities on board. They do not include railroad employees, trespassers or people committing suicide.

The average casualties in mainline passenger train accidents from 1993 to 2012 were plotted (Figure 2b) by the same five types of accidents as shown in Figure 2a. Annual passenger train casualties fluctuate widely. It is evident that although grade crossings are the most common causes of passenger train accidents (Figure 2a), they do not tend to result in large numbers of passenger casualties. Instead, derailments and collisions generally result in the highest rate of casualties, driven by a relatively small number of severe accidents that resulted in a large number of casualties *(23-33)*. Although there were 1,631 passenger train accidents during the 20-year study period, 144, or less than 10%, resulted in 95% of the casualties.



(2a)



(2b)

FIGURE 2 Mainline Passenger Train Accident Rates (2a) and Average Casualties (2b) by Type of Accidents, 1993 - 2012

To measure the risk from different types of accidents, we plotted the number of accidents per unit train travel to represent the accident frequency versus the average severity of mainline passenger train accidents by type (Figure 3). The graph is divided into four quadrants on the basis of the average frequency and severity along each axis. It enables easy comparison of the relative frequency and severity of different accident types. Accident types in the upper right quadrant would be the most likely to pose the greatest risk because they are both more frequent and more severe than average. The data indicate that the types of train accident most likely to result in high-casualty incidents are derailments and collisions. Although they account for only about 21% of all passenger train accidents, derailments and collision, combined, resulted in about 61% of total casualties (Table 1). Although grade crossings are the most common type of accident, they are among the least severe in their consequences. Collisions and derailments are caused by the interaction of two or more trains and motivate concern in shared-use corridors regarding passenger train collisions with a derailed freight train, or vice versa. Therefore, the next section of this paper examines mainline passenger derailments and collisions in more detail.

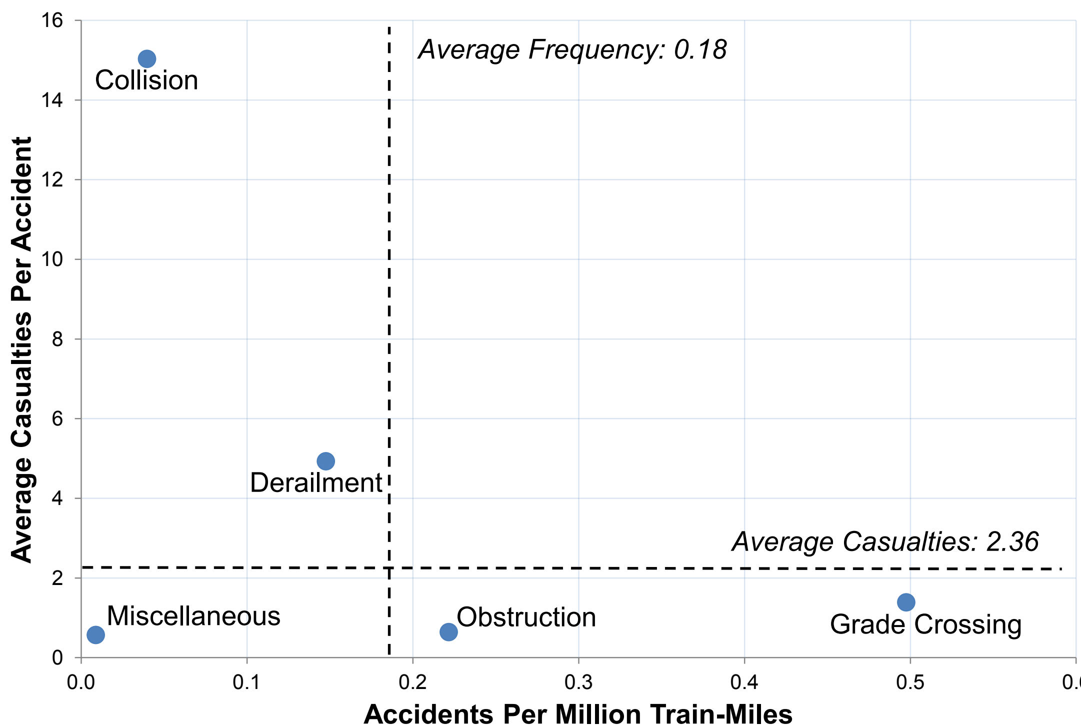


FIGURE 3 Frequency and Severity Graph of Mainline Passenger Train Accidents by Type of Accident, 1993 - 2012

TABLE 1 Accident Frequency and Severity by Type of Accident, Sorted by Frequency

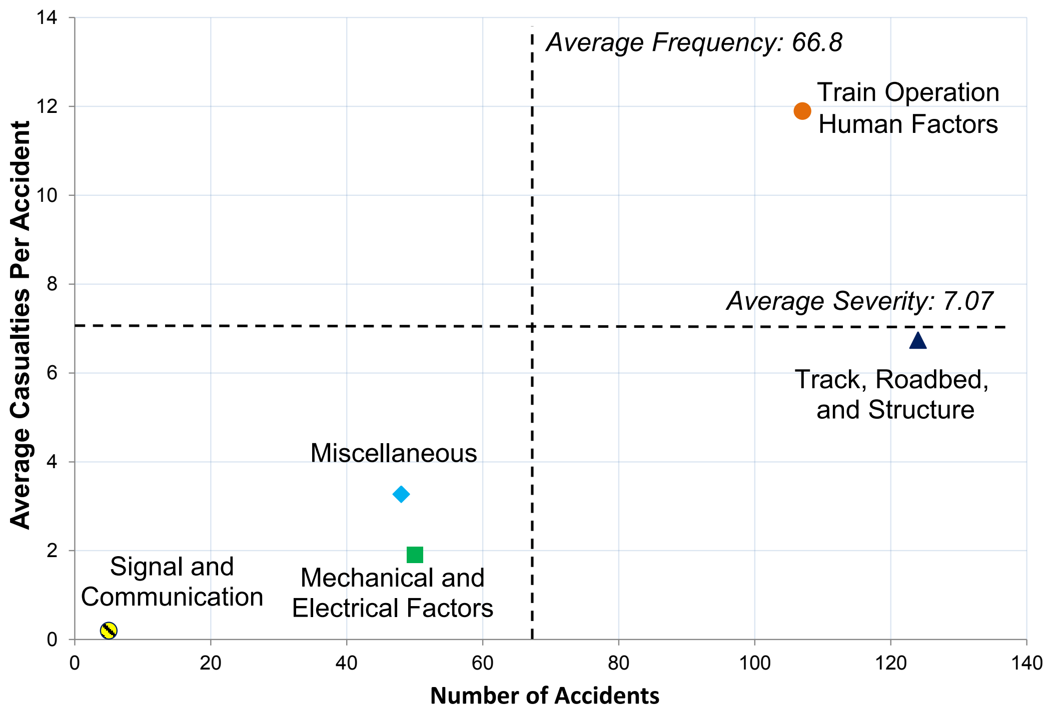
	Frequency	Percentage	Average Accident Rate	Total Casualties	Percentage	Average Casualties
Grade Crossing	886	54.3%	1.385	1,227	31.9%	1.38
Obstruction	395	24.2%	0.222	251	6.5%	0.64
Derailment	263	16.1%	0.148	1,295	33.6%	4.92
Collision	71	4.4%	0.040	1,067	27.7%	15.03
Miscellaneous	16	1.0%	0.009	9	0.2%	0.56
Total	1,631	100.0%	0.916	3,849	100.0%	2.36

Passenger Train Derailment and Collision Accident Cause Analysis

FRA train accident cause codes are hierarchically organized and categorized into major cause groups - track, equipment, human factors, signal and miscellaneous *(34)*. Each of these major cause groups has subgroups that includes individual cause codes of related causes such as roadbed, track geometry, etc. within the track group, and similar subgroups within the other major cause groups. In this paper, alternative FRA subgroups developed by Arthur D. Little (ADL) are used in which similar cause codes were grouped based on expert opinion *(35)*. @ enable greater resolution for certain causes. For example, FRA combines broken rails, joint bars and rail anchors in the same subgroup, whereas the ADL grouping distinguishes between broken rail and joint bar defects *(17)*.

Figure 4 shows the frequency and severity graphs by the major accident cause groups. The graph is also divided into four quadrants to enable easy comparison of the relative frequency and severity of different accident cause groups. Figure 4a uses average casualties as the severity indicator, while Figure 4b uses average cars derailed. In terms of average casualties (Figure 4a), the human factors accident cause group was identified as the most frequent and severe. The infrastructure-related cause group, as represented by Track, Roadbed, and Structures, was more frequent than the human factors accident cause group, but less severe. In terms of average cars derailed (Figure 4b), the infrastructure-related cause group was identified as the most frequent and severe group, and the human factors accident cause group had high frequency but low severity. The infrastructure-related causes led to more cars derailed than human factors accident causes did, whereas human factors accident causes resulted in more casualties than infrastructure-related accident caused.

Both human factors and infrastructure-related accident causes consistently represented the most frequent and severe accident cause groups and therefore were analyzed in more detail.



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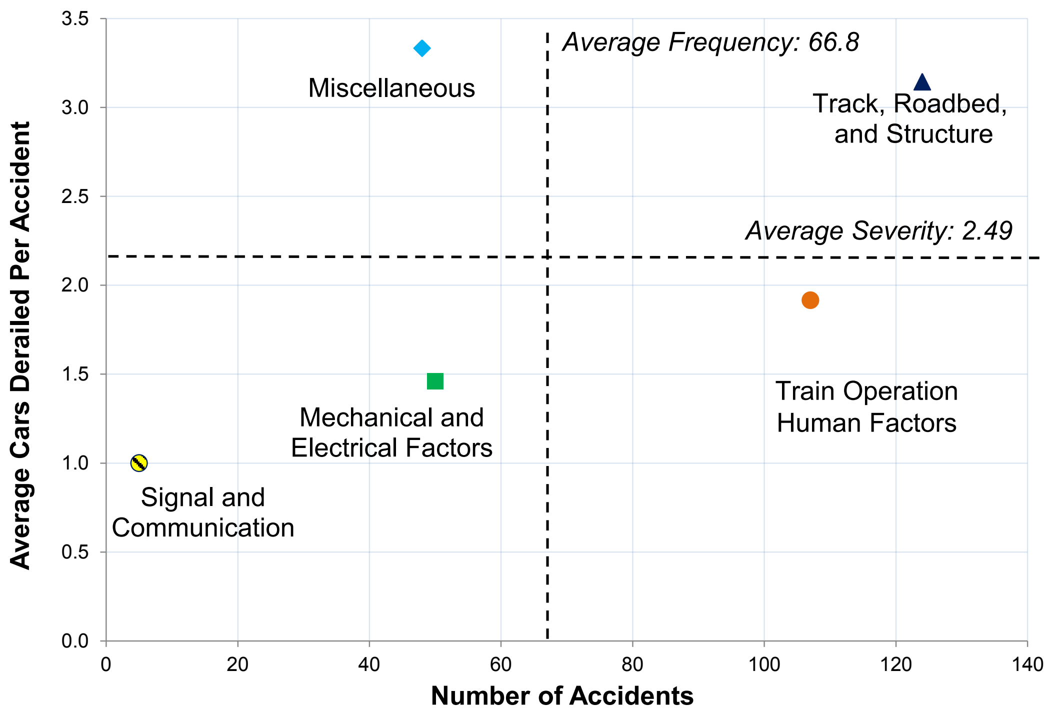


(4b)

FIGURE 4 Frequency and Severity Graph of Mainline Passenger Derailments and Collisions, 1993-2012, by Accident Cause Category with Average Casualties (4a) and Average Cars Derailed (4b) as Severity Indicator

Figure 5 shows the frequency and severity of the more detailed accident cause subgroups for human factors and infrastructure-related cause groups. Similar to the approach shown in Figures 3 and 4, the graph is divided into four quadrants to enable easy comparison of the relative frequency and severity of different accident cause subgroups. Each data point in Figure 5 represents one accident cause subgroup. Data points with the same color and shape indicate that these accident cause subgroups are in the same accident cause category. In terms of average casualties, four accident cause subgroups were in the upper right quadrant in Figure 5a, which were most likely to pose the greatest risk due to their high frequency and severity. They include:

- Failure to Display/Obey Signals (Human Factors)
- Train Speed (Human Factors)
- Miscellaneous Human Factors (Human Factors)
- Track Geometry Excluding Wide Gauge (Infrastructure-related)

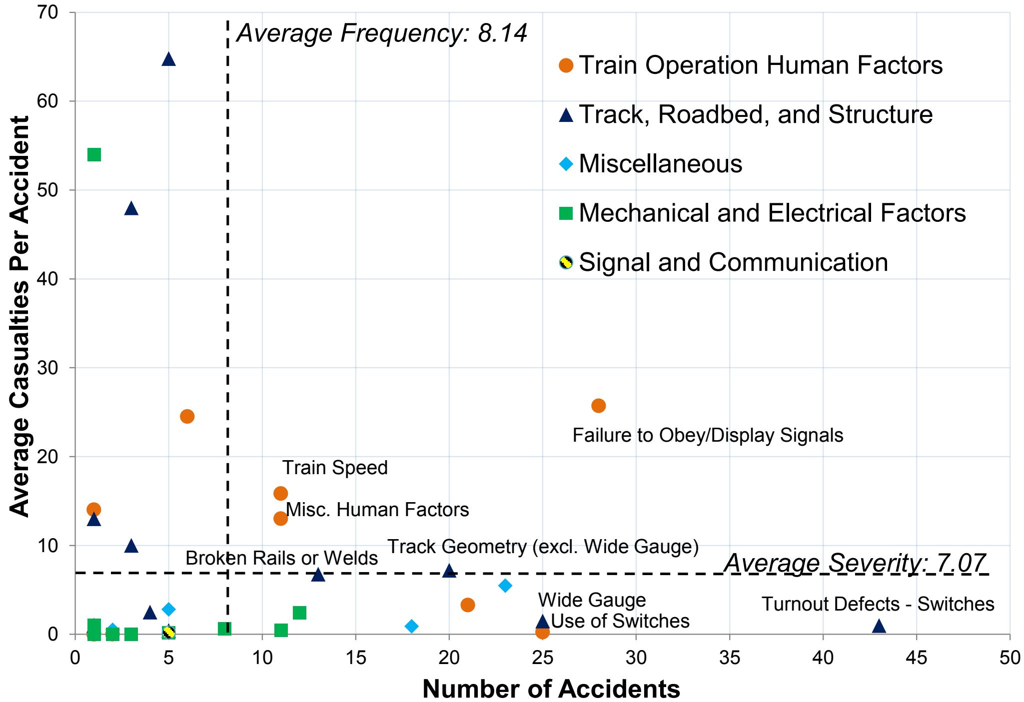
These subgroups account for about 21% of all mainline passenger derailments and collisions and 44% of total casualties (Table 2).

Similarly, in terms of average cars derailed, five accident cause subgroups were identified in the upper right quadrant in Figure 5b:

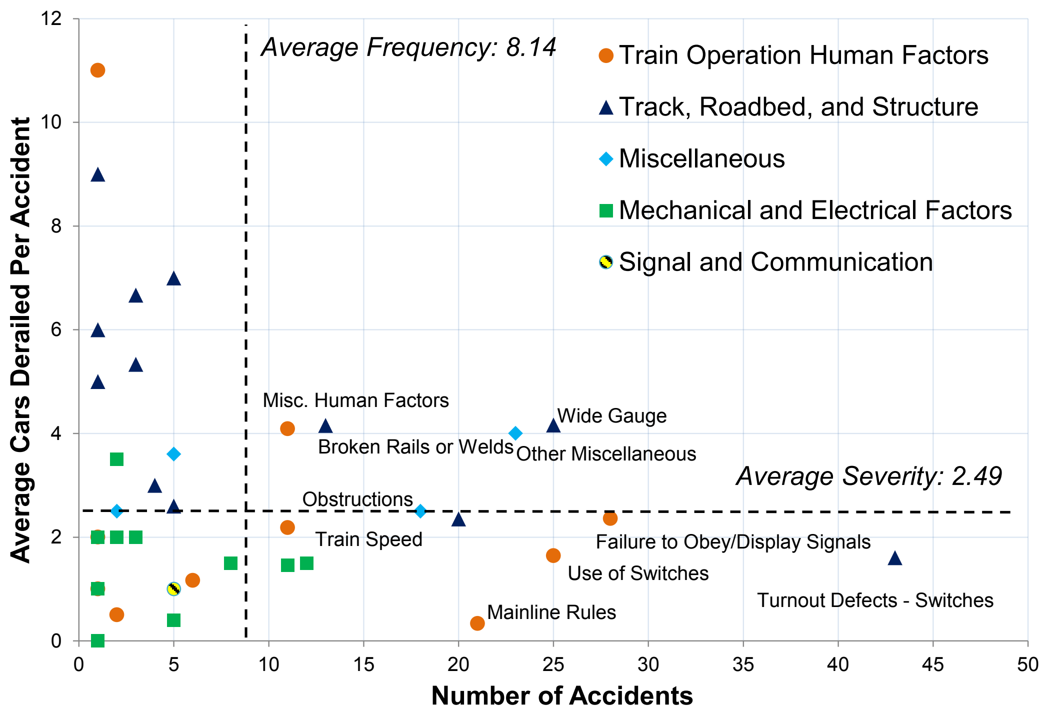
- Broken Rails or Welds (Infrastructure-related)
- Other Miscellaneous (Miscellaneous)
- Wide Gauge (Infrastructure-related)
- Miscellaneous Human Factors (Human Factors)
- Obstructions (Miscellaneous)

These subgroups account for 27% of all mainline passenger derailments and collisions and 41% of total cars derailed (Table 2).

Among all the subgroups identified in the top-right .
\+ Broken Rails or Welds and
had the highest average cars derailed per accident. Note that ellaneous
appeared on the upper right quadrant in both figures.



(5a)



(5b)

FIGURE 5 Frequency and Severity Graph of Mainline Passenger Derailments and Collisions, 1993-2012, by Accident Cause Groups with Average Casualties (5a) and Average Cars Derailed (5b) as Severity Indicator

TABLE 2 Derailment and Collision Frequency and Severity by Accident Cause Subgroup, Sorted by Frequency

				Accident Per	Casualties			Cars Derailed		
	Cause Subgroup Description	Frequency	Percentage	Million Train-Miles	Total	Percentage	Average	Total	Percentage	Average
10T	Turnout Defects - Switches	43	12.9%	0.024	42	1.8%	1.0	69	8.3%	1.6
05H	Failure to Obey/Display Signals	28	8.4%	0.016	720	30.5%	25.7	66	7.9%	2.4
03T	Wide Gauge	25	7.5%	0.014	37	1.6%	1.5	104	12.5%	4.2
11H	Use of Switches	25	7.5%	0.014	6	0.3%	0.2	41	4.9%	1.6
05M	Other Miscellaneous	23	6.9%	0.013	126	5.3%	5.5	92	11.0%	4.0
08H	Mainline Rules	21	6.3%	0.012	69	2.9%	3.3	7	0.8%	0.3
04T	Track Geometry (excl. Wide Gauge)	20	6.0%	0.011	144	6.1%	7.2	47	5.6%	2.4
01M	Obstructions	18	5.4%	0.010	16	0.7%	0.9	45	5.4%	2.5
08T	Broken Rails or Welds	13	3.9%	0.007	88	3.7%	6.8	54	6.5%	4.2
15E	Loco Trucks/Bearings/Wheels	12	3.6%	0.007	29	1.2%	2.4	18	2.2%	1.5
10H	Train Speed	11	3.3%	0.006	174	7.4%	15.8	24	2.9%	2.2
12H	Misc. Human Factors	11	3.3%	0.006	143	6.1%	13.0	45	5.4%	4.1
18E	All Other Car Defects	11	3.3%	0.006	5	0.2%	0.5	16	1.9%	1.5
13E	Other Wheel Defects (Car)	8	2.4%	0.004	5	0.2%	0.6	12	1.4%	1.5
02H	Handbrake Operations	6	1.8%	0.003	147	6.2%	24.5	7	0.8%	1.2
02T	Non-Traffic, Weather Causes	5	1.5%	0.003	324	13.7%	64.8	35	4.2%	7.0
03M	Lading Problems	5	1.5%	0.003	2	0.1%	0.4	13	1.6%	2.6
12T	Misc. Track and Structure Defects	5	1.5%	0.003	14	0.6%	2.8	18	2.2%	3.6
06E	Centerplate/Carbody Defects (Car)	5	1.5%	0.003	1	0.0%	0.2	2	0.2%	0.4
01S	Signal Failures	5	1.5%	0.003	1	0.0%	0.2	5	0.6%	1.0
09T	Other Rail and Joint Defects	4	1.2%	0.002	10	0.4%	2.5	12	1.4%	3.0
05T	Buckled Track	3	0.9%	0.002	144	6.1%	48.0	16	1.9%	5.3
06T	Rail Defects at Bolted Joint	3	0.9%	0.002	30	1.3%	10.0	20	2.4%	6.7
17E	All Other Locomotive Defects	3	0.9%	0.002	0	0.0%	0.0	6	0.7%	2.0
04M	Track-Train Interaction	2	0.6%	0.001	0	0.0%	0.0	1	0.1%	0.5
07H	Switching Rules	2	0.6%	0.001	1	0.0%	0.5	5	0.6%	2.5
11E	Other Axle/Journal Defects (Car)	2	0.6%	0.001	0	0.0%	0.0	7	0.8%	3.5
16E	Loco Electrical and Fires	2	0.6%	0.001	0	0.0%	0.0	4	0.5%	2.0
05E	Other Brake Defect (Car)	1	0.3%	0.001	13	0.6%	13.0	6	0.7%	6.0
04H	Employee Physical Condition	1	0.3%	0.001	1	0.0%	1.0	9	1.1%	9.0
01T	Roadbed Defects	1	0.3%	0.001	1	0.0%	1.0	5	0.6%	5.0
07T	Joint Bar Defects	1	0.3%	0.001	14	0.6%	14.0	11	1.3%	11.0
11T	Turnout Defects - Frogs	1	0.3%	0.001	0	0.0%	0.0	1	0.1%	1.0
04E	UDE (Car or Loco)	1	0.3%	0.001	0	0.0%	0.0	2	0.2%	2.0
06H	Radio Communications Error	1	0.3%	0.001	1	0.0%	1.0	2	0.2%	2.0
09H	Train Handling (excl. Brakes)	1	0.3%	0.001	54	2.3%	54.0	0	0.0%	0.0
07E	Coupler Defects (Car)	1	0.3%	0.001	0	0.0%	0.0	1	0.1%	1.0
09E	Sidebearing, Suspension Defects (Car)	1	0.3%	0.001	0	0.0%	0.0	2	0.2%	2.0
12E	Broken Wheels (Car)	1	0.3%	0.001	0	0.0%	0.0	2	0.2%	2.0
19E	Stiff Truck (Car)	1	0.3%	0.001	0	0.0%	0.0	1	0.1%	1.0
20E	Track/Train Interaction (Hunting) (Car)	1	0.3%	0.001	0	0.0%	0.0	0	0.0%	0.0
	Total	334	100.0%	0.188	2,362	100.0%	7.07	833	100.0%	2.49

Effect of Speed on Passenger Train Accident Cause

Train speed is an important factor in train accident analysis. Previous research has shown that train speed at the time of an accident affects the frequency and severity of accidents (*13, 14, 15, 17, 18, 36, 37, 38*). Figure 6 shows the number of mainline passenger train derailments and collisions by speed and accident cause category. The majority of the train accidents, about 57%, occurred below 20 mph. The main reason that passenger train accidents occur at lower speeds might be because these accidents occur at the defective mainline switches near stations, terminals, and the ends of sidings. At these locations, trains are likely to slow down due to scheduled stop or train pass/meet activities. Therefore, the train speed will be lower when the accident occurred at these locations, while the underlying reason of result is the defective switches. Infrastructure-related accidents are the most frequent at speed range 0 to 19 mph, 40 to 59 mph, and above 60 mph, while human factors related accidents are the most frequent at speed range 20 to 39 mph. Infrastructure-related accident and human factor related accidents are more frequent than others at all speed bands. Figure 7 shows the same graph but with more detailed accident cause subgroups. At speeds below 20 mph, turnout defects switches are the leading cause of derailments and collisions, while at speeds above 20 mph and below 40, failure to obey/display signals is the leading cause. The ranking of accident cause categories and subgroups in each speed band is subject to uncertainty due to the small data size.

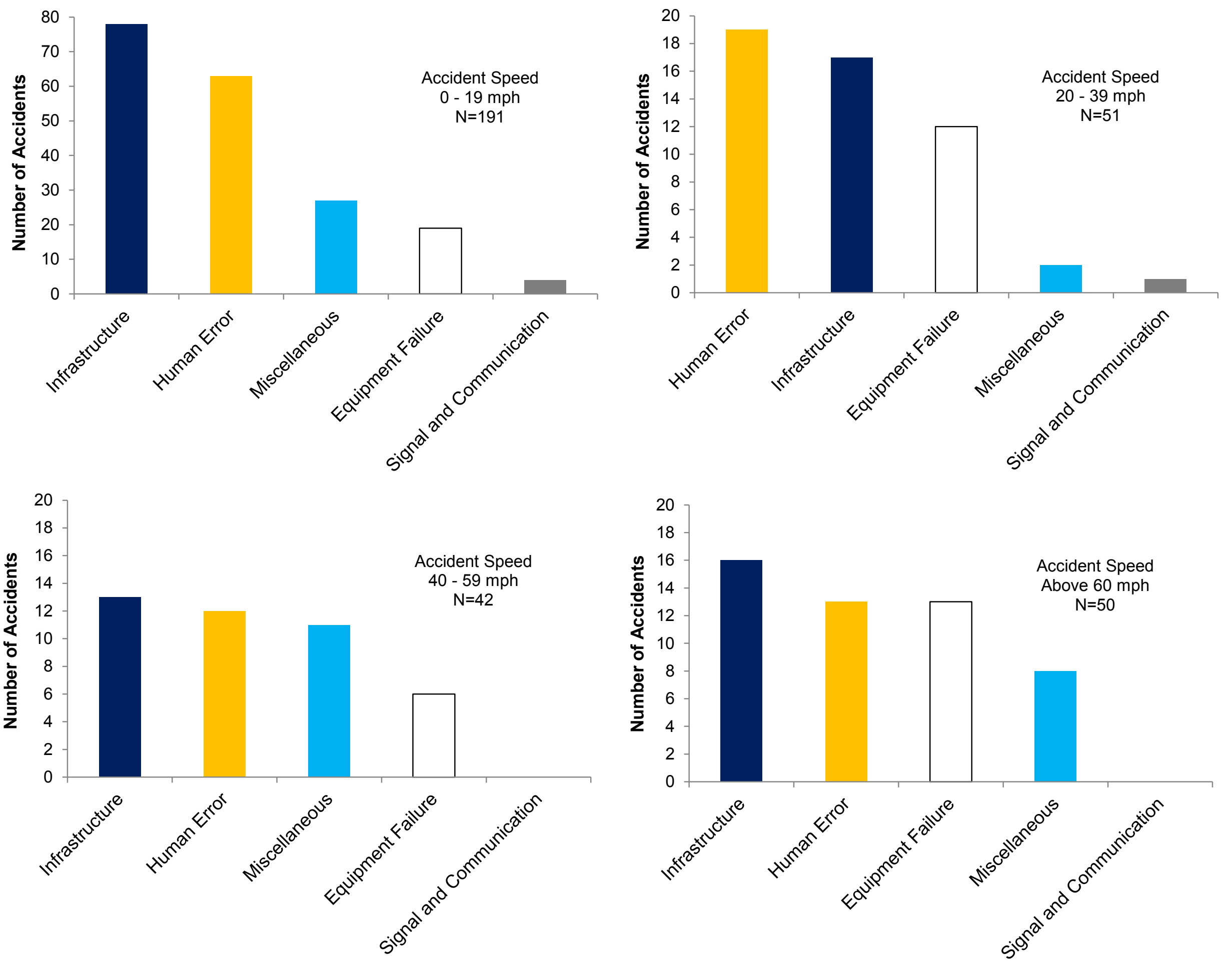


FIGURE 6 Number of Mainline Passenger Train Derailments and Collisions by Speed and Accident Cause Category, 1993 – 2012

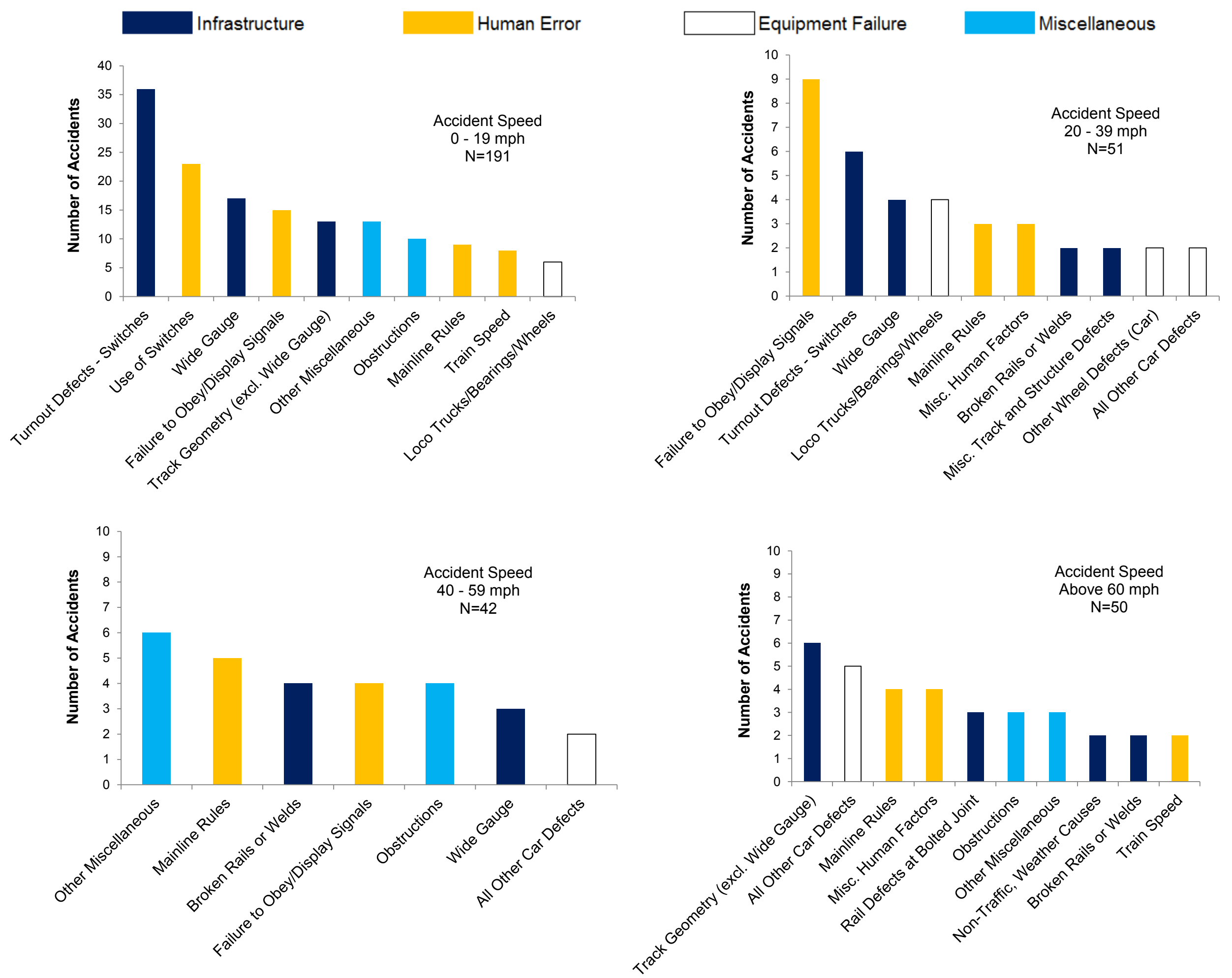


FIGURE 7 Number of Mainline Passenger Train Derailments and Collisions by Speed and Accident Cause Subgroup, 1993 – 2012

Accident Cause Comparison between Freight and Passenger Trains

By definition shared trackage and ROW operations involve passenger and freight trains sharing infrastructure, so it is important to understand the major accident causes of both types of train operation. If they have different trends, it is important to examine the factors affecting the difference. Mainline freight train derailment and collision records were collected from FRA Rail Equipment Accident database and were organized by their accident cause subgroups. There were 13,563 derailments and 851 collisions over the 20-year time period from 1993 to 2012. Table 3 shows the top ten most frequent accident cause subgroups for both mainline freight and passenger train derailments and collisions.

Overall, the accident rates of freight train accident are higher than the accident rates of passenger train accident regardless of accident causes. There were six accident cause subgroups in both top-ten lists. Most of the common cause subgroups were related to infrastructure defects because derailments are more frequent than collisions in both passenger and freight accidents, and most derailments were caused by infrastructure defects. The common accident cause subgroups were:

- Turnout Defects   Switches (Infrastructure-related)
- Wide Gauge (Infrastructure-related)
- Use of Switches (Human Factors)
- Other Miscellaneous (Miscellaneous)
- Track Geometry Excluding Wide Gauge (Infrastructure-related)
- Broken Rails or Welds (Infrastructure-related)

The most frequent accident cause subgroup for passenger train accidents is turnout defects   switches, while for freight train accidents, it is broken rails or welds. Although the infrastructure defects cause the majority of derailments for both passenger and freight service, there were different specific causes leading to freight and passenger train derailments. From risk management perspective, this provided additional information on mitigating the risk on shared-use rail corridors. For instance, on a freight-traffic-only line, we would prioritize the mitigation strategies that could reduce the occurrence of certain infrastructure defects which are significant in freight train accidents (e.g. broken rails or welds) (*17, 39, 40*). On a corridor with both passenger and freight train traffic, we would have to consider the prevalent accident causes for both freight train derailments and passenger train derailments (e.g. broken rails or welds and turnout defects). Some human factor + . +were only in the top-ten list of passenger train accidents, whereas other infrastructure-related causes, A +were only in the top-ten list of freight train accidents (Table 4).

TABLE 3 Comparisons of Top 10 Frequent Accident Cause Groups Between Mainline Passenger and Freight Train Derailments and Collisions, 1993 - 2012

Passenger Train Derailments and Collisions

Rank		Cause Subgroup Description	Number of Accidents	Percentage	Accident Per Million Train-Miles
1	10T	Turnout Defects - Switches	43	12.9%	0.024
2	05H	Failure to Obey/Display Signals	28	8.4%	0.016
3	03T	Wide Gauge	25	7.5%	0.014
4	11H	Use of Switches	25	7.5%	0.014
5	05M	Other Miscellaneous	23	6.9%	0.013
6	08H	Mainline Rules	21	6.3%	0.012
7	04T	Track Geometry (excl. Wide Gauge)	20	6.0%	0.011
8	01M	Obstructions	18	5.4%	0.010
9	08T	Broken Rails or Welds	13	3.9%	0.007
10	15E	Loco Trucks/Bearings/Wheels	12	3.6%	0.007

Freight Train Derailments and Collisions

Rank		Cause Subgroup Description	Number of Accidents	Percentage	Accident Per Million Train-Miles
1	08T	Broken Rails or Welds	1,948	13.5%	0.182
2	04T	Track Geometry (excl. Wide Gauge)	1,122	7.8%	0.105
3	03T	Wide Gauge	974	6.8%	0.091
4	10E	Bearing Failure (Car)	718	5.0%	0.067
5	09H	Train Handling (excl. Brakes)	661	4.6%	0.062
6	05T	Buckled Track	560	3.9%	0.052
7	05M	Other Miscellaneous	550	3.8%	0.051
8	10T	Turnout Defects - Switches	510	3.5%	0.048
9	11H	Use of Switches	497	3.4%	0.046
10	04M	Track-Train Interaction	435	3.0%	0.041

TABLE 4 Proportion of Derailment and Collision (Resulting from Various Accident Cause Groups) According to Type of Operation

	Passenger Train Accidents				**Freight Train Accidents**			
Number of	Derailments	Percentage	Collisions	Percentage	Derailments	Percentage	Collisions	Percentage
Infrastructure Related Causes	122	46.4%	2	2.8%	6,299	46.4%	19	2.2%
Human Factor Causes	58	22.1%	49	69.0%	2,197	16.2%	671	78.8%
Other Causes	83	31.6%	20	28.2%	5,067	37.4%	161	18.9%
Total	263	100.0%	71	100.0%	13,563	100.0%	851	100.0%
Percentage of All Accidents	**78.7%**		**21.3%**		**94.1%**		**5.9%**	

CONCLUSION

This paper presents the initial results of a study to identify the most important contributors to the risk of passenger train accidents on shared-used rail corridors. Derailments and collisions were identified as the most potentially significant train accident types while human factors accidents and track failures were the primary causes of those accidents. Some accident causes related to human factors on train operations were identified to have high risk such as train speed violation and not obeying signals. Some high-risk infrastructure-related factors include track geometry defects and broken rails or welds. Most passenger train derailments and collisions occurred at lower speed. Comparison of causes between freight and passenger accidents shows some infrastructure-related causes are common in both types of train accidents. Causes related to human factors are relatively more frequent on passenger train accidents, while infrastructure-related causes are relatively more prevalent on freight train accidents. This analysis of train accident causes is important for rational allocation of resources to reduce accident occurrence and consequences on shared-use corridors. Future work in this area will include how to quantitatively evaluate the risk from these causes and how these accident causes affect the likelihood of adjacent track derailments.

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