Back on Track: Bringing Rail Safety to the 21st Century

ALLIANCE FOR INNOVATION AND INFRASTRUCTURE

August 6th, 2015

EXECUTIVE SUMMARY

Rapid improvements in oil-extraction technology, and the resulting increase in domestic oil production, have helped produced significant economic opportunities for the U.S. While pipeline infrastructure has historically been the preferred method for transporting large volumes of energy products, these largely underground "energy highways" have not kept up with demand. Because pipelines constitute fixed infrastructure, connectivity between gathering and endpoints is crucial. The discovery and extraction of oil reserves from new production fields such as the Bakken have not always aligned with existing pipeline infrastructure.

While new projects have been proposed, the capital investment and time required to develop new infrastructure, along with a slow permitting process, has hindered the industry's ability to meet new demand. Added to this, recent anti-fossil fuel opponents have successfully targeted new pipeline infrastructure projects such as the Keystone XL project, which has made energy transportation by pipeline even more difficult. This transportation void has instead been primarily filled by rail, although trucking and waterborne traffic has also increased.

The country's extensive rail network has experienced a more than 40-fold increase in usage by the oil industry due to its status as the most effective method to transport crude oil from new production areas to the market.[1] Whether transporting hazardous materials, other commodities, or passengers, the U.S. rail network boasts a very strong safety record, and accidents remain rare. However, the industry is not accident free. Even with an accident rate of less than 16 per million miles traveled in 2014, rail accidents have led to loss of life, disrupted communities and sensitive environments, and proliferated staggering cleanup costs.[2]

Many of the existing safety regulations were not implemented under current railway-usage conditions, where increased freight volume amplifies the likelihood of a hazard. Accidents caused by track and rail failures, as well as human factors, are of particular interest. If these integrity issues are not addressed in a timely and comprehensive manner, accidents are likely to continue. On the other hand, integrity issues affecting the safety of transport by rail can be addressed with the deployment of new safety technologies, improvements in traditional safety and inspection devices, and numerous recommendations from safety experts. Innovation can and will improve the safety, functionality, and efficiency of the rail transport network.

We recommend government, the rail industry, shippers, first responder, and other stakeholders revisit present rail safety standards, strengthen measures to address track and rail integrity, and mitigate the potential effects of human error. These recommendations include, but are not limited to:

1) **Increase the use of commercially available technologies to continuously monitor track, equipment, and roadbed conditions.**

2) **Conduct more effective and more frequent track and rail inspections.**

3) **Implement operational and technological improvements to reduce the likelihood of accidents caused by human error.**

4) **Determine and make public enforcement policies and penalties for rail owners and operators who are subject to – but fail to meet – the December 31, 2015 Positive Train Control Requirement.**

1 U.S. Department of Energy, "Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure," (April 2015).

2 U.S. Department of Transportation, Federal Railroad Administration, online Query tool.

1. INTRODUCTION

This paper draws attention to the numerous opportunities currently available to enhance rail transportation safety in the United States (U.S). A dramatic increase in non-conventional domestic crude oil production coupled with inadequate pipeline connectivity from new production fields has led to a significant increase in shipments of crude oil by rail. While less than one-hundredth of a percent of hazardous material shipments result in accidents or derailments, these occurrences can have serious, headline-grabbing consequences. Recent accidents involving passenger and freight trains carrying other commodities have also received national attention, resulting in a renewed focus on rail safety.

Moreover, the paper intends to inform and advance rail safety efforts by illustrating how commercially available technologies, together with improved safety practices, can be leveraged in order to improve rail safety. While much of the original debate has focused upon the consequence management of the commodity being transported, such a debate has missed the mark by failing to address the root cause of accidents. While mitigation can and does play an important role in transportation safety, prevention is safety's first line of defense.

When taken together, prevention, mitigation, and response form a cohesive, multi-layered approach to transportation safety upon which all stakeholders will be invested and engaged. Rather than focus on the product transported and recent efforts to mitigate the consequences of derailments, this paper examines the root causes of accidents, catalogues potential safety measures, and strives to show how to better leverage technologies, ideas, and recommended practices to improve the safety and reliability of the U.S. rail transportation network.

The data, maps, descriptions of accident causation, technologies, and best practices described, and safety recommendations referenced are taken from government and industry sources. These sources include information from the Federal Railroad Administration (FRA), Pipeline and Hazardous Material Safety Administration (PHMSA), Energy Information Administration (EIA), National Transportation Safety Board (NTSB), Transportation Safety Board of Canada (TSB), Transport Canada, Transportation Research Board (TRB), and the Association of American Railroads (AAR).

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The Alliance for Innovation and Infrastructure (Aii) is an independent, national, educational organization dedicated to identifying the nation's infrastructure needs to promote proven, innovative technology and higher safety standards to achieve industry excellence nationwide. The Alliance consists of two non-profits, the National Infrastructure Safety Foundation (NISF) 501(c)(4) and the Public Institute for Facility Safety (PIFS) 501(c)(3).

2. SHIFTING CRUDE TRANSPORTATION DYNAMICS

The combination of horizontal drilling and hydraulic fracturing has allowed U.S. oil production to reach levels not seen in decades. Previously unreachable domestic crude oil reserves are now extractable and economical to ship to market. However, since these reserves were found in areas that have not traditionally been hotbeds for exploration and production, existing pipeline infrastructure is insufficient to transport current and forecast quantities of new product to market.

The U.S. rail network, in contrast, is far more widespread and distributed throughout the nation, providing producers a means to access domestic refining markets.

A. Domestic Oil Boom

From 2009-2014, crude oil production in the United States increased by more than 62 percent – up from 5.35 million barrels per day in 2009 to 8.68 million barrels per day in 2014.[3] Perhaps more notable is the majority of new production is occurring in shale formations that were not historically believed to host oil reserves of commercially extractable quantities (see Figure 1).

Although these newfound reserves have reduced U.S. dependence on foreign oil and boosted the industry, which in turn created numerous jobs and stimulated economic growth, they have also imposed challenges upon the existing transportation infrastructure.

B. Insufficient Pipeline Network

One of the primary challenges that arose with increased crude oil production in non-traditional areas, was the lack of infrastructure available to transport oil from production fields to downstream refineries for processing. According to the U.S. Department of Transportation (USDOT), the U.S. crude oil pipeline network only spanned 50,000 miles in 2013[4] and a large majority of this network (see Figure 2) was built to carry oil

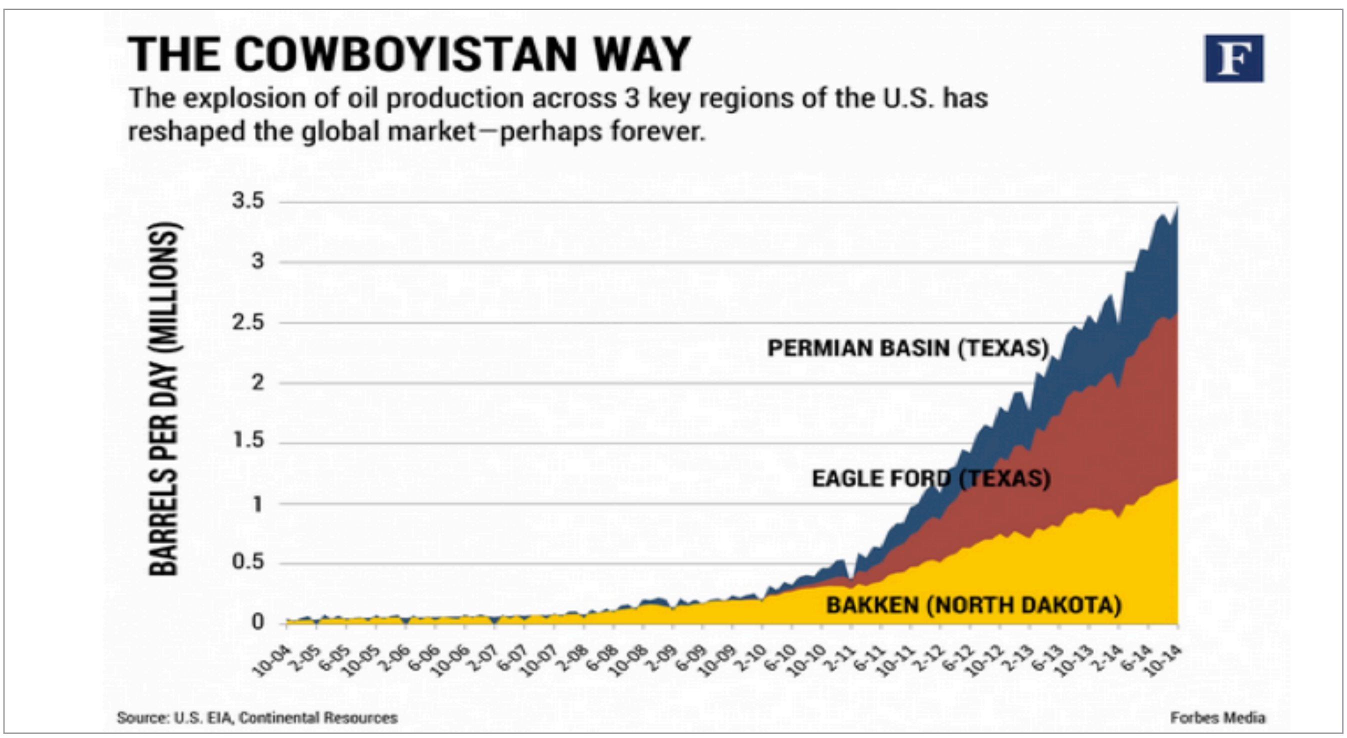


Figure 1 – Production Increases in Non-Traditional Formations

3 U.S. Department of Energy, Energy Information Administration, “Crude Oil Production,” (accessed May 27, 2015).

4 U.S. Department of Transportation, Bureau of Transportation Statistics, “Table 1-10 U.S. Oil and Gas Pipeline Mileage” (accessed June 1, 2015).

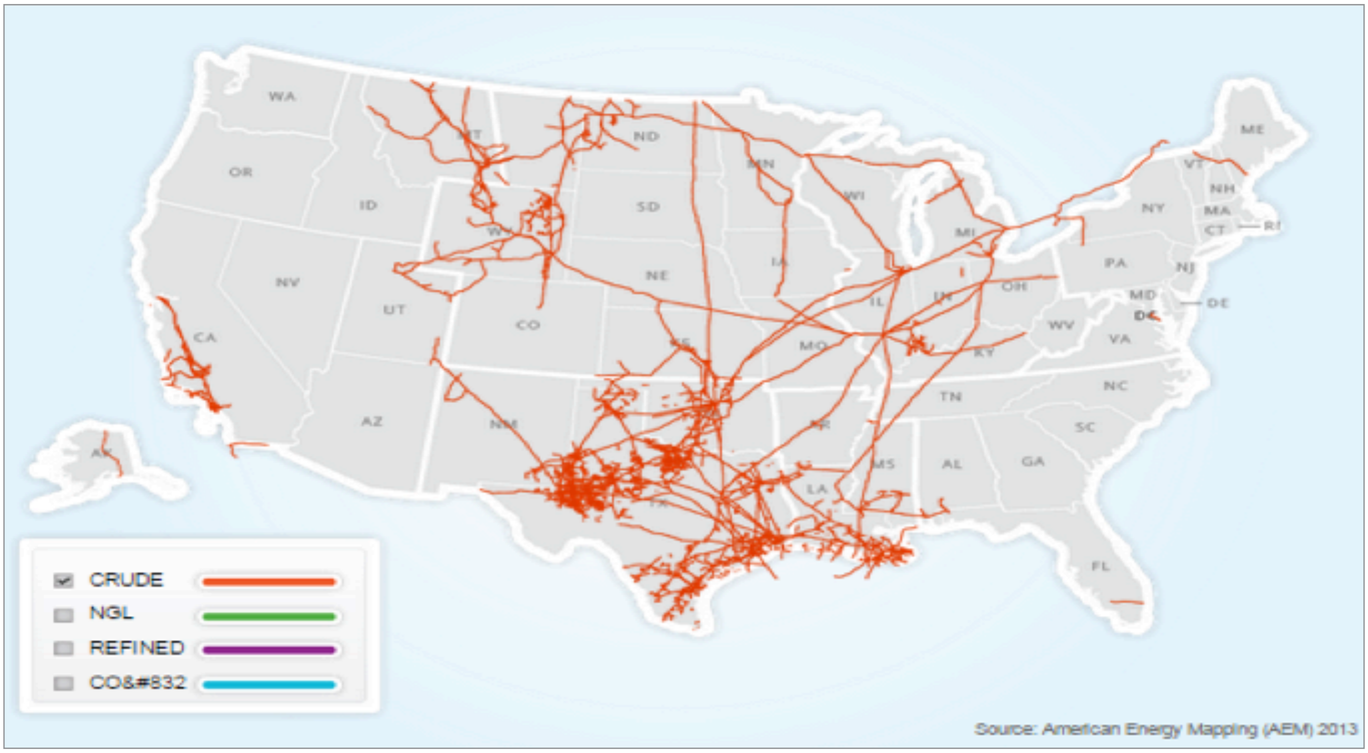


Figure 2 – Crude Oil Pipelines in the United States

from areas where conventional production has historically occurred. This resulted in the pipeline infrastructure system being unable to transport crude oil from newly developed reserves.[5]

C. Increase in Crude by Rail

Freight rail infrastructure is vast (140,000 miles)[6] and expansive, covering nearly every corner of the continental U.S.. Rail transportation also offers increased flexibility, as the routes are not static and predetermined from point A to point B. Rather, companies can utilize the entire network to ship products to and from any point in the country where a rail line is accessible. These factors have made rail the primary, and in some circumstances, the only mode of transportation easily available to transport crude oil to market.

The major geographic shift in crude oil production, combined with the lack of access to pipeline capacity and a vast rail network, led to a 4,400 percent increase in rail shipments of crude oil between 2009 and 2014.[7] More specifically, in 2009, approximately 10,800 carloads of crude oil were shipped on U.S. Class I[8] railroads.[9] By 2014, the number of carloads had expanded to more than 493,000.[10] While the accident rate for railroads has continued to decrease even in the face of such expansion, on an overall statistical basis, the raw number of accidents involving rail has in fact increased.

5 Total U.S. pipeline mileage totals 2.6 million miles, although the vast majority of lines support natural and other non-liquid gases.
6 U.S. Department of Transportation, Federal Railroad Administration, "Freight Rail Today," (Web, 2015).
7 U.S. Department of Energy, "Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure," (April 2015).
8 Class I railroads are railroads with annual carrier operating revenues of $250 million or more.
9 U.S. Department of Energy, "Quadrennial Energy Review: Energy Transmission, Storage, and Distribution Infrastructure," (April 2015).
10 Ibid.

3. SAFETY

The U.S. currently transports almost 1.5 million shipments of hazardous materials each and every day by air, land, sea, and rail. Hazardous materials regulations regarding transportation have been carefully developed over many years and are currently the responsibility of the USDOT and its operating modal administrations.

It is also important to note that hazardous materials transportation boasts a strong safety record. According to the AAR, 99.997 percent of all hazardous materials transported by rail reach their destination safely.[11] However, when accidents do occur, the consequences can be significant. This is particularly true in the event of a derailment. Federal regulators and the rail industry should use all available resources to identify, prevent, and mitigate the potential of accidents involving the transportation of hazardous materials by rail.

A. Causes and Severity of Derailments

Deficiencies in track and rail integrity are the largest causes of derailments by a significant margin. A study analyzing all derailments between 2001-2010 found broken rails, accounting for 670 accidents, to be the leading cause of derailments, and track geometry, accounting for 317 accidents, to be the second most common cause.[11] When examining the quantity of cars derailed rather than the event itself, broken rails far outstripped all other factors by an even larger margin, accounting for 8,512 cars derailed.[13] The second largest factor, track geometry, accounted for 2,057 cars derailed over the same period.[14]

The U.S. currently transports almost 1.5 million shipments of hazardous materials each and day by air, land, sea, and rail.

A detailed review of FRA accident statistics[15] from 2011-2014 yields similar findings. Track and roadbed deficiencies (including rail deficiencies) accounted for the largest number of derailments over the four-year period by a significant margin, also accounting for the largest number of derailments in each individual year. Similarly, human factors were the second leading cause of derailments under both metrics.

From 2011-2014, there were 5,303 total derailments. Despite some variety in the frequency of accidents over the four-year period, the ratio of accident causes remained mostly static.

Of the total derailments from 2011-2014, 42 percent or 2,238 were caused by track and roadbed deficiencies. These deficiencies were responsible for between 38 percent and 44 percent of accidents in each individual year. While demonstrating a slight downward trend from year to year, and ignoring the increases in volume transported, these numbers have remained almost static.

Derailments resulting from operational errors, designated by the FRA as "human factors," were similarly consistent, ranging from 30 percent in 2011 to 33 percent in 2014. The derailments caused by operational errors accounted for an average of 31 percent or 1,653 of accidents over the four-year period.

The slight decrease in derailments from track and roadbed deficiencies over the years was nearly offset by a slight increase in derailments resulting

11 Association of American Railroads, "Transporting Hazardous Materials Safely" (Web, 2015).

12 Xiang Liu, M. Rapik Saat, & Christopher P. L. Barkan,"Analysis of Causes of Major Train Derailment and Their Effect on Accident Rates," Transportation Research Record: Journal of the Transportation Research Board, No. 2289,Transportation Research Board of the National Academies, Washington, D.C., 2012, at 154

13 Ibid.

14 Ibid.

15 All accident data collected from the FRA and included for the remainder of this section was collected from: U.S. Department of Transportation, Federal Railroad Administration, online Query tool.

from human factors. As a result, the two combined categories made up an almost constant share of nearly three fourths of all derailments. All other causes combined, including track deficiencies, accounted for 27 percent of derailments of the four-year period.

Looking only at derailments caused by track and roadbed defects, similar patterns emerge – relatively few factors account for a disproportionate amount of accidents. Out of more than 60 different designations available to categorize the cause of a track or roadbed deficiency, the top five causes account for nearly half of all such derailments over the four-year period – 1,059 out of 2,238 (47%).

This data demonstrates that any additional efforts made through increased use of available technology or implementation of best practices, which can impact track structure, rail or roadbed integrity, and human factors, would have a tremendously positive impact on rail safety.

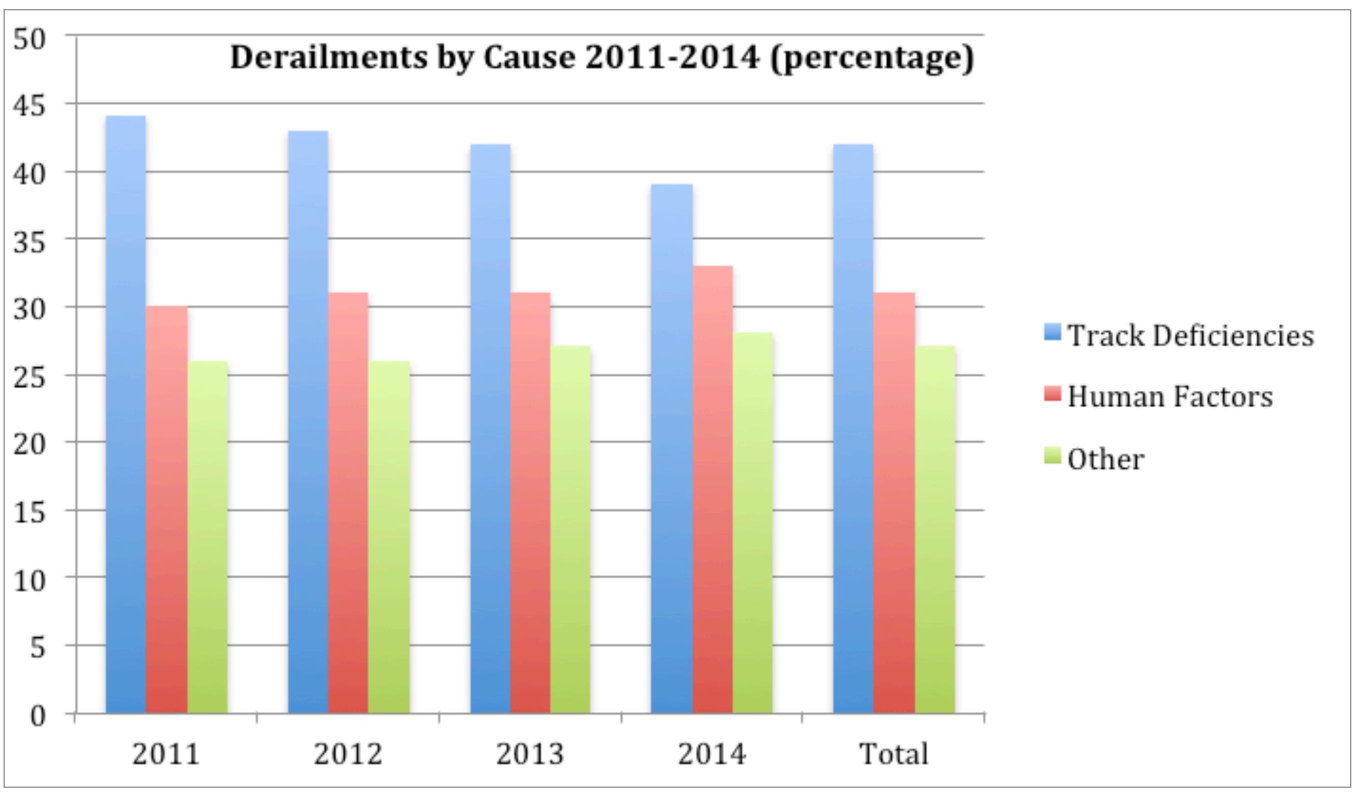
B. Summary of FRA Track and Rail Inspection and Maintenance Requirements

Track safety standards are found in Title 49, section 213 of The Code of Federal Regulations. This section covers inspection requirements for track, rail, switches, track crossings, automated inspection requirements for track switch concrete crossties, and special inspections after severe weather accidents.

1. Track Inspections

Track inspections are "visual inspections that look at the track structure (including ballast, crossties, track assembly fittings, and the physical conditions of rails), the roadbed and areas immediately adjacent to the roadbed and the track geometry."[16] Track inspections can be made on foot or by riding on a vehicle at a speed which allows the inspector to visually inspect the track structure.[17] Inspectors are allowed to

Figure 3 – Derailments by Cause



16 Derailment of Norfolk Southern Railway Company Train 68QB119, October 20, 2006, Accident Report RAR-08-02, National Transportation Safety Board (May 13, 2008).

17 49 C.F.R. §213.233

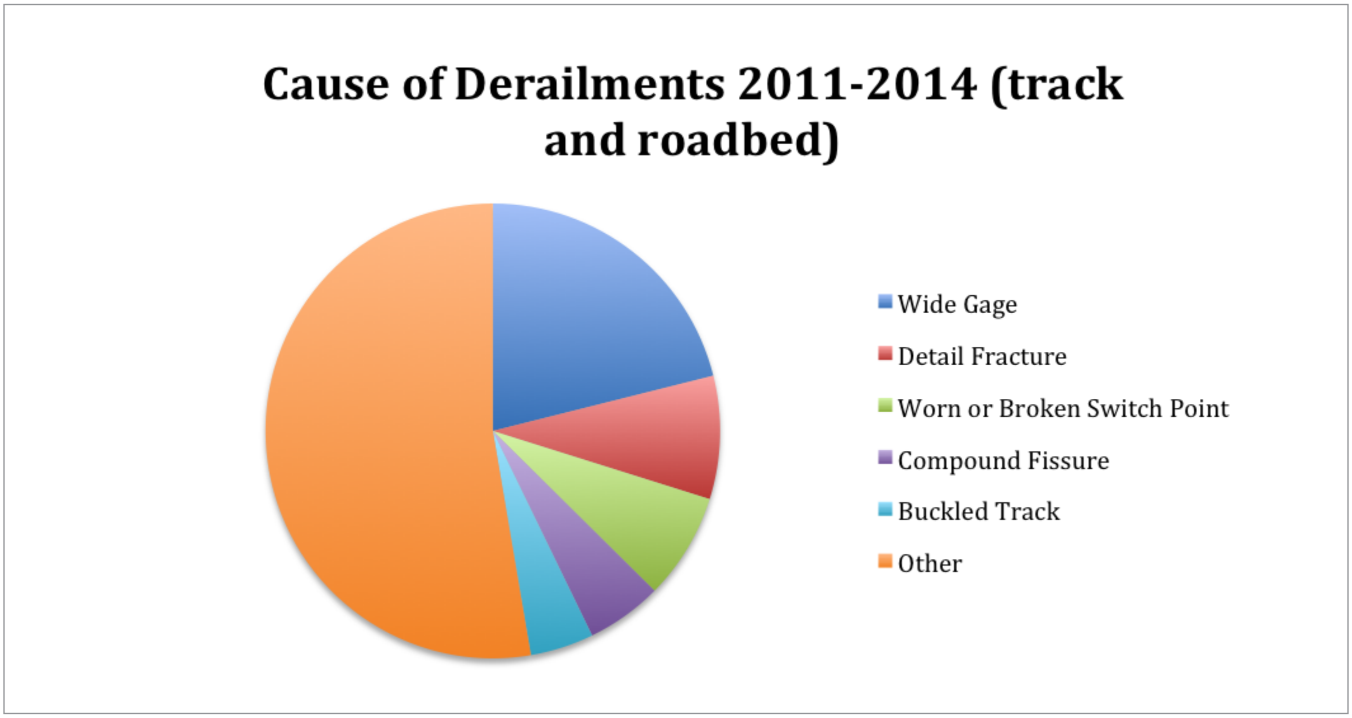


Figure 4 – Breakdown of Leading Causes of Track and Roadbed Derailments

use additional devices to supplement visual inspections, but are not required to do so.[18]

The main track and sidings of Class 1, 2, and 3 tracks must be inspected weekly, while everything other than the main track and sidings must be inspected monthly.[19] Class 4 and 5 tracks must be inspected twice weekly. [20] Classes are used to signify track quality. Each Class has the following speed limits for freight and passenger transport, respectively: Class 1, 10/15mph; Class 2, 25/30mph; Class 3, 40/60mph; Class 4, 60/79mph; and Class 5, 80/90mph.

To meet these requirements, one inspector in a vehicle may inspect up to two tracks at a time, as long as the inspector's vision is not obstructed and the second track is no more than 30 feet from the track the inspector is riding.[21] Two inspectors can inspect four tracks at a time as long as similar conditions are met.[22] However, each main track must be inspected by foot or vehicle at least once every two weeks, and each siding must be inspected on foot or by vehicle at least once per month.[23]

Additionally, Track Geometry Measuring Systems must be operated at least once per year on Class 6 tracks, twice per 120-day period for Class 7 tracks, and twice per 60-day period for Class 8 and 9 tracks.[24] There is no such requirement for Classes 1-5, but there are certain track conditions that prompt such a requirement.[25]

2. Rail Inspections

Rail Inspections differ from track inspections, in that rail inspections look for internal defects with ultrasonic or induction testing methods using an automated inspection vehicle or handheld device.[26] Railroads may independently set

18 Ibid.
19 Ibid
20 Ibid.
21 Ibid.
22 Ibid.
23 Ibid.
24 49 C.F.R. §213.333
25 Ibid.
26 Derailment of Norfolk Southern Railway Company Train 68QB119, October 20, 2006, Accident Report RAR-08-02, National Transportation Safety Board (May 13, 2008).

inspection schedules and determine how to define and calculate what constitutes a rail segment, as long as these inspections prove sufficient to satisfy required service failure rates.

Depending on the class of track, amount of usage, and products or passengers shipped, the acceptable failure rates range from .08 – 0.1 failures per mile of track in each segment per year.[27] A service failure is defined as "a broken rail occurrence, the cause of which is determined to be a compound fissure, transverse fissure, detail fracture, or vertical split head."[28] A stricter testing schedule is imposed if a segment fails to meet its acceptable failure rate for two consecutive years.[29]

Inspection intervals shall not exceed the shorter of 370 days, or the amount of time it takes to move 30 million gross tons over the segment.[30] Plug rail - A chunk of rail installed as a replacement to defective or flawed rail that has been removed - is not required to be inspected prior to re-use, but railroads are required to have knowledge of the date the plug rail was last tested and ensure it has not seen 30 million gross tons of traffic since its most recent test.[31]

3. Automated Inspections of Tracks with Concrete Ties

Tracks constructed with concrete ties are required to undergo periodic automated inspections.[32] Depending on annual tonnage and track class, these automated inspections must be conducted either once or twice each calendar year.[33]

4. Inspection of Switches, Track Crossings and Other Devices

Each switch, turnout, track crossing, and moveable bridge lift rail assembly or other transition device is required to be inspected on foot at least once per month.[34]

5. Special Inspections

All tracks should be inspected after an event, which could damage track structure, like a fire or severe storm.[35]

6. Remedial Action

The specific actions required in response to a track defect varies depending on the nature of the deficiency. Based on the severity of the defect, rail operators must do one or more of the following (see Appendix II for the FRA's "Remedial Action Table")[36]:

- Designate a person to supervise each operation over the defective rail;
- Allow service to continue at reduced speeds while determining a solution;
- Provide a remedy to the defect within 7 or 10 days (depending on the defect) reducing speeds in the interim;

27 49 C.F.R. §213.237
28 Ibid.
29 Ibid.
30 Ibid.
31 Ibid.
32 49 C.F.R. §213.234
33 Ibid.
34 49 C.F.R. §213.235
35 49 C.F.R. §213.239
36 See Appendix II.

- Inspect the rail within 30 or 90 days (depending on the severity of the case) of detecting the defect and restart the inspection cycle with each successive re-inspection unless or until the rail is replaced or the defect has increased in size sufficient to warrant further remedial action

C. New Tank Car Regulations: A Step in the Right Direction

On May 1, 2015, PHMSA, working in consultation with the FRA, issued a final rule many hoped would focus on preventing derailments and mitigating damages deriving therefrom. The ruling titled, "Enhanced Tank Car Standards and Operational Controls for High Hazard Flammable Trains," focused mainly on mitigation of releases in the event of a derailment, primarily through requirements for new tank cars used to transport flammable liquids and retrofitting existing tank cars carrying these hazardous materials. The rule also requires electronically controlled pneumatic (ECP) braking systems for all high hazard flammable unit trains (HHFUT)[37] travelling over 30 mph as of May 1, 2023.

Transportation jurisdiction is divided between different federal agencies within the USDOT. PHMSA's regulatory reach with respect to rail is limited to specific regulations pertaining to the transportation of hazardous materials. Thus PHMSA is, by its very nature, limited. The regulatory body having direct safety responsibility over rail infrastructure is the FRA. In preparing its rule, however, PHMSA acknowledged the presence of track integrity issues, and their status as the leading cause of derailments:

> "Broken rails or welds, track geometry, and human factors such as improper use of switches are the leading causes of derailments. For example, one study found that broken rails or welds resulted in approximately 670 derailments between 2001 and 2010, which far exceed the average of 89 derailments for all other causes. Rail defects have caused major accidents involving HHFT's."[38]

Yet, the rule contains no provisions to address these important factors. Stronger tank cars are a welcome improvement and PHMSA's regulation is certainly a starting point for ensuring comprehensive rail safety. However, PHMSA's rule could not address other important factors, including:

- Prevention as the primary focus of rail safety through maintaining track and rail integrity to mitigate from future accidents;
- Consequence management regulations issued by PHMSA should be considered an equally important, yet secondary line of defense when following an accident;
- Recent rulemakings by the USDOT did not address certain important aspects of rail safety, specifically in regard to passenger trains or shipments of non-hazardous commodities.

Additionally, the requirement for Electronically Controlled Pneumatic brake systems continues to be controversial. While this paper does not directly address ECP or other types of braking, such as utilizing distributive power, it is important to note the technology's current status

While some applaud its inclusion stating the need to evolve the technology widely used in train braking systems, others believe the data utilized is either inaccurate or outdated. The rail

37 Single trains consisting 70 or more tank cars loaded with Class 3 flammable liquids and one or more loaded tank car of a PG I flammable liquid are required to install ECP brakes by January 1, 2021.

38 79 F.R. 45026 (August 1, 2014)

industry's trade association believes, "the DOT has no substantial evidence to support a safety justification for mandating ECP brakes, which will not prevent accidents."[39] The use of other braking techniques has also been raised as an alternative to ECP.

In contrast, a recent NTSB study concludes ECP braking systems do provide additional safety benefits, but acknowledges benefits may be limited under a number of different scenarios. For example, NTSB states "The reported benefit may be limited to trains with lower trailing tonnage operating on lesser grades, and/or at lower speeds."[40]

Focusing on the actual root causes of accidents, rather than a single component, provides the most direct path to robust solutions aimed at analyzing, modeling, predicting, and hence preventing accidents from occurring in the first place. The reduction in accidents removes consequences entirely. Where an accident is prevented, it is entirely mitigated.

Track, roadbed, and structural deficiencies are the number one cause of derailments, accounting for 39 percent of all derailments in 2014.

As stated above, track, roadbed, and structural deficiencies are the number one cause of derailments, accounting for 39 percent of all derailments in 2014. Human factors are next, accounting for 33 percent. Commercial technologies and recommended best practices designed to prevent both factors are presently available. Recent regulations by the USDOT have not yet lead to a thorough analysis and adoption of innovative technologies as a solution to the two factors responsible for approximately 72 percent of derailments.

Accident prevention would carry the additional benefits of improving rail safety generally. According to AAR, 70 percent of miles travelled by Amtrak are on tracks owned by freight railroads.[41] Increased tank car standards will have an impact on improving overall safety of transporting hazardous materials, but will have little to no impact on improving the safety of passenger trains, or trains carrying any other commodity.

39 Association of American Railroads, "New U.S. Rules Governing Flammable Liquids Moved By Rail Enact Misguided Braking Requirement That Threatens Rail Capacity and Service." (Web 2015).

40 Train Braking Simulation Study, National Transportation Safety Board (July 20, 2015).

41 Association of American Railroads, "Passenger Rail," (Web, 2015).

4. PREVENTING ACCIDENTS

Future regulatory efforts by the USDOT and the FRA in particular should focus on mitigating the leading causes of derailments: broken rail, track geometry, and human causes. Thus, it is important for both entities to assert regulatory authority in this area in order to minimize the likelihood of such accidents.

A. Technologies for Improving Track and Rail Integrity

The following technologies or operational recommendations focus on the leading causes of derailments: Track and rail integrity and human error. Note that multiple vendors offer many of the technologies listed below. This paper does not list each. The purpose of this section is to identify available technologies, rather than highlight variations available or the pros and cons of different models from different vendors.

Also note, there is slight overlap in the functionality of different systems, but each offers some additional safety benefits when compared to the alternatives. Finally, some of the systems automate inspections currently performed manually, thereby improving safety by allowing for increased inspection frequency.

(Please note, the following systems are commercially available, but are not required by statute or regulation.)

1. Track Integrity Sensor: The Track Integrity Sensor is a device that can be secured to both the rail and an embedded ballast probe to monitor for rail deformation or ballast washout.[42] Should an anomaly occur, an alarm is activated and broadcast back to the monitoring station.[43]

2. Ballast Integrity Sensor: Ballast Integrity Sensors (BIS) provide continuous, real-time monitoring of subgrade movement in reference to the track structure. Infrastructure issues such as washouts, sink holes, side scour, thermal track buckles, impact deflection, security attacks, abutment scour, and general earth shifts can be monitored 24-hours a day in all weather conditions.[44]

3. Autonomous Track Geometry Measurement: Autonomous Track Geometry Measurement systems "measure and record track geometry remotely from an autonomous railcar in regular revenue train service. The system provides rail condition assessment continuously and at a much lower cost than dedicated surveys requiring personnel, instrumentation, and a special manned vehicle. With frequently repeated assessments, time profiles of track geometry can be recorded and rail management and repair strategies can be developed to avoid speed restrictions and derailments."[45]

4. Gage Restraint Measurement Systems (GRMS): These systems, "measure rail motion under a combined vertical and lateral load for the detection of weak ties and fasteners."[46]

42 Sentrack™ Track Monitoring System, Track Integrity Sensor, http://www.metrom-rail.com/filebin/images/products/pdf/SenTrack_Track_Monitoring_System.pdf

43 Ibid.

44 See Ballast Integrity Sensor, International Engineering Technologies and Global Connections, http://international-engineering.com/en/divisions/monitoring-division/Ballast-Integrity-Sensor.php

45 Transportation Research Board, "Evaluation of the Federal Railroad Administration Research and Development Program," Special Report 316 (March 2015).

46 U.S. Department of Transportation, Federal Railroad Administration, "Gage Restraint Measurement System T-18," (Web, 2015).

According to the NTSB, GRMS or other mechanical track inspection devices should be employed to supplement visual inspections.[47] This would allow inspectors to focus their efforts on specific conditions or portions of track,[48] increasing the likelihood of identifying and remedying the issue.

(Please note, unlike the technologies listed above, ultrasonic and induction technologies are widely employed and used to meet regulatory requirements, but are not necessarily being used to the fullest extent.)

5. Ultrasonic and Induction Rail Testing: Ultrasonic testing uses "sound waves, or vibrations, that are propagating at a frequency that is above the range of human hearing…"[49] The ultrasonic waves are sent into the rail at various angles to scan the entire rail head, web, and base directly below the web. Any defects will result in part of a wave being reflected back to the transducer, which may be analyzed, so that appropriate remediation may occur, and then saved for recordkeeping.[51]

Induction testing introduces "a high-level, direct current into the top of the rail and establishing a magnetic field around the railhead. An induction sensor unit is then passed through the magnetic field. The presence of a rail flaw will result in a distortion of the current flow, and it is this distortion of the magnetic field that is detected by the search unit."[52]

While these technologies are currently employed throughout the rail industry, improving best practices could make their use more effective. For example, to ensure defects are spotted, all surface defects on rails should be removed prior to ultrasonic testing. If not, "there is a risk that internal rail defects will remain undetected, leading to broken rails and derailments."[53] Additionally, FRA recommended, "plug rail be immediately inspected prior to reuse," but chose not to require such testing[54] despite NTSB recommendations that such testing be required.[55]

B. Best Practices for Improving Track and Rail Integrity

1. Improved Track Inspection Policies: The NTSB encourages improving and expanding track inspection regulations to increase the likelihood of identifying and remedying potential track deficiencies before they become problematic. NTSB points out that inspecting multiple tracks simultaneously seriously compromises the integrity of the inspection, stating:

> "When inspecting a track from a typical high rail vehicle, an inspector can see the track structure in front from about 20 feet. In addition to operating the vehicle and looking in the direction of travel for track defects 20 feet in front, an inspector may be expected to inspect an adjacent track up to 30 feet to the side. Furthermore, part of the inspection may include the sound or feel of the track as the inspection vehicle rides over the track. These parts of the inspection are not performed if the inspector is inspecting the adjacent track."[56]

Additionally, NTSB believes there should be speed restrictions on high rail track inspection vehicles, stating: "if track inspectors are required to find only defects that occur rapidly, a discretionary speed would be appropriate, but if inspectors are expected to detect gradual degradation patterns, the inspectors need to travel more slowly."[57]

The Brotherhood of Maintenance of Way Employees recommend the frequency of

47 Comments from Deborah Hersman, Chairman, NTSB, to Docket FRA-2011-0058 (RIN 2130-AC28) (Dec. 18, 2012).
48 Ibid.
49 79 F.R. 4234 (January 24, 2014) at 4237
50 Ibid.
51 Ibid.
52 Ibid.
53 Derailment of Canadian National freight train M30151-18, October 19, 2013, Railway Investigation Report R13E0142, Transportation Safety Board of Canada (February 27, 2015).
54 79 F.R. 4234 (January 24, 2014)
55 See Derailment of Amtrak Train No. 5-17, March 17, 2001, Safety Recommendation R-02-005, National Transportation Safety Board (March 21, 2002).
56 Comments from Deborah Hersman, Chairman, NTSB, to Docket FRA-2011-0058 (RIN 2130-AC28) (Dec. 18, 2012).
57 Ibid.

inspections using track geometry measurement equipment be increased to at least three times per year for Class 5 and 6 tracks.[58]

2. Improved Rail Inspection Policies: The FRA recently improved their rail inspection regulations, addressing NTSB concerns regarding inspection interval requirements, taking "into account the effect of rail wear, which can allow undetected internal rail defects to grow to critical size between inspections."[59]

Specifically, FRA's 2014 rulemaking[60] updated inspection standards to focus more on rail usage, tonnage and commodity being shipped, to be consistent with NTSB's recommendations. However, the rule also allowed railroads to set their own inspection schedules and determine how to define and calculate what constitutes a rail segment.

FRA should consider providing increased guidance on what constitutes a rail segment for purposes of tracking failure rates and how inspection schedules should be set. The current practice could become problematic, as "averaging out service failure rates over excessively large 'segments' of track often fail to identify discreet areas of weakness with chronically high concentrations of service failures."[61]

3. Define Specific Allowable Limits for Combinations of Minor Track Defects: There are circumstances where an isolated track deficiency would, on its own, not violate FRA standards, but when combined with other deficiencies, can lead to unsafe transport and derailment.[62] Track geometry cars can identify whether there are any unacceptable deviations in track conditions, but not whether multiple acceptable deviations add up to an unsafe stretch of rail.[63]

NTSB recommends updating regulations to "define specific allowable limits for combinations of track conditions, none of which individually amounts to a deviation from Federal Railroad Administration regulations that require remedial action, but, which when combined, require remedial action."[64] Once these actions have been completed, track geometry inspection vehicles should be programmed to detect combinations of defects that require remedial action.[65]

C. Technologies for Preventing Accidents Caused by Human Errors

1. Positive Train Control (PTC): This system of functional requirements for monitoring and controlling train movements provides increased rail safety.[66] In cases where human error could lead to catastrophic consequences, PTC can step in and prevent derailments and accidents.[67]

Specifically, PTC systems are "designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zone limits, and

58 Comments from Brotherhood of Maintenance of Way Employees Division to Docket PHMSA-2012-0082 (HM-251) (Sept. 30, 2014).
59 Derailment of Norfolk Southern Railway Company Train 68QB119, October 20, 2006, Accident Report RAR-08-02, National Transportation Safety Board (May 13, 2008).
60 See 49 C.F.R. §213.237
61 Comments from Brotherhood of Maintenance of Way Employees Division to Docket FRA-2011-0058 (RIN 2130-AC28) (Nov. 18, 2012).
62 Derailment of CSX Transportation Train Q70419, July 18, 2013, Safety Recommendation R-14-75 and 76, National Transportation Safety Board (December 30, 2014).
63 Ibid.
64 Ibid.
65 Ibid.
66 National Transportation Safety Board, "Implement Positive Train Control in 2015," (Web, 2015).
67 Ibid.

the movement of a train through a switch left in the wrong position."[68]

PTC systems vary, but there are numerous commercially available PTC technologies. Most Class I railroad mainlines and lines carrying passenger trains are required to have PTC systems in place by December 31, 2015.[69] Many regulated parties have stated they will miss the deadline. It is unclear how this regulation will be enforced.

2. Inward Facing Cab Cameras: NTSB stated that "while video recorders will assist in the investigation of accidents, their value in preventing accidents cannot be overstated," and added that "the installation of inward facing cameras could assist railroads in monitoring rules compliance and identifying fatigued engineers, which could prevent accidents."[70]

While video recorders will assist in the investigation of accidents, their value in preventing accidents cannot be overstated.

Despite the NTSB's numerous recommendations, FRA has not promulgated regulations requiring inward facing cameras to date. However, FRA recently indicated that they are working on regulations that will require these cameras in the future.[71]

D. Best Practices for Preventing Accidents Caused by Human Factors

1. Improve Effectiveness of "Alerter" Devices: If "alerter" devices, which require engineers to respond to alerts, sound an alarm and eventually stop the train if they are unresponsive in an emergency – are reset by anything other than engineer activity, all of the safety benefits of these "dead man switches" are lost.

NTSB recommends updating regulations and industry practices to ensure automatic systems are prohibited from resetting the locomotive electronic alertness device without engineer intervention.[72] Specifically, NTSB states all railroads should identify and document any systems that reset the alerter device without any manual intervention, and update these systems to eliminate such resets.[73]

2. Requiring Two Person Crews: Requiring two person crews in train cabs could significantly improve safety. FRA has made their position "very clear" that while they understand the nuances of railroad operations, when discussing safety, "the starting point for [the] discussion is mandating multiple person crews."[74]

Then FRA Administrator, Joseph Szabo, stressed the issue as early as 2013, however, FRA has not put forward any such mandate to date.

68 49 U.S.C. § 20157 (i)(3)

69 49 C.F.R. §236.1005

70 Collision of Union Pacific Railroad Freight Train with BNSF Railway Freight Train Near Chaffee, Missouri May 25, 2013, Accident Report RAR-15-02, National Transportation Safety Board (November 17, 2014).

71 U.S. Department of Transportation, Federal Railroad Administration, "FRA Statement Regarding Amtrak Inward Facing Camera Installation," Press Release number FRA 15-999 (May 26, 2015).

72 Collision of Two Union Pacific Railroad Trains Near Hoxie, AR, August 17, 2014, Safety Recommendation R-15-004 and 5, National Transportation Safety Board (February 4, 2015).

73 Ibid.

74 U.S. Department of Transportation, Federal Railroad Administration, Remarks at the 50th Meeting of the Railroad Safety Advisory Committee, Administrator Joseph Szabo, Washington D.C. 2015.

TABLE 1 – TECHNOLOGIES AND BEST PRACTICES TO COMBAT LEADING CAUSES OF FREIGHT TRAIN DERAILMENTS

	TECHNOLOGIES	BEST PRACTICES	BENEFIT/IMPROVEMENT
TRACK AND RAIL INTEGRITY	Track Integrity Sensor		Monitors relationship between track and ballast
	Ballast Integrity Sensor		Monitors ballast for deep and surface structural issues and subgrade movement
	Autonomous Track Geometry Measurement		Improves frequency, efficiency and quality of track assessments and data records
	Gage Restraint Measurement Systems		Supplement visual inspections and increase focus on problem areas
	Ultrasonic/Induction Testing		Use on plug rail would prevent faulty track from being reinstalled
		Track Inspection Policies	Increase frequency, require inspection of one track at a time, speed restrictions on inspections
		Rail Inspection Policies	Stronger guidance on regulatory definition of "rail segment"
		Combined Defect Rules	Identify nearly insignificant flaws that acting together can cause derailment
HUMAN FACTORS	Positive Train Control		Prevent human error accidents by stopping/ slowing train prior to accident or derailment
	Inward Facing Cab Cameras		Monitor compliance and identify fatigued engineers
		Improve Effectiveness of "Alerter" Devices	Ensure engineer activity is required to reset the "alarm" system
		Require Two Person Crews	Extra pair of eyes and backup engineer in case of emergency

5. POLICY RECOMMENDATIONS

The USDOT, specifically FRA, should focus all near-term future regulatory efforts on preventing the leading causes of derailments: track and roadbed integrity as well as human causes. In doing so, they should consider the following policy recommendations:

1) **Increasing use of commercially available technologies to continuously monitor track and roadbed conditions.**

   Subpar track geometry and ballast integrity are among the most common causes of derailments. They are also heavily interdependent – if the ballast washes out, sinks, or moves, the track will be negatively affected. Without constant monitoring, it is impossible to detect a subtle or immediate shift beneath the roadbed, even with a vigorous track inspection schedule.

   There are commercially available technologies, which can provide continuous monitoring of the ballast, monitor the relationship between the track, the rail and the ballast, and others that can autonomously record track geometry remotely, notifying inspectors of any problem areas.

   Widespread use of any or all of these technologies would allow operators to immediately identify and remedy any areas of track negatively affected by washouts and sinkholes from water damage, track movement resulting from heavy loads, thermal track buckling, and any other destructive accident.

2) **Conduct more effective and more frequent track and rail inspections.**

   Current regulations require frequent track inspections, but the quality of the inspections is suspect. First, the regulations allow a single inspector to inspect multiple tracks simultaneously, which reduces the inspectors ability to constantly assess either track at all times and eliminates the ability to ride along each track and physically feel the track condition.

There are also no speed limits set for inspectors using hi-rail vehicles. If the vehicle is moving too fast, the inspector could miss potentially serious track flaws, which would have otherwise been identified.

NTSB points out that "[t]he regulations are too focused on visual inspections and do not specify a frequency of use of GRMS or mechanical, electrical, and other track inspection devices for high-tonnage routes, passenger train routes, and hazardous material routes, which can and will deteriorate beyond federal requirements if not inspected more closely."[75]

FRA should define, in regulation, specific allowable combinations of track defects, which together can cause derailments, but alone would be safe and compliant with regulations. Mechanical track inspection devices should be recalibrated to account for these changes.

Rail inspection policies should also be improved. First, consistent with NTSB recommendations, all "plug rail" should undergo ultrasonic (or similar) testing to detect any potential internal flaws immediately prior to reuse. FRA should also consider providing increased guidance on what constitutes a rail segment for purposes of tracking failure rates and how inspection schedules should be set.

75 Comments from Deborah Hersman, Chairman, NTSB, to Docket FRA-2011-0058 (RIN 2130-AC28) (Dec. 18, 2012).

They should also set a minimum of at least three inspections per year, regardless of the metrics used to set the schedule.

3) **Implement operational and technological improvements to reduce the likelihood of accidents caused by human error.**

Rail safety policy should require two person crews at all times. Former FRA Administrator Joseph Szabo stressed the importance of this policy on numerous occasions. Additionally, alerter devices within the cab should be updated to ensure that only human activity triggers a reset. If any automatic or mechanical activity triggers a reset, all accident prevention value of this safety mechanism is lost. Finally, policies should also require inward facing cab cams in all locomotives.

Policies should also require inward facing cab cams in all locomotives.

4) **Determine and make public enforcement policies and penalties for rail owners and operators who fail to meet the December 31, 2015 Positive Train Control (PTC) requirement.**

The NTSB has recommended implementation of a PTC system for more than 45 years, stressing its many benefits. Congress mandated that all major rail operators implement PTC systems by December 31, 2015.[76] Highlighting the high costs of the technology, which they estimate to be $9 billion nationwide, the rail industry has stated, it will not have PTC implemented by the statutory deadline, and it is advocating for the deadline to be extended.[77]

With the deadline fast approaching, FRA should clearly articulate how they plan to enforce these requirements, the consequences for non-compliant regulated parties, and any safe harbors that may be available. Rail owners and operators deserve clarity on what they can expect so they can most effectively plan how to get these systems online. The public needs to know what the rules are so all parties can be held accountable if the rules are not enforced and the safety benefits not made available.

76 National Transportation Safety Board, “Implement Positive Train Control in 2015,” (Web, 2015).
77 Association of American Railroads, “Positive Train Control,” (Web, 2015).

APPENDIX 1: GLOSSARY OF TERMS

Ballast: forms the track bed upon which railroad ties are laid. It is packed between, below, and around the ties. It is used to bear the load from the railroad ties, to facilitate drainage of water, and also to keep down vegetation that might interfere with the track structure.

Cab: The space in the locomotive unit containing the operating controls and providing shelter and seats for the engine crew.

Gage: The spacing of the rails on a railway track, measured between the inner faces of the load-bearing rails.

Hazardous materials: Any substance or material could adversely affect the safety of the public, handlers or carriers during transportation.

Hi-Rail Inspection Vehicle: A modified highway vehicle equipped with rail wheels. These vehicles are used by some track inspectors while performing track inspections.

Human Factors: Accidents primarily caused by an act, omission, or physical condition of a railroad employee.

Locomotive: A powered rail vehicle used for pulling trains.

Non-Conventional Oil: is oil produced or extracted using techniques other than the conventional method. The combination of horizontal drilling and hydraulic fracturing is commonly used in the U.S. as a way to extract oil from shale formations.

Plug Rail: A chunk of rail installed as a replacement to defective or flawed rail that has been removed.

Rail: A set of parallel metal rails fixed to ties for transport of passengers and goods in trains. The rails are affixed on top of the track and the track is responsible for keeping the rails in place.

Switch: A mechanical installation enabling trains to be guided from one track to another, such as at a railway junction or where a spur or siding branches off.

Track: The space between the rails and space of not less than four feet outside each rail. The track structure consists of the rails, fasteners, railroad ties and ballast, plus the underlying subgrade.

Track Geometry: The composition of several geometric parameters of thee track, including track gage, alignment, elevation, curvature, and track surface.

APPENDIX 2: FRA REMEDIAL ACTION TABLE

REMEDIAL ACTION TABLE

Defect	Length of defect (inch(es))		Percentage of existing rail head cross-sectional area weakened by defect		If the defective rail is not replaced or repaired, take the remedial action prescribed in note
	More than	But not more than	Less than	But not less than	
Compound Fissure	……………………...... …………………….. ……………………..	……………………...... …………………….. ……………………..	70………………........... 100………………….. ………………………..	5……………………… 70……………………… 100……………………	B. A2. A.
Transverse Fissure Detail Fracture Engine Burn Fracture Defective Weld	……………………...... …………………… …………………….. ……………………	……………………...... …………………… …………………….. ……………………	25 .... 60 .... 100 .... …………………………	5......................... 25....................... 60…………………….. 100.....................	C. D. A2, or [E and H]. A, or [E and H].
Horizontal Split Head Vertical Split Head Split Web Piped Rail Head Web Separation Defective Weld (Longitudinal)	1……………………… 2……………………… 4……………………… (1)………………………	2......................... 4......................... .... (1)………………………	....	.... …………………………	H and F. I and G. B. A.
Bolt Hole Crack	½……………………… 1……………………… 1½ .... (1)………………………	1......................... 1½...................... .... (1)	....	.... ………………………..	H and F. H and G. B. A.
Broken Base	1………………………… 6 (2).....................	6.........................	....	....	D. A, or [E and I].
Ordinary Break	....	....	....	....	A or E.
Damaged Rail	....	....	....	....	C.
Flattened Rail Crushed Head	Depth ≥ ⅜ and Length ≥ 8………….	....	....	....	H.

(1) Break out in rail head.

(2) Remedial action D applies to a moon-shaped breakout, resulting from a derailment, with length greater than 6 inches but not exceeding 12 inches and width not exceeding one-third of the rail base width.

Notes:
A. Assign a person designated under § 213.7 to visually supervise each operation over the defective rail.

A2. Assign a person designated under § 213.7 to make a visual inspection. After a visual inspection, that person may authorize operation to continue without continuous visual supervision at a maximum of 10 m.p.h. for up to 24 hours prior to another such visual inspection or replacement or repair of the rail.

B. Limit operating speed over the defective rail to that as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance. The operating speed cannot be over 30 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

C. Apply joint bars bolted only through the outermost holes to the defect within 10 days after it is determined to continue the track in use. In the case of Class 3 through 5 track, limit the operating speed over the defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit the speed to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower. When a search for internal rail defects is conducted under § 213.237, and defects are discovered in Class 3 through 5 track that require remedial action C, the operating speed shall be limited to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower, for a period not to exceed 4 days. If the defective rail has not been removed from the track or a permanent repair made within 4 days of the discovery, limit operating speed over the defective rail to 30 m.p.h. until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower. When joint bars have not been applied within 10 days, the speed must be limited to 10 m.p.h. until joint bars are applied.

D. Apply joint bars bolted only through the outermost holes to the defect within 7 days after it is determined to continue the track in use. In the case of Class 3 through 5 track, limit operating speed over the defective rail to 30 m.p.h. or less as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance, until joint bars are applied; thereafter, limit speed to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower. When joint bars have not been applied within 7 days, the speed must be limited to 10 m.p.h. until the joint bars are applied.

E. Apply joint bars to the defect and bolt in accordance with § 213.121(d) and (e).

F. Inspect the rail within 90 days after it is determined to continue the track in use. If the rail remains in the track and is not replaced or repaired, the reinspection cycle starts over with each successive reinspection unless the reinspection reveals the rail defect to have increased in size and therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from the track or repaired. If not inspected within 90 days, limit speed to that for Class 2 track or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower, until it is inspected.

G. Inspect rail within 30 days after it is determined to continue the track in use. If the rail remains in the track and is not replaced or repaired, the reinspection cycle starts over with each successive reinspection unless the reinspection reveals the rail defect to have increased in size and therefore become subject to a more restrictive remedial action. This process continues indefinitely until the rail is removed from the track or repaired. If not inspected within 30 days, limit speed to that for Class 2 track or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower, until it is inspected.

H. Limit operating speed over the defective rail to 50 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

I. Limit operating speed over the defective rail to 30 m.p.h. or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.