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Analysis of North American Freight Rail Single-Person Crews: Safety and Economics

Association of American Railroads

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MARSH & McLENNAN COMPANIES

Contents

I. Executive Summary 1
II. Introduction 4
A. Summary of FRA Proposed Rulemaking 4
B. Overview of Positive Train Control 4
III. Background and Context of Single-Person Crews 6
A. Existing North American Single-Person Operations 6
IV. International Experience with Single-Person Crews 9
A. Relevant Deployment 9
B. Operating Case Studies: European Union 11
C. Safety Record 15
V. Safety Analysis and Comparison 17
A. Availability and Reporting Requirements for Railroad Safety Statistics 17
B. Potentially Relevant Safety Statistics 19
C. Statistical Comparison of Relevant Safety Data: Intra-US 21
D. Statistical Comparison of Relevant Safety Data: US versus Europe 27
E. Summary of Safety Analysis Findings 36
VI. Economic Analysis 37
A. Economic Model and Scenario Overview 37
B. Approach and Assumptions 37
C. Scenario A Modeling Results 44
D. Scenario B Modeling Results 47
E. Summary of Economic Analysis Findings 49
VII. Conclusion 50
Annex A. Safety Analysis Input Detail 51

I. Executive Summary

Existing Federal Railroad Administration (FRA) regulations do not mandate minimum crew requirements, although standard freight rail industry practice since 1991 has been to use a minimum of two employees per crew for over-the-road operations. In April 2014, however, the FRA announced its intention to issue a Notice of Proposed Rulemaking (NPRM) that would most likely require a minimum of two-person crews for most mainline train operations.

Multiple-person train crews have been the freight railroad industry norm over the past several decades for two reasons: 1) industry labor agreements have required them; 2) multiple-person crews made sense from an economic standpoint, as they could expeditiously handle work events between terminals and resolve en route equipment failures more quickly than a single-person crew. As labor relations, technology, and railroad operations continue to evolve, however, the need for multiple-person train crews for over-the-road trains is rapidly waning.

The FRA's proposed crew size rule appears to run counter to trends, both in the US and abroad, that are driving the use of single-person train crews. There is a long history of technological improvements in the railroad industry leading to productivity gains while, at the same time, setting new safety records. The advent of diesel locomotives eliminated the need for firemen; end-of-train (EOT) devices eliminated the need for a caboose and personnel at the end of the train; and remote controlled locomotives (RCL) have eliminated the need for locomotive engineers on many yard jobs.

Now, the Class I railroad industry is in the process of implementing federally mandated positive train control (PTC) on some 60,000 miles of railroad track (and at a total cost, including 20 years of maintenance, of up to $13.2 billion). PTC is designed to provide additional remote and continuous monitoring of train crews to automatically override any human error in controlling train speed and movements. By its design, PTC-based monitoring will render redundant the additional person in multiple-person train crews on affected routes. Other factors affecting railroad industry consideration of single-person train operations is the need to reduce costs for non-productive assets.

Single-person crews are neither novel nor untested. In North America, Amtrak and commuter rail operations both make use of single-person crews (in the cab). Regional freight railroads Indiana Rail Road (INRD) in the United States and the Quebec North Shore and Labrador (QNS&L) in Canada operate a significant number of trains with single-person crews.

Internationally, the use of single-person crews for trains is widespread in developed markets similar to the United States in size and complexity. In Europe and Australia for example, the use of single-person crews is the dominant practice on many freight railroads, including those in Germany, France, Sweden, Australia, the United Kingdom, and Queensland/New South Wales.

Safety Analysis and Comparison

Oliver Wyman screened public data on safety from the FRA and the European Railway Agency (ERA) to develop a set of safety statistics that could be used to compare the safety records of single- and multiple-person crews. Statistics were deemed relevant for this analysis where the crew had some degree of control over the incident, and where the presence of multiple persons versus one person in the cab could *arguably* make a difference in the outcome of the incident.[1]

For intra-US data, Oliver Wyman compared aggregate statistics on relevant equipment incidents and casualty incidents for 2007 through 2013 for operators using single-person crews (Amtrak, commuter operators, and INRD) versus operators using multiple-person crews (Class Is and other regional freight railroads). Across equipment incidents (derailments and collisions) and casualty incidents (serious injuries and fatalities), the analysis found that single-person train crew operations were as safe as multiple-person train crew operations.

For the US versus Europe, Oliver Wyman developed a comparative data set for 2007 through 2012 for US Class I rail operators and a selection of major European freight railroads that make use of single-person train crews. Oliver Wyman analyzed safety data for collisions, derailments, serious employee injuries, fatalities, and signals passed at danger. For all of these categories, major European operators using single-person crews appeared to be as safe as Class I multiple-person crew operations.

In addition, it is worth noting that there has been a positive long-term trend of declining rail accident risk within the European Union (EU), despite significant cuts in railroad staff and the expansion of single-person crew operations. In fact, those EU countries with the best safety records (least fatalities and weighted serious injuries per million train-kilometers) are all countries where railroads operate with single-person crews.

Economic Analysis

Oliver Wyman also developed an economic model to establish the value of single-person crew operations to the US Class I freight railroad industry. Two scenarios were modeled to represent the range of potential single-person crew operating options: the removal of trainmen (i.e., conductors) from all road trains without intermediate work, and the removal of trainmen only from road trains operating on high-density lines (on low-density rail lines, the use of round-the-clock utility personnel would be far more expensive than retaining the trainman position on the few trains operating over those lines). Together, these two scenarios bracket the range of

[1] The data is not robust enough to support a direct causal relationship, nor can other factors be discounted for which data is not readily available, such as level of experience and training of crews.

operational configurations that railroads could employ when implementing single-person crew operations.

Oliver Wyman modeled the savings that would be realized by the railroads on an aggregate basis under each scenario for 2013 and for 2020 through 2029 (since single-person crew operations are unlikely to be fully implemented prior to 2020). In both scenarios, the railroads would realize significant reductions to their cost of operations.

In conclusion, single-person crew operations are widespread in the world and appear to be as safe as multiple-person crew operations, even on complex systems running many mixed freight and passenger trains per day, as is the case in major European countries. With the coming implementation of PTC and other technologies that reduce human error and work on trains, single-person train crew operations could make sense on significant portions of the US Class I rail network. Reductions in train crew size would provide significant cost savings, which in turn could be used by the railroads to fund further capital and safety improvements. Prohibiting railroads from using technological improvements to reduce crew size greatly decreases the railroads' ability to control operating costs, without making the industry any safer.

II. Introduction

A. Summary of FRA Proposed Rulemaking

Existing FRA regulations do not mandate minimum crew requirements, although standard freight rail industry practice is to use two-person crews for over-the-road operations. In an April 9, 2014 press release, the FRA announced its intention to issue an NPRM that would require two-person crews on crude oil trains and establish minimum crew sizes for most mainline freight and passenger rail operations. The FRA further noted in its press release that the NPRM "will most likely require a minimum of two-person crews for most mainline train operations."[2]

The proposed rulemaking follows in the wake of the formation of three Railroad Safety Advisory Committee (RSAC) Working Groups, as requested by the US Department of Transportation (DOT) following the Lac-Megantic, Quebec derailment. These groups were asked to evaluate a number of different proposals to enhance railroad safety. Two produced recommendations that were adopted by the full RSAC for consideration in future rulemakings. The Working Group on "Appropriate Train Crew Size," failed to reach consensus, according to the FRA. Despite this, and a lack of data on the safety of two-person crews versus single-person crews, the agency has determined to proceed with direct rulemaking.

B. Overview of Positive Train Control

Any measurement of the potential benefits of a mandatory two-person crew must look closely at the safety improvements provided by PTC. PTC is a system of train control that is "designed to override human error in controlling the speed and movement of trains."[3] In essence, it is a more modern signaling control system.

Currently, there are three types of signaling control systems in use in the United States: No signal, otherwise known as "dark territory," automatic block signaling (ABS), and centralized traffic control (CTC). CTC automates the lining of turnouts and integrates this with the signal system affording the highest (excluding PTC) level of control, automation, and integration of safety logic. Dark territory is completely manual and has the lowest level of control.

CTC, which is common on medium and high density lines, allows a dispatcher to remotely operate a series of interlocking signals and switches, and ensures that conflicting movements of

[2] "FRA to Issue Proposed Rule on Minimum Train Crew Size," press release number FRA 03-14, Federal Railroad Administration, April 9, 2014 (http://www fra.dot.gov/eLib/Details/L04999).
[3] "U.S. Rail Transportation of Crude Oil: Background and Issues for Congress," Congressional Research Service, May 5, 2014, p. 21.

trains are not authorized (i.e., that two trains are not sharing the same section of track).[4] PTC is essentially the next generation of signal system after CTC and is expected to provide an additional layer of safety by ensuring that an inattentive crew cannot accidently move their train into unauthorized territory or operate above authorized speeds.

The Rail Safety Improvement Act (2008) requires each Class I railroad carrier and each entity providing regularly scheduled intercity or commuter rail passenger transportation to implement PTC on all segments or routes of mainline railroad tracks that (a) carry intercity passenger or commuter rail service, or (b) carry more than five million gross tons of freight per year and also are used for transporting poison-by-inhalation hazardous materials (PIH) (more commonly known as TIH – toxic inhalation hazard).[5] This mandate is expected to apply to about 60,000 miles of railroad track.

As per federal law, PTC it is a "system designed to prevent train-to-train collisions, over speed derailments, incursions into established work zone limits, and the movement of a train through a switch left in the wrong position."[6] The government has not imposed technical specifications for PTC systems, but all PTC systems share similar characteristics, and most importantly, from a safety perspective, "if the locomotive is violating a speed restriction or movement authority, onboard equipment will automatically slow or stop the train."[7] Thus, PTC essentially takes the place of a second crew member in the cab. Indeed, as a recent article noted, "On four occasions since September 2010, multi-person crews have been involved in serious train accidents where human error was the cause. PTC likely would have prevented each of the accidents."[8]

The cost to implement PTC – an unfunded mandate – for the major railroads will be significant: The FRA itself has estimated total capital costs for full deployment on all affected railroads, as well as 20 years of maintenance, to be up to $13 billion.[9]

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[4] Frank W. Bryan, "Railroad Traffic Control Systems," (http://trn.trains.com/railroads/abcs-of-railroading/2006/05/railroads-traffic-control-systems).
[5] P.L. 110-432, §104.
[6] US Code of Federal Regulations, Title 49, Section §236.
[7] "Positive Train Control (PTC): Overview and Policy Issues," Congressional Research Service, July 30, 2012, summary page.
[8] "Data drought haunts FRA crew-size mandate," *Railway Age*, April 11, 2014 ((http://www railroadage.com/index.php/blogs/frank-n-wilner/data-drought-haunts-fra-crew-size-mandate html).
[9] "Positive Train Control Systems Economic Analysis," Federal Railroad Administration, FRA-2006-0132, Notice No. 1, July 10, 2009, p. 120.

III. Background and Context of Single-Person Crews

A. Existing North American Single-Person Operations

Single-person crew operations currently exist in North America. Although labor agreements or, until recently, technology issues, generally have precluded the use of single-person crews in freight operations on Class I railroads, single-person crews are in use by other types of rail operators.

1. Amtrak and Commuter Operations

Amtrak often operates trains with a single person in the cab controlling train movements; the rest of the crew is entrained with the passengers. As the locomotive is usually isolated from the rest of the train, the locomotive engineer is physically isolated from the rest of the crew. Amtrak has operated single-person crews on the Northeast and Keystone corridors for more than 20 years.[10]

Safety backup for the engineer on the Northeast Corridor and Keystone lines is provided through the Advanced Civil Speed Enforcement System (ACSES), which can ensure compliance with speed restrictions, or signal indications, in the event of loss of engineer attentiveness. The system also includes cab signals, which allow the operator to be aware of the signal ahead and permitted approach speed, even in adverse weather conditions or on curves that may block the road signal view. In addition, on Amtrak's Michigan corridor, an ITCS (Incremental Train Control System) is used, which enforces signal compliance and conformance to temporary speed limits.[11]

Amtrak also uses single-person crews on their long distance trains where the planned duration of the engine crew's run is less than six hours. On these routes, the safety system is the same for the Amtrak trains and the freight trains operated by the host railroad. Amtrak estimates that 95 percent of its engine crews called to work comprise only one person.[12]

Overall safety of single-person crew operation on Amtrak is also supported by maintaining equipment in good condition and responsible scheduling of engineer shifts. Data presented in a 1985 US Government Accountability Office report shows no deterioration of operational safety and a decline in the number of injuries to employees over five years of Amtrak single-person operations from 1979 to 1984.[13]

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[10] "Amtrak's Northeast Corridor Trains Operate with a One-Person Locomotive Crew," US Government Accountability Office (GAO), April 18, 1985 (http://www.gao.gov/products/RCED-85-1).
[11] "Are two-person crews less safe than a single engineer?" *Railway Age*, December 2013 (http://www railroadage.com/index.php/blogs/frank-n-wilner/are-two-person-crews-less-safe-than-a-single-engineer html).
[12] Amtrak, 2014.
[13] "Amtrak's Northeast Corridor Trains," US GAO, op. cit.

Similarly, locomotive engineers operating trains from either locomotives or cab cars on commuter lines also are physically isolated (either the locomotive is separate from the passenger compartments, or there is only space for one person in the controller's cabin). Metrolink in California operates commuter trains with single-person crews over an Automatic Train Stop (ATS) system, which provides control of signal violation and over speed. In a dedicated 16-month pilot project, following the fatal Chatsworth, California accident in 2008, Metrolink converted 13 percent of its train operations to two-person crews. In reports to the California Public Utilities Commission in 2010, Metrolink found no evidence of increased safety of operations with two-person crews versus single-person crew operation.[14]

Other commuter railroads that operate over Class I freight lines (such as Chicago's Metra system), use Automatic Train Control (ATC) systems that will stop the train if the engineer does not acknowledge alerts or signals, although such systems do not enforce speed compliance.

2. US Non-Class I Operations

There are a small number of freight rail operations in North America that have utilized, or are currently utilizing, single-person crews. Montreal, Maine and Atlantic[15] and Wisconsin Central prior to its purchase by CN have operated trains with single-person crews in the United States. Their operations have been suspended, however, for various economic and/or state regulatory reasons.

One railroad that continues to employ single-person crews is Class II INRD, a regional railroad located in the US Midwest. INRD runs approximately 40 percent of its trains with single-person crews. [16] The INRD operates over about 500 miles of track, including in downtown Indianapolis.[17] Another railroad that makes limited use of single-person crews is the Genesee & Wyoming (G&W).

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[14] "Data drought haunts FRA crew-size mandate," *Railway Age*, April 2014, op. cit.

[15] In the case of the MM&A, single-person crew operations were suspended after an incident on July 6, 2013, where the engineer of a single-person crewed train failed to properly secure his train. The train rolled uncontrolled into the town of Lac Megantic, Quebec, derailed, and exploded, killing 47 people. The subsequent Transportation Safety Board (TSB) investigation, however, could not conclude "whether single-person train operations contributed to the incorrect securement of the train or to the decision to leave the locomotive running … despite its abnormal condition" (TSB Railway Investigation Report R13D0054, p. 131).

[16] Regional railroads are defined by the Association of American Railroads as non-Class I line-haul railroads earning revenue of at least $40 million, or that operate at least 350 miles of road and earn at least $20 million in revenue. Data on percentage of trains run with single-person crews from Robert Babcock, Senior Vice President of Operations and Business Development, INRD, email dated May 13, 2014.

[17] Indiana Rail Road website.

3. Canadian Operations

Canadian railroad legislation permits the use of single-person crews, as long as certain parameters are met and Transport Canada determines that there is no risk to safe railroad operations.[18] Two smaller railroads in Canada have regularly operated with single-person crews: the Montreal, Maine and Atlantic (MM&A) and the Quebec North Shore and Labrador (QNS&L). QNS&L was the first long-haul freight railroad in Canada to move to operations with a sole locomotive engineer. The QNS&L operates heavy iron ore unit trains from mine to port through a remote territory in Labrador which experiences severe winter weather. In addition to ore trains, it operates limited passenger and general freight traffic. Two-person crews however are used for the mainline operations of Canada's two major (Class I size) railroads – Canadian National and Canadian Pacific.

After an incident in July 1996, the Transportation Safety Board of Canada required the implementation of certain safety measures where single-person crews were in use.[19] One of the key requirements was the installation and operation of proximity detection devices (PDD) on all lead locomotive units, track units, and on-track vehicles operating on main line track. These devices use GPS-based tracking of all trains on the line, with connection to a central server, and can alert the locomotive engineer if a train is approaching another train on the track. Organizational changes, such as specific dispatcher training for single-person crews and fatigue controls, were also implemented.

[18] "Lac-Mégantic: Two-man crews limited damage in 1996 train wreck," Montreal Gazette, July 10, 2013 (http://www montrealgazette.com/business/M%C3%A9gantic+crews+limited+damage+1996+train+wreck/8649189/story.html).
[19] "Railway Occurrence Report, R96Q0050," Transportation Safety Board of Canada, July 14, 1996 (http://www.tsb.gc.ca/eng/rapports-reports/rail/1996/r96q0050/r96q0050.pdf).

IV. International Experience with Single-Person Crews

A. Relevant Deployment

Single-person crews for trains are common in mature international rail markets similar to the US in size and complexity. As in the United States, these markets generally have a long history of passenger and freight rail operation, well developed safety oversight and regulatory regimes, and have taken advantage of modern technology to improve safety while reducing crew sizes. The use of single-person crews is common practice on most freight railroads the world over, including DB Schenker (Germany), SNCF (France), Green Cargo (Sweden), Rail Cargo Austria, and Aurizon (Queensland/NSW), as well as on the passenger operations in those countries.

Data on a number of mature rail networks that make use of single-person operations are shown in Exhibit IV-1 on the next page (the US is included for comparative purposes). The systems shown are “mixed” systems that include both freight and passenger services. All systems, except Queensland, feature higher train densities than the US, by as much as seven to eight times. Although the US runs the heaviest freight trains on average, several systems also have comparable ratios of single track, while Germany, Japan, and the UK have comparable train-miles.

The next section profiles several case studies of operational and safety conditions that pertain to single-person crew operation within the European Union.

Exhibit IV-1: Mature International Rail Systems with Single-Person Train Operations[20]

Rail Network	Country	Rail line mileage	Gross ton-miles millions, freight	Train-miles thousands, total	Ratio: Passenger to freight trains	Network type	Train density train miles per line mile	Single-line track ratio	Average freight train weight
US Class I	USA	120,817	2,992,769	498,746	5%	Heavy-haul freight, minimal passenger	4,128	83%	6,289
Queensland	Australia	5,352	56,515	23,930	36%	Heavy-haul freight, some passenger	4,471	91%	3,691
OBB/RCA	Austria	3,132	30,930	89,203	69%	Light freight, predominant passenger,	28,483	65%	1,122
Deutsche Bahn	Germany	20,949	184,357	642,332	75%	Light freight, predominant passenger, high speed passenger	30,662	46%	1,155
Trafikverket	Sweden	6,188	31,826	81,897	68%	Light freight, predominant passenger, high speed passenger	13,234	82%	1,223
Network Rail	UK	10,016	28,778	351,160	93%	Minimal freight, predominant passenger, high speed passenger	35,061	26%	1,192
RFF/SNCF	France	18,546	81,775	301,280	84%	Light freight, predominant passenger, high speed passenger	16,245	42%	1,704
FS	Italia	11,194	N/A	207,165	85%	Light freight, predominant passenger, high speed passenger	18,507	53%	N/A
Japan Rail	Japan	11,986	N/A	433,608		Minimal freight, predominant passenger, high speed passenger	36,177	61%	N/A

[20] UIC Railway Statistics 2010, AAR Analysis of Class I Railroads 2010, Amtrak National Fact Sheet 2010. Note, tons are short tons.

B. Operating Case Studies: European Union

In the European Union, single-person crew operation has two preconditions:

- The presence of a working dead-man control system on the locomotive. This system involves a pedal or button that must be periodically pressed, thereby signaling that the train engineer is active and alert. If the device is not pressed when required, the train will come to a stop.
- The locomotive is equipped with working Automatic Train Control/Automatic Train Protection (ATC/ATP), which is similar to CTC in the United States. That is, ATC/ATP enables dispatchers to remotely operate signals and switches to ensure trains do not make conflicting movements.

As noted above, single-person crews in Europe operate in a somewhat different operating environment from North America. Specifically, population density and network density/train density on the network is higher in most EU countries than for much of North America outside of urban centers.

European rail lines are traditionally equipped with line-side signaling and interlocking facilities, which have recently been centralized into larger control centers, similar to North American CTC. In most countries, ATC/ATP systems have been installed for a long time. Temporary slow orders and other exceptional circumstances along the train run are typically communicated to train crews in written or electronic form before departure; their transmission via radio is possible, but confined to exceptional situations such as line-side signal failures.

Dark territory and operating regimes in which safety depends on (radio) communication and/or track warrants exchanged between the train crew and a central dispatcher are limited to low-density lines with low speeds and limited traffic. Such lines are often operated with single-person train crews, but supported as necessary by ground personnel. Consequently, in most European countries, a second crew member is required by regulation only in exceptional cases, such as equipment failures.

Three case studies are presented below that present more detail on the specific operating characteristics of European railroads operating single-person crews: Germany, Italy, and Sweden.

1. Germany

Germany has one of the largest and densest rail networks in Western Europe and carries significant freight volumes (compared to many other EU countries). With the exception of two dedicated high-speed lines, the entire network runs mixed freight and passenger traffic. On some of the more heavily traveled double-track lines, train volume can exceed 200 trains per day in both directions.

Germany was one of the first countries to implement an ATP system. The “Indusi” (short for Induktive Zugsicherung) was introduced in the 1920s and subsequently spread across nearly the entire network. It is based on track-side magnets that emit various frequencies, which stand for stopping signal, proceed with limited speed, and a warning to expect a stopping or speed limiting signal. While the line-side equipment has remained largely unchanged, the Indusi devices mounted on locomotives have seen steady improvement to reflect higher speeds and increased safety standards.[21] Since 1972, the Indusi system also has been able to monitor train speed ahead of critical speed restrictions that are not protected by signals. This function is achieved by placing a sequence of Indusi magnets in a segment of track ahead of the speed restriction. For about the same period of time, dead-man devices (called “Sifa”) have been in use on German railroads to ensure the engineer's attention and ability to work.

Single-person crews were introduced with the abolishment of steam traction in the 1950s and 1960s. With the introduction of electric and diesel engines and the essential safety systems of Indusi (ATC/ATP) and Sifa (dead-man device) already in place, eliminating the second crew member on the locomotive was widely seen as a natural productivity gain.

A second crew member was still required for speeds above 140 km/h (87 mph) by the “Eisenbahn-Bau- und Betriebsordnung” (EBO), the basic legal directive regarding railroad safety in Germany, until 1991. By the end of the 1980s, however, a new generation of Indusi locomotive devices had been introduced that could automatically adjust for high-speed braking on curves. Following this modification and after field testing, the requirement of having a second crew member for speeds above 140 km/h (87 mph) was abandoned with the third revision of the EBO in 1991.

As a result of this development, a second crew member (“Triebfahrzeugbegleiter” or locomotive assistant) is required only in exceptional circumstances:[22]

- In case of a failure of the dead-man device, train speed is limited to 50 km/h (31 mph) unless a second crew member is present in the cabin. The second crew member needs to be able to stop the train in case of the inability of the engineer to work (apply the brakes, turn off engine power, and secure the train by applying the hand brake once stopped) and call for help over the radio. To perform these tasks, the second crew member does not need to be a qualified engineer; this task can be performed by other employees such as conductors (passenger trains), switchers, or car inspectors.

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[21] Kollmannsberger, F.: Die Zugbeeinflussung als Instrument zur Erhöhung der Geschwindigkeit, Eisenbahntechnische Rundschau 11/1986.
[22] Metzdorf, E.: Triebfahrzeugbegleiter, Deine Bahn 9/2001.

- If the locomotive is only equipped with an Indusi device of older type, and so does not provide distance and time-dependent supervision of braking curves, train speed is limited to 140 km/h (87 mph) unless a second crew member is present in the cab. The second crew member needs to be able to observe the correct approach of the train to a stopping signal or a signal limiting its speed, thus substituting the continuous supervision of the braking curve performed by a more modern Indusi device. In these cases, the second crew member needs to be a qualified engineer.

There are no limitations in Germany on freight train size, train weight, or carriage of hazardous materials when trains are operated by single-person crews.

In passenger service, single-person operation (engineer-only operation) of trains is widespread on regional low density lines, on suburban networks, and more recently on bigger regional trains. In some of these cases, there may be a second employee on board the train who is not trained in operations and who only performs commercial tasks such as ticket inspection.

2. Italy

Italy only recently made the transition from two-person to one-person crews. Similar to other European countries, most of the network is electrified and has mixed passenger and freight operations; a few recently built high-speed lines are the exception to this rule.

Until recently, Italy did not have an ATC/ATP system covering the most important lines on the network. There was a cab signaling system “rs4codici” (similar to American Pulse Code Cab Signaling) in place,[23] which only covered high-speed and some of the more important main lines. It systematically excluded bigger stations and many passing tracks. Also, there were no dead-man devices mounted on locomotives.

Starting in 2003, a new state-of-the-art ATC system, Sistema di Controllo della Marcia del Treno (SCMT), was introduced and installed on the entire core network, as well as parts of the secondary network. The system is a national implementation of the ETCS concept (the European version of PTC). It transmits infrastructure data, most importantly permitted speed, to the locomotive at fixed locations along the track, typically at signals. Speed and speed reductions are then monitored by the locomotive device, which also includes a dead-man function, and the SCMT can apply emergency braking automatically. The remaining network of about 4,900 km has been equipped with the simpler Sistema Supporto Condotta (SSC), based on microwave

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[23] Cab signaling is a system which provides a display of upcoming track signals inside the locomotive cab.

transponder technology, which only displays information, such as traffic signals, speed limits, and special conditions, in the cab for the engineer.[24]

Single-person crews have been introduced in line with equipping the network with modern ATC/ATP systems. Freight trains are permitted to be operated with single-person crews and are in use on new entrant operators. Italy's largest rail freight operator, Trenitalia Cargo, still relies on two-person crews, but this is considered to be primarily for social reasons, i.e., a result of labor union resistance.

Passenger trains are generally operated with single-person crews and a minimum of one conductor present in the train, but not in the locomotive cab. The conductor may be required to assist the engineer in certain circumstances (i.e., a train recovery or equipment failure).

3. Sweden

Sweden's rail system is in some respects more similar to North American freight rail operations than those of other European countries. Specifically, train densities are lower than in central/western Europe, there is a higher proportion of single-track lines, and climate conditions are similar to the north/central portions of the US and Canada. In addition, lines in northern Sweden are in remote areas with no road access for long stretches of the network.

The entire Swedish rail network operates mixed passenger and freight services (although passenger train density in the upper north is low by European standards (2-4 trains per day in each direction). All passenger and freight trains in Sweden operate with single-person crews.

The Swedish ATC/ATP system (EBICAB) uses track-side bases to transmit signaling information to on-board devices mounted on locomotives and multiple units. It was rolled out originally in 1979-1980. In addition to ATC/ATP, all locomotives are equipped with a dead-man device.

There are no limitations on train size, train weight, or carriage of hazardous materials when trains are operated by single-person crews in Sweden. In addition, there is extensive use of remote-controlled locomotives, both for switching as well as for line-haul.

Single-crew operation notably also extends to iron ore trains operated by the mining company LKAB in northern Sweden, which run from mines in remote areas to ports and steel works on the coast. These trains are over 9,500 US tons with 264,000 pound car load limits. In winter,

[24] Rete Ferroviaria Italiana (RFI): Website. Sicurezza e tecnologia. SCMT, per il controllo della marcia del treno / SSC, per il supporto alla guida (http://www rfi.it/cms/v/index.jsp?vgnextoid=7c908c3e13e0a110VgnVCM10000080a3e90aRCRD and http://www rfi.it/cms/v/index.jsp?vgnextoid=e3908c3e13e0a110VgnVCM10000080a3e90aRCRD).

temperatures can fall to -30° C (-22° F) and long stretches of this single track railroad are not accessible by road.[25] Crew composition has not been identified as a factor in any incidents involving train operation.

C. Safety Record

As the case examples above make clear, single-person crew operations are common on mixed-use rail systems in Europe with high train densities, provided that safeguards are in place – be they automated train control or some other protection system – to provide a safety backup to the engineer.

Given the long history and widespread use of single-person crews in various European countries, it is possible at a summary level to consider the impact of such operations on safety. According to the European Railway Agency (ERA), there has been a positive long-term trend of declining rail accident risk within the EU, despite significant reductions in overall railroad staff and the expansion of single-person operations over the same period (Exhibit IV-2).

Exhibit IV-2: Fatal Train Collisions and Derailments, EU 27 Nations, Switzerland, and Norway, 1990-2013[26]

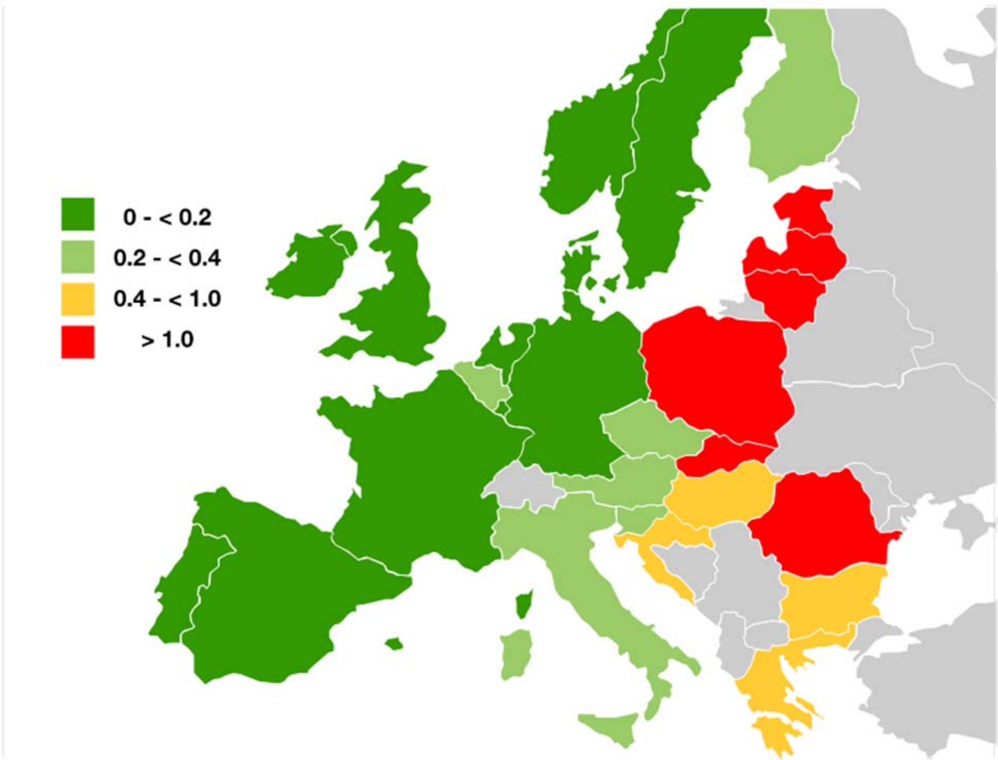
Per billion train-kilometers

Since efforts to harmonize European rail systems are recent and safety systems and standards do vary among EU member nations, it is important to note that there are still significant differences in the level of rail safety attained by individual EU countries. Most important to note, however,

[25] "Kiruna Electric Locomotives," *Railvolution*, February 2011.
[26] Railway Safety Performance in the European Union 2014, European Railway Agency.

is that those European countries with the best safety record (< 0.2 fatalities and weighted serious injuries per million train-km, 2007-2012) are Luxembourg, the United Kingdom, the Netherlands, Norway, Ireland, France, Denmark, Germany, Sweden, Portugal, and Spain. In all of these countries, railroads operate with single-person crews.

Exhibit IV-3: European Union: Fatalities and Weighted Serious Injuries, 2007-2012[27]
Per million train-kilometers



[27] Railway Safety Performance in the European Union 2014, op. cit.

V. Safety Analysis and Comparison

Safety is of paramount concern to railroad regulators and operators. The FRA highlights the importance of safety in its mission statement, listing it first, i.e., "The Federal Railroad Administration's mission is to enable the safe, reliable, and efficient movement of people and goods for a strong America, now and in the future."[28]

Railroads likewise have a similar focus on safety and consider it part of their corporate culture. Therefore, it is not surprising that extensive data is collected and analyzed for every railroad incident and accident in an effort to prevent future events. As described in this section, Oliver Wyman reviewed the availability of rail safety data for both the US and Europe, screened the data to arrive at a subset of safety statistics potentially relevant to the evaluation of the safety of single-person crews, and finally, compared these safety statistics for single- and multiple-person crews.[29]

A. Availability and Reporting Requirements for Railroad Safety Statistics

Data covering many different aspects of railroad incidents, accidents, and casualties is generated by railroads and tracked by rail regulatory authorities. Reporting categories for equipment and infrastructure incidents and accidents include collisions, derailments, fires, explosions, acts of god, and other events involving mechanical or infrastructure failure or human error that result in damage. Reporting categories for casualties include injuries resulting in medical treatment, loss of consciousness, time away from work, restricted work, job transfer, and death.

The FRA and ERA both collect incident data from the railroads and store the information in electronic databases that are available to the general public.[30] Data collection is ongoing, and thus data is both current and supported by many years of history. Additionally, the incident, accident, and casualty reports provided by the railroads are required by federal law, and must therefore contain information that is accurate and complete to the highest degree possible.

- Under federal law, US railroads are required to report all fatalities, grade crossing collisions, grade crossing signal equipment failures, and rail traffic signal equipment failures to the FRA. In addition, railroads must report rail equipment incidents and personal injuries to the FRA subject to certain financial and medical treatment thresholds, respectively. Publicly available

[28] "About FRA," Federal Railroad Administration (http://www fra.dot.gov/Page/P0002).
[29] Oliver Wyman also reviewed the availability of rail safety data for Canada. Transport Canada, Canada's transportation regulatory agency, only has made rail safety data up to 2009 available. As a result, the potential for comparison of Canada, US, and European railroads is limited. Rail safety data for Canada was thus omitted from this analysis, due to a lack of data transparency.
[30] FRA safety data is accessible at: http://safetydata fra.dot.gov/OfficeofSafety/Default.aspx, while ERA safety data is available at: http://erail.era.europa.eu/safety-indicators.aspx.

data is grouped into the following categories: rail equipment accidents, railroad casualties, highway-rail accidents, and signal equipment failures. The FRA also collects operational data from the various railroad companies concerning train-miles and employee hours to provide a basis of comparison for safety data.

- In the European Union, member state railroad regulatory agencies are required to report safety-related incidents meeting certain specified thresholds to the ERA. Publically available data is grouped into the following categories: rail equipment accidents, railroad casualties, grade-crossing accidents, and signals passed at danger (SPADs).[31] Like the FRA, the ERA also collects operational data for the purpose of providing a consistent basis for comparison of safety statistics.

Comparing FRA data across categories and years is relatively straightforward, as is the internal comparison of ERA data. However, comparing FRA data with ERA data presents some challenges. Each organization has its own mandates detailing which data is to be collected and at what level of detail. These differences are largely due the agencies' different purposes in collecting data:

- The FRA uses the data it collects to develop hazard elimination and risk reduction programs for the railroad industry that focus on preventing railroad injuries and accidents.[32] To develop effective safety programs, the FRA must collect data concerning not only the "who, what, and where" of an incident, but also the "how and why." Thus, the safety data collected by the FRA includes all of the basic information concerning an incident, as well as information on the underlying causes and circumstances.

- The ERA collects statistics based on agency-defined common safety indicators (CSIs) "to facilitate the assessment of the achievement of [common safety targets] and to provide for the monitoring of the general development of railroad safety."[33] CSIs are not expected to provide the same level of detail as the safety databases of individual railroads and infrastructure management companies, which are tailored to specific company needs.[34] Consequently, the available public data provides for limited analysis of underlying incident causes and circumstances.

Exhibit V-1 contains a summary of key differences between the FRA and ERA data, along with the corrective measures Oliver Wyman took to enable direct comparison, and a consideration of

[31] According to the ERA, SPADs occur when any part of a train proceeds beyond its authorized movement.
[32] US Code of Federal Regulations, Title 49, § 225.1.
[33] Article 5 of Directive 2004/49/EC, European Parliament.
[34] Implementation Guidance for CSIs; Annex I of Directive 2004/49/EC as Amended by Directive 2009/149/EC, version 2.3, ERA, May 24, 2013, p. 7.

any remaining differences that could potentially bias the results of the comparisons between the two data sets.

Exhibit V-1: Differences in FRA and ERA Data, Corrective Measures Taken, and Potential Bias

Category	Item	FRA	ERA	Corrective Measure	Potential Bias
Equipment incidents	Minimum cost threshold for reporting	$10,500	€150,000	Eliminated all US incidents below €150,000 in cost	None after correction
Serious injuries	Hospitalization	Hospital stays not reported	Only reported if there is a 24-hour minimum hospital stay	Eliminated US injuries resulting in less than eight lost working days	Not clear what bias this may introduce
Fatalities	Length of time after accident	Any fatality occurring within 180 days of the accident is recorded	Any fatality occurring within 30 days of the accident is recorded	None – data does not show date of death relative to date of incident	May show more deaths for US railroads

B. Potentially Relevant Safety Statistics

Only certain data from the FRA and ERA datasets will be relevant to evaluating the effect of road train crew size on railroad safety; specifically, this includes data on incidents where the crew has some control, and where the presence of multiple persons versus one person in the cab could *arguably* make a difference in the outcome of the incident. What follows is a description of the various safety-related incident categories for which data is collected and publicly available, and which data could be relevant in assessing road train crew size as it relates to safety performance.

1. Equipment Incidents: Potentially Relevant to Crew Size Analysis

Equipment incidents include train derailments, collision, fires, explosions, etc. Derailment and collision information, in particular, may be useful for evaluating road train crew safety performance as it relates to crew size. For the purpose of the present analysis, records were screened to ensure that only incidents potentially related to train crew actions were considered (i.e., derailments and collisions with railroad equipment that have a human factor cause). Data concerning the cause of the incident is a key screening criterion, as only incidents that are listed as due to human error in train operation are relevant to an evaluation of train crew safety performance.

2. Casualties: Potentially Relevant to Crew Size Analysis

Casualties include both injuries and fatalities. Data regarding such events may be useful in evaluating road train crew safety performance as it relates to crew size. It is important, however, to consider only incidents that may relate causally to a crew's actions. Therefore, Oliver Wyman screened the data for the type of person injured or killed (e.g., employee, passenger, third party), geographic location of injury, on-track equipment involved, events leading up to the injury, and the stated cause of injury, to weed out incidents that could not have been related to the actions of the train crew.

Oliver Wyman determined that criteria for a casualty incident that could bear some relationship to the actions of a road train crew would include the involvement of a person authorized to be in close proximity to on-track rail equipment, occur on or near the railroad right-of-way, as well as on or near on-track rail equipment, and stem from actions relating to train movement. As a practical matter, trespassers on railroad property were excluded from the analysis, as it is not reasonable to expect a train crew to be aware of an unauthorized person's presence at all times.

It is worth noting that by virtue of reducing the number of people on a train crew, the number of operating personnel exposed to potential injury is reduced. As a result, the implementation of single-person crews should reduce the overall number of train crew casualties. Still, there are other railroad employees (car men, locomotive mechanics, maintenance of way employees, managers, etc.), as well as other parties, that can be affected by the actions and decisions of train and engine employees. Consequently, the reduction in crew size by half may not necessarily result in a similar reduction in overall casualties.

3. Red Block Violations (SPADs): Potentially Relevant to Crew Size Analysis

"Red block violations," also called SPADs outside of North America, are incidents where a train continues beyond a line-side traffic control signal requiring the train to stop. The failure to stop puts the train onto a section of rail line that it does not have authority to occupy. While incidents reported only as red block violations do not involve derailments, collisions, or injuries, they indicate the potential for a serious incident. Violations are therefore treated as precursor events. As they may indicate human error, such violations may be potentially relevant to an evaluation of crew safety performance.

Red block violation data is publically available from the ERA. In the United States, however, such information, while collected and tracked by the railroad operators, is not made available to the general public. Nevertheless, several US Class I railroads made their red block violation data available for the purposes of this study. Consequently, a SPAD comparison between US Class Is and some of their European counterparts was made to provide some insights into crew safety performance relative to crew size.

4. Grade Crossing Incidents: Not Relevant to Crew Size Analysis

The potential utility of grade crossing incidents in measuring road train crew safety performance as it relates to crew size is limited. Grade crossings, also called level crossings outside of North America, are at-grade intersections between roads and railroads. A grade crossing incident involves the collision between a motor vehicle (or pedestrian) using the road portion of the crossing and a train on the rail portion of the crossing.

According to the US Federal Highway Administration, "Motorists bear most of the responsibility for avoiding collisions with trains,"[35] as drivers of motor vehicles can more easily control the direction and speed of their vehicles than can an engineer in control of a freight or passenger train. Consequently, when motor vehicles and trains meet at a grade crossing, it is the motor vehicle that must yield the right of way. When grade crossing collisions occur, it is almost always due to the motorist's failure to properly yield the right of way, and the data bears that out. According to the FRA Equipment Incident database, 99.87 percent of all highway-rail crossing collisions are due to motor vehicle driver error.[36]

5. Signaling Failures: Not Relevant to Crew Size Analysis

Signaling failures occur when grade crossing or rail traffic control equipment malfunctions in some way. The malfunction could be due to the equipment's manufacture, installation, inspection, or maintenance. As a train crew is not responsible for any aspect of a railroad's signaling equipment, short of complying with its indications, signaling failures are not useful in evaluating train crew performance. Further, as the train crew does not have any influence on signal equipment failures, neither does the size of the crew have any impact.

C. Statistical Comparison of Relevant Safety Data: Intra-US

The utility of FRA data in evaluating the safety performance of single-person versus multiple-person crews is limited, due to the fact that there are no railroad operators in the United States that use single-person crews exclusively. There are some railroads whose multiple-person crew operations resemble single-person crew operations (they have a single engineer in the locomotive cab, but other crew members present behind the locomotive on board the train) and can be utilized as representative of single-person crew operations. These rail operators, as described in

[35] Railroad-Highway Grade Crossing Handbook, 2nd ed., Federal Highway Administration, August 2007, p. 25.
[36] As the FRA's grade crossing incident database does not assign cause codes to incidents, it was necessary to look for data elsewhere. The FRA's equipment incident database contains records for grade crossing incidents that meet the minimum equipment damage thresholds established by the agency for inclusion in the database. More importantly, the incident records contain cause codes. Of the 1,594 non-duplicative grade crossing incident records during the 2006 to 2013 timeframe, only two incidents were not blamed on motorists. One incident involved a multiple-person crew's failure to flag a highway crossing (FRA cause code H205) on a short line railroad. The other incident involved a grade crossing signaling equipment failure (M307).

Section III, include Amtrak and some commuter railroad authorities. In addition, INRD, a Class II regional freight railroad, operates some of its road trains with single-person crews, and was included in this study as representative of single-person crew operations.

For multiple-person crew operations, Class I and regional railroad operators are representative.

- Class I railroads use multiple-person crews exclusively to move freight trains on main lines (where service density is highest) and provide extensive safety reporting data to the FRA.
- Regional railroads, with the exception of INRD, typically operate trains with multiple-person crews and likewise provide extensive safety reporting data to the FRA.

Oliver Wyman utilized FRA data for the above operators[37] for the years 2007 through 2013 to compare the safety performance of single-person crews to multiple-person crews.

To evaluate the safety performance of single-person crews versus multiple-person crews in relation to equipment incidents and casualty incidents, Oliver Wyman compiled all publically available FRA records for the representative rail operators for 2007 through 2013 on incidents that were potentially affected by the choices, actions, or inactions of a train crew, regardless of crew composition. Further, as this analysis concerns only road train crew performance, only freight, passenger, commuter, and work trains, along with light locomotive moves, were included in the analysis. These are generally the only types of equipment movements under the control of a road train crew.[38]

1. Equipment Incident Analysis

For the equipment incident analysis, all derailments and collisions (save for grade crossing collisions for the reasons given above) that reported a human factor were analyzed. Of those records, all human factor causes not related to actions attributable to a train crew (such as failure to properly secure engines or cars by a non-railroad employee, absence of a blue signal, and improper instruction to train/yard crew) were excluded.

Data compilation resulted in 2,169 equipment incident records.[39] These records were then aggregated into the railroad groups of Amtrak, Commuter, Class I, INRD, and Regionals. When divided by millions of train miles, the equipment incident rate for each group was obtained. Exhibit V-2 shows the seven-year incident rates for the five groups based on this data.

[37] See Exhibits A-1 through A-3 in the Annex for lists of the commuter, Class I, and regional railroads included in the analysis.
[38] See Exhibits A-4 through A-6 in the Annex for complete lists of accident types, human factor cause codes, and equipment types included and excluded from the analysis.
[39] See Exhibit A-7 in the Annex for a table showing how the application of data filters affected the number of equipment incident records remaining in the analysis.

Exhibit V-2: Equipment Incident Rates for Representative Rail Operator Groups, 2007-2013[40]

Aggregate data for incidents potentially related to train crew size

	Incident records	Train-miles (millions)	Incident rate (incidents per million train-miles)
Amtrak	63	270.5	0.23
Commuter	125	384.8	0.32
INRD	2	1.6	1.27
Class I	1,897	3,562.9	0.53
Regionals	82	74.7	1.10

For the past seven years, Amtrak and commuter railroads have had a lower equipment incident rate than the Class Is and other regional railroads. While it is impossible to say whether fewer passenger/commuter equipment incidents are at least in part due to a reliance on single-person crews and not to other factors, clearly the statistics show that such operations are as safe from an equipment incident perspective as those using multiple-person crews.

INRD has an equipment incident rate that is slightly higher than the other regionals. This figure is misleading, however. First, one of the two human-factor equipment incidents INRD suffered involved a three-person crew. The other involved a single-person crew where the engineer did not apply enough dynamic braking to control his train. In such a situation, a second person in the cab would have made little difference, as that person would not have had access to the locomotive controls. In addition, that person would most likely have been a trainman and not certified to operate a locomotive. Finally, for the years 2009 through 2013, INRD did not have a single human-factor derailment. Here, total incidents provide a better analysis of incidents due to INRD's small size. Further, the two equipment incidents had nothing to do with crew composition. Crew communication and poor train handling were the culprits, not crew size.

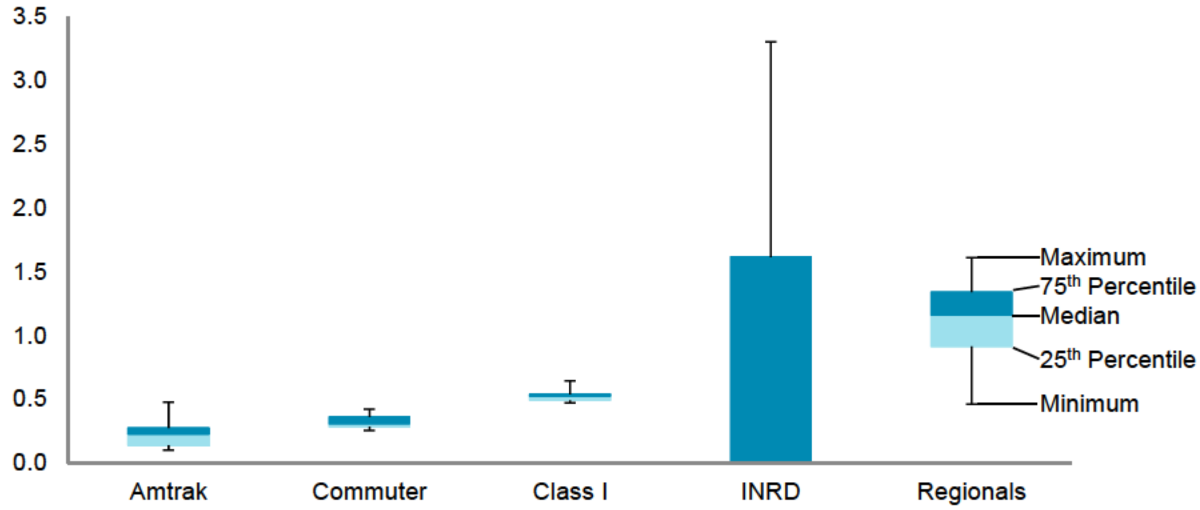
Because of the comparative rarity of equipment incidents, particularly in the case of INRD, it may be instructive to look at the equipment incident data in a different way. Using the incident data to determine the annual equipment incident rates for each group, it is possible to calculate the minimum, 25th percentile, median, 75th percentile, and maximum incident rate values for each group. When plotted on a chart, as shown in Exhibit V-3, one can see the variability of incident rates for each group of operators. In the case of INRD, it is apparent that it has the greatest variability, which further underscores the fact that one incident can greatly skew the statistics in what is otherwise a good safety record. Class Is have the least amount of variability, indicating greater consistency in the number of incidents suffered. Amtrak and the commuter authorities

[40] Source: FRA, Oliver Wyman analysis.

have slightly larger spreads than the Class Is, but they are below the minimum posted by the Class Is. The median rates for Amtrak and commuters, as well as INRD, also are below those for Class I and regional railroads. While the data may not conclusively support a claim that single-person crew operations are safer than multiple-person crew operations (given the possible existence of other influencing factors), it does appear that single-person crew operations are at least as safe as multiple-person crew operations.

Exhibit V-3: Annual Equipment Incident Rates for Representative Rail Operator Groups, 2007-2013[41]

Aggregate data for incidents potentially related to train crew size; minimum, 25th percentile, median, 75th percentile and maximum values, per million train miles



2. Casualty Incident Analysis

For the casualty incident analysis, the following records were analyzed:

- Incidents involving on-duty railroad employees, contractors, volunteers, and non-trespassers. Since these people are authorized to be in close proximity to on-track equipment, a train crew can reasonably be expected to be aware of their presence and location.

- Incidents occurring in close proximity to the railroad right of way and on or near trains, locomotives, or rolling stock, either moving or stationary.

- Incidents involving events, causes, physical acts, and tools directly related to train, locomotive, and on-track equipment operation.[42]

[41] Source: FRA, Oliver Wyman analysis.

It should be noted that incidents involving grade crossing collisions and remote control locomotive (RCL) operations were eliminated. As mentioned above, grade crossing collisions are usually the fault of the motor vehicle operator. Road train crews have little control over the casualties incurred as a result of such incidents.

The foregoing data collection resulted in 417 casualty records, which were aggregated into the rail operator groups: Amtrak, Commuter, Class I, INRD, and Regional.[43] The incident numbers for each railroad group were divided by each group's total employee hours to arrive at a casualty incident rate (incidents per 200,000 employee hours). Exhibit V-4 shows the seven-year incident rates for the five groups based on this data.

Exhibit V-4: Casualty Incident Rates for Representative Rail Operator Groups, 2007-2013[44]
Aggregate data for incidents potentially related to train crew size

Operator Type	Cab Crew Size	Total Incidents	Total Employee Hours (millions)	Incident Rate (Incidents per 200,000 employee hours)
Amtrak	Extensively single-person	17	268.8	0.01
Commuter	Extensively single-person	41	390.8	0.02
INRD	Some single-person	0	2.6	0.00
Class I	Multi-person	348	2,263.8	0.03
Regional	Multi-person	11	79.2	0.03

For the past seven years, Amtrak, commuter groups, and INRD have had a lower casualty incident rate than the Class I and regional railroads. Due to the fact that there are many different factors involved in casualty incidents, it cannot be stated with certainty that the difference in casualty performance is due to crew composition. However, the data does not indicate that those railroad operators making use of single-person crews are any less safe than those using only multiple-person crews, because their casualty incident rates are no higher than those of rail operators with multiple-person crews.

As with equipment incidents, it may be instructive to look at the variability of the annual casualty incident rates for the five railroad groups. Exhibit V-5 shows the minimum, 25th percentile, median, 75th percentile, and maximum casualty rate for each railroad group.

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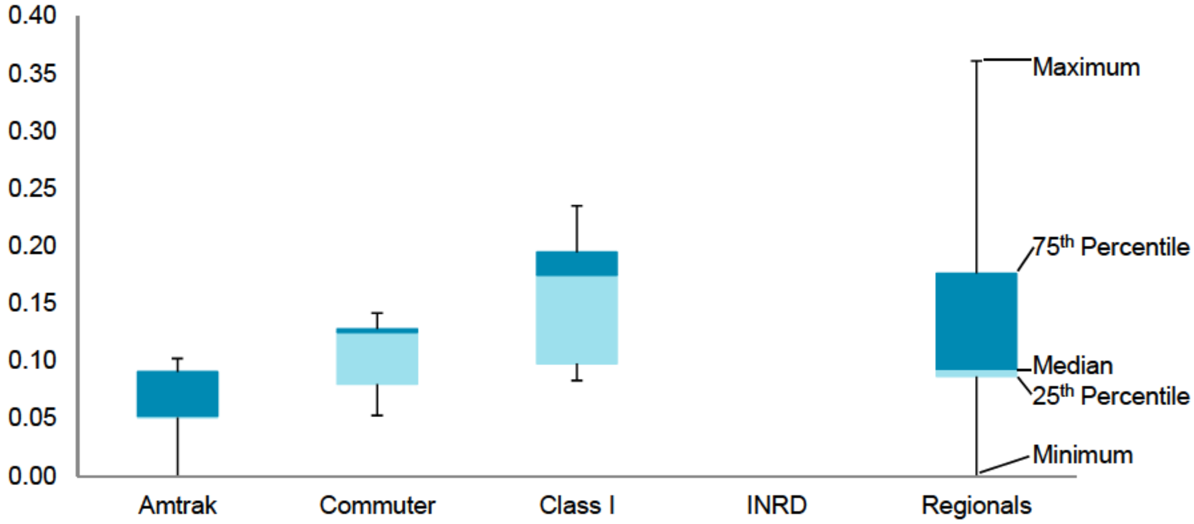
[42] See Exhibits A-8 through A-15 in the Annex for complete lists of person types, locations, physical acts, injury causes, events, and tools included and excluded from the analysis.
[43] See Exhibit A-16 in the Annex for a table showing how the application of data filters affected the number of casualty incident records remaining in the analysis.
[44] Source: FRA, Oliver Wyman analysis.

Exhibit V-5: Annual Casualty Incident Rates for Representative Rail Operator Groups, 2007-2013[45]

Aggregate data for incidents potentially related to train crew size; minimum, 25th percentile, median, 75th percentile and maximum values, per 200,000 employee hours



In Exhibit V-5, the range between maximum and minimum rates for Amtrak and commuter operators generally overlaps those of the Class I railroads. As the annual rates for Amtrak and commuters are generally lower than those for the Class Is, indicating fewer casualty incidents, this analysis also shows that one-person crew operations are as safe as multiple-person crew operations.

As for INRD and other regionals, there is not much to compare. INRD suffered no human-factor casualty incidents between 2007 and 2013. Other regionals show the largest spread between minimum and maximum values of all the groups, indicating a greater level of variability. The greater variability is largely due to the fact that injuries or fatalities stemming from train crew actions are generally rare. Thus when a casualty does occur, it creates a wide fluctuation in annual rates. Nevertheless, the data does not support the view that multiple-person crews have lower casualty rates. All the data shows is that those rail operators using single-person crews are at least as safe as their counterparts relying on multiple-person crew to operate their trains.

[45] Source: FRA, Oliver Wyman analysis.

D. Statistical Comparison of Relevant Safety Data: US versus Europe

1. Comparing US and European Safety Records

Section IV.A above provides an overview of rail systems comparable to the US in terms of market maturity, regulatory oversight, and technological development in which single-person train operation is frequently the norm. As illustrated by the case studies in Section IV.B, many European railroads employ single-person train crews throughout their national networks. In particular, France, Germany, Italy, Sweden, and the United Kingdom – some of Western Europe's largest railroad networks in terms of train-kilometers – have used single-person crews to staff both freight and passenger trains for years, sometimes decades. Consequently, the safety performance of the rail operators in these countries presents a potential basis for comparison to the US Class I railroads and their multiple-person crew operations.

2. Comparison of Derailment and Collision Data

According to the ERA, train derailments and collisions belong to a group of events simply called "accidents." For an event to be considered an accident, it must be "an unwanted and unintended sudden event or a specific chain of such events which have harmful consequences."[46] To be recorded in CSI statistics, an accident also must be "significant," where significant accidents are defined as:

- Unwanted or unintended
- Related to a rail vehicle in motion
- Caused at least one fatality or seriously injured person; or damage to rolling stock, track, other installations, or environment that is equivalent to €150,000 or more; or forced suspension of train services on a main railroad line for six hours or more
- Did not occur in a workshop, warehouse, or depot[47]

The FRA's minimum thresholds for reporting equipment incidents like derailments and collisions are much lower than the ERA's. Currently, the FRA requires rail equipment incidents involving trains, rolling stock, and other on-track equipment, either moving or standing, and meeting the minimum reportable damage threshold of $10,500 be reported.[48]

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[46] Implementation Guidance for CSIs; Annex I of Directive 2004/49/EC as Amended by Directive 2009/149/EC, version 2.3, ERA, May 24, 2013, p. 11.
[47] Ibid.
[48] "Railroad Reporting Thresholds, Table 9.06, Federal Railroad Administration.

To develop a comparative data set, records involving equipment derailments or collisions were collected from the FRA's Equipment Incident database. A euro value was calculated from the total damage amount contained in each equipment incident record. If the resulting euro value was less than the €150,000 threshold required by the ERA, the record was then evaluated to determine if any injuries or fatalities were associated with the incident described. If no injuries or fatalities were evident, the record was eliminated from further consideration.

The remaining records were then evaluated for equipment type, speed, and railroad type. Any record involving a single railcar, cut of railcars, or yard and switching activities were eliminated, as the CSIs published by the ERA involve trains only.[49]

Speed was considered, because, according to the ERA, an accident involves moving railroad vehicles. Incident records in the FRA data showing no speed were looked at more closely to ensure that there truly was no motion related to the incident. After reading through the narratives, it was determined that only ten of those records involved no motion, and these were consequently eliminated from the analysis. Finally, since all US Class I rail carriers employ multiple-person crews for train operation, only those carriers meeting the definition of a Class I remained in the analysis.

Once duplicate records were eliminated, 1,051 records remained (121 collisions and 930 derailments).[50] When aggregated into years of occurrence and divided by total train kilometers, the collision and derailment rates for US Class I railroads from 2007 to 2012 are as shown in Exhibit V-6.

Exhibit V-6: Annual US Collision and Derailment Rates per Million Train-Kilometers, 2007-2012[51]
Records conforming to ERA CSI guidelines only

	2007	2008	2009	2010	2011	2012
Collisions	0.033	0.030	0.016	0.017	0.024	0.026
Derailments	0.225	0.211	0.198	0.183	0.180	0.138

With this data set in hand, it was possible to compare Class I railroad safety performance to counterparts in Europe operating with single-person crews. Exhibits V-7 through V-9 illustrate

[49] The ERA defines a train as "one or more railroad vehicles hauled by one or more locomotives or railcars, or one railcar travelling alone, running under a given number or specific designation from an initial fixed point to a terminal fixed point." Implementation Guidance for CSIs; Annex I of Directive 2004/49/EC as Amended by Directive 2009/149/EC, version 2.3, ERA, May 24, 2013, p. 12.
[50] See Exhibit A-17 in the Annex for a table showing how the application of data filters affected the number of casualty incident records remaining in the analysis.
[51] Source: FRA, Oliver Wyman analysis.

the collision and derailment rates for the US Class Is, France, Germany, Italy, Sweden, and the United Kingdom.

Exhibit V-7: Annual Collision Rates by Country, 2007-2012[52]

Records conforming to ERA CSI guidelines only, incidents per million train kilometers

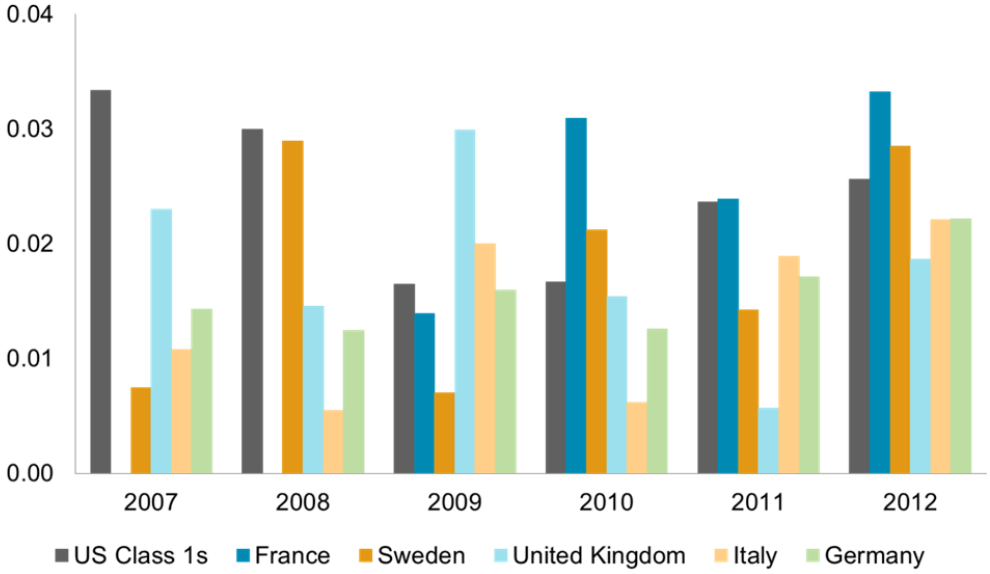
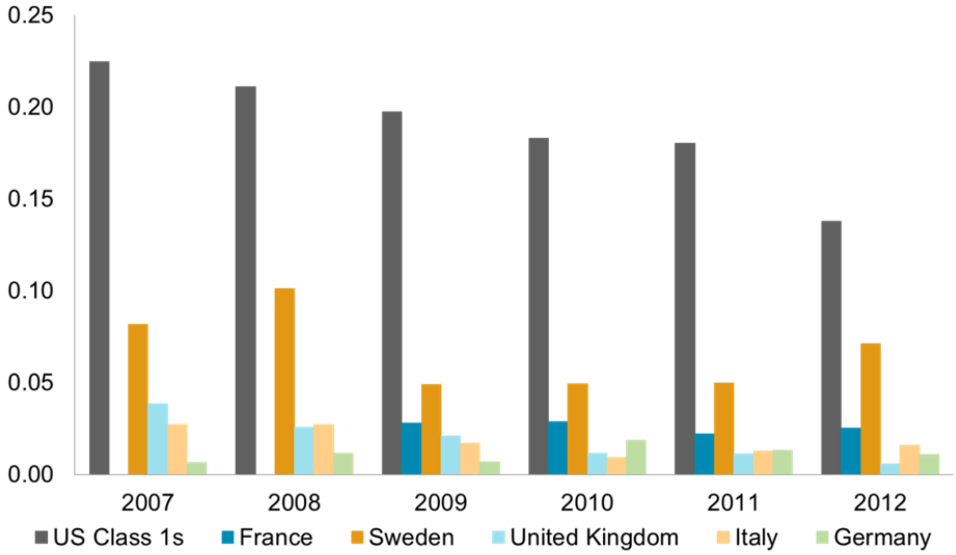


Exhibit V-8: Annual Derailment Rates by Country, 2007-2012[53]

Records conforming to ERA CSI guidelines only, incidents per million train kilometers



[52] Source: ERA, FRA, Oliver Wyman analysis. For 2007 and 2008, data from France utilized a different reporting procedure for collisions than they do currently. Consequently, the numbers for those years were removed from the chart.
[53] Ibid.

Exhibit V-9: Average Annual Collision and Derailment Rates by Country, 2007-2012[54]
Per million train-kilometers

	US Class Is	France	Germany	Italy	Sweden	United Kingdom
Collisions	0.025	0.025	0.016	0.014	0.018	0.018
Derailments	0.190	0.026	0.011	0.019	0.067	0.019

The collision data, while showing a high degree of variance on a year-by-year basis due to the rarity of such events, still supports the assertion that single-person crews are at least as safe as single-person crews. The United States average is equal to the French average, but higher than the rate for the other major European operations.

US Class I's have had a significantly higher derailment rate than their European counterparts. However, it is difficult to correlate derailments with crew size, especially since the data for both US and European railroads includes all derailment incidents (not just human-factor related). Either way, the derailment rate data supports the conclusion that single-person crews are at least as safe as multiple-person crews.

3. Evaluation of Casualty Incident Data

For casualty incidents, comparing US and European railroad data is more challenging. The difficulty stems ERA definitions, as well as the available data in the FRA's casualty database:

- Serious injuries, according to the ERA, involve injuries where hospitalization for a minimum of 24 hours is required. Since the FRA casualty data contains no information regarding hospitalization, it is not possible to construct a comparable CSI for US railroads.
- Similarly, ERA defines a fatality as "any person killed immediately or dying within 30 days as a result of an accident, excluding suicides." The FRA defines a fatality in roughly the same manner, except that it can include a death that occurs up to 180 days from the date of injury. Since the FRA does not provide record detail concerning the number of days between the date of injury and the date of death, a direct comparison between US and European fatalities runs the risk of including too many fatalities in the case of US railroads, or not enough in the case of European railroads.
- Finally, accidents to persons caused by rolling stock in motion are defined as "accidents to one or more persons that are either hit by a railroad vehicle or by an object attached to or that

[54] Source: ERA, FRA, Oliver Wyman analysis. Due to different calculation procedures used for French data in 2007 and 2008 for collisions and derailments, annual averages for France include only the four years from 2009 through 2012.

has become detached from the vehicle. Persons that fall from railroad vehicles are included, as well as persons that fall or are hit by loose objects when travelling on-board vehicles." As mentioned earlier, an incident is included in CSI statistics only if it meets the definition of a significant accident, which, when it comes to casualties, requires injuries that are either serious, or fatal, as defined by the ERA. Again, the FRA does not provide enough detail in its casualty records to allow for a direct comparison.

Serious Injuries

Definition issues notwithstanding, it is still possible to construct US railroad CSIs that are somewhat similar to, but not exact matches for, the CSIs used by ERA. To determine serious injuries, days absent (also known as lost work days) in regards to an injury can be used as a proxy for hospitalization. Assuming seven lost work days are equal to a 24-hour hospital stay, all casualty records that did not have at least eight lost work days were removed from the assessment.[55] While not a perfect substitute, this methodology removed minor injuries from the analysis.

Typically, a railroad will only be able to record the work absence of its employees. Other injured parties often do not provide rail carriers with such information due to privacy concerns. Consequently, only records detailing injuries sustained by railroad employees were used in the analysis. Also, as all US Class I rail carriers employ multiple-person crews for train operation, only those employee injuries occurring on carriers meeting the definition of a Class I were used.

Finally, in regards to serious injuries related to rolling stock in motion, data concerning location, cause of injury, physical action, and tools utilized at the time of the injury were taken into account to further screen injury incidents not related to train operation.[56]

The final set of data for the US CSIs involved records for employees seriously injured in accidents involving rolling stock in motion, in train collisions, and in train derailments. Exhibit V-10 shows this data for 2007 through 2012. Exhibits V-11 through V-14 illustrate this data in comparison to the ERA CSI collision and derailment data for a range of European countries that use single-person crews.

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[55] The assumption that seven lost work days is equal to a 24-hour hospital stay is based on observation of the days absent distribution for railroad employees. Employees of the evaluated railroads (Class Is, regionals, Amtrak, and commuter agencies) posted 14,284 injuries for 2007-2013. Of those injuries, 4,353 resulted in no lost work days and 615 incidents resulted in one lost work day. Between two and seven lost work days, injuries declined from 374 to 260. Finally, 175 injuries resulted in eight lost work days. The inflection point between seven and eight lost work days indicates a change in injury severity, and appears to be a logical point at which to say that a minimum of seven lost work days equals a 24-hour hospital stay.

[56] See Exhibits A-18 through A-26 in the Annex for detail on items included and excluded from the US/Europe serious injury analysis.

Exhibit V-10: US Railway Employee Injury Rates per Million Train-Kilometers, 2007-2012[57]
Screened records only

	2007	2008	2009	2010	2011	2012
Rolling stock in motion	0.027	0.031	0.022	0.020	0.011	0.017
Train collisions	0.018	0.020	0.011	0.014	0.012	0.010
Train derailments	0.007	0.008	0.003	0.010	0.010	0.001

Exhibit V-11: Employee Serious Injury Rates, Rolling Stock in Motion, by Country, 2007-2012[58]
US screened record set, ERA CSI indicators, incidents per million train-kilometers

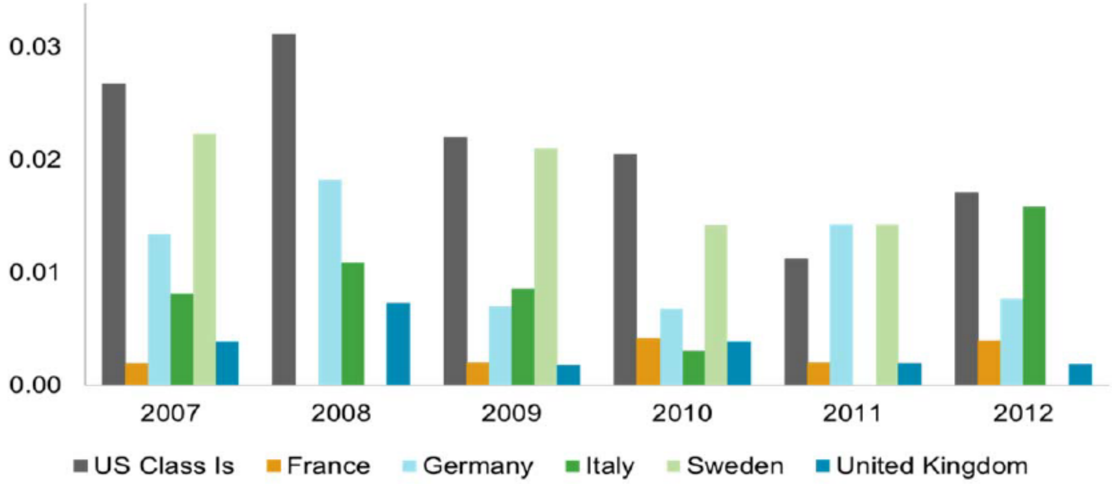
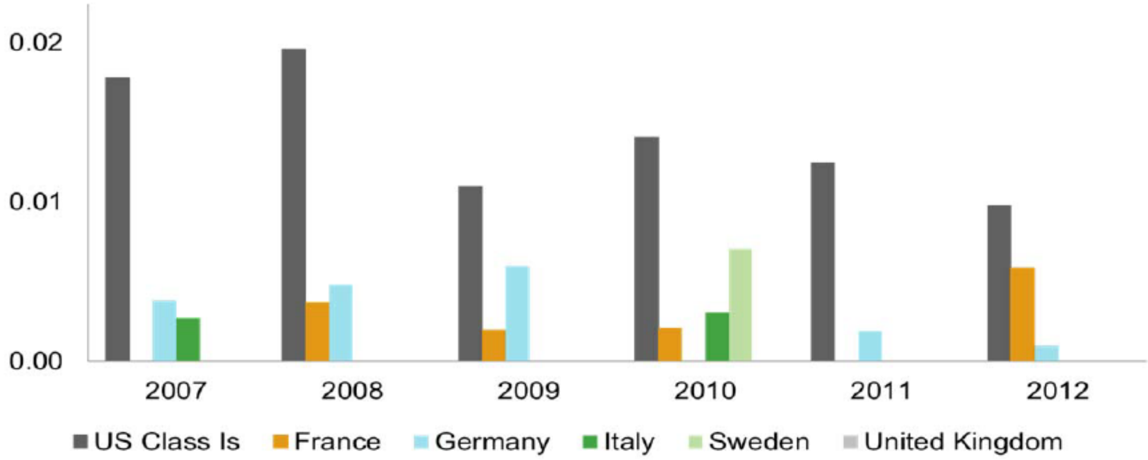


Exhibit V-12: Employee Serious Injury Rates, Collisions, by Country, 2007-2012[59]
US screened record set, ERA CSI indicators, incidents per million train-kilometers



[57] Source: FRA, Oliver Wyman analysis.
[58] Source: ERA, FRA, Oliver Wyman analysis.
[59] Ibid.

Exhibit V-13: Employee Serious Injury Rates, Derailments, by Country, 2007-2012[60]

US screened record set, ERA CSI indicators, incidents per million train-kilometers

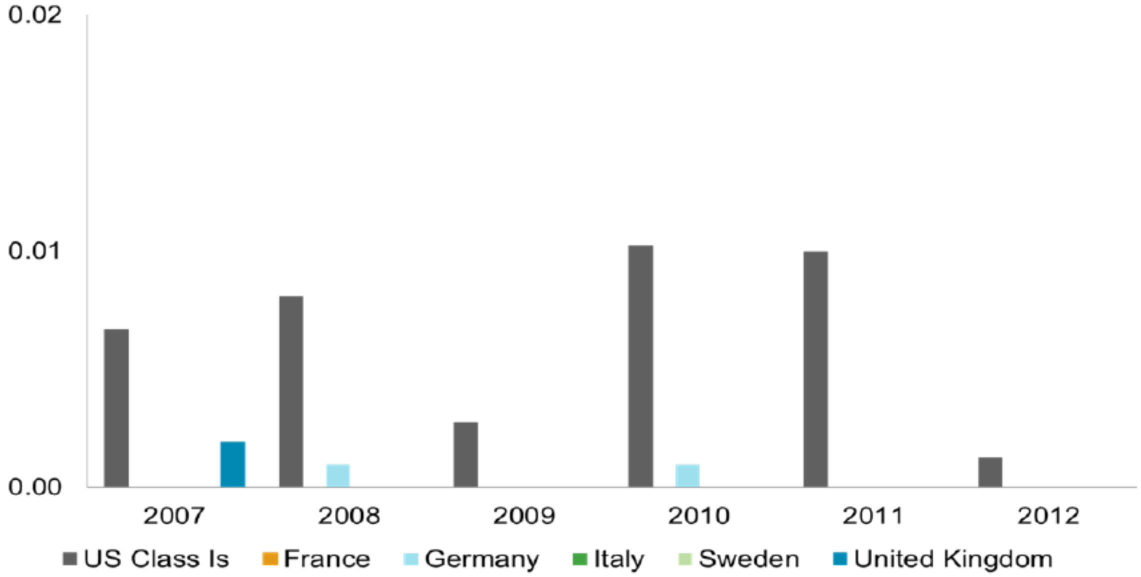


Exhibit V-14: Average Annual Employee Serious Injury Rates by Country, 2007-2012[61]

Per million train-kilometers

	US Class Is	France	Germany	Italy	Sweden	United Kingdom
Collision injuries	0.014	0.002	0.003	0.001	0.001	0.000
Derailment injuries	0.007	0.000	0.000	0.000	0.000	0.000
Rolling stock in motion injuries	0.022	0.002	0.011	0.008	0.012	0.003

The exhibits above show that US rail carriers have had a higher injury rate than their European counterparts, when similar data sets for employee injuries are considered. It should be noted that given the data comparison challenges, the serious injury rate for US rail carriers may be overstated, because seven lost work days may not equate to a hospital stay. Nevertheless, single-person crew operations do appear to be at least as safe as multiple-person crew operations when it comes to the potential for employee injuries.

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60 Ibid.

61 Source: ERA, FRA, Oliver Wyman analysis.

Fatalities

Another metric generally used to evaluate the safety of rail operations is the number of employee fatalities. The FRA classifies a fatal accident as one where death occurs within 180 days of the accident, due to injuries sustained during the accident. The ERA uses a smaller time window, considering a fatal accident as one where a death occurs within 30 days. The longer time period considered by the FRA may have the effect of increasing the number of fatalities relative to the ERA data. The data does not enable number of deaths occurring between days 31 and 180 to be determined; however, this number is expected to be small and should not have a significant impact on the results of the evaluation.

Using the same methodology employed to calculate serious injury rates, but keeping only fatality data, employee fatality CSIs were calculated for US Class I railroads and for a range of European railroads that use single-person crews. Due to the fact that fatal events are rare in railroad operations for both the US and Europe, to obtain a larger sample size, the data for rolling stock in motion, train collision, and train derailment fatalities were added together for the years 2007 through 2012. From the amalgamation of fatality data, an average annual fatality rate was calculated for each country. It is presented in Exhibit V-15.

Exhibit V-15: Average Annual Employee Fatality Rates by Country, 2007-2012[62]
Per million train-kilometers

	US Class Is	France	Germany	Italy	Sweden	United Kingdom
Fatalities	0.004	0.003	0.007	0.009	0.005	0.001

The exhibit shows that US Class I employee fatalities occur at roughly the same rate as at their European counterparts. A further calculation to compare the average rates of the US versus the combined five European countries found that the averages are statistically similar.

4. Evaluation of Signals Passed at Danger (SPADs)

Unlike data for collisions, derailments, serious injuries, and fatalities, there is little difference between US Class I and ERA reporting of SPADs, as both are concerned with the movement of trains beyond the limits of their authority. As mentioned earlier, SPAD data for European railroads is readily available from the ERA. In the US, the FRA does not make such information available to the general public; however, several Class I railroads made their data available for the purposes of this study. When this data is normalized across millions of train-kilometers for

[62] Source: ERA, FRA, and Oliver Wyman analysis.

each reporting railroad, the resulting data points are reasonable indicators of overall US Class I railroad SPAD performance.

Exhibit V-16 shows the average annual SPAD rates for US Class Is and several of their European counterparts between 2007 and 2012. In addition, a composite SPAD rate for the five European nations is provided (Euro-5).

Exhibit V-16: Average Annual SPAD Rates by Country, 2007-2012[63]

Per million train-kilometers

	US Class Is	France	Germany	Italy	Sweden	United Kingdom	Euro-5
SPADs	0.630	0.238	0.492	0.045	2.173	0.525	0.480

Overall, US Class Is have a slightly higher rate of SPADs than the majority of their European counterparts. The one exception is Sweden, which experienced SPADs at a higher rate than the other European railroads. According to the Swedish Transport Agency, the reason for the high rate of SPADs is due to several factors. First, the request for SPAD data from the ERA is relatively new. As a consequence, many railroad operators in Sweden are reporting a variety of incidents as SPADs, not just the incidents that meet the ERA definition.[64] Second, incorrect car lists (also known as train consists in the US) have been identified as a contributing factor to the high rate of SPADs.[65] As car lists specify train length and tonnage for the engineer, the lack of correct information can lead to improper train handling (insufficient braking, for instance). Finally, cell phone usage by engineers was identified as a contributing factor to the high rate of SPADs.[66] New regulations restricting cell phone use were introduced in late 2011, but as yet, no discernable improvement in SPAD performance has been noted.

US Class I carriers with multiple-person crews possess a SPAD rate that is slightly higher than the average for all five European nations. As noted before, this difference in performance rates may be due to a range of factors, of which crew composition is only one. While it is possible to argue from this data that European railroads with single-person crews are safer than US multi-person crews when it comes to SPADs, it is more realistic to say that single-person crew operations are at least as safe as multiple-person crew operations.

[63] Source: ERA, several Class I railroads, and Oliver Wyman analysis.
[64] Railway Safety Report, 2010 Annual Report Pursuant to Article 18of Directive 2004/49/EC (the Railway Safety Directive), Swedish Transport Agency, p. 7.
[65] Railway Safety Report, Swedish Transport Agency, op. cit., p. 16.
[66] Ibid.

E. Summary of Safety Analysis Findings

The foregoing analysis does not suggest that single-person crews are any less safe than the multiple-person crews currently employed by most US freight railroads. In comparing the single-person crew proxy operations of Amtrak, commuter rail operators, and INRD to Class I and regional railroads with multi-person crews, the data supports the finding that single-person crews are as safe as multiple-person crews. Similarly, when assessing similar data sets for US Class I rail operations and European rail operations, it appears that European railroads and their single-person crews realize better safety performance than their US counterparts when it comes to derailments, employee injuries, and SPADs, and similar outcomes with regard to collisions and fatalities. This data, too, supports the conclusion that single-person crews appear to be as safe as multiple-person crews.

VI. Economic Analysis

A. Economic Model and Scenario Overview

Oliver Wyman developed an economic model to establish the potential cost savings of single-person crews to the freight railroad industry. The implementation of single-person crew operations could take several different forms, based on each Class I's pace and scope. Hence, two different scenarios were modeled to provide dimensions around potential economic benefits:

- **Scenario A – Single person-crews limited to trains without intermediate work:** This scenario assumes that all road trains (unit and through) with intermediate work between crew change locations are run with a minimum of two employees. Those road trains that do not have intermediate work would operate with only a locomotive engineer. Should an en route failure or unscheduled work event occur, the engineer-only train would be assisted by local railroad personnel in the area.

- **Scenario B – Single-person crews on high density lines, with or without intermediate work:** This scenario assumes that only road trains operating on rail lines with high traffic density would have a single locomotive engineer on board. All en route work events, whether scheduled or unscheduled, and en route equipment failures would be handled by the locomotive engineer working in concert with a utility person. The utility person would help all road trains needing assistance in a defined territory. For road trains operating on corridors with lower traffic densities, the train crew would comprise at least two employees. Staffing utility personnel on low-density lines is assumed to be more expensive than retaining a second employee on each road train.

Taken together, these scenarios represent the lower (Scenario A) and upper bounds (Scenario B) of a range of single-person crew implementation approaches that could be adopted by US freight railroads. Scenario A outlines a base scenario of no ancillary support, where those road trains without scheduled en route work have only an engineer on board and no additional resources are deployed to assist trains between crew change locations. Scenario B outlines a high ancillary support scenario, where the trainman would only be removed from road trains traveling on corridors with traffic volumes high enough to justify the round-the-clock staffing of utility personnel.

B. Approach and Assumptions

In general, modeling of each scenario began with a determination of the number of road trains operated annually over the US Class I railroad network. The number of crews required to operate these trains was then calculated. Historical en route work events and equipment failures were added in to determine the number of times that a second employee may be necessary to the efficient execution of the activities required to complete a work event or resolve an equipment failure. Those employees not necessary to handle en route events were subtracted from the scenarios, and their wages, fringe benefits, and payroll taxes were calculated to derive the cost savings associated with single-person crew operation. Any additional costs necessary to make the scenario viable, such as utility personnel, additional highway vehicles, and additional locomotive engineers to staff up for potential re-crews, were also calculated and subtracted from the savings generated by eliminating a second person on the train.

Each scenario description in this chapter presents the estimated net economic benefits of single-person crew operations for the year 2013, as if such operations were fully implemented at that time. In addition, estimated net economic benefits for the years 2020 through 2029 are presented. The year 2020 was chosen as a starting point for projections because the next round of national rail labor bargaining will conclude in 2019. Finally, it was assumed that PTC, a key enabling technology for single-person crew operations, will be in full operation by 2020.

The development of each scenario involved calculations and assumptions regarding traffic, en route events, and employees, as outlined below. In addition, Scenario B incorporates an additional dimension, characteristics of the US Class I railroad network, as a core assumption for the scenario is that single-person train crew operations do not make sense on all railroad routes. For Scenario B, traffic density determines where single-person crew operations make the most sense.

1. Traffic

The freight tonnage likely to be handled over the US railroad network in coming years was estimated by applying a compound annual growth rate to the tons carried by Class I railroads in 2013 (as provided by the STB's annual R-1 reports). The annual growth rate was determined by the US DOT's projected change in rail (1.138 percent) and multi-modal (2.941 percent) tonnage between the years 2012 and 2040.[67]

Freight tons were then converted into freight ton-miles, gross ton-miles, and then car-miles using ratios determined from 2013 Class I railroad performance data. In addition, the historic changes in those ratios were derived from prior years' operating data and applied to the estimates going forward. Thus, several assumptions were built into the forecast: that miles per freight ton carried will continue to increase, that freight ton to gross ton-mile ratio will continue to improve (indicating improved management of empty railcars), and that railcars will carry heavier loads on average in the future.

[67] Freight Facts and Figures 2013, US DOT, Table 2-1; Oliver Wyman analysis.

Once car-miles, both loaded and empty, were determined, the number of trains operated, as well as the number of train-miles generated, were calculated.[68] These figures are important inputs for the scenarios. Example data for 2013 and 2029 is shown in Exhibit VI-1.

Exhibit VI-1: Example Class I Traffic Input Data

	2013 Actual	2029 Estimate
Car-miles - Loaded - Empty	 20.2 billion 15.0 billion	 22.4 billion 16.1 billion
Number of road trains operated	1.26 million	1.28 million
Number of train-miles	511.3 million	551.5 million

2. En Route Work Events and Equipment Failures

Another important input for the economic models is stops en route for work events and equipment failures. Work events, both scheduled and unscheduled, are carried out by road trains between crew change points and terminals and often require more than one employee to accomplish. Similarly, en route equipment failures (e.g., emergencies, line side equipment detector activations, and detector failures) also require more than one employee to inspect and correct. The annual average frequency of these events in recent years was derived from data provided by Class I railroads for the purposes of this study and is shown in Exhibit VI-2.[69]

Exhibit VI-2: Annual Average En Route Work Events and Equipment Failures

	Per Million Train-Miles
Scheduled work events	1,499
Unscheduled work events	243
En route equipment failures	278

Another assumption with regard to en route work events and equipment failures is that only one will occur per crew start. So, for instance, in 2013, an estimated 700,000 scheduled en route work events occurred.[70] In keeping with our assumption, this means that 700,000 crew starts had to deal with this type of work. The same assumption was applied to unscheduled work events and en route equipment failures. Further, it was assumed that where a scheduled work event occurs, no unscheduled work or equipment failure will occur.

[68] R-1 Reports for 2013 for all seven Class I railroads, Schedule 755, US STB; Oliver Wyman analysis.
[69] Based on 2012-2014 data provided by several Class I railroads and Oliver Wyman analysis.
[70] Oliver Wyman analysis.

In short, scheduled and unscheduled work and equipment failure events were assumed to be mutually exclusive. While this is not always the case in reality, it does allow for more conservative estimates in the economic model: A higher number of standalone work events and equipment failures reduces the number of single-person crew starts, thereby lowering the economic advantage that would accrue to the railroad operator.

3. Employees, Wages, Benefits, and Payroll Taxes

Employee productivity is an important consideration for railroads, as employee compensation is the largest component of railroad operating expenses. Exhibit VI-3 shows that, in 2012, salaries, wages, and fringe benefits for all Class I railroad employees accounted for 30 percent of the industry segment's total operating expenses. Train, engine, and yard (TE&Y) employees comprised approximately 41 percent of all active US Class I railroad employees. With mean annual compensation, not including benefits, of over $80,000, TE&Y personnel represented over $5.3 billion in operational costs for US Class I railroads in 2012. Altogether, TE&Y personnel accounted for 42 percent of total Class I railroad compensation and 11 percent of overall operating expenses. [71]

As compensation for TE&Y personnel is a significant percentage of industry operating expenses, railroads can ill afford to continue paying employees when their positions are rendered redundant by technological advances. Federally mandated PTC will do just that for a second person in the locomotive cab, because it is designed to provide the train operation oversight that traditionally rested with the crew. Thus, since PTC investments directly impact crew tasks, crew size reductions are a logical source of expense reductions to fund the PTC investment.

Exhibit VI-3: Major Cost Components of Class I Railroad Operating Expenses[72]

Expense category	Amount (billions)	Percent of total expenses
Compensation	$15.3	30%
– TE&Y Compensation	$5.3	11%
Fuel	$11.5	23%
Other	$10.1	20%
Depreciation	$6.1	12%
Materials, supplies, and rents	$5.6	11%
Property and taxes	$1.1	2%
Casualties, insurance, and freight loss and damage	$0.7	1%
Total	**$50.3**	**100%**

[71] All data in this paragraph: Analysis of Class I Railroads, Association of American Railroads, 2012.
[72] Analysis of Class I Railroads, AAR, 2012, op. cit.

As the economic advantage of single-person crew operations derives primarily from workforce reduction, data on employment, wages, fringe benefits, and payroll taxes are important inputs for all scenarios. The National Railway Labor Conference (NRLC) provided the necessary data for both trainmen and locomotive engineers for the year 2012. Using this data, Oliver Wyman calculated trainmen wage statistics and annual fringe benefit costs and payroll tax information, as shown in Exhibit VI-4.[73]

Exhibit VI-4: Trainman Wage, Benefit, and Payroll Tax Base Costs

	2012 Data
Wages	
- Average hourly straight time pay	$25.86
- Average hourly overtime pay	$33.68
- Average pay per trip (straight time plus overtime)	$238.31
Annual fringe benefit cost and payroll tax (per employee)	$33,800

For subsequent years, the 2012 figures were inflated using a compound annual growth rate derived from the wage rate (3.0 percent) and wage supplement (4.6 percent) cost indices for the years 2000 through 2013 found in the AAR's Railroad Cost Indexes. Finally, basic worker statistics, such as average miles per trip (131) and annual trips per employee (190) were derived from the NRLC's data.[74] Altogether, these different data elements concerning trainmen and locomotive engineers were used to determine the economic benefits stemming from each single-person crew operation scenario.

The economic benefits for each scenario are offset by expenses accrued through the use of utility personnel and others to assist trains operated with only an engineer. As explained above, Scenario A assumes that all unscheduled work events and en route equipment failures are handled by the engineer with assistance from other railroad personnel, such as mechanical, engineering, or operations employees. It would take time for these personnel to travel from their normal job locations to the location of a train needing assistance, and likely by the time they arrived and executed the necessary actions to get the train underway again, the train engineer will have reached the end of his or her federally-mandated hours of service. Consequently, for Scenario A, it was assumed that all unscheduled work events or en route equipment failures would result in a re-crew of the train ($323.20 per instance in 2013).[75]

[73] Email from H. Glen Williams, Jr., Director Economic Research, National Railway Labor Conference (NRLC), on July 22, 2014, and Oliver Wyman analysis. Comparable figures for locomotive engineers are $31.43 per straight time hour, $38.56 per hour of overtime, and $313.72 average per trip.
[74] Email from H. Glen Williams, Jr., NRLC, Oliver Wyman analysis, op. cit.
[75] Ibid.

In Scenario B, utility personnel would be staffed on a round-the-clock basis (necessitating three shifts of eight hours each) for crew districts with high traffic density. In lieu of a trainman on board a train, these employees would be responsible for assisting road trains that have work events, both scheduled and unscheduled, and that encounter en route equipment failures. Oliver Wyman estimated the cost of this staffing at $250.60 per shift, plus $35,338 in fringe benefits and payroll taxes per employee, in 2013.[76]

4. Network

For Scenario B, it was necessary to determine the overall route miles of the densest railroad corridors in the United States. The STB's annual R-1 reports divide track miles into density categories A through D, with A being the heaviest at 20 million or more gross ton-miles (GTMs) per track mile, B between 5 and 20 million GTMs per track mile, C between 1 and 5 million GTMs per track mile, and D with less than 1 million GTMs per track mile. (There is also a category E that includes yard and way switching track miles.) To properly estimate the route miles that fall into each traffic density classification, Oliver Wyman made the following assumptions:

- All second and other main track mileage is part of track category A.
- Passing tracks, crossovers, and turnouts mileage were apportioned as follows:
  - Passing tracks: 80% of mileage
  - Crossovers: 10% of mileage
  - Turnouts: 10% of mileage
- All passing tracks were associated with single-track mainlines only.
- Crossovers were associated with multiple-track mainlines only.
- Turnouts were apportioned evenly across mainline types.

Based on the above assumptions, route mileage under category A was calculated to be approximately 43,000 miles, category B was 29,000 miles, category C was 10,000 miles, and category D was 12,000 miles. Since categories A and B represent the most heavily traveled rail corridors, it was assumed that single-person crew operations would make the most economic sense on these corridors, as there would be enough road trains on average to justify the staffing of utility personnel. Road trains operating over rail lines in categories C and D would continue to operate with multiple-person crews.

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[76] National Railway Labor Conference, AAR Railroad Cost Indexes, and Oliver Wyman analysis. The average shift length for a utility person is assumed to be 9.08 hours. The additional time would be expended in turnover with the following shift, returning to the home terminal from helping a train, etc.

5. Other Assumptions

To perform their duties, utility personnel would need to use company vehicles assigned to their particular work area. According to one Class I railroad, a suitable vehicle for utility duties costs $33,000. Maintenance, repair, and administration would be an additional $3,200 per year. These costs were inflated by the compound annual growth rate of the AAR's materials and supplies cost index from 2000 to 2013 (4.5 percent).[77] While the Class I railroad providing the information assumed that the vehicle would last 12 years, Oliver Wyman believes that a more likely timeframe is six years, owing to the environment in which such vehicles operate. Each crew district employing utility personnel was assigned one vehicle.

Fuel for the utility vehicles is another cost consideration for Scenario B, and Oliver Wyman calculated 2013 fuel cost per vehicle to be nearly $17,000.[78] For subsequent years, fuel price per gallon was increased in the model at a compound annual growth rate of 6.8 percent (the historic CAGR for 2000 to 2013).[79]

Finally, train delay costs were estimated for Scenario A, since road trains experiencing en route equipment failures or performing unscheduled work were assumed to require re-crews. The delay entailed by a re-crew generates costs not only for the train involved (direct delay cost), but also for other trains in the general vicinity (indirect delay cost). Costs are incurred for locomotives, railcars, fuel, and crews, as shown in Exhibit VI-5. For years subsequent to 2013, the compound annual growth rate of the appropriate railroad cost inflation factors for the years 2000 through 2013 were applied to unit costs.

Exhibit VI-5: Scenario A: Train Delay Cost Assumptions[80]

	Cost per hour
Locomotive	$9.51
Railcar	$3.65
Fuel	$12.49
Single-person crew (includes fringes and taxes)	$46.72
Multiple-person crew (includes fringes and taxes)	$87.55

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[77] AAR, Railroad Cost Indexes.
[78] It was assumed that vehicles would average 15 miles per gallon in regular usage and be driven 73,000 miles annually (or 200 miles per day), thus consuming 4,900 gallons of fuel per year, at an average fuel cost of $3.51 per gallon in 2013. Energy Information Administration, http://www.eia.gov/petroleum/gasdiesel/, arithmetic mean of the 52 weeks reported in 2013, US, All grades, conventional.
[79] Energy Information Administration, op. cit.
[80] Locomotive and railcar per hour cost based on Oliver Wyman analysis. Fuel per hour cost based on $3.12 per gallon for diesel fuel (Surface Transportation Board Annual R-1 Reports for 2013) and an estimated four hours idling time per re-crew (Oliver Wyman analysis). Overall crew cost per hour based on National Railway Labor Conference and Oliver Wyman analysis.

For Scenario B, delay costs were not considered, as it was assumed that utility personnel would respond to equipment failures and unscheduled work events in a timely manner, and re-crews would not be required.

C. Scenario A Modeling Results

Under Scenario A, as noted above, train crews with no scheduled work events would have their trainman positions removed. Should an en route failure or unscheduled work event occur, the locomotive engineer in these cases would be assisted by local railroad personnel in the area.

Oliver Wyman baseline data estimates for 2013 US Class I train crews are shown in Exhibit VI-6. Model results for 2013 for Scenario A are shown in Exhibit VI-7. Of note is that under Scenario A, an estimated 15,000 trainman positions could be eliminated, saving almost $1.3 billion in wages, benefits, and payroll taxes. This would be offset by costs for re-crew, direct delay, and indirect delay.

In particular, re-crew costs would include the wages of locomotive engineers called to replace engineers assumed to expire on hours of service, as well as the fringe benefits and payroll taxes associated with the 1,200 additional locomotive engineers that would be needed to handle increased re-crews. Thus, the total estimated savings of Scenario A for the Class I railroads in 2013 would be $703 million.

Exhibit VI-6: Baseline Train Crew Data for 2013

	2013
Road trains operated (unit and through)	1.26 million
Train crews (locomotive engineer, trainman, and conductor)	3.54 million
Crews performing scheduled work	700,000
Crews performing unscheduled work or handling en route equipment failures	241,000

Exhibit VI-7: Estimated Results of Scenario A for 2013

	2013
Train crews with a trainman removed	2.85 million
Trainmen positions to eliminate[81]	15,000
Wages, fringe benefits, and payroll tax savings	$1.23 billion
Re-crew costs (for unscheduled work or en route equipment failures)	$126 million
Direct delay costs	$179 million
Indirect delay costs	$223 million
Net scenario savings	**$703 million**

Since single-person crew operations most likely would not be implemented before 2020, however, Exhibit VI-8 presents the annual savings that Class I railroads could see for the years 2020 through 2029 if Scenario A were implemented. As traffic grows throughout the decade, Class I railroads would see Scenario A savings increase by a compound annual growth rate of 2.8 percent, from $878 million in 2020 to $1.130 billion in 2029.

[81] Assumes each trainman is part of approximately 190 crews per annum.

Exhibit VI-8: Economic Scenario A: Estimated Annual Costs and Savings, 2020-2029[82]

Figures in millions of units and millions of nominal US dollars

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRAINS & CREWS										
Total road trains	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.28	1.28
Total road train crews	3.68	3.70	3.72	3.74	3.76	3.78	3.80	3.82	3.85	3.87
TRAINMEN										
Scheduled work events	0.72	0.72	0.73	0.73	0.74	0.74	0.74	0.75	0.75	0.76
Trainmen trips eliminated	2.96	2.97	2.99	3.01	3.02	3.04	3.06	3.08	3.09	3.11
Total trainmen wage savings	$894	$926	$960	$994	$1,030	$1,067	$1,105	$1,145	$1,187	$1,230
Fringe benefit and payroll tax savings	$753	$791	$832	$875	$919	$967	$1,016	$1,069	$1,124	$1,182
Total savings	**$1,647**	**$1,718**	**$1,791**	**$1,869**	**$1,949**	**$2,034**	**$2,122**	**$2,214**	**$2,311**	**$2,412**
LOCOMOTIVE ENGINEERS										
Unscheduled work	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
Equipment failures	0.13	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Engineer wage costs	$100	$10030	$107	$111	$115	$119	$123	$128	$132	$137
Fringe benefit and payroll tax costs	$68	$72	$75	$79	$83	$88	$92	$97	$102	$107
Total costs	**$168**	**$175**	**$182**	**$190**	**$198**	**$206**	**$215**	**$224**	**$234**	**$244**
DELAYS										
Direct delay costs	$267	$282	$300	$318	$337	$358	$380	$404	$429	$456
Indirect delay costs	$334	$355	$377	$400	$425	$452	$481	$512	$545	$581
Total delay costs	**$601**	**$637**	**$676**	**$718**	**$762**	**$810**	**$861**	**$916**	**$975**	**$1,037**
NET SCENARIO A SAVINGS	**$878**	**$905**	**$933**	**$961**	**$989**	**$1,017**	**$1,046**	**$1,074**	**$1,102**	**$1,130**

[82] Oliver Wyman analysis. Numbers may not add due to rounding.

D. Scenario B Modeling Results

Under Scenario B, as noted above, only road trains operating on rail lines with high traffic density (STB track density categories A and B) would have the trainman position removed from train crews. All en route work events, whether scheduled or unscheduled, and en route equipment failures would be handled by the locomotive engineer working in concert with utility personnel.

Model results for 2013 for Scenario B are shown in Exhibit VI-9. In this instance, an estimated 18,500 trainmen would be furloughed, saving over $1.5 billion in wages, fringe benefits, and payroll taxes. This figure would be offset by utility personnel costs and vehicle costs.

Exhibit VI-9: Estimated Results of Scenario B for 2013

	2013
Train crews with a trainman removed	3.51 million
Trainmen eligible for furlough[83]	18,500
Trainmen wages, fringe benefits, and payroll tax savings	$1.5 billion
Utility personnel wages, fringe benefits, and payroll tax costs	$203 million
Utility vehicle costs (acquisition, maintenance, repair, fuel)	$14.2 million
Net scenario savings	**$1.2 billion**

Utility personnel requirements were calculated based on assigning three 8-hour shifts to each crew district. According to NRLC data, miles per trainman trip averaged 131 in 2012, which was assumed to also be the average length of a crew district. The route miles of STB category A and B rail lines were divided by the average crew district length to arrive at an assumed 552 crew districts. With over 600,000 "utility starts"[84] to be filled annually, however, and assuming that each utility person undertakes 190 starts per year, Class I railroads would need almost 3,200 utility personnel, at a cost of $203 million. As noted above, the vehicles used by utility personnel would generate additional expense, totaling approximately $14.2 million.[85] Thus, the total estimated savings of Scenario B for the Class I railroads in 2013 would be $1.2 billion.

Since single-person crew operations most likely would not be implemented before 2020, Exhibit VI-10 presents the annual savings that Class I railroads could see for the years 2020 through 2029 if Scenario B were implemented. As traffic grows throughout the decade, Class I railroads would see Scenario B savings increase by a compound annual growth rate of 4.4 percent, from $1.7 billion in 2020 to $2.5 billion in 2029.

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[83] Assumes each trainman is part of approximately 190 crews per annum.
[84] Utility starts are calculated based on number of crew districts x three shifts per day x 365 days of the year.
[85] For the model, vehicle acquisition costs were spread evenly over six years. For 2013, those costs would have been over $3.0 million. Maintenance, repair, and administration costs were calculated to be $1.8 million and fuel $9.4 million.

Exhibit VI-10: Economic Scenario B: Estimated Annual Costs and Savings, 2020-2029[86]

Figures in millions of units and millions of nominal US dollars

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
TRAINS & CREWS										
Total road trains on A and B track	1.25	1.25	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Total road train crews on A and B track	3.64	3.66	3.68	3.70	3.72	3.74	3.77	3.79	3.81	3.83
TRAINMEN										
Trainmen trips eliminated	3.64	3.66	3.68	3.70	3.72	3.74	3.77	3.79	3.81	3.83
Total trainmen wage savings	$1,101	$1,141	$1,182	$1,224	$1,268	$1,314	$1,361	$1,410	$1,461	$1,514
Fringe benefit & payroll tax savings	$927	$974	$1,024	$1,077	$1,132	$1,190	$1,252	$1,316	$1,384	$1,455
Total trainmen savings	**$2,028**	**$2,115**	**$2,206**	**$2,301**	**$2,400**	**$2,504**	**$2,613**	**$2,727**	**$2,846**	**$2,970**
UTILITY PERSONNEL										
Utility wage costs	$187	$192	$198	$204	$210	$216	$223	$230	$237	$244
Fringe benefit and payroll tax costs	$154	$161	$168	$176	$184	$192	$201	$210	$220	$230
Total utility personnel costs	**$340**	**$353**	**$366**	**$380**	**$394**	**$409**	**$424**	**$440**	**$456**	**$473**
UTILITY VEHICLES										
Total vehicle purchase cost	$4	$4	$5	$5	$5	$5	$5	$6	$6	$6
Maintenance, repair, & admin.	$2	$3	$3	$3	$3	$3	$3	$3	$3	$4
Total fuel cost	$15	$16	$17	$18	$19	$21	$22	$24	$25	$27
Total vehicle costs	$21	$23	$24	$26	$27	$29	$31	$32	$34	$37
Total utility costs	**$362**	**$376**	**$390**	**$405**	**$421**	**$437**	**$454**	**$472**	**$491**	**$510**
NET SCENARIO B SAVINGS	**$1,666**	**$1,739**	**$1,816**	**$1,896**	**$1,979**	**$2,067**	**$2,159**	**$2,254**	**$2,355**	**$2,460**

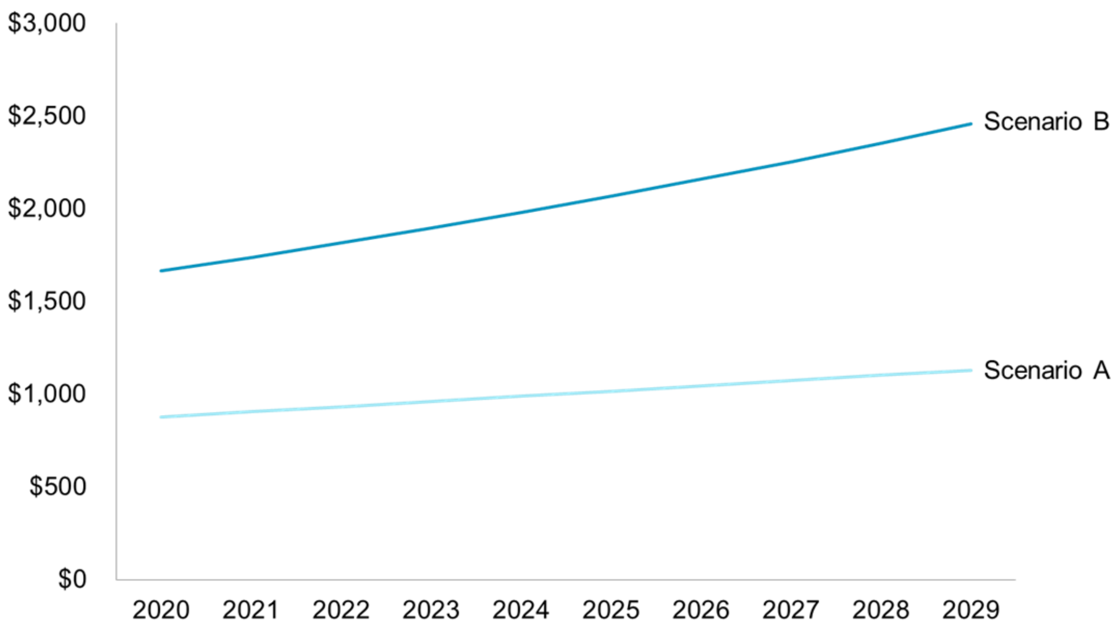
[86] Oliver Wyman analysis. Numbers may not add due to rounding.

E. Summary of Economic Analysis Findings

Exhibit VI-11 compares the annual cost savings of both scenarios for the years 2020 through 2029. In each scenario, single-person crew operations would provide substantial cost savings for the US Class I rail industry. Scenario A, where trainmen are eliminated from all road trains with no scheduled en route work, would have provided an estimated industry savings of $703 million in 2013. In 2020, the first year that single-person crew operations would most likely be implemented, Scenario A would save the railroad industry an estimated $878 million. That savings is expected to grow at a compound annual growth rate (CAGR) of 2.8 percent until at least 2029. Scenario B, where trainmen are eliminated from all road trains operating on high-density rail lines and round-the-clock utility positions are created to assist with scheduled and unscheduled events, would have provided the railroad industry with an estimated savings of $1.2 billion in 2013. In 2020, savings are estimated to be almost $1.7 billion, growing at a CAGR of 4.4 percent through at least 2029. Thus, no matter the structure chosen, single-person crew operations would confer substantial cost savings upon the railroad industry.

Exhibit VI-11: Annual Projected Savings by Scenario for Class I Railroad Single-Person Crew Operations, 2020-2029

US $ millions, dollar amounts are nominal values



VII. Conclusion

In conclusion, single-person crew operations are in widespread use on complex railway systems around the world. In particular, major European railway systems running many mixed freight and passenger trains per day have had great success in their implementation of single-person train crews. As both the intra-US and US/EU safety data analyses show, single-person crew operations appear to be as safe as multiple-person crew operations, if not safer.

With the coming implementation of PTC and other technologies that reduce human error in train operations, single-person train crews would make sense on significant portions of the US Class I rail network. Reduction in train crew size would provide significant cost savings without sacrificing operational safety. The cost savings that accrue through the implementation of single-person crew operations could then be used by the railroads to fund further capital and safety improvements. Thus, by prohibiting railroads from adjusting train crew size to take full advantage of coming technological improvements, the FRA will greatly reduce US railroads' ability to control operating costs, without making the industry any safer.

Annex A. Safety Analysis Input Detail

Exhibit A-1: Commuter rail agencies included in Commuter group

Group	RAILROAD	NAME
Commuter	BNSO	Burlington Northern Santa Fe Suburban Operations
Commuter	CDOT	Connecticut Department Of Transportation
Commuter	CMTY	Capital Metropolitan Transportation Authority
Commuter	DART	Dallas Area Rapid Transit
Commuter	DCTA	Denton County Transportation Authority
Commuter	LI	Long Island Rail Road
Commuter	MACZ	MARC Train Service
Commuter	MBTA	Massachusetts Bay Transit Authority
Commuter	MNCW	Metro North Commuter Railroad Company
Commuter	NCTC	North County Transportation District - Coaster
Commuter	NICD	Northern Indiana Commuter Transportation District
Commuter	NIRC	Northeast IL Regional Commuter Rail Corp.(METRA)
Commuter	NJTR	New Jersey Transit Rail Operations
Commuter	NMRX	New Mexico Rail Runner Express
Commuter	PCMZ	Caltrain Commuter Railroad Company
Commuter	SCAX	Southern California Regional Rail Authority
Commuter	SCR	Sounder Commuter Rail
Commuter	SDNX	San Diego Northern Railway
Commuter	SEPA	Southeastern Pennsylvania Transportation Authority
Commuter	SFRV	South Florida Regional Transit Authority
Commuter	TCCX	Tri-county Commuter Rail Authority
Commuter	TRE	Trinity Railway Express (previously TREX)
Commuter	UFRC	UTA Front Runner Commuter Rail
Commuter	UPME	Union Pacific Metra
Commuter	VREX	Virginia Railway Express

Exhibit A-2: Railroads included in Class I group

Group	RR_Sys	RAILROAD	NAME
Class I	BNSF	BNSF	BNSF Railway Company
Class I	CN	BLE	Bessemer & Lake Erie Railroad Company
Class I	CN	CC	Chicago, Central & Pacific Railroad Company
Class I	CN	CEDR	Cedar River Railroad Company
Class I	CN	CN	Canadian National
Class I	CN	DMIR	Duluth, Missabe & Iron Range Railway Company
Class I	CN	DWP	Duluth, Winnipeg & Pacific Railway
Class I	CN	EJE	Elgin, Joliet & Eastern Railway Company
Class I	CN	GTW	Grand Trunk Western Railroad Incorporated
Class I	CN	IC	Illinois Central Railroad Company
Class I	CN	MMR	Minnesota & Manitoba Railroad
Class I	CN	PI	Paducah & Illinois Railroad Company
Class I	CN	WC	Wisconsin Central Ltd. (also Railway)
Class I	CP	CP	Canadian Pacific
Class I	CP	DH	Delaware & Hudson Railway Company
Class I	CP	DME	Dakota, Minnesota & Eastern Railroad
Class I	CP	ICE	Iowa Chicago and Eastern Railroad Corporation
Class I	CP	SOO	SOO Line Railroad Company
Class I	CSX	CSX	CSX Transportation
Class I	KCS	GWWE	Gateway Eastern Railroad Company
Class I	KCS	KCS	Kansas City Southern Railway Company
Class I	KCS	TM	Texas Mexican Railway Company
Class I	NS	NS	Norfolk Southern Corporation
Class I	UP	UP	Union Pacific Railroad Company

Exhibit A-3: Railroads included in Regional group

Group	Railroad	Name
Regional	AGR	Alabama & Gulf Coast Railway
Regional	ARR	Alaska Railroad
Regional	BPRR	Buffalo & Pittsburgh Railroad, Inc.
Regional	DMVW	Dakota, Missouri Valley, & Western
Regional	FEC	Florida East Coast Railway
Regional	IAIS	Iowa Interstate Railroad, Ltd.
Regional	KO	Kansas & Oklahoma Railroad, Inc.
Regional	KYLE	Kyle Railroad
Regional	MRL	Montana Rail Link
Regional	MMA	Montreal, Maine & Atlantic Railway Ltd.
Regional	NKCR	Nebraska Kansas Colorado Railway, Inc.
Regional	NECR	New England Central Railroad, Inc.
Regional	NYSW	New York, Susquehanna & Western Rwy.
Regional	PAL	Paducah & Louisville Railway
Regional	GRS	Pan Am Railways
Regional	PWRR	Portland & Western Railroad, Inc.
Regional	PW	Providence and Worcester Railroad Co.
Regional	RRVW	Red River Valley & Western Railroad Co.
Regional	WE	Wheeling & Lake Erie Railway Co.
Regional	WSOR	Wisconsin & Southern Railroad, LLC

Exhibit A-4: Type equipment (TYPEQ) data field

TYPE	Status	Description
01	Include	Derailment
02	Include	Head on collision
03	Include	Rear end collision
04	Include	Side collision
05	Include	Raking collision
06	Include	Broken train collision
07	Exclude	Hwy-rail crossing
08	Include	RR grade crossing
09	Include	Obstruction
10	Include	Explosive-detonation
11	Include	Fire/violent rupture
12	Include	Other impacts
13	Include	Other (described in narrative)

Exhibit A-5: Human factor causes (CAUSE) data field

Code	Include/ Exclude	Description
H008	Include	Improper operation of train line air connections (bottling the air)
H017	Include	Failure to properly secure engine(s) (railroad employee)
H018	Include	Failure to properly secure hand brake on car(s) (railroad employee)
H019	Include	Failure to release hand brakes on car(s) (railroad employee)
H020	Include	Failure to apply sufficient number of hand brakes on car(s) (railroad employee)
H021	Include	Failure to apply hand brakes on car(s) (railroad employee)
H022	Exclude	Failure to properly secure engine(s) or car(s) (non-railroad employee)
H025	Include	Failure to control speed of car using hand brake (railroad employee)
H099	Include	Use of brakes, other (Provide detailed description in narrative)
H101	Include	Impairment of efficiency or judgment because of drugs or alcohol
H102	Include	Incapacitation due to injury or illness
H103	Include	Employee restricted in work or motion
H104	Include	Employee asleep
H199	Include	Employee physical condition, other (Provide detailed description in narrative)
H201	Exclude	Blue Signal, absence of
H202	Exclude	Blue Signal, imperfectly displayed
H205	Include	Flagging, improper or failure to flag
H206	Include	Flagging signal, failure to comply
H207	Include	Hand signal, failure to comply
H208	Include	Hand signal improper
H209	Include	Hand signal, failure to give/receive
H210	Include	Radio communication, failure to comply
H211	Include	Radio communication, improper
H212	Include	Radio communication, failure to give/receive
H217	Include	Failure to observe hand signals given during a wayside inspection of moving train
H218	Include	Failure to comply with failed equipment detector warning or with applicable train inspection rules.
H219	Exclude	Fixed signal (other than automatic block or interlocking signal), improperly displayed.
H220	Include	Fixed signal (other than automatic block or interlocking signal), failure to comply.
H221	Include	Automatic block or interlocking signal displaying a stop indication - failure to comply.*
H222	Include	Automatic block or interlocking signal displaying other than a stop indication - failure to comply.*
H299	Include	Other signal causes (Provide detailed description in narrative)
H301	Include	Car(s) shoved out and left out of clear
H302	Include	Cars left foul
H303	Include	Derail, failure to apply or remove

Exhibit A-5: Human factor causes (CAUSE) data field

Code	Include/ Exclude	Description
H304	Include	Hazardous materials regulations, failure to comply
H305	Exclude	Instruction to train/yard crew improper
H306	Include	Shoving movement, absence of man on or at leading end of movement
H307	Include	Shoving movement, man on or at leading end of movement, failure to control
H308	Include	Skate, failure to remove or place
H309	Include	Failure to stretch cars before shoving
H310	Include	Failure to couple
H311	Exclude	Moving cars while loading ramp/hose/chute/cables/bridge plate, etc., not in proper position
H312	Exclude	Passed couplers (other than automated classification yard)
H313	Exclude	Retarder, improper manual operation
H314	Exclude	Retarder yard skate improperly applied
H315	Exclude	Portable derail, improperly applied
H316	Exclude	Manual intervention of classification yard automatic control system modes by operator
H317	Exclude	Humping or cutting off in motion equipment susceptible to damage, or to cause damage to other equipment
H318	Exclude	Kicking or dropping cars, inadequate precautions
H399	Include	Other general switching rules (Provide detailed description in narrative)
H401	Include	Failure to stop train in clear
H402	Exclude	Motor car or on-track equipment rules, failure to comply
H403	Include	Movement of engine(s) or car(s) without authority (railroad employee)
H404	Include	Train order, track warrant, track bulletin, or timetable authority, failure to comply
H405	Exclude	Train orders, track warrants, direct traffic control, track bulletins, radio, error in preparation, transmission or delivery
H406	Exclude	Train orders, track warrants, direct traffic control, track bulletins, written, error in preparation, transmission or delivery
H499	Include	Other main track authority causes (Provide detailed description in narrative)
H501	Include	Improper train make-up at initial terminal
H502	Include	Improper placement of cars in train between terminals
H503	Include	Buffing or slack action excessive, train handling
H504	Include	Buffing or slack action excessive, train make-up
H505	Include	Lateral drawbar force on curve excessive, train handling
H506	Include	Lateral drawbar force on curve excessive, train make-up
H507	Include	Lateral drawbar force on curve excessive, car geometry (short car/long car combination)
H508	Include	Improper train make-up
H509	Include	Improper train inspection

Exhibit A-5: Human factor causes (CAUSE) data field

Code	Include/ Exclude	Description
H510	Include	Automatic brake, insufficient (H001) -- see note after cause H599
H511	Include	Automatic brake, excessive (H002)
H512	Include	Automatic brake, failure to use split reduction (H003)
H513	Include	Automatic brake, other improper use (H004)
H514	Include	Failure to allow air brakes to fully release before proceeding (H005)
H515	Include	Failure to properly cut-out brake valves on locomotives (H006)
H516	Include	Failure to properly cut-in brake valves on locomotives (H007)
H517	Include	Dynamic brake, insufficient (H009)
H518	Include	Dynamic brake, excessive (H010)
H519	Include	Dynamic brake, too rapid adjustment (H011)
H520	Include	Dynamic brake, excessive axles (H012)
H521	Include	Dynamic brake, other improper use (H013)
H522	Include	Throttle (power), improper use (H014)
H523	Include	Throttle (power), too rapid adjustment (H015)
H524	Include	Excessive horsepower (H016)
H525	Include	Independent (engine) brake, improper use (except actuation) (H023)
H526	Include	Failure to actuate off independent brake (H024)
H599	Include	Other causes relating to train handling or makeup (Provide detailed description in narrative)
H601	Include	Coupling speed excessive
H602	Include	Switching movement, excessive speed
H603	Include	Train on main track inside yard limits, excessive speed
H604	Include	Train outside yard limits, in block signal or interlocking territory, excessive speed
H605	Include	Failure to comply with restricted speed in connection with the restrictive indication of a block or interlocking signal.
H606	Include	Train outside yard limits in non-block territory, excessive speed
H607	Include	Failure to comply with restricted speed or its equivalent not in connection with a block or interlocking signal.
H699	Include	Speed, other (Provide detailed description in narrative)
H701	Include	Spring Switch not cleared before reversing
H702	Include	Switch improperly lined
H703	Include	Switch not latched or locked
H704	Include	Switch previously run through
H705	Include	Moveable point switch frog improperly lined
H706	Include	Switch improperly lined, radio controlled
H707	Include	Radio controlled switch not locked effectively
H799	Include	Use of switches, other (Provide detailed description in narrative)

Exhibit A-5: Human factor causes (CAUSE) data field

Code	Include/ Exclude	Description
H821	Include	Automatic cab signal, failure to comply
H822	Include	Automatic cab signal cut out
H823	Include	Automatic train-stop device cut out
H824	Include	Automatic train control device cut out
H899	Include	Other causes relating to cab signals (provide detailed description in narrative)
H991	Include	Tampering with safety/protective device(s)
H992	Include	Operation of locomotive by uncertified/unqualified person
H993	Exclude	Human Factor - track
H994	Exclude	Human Factor - Signal installation or maintenance error (field)
H995	Exclude	Human Factor - motive power and equipment
H996	Include	Oversized loads or Excess Height/Width cars misrouted or switched.
H997	Exclude	Motor car or other on-track equipment rules (other than main track authority) - Failure to Comply.
H999	Include	Other train operation/human factors (Provide detailed description in narrative)
H99A	Exclude	Human Factor - Signal - Train Control - Installation or maintenance error (shop).
H99B	Exclude	Human Factor - Signal - Train Control - Operator Input On-board computer incorrect data entry.
H99C	Exclude	Human Factor - Signal - Train Control - Operator Input On-board computer incorrect data provided
H99D	Exclude	Computer system design error (non-vendor)
H99E	Exclude	Computer system configuration/management error (non-vendor)

Exhibit A-6: Type of equipment (TYPEQ) data field

TYPEQ	Status	Description
1	Include	Freight train
2	Include	passenger train pulling * (as of June 1, 2011 - name change)
3	Include	commuter train pulling (as of June 1, 2011 - name change)
4	Include	work train
5	Exclude	single car
6	Exclude	cut of cars
7	Exclude	yard/switching
8	Include	light locos
9	Exclude	maintenance/inspection car
-	Exclude	Unknown
A	Exclude	Special MOW equip
B	Include	Passenger train pushing (new selection; available after June 1, 2011)
C	Include	Commuter train pushing (new selection; available after June 1, 2011)
D	Include	EMU (new selection; available after June 1, 2011)
E	Include	DMU (new selection; available after June 1, 2011)

Exhibit A-7: Equipment incident data filter

Filter	Records	Notes
Total equipment records	20,015	
Type accident	18,415	Keeping only records regarding collisions and derailments
Human factors	7,527	Records remaining after only human factors accidents are retained
Selected human factors	6,447	Records remaining after only human factors involving road crew retained
Type equipment	2,727	Records remaining after retaining only records relating to trains and light engine movement
Remove records involving more than one railroad	2,656	Ensured records naming RR responsible for incident remain
Railroad	2,375	Keep only those records describing incidents on AMTK, commuters, Class 1s, INRD, and regional
Final duplicate removal	2,169	Removed duplicates

Exhibit A-8: Type of person (TYPPERS) data field

TYPPERS	Description	Status
-	Unassigned	Exclude
A	Worker on duty - employee	Include
B	Employee - not on duty	Exclude
C	Passenger on train	Exclude
D	Non-trespasser - on railroad property	Include
E	Trespassers	Exclude
F	Worker on duty - contractor	Include
G	Contractor - other	Include
H	Worker on duty - volunteer	Include
I	Volunteer - other	Include
J	Non-trespassers - off railroad property	Include

Exhibit A-9: Injury cause (INJCAUS) data field

INJCAUS	Environment	Circumstance	Status
01	Conventional	Environmental	Exclude
02	Conventional	Safety Equipment not worn or in place	Exclude
03	Conventional	Procedures for operating/using equipment not followed	Include
04	Conventional	Equipment	Include
05	Conventional	Signal	Exclude
06	Conventional	Track	Exclude
07	Conventional	Impairment, substance use	Exclude
08	Conventional	Impairment, physical condition, e.g. fatigue	Exclude
09	Conventional	Human factors	Include
10	Conventional	Trespassing	Exclude
11	Conventional	Object fouling track	Include
12	Conventional	Outside caused (e.g. assaulted/attached)	Exclude
13	Conventional	Lack of communication	Include
14	Conventional	Slack adjustment during switching operation	Include
15	Conventional	Insufficient training	Include
16	Conventional	Failure to provide adequate space between equipment during switching operation	Include
17	Conventional	Close or no clearance	Include
18	Conventional	Slipped, fell, stumbled due to Passenger Station Platform Gap	Exclude
19	Conventional	Act of God	Exclude
21	RCL	Environmental, related to using RCL	Exclude
22	RCL	Safety Equipment not worn or in place, related to using RCL	Exclude
23	RCL	Procedures for operating/using equipment not followed, related to using RCL	Exclude
24	RCL	Equipment, related to using RCL	Exclude
25	RCL	Signal, related to using RCL	Exclude
26	RCL	Track, related to using RCL	Exclude
27	RCL	Impairment, substance use, related to using RCL	Exclude
28	RCL	Impairment, physical condition, e.g. fatigue, related to using RCL	Exclude
29	RCL	Human factors, related to using RCL	Exclude
31	RCL	Trespassing, related to using RCL	Exclude
39	RCL	Undetermined, related to using RCL	Exclude
41	RCL	Environmental, unrelated to using RCL	Exclude
42	RCL	Safety equipment no worn or in place, unrelated to using RCL	Exclude

Exhibit A-9: Injury cause (INJCAUS) data field

INJCAUS	Environment	Circumstance	Status
43	RCL	Procedures for operating/using equipment not followed, unrelated to using RCL	Exclude
44	RCL	Equipment, unrelated to using RCL	Exclude
45	RCL	Signal, unrelated to using RCL	Exclude
46	RCL	Track, unrelated to using RCL	Exclude
47	RCL	Impairment, substance use, unrelated to using RCL	Exclude
48	RCL	Impairment, physical condition, e.g. fatigue, unrelated to using RCL	Exclude
49	RCL	Human factors, unrelated to using RCL	Exclude
50	RCL	Trespassing, unrelated to using RCL	Exclude
59	RCL	Undetermined, unrelated to using RCL	Exclude
99	RCL	Undetermined	Exclude
R1	RCL	Object fouling track, related to using RCL	Exclude
R2	RCL	Outside caused (e.g., assaulted/attacked) , related to RCL	Exclude
R3	RCL	Lack of communication, related to RCL	Exclude
R4	RCL	Slack adjustment during switching operation, related to using RCL	Exclude
R6	RCL	Failure to provide adequate space between equipment during switching operation, related to using RCL	Exclude
R7	RCL	Close or no clearance, related to using RCL	Exclude
R8	RCL	Act of God, related to using RCL	Exclude
U1	RCL	Object fouling track, unrelated to using RCL	Exclude
U2	RCL	Outside caused (e.g., assaulted/attacked) , unrelated to RCL	Exclude
U3	RCL	Lack of communication, unrelated to RCL	Exclude
U4	RCL	Slack adjustment during switching operation, unrelated to using RCL	Exclude
U6	RCL	Failure to provide adequate space between equipment during switching operation, unrelated to using RCL	Exclude
U7	RCL	Close or no clearance, unrelated to using RCL	Exclude
U8	RCL	Act of God, unrelated to using RCL	Exclude

Exhibit A-10: Physical act (PHYSACT) data field

PHYACT	Description	Status
01	Adjusting coupler	Include
02	Adjusting drawbar	Include
03	Adjusting, other	Include
04	Applying rail anchor/fastener	Exclude
05	Bending/stooping	Exclude
06	Carrying	Exclude
07	Chaining, cabling car or locomotive	Exclude
08	Cleaning/scrubbing	Exclude
09	Climbing over/on	Include
10	Closing	Include
11	Coupling electric cables	Include
12	Coupling steam hose	Include
13	Coupling air hose	Include
14	Crossing over	Include
15	Crossing or crawling under	Include
16	Crossing between	Include
17	Cutting rail	Exclude
18	Cutting vegetation	Exclude
19	Cutting, other	Exclude
20	Digging, excavating	Exclude
21	Driving (motor vehicle, forklift, etc.)	Exclude
22	Flagging	Include
23	Fueling	Exclude
24	Getting on	Include
25	Getting off	Include
26	Grinding	Exclude
27	Handling baggage	Exclude
28	Handling car parts	Exclude
29	handling material, general	Exclude
30	handling locomotive parts	Exclude
31	Handling wheels/trucks	Exclude
32	handling, other	Exclude
33	Handling other track material/supplies	Exclude
34	Handling poles	Exclude
35	Handling tie plates	Exclude
36	Handling ties	Exclude
37	Handling rail	Exclude

Exhibit A-10: Physical act (PHYSACT) data field

PHYACT	Description	Status
38	Inspecting	Exclude
39	Installing	Exclude
40	Jumping from	Include
41	Jumping onto	Include
42	Laying	Include
43	Lifting other materials	Exclude
44	Lifting equipment (tools, parts, etc.)	Exclude
45	Lining switches	Include
46	Lining other	Include
47	Loading/unloading	Exclude
48	Maintaining/servicing	Exclude
49	Opening	Exclude
50	Opening/closing angle cock	Exclude
51	Operating	Include
52	Pulling pin lifter/operating uncoupling lever	Include
53	Pulling pin lifter/operating uncoupling lever	Include
54	Pushing	Include
55	Reaching	Include
56	Removing rail anchors/fasteners	Exclude
57	Repairing	Exclude
58	Riding	Include
59	Running	Include
60	Sitting	Include
61	Spiking	Exclude
62	Standing	Include
63	Stepping up	Include
64	Stepping down	Include
65	Stepping over	Include
66	Uncoupling air hose	Include
67	Uncoupling steam hose	Include
68	Uncoupling electric cable	Include
69	Using hand signals	Include
70	Using hand tool	Exclude
71	Using, other	Exclude
72	Walking	Exclude
73	Welding (including field welding)	Exclude
74	Handbrakes, applying	Include

Exhibit A-10: Physical act (PHYSACT) data field

PHYACT	Description	Status
75	Handbrakes, releasing	Include
76	Handbrakes, other	Include
77	Derail, applying	Exclude
78	Derail, removing	Exclude
79	Derail, other	Exclude
80	Stepping across (passenger cars)	Include
99	Other (narrative must be provided)	Include
A1	Replacing	Exclude
A2	Ascending	Include
A3	Descending	Include
A4	Exercising	Exclude
A5	Getting in	Include
A6	Getting out	Include
A7	Hauling	Exclude
A8	Moving	Exclude
A9	Washing	Exclude
B1	Servicing	Exclude
B2	Sanding	Exclude
B3	Arresting/apprehending/subduing	Exclude
B4	Sleeping	Include
B5	Stepped on	Include
B6	Lying down	Include

Exhibit A-11: Location circumstance (LOCA) data field

LOCA	Description	Status
A	Main/branch	Include
B	Yard	Include
C	Siding	Include
D	Industry	Include
E	Repair	Exclude
F	Restroom	Exclude
G	Break/lunch room	Exclude
H	Freight terminal	Exclude
J	Highway/roadway	Exclude
K	Loading dock	Exclude
L	Lodging facility	Exclude
M	Office environment	Exclude
N	Parking lot	Exclude
P	Passenger terminal	Exclude
Q	Repair shop	Exclude
R	Storage facility	Exclude
S	Sidewalk/walkway	Exclude
T	Other , (off-site location)	Exclude
U	Airport/Plane	Exclude
V	Freight terminal	Exclude
W	Private property	Exclude
Y	Other track (explain in narrative)	Exclude
Z	Other location (describe in narrative)	Exclude

Exhibit A-12: Location circumstance (LOCB) data field

LOCB	Description	Status
01	Camp car- moving	Exclude
02	camp car - standing	Exclude
03	Freight train - moving	Include
04	Freight train - standing	Exclude
05	Freight car(s) - standing	Exclude
06	Freight car(s) - moving	Exclude
07	hi-rail/other inspection vehicle - moving	Exclude
08	hi-rail/other inspection vehicle -standing	Exclude
09	Locomotive(s), not remote controlled - standing	Exclude
10	Locomotive(s), not remote controlled - moving	Include
11	MOW Equipment - standing	Exclude
12	MOW equipment - moving	Exclude
13	Passenger train - standing	Exclude
14	Passenger train - moving	Include
15	Passenger car(s) - moving	Exclude
16	Passenger car(s) - standing	Exclude
17	Locomotive(s), remote control - standing	Exclude
18	Locomotive(s), remote control - moving	Exclude
49	Other on-track equipment - moving	Exclude
50	Other on-track equipment - standing	Exclude
51	Automobile	Exclude
52	Crane, hoists, etc.	Exclude
53	Excavating machinery	Exclude
54	Grading/surfacing machinery	Exclude
55	Loaders, forklifts, tractor, etc.	Exclude
56	Off road vehicle - industrial	Exclude
57	Off road vehicle - recreational	Exclude
58	Other construction type equipment	Exclude
59	Taxi/commercial vehicle	Exclude
60	Truck	Exclude
61	Van (utility)	Exclude
62	Van (passenger)	Exclude
63	Water vehicle, ship, boat, barge, etc.	Exclude
64	Motorcycle	Exclude
65	Bus	Exclude
66	Tractor	Exclude
97	Other operated equipment (explain in narrative)	Exclude

Exhibit A-12: Location circumstance (LOCB) data field

LOCB	Description	Status
98	Other equipment (explain in narrative)	Exclude
99	Not associated with on-track equipment of any listed vehicle type	Exclude

Exhibit A-13: Location circumstance (LOCC) data field

LOCC	Description	Status
A1	Alongside of on-track equipment - on ground	Include
A2	At work station	Exclude
A3	Track, beside	Include
A4	Track, between	Include
A5	Between car/locomotive	Include
A6	Locomotive, in cab or on walkways	Include
A7	Car, in (rail car)	Include
A8	In elevator	Exclude
A9	In /operating vehicle	Exclude
AA	At freight terminal	Exclude
AB	On tower	Exclude
AC	In cafeteria/lunch room	Exclude
B1	In tower	Exclude
B2	In tunnel	Include
B3	On bridge/trestle	Include
B4	On highway-rail crossing	Exclude
B5	On other rail crossing	Exclude
B6	Car, on side of (rail car)	Include
B7	Track, on	Include
B8	Car, on end of (rail car)	Include
B9	On pole/signal mast	Exclude
C1	On scaffold	Exclude
C2	On platform	Include
C3	On escalator	Exclude
C4	On stairs	Include
C5	On ladder	Include
C6	Locomotive, other location	Include
C7	Car, under (rail car)	Include
C8	Locomotive, under	Include
C9	Locomotive, on top of	Include
CA	Car, on top of (rail car)	Include
CB	On top of equipment, other than on-track equipment	Exclude
CC	Depot	Exclude
CD	On elevated work station	Exclude
CE	On station platform	Exclude
D1	At lodging facility	Exclude
D2	On highway/street	Exclude

Exhibit A-13: Location circumstance (LOCC) data field

LOCC	Description	Status
D3	On private property	Exclude
D4	On sidewalk/walkway	Exclude
D5	In airport	Exclude
D6	In airplane	Exclude
D7	In hotel room	Exclude
E1	On parking lot	Exclude
E2	In building	Exclude
E3	In restroom	Exclude
G1	Rail Car Door Threshold Plate to Edge of Platform-GAP	Include
G2	Area between coupled car and platform	Include
G3	Area along car body, other than threshold plate and platform edge	Include
G4	Car in Vestibule	Include
X9	Other location (describe in narrative)	Exclude

Exhibit A-14: Event circumstance (EVENT) data field

EVENT	Description	Status
01	Aggravated pre-existing condition	Include
02	Apprehending/removing from property	Exclude
03	Assaulted by other	Exclude
04	Assaulted by co-worker	Exclude
05	Bitten/stung by bee, spider, other insect	Exclude
06	Bitten by animal	Exclude
07	Bodily function/sudden movement, e.g., sneezing, twisting	Exclude
08	Caught in or compressed by hand tools	Exclude
09	Caught in or compressed by other machinery	Exclude
10	Caught in or crushed by materials	Exclude
11	Caught in or crushed in excavation, land slide, cave-in, etc.	Exclude
12	Caught in or compressed by powered hand tools	Exclude
13	Cave in, slide, etc.	Exclude
14	Climatic conditions, other (e.g., high winds)	Exclude
15	Climatic condition, exposure to environmental heat	Exclude
16	Climatic condition, exposure to environmental cold	Exclude
17	Collision - between on track equipment	Include
18	Collision/impact - auto, truck, bus, van, etc.	Exclude
19	Committing vandalism/theft	Exclude
20	Defective/malfunctioning equipment	Exclude
21	Derailment	Include
22	Electrical shock while operating welding equipment	Exclude
23	Electrical shock due to contact with 3rd rail, catenary, pantograph	Exclude
24	Electrical shock, other	Exclude
25	Electrical shock from hand tool	Exclude
26	Exposure to fumes - inhalation	Exclude
27	Exposure to chemicals - external	Exclude
28	Exposure to poisonous plants	Exclude
29	Exposure to noise over time	Exclude
30	Exposure to noise - single incident	Exclude
31	Exposure to welding light	Exclude
32	Highway-rail collision/impact	Exclude
33	Horseplay-practical joke, tec.	Exclude
34	Lost balance	Exclude
35	Missed handhold	Exclude
36	Need puncture/prick/stick	Exclude

Exhibit A-14: Event circumstance (EVENT) data field

EVENT	Description	Status
37	Other impacts - on track equipment	Include
38	Overexertion	Exclude
39	Pushed/shoved into/against	Exclude
40	Pushed/shoved onto	Exclude
41	Pushed/shoved from	Exclude
42	Ran into on-track equipment	Include
43	Ran into object/equipment	Include
44	Repetitive motion - work processes	Exclude
45	Repetitive motion - typing, keyboard, etc.	Exclude
46	Repetitive motion - tools	Exclude
47	Repetitive motion - other	Exclude
48	Rubbed, abraded, etc.	Exclude
49	Shot	Exclude
50	Slack action, draft, compressive	Include
51	Slipped, fell, stumbled, etc. due to irregular surface, e.g. depression, slope, etc.	Exclude
52	Slipped, fell, stumbled, etc. due to climatic condition (rain, snow, ice, etc.)	Exclude
53	Slipped, fell, stumbled, etc. on oil, grease, other slippery substance	Exclude
54	Slipped, fell, stumbled, etc. due to object, e.g. ballast, spike, material, etc.	Exclude
55	Stabbing, knifing, etc.	Exclude
56	Stepped on object	Exclude
57	Struck by thrown or propelled object	Include
58	Struck by object	Exclude
59	Struck by on-track equipment	Include
60	Struck by falling object	Exclude
61	Struck against object	Exclude
62	Sudden release of air	Include
63	Sudden/Unexpected Movement of material	Exclude
64	Sudden/unexpected movement of on-track equipment	Include
65	Sudden/unexpected movement of vehicle	Exclude
66	Sustained viewing	Exclude
67	Thrill seeking	Exclude
68	Caught, crushed, pinched, other.	Exclude
69	On track equipment, other incidents	Include
70	Slipped, fell, stumbled, other	Exclude

Exhibit A-14: Event circumstance (EVENT) data field

EVENT	Description	Status
71	sudden, unexpected, other	Exclude
72	Bumped	Exclude
73	Burned	Exclude
74	Blowing/falling debris	Exclude
75	Sudden/unexpected movement of tools	Exclude
76	Struck by own remote control locomotive - controlled equipment	Exclude
77	Struck by other remote control locomotive - controlled equipment	Exclude
79	Caught between machinery	Exclude
80	Slack adjustment during switching operation	Include
81	Caught between equipment	Include
82	Caught between material	Exclude
99	Other (describe in narrative)	Exclude

Exhibit A-15: Tools used (TOOLS) data field

TOOLS	Description	Status
01	Baggage	Exclude
02	Ballast, stones, etc.	Include
03	Boring tools	Exclude
04	Bridge/trestle	Include
05	Caboose	Include
06	Coupler	Include
07	Cutting tools	Exclude
08	Derail	Include
09	Door	Exclude
10	End of train device	Include
11	Floor	Include
12	Fusees/torpedoes	Include
13	Grab iron	Include
14	Ground	Include
15	Hand tools, digging, e.g., shovels, picks, etc.	Exclude
16	Hand tools, gripping, e.g., pliers, tongs, clamps	Exclude
17	Hand tools, striking & nailing, e.g., hammers, mallets	Exclude
18	Highway, street, road	Exclude
19	Hose	Include
20	Inspection Pit	Exclude
21	Jack	Exclude
22	Ladder	Include
23	Office equipment	Exclude
24	Power tools	Exclude
25	Pry bar	Exclude
26	Rail bike	Exclude
27	Stair	Include
28	Switch	Include
29	Tie	Include
30	Torch, acetylene, gas, etc.	Exclude
31	Trailer/container on flat car (TOFC, COFC)	Include
32	Welder - electric	Exclude
33	Window	Include
34	Chair/seat	Include
35	Chock	Include
36	Step/stirrup, equipment	Include
37	Handbrake	Include

Exhibit A-15: Tools used (TOOLS) data field

TOOLS	Description	Status
38	Spike, tie plates, rail fasteners, etc.	Exclude
39		Include
40	Lever	Include
41		Include
42		Include
43	Platform	Include
44	Cable	Include
45	Electrical connections, wiring, etc.	Exclude
46	Chemicals, fumes, etc.	Exclude
47	Locomotive horn	Exclude
48	Locomotive refrigerator	Exclude
49	Locomotive toilet	Exclude
50	Locomotive fire extinguisher	Exclude
51	Locomotive cab Door(s)	Exclude
52	Locomotive cab electric locker doors	Exclude
53	Locomotive car-body doors	Exclude
54	Locomotive radios	Exclude
56	Hose connections	Exclude
57	Soap	Exclude
58	Traction motor	Exclude
59	Anchor	Exclude
60	Signal equipment (gates, poles, gaffs, etc.)	Exclude
61	Bed	Exclude
62	Toilet	Exclude
63	Food	Exclude
64	Refrigerator	Exclude
65	Stove	Exclude
66	Motor	Exclude
67	Box	Exclude
80	Brake-shoe	Exclude
81	Track (Rail)	Include
82	Locomotive, other	Include
83	Crane	Exclude
84	MOW equipment	Exclude
85	Repair shop-locomotive	Exclude
86	Repair shop-Car	Exclude
87	Switch machine	Exclude

Exhibit A-15: Tools used (TOOLS) data field

TOOLS	Description	Status
88	Rock, other than ballast	Exclude
89	Locomotive cab floor	Include
90	Locomotive cab seat	Include
91	Repair shop - MOW	Exclude
99	Other (describe in narrative)	Include
1G	Door, End or Side-Passenger Train	Include
2G	Door, Trap-Passenger Train	Include
7A	Luggage	Exclude
7C	Computer equipment	Exclude
7E	Chains, straps, tie down devices.	Exclude
7F	Animal, insect, reptile	Exclude
7G	Plants, trees, foliage, etc.	Exclude
7H	Compressor	Exclude
7I	Step	Include
7J	Needle, syringe, sharps	Exclude
7K	Motor vehicle, non-rail	Exclude
7L	Weapon	Exclude
7M	Welder/torch, other	Exclude
8F	Hand tools, other	Exclude
8K	Knuckle	Include
8N	Remote control transmitter	Exclude

Exhibit A-16: Casualty incident data filter

Filter	Records	Notes
Total casualty records	66,154	
RR selection	59,321	Records remaining after application of railroad filter
CS 57 Files	51,429	Record remaining after incidents with CS57 reports (rail-highway grade crossings) are eliminated
Person Type	36,199	Records remaining after trespassers, passengers, and other unauthorized persons eliminated
Injury Cause	23,350	Records remaining after INJCAUSE filter applied
Physical Activity	11,407	Records remaining after PHYSACT filter applied
LOCA	6,933	Records remaining after LOCA filter applied
LOCB	1,155	Records remaining after LOCB filter applied
LOCC	1,066	Records remaining after LOCC filter applied
Event	441	Records remaining after EVENT filter applied
Tool	417	Records remaining after TOOL filter applied

Exhibit A-17: Equipment incident data filter

Filter	Records	Notes
Total equipment records	20,015	Records for 2007 through 2013
Type accident	17,267	Records remaining after incidents involving only collisions, derailments, obstructions, and other impacts are retained
Accident damage	2,034	Records remaining after incidents causing less than 150,000 euros of reportable damage or not involving casualties are eliminated
Incidents with casualties	2,304	Added back those incidents that were below the cost threshold but had injuries or fatalities
Equipment type	1,963	Records remaining after single cars, cuts of cars, and yard switching are eliminated
Track type	1,661	Retained records relating incidents occurring on mains or sidings
Duplicates	1,523	Duplicate records removed
Train speed	1,502	Records remaining after incidents involving railroad equipment not in motion eliminated
RR selection	1,222	Non-Class I incident records removed
Years	1,051	Kept only those records for 2007 through 2012

Exhibit A-18: Case 57 (FRA highway-rail grade crossing incident report form 57) filed field

CAS57	Description	Status
N	No	Include
Y	Yes	Exclude

Exhibit A-19: Case 54 (FRA equipment incident form 54) filed filter

CAS54	Description	Status
N	No	Include
Y	Yes	Include

Exhibit A-20: Location circumstance (LOCB) data field

LOCB	Description	Status
01	Camp car- moving	Include
02	camp car - standing	Exclude
03	Freight train - moving	Include
04	Freight train - standing	Exclude
05	Freight car(s) - standing	Exclude
06	Freight car(s) - moving	Include
07	hi-rail/other inspection vehicle - moving	Include
08	hi-rail/other inspection vehicle -standing	Exclude
09	Locomotive(s), not remote controlled - standing	Exclude
10	Locomotive(s), not remote controlled - moving	Include
11	MOW Equipment - standing	Exclude
12	MOW equipment - moving	Include
13	Passenger train - standing	Exclude
14	Passenger train - moving	Include
15	Passenger car(s) - moving	Include
16	Passenger car(s) - standing	Exclude
17	Locomotive(s), remote control - standing	Exclude
18	Locomotive(s), remote control - moving	Include
49	Other on-track equipment - moving	Exclude
50	Other on-track equipment - standing	Exclude
51	Automobile	Exclude
52	Crane, hoists, etc.	Exclude
53	Excavating machinery	Exclude
54	Grading/surfacing machinery	Exclude
55	Loaders, forklifts, tractor, etc.	Exclude
56	Off road vehicle - industrial	Exclude
57	Off road vehicle - recreational	Exclude
58	Other construction type equipment	Exclude
59	Taxi/commercial vehicle	Exclude
60	Truck	Exclude
61	Van (utility)	Exclude
62	Van (passenger)	Exclude
63	Water vehicle, ship, boat, barge, etc.	Exclude
64	Motorcycle	Exclude
65	Bus	Exclude
66	Tractor	Exclude
97	Other operated equipment (explain in narrative)	Exclude

Exhibit A-20: Location circumstance (LOCB) data field

LOCB	Description	Status
98	Other equipment (explain in narrative)	Exclude
99	A/I was not associated with on-track equipment of any listed vehicle type	Exclude

Exhibit A-21: Probable injury cause (INJCAUS) data field

INJCAUS	Environment	Circumstance	Status
01	Conventional	Environmental	Exclude
02	Conventional	Safety Equipment not worn or in place	Exclude
03	Conventional	Procedures for operating/using equipment not followed	Include
04	Conventional	Equipment	Include
05	Conventional	Signal	Exclude
06	Conventional	Track	Exclude
07	Conventional	Impairment, substance use	Exclude
08	Conventional	Impairment, physical condition, e.g. fatigue	Exclude
09	Conventional	Human factors	Include
10	Conventional	Trespassing	Include
11	Conventional	Object fouling track	Include
12	Conventional	Outside caused (e.g. assaulted/attached)	Exclude
13	Conventional	Lack of communication	Include
14	Conventional	Slack adjustment during switching operation	Include
15	Conventional	Insufficient training	Include
16	Conventional	Failure to provide adequate space between equipment during switching operation	Include
17	Conventional	Close or no clearance	Include
18	Conventional	Slipped, fell, stumbled due to Passenger Station Platform Gap	Exclude
19	Conventional	Act of God	Exclude
21	RCL	Environmental, related to using RCL	Exclude
22	RCL	Safety Equipment not worn or in place, related to using RCL	Exclude
23	RCL	Procedures for operating/using equipment not followed, related to using RCL	Include
24	RCL	Equipment, related to using RCL	Include
25	RCL	Signal, related to using RCL	Exclude
26	RCL	Track, related to using RCL	Exclude
27	RCL	Impairment, substance use, related to using RCL	Exclude
28	RCL	Impairment, physical condition, e.g. fatigue, related to using RCL	Exclude
29	RCL	Human factors, related to using RCL	Include
31	RCL	Trespassing, related to using RCL	Include
39	RCL	Undetermined, related to using RCL	Exclude
41	RCL	Environmental, unrelated to using RCL	Exclude
42	RCL	Safety equipment no worn or in place, unrelated to using RCL	Exclude

Exhibit A-21: Probable injury cause (INJCAUS) data field

INJCAUS	Environment	Circumstance	Status
43	RCL	Procedures for operating/using equipment not followed, unrelated to using RCL	Include
44	RCL	Equipment, unrelated to using RCL	Include
45	RCL	Signal, unrelated to using RCL	Exclude
46	RCL	Track, unrelated to using RCL	Exclude
47	RCL	Impairment, substance use, unrelated to using RCL	Exclude
48	RCL	Impairment, physical condition, e.g. fatigue, unrelated to using RCL	Exclude
49	RCL	Human factors, unrelated to using RCL	Include
50	RCL	Trespassing, unrelated to using RCL	Include
59	RCL	Undetermined, unrelated to using RCL	Exclude
99	RCL	Undetermined	Exclude
R1	RCL	Object fouling track, related to using RCL	Include
R2	RCL	Outside caused (e.g., assaulted/attacked) , related to RCL	Exclude
R3	RCL	Lack of communication, related to RCL	Include
R4	RCL	Slack adjustment during switching operation, related to using RCL	Include
R6	RCL	Failure to provide adequate space between equipment during switching operation, related to using RCL	Include
R7	RCL	Close or no clearance, related to using RCL	Include
R8	RCL	Act of God, related to using RCL	Exclude
U1	RCL	Object fouling track, unrelated to using RCL	Include
U2	RCL	Outside caused (e.g., assaulted/attacked) , unrelated to RCL	Exclude
U3	RCL	Lack of communication, unrelated to RCL	Include
U4	RCL	Slack adjustment during switching operation, unrelated to using RCL	Include
U6	RCL	Failure to provide adequate space between equipment during switching operation, unrelated to using RCL	Include
U7	RCL	Close or no clearance, unrelated to using RCL	Include
U8	RCL	Act of God, unrelated to using RCL	Exclude

Exhibit A-22: Location circumstance (LOCA) data field

LOCA	Description	Status
A	Main/branch	Include
B	Yard	Exclude
C	Siding	Include
D	Industry	Exclude
E	Repair	Exclude
F	Restroom	Exclude
G	Break/lunch room	Exclude
H	Freight terminal	Exclude
J	Highway/roadway	Exclude
K	Loading dock	Exclude
L	Lodging facility	Exclude
M	Office environment	Exclude
N	Parking lot	Exclude
P	Passenger terminal	Exclude
Q	Repair shop	Exclude
R	Storage facility	Exclude
S	Sidewalk/walkway	Exclude
T	Other , (off-site location)	Exclude
U	Airport/Plane	Exclude
V	Freight terminal	Exclude
W	Private property	Exclude
Y	Other track (explain in narrative)	Exclude
Z	Other location (describe in narrative)	Exclude

Exhibit A-23: Location circumstance (LOCC) data field

LOCC	Description	Status
A1	Alongside of on-track equipment - on ground	Include
A2	At work station	Exclude
A3	Track, beside	Include
A4	Track, between	Include
A5	Between car/locomotive	Include
A6	Locomotive, in cab or on walkways	Include
A7	Car, in (rail car)	Include
A8	In elevator	Exclude
A9	In /operating vehicle	Exclude
AA	At freight terminal	Exclude
AB	On tower	Exclude
AC	In cafeteria/lunch room	Exclude
B1	In tower	Exclude
B2	In tunnel	Include
B3	On bridge/trestle	Include
B4	On highway-rail crossing	Exclude
B5	On other rail crossing	Exclude
B6	Car, on side of (rail car)	Include
B7	Track, on	Include
B8	Car, on end of (rail car)	Include
B9	On pole/signal mast	Exclude
C1	On scaffold	Exclude
C2	On platform	Include
C3	On escalator	Exclude
C4	On stairs	Include
C5	On ladder	Include
C6	Locomotive, other location	Include
C7	Car, under (rail car)	Include
C8	Locomotive, under	Include
C9	Locomotive, on top of	Include
CA	Car, on top of (rail car)	Include
CB	On top of equipment, other than on-track equipment	Exclude
CC	Depot	Exclude
CD	On elevated work station	Exclude
CE	On station platform	Exclude
D1	At lodging facility	Exclude
D2	On highway/street	Exclude

Exhibit A-23: Location circumstance (LOCC) data field

LOCC	Description	Status
D3	On private property	Exclude
D4	On sidewalk/walkway	Exclude
D5	In airport	Exclude
D6	In airplane	Exclude
D7	In hotel room	Exclude
E1	On parking lot	Exclude
E2	In building	Exclude
E3	In restroom	Exclude
G1	Rail Car Door Threshold Plate to Edge of Platform-GAP	Include
G2	Area between coupled car and platform	Include
G3	Area along car body, other than threshold plate and platform edge	Include
G4	Car in Vestibule	Include
X9	Other location (describe in narrative)	Exclude

Exhibit A-24: Event circumstance (EVENT) data field

EVENT	Description	Status
01	Aggravated pre-existing condition	Include
02	Apprehending/removing from property	Exclude
03	Assaulted by other	Exclude
04	Assaulted by co-worker	Exclude
05	Bitten/stung by bee, spider, other insect	Exclude
06	Bitten by animal	Exclude
07	Bodily function/sudden movement, e.g., sneezing, twisting	Exclude
08	Caught in or compressed by hand tools	Exclude
09	Caught in or compressed by other machinery	Exclude
10	Caught in or crushed by materials	Exclude
11	Caught in or crushed in excavation, land slide, cave-in, etc.	Exclude
12	Caught in or compressed by powered hand tools	Exclude
13	Cave in, slide, etc.	Exclude
14	Climatic conditions, other (e.g., high winds)	Exclude
15	Climatic condition, exposure to environmental heat	Exclude
16	Climatic condition, exposure to environmental cold	Exclude
17	Collision - between on track equipment	Include
18	Collision/impact - auto, truck, bus, van, etc.	Exclude
19	Committing vandalism/theft	Exclude
20	Defective/malfunctioning equipment	Exclude
21	Derailment	Include
22	Electrical shock while operating welding equipment	Exclude
23	Electrical shock due to contact with 3rd rail, catenary, pantograph	Exclude
24	Electrical shock, other	Exclude
25	Electrical shock from hand tool	Exclude
26	Exposure to fumes - inhalation	Exclude
27	Exposure to chemicals - external	Exclude
28	Exposure to poisonous plants	Exclude
29	Exposure to noise over time	Exclude
30	Exposure to noise - single incident	Exclude
31	Exposure to welding light	Exclude
32	Highway-rail collision/impact	Exclude
33	Horseplay-practical joke, tec.	Exclude
34	Lost balance	Exclude
35	Missed handhold	Exclude
36	Need puncture/prick/stick	Exclude

Exhibit A-24: Event circumstance (EVENT) data field

EVENT	Description	Status
37	Other impacts - on track equipment	Include
38	Overexertion	Exclude
39	Pushed/shoved into/against	Exclude
40	Pushed/shoved onto	Exclude
41	Pushed/shoved from	Exclude
42	Ran into on-track equipment	Include
43	Ran into object/equipment	Include
44	Repetitive motion - work processes	Exclude
45	Repetitive motion - typing, keyboard, etc.	Exclude
46	Repetitive motion - tools	Exclude
47	Repetitive motion - other	Exclude
48	Rubbed, abraded, etc.	Exclude
49	Shot	Exclude
50	Slack action, draft, compressive	Include
51	Slipped, fell, stumbled, etc. due to irregular surface, e.g. depression, slope, etc.	Exclude
52	Slipped, fell, stumbled, etc. due to climatic condition (rain, snow, ice, etc.)	Exclude
53	Slipped, fell, stumbled, etc. on oil, grease, other slippery substance	Exclude
54	Slipped, fell, stumbled, etc. due to object, e.g. ballast, spike, material, etc.	Exclude
55	Stabbing, knifing, etc.	Exclude
56	Stepped on object	Exclude
57	Struck by thrown or propelled object	Include
58	Struck by object	Exclude
59	Struck by on-track equipment	Include
60	Struck by falling object	Exclude
61	Struck against object	Exclude
62	Sudden release of air	Include
63	Sudden/Unexpected Movement of material	Exclude
64	Sudden/unexpected movement of on-track equipment	Include
65	Sudden/unexpected movement of vehicle	Exclude
66	Sustained viewing	Exclude
67	Thrill seeking	Exclude
68	Caught, crushed, pinched, other.	Exclude
69	On track equipment, other incidents	Include
70	Slipped, fell, stumbled, other	Exclude

Exhibit A-24: Event circumstance (EVENT) data field

EVENT	Description	Status
71	sudden, unexpected, other	Exclude
72	Bumped	Exclude
73	Burned	Exclude
74	Blowing/falling debris	Exclude
75	Sudden/unexpected movement of tools	Exclude
76	Struck by own remote control locomotive - controlled equipment	Include
77	Struck by other remote control locomotive - controlled equipment	Include
79	Caught between machinery	Exclude
80	Slack adjustment during switching operation	Include
81	Caught between equipment	Include
82	Caught between material	Exclude
99	Other (describe in narrative)	Exclude

Exhibit A-25: Tools used (TOOLS) data field

TOOLS	Description	Status
01	Baggage	Include
02	Ballast, stones, etc.	Include
03	Boring tools	Exclude
04	Bridge/trestle	Include
05	Caboose	Include
06	Coupler	Include
07	Cutting tools	Exclude
08	Derail	Include
09	Door	Include
10	End of train device	Include
11	Floor	Include
12	Fusees/torpedoes	Exclude
13	Grab iron	Include
14	Ground	Include
15	Hand tools, digging, e.g., shovels, picks, etc.	Exclude
16	Hand tools, gripping, e.g., pliers, tongs, clamps	Exclude
17	Hand tools, striking & nailing, e.g., hammers, mallets	Exclude
18	Highway, street, road	Exclude
19	Hose	Include
20	Inspection Pit	Exclude
21	Jack	Exclude
22	Ladder	Include
23	Office equipment	Exclude
24	Power tools	Exclude
25	Pry bar	Exclude
26	Rail bike	Exclude
27	Stair	Include
28	Switch	Include
29	Tie	Include
30	Torch, acetylene, gas, etc.	Exclude
31	Trailer/container on flat car (TOFC, COFC)	Include
32	Welder - electric	Exclude
33	Window	Include
34	Chair/seat	Include
35	Chock	Include
36	Step/stirrup, equipment	Include
37	Handbrake	Include

Exhibit A-25: Tools used (TOOLS) data field

TOOLS	Description	Status
38	Spike, tie plates, rail fasteners, etc.	Exclude
39		Include
40	Lever	Include
41		Include
42		Include
43	Platform	Include
44	Cable	Include
45	Electrical connections, wiring, etc.	Exclude
46	Chemicals, fumes, etc.	Exclude
47	Locomotive horn	Exclude
48	Locomotive refrigerator	Exclude
49	Locomotive toilet	Exclude
50	Locomotive fire extinguisher	Exclude
51	Locomotive cab Door(s)	Include
52	Locomotive cab electric locker doors	Exclude
53	Locomotive car-body doors	Exclude
54	Locomotive radios	Exclude
56	Hose connections	Exclude
57	Soap	Exclude
58	Traction motor	Exclude
59	Anchor	Exclude
60	Signal equipment (gates, poles, gaffs, etc.)	Exclude
61	Bed	Exclude
62	Toilet	Exclude
63	Food	Exclude
64	Refrigerator	Exclude
65	Stove	Exclude
66	Motor	Exclude
67	Box	Exclude
80	Brake-shoe	Exclude
81	Track (Rail)	Include
82	Locomotive, other	Include
83	Crane	Exclude
84	MOW equipment	Exclude
85	Repair shop-locomotive	Exclude
86	Repair shop-Car	Exclude
87	Switch machine	Exclude

Exhibit A-25: Tools used (TOOLS) data field

TOOLS	Description	Status
88	Rock, other than ballast	Exclude
89	Locomotive cab floor	Include
90	Locomotive cab seat	Include
91	Repair shop - MOW	Exclude
99	Other (describe in narrative)	Include
1G	Door, End or Side-Passenger Train	Include
2G	Door, Trap-Passenger Train	Include
7A	Luggage	Include
7C	Computer equipment	Exclude
7E	Chains, straps, tie down devices.	Include
7F	Animal, insect, reptile	Exclude
7G	Plants, trees, foliage, etc.	Exclude
7H	Compressor	Exclude
7I	Step	Include
7J	Needle, syringe, sharps	Exclude
7K	Motor vehicle, non-rail	Exclude
7L	Weapon	Exclude
7M	Welder/torch, other	Exclude
8F	Hand tools, other	Exclude
8K	Knuckle	Include
8N	Remote control transmitter	Exclude

Exhibit A-26: Physical act (PHYSACT) data field

PHYACT	Description	Status
01	Adjusting coupler	Include
02	Adjusting drawbar	Include
03	Adjusting, other	Include
04	Applying rail anchor/fastener	Exclude
05	Bending/stooping	Include
06	Carrying	Exclude
07	Chaining, cabling car or locomotive	Exclude
08	Cleaning/scrubbing	Exclude
09	Climbing over/on	Include
10	Closing	Include
11	Coupling electric cables	Include
12	Coupling steam hose	Include
13	Coupling air hose	Include
14	Crossing over	Include
15	Crossing or crawling under	Include
16	Crossing between	Include
17	Cutting rail	Exclude
18	Cutting vegetation	Exclude
19	Cutting, other	Exclude
20	Digging, excavating	Exclude
21	Driving (motor vehicle, forklift, etc.)	Exclude
22	Flagging	Include
23	Fueling	Include
24	Getting on	Include
25	Getting off	Include
26	Grinding	Exclude
27	Handling baggage	Exclude
28	Handling car parts	Exclude
29	handling material, general	Exclude
30	handling locomotive parts	Exclude
31	Handling wheels/trucks	Exclude
32	handling, other	Exclude
33	Handling other track material/supplies	Exclude
34	Handling poles	Exclude
35	Handling tie plates	Exclude
36	Handling ties	Exclude
37	Handling rail	Exclude

Exhibit A-26: Physical act (PHYSACT) data field

PHYACT	Description	Status
38	Inspecting	Include
39	Installing	Exclude
40	Jumping from	Include
41	Jumping onto	Include
42	Laying	Include
43	Lifting other materials	Exclude
44	Lifting equipment (tools, parts, etc.)	Exclude
45	Lining switches	Include
46	Lining other	Include
47	Loading/unloading	Exclude
48	Maintaining/servicing	Exclude
49	Opening	Exclude
50	Opening/closing angle cock	Include
51	Operating	Include
52	Pulling pin lifter/operating uncoupling lever	Include
53	Pulling pin lifter/operating uncoupling lever	Include
54	Pushing	Include
55	Reaching	Include
56	Removing rail anchors/fasteners	Exclude
57	Repairing	Exclude
58	Riding	Include
59	Running	Include
60	Sitting	Include
61	Spiking	Exclude
62	Standing	Include
63	Stepping up	Include
64	Stepping down	Include
65	Stepping over	Include
66	Uncoupling air hose	Include
67	Uncoupling steam hose	Include
68	Uncoupling electric cable	Include
69	Using hand signals	Include
70	Using hand tool	Exclude
71	Using, other	Exclude
72	Walking	Include
73	Welding (including field welding)	Exclude
74	Handbrakes, applying	Include

Exhibit A-26: Physical act (PHYSACT) data field

PHYACT	Description	Status
75	Handbrakes, releasing	Include
76	Handbrakes, other	Include
77	Derail, applying	Exclude
78	Derail, removing	Exclude
79	Derail, other	Exclude
80	Stepping across (passenger cars)	Include
99	Other (narrative must be provided)	Include
.		Exclude
A1	Replacing	Exclude
A2	Ascending	Include
A3	Descending	Include
A4	Exercising	Exclude
A5	Getting in	Include
A6	Getting out	Include
A7	Hauling	Exclude
A8	Moving	Exclude
A9	Washing	Exclude
B1	Servicing	Exclude
B2	Sanding	Exclude
B3	Arresting/apprehending/subduing	Exclude
B4	Sleeping	Include
B5	Stepped on	Include
B6	Lying down	Include

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OLIVER WYMAN

ANALYSIS OF FREIGHT RAIL SINGLE-PERSON CREWS: SAFETY AND ECONOMICS

February 12, 2015

Rodney Case, Partner

MARSH & McLENNAN COMPANIES

Introduction

Oliver Wyman was asked by the Association of American Railroads (AAR) to analyze data related to the safety and economics of single-person crew operations on Class I freight railroads

Key Findings

- Single-person train crews have a long history of use, both in the US and abroad, even on high-density, mixed-use freight and passenger systems
- Based on an analysis of relevant safety data for the US and Europe, single-person crews *are no less safe* than multiple-person crews
- Federally-mandated positive train control (PTC), which the railroads are now implementing at a cost of $13.2 billion on 60,000 miles of network, will provide the same redundancy as a second person in the engineer's cab
- From an economic standpoint, Class I railroads could realize significant cost savings from implementing single-person crews on a portion of trains – money which could then be used to offset the costs of PTC and other new safety technologies

Relevant safety incidents

Oliver Wyman determined that the following types of railroad incidents could *potentially* be influenced by train crew size

Equipment Incidents

- Derailments, collisions, fires, explosions, etc.
- *Key screening criteria:* Human error in train operation (excludes all track-caused incidents)

Signals Passed At Danger (SPADs)

- Also known as “red-block violations” in the US
- Train continues beyond a line-side traffic control signal requiring the train to stop
- May be caused by human error
- US versus Europe analysis only

Casualties

- Fatalities and serious injuries
- *Key screening criteria:* Person authorized to be on/near on-track rail equipment, incident occurred on/near the railroad right-of-way and on-track rail equipment, stemmed from actions relating to train movement

Not Relevant Incident types

- Grade-crossing incidents: Motorists are responsible 99.87% of the time
- Signaling failures: Train crew has no influence over grade crossing and traffic control signal malfunctions

1 Intra-US Safety Review

Intra-US safety record comparison

Oliver Wyman compared the safety records for US rail operations that use single-person crews to multiple-person crews for 2007-2013

Intra-US: Single-Person Crews

- Amtrak
  - 95 percent of engine crews in the locomotive cab are single-person
  - 20 years experience on Northeast and Keystone corridors
- Commuter railroads
  - Generally, only one person in the cab
- Indiana Rail Road (INRD)
  - Class II regional railroad
  - 40 percent of operations run engineer-only

Intra-US: Multiple-Person Crews

- Class I freight railroads: BNSF, UP, NS, CSX, KCS, CN, CP
- Class II regional freight railroads (other than INRD)

Data Sources

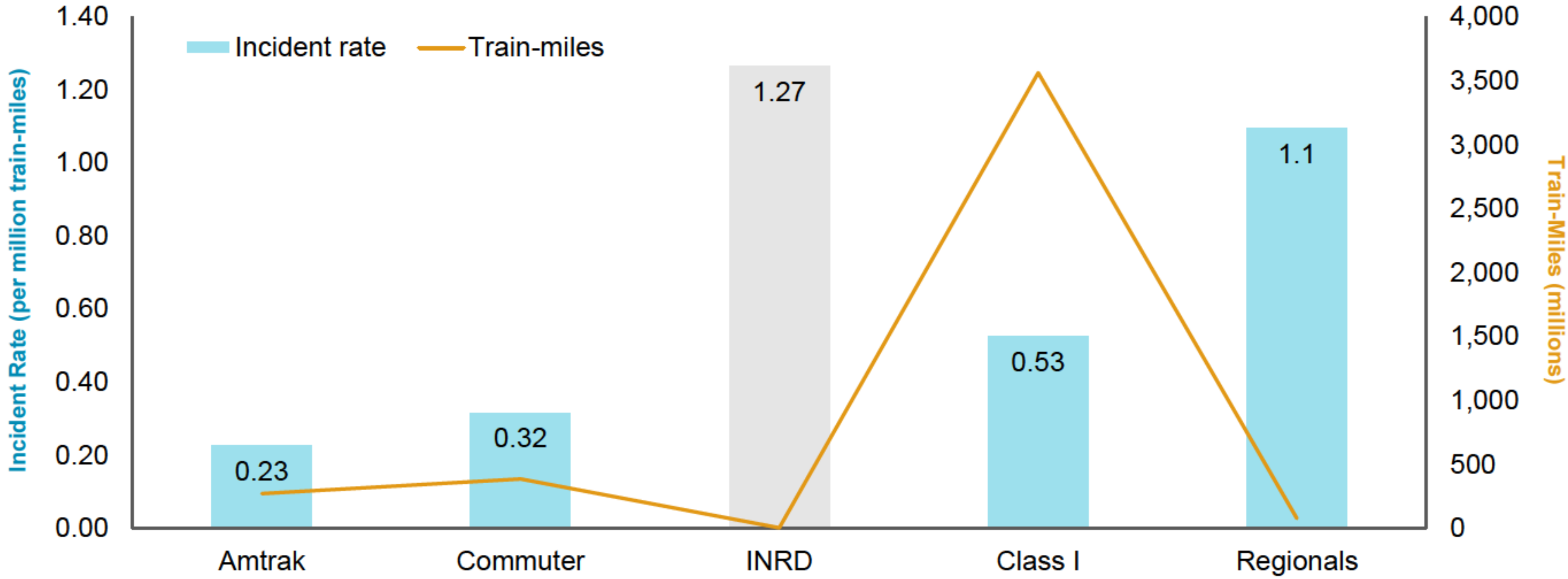
- Federal Railroad Administration (FRA): Requires detailed railroad reporting on safety incidents for Class I and II railroads
- US Class I railroads: Provided additional data on request for this study

Intra-US: Equipment incident analysis

Amtrak and commuter rail operators had lower rates of equipment incidents than the Class Is and regionals (INRD is an outlier)[1]

Equipment Incident Rates for Representative US Rail Operator Groups, 2007-2013

Aggregate data, derailments and collisions reporting a human factor[2]



	Amtrak	Commuter	INRD	Class I	Regionals
Incident Records	63	125	2	1,897	82

1. INRD had only two human-factor incidents in 7 years. One involved a three-person crew. The other involved a single-person crew and related to train handling, which a second person could not have influenced
2. With the exception of grade crossing collisions, where FRA data show that 99.87% are caused by motorists

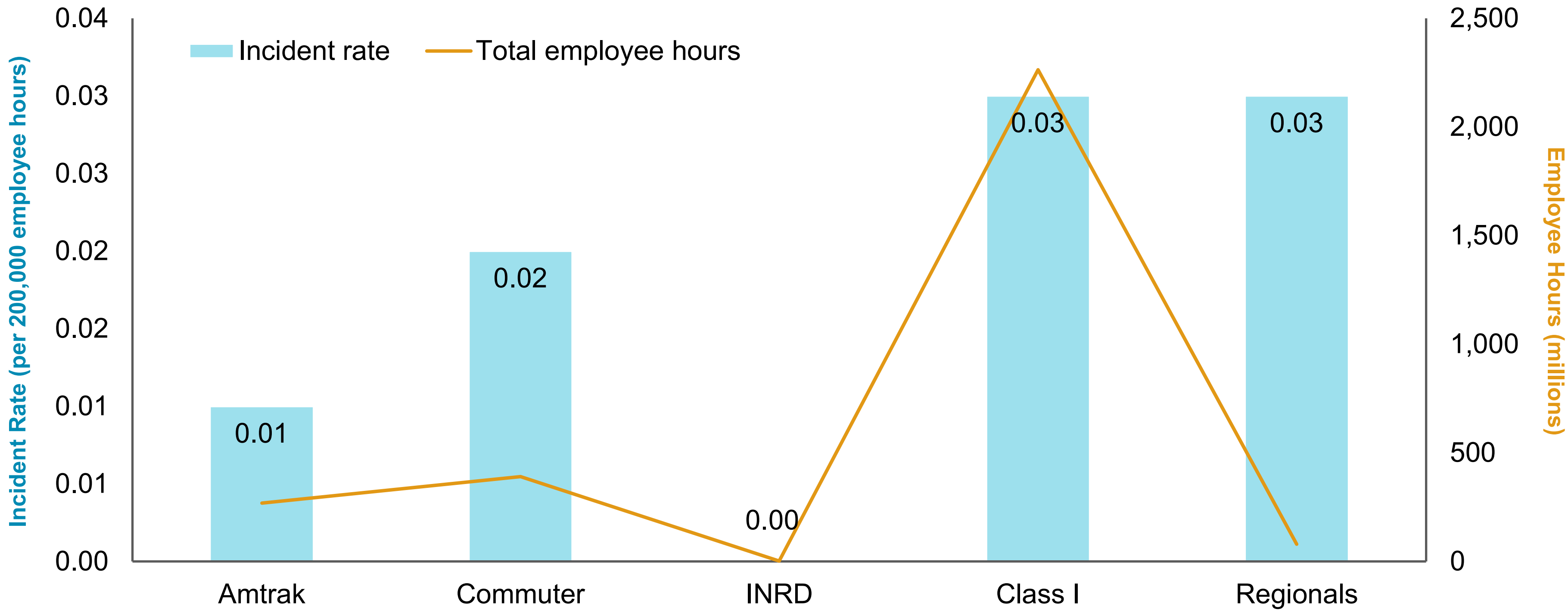
Source: FRA and Oliver Wyman analysis

Intra-US: Casualty incident analysis

Amtrak, commuter rail operators, and INRD had lower rates of casualty incidents than the Class Is and regionals

Casualty Incident Rates for Representative US Rail Operator Groups, 2007-2013

Aggregate data, incidents potentially related to train crew size



	Amtrak	Commuter	INRD	Class I	Regionals
Incident Records	17	41	0	348	11

Source: FRA and Oliver Wyman analysis

2 US versus Europe Safety Review

International use of single-person crews

Single-person train crews are common in mature international rail markets similar to the US in size and complexity

Rail Network/ Country	Rail line mileage	Gross ton-miles millions, freight	Train-miles thousands, total	Ratio: Passenger to freight trains	Network type	Train density train miles per line mile	Single-line track ratio	Average freight train weight
US Class I, USA	120,817	2,992,769	498,746	5%	Heavy-haul freight, minimal passenger	4,128	83%	6,289
Queensland, Australia	5,352	56,515	23,930	36%	Heavy-haul freight, some passenger	4,471	91%	3,691
OBB/RCA, Austria	3,132	30,930	89,203	69%	Light freight, predominant passenger,	28,483	65%	1,122
DB, Germany	20,949	184,357	642,332	75%	Light freight, predominant passenger, high speed passenger	30,662	46%	1,155
Trafikverket, Sweden	6,188	31,826	81,897	68%	Light freight, predominant passenger, high speed passenger	13,234	82%	1,223
Network Rail, UK	10,016	28,778	351,160	93%	Minimal freight, predominant passenger, high speed passenger	35,061	26%	1,192
RFF/SNCF, France	18,546	81,775	301,280	84%	Light freight, predominant passenger, high speed passenger	16,245	42%	1,704
FS, Italy	11,194	N/A	207,165	85%	Light freight, predominant passenger, high speed passenger	18,507	53%	N/A
Japan Rail, Japan	11,986	N/A	433,608		Minimal freight, predominant passenger, high speed passenger	36,177	61%	N/A

Source: UIC Railway statistic 2010, AAR Analysis of Class 1 Railways 2010, and Amtrak National Fact Sheet 2010

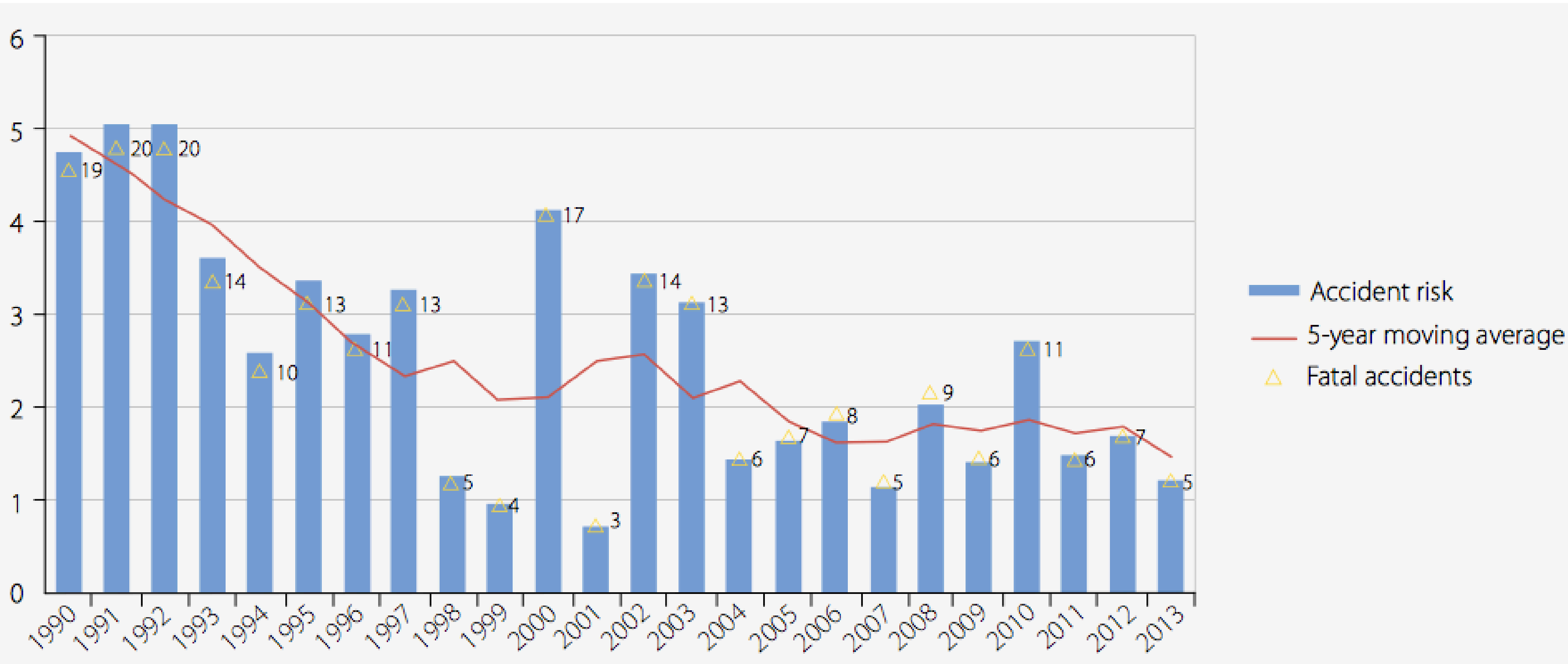
High → Low

European safety record

Even with widespread use of single-person crews, European rail safety continues to improve

Fatal Train Collisions and Derailments, EU-27 Nations, Switzerland, and Norway, 1990-2013

Per billion train-kilometers



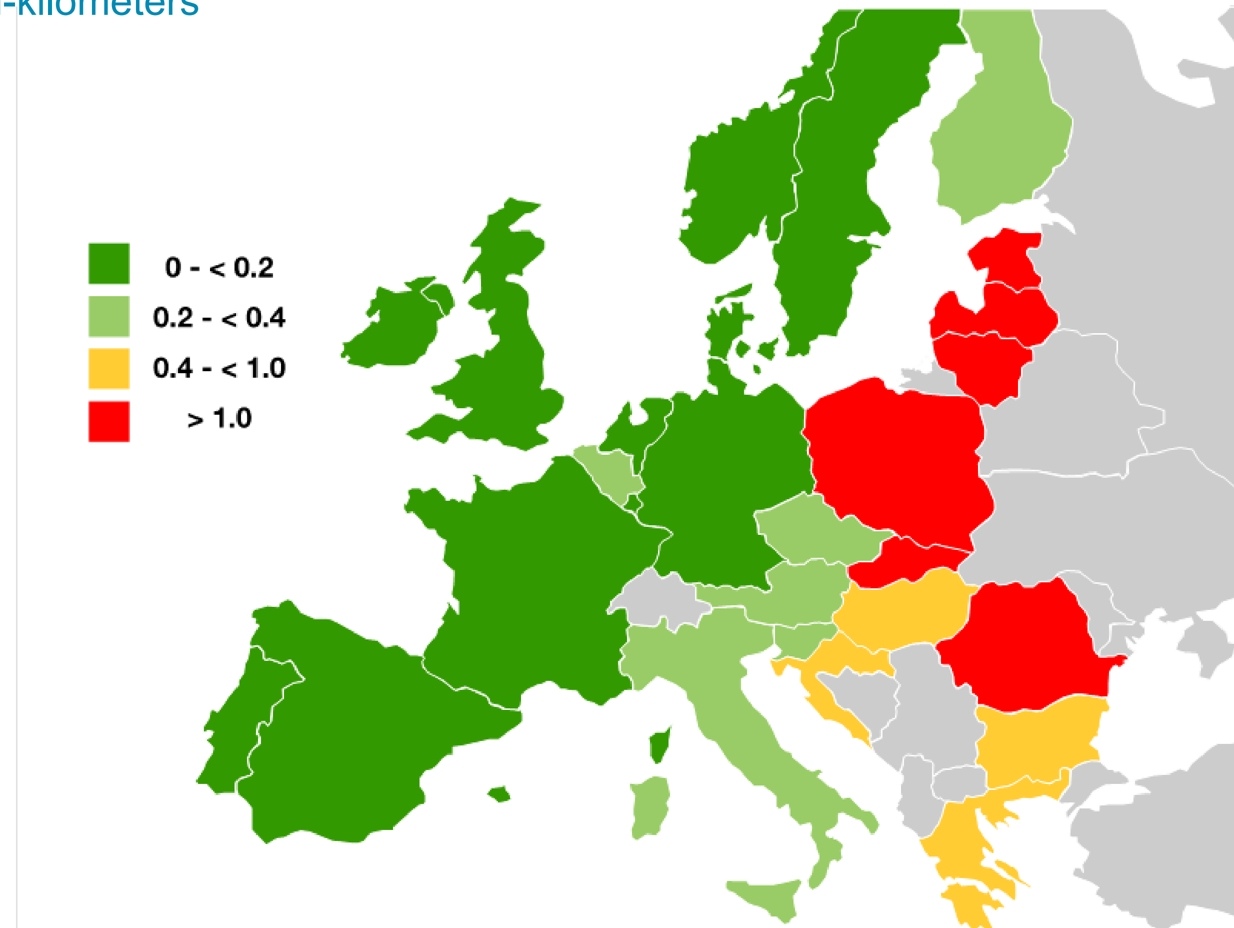
Source :Railway Safety Performance in the European Union 2014, European Railway Agency

European safety record

In fact, those European countries with the *best* safety records (shown in dark green) all use single-person crews

European Union: Fatalities and Weighted Serious Injuries, 2007-2012

Per million train-kilometers



Source :Railway Safety Performance in the European Union 2014, European Railway Agency

US vs. Europe safety record comparison for 2007 through 2012

Oliver Wyman compared the safety records for US Class I railroads to those of several European railroads with single-person operations

Basis of Comparison

- Single-person crews: Rail safety data for France, Germany, Italy, UK, and Sweden
- Multiple-person crews: Rail safety data for US Class I freight railroads

Differences in FRA and ERA* Data, Corrective Measures Taken, and Potential Bias

Category	Item	FRA	ERA	Corrective Measure	Potential Bias
Equipment incidents	Minimum cost threshold for reporting	$10,500	€150,000	Eliminated all US incidents below €150,000 in cost	None after correction
Serious injuries	Hospitalization	Hospital stays not reported	Only reported if there is a 24-hour minimum hospital stay	Eliminated US injuries resulting in less than eight lost working days	Not clear what bias this may introduce
Fatalities	Length of time after accident	Any fatality occurring within 180 days of the accident is recorded	Any fatality occurring within 30 days of the accident is recorded	None – data does not show date of death relative to date of incident	May show more deaths for US railroads

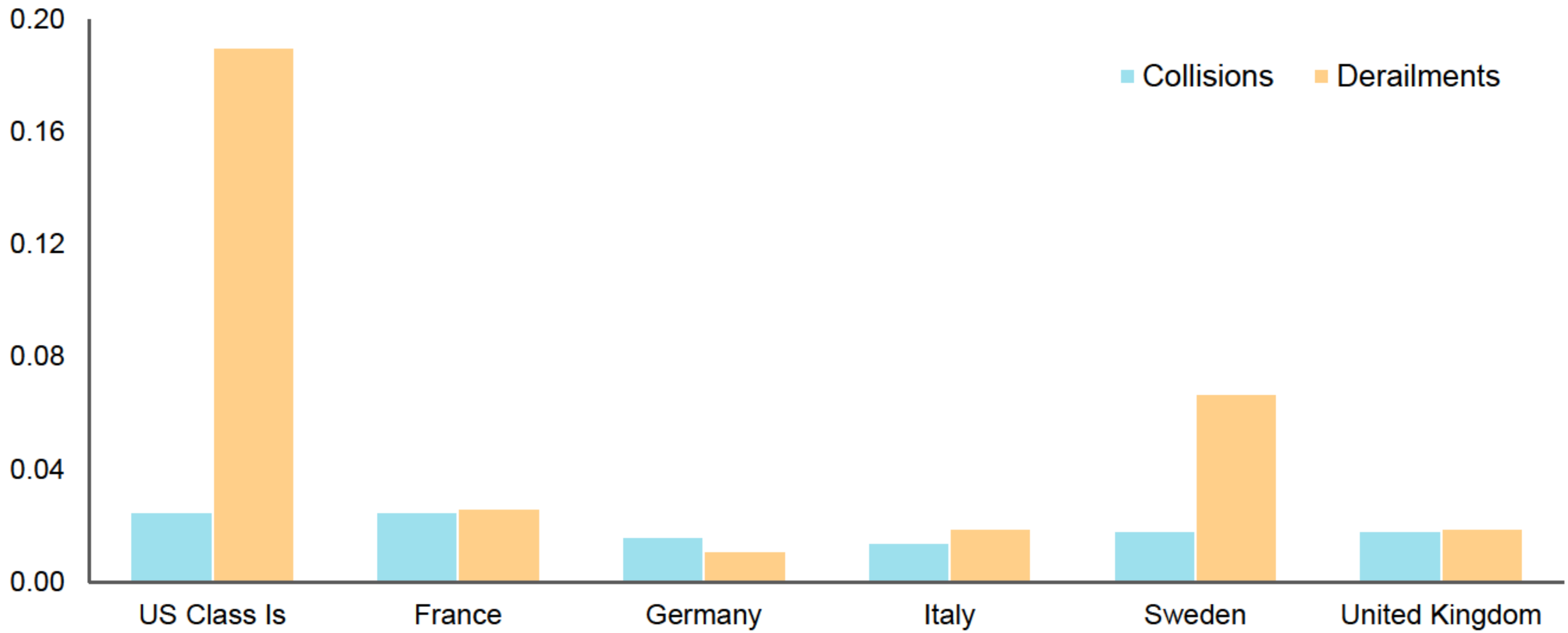
* ERA is the European Railway Agency, the railroad industry regulatory body of the European Union

US vs. Europe: Equipment incident analysis

Collision and derailment data support the assertion that single-person operations are at least as safe as multiple-person operations

Average Annual Collision and Derailment Rates by Country, 2007-2012

Per million train-kilometers



Note: it is difficult to correlate derailments with crew size, especially since the data for both US and European railroads includes all derailment incidents (not just human-factor related)

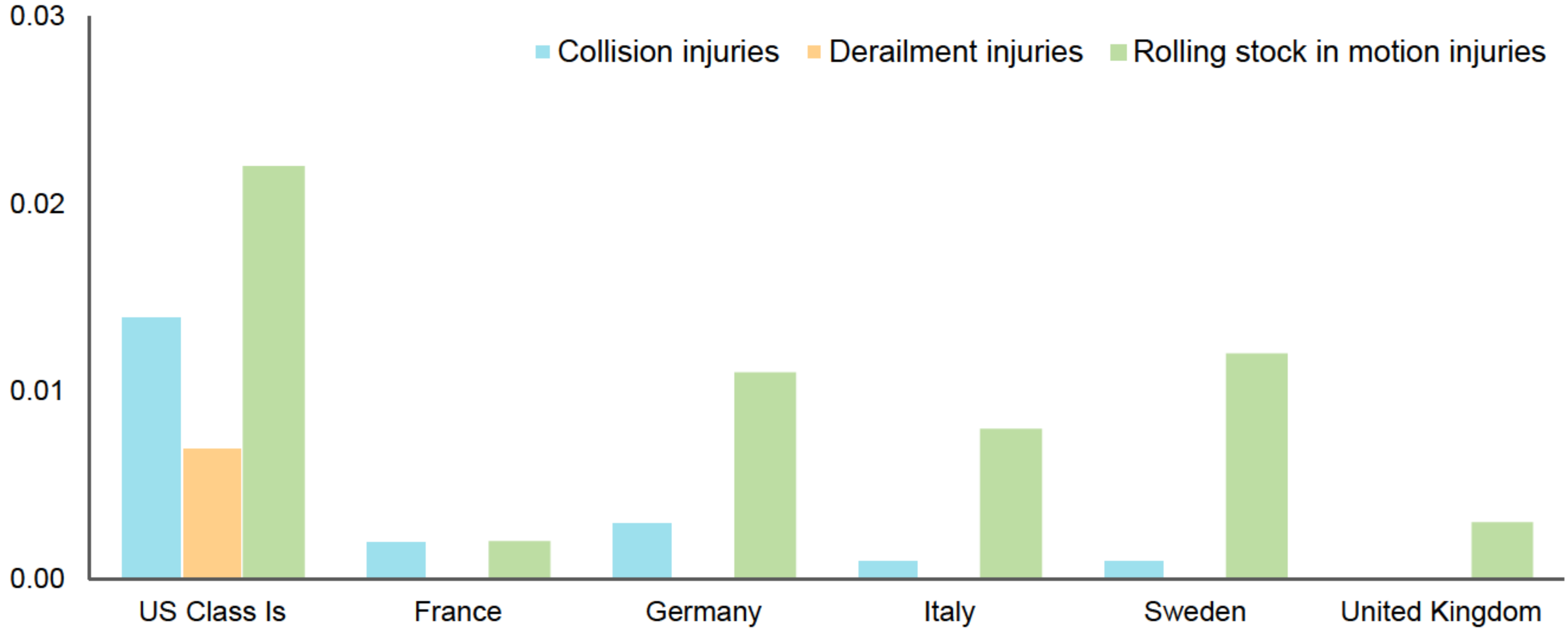
Source: FRA, ERA and Oliver Wyman analysis

US vs. Europe: Casualty incident analysis-Injuries

Injury data also supports the assertion that single-person operations are at least as safe as multiple-person operations

Average Annual Injury Rates by Country, 2007-2012

Per million train-kilometers



Note: Due to major differences in data collection and thus data comparison challenges, the serious injury rate for US rail carriers may be overstated

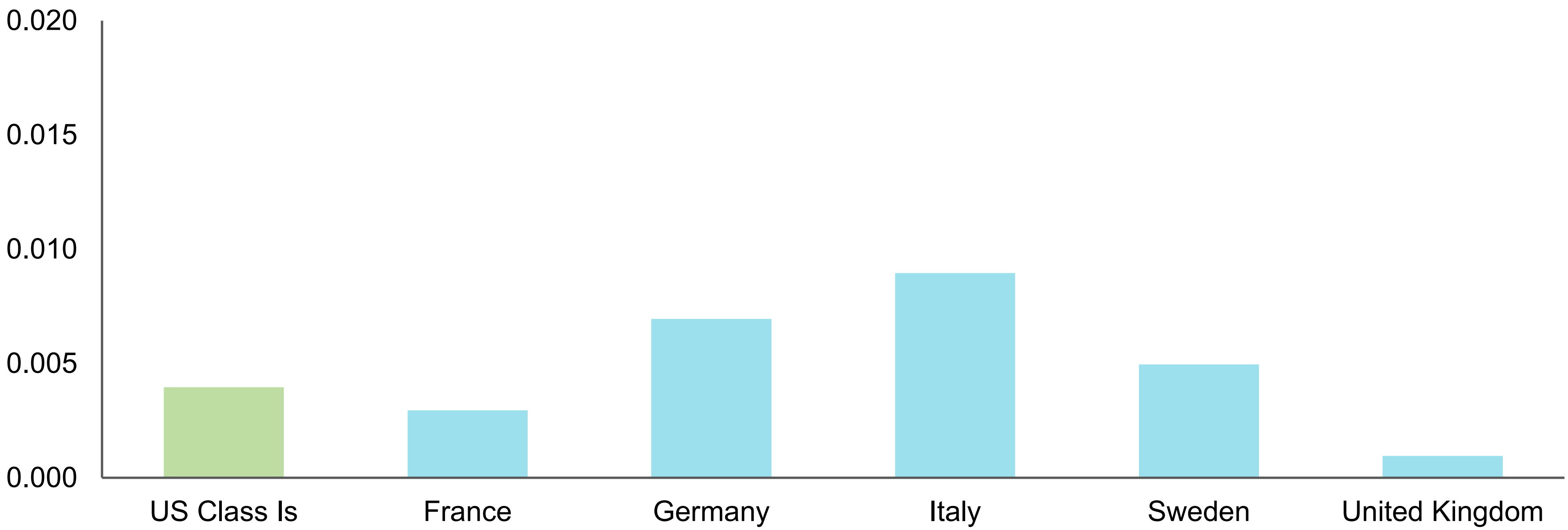
Source: FRA, ERA, and Oliver Wyman analysis.

US vs. Europe: Casualty incident analysis-Fatalities

Fatalities are rare on all railroads, as US rail fatalities occur at roughly the same rate as on their European counterparts – less than 0.01 per million tkm

Average Annual Fatality Rates by Country, 2007-2012

Per million train-kilometers



Note: The FRA classifies as fatalities deaths occurring within 180 days; the ERA only requires reporting of deaths with 30 days. This discrepancy may increase the number of fatalities reported in US data relative to the European data.

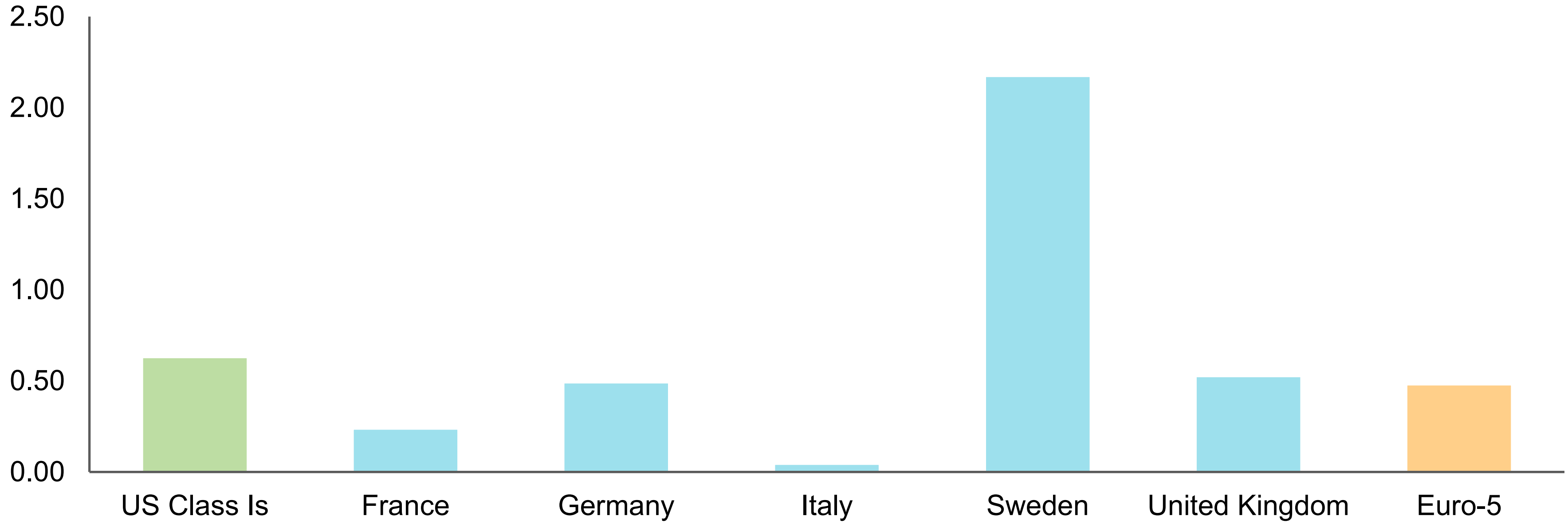
Source: FRA, ERA, and Oliver Wyman analysis

US vs. Europe: Signals Passed at Danger (SPADs)

SPAD data supports the assertion that single-person crew operations are at least as safe as multiple-person crew operations

Average Annual SPAD Rates by Country, 2007-2012

Per million train-kilometers



Note: Swedish data is somewhat skewed according to the Swedish Transportation Agency, for several reasons: 1) SPAD data reporting to the ERA is new; 2) Incorrect train consist information led to improper train handling in some cases; 3) Engineer cell phone usage was identified as a contributing factor, but was banned starting in late 2011.

Source: FRA, ERA, and Oliver Wyman analysis

3 Economic Analysis

Economic analysis: Overview

Oliver Wyman developed an economic model and scenarios to establish the potential cost savings of single-person crews to the freight railroad industry

Scenario A – Single person-crews only on trains without scheduled work

- Trains without scheduled work between crew change locations operate with only an engineer
- Local railroad personnel in the area assist in the event of an en route failure or unscheduled work event

Scenario B – Single-person crews only on high-density routes

- Trains operating on rail lines with high traffic density operate with a single engineer
- Utility staff in the area assist with all work events and en route equipment failures

Model inputs for both scenarios

- ✓ Traffic: car-miles, train-miles, total trains
- ✓ En route work events
- ✓ Scheduled & unscheduled equipment failures
- ✓ Employee compensation: wages, benefits, payroll taxes
- ✓ Network route miles
- ✓ Train delay costs

Estimating the number of single-person crews

The 511 million train miles produced by US Class Is in 2013 was the starting point for Oliver Wyman's estimate of single-person crew starts

Data category	Scenario A	Scenario B
Total train miles (2013)	511 million	511 million
Remove way and company train miles	49 million	49 million
Total road train miles	463 million	463 million
Average train miles per train start	367.6	367.6
Estimated road train starts	1.26 million	1.26 million
Remove road trains on Class C & D track	-	12,300
Road trains operating on Class A & B track	-	1.25 million
Average crews per train start	2.81	2.81
Estimated total road train crew starts	3.54 million	3.51 million
Scheduled en route work events	700,000	-
Estimated single-person crews	**2.85 million**	**3.51 million**

Sources: Surface Transportation Board, Annual R-1 Reports; AAR, Analysis of Class I Railroads; National Railway Labor Conference; Class I railroads; and Oliver Wyman analysis

Estimating the resources required under each scenario

Additional data was used to estimate the amount of resources needed to support each scenario

Data category	Scenario A	Scenario B
Estimated single-person crews	2.85 million	3.51 million
En route failures and unscheduled work events	241,000	-
Estimated recrew events	241,000	-
Average annual tours per engineer	188	-
Average length of crew district	-	130 miles
Class A & B route miles	-	72,000
Estimated crew districts on Class A & B track	-	552
Assumed shifts per 24-hour period	-	3

	Scenario A	Scenario B
Additional engineers required	**1,300**	**N/A**
Utility personnel required	**N/A**	**3,200**

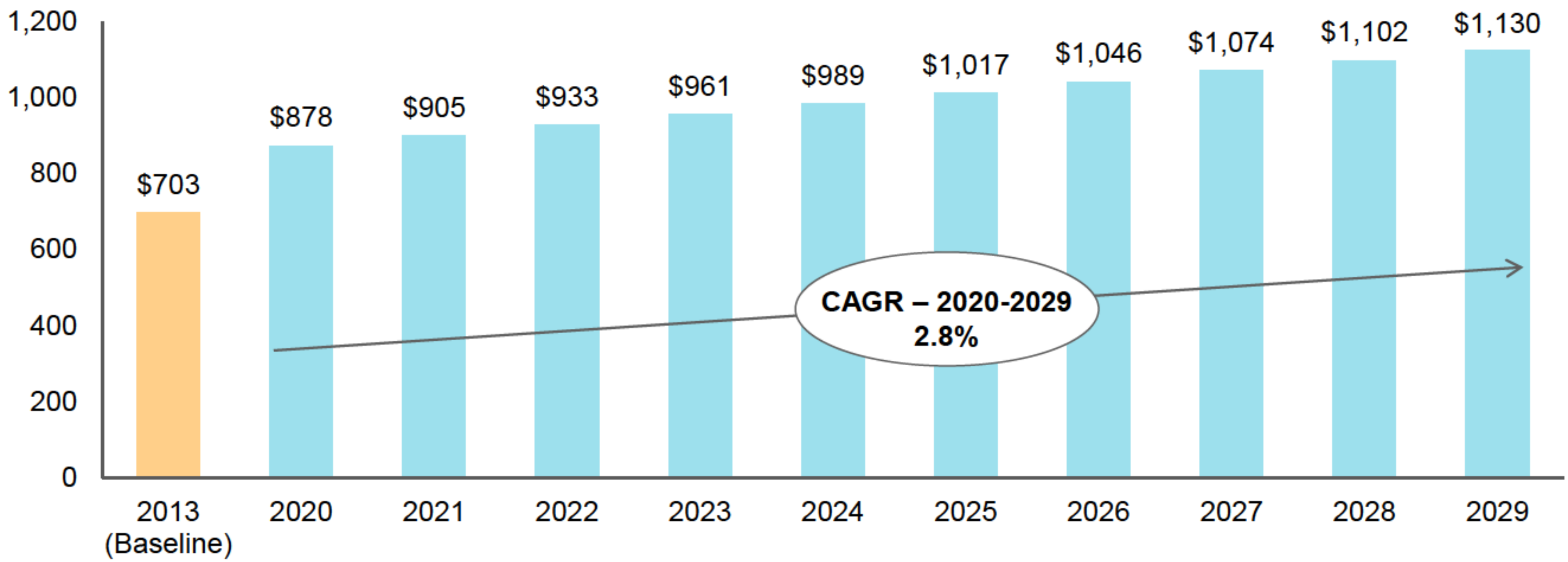
Sources: Surface Transportation Board, Annual R-1 Reports; AAR, Analysis of Class I Railroads; National Railway Labor Conference; Class I railroads; and Oliver Wyman analysis

Scenario A – single-person crews on trains w/o scheduled work-Model results

Class I railroads would see estimated savings from Scenario A of $878 million in 2020, increasing to $1.13 billion in 2029

Estimated Net Scenario Savings, Scenario A

Millions



Cost reduction due to: Elimination of trainman position on over 80 percent of the unit and through train crews called in 2013

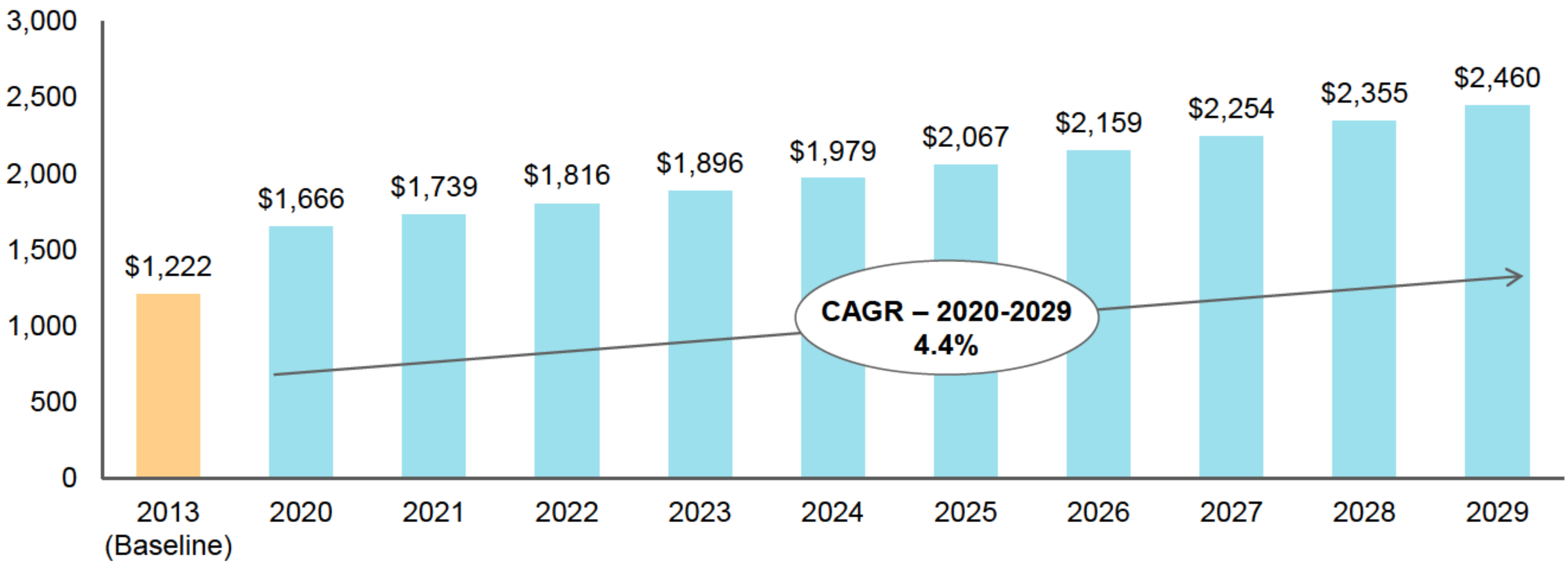
Cost increase due to: Hiring of additional locomotive engineers for re-crews and direct/indirect delay costs

Source: Oliver Wyman analysis

Scenario B – single-person crews on high-density lines-Model results

Class I railroads would see estimated savings from Scenario B of $1.67 billion in 2020, increasing to $2.46 billion in 2029

Estimated Net Scenario Savings, Scenario B
Millions



Cost reduction due to: Elimination of trainman position on 99 percent of unit and through train crews called in 2013

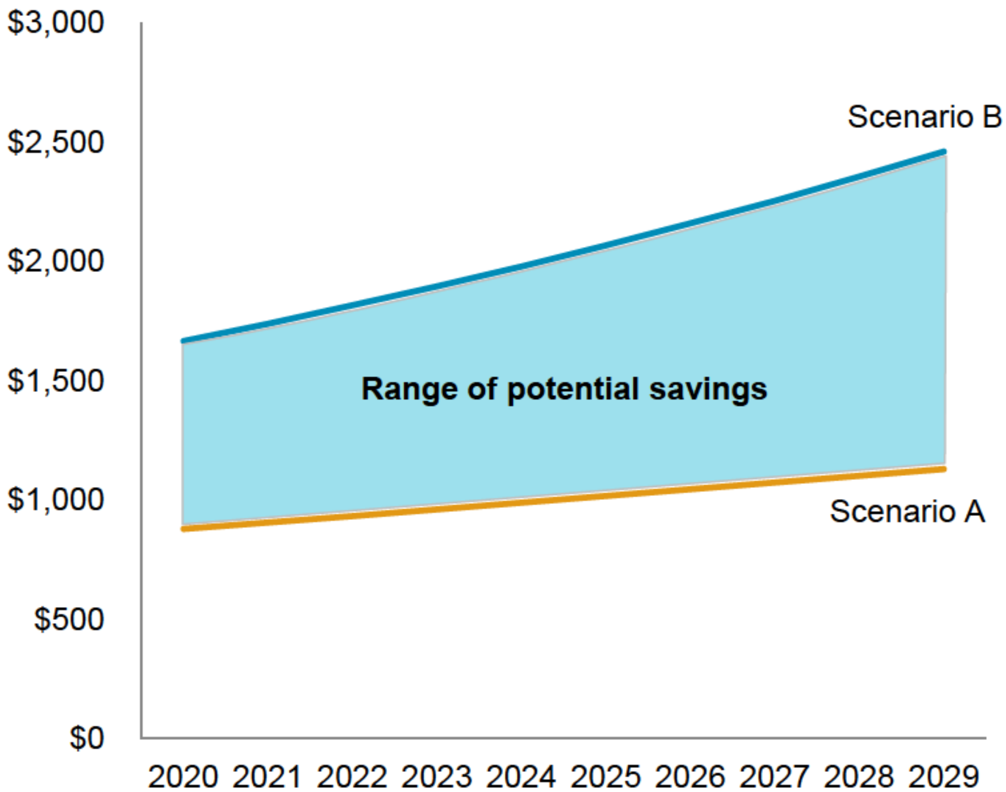
Cost increase due to: Hiring of utility personnel and utility vehicle purchasing and maintenance

Source: Oliver Wyman analysis

Economic analysis: Summary

In either scenario, single-person crew operations would provide substantial cost savings for the US Class I rail industry, helping to offset the costs of PTC implementation, without sacrificing operational safety

Annual Projected Savings by Scenario for Class I Railroad Single-Person Crew Operations, 2020-2029
Millions, dollar amounts are nominal values



Note: NPVs are 2015 dollars at a 3% discount rate
Source: Oliver Wyman analysis

- PTC and other new technologies will reduce human error in train operations
- With PTC in place, train crew size can be reduced without compromising safety
- The cost savings that accrue from implementing single-person crew operations could be used by the railroads to fund further capital and safety improvements
  - Scenario A NPV: $7.6 billion
  - Scenario B NPV: $15.3 billion

By prohibiting railroads from adjusting train crew size, the FRA will greatly reduce US railroads' ability to control operating costs, without making the industry safer

OLIVER WYMAN