SEPTEMBER 2021

Safer Railroading

A Guide Toward Targeted Safety Policy

Eno
Center for Transportation

Authors

Paul Lewis, *Eno Center for Transportation*
Malcolm Kenton, *Independent Consultant*

Acknowledgements

The Eno Center for Transportation would like to thank the following individuals for contributing their expertise, constructive feedback, and support as members of the advisory panel convened for this research initiative:

- Carol Comer, Georgia Department of Transportation
- Chris Zappi, Amtrak
- Chuck Baker, American Short Line and Regional Railroad Association
- Henry Posner, Railroad Development Corporation
- John Gray, Association of American Railroads
- Kate Fox Wood, American Equipment Manufacturers
- Robyn Boerstling, National Association of Manufacturers

This work was funded in part by a generous donation from the Railroad Development Corporation.

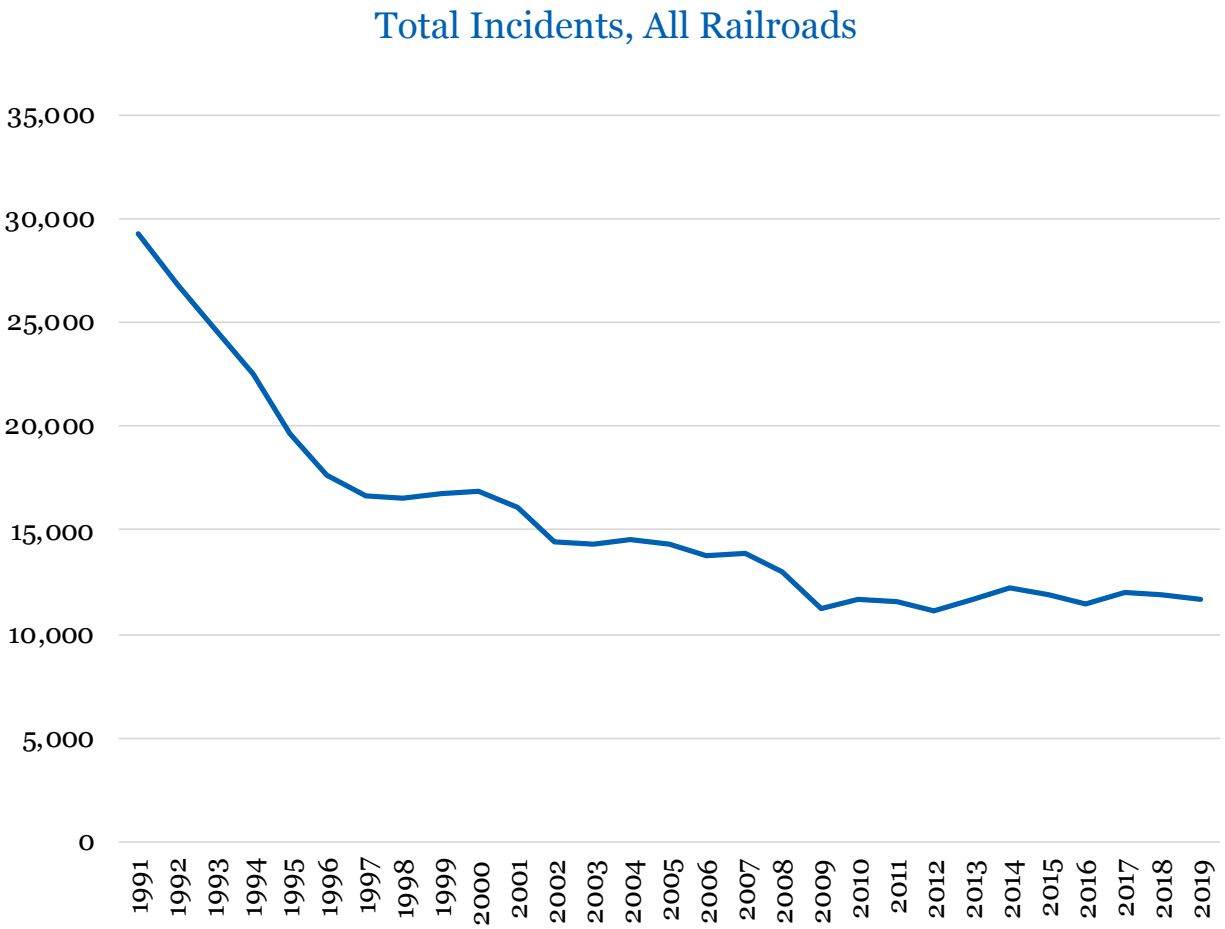
About the Eno Center for Transportation

The Eno Center for Transportation is an independent, nonpartisan think tank whose vision is for a transportation system that fosters economic vitality, advances social equity, and improves the quality of life for all. The mission of Eno is to shape public debate on critical multimodal transportation issues and build an innovative network of transportation professionals.

Table of Contents

Executive Summary

Freight and passenger railroads are among the safest modes of transportation for workers, riders, and the public. Strong federal standards for railroad track and operations, technological investments like positive train control, and communities' infrastructure improvements have yielded significant gains. But most of these gains have plateaued and, in some cases, safety trends are moving in the wrong direction.



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

The following are some of the key statistics from the review of Federal Railroad Administration (FRA) safety data:

- Overall fatalities declined 45 percent between 1991 and 2012 but have since risen 31 percent.
- While incidents involving grade crossings and trespassing made up only 29 percent of total railroad safety incidents in 2019, they accounted for 97 percent of railroad-related fatalities.

- Amtrak, commuter railroads, and short line railroads have the greatest rates of safety incidents, but Class I railroads have the highest overall numbers given that they operate the vast majority of the nation's train-miles.
- Short line railroads have the highest rate of grade crossing incidents and derailments.
- Amtrak and commuter railroads have the highest rates of trespasser and workforce incidents.
- Alabama, California, Florida, Illinois, Indiana, Louisiana, Ohio, and Texas each have more than 80 grade crossing incidents per year and incidents have increased more than 10 percent in those states over the past decade.
- Georgia has the highest rate of trespassing-related injuries and fatalities adjusted for population, and California, Colorado, Florida, and Oregon have high rates and worsening trends.

Safety Metrics for Railroad Groups and Incident Types (Red Indicates Higher than Industry Average)

	Total Incidents per million train miles	Highway-rail incidents per million train miles	Highway-Rail deaths*	Train accidents (not at grade crossings) per million train miles**	Trespasser incidents per million train miles	Trespasser Deaths*	Employee on duty incidents per 200,000 hours
All Railroads	17.2	3.29	297	2.91	1.55	549	1.87
Class I Railroads	11.1	3.02	169	**3.00**	1.47	377	1.15
Group 2 Railroads	**31.6**	2.74	40	2.73	1.46	77	**2.96**
Group 3 Railroads	**27.8**	**7.38**	39	5.33	**1.58**	44	**2.55**
Amtrak	**51.0**	**3.97**	59	2.11	**2.33**	58	**3.72**
Commuter Railroads	**37.7**	2.54	61	1.55	**2.02**	69	**3.44**

Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal
** Numbers sum to more than total because Amtrak and Commuter Railroads are also counted in other categories*
***Does not include highway-rail grade crossings or trespassing incidents*

A new strategy and framework is needed to address the most significant safety issues facing railroads. This research examines trends in railroad safety data and the ways safety standards are crafted and enforced. It presents actionable recommendations for federal, state, local, and private sector actors to improve recent trends and make a demonstrable improvement in passenger and freight railroad safety.

Based on these findings, more targeted policies are needed to **address the significant and growing trend associated with trespassing and highway grade crossing fatalities.** This report's review of the policy framework finds that the federal government is primarily focused on addressing train crashes and workforce incidents.

But addressing grade crossing and trespassing problems **requires a tailored approach** since conditions affecting safety on the railroad network vary from state to state and from railroad to railroad. For example, California, Texas, and Florida all have significant problems with grade crossings and trespassing, even when controlling for population and rail traffic. Meanwhile, other states like Michigan and New Jersey have a fraction of the national average for incidents involving trespassing and grade crossings, respectively. In terms of incidents per million train miles, Amtrak and short line railroads have above average incidents at grade crossings and with trespassing deaths, though many passenger trains travel on host railroads that own, control, and maintain the infrastructure. Conversely, train derailments and collisions tend to happen more often on freight railroads than passenger railroads.

To start, the federal government should expand eligibility for federal railroad grade crossing grants to include comprehensive engineering, education, and enforcement approaches. More funding is needed to make improvements, and the statutory federal $7,500 grant cap on incentives to close grade crossings should be increased or eliminated. The federal government and localities should target greater funding toward Amtrak and commuter railroads and their freight railroad hosts to address persistent problems with grade crossing incidents.

Many grade crossing and trespassing incidents need to be **addressed using combined education, enforcement, and engineering approaches**. The statistics on factors influencing the frequency and severity of grade crossing crashes suggest that efforts to prevent collisions between trains and road vehicles should be more focused on educational and engineering efforts to deter risky behavior and redesign or eliminate the types of crossings that have been shown to be more dangerous. There are smart ways to target enforcement, create better environments for crossing, and better site key destinations to enable safe and convenient ways for pedestrians to cross railroad rights of way.

The tailored approach for addressing safety also requires thinking outside the traditional box of the railroad industry. Addressing issues of suicide, homelessness, poverty, despair, addiction, road design and the like are broader societal issues that go beyond the ability of transportation professionals and policymakers concerned solely with transportation to fix. The next phase of federal railroad safety policy needs to extend beyond railroading and acknowledge its relationship to other societal issues. It also requires a more discrete approach involving finding the problem areas and addressing them in the local context.

While the federal government has a program devoted to funding grade crossing improvements, there is no ongoing multi-agency federal program devoted to rail trespass prevention. The federal government should expand federal funding for rail trespassing prevention for organizations like Operation Lifesaver to assist railroads and local jurisdictions with ongoing issues. Similarly, states and localities, particularly those with higher grade crossing and trespassing incidents, need to spend more resources to tackling those localized issues.

There is also a significant need for more research to determine the outcomes and costs of existing and new policies and treatments. Many states, law enforcement groups, universities, and localities are piloting innovative approaches to tackle problems associated with trespassing and grade crossings. While anecdotally these programs might be achieving their intended goals, data that quantify how much they cost and how much they reduced specific incidents are often not recorded or reported. The federal government should fund more studies that quantify the outcomes of specific initiatives and provide cost ranges for various safety treatments, particularly when it comes to innovative technologies and new approaches to education and enforcement. Congress should remove legal and procedural barriers to railroads' sharing of more trespasser data with FRA and other authorities. The FRA and industry trade groups need to publish a list of infrastructure and signaling treatments and their respective cost ranges.

1.0 Introduction and Methodology

Rail is one of the safest modes of transportation and the U.S. rail industry has made significant progress over the past several decades dramatically reducing collisions, cutting trespassing incidents, and improving workplace safety. However, fatalities and injuries from trespassing have reversed their long-term trends and increased over the past few years. Graffiti remains a problem on rail cars and structures. Railroads and governments at all levels are increasingly looking to deploy scarce resources into the most beneficial programs, from education campaigns to infrastructure improvements. This report reviews the various safety initiatives and proposals over the past few decades and gauges their effectiveness at improving safety. Recommendations based on this work inform industry leaders and policymakers on how to best craft policies and funding programs that continually improve railroad safety.

This research focuses on railroad safety, including incidents, injuries, and deaths related to the freight, commuter, and intercity passenger rail systems in the United States. That includes Class I, II and III freight railroads, and passenger railroads subject to Federal Railroad Administration (FRA) regulation, including most commuter railroads and Amtrak. This report does not include urban rail transit, such as heavy rail/metro/subway or light rail/streetcar systems.

The goal of this report is for the reader to understand the current state of rail safety in the U.S. from a multi-dimensional perspective and steps that might be taken to improve it. First, we reviewed the current roles of federal, state, and local governments along with private and non-profit groups that also help to regulate and manage safety. Then we reviewed data from the FRA and existing literature to understand where and how safety has improved and what might be possible lessons learned and best practices to address safety concerns. Then we engaged with the project's advisory panel and other experts to craft actionable and pragmatic policy recommendations for public and private railroad stakeholders.

2.0 Safety Regulatory Framework

Safety in the railroad industry has long been regulated at the federal level. While states and localities have some role in safety regulation, the federal government spends significant resources and has many requirements pertaining to the safe operation of railroad activities. The following federal, state, local, private, and non-profit entities, all have a role in regulating and managing railroad safety, and each are reviewed below:

- The Federal Railroad Administration
- The Federal Highway Administration
- The National Highway Traffic Safety Administration
- The Federal Motor Carrier Safety Administration
- The National Transportation Safety Board
- State and Local governments
- Individual public and private railroads
- Associations and non-profit organizations
- Trade unions
- Industry working groups

2.1 Federal Railroad Administration (FRA)

The primary entity responsible for creating and enforcing safety rules and regulations on the United States' railroad network is the FRA, a branch of the United States Department of Transportation (USDOT). FRA is one of ten USDOT agencies created by the Department of Transportation Act of 1966. Its statutory mission is "to enable the safe, reliable and efficient movement of people and goods for a strong America, now and in the future."[1]

Organizational Structure

FRA consists of eight offices: five functional and three administrative, overseen by an Administrator and Deputy Administrator, both of whom are political appointees of the President of the United States confirmed by the U.S. Senate, as well as by an Executive Director, who is a civil service employee. The office of concern to this report is the Office of Railroad Safety. It is FRA's largest branch in terms of budget and number of employees: of FRA's 934 full-time-equivalent employees in fiscal 2016, around 400 were safety inspectors, and the Office of Safety accounted for $199 million out of the agency's $309.2 million budget in fiscal 2016 (excluding the $1.3 billion budgeted to FRA to grant directly to Amtrak for operations and capital expenses).[2] It has four sub-offices and 16 Divisions.[3]

The staff of FRA's Office of Safety includes nearly 400 safety inspectors who specialize in one of six technical disciplines: grade crossings, hazardous materials, motive power

and equipment, operating practices, signal and train control, and track. In addition to conducting inspections and enforcing regulations, the Office of Safety also conducts railroad safety and stakeholder training, accident and fatality investigation and reporting (a responsibility shared with the National Transportation Safety Board in some cases), coordinates partnerships between labor, management and the agency, and develops and implements safety rules and standards.[4]

The FRA is divided into eight regions, each overseeing railroads within a defined group of states (with the District of Columbia being treated as if it were a state). Inspectors in each region report to staff at FRA headquarters. The Office of Safety provides support to field activities through the Office of Safety Programs (in the area of compliance and enforcement of program guidance) and through the Office of Standards and Procedures (in the area of program disciplines and accident and inspection report analysis). Each inspector works under a Supervising Railroad Safety Inspector. There is also a Regional Railroad Safety Specialist who provides technical support and guidance to inspectors in each region.[5]

What FRA Does

FRA issues safety rules and standards in the following areas:[6]

- Grade crossings and trespassing
- Hazardous materials
- Motive power and equipment
- Operating practices
- Technical training standards
- Security and emergency preparedness
- Accident reporting and analysis
- Signals and train control
- Technology and automation
- Track
- Drug and alcohol use by railroad workers

FRA enforces statutory requirements for railroads to implement safety systems such as Positive Train Control (PTC), a system that takes over a train's controls to slow or stop it if the engineer violates a signal or speed restriction. A 2008 law mandated that all FRA-regulated railroads install PTC on most lines carrying passengers and/or certain hazardous cargo.[7] FRA develops and establishes operational standards, rules and practices in areas such as filing, recordkeeping and operational tests for inspectors. FRA's rules also protect workers and pertain to areas such as yard limits, remotely controlled switches and safety devices, as well as speed limits. It's important to note that none of FRA's rules apply to facilities not connected to the national rail network or to

urban metro, subway, light rail or streetcar systems, which fall under the Federal Transit Administration's jurisdiction.[8]

Beyond setting the rules and regulations, FRA's primary role is one of monitoring and enforcement. Ensuring that adequate preventive measures are in place is the responsibility of railroads themselves. Each railroad is responsible under the law for ensuring that it is in compliance with all applicable regulations and thus is directly responsible for preventing crashes and other incidents. All inspection programs are predicated on the ability of inspectors to measure the existing conditions against a standard.[9] While railroads are required to adhere to the standards that FRA sets, FRA typically does not provide railroads with funding to comply except where railroads may be eligible under broader discretionary grant programs. This situation was particularly apparent in the case of PTC, which railroads combined spent an approximate estimate of $14 billion of their own funds to implement.[10]

Legal Basis for FRA's Powers

The federal government has a near-exclusive right to regulate railroads under the Commerce Clause of Article 1 of the U.S. Constitution, which the U.S. Supreme Court has generally interpreted as giving the federal government broad powers in this area.[11] Even railroad companies that operate entirely within a single state are considered to be part of interstate commerce if they interchange with or share equipment with other railroads.[12] The primary federal laws that govern railroad safety are the Federal Railroad Safety Act of 1970 (FRSA) and the Interstate Commerce Commission Termination Act of 1995 (ICCTA).[13] Other laws that give FRA regulatory powers in specific areas are the Signal Inspection Act (SIA), the Accident Reports Act (ARA), the Railroad Safety Appliance Act (RSAA), the Locomotive Inspection Act (LIA) and the Noise Control Act of 1972 (NCA).[14]

The FRSA grants the FRA most of its regulatory powers in the area of safety and makes it responsible for investigating and prosecuting all railroad issues. It also protects railroad employees against wrongful termination, suspension and demotion, guarantees employees the right to prompt medical attention for injuries sustained on the job and the right to damages if they are involved in an accident, and prevents railroads from dismissing employees who report hazardous conditions.[15] The FRSA gives state and local governments the power to regulate only those matters which the FRA does not regulate.[16]

States are prohibited from regulating railroad operations, contracts between rail carriers, and attempts to condemn railroad tracks or nearby land, and from pursuing negligence or nuisance claims against railroads. States may, however, enter into voluntary agreements with railroads, exercise traditional police powers over the

development of railroad property, apply zoning laws to railroad-owned land used for non-railroad purposes, require railroads to pay for pedestrian crossings across railroad tracks, and regulate any activity determined to have nothing to do with rail transportation.[17] The Surface Transportation Board (an economic regulatory body that is functionally independent from the US DOT) must pre-clear any state law or regulatory action that pertains to railroad construction, environmental/land use or demolition permitting, or that would require railroad companies to obtain state approval before discontinuing station agents or abandoning or removing rail lines, sidings or spurs.

Inspections and Inspectors

The FRA's inspection activities focus on five major aspects of railroad operations: track, operating practices, motive power and equipment, grade crossings, signals and train control, and hazardous materials. Each individual inspector is assigned to one of these five areas. The FRA has the power to assess civil penalties against rail carriers and their parent companies in each of these areas ranging from $250 to $2,500 per violation in the first four areas and much higher fines and criminal penalties when hazardous materials are involved.[18] Since 2000, FRA has assessed a grand total of over $154.4 million in penalties against over 300 companies in 15,116 cases of regulatory violations.[19]

Each FRA inspection falls under one of six purposes, shown in Table 1.

Table 1: FRA Inspections by purpose

Purpose	Priority Level	Initiating Body
Accident investigation	Highest	FRA
Emergency situation investigation	Second highest	FRA (handled directly by Washington headquarters)
Complaint investigation	None	Members of the public, including railroad employees
Petition and application investigation	None	Railroads
Follow-up investigation	None	FRA

The purpose of each investigation is to determine whether the railroad has complied with federal safety standards and, if not, to make a judgment about appropriate

remedial action and/or penalty assessment. Depending on the situation, each investigation requires anywhere from several hours to several weeks to carry out. FRA must notify railroads in advance of routine inspections for track and signal inspections, and FRA inspectors are generally accompanied by railroad employees.[20] They may or may not notify in advance for mechanical, operating practices, or hazardous materials.

When an FRA inspector determines that a railroad is not in compliance with a regulation, the inspector will recommend the assessment of penalties to the FRA's Office of Chief Counsel. State regulatory bodies may assist FRA in inspection activities within the areas of track and motive power/equipment (specifically freight railcar safety standards). Railroads also carry out their own internal safety inspection and audit efforts -- usually more frequently than FRA and state inspections -- to ensure compliance with federal regulations and to serve as an "early warning system" and guide preventive maintenance efforts. FRA and state inspectors check on the adequacy of railroads' internal inspections to ensure compliance with federal requirements.[21]

Labor and Workforce Powers

While the National Mediation Board is the primary federal body responsible for overseeing the complex and lengthy labor dispute resolution process, FRA also plays a role in monitoring labor negotiations and providing legal and factual advice to the Secretary of Transportation and to Congress regarding the impact of potential and actual work stoppages.

FRA's other powers in the area of labor and workforce rules, as discussed previously, are to set standards for training for specific job functions and for drug and alcohol use by rail workers. As with other aspects of rail safety regulation, rail carriers are responsible for adhering to FRA rules in these areas, with the agency having a monitoring and enforcement role.

Grant Programs

In addition to monitoring and enforcement of safety regulations, FRA also determines eligibility for, provides and administers federal grants to help states, localities, public agencies, railroads and other entities improve safety in specific areas. These grant programs are authorized by Congress through each six-year surface transportation policy law and are provided with a different level of funding each fiscal year through the appropriations process.[22] Below is a description of each rail safety-related grant program that FRA has administered since 2008, as authorized by the current law as of this writing, the Fixing America's Surface Transportation (FAST) Act of 2015, which is set to expire on Sept. 30, 2021, as well as its predecessor, the Rail Safety Improvement Act of 2008:[23]

Consolidated Rail Infrastructure and Safety Improvements Program (CRISI)

Description: Assists with the deployment of rail safety technology, capital projects that address congestion or improve rail infrastructure, grade crossing improvements, rail line relocation projects, rail corridor development plans and environmental analyses, projects facilitating multimodal connections, development or implementation of a safety program or institute, and related research and workforce development activities.
Eligibility: States, groups of states, public agencies, local governments, private railroads, the Transportation Research Board, universities, and nonprofit organizations
Total amount awarded: $320.6 million from FY 2017 to FY 2020
Total number of projects receiving awards: 50 projects in 29 states

Railroad Trespassing and Suicide Prevention Grant Program of FY 2019 and 2020

Description: Funds targeted outreach campaigns to reduce the number of railroad-related suicides that involve trespassing on railroad property through methods such as staff training, signage, public awareness campaigns, and "other strategies likely to be effective."
Eligibility: Rail carriers (public and private), nonprofit organizations focused on suicide prevention and/or mental health assistance
Total amount awarded: $293,000 in FY 2019 and FY2020

Railroad Trespassing Enforcement Grant Program

Description: Funds law enforcement agency efforts to assist communities at risk for railroad trespassing-related incidents and fatalities, including investigating incidents of trespassing and providing warnings and citations to trespassers.
Eligibility: State, county, municipal and regional law enforcement agencies within whose jurisdictional boundaries lies at least one mile of FRA-regulated railroad track
Total amount awarded: $150,000 in FY 2018, $150,000 in FY 2019, and $378,028 in FY 2020
Total number of projects receiving awards: 11 projects in six states

Positive Train Control Grant Program of FY 2017

Description: Funded the installation of PTC system infrastructure and related technology including back-office systems, wayside, communications and onboard hardware, and wireless communication spectrum acquisition
Eligibility: Transit agencies operating commuter railroads and state and local governments, provided that the commuter carrier and its host railroad(s) had previously submitted a PTC Implementation Plan to FRA
Total amount awarded: $197 million in FY 2017
Total number of projects receiving awards: 17 commuter railroads in 13 states

Railroad Safety Technology Grants for PTC Program of FY 2010, 2014 and 2016

Description: Funded PTC implementation projects or projects that benefit overall PTC implementation on freight, commuter and intercity passenger railroads.
Eligibility: Rail carriers, railroad suppliers, state and local governments
Total amount awarded: $50 million in FY 2010, $11 million in FY 2015, and $25 million in FY 2016

Railroad Safety Infrastructure Improvement Grant Program of FY 2016

Description: Funded safety improvements to railroad infrastructure including acquisition, improvement or rehabilitation of intermodal facilities; improvements to track, bridges, yards and tunnels; grade crossing upgrades; and railroad-highway grade separation projects
Eligibility: Rail carriers, state and local governments
Total amount awarded: $25 million in FY 2016

Railroad Safety Grants for the Safe Transportation of Energy Products by Rail Grant Program of FY 2015

Description: Funded public and private grade crossing enhancement and track improvement projects on rail routes that transport flammable energy products (crude oil, ethanol and natural gas)
Eligibility: States, groups of states and interstate compacts
Total amount awarded: $10 million in FY 2015

Railroad Employee Certification

FRA sets the standards under which railroads certify or qualify their front-line employees. Federal regulations, based on Congressional mandates, require that locomotive engineers and train conductors be certified, while all other employees in safety-sensitive roles must be qualified. Each regulated railroad administers the certification or qualification requirements to its own employees through training and testing. Each locomotive engineer or conductor must be re-certified every three years (36 months) regardless of whether his/her territory or assignment changes, and each change of assigned route or movement between railroads requires re-certification. The regulation provides employees with a review and comment period after the employer makes a decision regarding certification or qualification, as well as a process for formally appealing employer decisions to the FRA's Operating Crew Review Board and for appealing a Board ruling to the Federal Railroad Administrator.

FRA's certification or qualification requirements for these positions are summarized as follows:

Locomotive Engineer Certification (49 CFR Part 240): Maintain a good safety record while working for a railroad or in a safety-sensitive position elsewhere in transportation or in another industry, and as a motor vehicle operator. Complete additional employer-provided training, including classroom, simulator and hands-on training on the route to which the employee will be assigned. Take the certification test for the given route, including the written test and demonstration of ability to run the route through supervised locomotive or simulator operation. Take and pass the required vision and hearing exams. Comply with FRA drug and alcohol rules.[24]

Train Conductor Certification (49 CFR Part 242): Maintain a good safety record while working for a railroad or in a safety-sensitive position elsewhere in transportation or in another industry, and as a motor vehicle operator. Complete additional employer-provided training, including classroom, simulator and hands-on training on the route to which the employee will be assigned. Take the certification test for the given route, including the written test and demonstration of ability to run the route through supervised locomotive or simulator operation. Take and pass the required vision and hearing exams. Comply with FRA drug and alcohol rules.

For other railroad employees in safety-related roles (49 CFR Part 243), each FRA-regulated railroad must submit, adopt and comply with a training program for safety-related employees. The railroad must categorize its safety-related employees by craft, class, task or other such terminology and design and develop key learning points for task-based or knowledge-based training. Each training course must have a unique name or identifier, an outline and brief description, method of delivery, anticipated duration, syllabus and assessment method, among other criteria. Upon successful completion of all the required training courses and passage of the assessment for each course required for his/her craft, class or task, a safety-related employee is considered qualified. Only designated employees may be permitted to perform safety-related service in the relevant occupational category or subcategory.

49 CFR Part 243 is a new regulation, finalized in 2015, created to fulfill a statutory requirement in the Rail Safety Improvement Act of 2008. A “safety-related railroad employee” is defined as any employee covered by the hours-of-service laws and any employee performing work as an operating employee (including supervisors), even if not covered by the hours-of-service laws, as well as all engineering and maintenance-of-way employees and mechanical personnel who inspect, repair or install parts on any locomotive, freight railcar, passenger railcar or maintenance-of-way vehicle. The definition also includes anyone who supervises any of the above-listed types of employees.[25] Railroads have until January 1, 2022 to designate all existing safety-related employees by occupational category or subcategory and apply qualification requirements accordingly. Refresher training must be conducted no less frequently than

every three years beginning May 1, 2023. Employees need not be re-qualified upon changing railroad employers if they remain in the same occupational category/subcategory as they were with their previous employer.

FRA Funding and Execution of Safety-Related Research

In addition to the grant programs discussed above, which fund both research and implementation of targeted technologies and practices, FRA's Office of Research and Development (R&D) has consistently received between $30 and $40 million in funding annually from Congress since FY 2001. This enables FRA to make multi-year investments in test facilities and equipment and for building and retaining expertise.[26] FRA R&D is divided into ten Program Areas within the categories of railroad systems issues, human factors, track, rolling stock, and train control and communications.[27]

Part of this funding goes to universities to develop educational programs to ensure the availability of qualified personnel for the railroad industry, and part goes to R&D partnerships between FRA and industry stakeholders, such as the Transportation Technology Center in Pueblo, Colorado, a world-class railroad research and testing facility operated by a multi-year partnership between FRA and the Association of American Railroads. Other partnerships include ENSCO Inc.'s operation, maintenance, instrumentation and analysis of FRA's test railcars and road-rail vehicles, and a number of concurrent five-year Indefinite Delivery - Indefinite Quantity contracts with several suppliers that have particular expertise in research services.

FRA R&D also partners with the Transportation Research Board (TRB) of the National Academies to administer two research programs. The Innovations Deserving Exploratory Analysis (IDEA) program seeks technology developed outside of the rail industry that might have railroad applications. The National Cooperative Rail Research Program, which has been in existence since 2010, invites the industry to submit policy-focused research topic ideas and tasks TRB panels with choosing which ideas are either granted research funds or may be published in TRB's scholarly journals.

Most FRA-sponsored R&D is undertaken by contractors and grantees, including universities, research institutions and consulting firms, all part of the strong R&D supply base that consistent funding levels have allowed FRA to build. R&D contracts are generally awarded competitively on a best-value basis but may also be awarded through grants (if the grantee is solely responsible for the project) or cooperative agreements (where the grantee and the federal government or a third party participate jointly in the effort) with universities and nonprofit institutions. Most R&D work is funded through an interagency agreement between FRA and the U.S. DOT's John A. Volpe National Transportation Systems Center in Cambridge, Massachusetts.

According to FRA, current funding levels enable the agency to meet the most pressing needs for safety-related R&D, but additional funding would provide opportunities to expand university R&D programs, strengthen research collaboration, help address future workforce education demands, and develop new technologies and testing facilities to support next-generation railroading. FRA could also help create and sustain more domestic suppliers and jobs and expand its efforts in energy, the environment and rail transportation efficiency.[28]

FRA Collaboration in Working Groups and Committees

The primary industry body dealing with safety matters that FRA participates in is the Railroad Safety Advisory Committee (RSAC). Established by the Secretary of Transportation in 1996 under the Federal Advisory Committee Act, RSAC is made up of 40 representatives from 29 member organizations representing various rail industry perspectives, including Class I, short-line and regional freight railroads, Amtrak, commuter railroads, various labor groups, suppliers, and advocates for rail shippers and passengers. Its task is to provide recommendations to the FRA Administrator. RSAC was dormant for a brief period from May 2017 to October 2018.[29] Its charter is typically renewed every two years and was most recently renewed through October 2022. It meets at the call of the FRA Administrator. It last met in April 2019 and no future meeting has been scheduled as of this writing.[30]

Data Collection

Federal regulations require FRA-regulated railroads to report specific sets of safety-related data to the agency, including accidents and incidents meeting certain thresholds in terms of people killed or injured or dollar value of damage caused, inventory, and highway-rail grade crossing data. This information is compiled and made available to the public online by the Office of Safety Analysis (OSA), a branch of FRA's Office of Safety. The reports published by OSA include basic operational data such as total train-miles operated and employee hours worked, one-year and ten-year accident & incident overviews sorted by type and probable cause, employee on duty and trespasser casualties, and accident and casualty rates and trends. All this data can be searched and sorted by state, FRA region, individual railroad, railroad size and type, and other criteria.[31]

2.2 Federal Highway Administration (FHWA)

The extent of the FHWA's involvement in rail safety is its role in administering the Section 130 Railway-Highway Crossings Program, which provides funds for the elimination of hazards at all public grade crossings, including roadways, bicycle trails and pedestrian paths. These funds are distributed to state departments of transportation according to a formula, with states funding each grade crossing improvement project

with a 90% federal share. The FAST Act continues the set-aside of Highway Safety Improvement Program funds for grade crossing improvements under Title 23 U.S. Code, Section 130(e) and increases the set-aside amount in each fiscal year. There was an additional one-time increase in funds for the program in the FY 2016 appropriations law. The set-aside for FY 2020 totaled $245 million.

Half of the funding available to each state is dedicated to the installation of protective devices at grade crossings, while the remainder can be used for any hazard elimination project, including protective devices. The FAST Act extended eligibility to include projects designed to reduce the amount of time grade crossings are blocked by idling trains. States can use these funds as incentive payments for local agencies to close public crossings if there are matching funds from the railroad. Localities can also use these funds as matching funds for state-sponsored projects.

Section 130 requires each state to maintain a survey of all highways to identify railroad crossings that may require separation, relocation or protective devices, to update information for each public crossing in the U.S. DOT crossing inventory database (maintained by FRA), and to establish and implement a schedule of projects. It also requires states to place signage at every public crossing and requires railroads to provide a phone number to call to report emergencies or other unsafe conditions at crossings, which is printed on the required signage. States must also submit annual reports to FHWA on the progress of implementing their Railway-Highway Crossings Program. Additionally, railroads must submit information to the crossing inventory database about public crossings through which they operate.

FHWA maintains the Manual on Uniform Traffic Control Devices, developed under the advice of the National Committee on Uniform Traffic Laws and Ordinances (a body consisting primarily of state Department of Transportation or Highways officials), which contains the Railroad-Highway Grade Crossing Handbook. This document, most recently revised in August 2007, establishes the national standards for signage and protective devices used at grade crossings, including the shape and lettering of the crossbuck, the size, color and materials of the warning lights and the placement of reflective paint and lights on crossing arms, and is fully incorporated into 49 CFR Part 234.[32]

2.3 National Highway Traffic Safety Administration (NHTSA)

NHTSA had not had any role regarding railroad safety prior to 2017, but every year since then, it and FRA have conducted a public awareness campaign (with funding from the FAST Act) entitled “Stop. Trains Can’t,” encouraging road users to exercise caution when approaching grade crossings. The 2019 campaign spent $5.6 million on advertising, tested with focus groups in December 2018, targeted to communities with

high incident rates in 16 states that ran from April 16 to May 12.[33] The 2020 version spent $6.6 million on radio, digital and social media advertising that ran in seven states from October 6 to November 8.[34] Another series of advertisements was planned for March 22 to April 12, 2021.[35]

2.4 Federal Motor Carrier Safety Administration (FMCSA)

Two Parts of Title 49 CFR dealing with grade crossing safety are administered by FMCSA: Parts 392 and 383. FMCSA's role regarding commercial motor carriers is like FRA's role regarding rail carriers: it establishes the safety standards that motor carrier employees must meet and conducts inspections and oversight to ensure that motor carriers are applying those standards uniformly to their employees.

Part 392 applies to drivers of all types of commercial roadway motor vehicles and has been in place since 1936. It requires such drivers to stop their vehicle within 50 feet of, but not closer than 15 feet to, any grade crossing (with a few specified exemptions), listen and look in each direction for an approaching train, then proceed through the crossing without changing gears once the driver has ascertained that no train is approaching. This applies regardless of whether the crossing is equipped with protective equipment and whether the lights are flashing or not.[36]

Part 383 applies to drivers who hold a Commercial Driver's License (CDL). It states that such drivers must be disqualified if convicted of operating a Commercial Motor Vehicle (CMV) in violation of federal, state or local grade crossing laws, among a number of other grounds for disqualification.[37]

A new regulation, the Safe Clearance Rule, was added to Part 392 in September 2013. It prohibits a driver of a CMV or a motor vehicle transporting certain hazardous materials, agents or toxins from entering a grade crossing unless there is sufficient space to drive completely though the crossing without stopping.[38]

2.5 National Transportation Safety Board (NTSB)

The NTSB is an independent federal body (not part of U.S. DOT) created by Congress in 1967 whose statutory mandate is to conduct accident and incident investigations on all modes of transportation, advocate for safety improvements, assist victims of transportation accidents and their families, and rule on appeals of certification by pilots and mariners. The five-member Board (each appointed by the U.S. President and confirmed by the Senate for a five-year term), which is aided by a professional staff of 415 who conduct investigations and draft reports, must remain objective and politically independent and conduct objective and precise investigations and studies.[39]

The Board typically recommends specific changes with measurable outcomes for transportation operators, manufacturers, suppliers and regulators to prevent recurrence of the underlying causes that led to one or more fatalities or injuries. The NTSB's recommendations carry no legal weight and are not directly enforceable, but they carry significant moral authority. Additionally, federal law requires each DOT agency to review and respond to the items NTSB's 'most wanted list' that are within the agency's jurisdiction, as well as to recommendations made in specific accident investigation reports, within 90 days of NTSB's issuing them.[40] For example, the fact that requiring railroads to implement PTC on most lines had been on the NTSB's 'most wanted list' for nearly two decades prior was a major factor in influencing Congress to write a PTC mandate into law in light of the 2008 Metrolink commuter train crash in Chatsworth, Calif. that killed 25 people and injured over 100 others.[41] NTSB recommendations typically also influence FRA rulemaking.

The following are the NTSB's most recent recommendations and 'most wanted list' items that pertain directly to railroad safety. All recommendations are currently open (meaning that the NTSB has not yet been satisfied that they have been satisfactorily acted upon) unless otherwise noted:

Most Wanted List:

- For railroads required to do so to fully implement PTC in advance of the extended deadline of Dec. 31, 2020 (2020 - NTSB has closed three of its PTC-related recommendations with acceptable action taken, but others are still open, and Board Chair Robert Sumwalt noted in January 2021 that only about 40 percent of rail miles nationwide that NTSB considers to be at high risk for PTC-preventable accidents are now fully covered by PTC)[42]
- For the rail industry to meet existing federal deadlines for replacing or retrofitting tank cars (2020)[43]
- For railroads and other transportation companies, their regulators and lawmakers to address distracted rail or road vehicle operation through a three-pronged approach of education, legislation and enforcement (2020)[44]
- Require railroads and motor carriers to implement mandatory screening and treatment of obstructive sleep apnea for personnel in safety-sensitive positions (2020)[45]
- For federal and state lawmakers and regulators to enact requirements for enhanced vehicle and rail rolling stock design to provide better occupant protection, perhaps including seat belts in locomotive cabs and rail passenger cars (2020)[46]
- For the FRA to require PTC systems to detect the rear ends of trains and prevent rear-end collisions (2012 - 'closed but with unacceptable action taken' as of Jan. 2020)[47]

- For the FRA to revise 49 CFR Part 229 to ensure protection of the occupants of isolated locomotive operating cabs in the event of a collision and to make the revision applicable to all locomotives, new or existing, unless the cab will never be occupied (2012 - 'closed but with unacceptable action taken' as of Jan. 2020)[48]
- For the FRA to issue an Emergency Order requiring that when signal suspensions are in effect and a switch has been reported relined for a main track, the next train or locomotive to pass through the switch must do so at restricted speed and report to the dispatcher that the switch is correctly lined before being given permission to resume operating at track speed (2018 - 'closed but with unacceptable action taken' as of Jan. 2020)[49]
- For the Association of American Railroads (AAR) to amend the U.S. Hazardous Materials Instructions for Railroads to require train crews to immediately provide their train consists and the emergency response information for all hazardous materials on the train to federal, state or local emergency responders when accidents occur (2019 - 'closed with acceptable action' as of Jan. 2020)[50]

Other Railroad-Related NTSB Recommendations:

- For the FRA to require railroads to provide their crewmembers on trains carrying hazardous materials with emergency escape breathing apparatuses (2005 - still open)[51]
- For the FRA to develop guidance for railroads to use in developing required risk reduction programs and revise the rules for building train consists (Dec. 2020)[52]
- To prohibit the use of hand brakes on empty rail cars for controlling train movement in territory with grades (Dec. 2020)[53]
- For the AAR and the American Short Line and Regional Railroad Association (ASLRRA) to alert member railroads to conduct analysis of radio frequency propagation in grade territories to determine where radio communication between the head and rear ends of trains may be lost and make recommendations to rectify these deficiencies (Jan. 2021)[54]
- For the FRA to require that emergency brake signal transmission is repeated until received by the end-of-train device (Jan. 2021)[55]
- For the AAR to revise its Manual of Standards and Recommended Practices to provide that emergency air brake commands be continuously transmitted to the end-of-train device until a confirmation message or a decrease in brake pipe pressure message is received by the front-of-train device (Jan. 2021)[56]
- For the FRA to revise 49 CFR Part 232 to require more frequent communication checks between a head-of-train device and an end-of-train device (Jan. 2021)[57]
- For the AAR, the ASLRRA, and the Renewable Fuels Association to develop and adopt guidelines and recommendations for the systematic placement of the most vulnerable tank cars in high-hazard flammable trains in positions in the train consist where they are least likely to derail or sustain damage in an accident (Dec. 2020)[58]

- For the FRA to develop and issue guidance for railroads to use in developing FRA-required risk reduction programs, and for the Association of American Railroads to work with member railroads to develop guidance material and best practices for these programs (Dec. 2020)[59]
- For the AAR, the ASLRRA, Amtrak, the Alaska Railroad and the American Public Transportation Association to inform their members of the circumstances of the August 2019 CSX collision between Columbus and Fostoria, Ohio, and review their training and managerial oversight programs as they relate to restricted speed operations in territories where PTC systems are operated in Restricted Mode to identify and implement appropriate training improvements and mitigating actions (Oct. 2020)[60]

2.6 State & Local Governments

Under the U.S. federalist system, generally speaking, federal laws and regulations supersede state and local ones, but states and localities may enact and enforce more stringent laws and regulations in some areas. One example of an area that is under exclusive federal jurisdiction, under the U.S. Constitution's Commerce Clause, is rules affecting the level of service railroads provide or rail labor rules. In terms of grade crossings, state law or regulation tends to have more influence than federal when it comes to the length of time for which railroads are allowed to block public crossings with idling trains and the establishment of "quiet zones" where locomotive horns are not required to be sounded at grade crossings within set boundaries.[61]

Some state governments take a more active role in overseeing and promoting railroad safety than others. Most state regulation and enforcement pertaining to railroads is undertaken by the state Department of Transportation (DOT) or Transportation Commission, but some states have independent agencies or commissions that oversee railroads. Examples include the Public Utilities Commissions of California, Nevada, Colorado, Idaho, Rhode Island and Pennsylvania, the Montana Public Service Commission, the Oklahoma Corporation Commission, the New Jersey Board of Public Utility Commissioners, the Virginia Department of Rail and Public Transportation and Commonwealth Transportation Board, and the Washington Utilities and Transportation Commission.

Jurisdiction over highway-rail grade crossings resides primarily with the states, but some states exercise regulatory jurisdiction while others' role is merely administrative. Most states (36, plus the District of Columbia) vest powers regarding crossings in the state DOT or the state Department of Highways, but nine states require local governments to initiate actions regarding grade crossings (though the state government may provide assistance), while in five states, the responsibility is shared between the state and local levels.[62] Most states, along with private railroads, also engage in public

education campaigns regarding the hazards of crossings, which are coordinated nationally by the nonprofit Operation Lifesaver, Inc (see section 2.8).[63]

State and local law enforcement agencies are responsible for enforcing traffic laws at crossings and for being the first responders to grade crossing collisions. Ordinances and operational matters pertaining to crossings are local governments' responsibility.[64]

States and localities, along with federal grants, are primarily responsible for funding improvements to grade crossings. Railroads sometimes contribute to the upfront costs, and they are responsible for installing and maintaining crossing protection signs and systems, as well as for construction and maintenance of the track structure and riding surface at crossings (only up to within a few inches of the outside edges of the cross ties of the track leading up to the crossing). State and federal governments oversee the railroads to ensure compliance with national standards. The highway agency that has jurisdiction at the crossing is the only entity that can legally control traffic. States and localities are also responsible for signage on the road(s) leading up to the crossing and for designing, building, and maintaining roadway approaches to the crossing, even when part of the approach lies within the railroad's right of way.[65]

Some states assist the FRA in its mission of inspecting railroad properties for compliance with federal laws and regulations through the Rail State Safety Participation Program. Under the program, each participating state enters into a multi-year agreement with FRA for the exercise of specific authority. The FRA trains state inspectors and assists states with the costs associated with such training. 31 states and the District of Columbia currently participate in the program. The states' role in inspection emphasizes planned, routine compliance inspections, but states may undertake additional investigative and surveillance activities consistent with overall program needs and individual state capabilities.[66]

One state with a particularly robust rail safety oversight regime is California, where the Railroad Operations and Safety Branch of the California Public Utilities Commission oversees a crude-oil-by-rail safety campaign, conducts a railroad bridge evaluation program, monitors railroads' implementation of PTC, and partners with Operation Lifesaver to conduct public education campaigns around grade crossing safety and railroad trespassing prevention, in addition to employing inspectors who assist FRA inspectors.[67]

The American Association of State Highway and Transportation Officials (AASHTO)

State government bodies with authority over transportation coordinate their activities, share knowledge and resources, set national technical standards, and educate the public

and lawmakers nationally through AASHTO, whose membership includes highway and transportation departments in all 50 states, the District of Columbia and Puerto Rico. AASHTO's Rail Council addresses all railroad policy, safety, regulatory, operations and investment issues and makes recommendations to the FRA and Congress on behalf of the states through reports, presentations and other means.

AASHTO and ASLRRA have an ongoing partnership to assist states with securing financing for projects to enhance the service and capacity of short-line and regional railroads. These projects often result in safety improvements, such as the elimination and fortification of grade crossings (such as by installing barriers in road medians to prevent vehicles from going around lowered gates) and upgrades to signal and train control systems. Two participating states, Kentucky and Oklahoma, restrict their financing programs exclusively to grade crossing improvement projects.[68]

2.7 Individual Railroads

The entities with the greatest responsibility for ensuring safe operation, complying with federal and state laws, regulations and technical standards, and investing their resources into physical and technological changes that impact safety are the public and private railroad companies themselves. The vast majority of FRA-regulated railroad track in the U.S. is owned by private companies, while a small minority is owned by public entities – either regional passenger service operators or state or local bodies that lease trackage to freight railroads.

The Class I freight railroads, by virtue of owning the majority of the track, are the key actors in determining how safety programs are to be carried out and how safety technologies are to be deployed, with short-line and regional railroads as well as most passenger carriers generally following their lead. There are also 30 commuter railroads in the US, half of which own all or part of the tracks they use. Half of these also contract out train operations and equipment maintenance to private contracting firms, and seven of the 15 that own all or part of their infrastructure contract out maintenance of way in the same manner. Five commuter railroads have the track-owning railroad over which they operate (either a freight railroad or Amtrak) conduct all operations and maintenance under purchase-of-service agreements. In all cases except for those five, however, the public agency that manages the service, not the contract operator/maintainer or track owner, is the "entity of record" responsible for safety and regulatory compliance and for reporting to FRA and state regulators. Thus, it is incumbent upon the agency to ensure that its contractors are in compliance. In most cases, both the agency and the contractor employ safety professionals -- the agency's employees overseeing the contractor's management, which then oversees its workforce.

The national intercity passenger rail carrier, Amtrak, is a unique hybrid of public agency and private corporation. Established by the Rail Passenger Service Act of 1970, Amtrak is legally a for-profit corporation chartered and headquartered in the District of Columbia. However, its Board of Directors is appointed by the U.S. President and confirmed by the U.S. Senate;[69] it is considered a government entity for the purpose of many constitutional provisions;[70] its Office of the Inspector General is a fully federal government agency;[71] and it enjoys distinct legal advantages in negotiating agreements with the private freight railroads that host the vast majority of the train-miles it operates.[72] Its law enforcement arm, Amtrak Police, is considered a federal law enforcement force that has general enforcement power within Amtrak property and at facilities served by Amtrak trains that are owned by other entities.[73]

Funding Grade Crossing Improvements

Funding for grade crossing improvement projects has come largely from the federal government through the Section 130 program, funded by the Highway Trust Fund. 10 percent of the cost of such projects must be paid by non-federal funds, which can come from state or local governments or from railroads. However, as current surface transportation policy law expires on Sept. 30, 2021, Congress is considering whether private railroads should be made to pay a greater share. House Democrats' 2020 bill would require a higher railroad contribution, which railroads would be allowed to meet in whole or part with non-cash contributions like materials or labor. [74]

Railroads already contribute to certain Section 130 projects at a level that is theoretically commensurate with the net benefits that would accrue to their bottom lines, such as reduced maintenance and inspection costs, fewer accidents, and less disruption to rail traffic.[75] U.S. DOT may require a railroad to pay up to 10 percent of the cost of a Section 130 project in cash depending on the project type, but in practice has never required a contribution that large, and most project types require no railroad contribution.[76] The cost and task of installation, maintenance, and operation remain a railroad responsibility.

Railroad Police Forces

Every U.S. Class I railroad (except Kansas City Southern), Amtrak, and most commuter railroads has its own police force consisting of railroad employees. Some of these are certified law enforcement officers who carry full police and arrest powers. Under a 1990 federal law, any such officer who is certified or commissioned in one jurisdiction may enforce laws in any other jurisdiction where the railroad owns property. [77] They may be considered certified or deputized police officers or company special agents. Most states limit railroad police's authority to railroad property, while others, like California, give them general peace officer authority statewide.[78]

The most common crime types that railroad police investigate are trespassing, assaults against passengers, terrorism threats, arson, graffiti, signal vandalism, pickpocketing, ticket fraud, robbery and theft of baggage or freight.[79] They also often have a role, alongside local law enforcement, FRA and NTSB personnel, in investigating derailments, grade crossing collisions, vehicle accidents in railroad rights of way and hazardous materials releases. Railroad police officer training usually includes inspecting trains and checking for fire and other safety hazards, as well as learning the fundamentals of almost every operation of the railroad.[80]

Additionally, Operation Lifesaver offers a Railroad Investigation and Safety Course, developed with the help of railroad police, to North American law enforcement officers to prepare them to properly investigate a grade crossing collision or trespasser incident and to maintain on-scene safety in the unique railroad environment. Nearly 15 percent of Operation Lifesaver's trained volunteers are law enforcement officers.[81]

Railroads Working with Other Organizations to Craft Safety Policy

The process of developing federal laws and regulations is one that involves a good deal of two-way communication between the relevant federal body and those affected by the proposed action (stakeholders). FRA and other regulatory bodies regularly solicit both formal and informal input from rail industry stakeholders, including railroad companies, in the process of crafting and revising regulations. Every proposed new regulation or change to existing regulation must go through a public comment process and the agency is obligated to consider the comments received. FRA also has regular industry open houses that allow information to be shared both ways.[82] State governments have similar processes, each guided by the state law that govern public comment and state agency interaction with stakeholders.

Most larger railroad companies have legal and government affairs departments that stay on top of both legislative and regulatory actions and provide information, comment on proposals, and 'want lists' or suggestions for what they would like to see in legislation or regulation. They also have staff who regularly engage with labor unions and organizations like Operation Lifesaver.[83] Labor contracts include work rule provisions such as minimum crew sizes and hours of service that have a bearing on safety -- these can be more strict than FRA regulations, but cannot be more lenient.[84] Labor unions generally will not hesitate to notify their contacts in railroad management about safety issues reported by their members and follow up with management to find out if and how the issues are being resolved. Federal law offers protections for whistleblowers who report safety concerns to FRA. Since a 2007 change in federal law, the responsibility of protecting and interacting with whistleblowers was transferred from FRA to the Occupational Safety and Health Administration (OSHA).[85]

As mentioned above, another way railroads cooperate with FRA is in the area of safety inspections. Railroads' own inspectors or other safety personnel often host, accompany or work alongside FRA inspectors, and conduct spot or pre-emptive inspections independently from FRA. Most on-the-ground regulation enforcement and compliance assurance work is done by railroad employees, with FRA inspectors "checking their work" on a regular basis.

Differences Between Class Is and Short Lines, Freight, and Passenger

While nearly all railroads, regardless of size, have at least one full-time management employee devoted to safety (often along with security and/or training), larger railroads have entire departments staffed with inspectors and other safety specialists. Given the Class I railroads' position of influence, short lines generally follow the safety standards established by the Class Is. Short lines also tend not to have the budget or staff capability to develop and administer a robust safety training program using technologies like locomotive cab simulators, and thus rely on assistance from government, Class Is and other short lines to provide training and workforce development assistance.[86]

The ASLRRA generally cooperates with the AAR's safety program, but also develops and promulgates safety-related instructions and recommendations that are specific to smaller railroads, many of which lack the sophisticated signal and train control systems that larger railroads have and tend to operate fewer and lower-speed trains with a greater mix in types of cars and materials carried. Several short lines are owned by national or international holding companies, such as Genesee and Wyoming or Anacostia Rail Holdings, that own multiple railroads and tend to provide uniform safety guidance for their properties.

Where passenger operators (Amtrak and many commuter railroads) operate as tenant railroads using tracks owned by a host railroad (generally a freight carrier), the tenant is fully subject to all the host's operating rules and safety requirements, while also independently complying with federal and state rules and regulations specific to passenger carriers. Passenger trains are generally authorized to operate at higher speeds than freight trains using the same lines, and host railroads often must spend additional resources to maintain tracks to passenger standards. As maximum authorized passenger train speeds begin to exceed 90 mph, the host railroad must meet additional requirements for signal systems and grade crossing protections (such as gates blocking the entirety of the roadway at the crossing and signage indicating the presence of high-speed trains), and any line hosting passenger trains operating at higher than 110 mph must be completely grade-separated from roadways. Under the 2008 federal rail safety law, the presence of regular passenger trains on a given line automatically triggers the requirement that it be equipped with PTC.

In cases where the passenger operator owns its own track (as many older commuter railroads do and as Amtrak does on most of the Northeast Corridor, on 232 miles of track in Michigan, and at its major terminals like Chicago and New Orleans), it is completely responsible for establishing operating rules, complying with FRA and state requirements, and overseeing all aspects of safety, including for any tenant railroads (other passenger carriers or freight carriers). The passenger-dominated Northeast Corridor and many of its branches, for example, use a different set of operating rules than those used on nearly all other U.S. railroads.

2.8 Associations and Nonprofits

Association of American Railroads (AAR)

The AAR's membership consists of 20 full members: the seven Class I freight railroads operating in the U.S., along with Amtrak, one commuter railroad and several short line freight railroads and holding companies. It also has eight "special members" operating in Canada and Mexico, 21 "railroad affiliates" (commuter and private intercity passenger and tourist train operators), and dozens of "associates," which are rail industry vendors and consulting companies.[87] The AAR is "the standard setting organization for North America's railroads," according to its website, establishing safety, security and operating standards that guide seamless and safe operations across the 140,000-mile U.S. freight rail network. It also has two subsidiaries, TTCI and Railinc, that conduct research, development and testing to enhance rail safety, security and efficiency and serve as clearinghouses for data and information. AAR further supports the Railroad Research Foundation, which also conducts safety and security-related research.[88]

The AAR's Technical Services group of committees develops, maintains and enforces North American railroad interchange rules, mechanical standards and component specifications. Class Is and short lines, FRA, Transport Canada, private railcar owners, shippers and suppliers all refer to these standards. These standards are guided by and compliant with federal law and with FRA and Transport Canada regulations, but also cover areas not explicitly covered by government mandates. Committee members include railroad and non-railroad subject matter experts, and each committee is managed either by a member of AAR's Washington staff or by a member of TTCI's staff in Pueblo, Colorado. These standards cover such areas as railcar brake systems, safety device and structural soundness inspections, facility certifications, component approvals, and the Early Warning and Maintenance Advisory System that alerts railroads to potential hazards related to equipment.[89]

The AAR touts freight rail as one of the country's safest industries, with employee injury rates lower than those of other modes of transportation and other major industries. The association credits this to railroads' strong safety culture consisting of daily briefings, peer-to-peer safety programs, and state-of-the-art training programs that feature

simulators and virtual reality. Other safety technologies that AAR has helped railroads develop and deploy are PTC, remote-controlled yard locomotives, the use of drones to inspect bridges and remote locations, and advanced track inspection and track geometry vehicles.[90]

AAR and other trade groups' staff routinely work with Congress, FRA and other regulators to advance their interests, and FRA routinely solicits AAR's input in the rulemaking process, as do congressional committees. AAR is currently asking Congress and FRA to make the federal railroad regulatory regime less prescriptive and more performance-based, and better able to adapt to the latest technologies. AAR seeks a regulatory framework that holds "railroads accountable for safety performance while also enabling and incentivizing railroads to develop safer, more efficient practices and technology." One example is the use of data analytics to process the vast quantities of information that modern sensors and measuring devices collect to gain insights to improve operations and infrastructure. AAR opposes the idea of requiring a minimum of two crew members in the locomotive cab while in operation, which all the rail labor unions support.[91]

American Short Line and Regional Railroad Association (ASLRRA)

The ASLRRA's membership consists of approximately 600 freight railroads whose annual revenues fall below the threshold to be considered Class Is, which combined own about 40% of the nation's FRA-regulated trackage, handling one out of every four freight railcars moving throughout the national rail system.[92] This includes large regional railroads with hundreds of miles of main-line track operating in several states, such as Pan Am Railways and the Iowa Interstate Railroad, all the way to very small railroads that may only operate a single branch line, connector or industrial spur.

The ASLRRA produces aid documents and presentations to keep its members abreast of the latest FRA regulations, coordinates the distribution of federal safety improvement grant funding to Class II and III railroads, assists members in developing disaster recovery plans, provides expert staff to member railroads to help them conduct compliance audits, conducts safety training seminars, and recognizes railroads with outstanding safety records and programs with awards. FRA mobile apps help members track and comply with regulations on hours of service, post-accident toxicology testing and hazardous materials safety, as well as to locate and find information about grade crossings.[93]

The ASLRRA also hosts the Short Line Safety Institute (SLSI), which develops safety training programs and provides them to short lines. In March 2021, SLSI developed two new training programs that will be distributed at no cost across the industry. One of these is a Transportation Emergency Response Plan (TERP) for short-line and regional

railroads that haul hazardous materials, which can also be shared with first responders in emergency situations, providing them with detailed maps and key locations of rail yards, emergency access instructions to rail facilities, and contact information for key railroad personnel.

With the help of a $6.7 million federal CRISI grant leveraged by the Iowa Northern Railway, ASLRRA launched a comprehensive computer-based safety and education training program for short lines, available both virtually and in-person, which focuses on FRA compliance, best practices, leadership and development, operating rules, and mechanical and maintenance of way training. Locomotive simulators will also be available to short lines via a mobile simulator and classroom trailer.[94]

American Public Transportation Association (APTA)

APTA is a trade association whose membership of over 1,500 companies and agencies comprises nearly all North American public transportation and intercity passenger rail agencies and operators, as well as transit contracting and consulting firms and suppliers. This includes FRA-regulated commuter railroads and Amtrak, along with FTA-regulated metro/subway, light rail, streetcar and bus operators.[95] In addition to advocating for funding and supportive policies for passenger rail and transit development and serving as a networking and professional/career development organization, APTA also provides its members and the public with information about transit-related topics, including safety.

APTA is a recognized Standards Development Organization, having produced over 300 standards to promote best practices. It also houses peer review and safety audit programs that strengthen and aid member organizations in keeping in line with best practices.[96] Among APTA's many committees and working groups are a Rail Safety Committee and a Commuter Rail Safety & Security Subcommittee. APTA's catalog of 83 individual safety standards for commuter, intercity and high-speed rail covers construction and structural, electrical, inspection and maintenance, mechanical, and passenger communication and emergency evacuation equipment.[97]

Operation Lifesaver, Inc. (OLI)

OLI is the largest rail safety education organization in the United States and the only nonprofit that receives funding directly from three U.S. DOT agencies to conduct educational campaigns. It consists of a national umbrella organization and affiliated, but independent, state organizations in all but three states (these three state programs still use the Operation Lifesaver (OL) name but have ceased to be formally affiliated with OLI). OLI has a staff of four headquartered in Washington, DC, with a $2 million annual budget, but the vast majority of OLI's work is undertaken by volunteers and the

bulk of its budget goes directly to state organizations. OLI has sibling organizations in Canada, Estonia and South Africa. [98]

OLI's Board of Directors (consisting of representatives of Class I, short line and passenger railroads as well as industry associations) and National Advisory Council (consisting of subject matter experts from across the railroad industry, rail labor unions, US DOT, and state DOTs) are all-volunteer, as are the leaderships of all the state OLI organizations. Each State Coordinator sits on the OLI Board, and OLI leaders from each FRA Region elect a regional representative to the National Advisory Council.

Founded by the Union Pacific Railroad in 1972 as a pilot project, Operation Lifesaver grew rapidly in the 1990s and 2000s to have a presence in nearly every community in the country where there is an active railroad.[99] Its areas of focus are educating motorists and pedestrians on safely navigating grade crossings, educating the public about the dangers and illegality of trespassing on railroad property, and educating law enforcement and first responders on properly handling incidents involving railroads. A large portion of the federal funding that OLI receives from the FRA is from a grant from the FRA Office of Safety and can only be used in very specific ways as defined by the federal statute.

OL-authorized volunteer speakers and instructors provide free education programs to school groups, driver education classes, community organizations, professional drivers, law enforcement officers and emergency responders across the US. These programs are co-sponsored by federal, state and local governments, highway safety organizations and private railroads. OLI and state OL groups also reach members of the public through advertising (on TV, radio, Internet, billboards, and signage on passenger trains and at train stations) and social media engagement.

Any presentation given under the OLI umbrella must be conducted by an OLI-approved presenter and use OLI-approved materials and scripts from which presenters may not deviate. To ensure accuracy of information and consistent, effective messaging, materials and scripts are thoroughly vetted by subject matter experts on the Material Review Committee of OLI's National Advisory Council. All OLI's materials are available free of charge to the public on its website.

Any adult may become an OLI-approved presenter by demonstrating that they understand the OLI materials and can present in an effective way. OLI authorizes presenters after they take an online course and have a face to face meeting to become a volunteer. OLI has conducted Rail Safety Week in the US in September every year since 2017, consisting of a blitz of advertising and local events centered around one or two rail safety messages. OLI also participates in International Level Crossing Awareness Day.

In early 2021, OLI revamped its campaign to teach emergency responders how to be safe around railroads. OLI also has a new partnership with Head Start called Safe Kids Worldwide, through which OLI develops materials to be presented to parents of children in Head Start programs.

In 2018, state OL organizations in three western states – Utah, Idaho and Nevada – decided to part ways with OLI and form their own multi-state organization, the Rail Safety Alliance. Although the exact reason is unclear, these states left because they refused to sign OLI's revised agreement. OLI made substantial revisions to its standard agreement with state OL organizations. Most state OL groups were receptive to the changes, but some were not. These three state organizations still use the OL name and their websites still have OLI materials and offer presentations, without OLI permission. OLI remains in discussions with these states to return them to the organization. In the meantime, these state programs retain access to some FRA funds but do not have access to funding from OLI.

OLI has practically no influence over the level of enforcement that's undertaken or the allocation of enforcement resources, but it does provide training to law enforcement and first responders, which contributes to more effective enforcement.

2.9 Trade Unions

Sheet Metal, Air, Rail and Transportation Workers, Transportation Division (SMART-TD)

Formerly the United Transportation Union, SMART-TD, an AFL-CIO affiliate, represents all freight and passenger train conductors on FRA-regulated railroads, as well as most intercity bus drivers and some transit employees.[100] According to its website, the union "has no higher priority than fighting for laws, regulations and work rules that ensure our members go home to their families in one piece." In addition to advocating before legislative and regulatory bodies (including electioneering activities) and at the negotiating table with railroads, SMART-TD has several dedicated teams that study safety issues and make recommendations. Along with participating in SOFA (discussed below), SMART-TD has a National Safety Team, which assists NTSB investigations, and a Rail Safety Task Force, which works with state and local union leaders to develop practices to heighten situational awareness in yard and road operations. SMART-TD members may submit safety condition and railroad technology event reports (anonymously or not) to the union through its website.[101]

Brotherhood of Locomotive Engineers and Trainmen (BLET)

BLET, a division of the Rail Conference of the International Brotherhood of Teamsters, represents all locomotive engineers on FRA-regulated U.S. railroads, as well as other

train and yard operating crew members other than conductors[102]. Like SMART-TD, it primarily engages in legislative and regulatory advocacy, and participates in industrywide safety committees and working groups like SOFA. Some of BLET's current priorities are improved cab safety standards, continuing to require a minimum of two-person crews in the locomotive cab, devoting more resources to prevent trespassing and handle trespassers, and addressing the security of the nation's rail system against terrorist attacks.[103]

Brotherhood of Maintenance of Way Employees Division (BMWED)

BMWED, a division of the International Brotherhood of Teamsters, represents railroad employees involved in the maintenance of track and structures other than signals.[104] In addition to legislative and regulatory advocacy and participation in safety committees and working groups like FAMES, BMWED has its own Department of Safety, which assists members and officers in addressing safety-related matters and seeks to improve health & safety conditions for maintenance-of-way workers through regulatory oversight, federal rulemaking, labor-management collaboration and health & safety education and training for members. The Department of Safety is responsible for preparing safety testimony and presentations for hearings and inquisitions of policy and lawmaking bodies, including RSAC, OSHA, FRA, NTSB and Congress. It also researches and files comments on proposed federal rulemakings and railroad requests for waivers from federal safety rules.[105]

Brotherhood of Railway Signalmen (BRS)

BRS, an AFL-CIO affiliate, represents railroad employees and contractors involved in the construction and maintenance of signal systems and devices, including grade crossing warning devices. It educates its members about their rights and responsibilities under U.S. rail labor laws, including the reporting and resolution of safety-related incidents.[106] Some local branches of BRS provide members with educational materials on safety topics including fatigue awareness, maintaining situational awareness, safe tool use, personal protective equipment, and fire and weather safety.[107]

2.10 Other Industry-Wide Committees and Working Groups

Fatality Analysis of Maintenance-of-Way Employees and Signalmen (FAMES) Committee

This voluntary committee of labor (BMWED and BRS), management (AAR and ASLRRA), and government reviews and analyzes roadway worker fatalities to define trends and determine how best to direct resources and adjust operating and training practices to reduce such fatalities. FAMES produces several reports annually on topics such as accidents involving boom, crane or other maintenance machine usage, bridge

worker safety, roadway worker safety at grade crossings, the use of electronic devices, and the importance of safety briefings.[108]

Switching and Operations Fatality Analysis (SOFA) Working Group

This voluntary group made up of representatives of AAR, ASLRRA, FRA, SMART-TD and BLET aims to identify and eradicate the causes of fatalities occurring while switching and other railroad operations. Since its founding in 1998, its publications cover topics such as industrial track hazards (found to be responsible for one in five switching operations fatalities), adequate job briefings (also found to be responsible for one in five switching fatalities) and close clearance situations.[109]

3.0 Safety Trends and Possible Solutions

The overall historical picture of safety in the railroad industry is one of success. Strong public policies coupled with private and public investment has created an industry that is much safer than it was a few decades ago, and certainly safer than its truck freight competitors on all measures. But recent trends show that overall safety gains have stalled, and in some cases are trending in the wrong direction. This section reviews aggregate and granular railroad safety data as it relates to different types of incidents, different groups of railroads, and different parts of the country.

The Federal Railroad Administration has been collecting robust data on safety for decades, measuring the various incidents, injuries and deaths. Most incidents do not involve fatalities or injuries, but federal regulations require reporting for any illness, injury, or incident that has total monetary damage over a certain threshold, which is currently set at $11,200.[110]

This data analysis looks at four main categories of safety incidents:

1. **Highway-rail grade crossing incidents**. These are collisions that happen at public or private grade crossings with active or passive warning devices.
2. **Train accidents (not at grade crossings)**. While train accidents can mean a major collision between trains, the vast majority of these incidents are derailments that happen in yards or elsewhere on rail property.
3. **Workforce and other incidents**. These primarily involve employee illnesses or injuries (slips, trips, or falls) on the job.
4. **Trespasser incidents not at grade crossings**. Incidents can range from graffiti to suicides that take place at locations other than grade crossings.

This analysis divides the data into several different types of railroad groups to better understand trends related to different sectors of the railroad industry:[111]

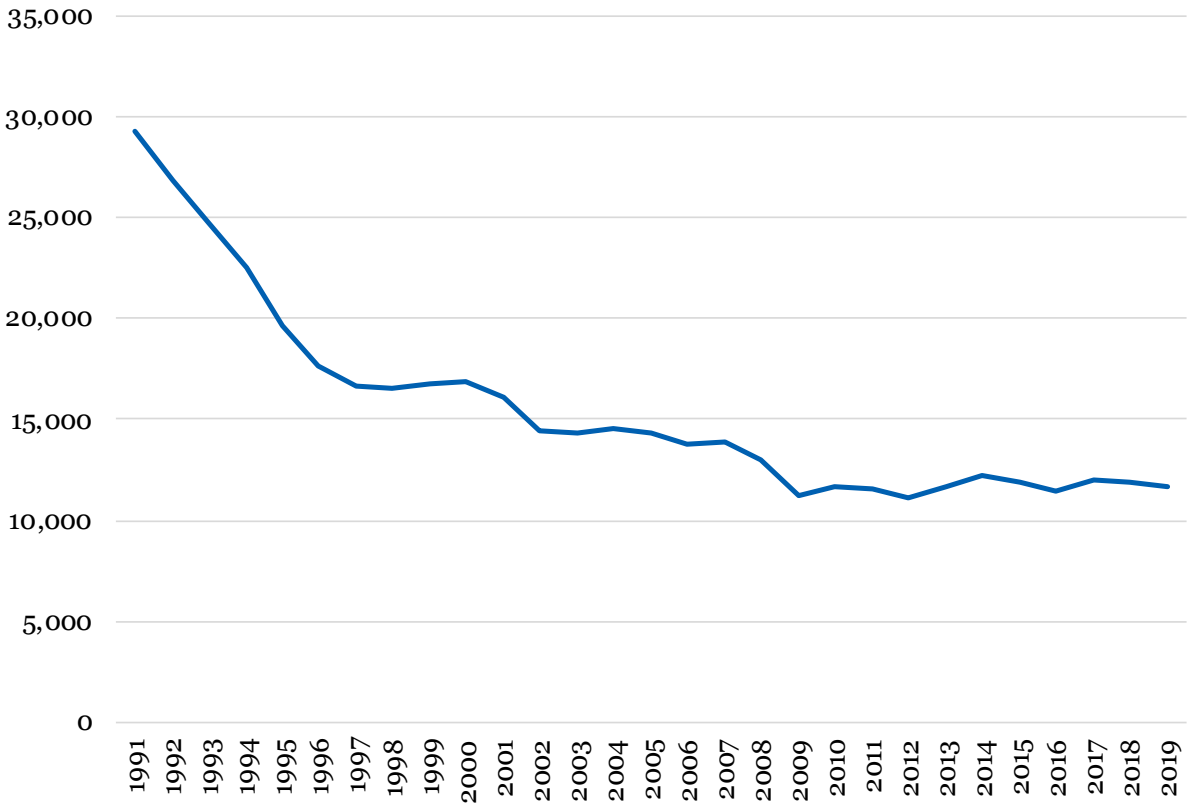
- **Class I freight railroads**. This includes the seven largest railroads: Union Pacific, BNSF, CSX, Norfolk Southern, Canadian Pacific, Canadian National and Kansas City Southern.
- **Group 2 Railroads**. FRA's Office of Safety Analysis grouping of railroads that are not Class Is but have more than 400,000 employee hours in the latest calendar year
- **Group 3 Railroads**. FRA's Office of Safety Analysis grouping of railroads that have fewer than 400,000 employee hours in the latest calendar year
- **Commuter railroads**. This includes all commuter passenger railroads that are governed by FRA regulations. Some commuter railroads are also counted in Group 2 and Group 3, as are intercity passenger rail carriers other than Amtrak and tourist railroads.
- **Amtrak.**

Most railroad safety data is collected via incident reporting forms that railroads need to fill out whenever there is an incident that meets the threshold.[112] In some cases, multiple railroads fill out forms for the same incident, so examining railroad data involves careful analysis to ensure that some incidents are not double counted or omitted.

3.1 Overall Trends

Incidents on U.S. railroads have declined nearly 60 percent over the past three decades, as shown in Figure 1, below. The decline was remarkably steep in the 1990s, with safety gains continuing into the 2000s and reaching its lowest point in 2009. Since then, safety incidents have been stable at around 12,000 annually.

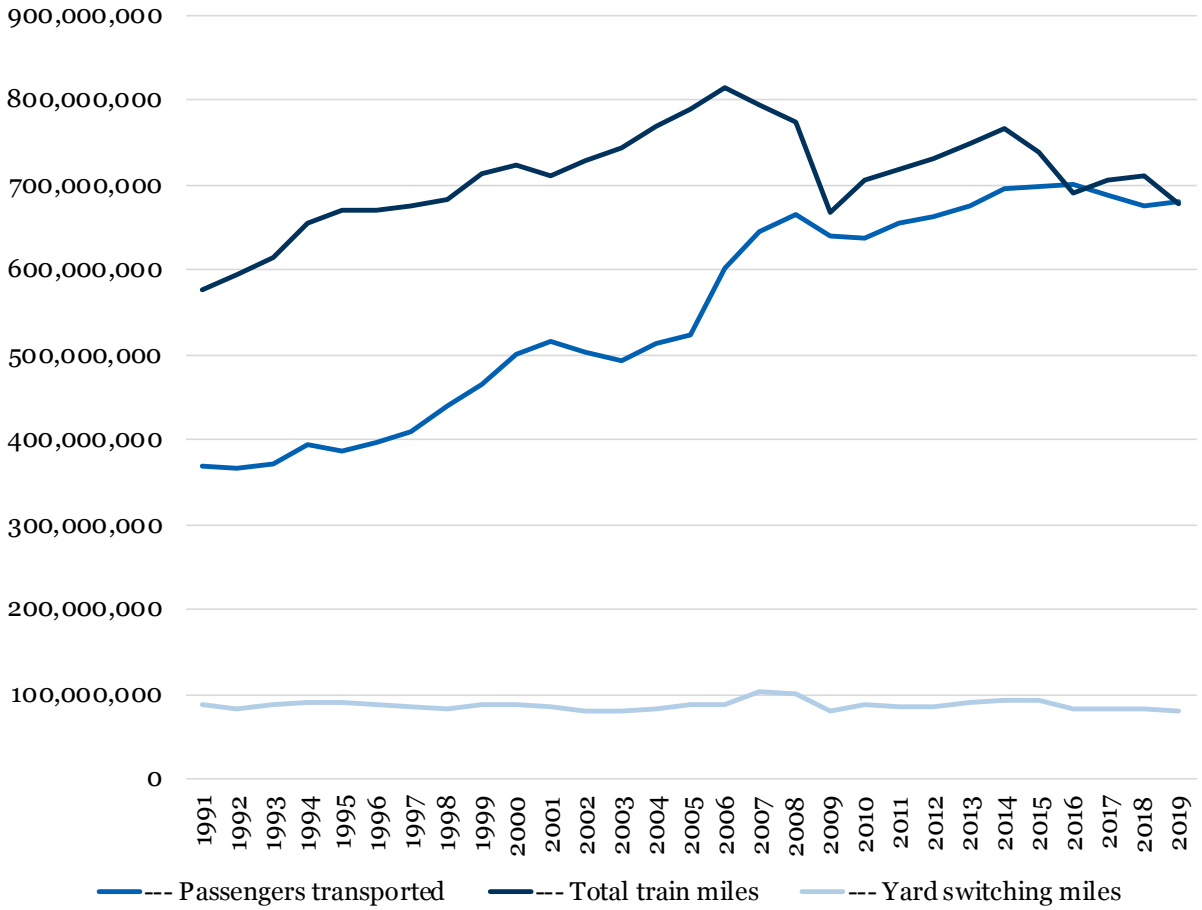
Figure 1: Total Incidents, All Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

What is more remarkable about the dramatic decline in railroad safety incidents is that this happened while rail traffic was increasing. Figure 2 shows significant increases in passenger levels and freight train miles, indicating the rates of incidents and injuries have declined even more dramatically than the overall numbers.

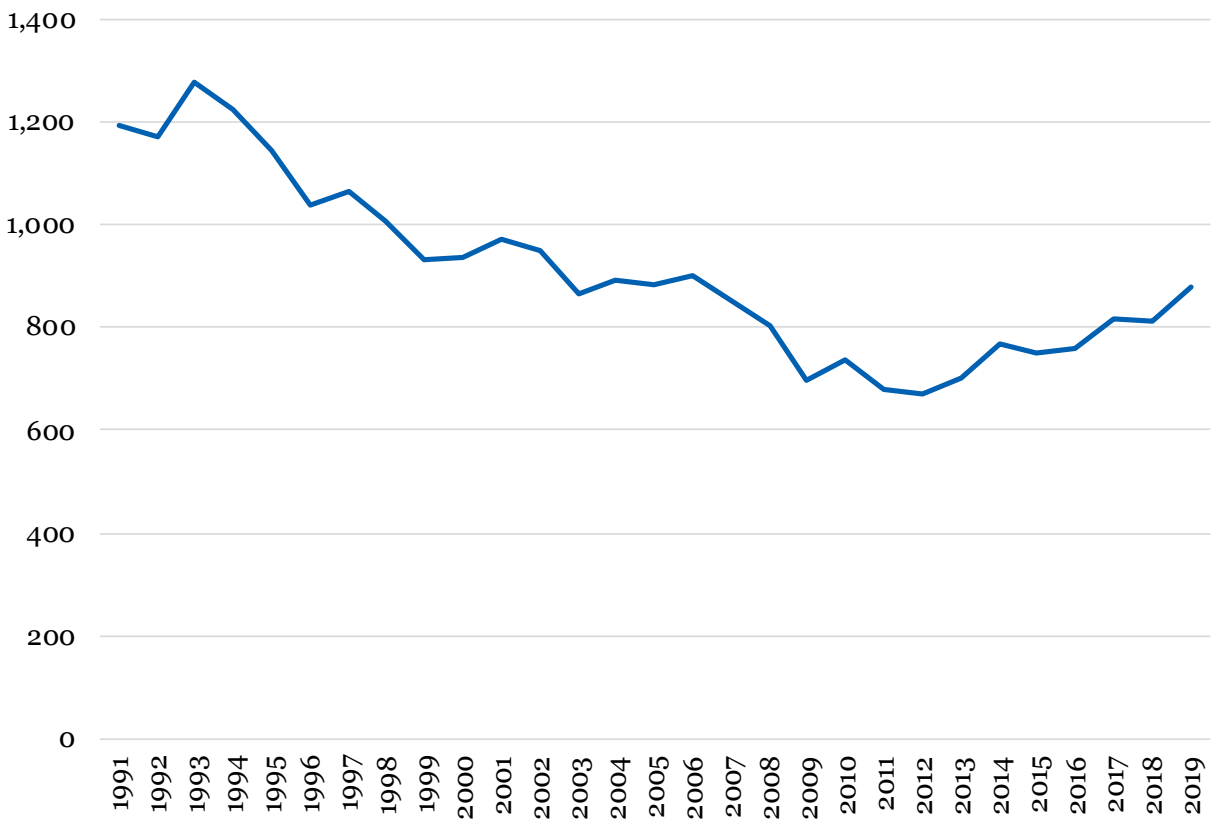
Figure 2: Passengers, Train Miles, and Switching Miles, All U.S. Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

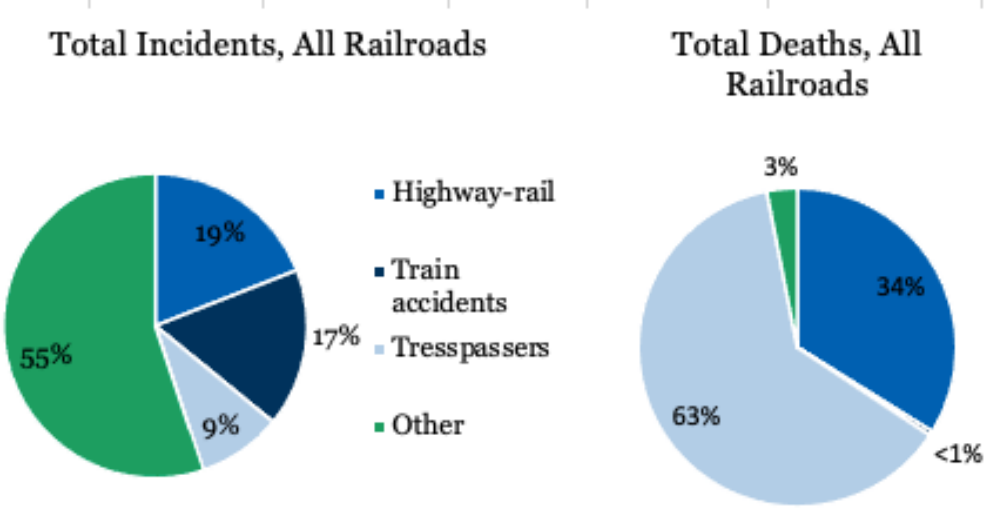
While injuries on railroads have followed the same trends as overall incidents, fatalities have not. As shown in Figure 3, fatalities declined 45 percent between 1991 and 2012 but have since risen 31 percent. The diverging trends between declining incidents and increasing fatalities points to the fact that most incidents are relatively minor injuries or illnesses to the railroad workforce, shown in Figure 4, but nearly all fatalities are at highway grade crossings or involve trespassers.

Figure 3: Fatalities, All U.S. Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

Figure 4: Incidents and Fatalities by Type, 2019



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal.
Note: Trespassing includes suicides

Table 1 shows how key safety metrics vary by type of incident and railroad grouping. The Class I railroads move 75 percent of the rail freight carloads, so often have the greatest total numbers of incidents, injuries, and deaths on their property. But they also are the safest overall when normalized for train miles and tend to be the safest for employees and have some of the lowest trespasser incident rates. However, rates for train accidents on Class I railroads are higher than the industry average. Amtrak and commuter railroads have the highest incident rate per train mile, with heightened problems with trespassers and employees.

Table 2: Safety Metrics for Railroad Groups and Incident Types (Red Indicates Higher than Industry Average)

	Total Incidents per million train miles	Highway-rail incidents per million train miles	Highway-Rail deaths*	Train accidents (not at grade crossings) per million train miles**	Trespasser incidents per million train miles	Trespasser Deaths*	Employee on duty incidents per 200,000 hours
All Railroads	17.2	3.29	297	2.91	1.55	549	1.87
Class I Railroads	11.1	3.02	169	**3.00**	1.47	377	1.15
Group 2 Railroads	**31.6**	2.74	40	2.73	1.46	77	**2.96**
Group 3 Railroads	**27.8**	**7.38**	39	5.33	**1.58**	44	**2.55**
Amtrak	**51.0**	**3.97**	59	2.11	**2.33**	58	**3.72**
Commuter Railroads	**37.7**	2.54	61	1.55	**2.02**	69	**3.44**

Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal
** Numbers sum to more than total because Amtrak and Commuter Railroads are also counted in other categories*
***Does not include highway-rail grade crossings or trespassing incidents*

When compared to other sectors of the industry, railroads are about four times safer than trucking on a fatality basis, but they have about 20 times as many deaths as waterborne shipping (See Table 2). Water transportation has fewer fatalities mostly because it does not have the same opportunities for grade crossings or trespassing. Taking out deaths related to rail grade crossings and trespassing, railroads are the safest

mode of freight shipment: in that case railroads have a quarter of the fatality rate per ton mile than waterborne and are 100 times safer than trucking.

Table 3: Fatalities and Fatality Rates Across Freight Modes

	Fatalities, 2019	Ton-miles (billions)	Fatalities per billion ton-miles
Waterborne Freight or Industrial Transportation	40	492	0.08
Passenger and freight railroads	878	1730	0.50
Trucking	4119	2034	2.02

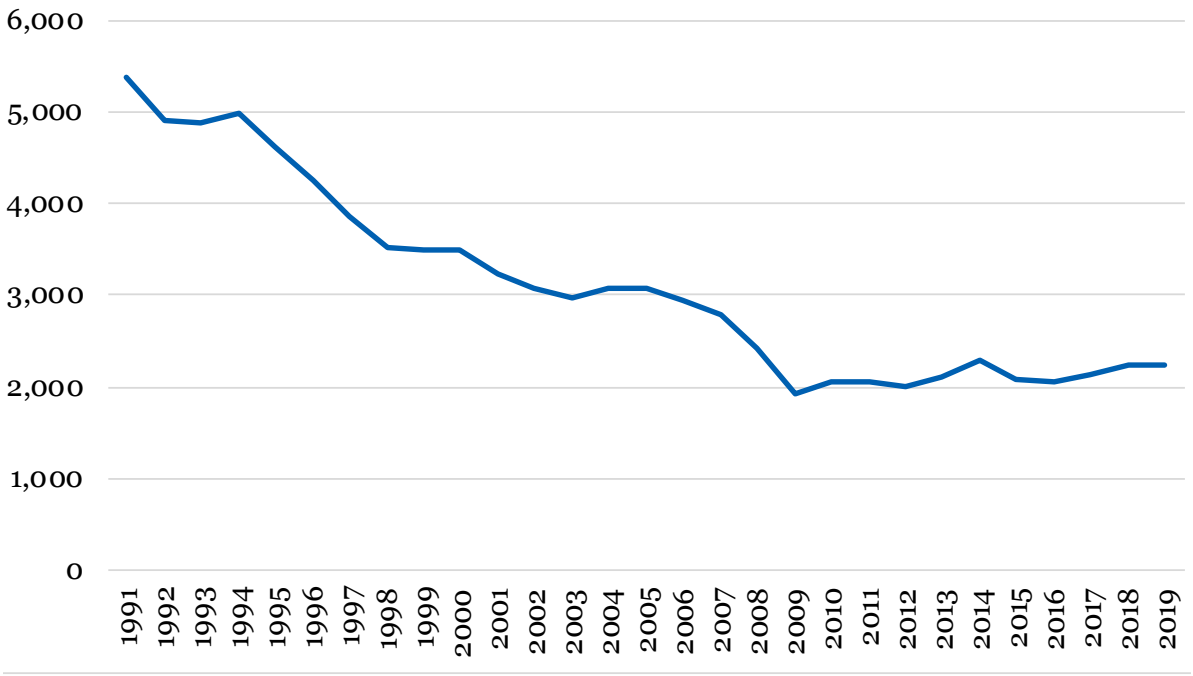
Sources: Bureau of Transportation Statistics, "U.S. Ton-Miles of Freight," 2018; "Fatality Facts 2019: Large Trucks," IIHS, 2021; Bureau of Transportation Statistics, "Transportation Fatalities by Mode," 2019

Regardless, policies that are directed toward reducing injuries and fatalities will be most useful if targeted to the areas where the problem is the greatest. Therefore, the next few sections examine the details of railroad safety incidents for grade crossings, train accidents not at grade crossings, workforce incidents, and trespassing.

3.2 Grade Crossings

Grade crossings are one of the deadliest and most common areas of safety concern for railroads. Fortunately, incidents at grade crossings have decreased by over 60 percent since 1991, shown in Figure 5. But the progress stopped in 2009, and after a few years with about 2,000 annual incidents, numbers appear to be trending upward. Grade crossing incidents are particularly deadly. For every 100 incidents there are about 40 injuries and 12 deaths, a rate that has stayed remarkably consistent for the past three decades.

Figure 5: Railroad Grade Crossing Incidents, All Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

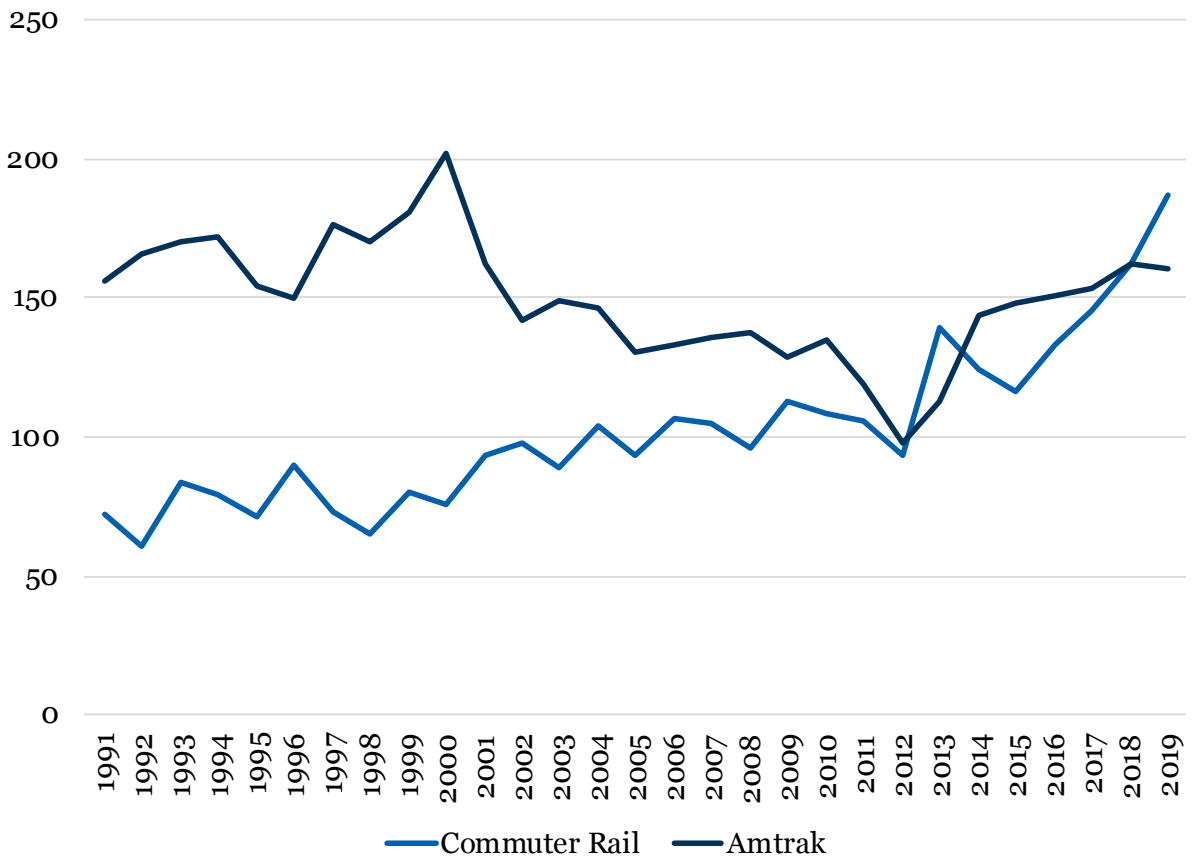
An FRA study credits the drop in grade crossing collisions in the mid-1990s and early 2000s to the following measures, presented here along with their relative impact:[113]

- **Commercial driver safety (34.6% projected contribution to the drop in crossing incidents)**: Federal regulations enacted during this time require commercial drivers to come to a full stop at each non-exempt grade crossing, look and listen for trains before proceeding. Also, a 1999 law mandates that Commercial Drivers Licenses be suspended for any driver convicted of violating grade crossing warning devices. Therefore, the grade crossing incident rate decrease for commercial vehicles from 1994 to 2003 was more dramatic than that for non-commercial vehicles.
- **Locomotive conspicuity (13.6%)**: In 1997, FRA mandated that nearly all locomotives be equipped with ditch lights on both sides of the nose in addition to the headlight, which makes oncoming trains much more visible at night.
- **More reliable motor vehicles (3.1%)**: Newer vehicles are less prone to stalling in the middle of crossings.
- **Clearance of vegetation** and other obstructions to increase sight lines at crossings (3.6%).
- **More reliable warning devices (3.1%)**: 1995 FRA regulations tightened the maintenance, inspection and testing rules for grade crossings and warning devices, resulting in a sharp decline in the activation failure rate for active warning devices.

The FRA report also cites closures of grade crossings and grade separation projects funded in part by the Section 130 program, new grade crossing warning devices, increased law enforcement, and various educational campaigns by Operation Lifesaver.

The trend shown in Figure 5 is consistent across freight railroads regardless of train-miles operated or number of employees. However, the Group 3 (smaller) freight railroads have a significantly higher rate of grade crossing incidents per train-mile than their larger peers (see Table 1). And while Amtrak has a similar incident rate to the industry average and commuter railroads are significantly safer on average, commuter railroads in particular are trending in the wrong direction, as shown in Figure 6.

Figure 6: Railroad Grade Crossing Incidents, Passenger Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

Installation and maintenance of grade crossing safety infrastructure is a shared responsibility between the railroads and states and localities in terms of maintaining the roadway and installing warning systems or signage. Different states have different approaches, and thus results, when it comes to grade crossing issues. Table 3 examines

the total incidents per state, the incidents relative to freight rail carloads, and recent trends.

An analysis of this data found no correlation between whether a state had a high percentage of active warning devices (flashing signals or gates, for example, compared to static crossbucks or stop signs) and the number of reported incidents. In fact, the data show some indication that states with higher percentages of active warning devices have higher rates of incidents. One possible explanation is that these states are investing in addressing a problem that could be much worse without the active signals, or that there is a lack of investment in some of the more problem-prone areas in these states.

Table 4: Key Grade Crossing Metrics, by State

	2019 Grade Crossing Incidents	Percent change in incidence 2009-2019	Total Highway Grade Crossings	Percentage of Active Warning Devices	2019 Originated and terminated carloads
Alabama	85	21%	2,732	50.3%	819,600
Alaska	0	-100%	152	55.3%	104,900
Arizona	13	-35%	692	68.2%	373,400
Arkansas	34	-23%	2,451	36.4%	604,500
California	176	50%	5,494	72.5%	7,238,000
Colorado	31	29%	1,749	45.0%	678,100
Connecticut	7	40%	354	74.0%	31,900
Delaware	7	75%	266	86.8%	n/a
Florida	136	167%	3,628	80.0%	2,142,300
Georgia	112	5%	5,014	49.7%	2,831,000
Idaho	14	40%	1,204	30.6%	195,100
Illinois	122	15%	7,565	71.6%	8,096,300
Indiana	120	22%	5,480	59.0%	1,450,800
Iowa	55	6%	4,152	45.0%	900,000
Kansas	32	-30%	5,057	42.0%	791,000
Kentucky	41	-29%	2,147	54.3%	803,900
Louisiana	97	15%	2,730	54.8%	828,700
Maine	1	-75%	774	62.9%	50,900
Maryland	14	8%	625	60.2%	470,900
Massachusetts	13	225%	742	81.9%	393,400
Michigan	49	-2%	4,654	51.8%	1,248,500
Minnesota	46	15%	4,187	39.0%	1,917,000
Mississippi	52	24%	2,122	46.4%	271,300
Missouri	39	0%	3,256	51.4%	1,292,000
Montana	11	-27%	1,363	36.3%	368,100
Nebraska	29	-29%	2,850	31.1%	537,800
Nevada	3	-25%	282	53.2%	n/a
New Hampshire	2	0%	327	48.3%	14,000
New Jersey	37	-10%	1,411	71.7%	1,411,100
New Mexico	8	-38%	704	56.3%	n/a
New York	29	-6%	2,644	77.8%	511,000
North Carolina	53	-4%	3,793	68.5%	900,000
North Dakota	15	-6%	3,280	19.6%	574,500
Ohio	82	30%	5,623	68.3%	2,348,000
Oklahoma	35	-29%	3,637	45.1%	479,600
Oregon	21	133%	1,762	47.1%	n/a
Pennsylvania	65	38%	3,553	59.6%	2,192,300
Rhode Island	0	0%%	58	65.5%	n/a
South Carolina	60	46%	2,619	58.6%	826,500
South Dakota	12	-29%	1,867	17.3%	181,100
Tennessee	52	-7%	2,724	52.6%	1,162,700
Texas	251	40%	9,137	68.8%	5,482,200
Utah	16	23%	707	51.8%	n/a
Vermont	6	-33%	370	63.0%	31,200
Virginia	38	9%	1,806	76.2%	1,441,400
Washington	43	34%	2,233	44.3%	1,892,800
West Virginia	12	-48%	1,326	51.8%	671,200
Wisconsin	48	4%	3,890	46.1%	781,900
Wyoming	6	50%	399	66.4%	3,065,200

Sources: FRA Grade Crossing Inventory, FRA Highway-Rail Grade Crossing Database, Association of American Railroads 2017 State Rankings. Some AAR data was not available (marked with n/a)

The state-by-state data show some diverging and counterintuitive trends. North Dakota and Wisconsin, for example, have similar numbers of grade crossings and traffic, but North Dakota has only 20 percent of its crossings with active warnings, compared to 46 percent in Wisconsin. But Wisconsin has more than three times the grade crossing incidents than North Dakota, and both are trending farther apart.

Alabama, California, Florida, Illinois, Indiana, Louisiana, Ohio, and Texas all have more than 80 incidents per year and have increased more than 10 percent over the past decade (indicated in Table 3 by **bolded orange**). Grade crossings in Florida and Texas, despite their high percentages of active warnings, are particularly problematic. These are possible areas for targeted assistance. Meanwhile the data show lower-than-expected rates and declining trends of grade crossing incidents in Arkansas, Kansas, Kentucky, New Jersey, and Oklahoma (indicated in Table 3 by *italicized green*).

Research suggests several different approaches can address safety problems at grade crossings. These are generally grouped into infrastructure and visibility, driver behavior and training, operational speeds, and issues related to pedestrians.

3.2.1 Infrastructure, Roadway Design and Visibility

Improvements to grade crossing signs and signals, the design of the roadway leading up to the crossing, and visibility around the crossing all affect safety. But other factors, such as vehicle and train speed and driver age, influence the likelihood of a crash to a greater degree than the presence or absence of such treatments. A great majority of crossing collisions worldwide are caused by drivers' negligence or incapacity, particularly in environments where safety consciousness is low.[114] Designing and operating a grade crossing with that in mind is helpful in addressing safety problems.

According to the FHWA, from the program's 1987 inception to 2014, fatalities at crossings that have been improved using Section 130 funds have decreased 57 percent, despite an increase in vehicle miles traveled on roadways and an increase in railroad traffic during that time period.[115] Crashes occur less frequently at crossings equipped with devices like automatic gates, flashing lights and bells than at those marked only by a crossbuck or stop sign. Based on one study's estimates from 2005-2015 FRA data, 67% of drivers observed exhibited appropriate behaviors at actively controlled crossings, while only 33% did so at passively controlled crossings.[116] Crossings protected by automatic gates had the lowest collision rates of all crossings but had the highest rate of fatalities relative to the number of collisions.[117]

In a 2018 report, the U.S. Government Accountability Office says more can be done to ensure that Section 130 grant money is targeted to where data suggest that it would have the greatest impact. Currently, many factors other than accident data (actual and

predictive) influence states' distribution of these funds, including the proximity of projects to each other on a railroad corridor, the fair distribution of funds across the state, requests from local jurisdictions and railroads, and availability of local or railroad funding for the required 10-percent match.[118]

GAO also recommends states have more complete information when deciding how to spend Section 130 funds. FRA could require railroads to report 'close calls' or 'near misses' at crossings, which is currently voluntarily.[119] Currently, states must spend at least 50 percent of their Section 130 funds on protective devices. However, grade separation usually results in better safety outcomes but costs on average 16 times as much as installing active warning devices.[120] Another legislative change that GAO suggests might improve safety outcomes is to increase the maximum amount that states are allowed to spend to incentivize local governments to close crossings. Most local governments consider the current maximum of $7,500 per crossing to be too low.[121]

A 2006 U.S. study found that crossings protected only by a stop sign experienced higher collision rates than crossings protected by any other type of warning device, passive or active, and 31 times higher than gated crossings. Collision rates *increased* when stop signs were added to crossings that were previously protected only by crossbucks. In 59 percent of collisions at stop sign-protected crossings, the driver was found to have ignored the stop sign. Possible explanations for this phenomenon include the observed behavior pattern whereby compliance with stop signs decreases as traffic volume decreases, and drivers' misjudgment of trains' speeds. At least one study suggests that yield signs may be more effective.[122]

At crossings protected by flashing lights and gates, the credibility of these devices can be a bigger problem than their conspicuity. In most of the cases where a driver recognized the hazard but failed to act appropriately or in time to prevent a crash, the driver went around lowered gates, spurred by their familiarity with the crossing and excessive warning times due to lower-speed trains or track circuits that were designed for higher-speed trains. These factors can be mitigated through better maintenance of active warning devices and through frequent recalibration of track circuit equipment so that warning times are in keeping with the actual speeds of most trains on the line.

There is also a need to differentiate between signaling for vehicles and signaling for pedestrians at railroad crossings. While pedestrians were involved in only 9 percent of accidents at public crossings in 2017, almost 40 percent of fatal crossing collisions that year involved pedestrians. Solutions include additional gates blocking sidewalks and 'gate skirts' that make it harder for pedestrians to duck under lowered gates.[123] Bells are most effective at warning pedestrians and bicyclists; not necessarily drivers.[124]

Beyond signals and signage, aspects of the physical shape and size of the roadway at the crossing, such as the number of roadway lanes and the angle at which the railroad crosses the road, were shown to have a significant effect on crash rates, with more lanes and crossings at closer to a 45-degree angle being more dangerous than fewer lanes and angles closer to 90 degrees.[125]

Crashes also tend to be more severe in conditions where visibility is reduced and in conditions that make it harder for the driver to slow down or stop in time.[126] Crashes tend to occur less frequently, but are more severe when they do occur, in open-space areas than in more densely built-up urban areas as motorists tend to drive faster in these areas.[127]

There are international examples of different types of active warning devices and roadway barriers that have not yet been deployed in the US. One study in Greece showed that installing automatic barriers at 50 crossings halved the rate of fatal collisions, but an economic analysis showed that the cost of installing these barriers (averaging to about €570,000, or $696,000 USD, for installation, plus €5,000 annually for maintenance, or $6,100 USD at May 2021 exchange rates) exceeded their benefit (based on the Greek government's value of a statistical life saved) by almost 3 to 1.[128] An Australian study showed the installation of gates at crossings that previously lacked them between 1971 and 1989 to be highly effective, cutting the mortality rate from 5.71 crossing deaths per 100 crossing-years to 0.33, while the rate at a control group of unchanged crossings on the same rail lines rose from 1.22 to 1.63 during the same period.[129]

Emerging technologies that could replace existing approaches to track circuits and other signaling devices hold great promise. The US DOT's Volpe Center in 2011 identified about a dozen alternative crossing protection technologies that various railroads and the Transportation Technology Center have experimented with that are five to 30 percent of the cost of the traditional track circuit-based active warning systems (the large deviation being attributed to the variance in performance and functional requirements of each technology), but "a variety of technical, cost and institutional issues must be resolved before these technologies are considered mature enough for railroads and government regulatory agencies to adopt." Volpe did, however, commend regulators' increasing adoption of performance-based regulations, which are more adaptable to newer technologies than more prescriptive regulations.[130]

Examples of methods of detecting approaching trains other than track circuits include radar and acoustic detection, the use of Global Positioning Systems (GPS) with wireless communications between locomotives and grade crossing warning devices, and magnetometer-based train detection. Both the radar and acoustic methods exhibited

high false detection rates, but the GPS-based system was found to have accurately warned and provided adequate warning times to motorists. In a 1999 Volpe Center experiment, only one detection method out of four that were tested – double-wheel sensor technology – did not exhibit any failures, missed detections or false alarms.[131] Insufficient data is available regarding the magnetometer-based technology that has recently been tested in Canada and Australia.

The costliest aspect of rolling out new technologies is the requirement that they be highly reliable and fail-safe, and that they provide a consistent minimum warning time of 20 seconds in advance of a train's occupation of a crossing. While some alternative detection methods produce high false detection rates, faulty track circuits may also result in false warnings and excessive warning times. There will always be a tradeoff between minimizing the number of false warnings and the amount of excessive warning time – which risks habituating drivers who frequent certain crossings to not take the warning seriously – and ensuring that warning device activation systems always fail safe.[132]

As autonomous and connected vehicles and 'smart infrastructure' technologies (allowing vehicles' control and driver information systems to communicate with surrounding physical features like traffic signals) continue to develop and be deployed, grade crossing warning systems should be one of the interconnected elements. Crossing warning devices will likely eventually need to be equipped with sensors and/or transmitters so that they can 'talk' with road vehicles passing through the crossing to warn the driver in advance or to intervene to slow or stop a vehicle that is about to enter a crossing at danger.[133]

Another promising area of technological development is the cooperation of railroads with the developers and vendors of wayfinding and driver information mobile apps. Apps like Waze alert drivers to upcoming hazards on their route, which can include grade crossing hazards, regardless of whether the user is actively interacting with the app. For one example, two New York City-area regional passenger carriers, Long Island Rail Road and Metro-North Railroad, joined Waze's Connected Citizens program in 2018 and continue to feed real-time grade crossing alerts into Waze.[134] It is so far unclear whether this has had a tangible effect on the number of grade crossing incidents on their lines.

Finally, future generations of Positive Train Control systems (as discussed later in this report) could be designed to detect grade crossing warning system failures and vehicles blocking tracks to provide advance warning to train engineers and railroad dispatchers. The PTC system's knowledge of train locations could also inform the more precise control of grade crossing warning device activation, reducing the number of false

warnings and the duration of excessive warning times. This would help ensure that the time during which crossing gates are down directly correlates with the speed of the approaching train, instead of a fixed time based on the worst-case time for an approaching train to reach the crossing. This would increase drivers' faith in the credibility of warning devices.[135]

3.2.2 Driver Behavior, Licensing, Training, and Public Education

A 2019 NHTSA press release noted that 270 people were killed in grade crossing collisions in 2018 alone. Of those, 99 died after the driver went around lowered crossing gate arms, a ten-year high.[136] 94 percent of crashes from 1994 to 2003 can be attributed to risky driver behavior or poor judgment, according to the FRA.[137]

In most crashes, the driver's failure to take decisive action after recognizing the hazard (decision error) was the cause, while the driver's failure to recognize the hazard (recognition error) was at fault in about a third of cases. Removing vegetation and objects obstructing the view of approaching trains can help but other less easily addressed factors include low driver expectancy due to low train traffic volume and the presence of distractions to the driver. However, when it comes to reducing decision errors, education and enforcement will help.[138] The following actions have been proposed:

- **Increase and better target enforcement during rush hours and at passively protected crossings**: Stricter police surveillance of, and enforcement against, speeding during rush hours in areas with passively controlled crossings would be an effective measure according to one team of researchers.[139] The presence of alcohol dominates any other contributing factor in all cases, so any overall reduction in intoxicated driving will lead to a reduction in grade crossing crashes.[140]
- **Target education towards the young male demographic**: The victims of grade crossing crashes are predominantly young men who exhibit aggressive driving behavior. Men are generally more likely to drive aggressively than women, and younger drivers tend to underestimate the risk of being involved in a crash and lack vehicle handling skills. Thus, education and enforcement efforts should focus on this population segment.[141] But while one's likelihood of being involved in a grade crossing crash as a driver decreases with age and is less for women than for men, the chance of such a crash being severe is greater for older people and for women.[142]
- **Better educate truck drivers**: A sizable percentage of grade crossing crashes still involve trucks, even though commercial drivers have been subject to additional regulatory requirements and penalties regarding grade crossings for nearly two decades from which non-commercial drivers are exempt. Trucking companies should make sure their drivers are fully aware of grade crossing hazards and know how to safely navigate their trucks through different types of crossings.[143]

Despite research showing risky driver behavior to be the key factor in most grade crossing crashes Section 130 funds are ineligible to be spent on driver education and enhanced surveillance and enforcement. Most state DOTs and other stakeholders say these efforts are crucial to further improving crossing safety, but they are not currently eligible for federal grants.[144]

A United Nations group of experts' 2016 assessment concluded that human factors (factors that have to do with human behavior that are not easily solved with technology, such as intentional risk-taking by road users) must be at the heart of government and railway actions for improving crossing safety, and that there should be a standardized international 'toolbox' for analyzing human factors. In other words, the group believes that European countries have done about all they can as far as technological interventions to make grade crossings safer – what remains to be done is to influence human behavior through ongoing, targeted, and consistent education and enforcement.[145]

The North Carolina Department of Transportation since the early 2010s has undertaken a campaign to educate law enforcement and first responders, as well as the public, about railroad situations, particularly grade crossings, called BeRailSafe. [146] The campaign is separate from North Carolina Operation Lifesaver, which focuses on messaging and education, while BeRailSafe focuses on injecting rail safety awareness into driver and law enforcement training.[147] Since its inception, the number of grade crossing collisions in the state has not changed significantly, but anecdotal feedback indicates that responders are able to clear incidents more quickly when investigating.

Among BeRailSafe's initiatives include an update to the NC Department of Motor Vehicles' school bus driver training manual and the addition of rail trespassing and grade crossing safety information to criminal justice education training standards. A refresher course for these audiences is being designed for the 2022 training year. A bill moving through the state legislature with hardly any opposition as of this writing (June 2021) would make North Carolina the first state in the nation to require rail safety instruction to be part of driver education. [148]

3.2.3 Train and Roadway Speeds and Operations

While it may seem obvious, the FRA found that the volume and speed of traffic on both rail and road at a given crossing are the biggest predictors of crashes.[149] This indicates that rural roads with low traffic volume and lightly used railroads are likely not wise targets for significant investment in grade crossing improvements.

According to one study, the probability of a driver being killed in a grade crossing crash increases significantly for all demographics when either the train or the road vehicle's

speed exceeds 55 mph. This study also suggested that vehicle speed is a much more significant predictor of crash lethality than the presence or absence of active warning devices.[150]

While there is some contradiction in the literature as to the effect of the speed of the rail or road vehicle, one study finds that the maximum speed for trains on the given line according to the railroad's timetable has a significant effect on collision rates, while the actual speed of the train or road vehicle at the time of collision has a less significant effect.[151] The source does not explain why this is, but it may have to do with warning devices being activated for longer before a train arrives on lines with higher timetable speeds (especially if trains are traveling slower than the timetable speed), increasing the odds that drivers who frequent crossings on such lines will try to beat the train.

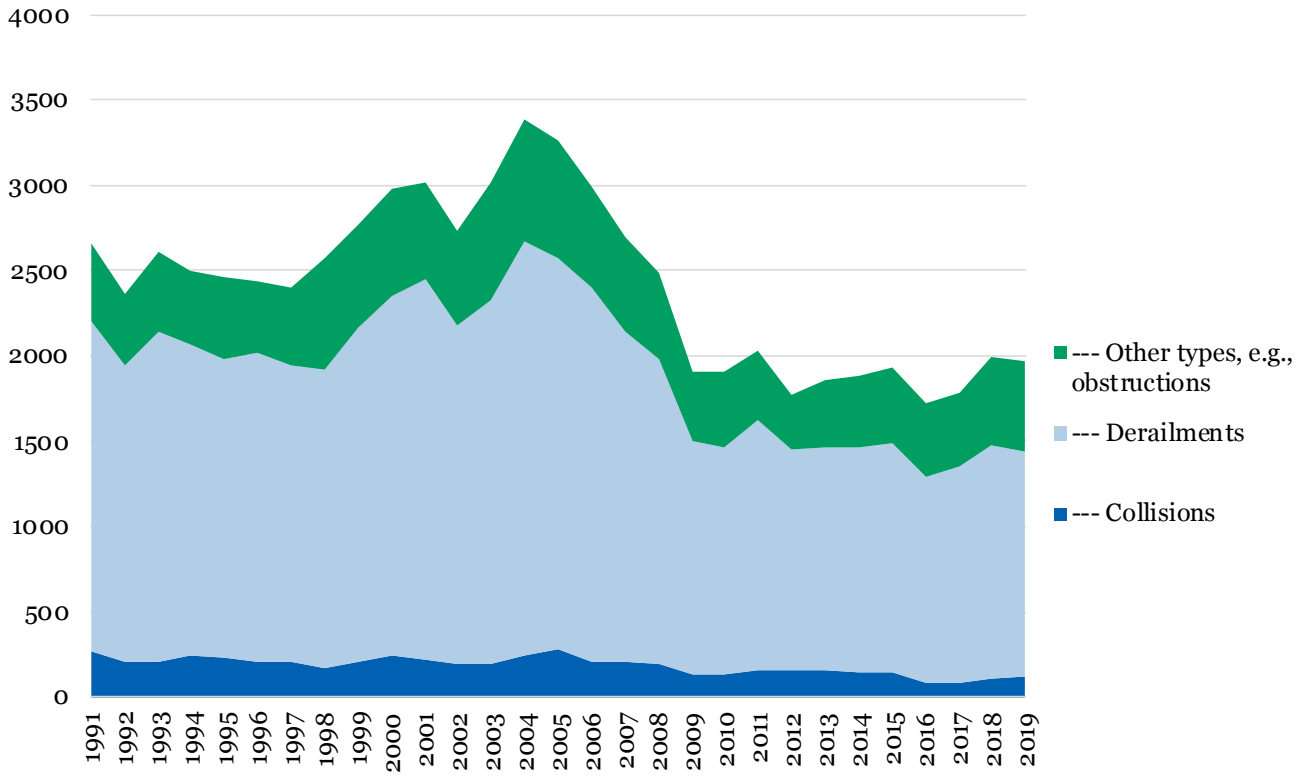
The literature consistently finds that restricting trains' speeds in areas with high-traffic grade crossings could help reduce injury severity, reduce the time it takes trains to stop, and help lessen the instance and severity of trespasser strikes (which tend to occur within a mile of grade crossings). But such restrictions would affect passenger and freight timetables as well as operational fluidity. Reducing road speed limits around grade crossings would similarly help, but to be most effective, reduced speed limits should be combined with other roadway engineering modifications that have been shown to make motorists slow down and pay more attention to oncoming hazards, such as narrower roadways, sharper turns, and speed humps.[152]

3.3 Train Accidents (Not at Grade Crossings)

Train accidents not at grade crossings are events such as derailments, train-train collisions, and other events that don't involve grade crossings or trespassers. Most of the events that FRA reports under this category are relatively minor, however when a train-train collision occurs, particularly with a passenger train, the results can be catastrophic.

The early 2000s saw a significant spike in train accidents, followed by a significant decline and then a relative plateau for the past decade, shown in Figure 7. 78 percent of all train accidents are on Class I freight railroads, similar to their proportion of the overall carload volumes. While train accidents account for more than 15 percent of incidents, injuries and deaths are relatively rare, with about seven fatalities annually over the past decade. But the data show significant spikes when there is a major incident involving Amtrak or a commuter train.

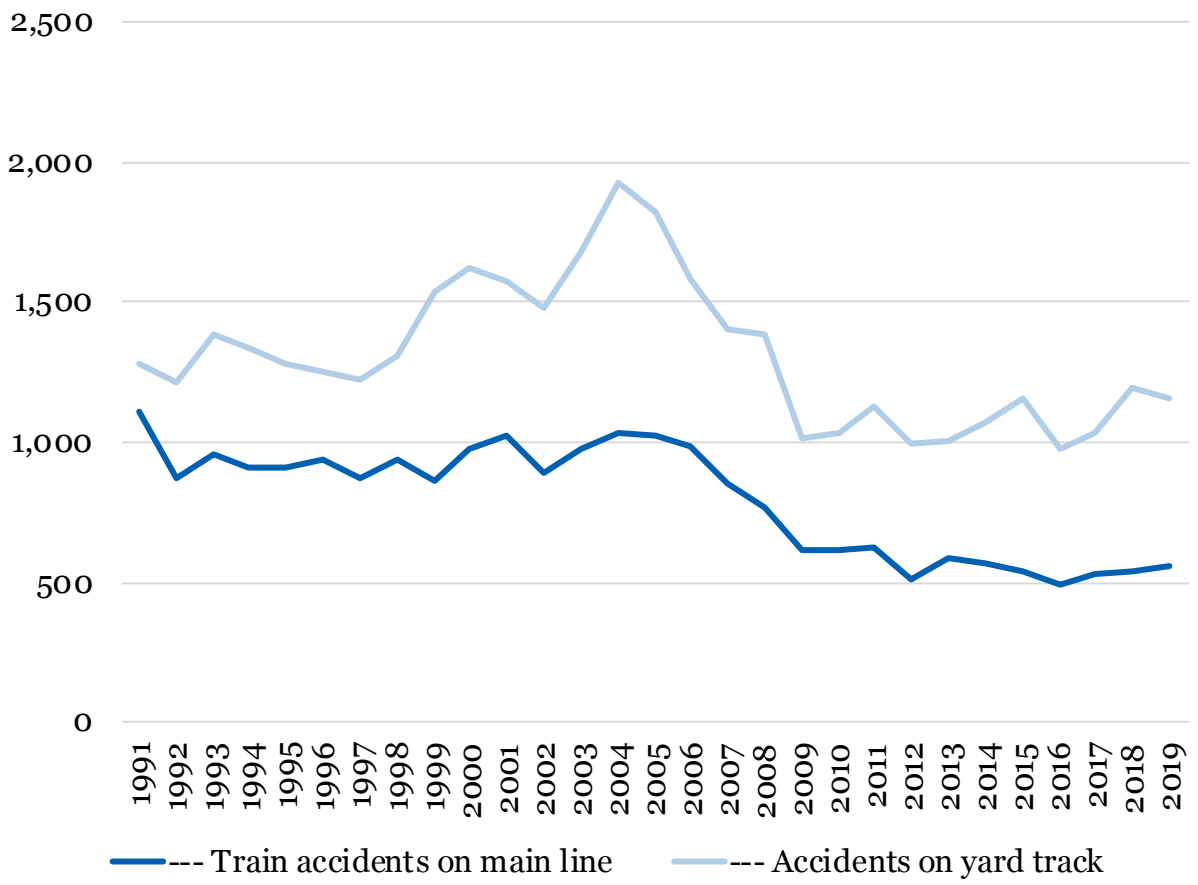
Figure 7: Train Accidents (Not at Grade Crossings) by Type



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

As shown in Figure 8, over 60 percent of train accidents (not at grade crossings) happen on yard track, meaning they are often low speed and not interfacing with the public or passengers. Commuter railroads and Amtrak have higher proportion of train accidents that happen on mainline track, but the data shows that derailments and collisions on passenger railroads are much less common than on freight railroads.[153] Still, more than four derailments happen somewhere in the United States every day.

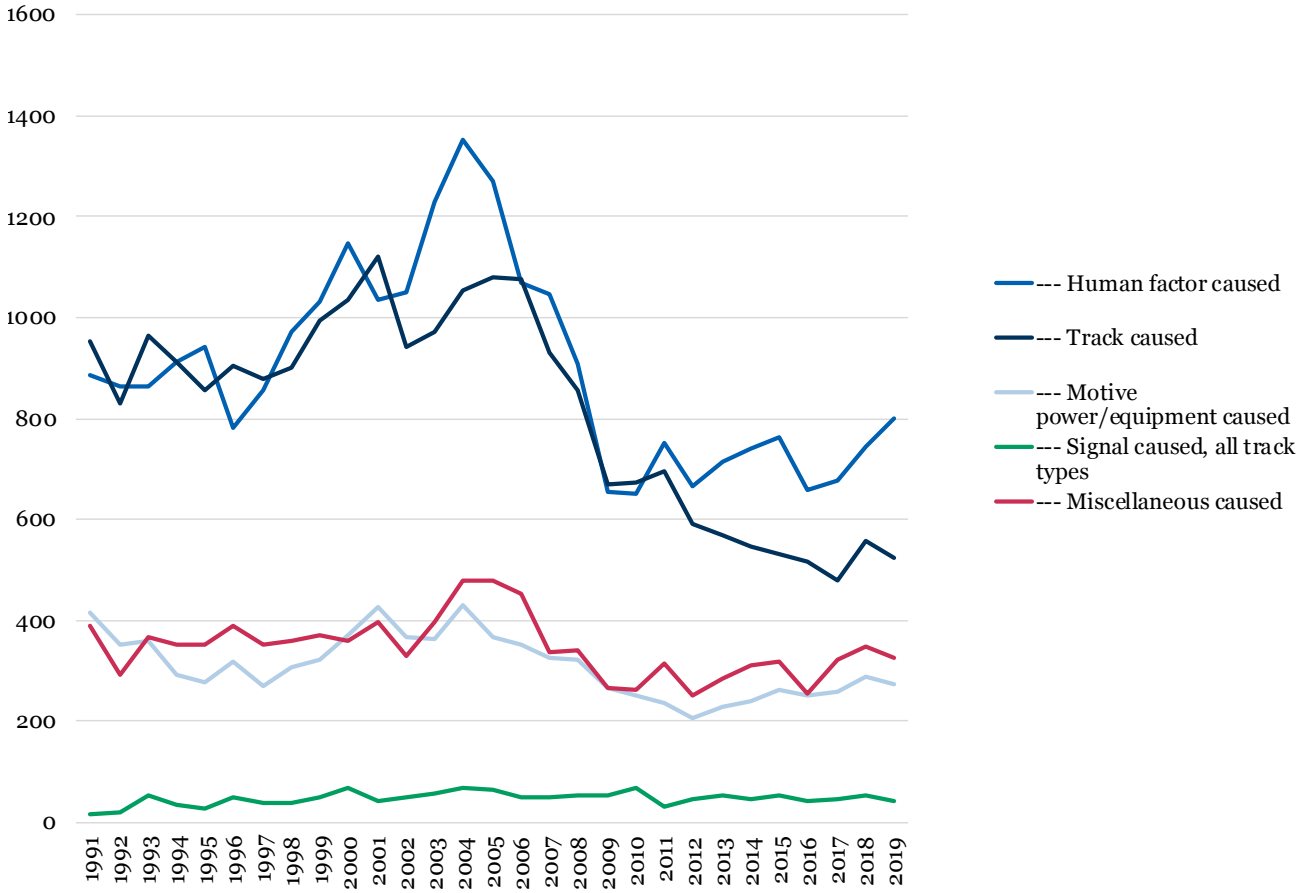
Figure 8: Train Accidents (Not at Highway Grade Crossings) by Location



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

Most train accidents are caused by human error, as shown in Figure 9. Problems with track, the second largest main factor, are declining. But recent increases in human error indicate a potential area for improvement. For example, positive train control, which has been fully implemented as of December 2020, is designed to reduce train-to-train collisions and overspeed derailments related to human error.

Figure 9: Train Accidents (Not at Highway Grade Crossings) by Cause



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

In 2008, the year of the Chatsworth, California collision that prompted Congress to mandate railroads install PTC technology nationwide, there were 27 fatalities and 318 injuries attributable to train-train collisions and derailments in the U.S. In 2019, with PTC in place on most of the trackage where it is required, there were just three deaths and 57 injuries due to train-train collisions and derailments.[154]

PTC is a networked computer system that steps in to take over a train's controls from the engineer to prevent signal and speed violations that could lead to collisions or derailments. It reduces the number of accidents due to excessive speed, conflicting train movements, and engineer failure to observe wayside signals. However, PTC does not prevent incidents due to trespassing or grade crossing collisions, which account for the vast majority of rail-related fatalities.[155]

PTC systems as implemented have provided most of the promised safety benefits (except that they are not required to, and do not, detect the rear ends of trains and thus do not prevent rear-end collisions), but at a high economic cost (approximately $14

billion over a decade, most of which railroads, both private and public, paid out of their own pockets without any operational benefits) and resulting in a reduction in train velocity across the U.S. rail network.[156] Locomotive engineers now tend to operate three to five miles per hour below the maximum authorized speed to avoid triggering a warning or brake application by the PTC computer. Further, not only must individual trains come to a stop when the on-board PTC computer needs to be reset, but a glitch in a railroad's back-office PTC computer can cause all traffic on the railroad's entire network to come to a halt until it is resolved.[157] Further safety improvements are still desired, along with the anticipated economic benefits of next-generation train control systems. The economic benefits can help defray the systems' ongoing maintenance costs.[158]

PTC has been on the National Transportation Safety Board's 'Most Wanted List' since 1990. FRA submitted a cost-benefit analysis of PTC to Congress in 2004, which concluded that its costs would outweigh its safety benefits but stated "we believe PTC will be more affordable in the future."[159] Railroads have implemented PTC as an overlay to their existing signal systems and operating blocks, therefore it delivers little to no business benefit to railroads. However, several railroads are developing and experimenting with next-generation train control systems that could replace existing signal systems.[160]

PTC does not refer to a particular technology, but rather to any number of possible technologies that provide certain functional behaviors. These systems are complex in nature and are made up of widely distributed physical, but closely coupled, functional subsystems, all derived from a single basic functional architecture that is enhanced and modified to serve each railroad's needs. The three major functional subsystems are the wayside system, the on-board computer, and the dispatch/control subsystem.[161]

Roughly 40 percent of all FRA-regulated U.S. trackage is 'dark territory' controlled solely via train orders and dispatcher instructions communicated primarily via two-way radio. In such territory, PTC has proven very effective at reducing mistakes made in the verbal read-and-repeat cycle and warns engineers to stop trains as they approach the end of their movement authority.[162]

PTC is now in operation on all 57,536 required route-miles of the FRA-regulated U.S. railroad network, ahead of the extended federal deadline of Dec. 31, 2020 (defined as all affected railroads having received at least conditional certification of their PTC systems from FRA). This is the culmination of more than a decade of work by FRA, the 41 freight and passenger railroads subject to the mandate, industry associations, suppliers, and other service providers.[163]

Absolute perfection of PTC is unrealistic and unobtainable. Even if it were feasible to determine all failure modes, the economics of engineering such a system would preclude its deployment. Thus, the regulations only require railroads to present a valid and demonstrable argument that a system is adequately safe for a given application within the given operational environment over the system's lifetime.

Communications-based train control (CBTC) would bring additional safety and business benefits beyond those that PTC currently offers, such as increased capacity and reduced fuel consumption. More advanced train control systems can enable railroads to run scheduled operations and provide improved running times, greater running time reliability, higher asset utilization and greater track capacity.[164] The safety benefits of replacing existing fixed-block signal systems with moving blocks governed only by PTC-enforced in-cab signals include the reduction in the amount of wayside signal equipment that is expensive to maintain, difficult to troubleshoot in remote areas, and prone to failure and to being disabled or interrupted by weather, vandalism and theft.[165]

There is currently no requirement that PTC systems be capable of detecting and alerting dispatchers to grade crossing warning system failures, vehicles blocking tracks, or trespassers. Such capabilities can, however, be incorporated into PTC or CBTC systems in the future. In advanced Levels 3 and 4 PTC systems, slide fences that can detect incursion of trespassers may be linked to the PTC system and may be able to prevent collisions.[166]

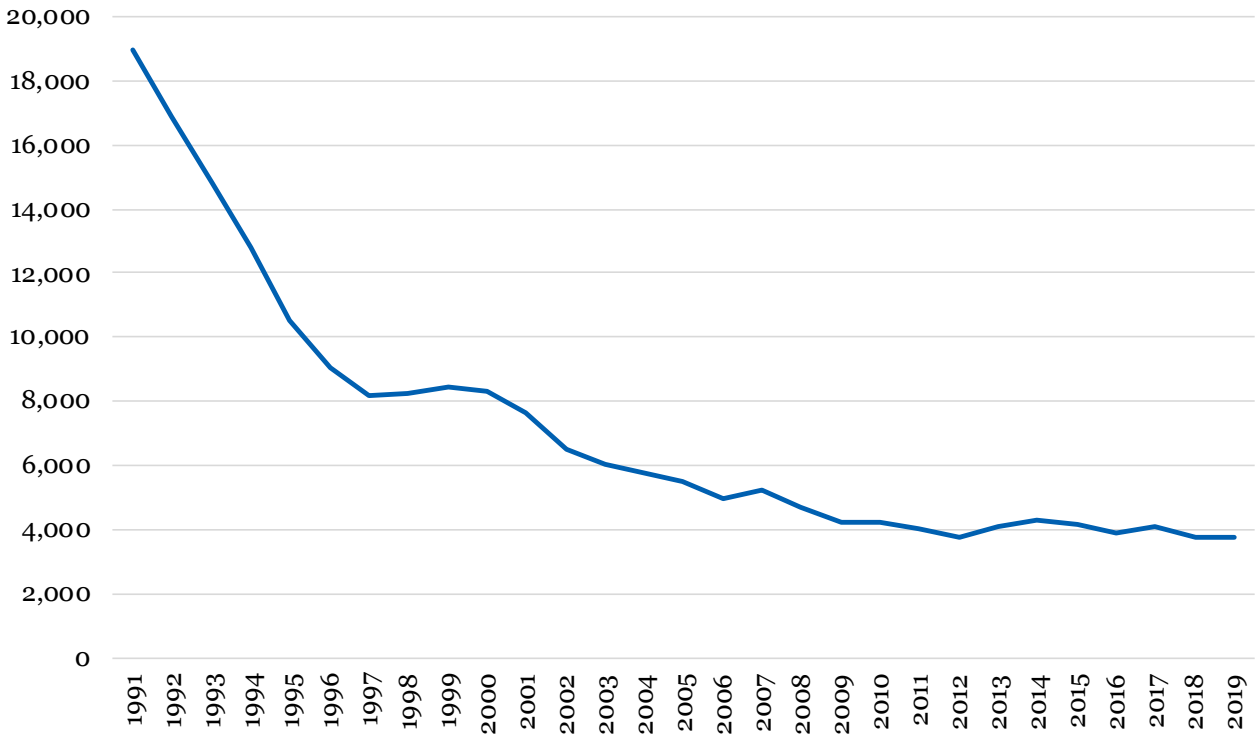
Safety is increased when a train's initial location can be established without human input that can be in error. If the potential for human error in providing a train's location to the PTC system exists, there is the potential for a train to enter a PTC-controlled segment of track where it has no movement authority, but another train does. The addition of a third satellite constellation would provide additional improvement in availability and reliability of train location over using GPS alone, or GPS with Galileo. US authorities are seeking approval to use a Russian satellite positioning system as part of the PVT solution for PTC. Highly accurate train location integrated with an end-of-train device also allows reverse or backup moves to be protected from train-to-train collisions.[167]

Finally, artificial intelligence (AI) represents a major area of potential improvement in the rail industry. Next-generation PTC systems are expected to make significant use of AI. AI can help railroads process and understand the vast quantities of data coming from sensors on locomotives, wayside equipment and other systems and easily put it to work to predict and prevent failures.[168]

3.4 Workforce Incidents

A railroad is an inherently dangerous place to work, with lots of ladders, heavy machinery, and complex, moving environments. Investments in safety and safety culture have produced a dramatic decline in incidents involving the workforce, with injuries declining from more than 19,000 annually in 1991 to fewer than 4,000 in 2019, shown in Figure 10. Fatalities have also declined, but the job still can be deadly: an average of 14 employees died on the job annually between 2009 and 2019.

Figure 10: Nonfatal Employee on Duty Injuries, All Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

Class I railroads have the lowest rates of workforce injuries, measured by incidents per 200,000 hours worked (see Table 1). While the overall trend is down, passenger railroads have had more difficulties with workforce injuries. Amtrak and commuter rail employees are three times more likely to be injured on the job than their freight railroad counterparts, which may be explained by differing job functions, tasks, and responsibilities.

In most organizations, there is a simultaneous trade-off and correlation between safety, efficiency (regarding cost considerations), quality, and service reliability, all in the context of a system with limited capacity. It is impossible for a railroad to have 100 percent safety among its workforce, and certainly not at a realistic price. Procedures that

are implemented to improve safety, if put in place reactively in a panic, may not actually improve safety and may impair effectiveness and performance, thus promoting a culture of violations.

A 2008 survey of railroad maintenance of way workers showed that management safety, coworker safety and work-safety tension were all significantly associated with safety behavior. Of these three factors, work-safety tension (the tension felt when working safely is perceived to be at odds with effectively performing one's job) has the greatest impact on safety behavior. The survey also found that management attitudes towards safety did not reliably dominate coworker safety as a predictor of unsafe behavior. The researchers speculate that work-safety tension may be of distinct relative importance because it indicates an employee's perception of the inherent level of tolerance for risk in the work environment and thus the extent of his or her ability to perform the job safely.[169]

Another 2008 study of the rail industry found that most documented safety violations were regularly occurring activities "often going unnoticed or even tolerated by authority." Even though the individual employee has a role to play, the organizational environment largely determines the relevant attitudes, beliefs, and perceptions of safety.[170]

There is no widely agreed definition of the term "safety culture," but it can be understood to be the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior. Organizations with a positive safety culture are characterized by communication with mutual trust, shared perceptions of the importance of safety, and confidence in the efficacy or preventative measures. Each organization with a safety culture problem will need to assess its own problems.[171]

FRA's vision that PTC effectively protect workers on the right-of-way from being hit by trains that violate a speed restriction or the signals of a work crew foreman has yet to be achieved, as the process for protecting workers from errant train movement is still highly prone to human error. PTC's ability to prevent trains from entering established work zones without authority and verification from the dispatcher or work crew foreman is still dependent on the foreman giving verbal permission that is then acknowledged by the train crew on a cab display screen. After acknowledgment, the in-cab display still shows maximum authorized speed, even if the speed limit in effect was reduced due to track work.[172]

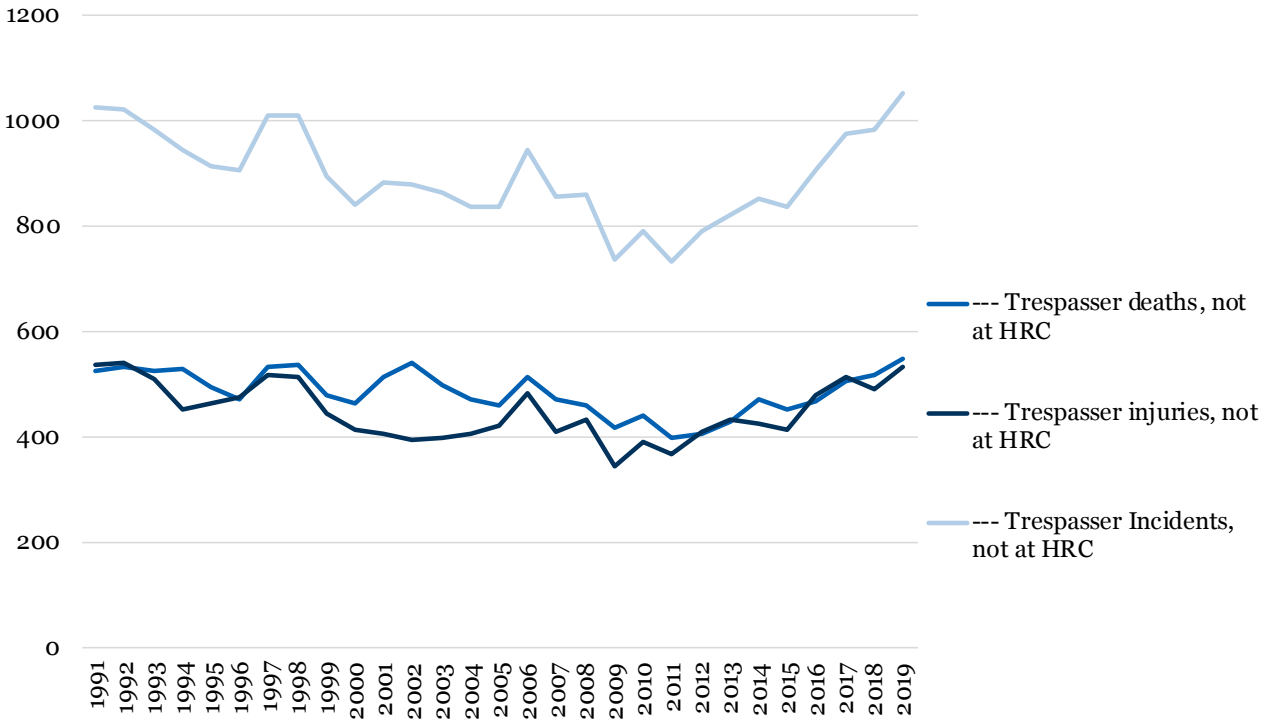
Track workers continue to deploy on-track equipment on unauthorized tracks with catastrophic consequences. PTC with more accurate GPS sensors can ensure that on-track equipment is deployed in the correct location and display where trains and track

workers are located, with alerts and warnings if the wrong location is detected. This technology already exists.[173]

3.5 Trespassing

Trespassing represents a small portion of the overall incidents, but accounts for 63 percent of the fatalities associated with railroads (see Figure 4). After a slow, two-decade decline in incidents, injuries, and fatalities, trespassing incident numbers have increased rapidly over the past 10 years, as shown in Figure 11. Trespassers enter railroad property for myriad reasons, including because it may be the most direct route to their destination on foot or to spray graffiti (a topic which is often unreported).

Figure 11: Trespasser Incidents, Injuries, and Deaths, All Railroads



Source: Eno analysis of FRA's Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview" data portal

Examining trespassing injuries and fatalities by state shows significant variation between rates, shown in Table 4. Georgia has the highest rate of injuries and fatalities adjusted for population, and California, Colorado, Florida, and Oregon have high rates and troublesome trends (indicated in Table 4 in **bold orange**). Meanwhile, Massachusetts, Michigan, Minnesota, and Washington all have relatively low and declining rates (indicated in Table 4 in *italicized green*).

Table 5: Key Trespasser Safety Metrics, All Railroads

	Nonfatal Trespassing Incidents, 2019			Trespasser Fatalities		
	2019	% Change from 2009	Rate per million population	2019	% Change from 2009	Rate per million population
Alabama	9	50%	1.83	9	29%	1.83
Alaska	1	+100%	1.37	0	-100%	0.00
Arizona	18	50%	2.43	12	50%	1.62
Arkansas	9	29%	2.97	4	+100%	1.32
California	96	140%	2.44	135	187%	3.43
Colorado	11	267%	1.89	7	250%	1.21
Connecticut	5	25%	1.41	3	0%	0.84
Delaware	0	-	0.00	0	-100%	0.00
DC	0	-100%	0.00	0	-100%	0.00
Florida	33	313%	3.08	37	95%	3.45
Georgia	17	21%	12.08	14	40%	9.95
Idaho	0	-100%	0.00	1	-50%	0.55
Illinois	20	-13%	1.59	27	35%	2.14
Indiana	8	-43%	1.18	9	-36%	1.33
Iowa	4	0%	1.26	6	100%	1.90
Kansas	9	13%	3.09	3	-25%	1.03
Kentucky	12	71%	2.68	9	80%	2.01
Louisiana	8	60%	1.72	6	-40%	1.29
Maine	0	-	0.00	1	0%	0.74
Maryland	11	267%	1.82	7	40%	1.16
Massachusetts	7	250%	1.02	5	-55%	0.73
Michigan	2	-50%	0.20	3	-63%	0.30
Minnesota	5	0%	0.88	5	-50%	0.88
Mississippi	4	-20%	1.35	3	-50%	1.01
Missouri	5	-29%	0.81	11	0%	1.79
Montana	1	0%	0.93	3	0%	2.78
Nebraska	8	33%	4.13	5	67%	2.58
Nevada	10	400%	3.19	6	+100%	1.91
New Hampshire	2	+100%	1.46	0	+100%	0.00
New Jersey	11	22%	1.24	10	-47%	1.13
New Mexico	5	25%	2.37	5	-50%	2.37
New York	14	-33%	0.72	13	-28%	0.67
North Carolina	12	-14%	1.13	18	20%	1.70
North Dakota	1	+100%	1.31	2	+100%	2.61
Ohio	14	100%	1.20	16	-27%	1.37
Oklahoma	5	25%	1.26	11	57%	2.76
Oregon	8	60%	1.89	13	225%	3.06
Pennsylvania	24	50%	1.88	25	-17%	1.96
Rhode Island	0	-	0.00	1	-67%	0.95
South Carolina	11	267%	2.11	11	83%	2.11
South Dakota	0	-100%	0.00	0	-100%	0.00
Tennessee	21	163%	3.05	12	200%	1.74
Texas	56	81%	1.91	43	39%	1.46
Utah	4	300%	1.23	3	200%	0.92
Vermont	1	100%	1.60	0	-	0.00
Virginia	5	-29%	0.58	15	114%	1.75
Washington	8	14%	1.04	12	-14%	1.56
West Virginia	11	175%	6.16	4	-20%	2.24
Wisconsin	2	-50%	0.34	4	300%	0.69
Wyoming	3	200%	5.15	0	-100%	0.00
TOTAL	531	54%	1.62	549	32%	1.67

Source: FRA Safety Analysis Database, 2021, US Census Bureau July 2020 Estimates

Most fatalities on U.S. railroads are of pedestrians on the right of way not at a grade crossing, though only a very small percentage of railroad trespassers are killed. About 30 percent of fatalities are of individuals who intentionally took their own lives, while the remaining 70 percent are people who trespass on railroad property for a variety of reasons. Railroad trespassing collisions claim around 500 lives annually and cost society about $43 billion between 2012 and 2016.[174]

The benefits of reducing trespassing accidents can be measured in lives saved, injuries reduced, and train delays avoided. A fatal trespasser strike, suicide or otherwise, halts train traffic on the affected line by an average of four hours. Operating a train that strikes a pedestrian psychologically affects even the most experienced locomotive engineers so much that many are unable to continue work afterwards. This adversely impacts the railroad's labor and training costs as well as its overall safety, as more experienced engineers get replaced with less experienced ones.[175]

Trespassers can be divided into four broad categories, assisting in the appropriate targeting of countermeasures:[176]

1. **Loiterers**: Constituting about half of all US rail trespasser casualties, this segment of society probably gravitates towards railroads because one can do things on railroads that one cannot do in public parks or parking lots where they would be in full view of the street and exposed to citizen complaints or law enforcement intervention. The fact that many parts of railroad property are poorly illuminated, not routinely surveilled, and obscured by vegetation or fencing increases the attractiveness of railroads to this segment of trespassers. This category includes people experiencing homelessness who sleep, camp or spend significant amounts of time near tracks or on railroad property.
2. **Suicides**: This category accounts for about 30 percent of all US rail 'trespasser' fatalities.
3. **Those looking for transportation**: While the number of people who hitch rides on freight trains is much lower than it was in the early 20th century, there is a problem of undocumented immigrants hopping freight trains and using railroads as migratory pathways in the Southwestern states. Mitigation strategies targeted to this population need further study.
4. **Everyone else**: This category comprises most trespassers but only about 18 percent of trespasser casualties. It includes people crossing tracks as the quickest way to get from point A to point B on foot (who constitute the majority of this category) as well as thrill seekers and those looking for a unique setting for photography, in addition to people experiencing homelessness who do not sleep on or near railroad property, but cross or walk along tracks frequently to access food and other services.

Trespassing is a much smaller issue than it used to be—the per capita risk of trespasser strikes by trains in the US was 35 times greater in 1905 than in 2005. The annual trespasser casualty rate has remained relatively stable in recent decades despite train traffic and population size having increased. This can be attributed largely to the tendency of growing affluence to reduce risk-taking behavior.[177]

Regardless, safety incidents with trespassers remain a consistent problem and are concentrated at certain locations and among specific demographics. 74 percent of trespasser deaths and injuries occurred within a quarter mile of a grade crossing, and 14 percent occurred in just 10 counties in four states. Railroad trespassing is far more likely to result in death (50 percent of known trespassing incidents ended in fatalities) compared to grade crossing collisions, which have a fatality rate of about 20 percent.[178] Trespasser fatalities most often involved a passive action like lying down, sitting, or standing, while injuries most often involved active movement like running, jumping or walking. Trespassing incidents occurred more often on weekends than suicide incidents, particularly when a passenger train was involved.[179]

The statistical average railroad trespasser in the U.S. is a white male with an average age of 38 and of low socioeconomic status. FRA believes that many in this demographic are intoxicated at the time of trespassing.[180] Individuals involved in trespassing incidents are most likely to be renters in second-tier cities with lower income and education levels, whereas a small but significant subset are from more rural or isolated areas who are likely to be less socially engaged and may enjoy being removed from urban areas.

Safety issues related to railroad trespassing and suicide are interrelated but should be treated separately since the victims have different characteristics and motivations. Pre-incident countermeasures for suicides should be different from those for other trespassers to avoid undesirable unintended consequences. Measures targeting trespassing may ultimately have a different or unexpected effect on suicide occurrence.

As with other types of rail trespassing, there is no 'one size fits all' solution to rail suicide. Most measures aim only to change the environment or deter risky behavior; little research has been done on efforts to encourage behavioral change or support correct decisions. There is also no universal way to classify existing measures based on the mechanisms underlying their effect.

At least 52.4 percent of all trespassing incidents reported between 2005 and 2010 involved alcohol and/or drugs, down slightly from FRA's 2008 report. The majority of those involved alcohol; about a third involved drugs; and about a quarter involved both. 23.3 percent of trespassers killed during that period were walking or standing on the track, while 19.9 percent were sleeping, lying, reclining, lounging, or sitting. Alcohol is

much more likely to be a factor in non-suicide fatalities than in suicides, but the incidence of drugs is consistent across both fatality types.[181]

Suicides tend to take place after 8:00 PM, while non-suicide strikes are most common in the early morning (before dawn), on weekends and during common evening commute times. Factors that influence people to trespass on railroads include alcohol, drugs, depression and other mental illness, and lack of knowledge and appreciation of the dangers of the railroad environment and/or the illegality of trespassing.

At least 30 percent of all fatalities on US railroad property result from an intentional act of suicide, but railroads are the means of less than one percent of all US suicides. 73 percent of all suicide attempts on railroad property occur within one quarter mile of a grade crossing. 76 percent of rail suicide victims lived within one mile of the site of their death, indicating that track availability is one of the strongest precursors to completed rail suicides.[182]

About 90 percent of U.S. rail suicide victims are adult males, the vast majority being between the ages of 20 and 49, 80 percent being unmarried, and 45 percent having graduated from high school. Only 10 percent are classified as transients; 80 percent of deaths occur in the victim's county of residence. Less than one quarter occurred outside city or town limits. Alcohol appears to be involved in most cases. Localized studies have found African Americans and Native Americans to be overrepresented among rail suicide victims compared to their percentage of the local population. In 85 percent of cases, there was no fence protecting the railroad right of way.[183]

In U.S. studies conducted between 2007 and 2010, railroad suicide decedents were found to exhibit considerable predisposing risk for suicide, with high prevalence of severe mental disorders and substance abuse, and displaying acute risk factors like suicide ideation, hopelessness, anxiety, and anger. 96 percent had at least one confirmed mental disorder, a substance abuse disorder, or both. 94 percent had experienced a job or relationship loss. The majority were either unemployed or employed insufficiently to provide any long-term security.[184] Greater wealth and older age tend to increase the likelihood of railroad suicide but decrease the overall likelihood of suicide.[185]

The percent of all suicides that are undertaken on railroads in the United States is very low compared to most other countries. One likely reason for this is the widespread availability of firearms in the United States. The US rate of suicide by firearm is more than eight times that of other wealthy countries,[186] while 78 percent of railroad suicide victims did not have access to a firearm at the time of their death.[187] Access to a firearm

and the proximity of a railroad to the victim's residence are the major factors in the choice of rail as a means of suicide.

Finally, vandalism and graffiti on railroad property have significant impact on railroads, the patronization of passenger trains, expenditures to remediate occurrences, and punctual operation, and carry social costs stemming from passengers feeling unsafe and the environmental costs of removing graffiti and repairing vandalism. Graffiti tagging is largely motivated by the desire to say "I was here." While the physical environment may determine the place of crime, the social environment provides the reason for committing it.

There is no evidence that those who graffiti also commit other common acts of vandalism (some consider graffiti to be a form of vandalism, while others do not), or for any significant relationship between graffiti and potential or actual violence. Nevertheless, the common perception that a greater presence of graffiti means a higher risk of crime persists.

Addressing trespassing safety issues typically involves the FRA's "three E's" policy framework: engineering, education, and enforcement. Within these, new technologies, systems, components, and education and enforcement initiatives that have the potential to decrease rail trespassing.

3.5.1 Engineering

Each local trespassing and suicide problem must be addressed individually based on local needs -- there is no single 'magic bullet' countermeasure that works everywhere nationwide. While measures to prevent people from entering the track area in the first place differ between suicidal individuals and other trespassers, the possible countermeasures to be taken after a person reaches railroad property are the same. Thus, at some point in the prevention process, trespassing and suicide can be treated as a single problem, a point bolstered by the fact that suicidal intent is not always clear or easy to prove.[188]

Below are brief discussions of types of engineering countermeasures to prevent railroad trespassing:

Urban planning: Given that a significant number of fatalities occurred near homeless shelters, schools and food pantries, the lack of grade crossings on large track segments contributes to trespassing for convenience, as does the presence of mid-block bus stops. Moving bus stops and other facilities closer to grade crossings could be a viable strategy.[189] Alternatively, localities could create new, safe crossings at areas where pedestrian demand to cross railroad property is high.

Fencing was already installed at most locations surveyed by FRA; the assumption was that trespassers are climbing or finding gaps in fences.[190] While a study in Finland found that fencing reduced trespassing by 94.6% from 2006 to 2007,[191] the high cost of installation and maintenance makes it one of the least cost-effective solutions to the trespassing problem. Fencing is best limited to areas where incursion is most likely. To be effective, fencing should prevent access from all sides, and the installing railroad should have a policy that strongly supports fencing.[192] A 1998 study found that installing and maintaining fencing in urban areas would be marginally justified on a cost-benefit basis based on the number of fatalities expected to be averted.[193]

A 2015 literature review found that the most effective means of preventing rail suicides in Europe, North America and New Zealand were fencing and other physical barriers, along with media reporting guidelines. Installing structural means of restricting access to bridges in nine locations reduced the number of deaths by jumping greater than the rate of increase at neighboring sites, while the removal of barriers to a bridge in New Zealand resulted in a fivefold increase in the rate of suicides by jumping from that bridge.[194]

Clearing vegetation and greater lighting: While railroads are private property, they are easily accessed, and the risk of law enforcement is very low. Vegetation usually shields rights of way from public view and local police tend to have no jurisdiction and little interest in removing trespassers. For the 'loiterer' segment of trespassers who are attracted to railroads because they are out of public view, fencing may prove counterproductive as it further shields the right of way. Clearcutting vegetation and installing more lighting may be more productive.[195]

Restricting train speeds and frequencies in areas with high observed levels of trespassing may help, but further study is needed and the operational impact on the railroad could be significant.[196] On rail lines in the Netherlands and Germany where train frequencies were reduced between 2000 and 2007, the rate of rail suicides decreased.[197]

Installing screen doors on passenger train platforms is very effective at deterring both suicide and trespassing but must be limited to areas where access is tightly controlled and not at street level. Installing platform screen doors at 30 train stations in Hong Kong reduced railway injuries by 68.8 percent and suicides by 59 percent, with no apparent substitution effect to other means of suicide.[198] Their use is very rare in the US, confined mostly to airport people-mover systems.[199]

Signage is a relatively low-cost measure but must be paired with other measures to maximize its potential. Signage is not likely to be effective unless the would-be

trespasser perceives a real chance of being detected and prosecuted. Help-seeking signage may not be the best tactic to prevent suicides for several reasons.[200]

Better technology for detecting the presence of trespassers, including in-ground detectors and drones, could save lives, and the cost of these technologies should go down with time, but only if the system notifies responsible railroad personnel in time for remedial action to take place.[201] One promising area of development is **artificial intelligence-aided trespasser detection**, deploying an AI algorithm to screen existing closed-circuit camera footage, perhaps coupled with a live alert system. The highway and aviation industries have had some success with AI-aided surveillance. Learning from AI analysis of trespasser behavior can inform education, enforcement, and engineering solutions.[202]

Automated trespasser detection and warning systems: When such a system was installed on a railroad bridge in Pittsford, NY in 2001, the number of observed trespassing incidents dropped 60% from the first to the second year and 17% from the second to the third year.[203]

Measures to influence the determination of those intent on suicide while awaiting a train: A literature review lists this as a broad theme among prevention strategies, but does not elaborate further or list examples of specific measures that meet this definition.[204] Presumably this would involve communicating with a person intent on suicide who is on or about the tracks and appears to be waiting for a train to come with the intent of dissuading them from completing the suicide, either by dispatching a railroad official or first responder or using loudspeakers. This would depend on others or loudspeakers being nearby, and on the person communicating with the victim being properly trained to defuse or de-escalate such situations.

NCDOT and ITRE Rail Trespass Project (2020)

From 2017 to early 2020, a team with the Institute for Transportation Research and Education at North Carolina State University (ITRE) collected data samples at 11 locations across North Carolina's rail network using the Access Thermal Camera System, using these data to develop models to estimate and forecast trespassing events by location as well as a prototype tool for presenting the data in a user-friendly manner. The camera system was programmed to differentiate between apparent human pedestrians and things like fast-moving birds, waving vegetation and motor vehicles at grade crossings, but all event data was manually reviewed. Its goal was to get a better sense of the frequency of railroad trespassing in North Carolina, particularly of incidents not captured in the FRA database, which only captures events involving injury or death. Such a system would not be practical for real-time notification of railroad officials due to the high number of false positives -- more effective systems for this purpose are under development.

By collecting observational data 24/7 for at least one week during each season of the year at these 11 locations, the study produced a representative sample of pedestrian trespassing activity. The study found that trespassing frequency is much greater than that indicated by FRA reporting. The only missing piece is qualitative data, such as trespassers' motivations, trip patterns, etc. This study was only able to generate limited profiles from the camera counts and pair it with anecdotal evidence from community members. Also missing is identification of where there are and are not safe alternative routes for pedestrians to cross the tracks.

The study revealed that most trespassing events are short in duration and involve individuals crossing tracks perpendicularly rather than walking along the right of way. Most observed events occurred during daylight hours at consistent volumes across days of the week and month to month. According to the researchers, the profile of the average trespasser in North Carolina is probably inconsistent with the profiles shown in FRA incident data.

The researchers estimate that the total cost to install one thermal video camera system at one location is about $8,600, with maintenance costing about $400 per maintainer's visit (mostly labor), adding up to about $1,600 per location per year, excluding the costs of video production and post-processing. Thus, the grand total first-year cost of a thermal camera system is roughly $10,000 per location. ITRE recently developed a cost estimation tool to determine the comprehensive cost of rail incidents in North Carolina, whether resulting from an individual event or to aggregate costs over specific periods.

NCDOT is not making the cameras permanent beyond the one-year study period. The cameras alone are not intended to be a trespassing deterrent – they are simply a research tool. The predictive models that the team developed will be part of a Trespass Awareness Outreach Workshop to be delivered to politicians, law enforcement, safety departments and other stakeholders in North Carolina.

Further research is needed to determine the reasons and motivations behind railroad trespassing. Limited research exists that focuses on interviewing and surveying trespassers about their motivations and perceptions of the safety and legality of the act. Trespasser survey data is needed at the case study level so that FRA, NCDOT and local governments can construct a better picture of trespassing activities that do not result in death or injury.

3.5.2 Education

Most railroad trespassers interviewed in 2017-2018 said they knew they were illegally trespassing, yet did so anyway, suggesting that there may be a limit to education efforts as a means of deterring such behavior. Education might want to focus on the common misperception that someone on or about railroad tracks will always be able to hear a train coming in time to avoid it, and on the dangers of being distracted by wearing headphones or looking at smartphones, and of being under the influence of alcohol or drugs, while on or about railroad tracks.[205] Distraction and sensory deprivation resulting from greater use of devices with noise-canceling headphones or earbuds poses a very high risk to railroad trespassers.[206]

Education efforts targeted at schools and other congregate facilities located near railroad tracks are effective, as evidenced by a study at an Auckland, New Zealand school where trespassing over a nearby railroad significantly decreased following educational programming at the school and decreased even further when repeat offenders were punished. However, the mere placement of billboards near the platforms and leaflets and posters in the school did not decrease trespassing. The later installation of fencing around the railroad at this location had an even greater deterrent effect.[207]

For the population segment that loiters on railroad property, research suggests it may be productive for Operation Lifesaver to conduct educational activities at soup kitchens, taverns or other facilities located near railroad properties where loitering is common.[208]

Some researchers suggest a more education-centered alternative to FRA's three E's approach that would vary based on the entity providing the countermeasure and on the mode of implementation. This approach would focus attention on the person who trespasses and base countermeasures on that person's decision-making process.[209] One model for such an alternative approach, which was developed by European railways in 2014, is the RESTRAIL (REduction of Suicides and Trespasses on RAILway Property) Toolbox. This is a problem-solving guide for implementing suicide and trespass prevention measures and to mitigate consequences after incidents. The five steps of the RESTRAIL Toolbox are:[210]

- **Selection of countermeasures following a comprehensive analysis of the local situation**: Is trespassing localized to specific 'hotspots' or more generalized along a rail line? What are the reasons most people are trespassing? What are the characteristics of the trespassers and the surrounding area?
- **Determination of which countermeasures to pursue**: Organizational/procedural (i.e., patrols and targeted punishment of offenders), physical/technological (i.e., detection and surveillance), or public awareness/education (including reporting suicide incidents differently from other trespassing incidents).

- **Development of an implementation plan**, considering practicality, finance, stakeholder commitment and plans for ongoing evaluation.
- **Implementation** of chosen measures.
- **Evaluation of the outcome**, collecting data on both expected and unexpected outcomes and making any changes to the plan while documenting lessons learned.

Commuter railroads have been particularly successful at ingraining safety messages in their captive audiences through signage on trains and at stations. New Jersey Transit and Chicago's Metra have particularly noteworthy anti-suicide campaigns.[211] All OLI materials are now offered in both English and Spanish, and some materials are available in Navajo to target a recent uptick in trespassing on the BNSF Railway mainline near the Navajo Nation in New Mexico.

OLI started a campaign in 2020 to promote more helpful media reporting guidelines for rail suicides, thanks to grants from the Posner Foundation of Pittsburgh. Subject matter experts from the Volpe National Transportation Systems Center and the Federal Railroad Administration's Office of Research and Development served on the working group created these important materials. [212] OLI is also part of a global suicide prevention organization that works closely with the Volpe Center. There is a new focus on suicides within OLI as the national suicide rate rose during the pandemic, and one of OLI's next projects is to educate service providers working with the homeless population – many of these are located near railroad tracks. Some state OL programs also partner with mental health providers in their communities as well as food banks, as there has shown to be a correlation between the locations of rail suicides and those of mental health facilities.[213]

When it comes to rail suicide, media reports that include specific descriptions of locations and images that oversimplify suicide or glamorize the victim, that use the word "suicide," and that include images of trains can lead to copycat behavior. Instead, media reports should refrain from sensationalism and include the phone numbers or websites for organizations that help people who are contemplating suicide.[214] Extensive media coverage of a rail suicide in Germany in 2007 increased suicidal behaviors by 44 percent, while the introduction of media guidelines in Vienna, Austria in 1988 decreased subway suicides there by approximately 62 cases.[215] FRA and the Volpe Center in 2017 began a pilot program working with rail carriers to evaluate a strategy for improving media reporting, focused on the Northeast Corridor.[216]

Germany saw a significant fall in the rate of rail suicides compared to the general suicide rate in the four years following the implementation of an education-focused national prevention project in 2002.[217] The project involved the combination of a public awareness program, media reporting guidelines (see above), hotspot analyses, and the

introduction of a rule to avoid using the term "suicide" in passenger announcements about train delays caused by suicide incidents.[218]

Public and professional education and training programs focused on observed and observable warning signs of suicide may increase detection, referral, and treatment of individuals at risk. The literature describes a potentially identifiable population of at-risk individuals that could be better served and targeted for prevention programs that focus on social system interventions. For one example, FRA in April 2021 awarded a $59,000 grant from its Trespassing Suicide Prevention Grant Program to Metrolink, the Los Angeles-area commuter railroad, to address suicide prevention through outreach and training of key railroad staff, first responders and community members. The project, guided by a team of psychologists, will last 12 months. Most of the suicides within Metrolink's system between 2017 and 2019 occurred at three hot spots.[219]

3.5.3 Enforcement

Trespassing in the U.S. is a law enforcement issue governed by state and local law, which limits FRA's ability to address the issue directly. Localities tend to focus their finite law enforcement resources on higher-priority issues like homicides, drugs, and highway crashes. Thus, trespassing is rarely prosecuted, which reduces the perceived negative consequences of trespassing. Not all states treat acts of trespassing the same under their laws. In most states, it is a misdemeanor punishable by fine and/or imprisonment, but some have carved out exemptions holding railroads liable if they have failed to stop the public from traveling over the track at a specific location for a considerable period of time and a sizable number of people have done so.[220]

FRA says states should encourage law enforcement to enforce trespassing and vandalism laws more vigorously and judges should be encouraged to issue sentences that more effectively discourage dangerous and illegal behavior. Since these are matters of state law, it would be up to governors or state agencies to influence police and judges. FRA says prosecutors should encourage local police to partner with railroad police to help identify trespassers and vandals and make arrests – police will be more motivated to make these arrests if they know that these cases will be prosecuted. FRA has provided model state legislation covering railroad trespassing and vandalism.[221]

Another factor is that most Class I railroads' police forces have shrunk dramatically since 2015 as shareholders have pressured them to cut costs. CSX, for example, has only 166 special agents covering 26 states after a major downsizing in 2017.[222]

Transportation Security Administration funding for surveillance and sensors along tracks was shown to be helpful in identifying high-risk areas for trespassing in Los Angeles.[223] However, if increased surveillance is to be effective, railroads and/or law

enforcement must be committed to dealing with individuals once they are identified, which could be labor-intensive and expensive and thus should be limited to known hotspots or known high-risk times of the day or week.[224]

According to a 2016 report, when law enforcement personnel participate in rail safety, the number of risky behaviors occurring along railroad rights of way, including trespassing, is reduced.[225] Thus, better education and training of law enforcement personnel in railroad trespassing and suicide intervention would be helpful. Another researcher concludes that more robust, evidence-based measures aimed at improving public health, particularly with regards to mental illness and addiction treatment, would be more productive than railroad-specific anti-trespassing measures.[226]

Comprehensive approaches to combating vandalism and graffiti on railroad property are founded on a thorough understanding of local graffiti culture(s) and the behavior and movements of individuals within that culture. Further ethnographic research is needed into graffiti writers and gangs' motives and cultural significances beyond those commonly associated with graffiti.

A team of researchers exploring railroad graffiti and vandalism internationally recommends encouraging and facilitating ownership and involvement at the community level.[227] In one experiment in San Diego, youth were engaged in graffiti prevention through a joint youth bike patrol in popular tagging sites, and local students were recruited to paint positive murals over highly tagged walls. The program led to a 90 percent reduction in reports of graffiti and a 30 percent reduction in offending by taggers who underwent counseling. This kind of approach helps break down an 'us versus them' mentality whereby offenders believe their actions only affect others, not themselves.

In Germany, offenders caught spraying are required to remove their own graffiti.[228] This technique has proven to make perpetrators less likely to reoffend by showing them the difficulty of cleaning graffiti and publicly embarrassing them, but further research is needed as to how it may be applied in other contexts like railroads.

Punitive measures against those who commit vandalism or graffiti have been found to be counterproductive as they provoke a rise in anti-government graffiti.[229] However, youth education efforts about the consequences of graffiti in the United Kingdom have enjoyed considerable success. Research has shown rapid graffiti removal programs to be ineffective when implemented on their own, as many graffiti writers consider removal as part of the process and rapid removal often leads to increased activity. [230]

Legal graffiti walls tend not to be effective because those not invited to participate become jealous, and the walls send mixed messages to the public and graffiti writers about the status of graffiti as legal or illegal and the conflicting message that graffiti is art only when it is legal. Legal murals are only effective in very specific locations, in association with other interventions and with full awareness of their limitations.[231]

Another thing to keep in mind is that a combination of behavioral and engineering measures could be the most effective at deterring rail trespassing and suicides, but little is known about the effects of combining multiple measures into a single strategy aimed at reducing train-pedestrian collisions in specific circumstances. Only one study to have evaluated combined measures showed that this significantly improved the outcome. Engineering measures could create a first line of defense but might be more effective when supplemented with efforts to point toward the correct behavioral outcome.[232] One potential approach for this is for police, railroad officials or a research team to conduct intercept surveys at hot spots identified by cameras or train crews. For one example, starting in late 2016, the Greensboro, NC Police Department began collecting basic intercept survey data from trespassers encountered by police conducting patrols using all-terrain vehicles over a four-hour period at least once monthly.[233] This "eduforcement" program led police to engage with a number of homeless people along the city's busy rail corridor, building a good rapport with that community.[234] FRA has used Greensboro's program as the model for its Law Enforcement Strategies for Reducing Trespassing Pilot Grant Program, now in its third year of operation.[235]

Some of the reasons why little recent progress has been made in reducing trespassing and suicide incidents include the relative lack of publicly available studies on the effectiveness of various countermeasures, a lack of funds to implement countermeasures, a lack of local expertise to select and implement locally effective countermeasures, and the inability to implement a combination of tactics in concert with each other due to institutional silos, lack of communication between the public and private sectors and between different actors within each sector, and other organizational difficulties.[236] Another factor is that trespassers are not as easily identifiable a subset of the population as the (particularly young) automobile drivers most likely to be involved in grade crossing collisions.[237]

4.0 Key Takeaways

The most acute problems in railroad safety are with trespassing and grade crossing incidents, but most federal focus is on train accidents and crashes not at grade crossings.

Existing federal policy on rail safety has largely been successful. Dramatic declines in train crashes and safer workplaces for employees are the direct result in the rules, regulations, and mandates like PTC. Aside from addressing some specific issues such as persistent derailments in yards, significant further improvement will be challenging without immense expense.

On the other hand, trespassing and grade crossing incidents are trending in the wrong direction. Together these make up only 28 percent of total railroad safety incidents, but they comprise 97 percent of all deaths on the railroads.

While some federal policies and grant programs exist, more federal action is warranted in addressing the persistent and growing problems related to grade crossings and trespassing. For example, of the 19 most wanted and other recommendations from the NTSB, only two are tangentially related to grade crossings and trespassing. The federal grant programs directly addressing grade crossings and trespassing are relatively small.

Addressing railroad safety will require a tailored approach.

Part of the problem in crafting the next phase of railroad safety will be the fact that the conditions affecting safety on the railroad network vary from state to state and from railroad to railroad. California, Texas, and Florida all have significant problems with grade crossings and trespassing, even when controlling for population and rail traffic. Meanwhile, other states like Michigan and New Jersey have a fraction of the national average for incidents involving trespassing and grade crossings, respectively. Amtrak and short line railroads have above average incident rates at grade crossings and trespassing deaths, which often happen on host railroad infrastructure. Conversely, train derailments and crashes tend to happen more often on freight railroads than passenger railroads.

Part of the problem in addressing railroad safety is that the issues surrounding suicide, homelessness, poverty, despair, addiction, road design and the like are broader societal issues that go beyond the ability of transportation professionals and policymakers concerned solely with transportation to fix. The next phase of federal railroad safety policy will need to both extend beyond railroading and acknowledge its relationship to other societal issues and also require a more discrete approach involving finding the problem areas and addressing them in the local context.

Many grade crossing and trespassing incidents can be addressed using combined education, enforcement, and engineering approaches.

The statistics on factors influencing the frequency and severity of grade crossing crashes presented in Section 3 tend to suggest that efforts to prevent collisions between trains and road vehicles at grade crossings, or to make them less severe when they do occur, should be less focused on upgrading warning devices (which is where the bulk of federal and state money devoted to grade crossing safety currently goes) and more focused on educational and engineering efforts to deter risky behavior and redesign or eliminate the types of crossings that have been shown to be more dangerous.

Research on best practices for designing roads to slow traffic and force motorists to pay more attention to their surroundings, for example, could be instructive for designing safer roadway approaches to grade crossings. Educational efforts should be targeted toward younger drivers, particularly men. And while there is no way to control for weather conditions, installing warning lights before crossings that activate during poor weather, installing lighting at strategic points near crossings, and clearing vegetation and other obstructions to motorists' view of oncoming trains could all help mitigate these factors.

One area where it would make sense to further develop and deploy active warning devices is in protecting pedestrians at grade crossings and at designated pedestrian-only crossings, such as at train stations or along multi-use trails. While pedestrians were involved in only 9 percent of accidents at public crossings in 2017, almost 40 percent of fatal grade crossing collisions that year involved pedestrians. Possible mitigation measures include installing additional gates blocking sidewalks and 'gate skirts' that make it harder for pedestrians to duck under lowered gates. The FHWA also says that bells or other auditory signals are more effective at warning pedestrians and bicyclists than at warning motorists.

Similarly, localities and railroads need to pay more attention to urban design and needs of pedestrians that might be crossing tracks. Better siting of facilities near safe crossings, more pedestrian-focused warnings, and safe pedestrian crossings in areas with high rates of walking across tracks to get to specific destinations would all have a positive impact. Making it easy to cross tracks and less appealing to linger near them might also reduce loitering and graffiti.

More research is needed to determine the outcomes and costs of existing and new policies and treatments.

This research found that many states, law enforcement groups, universities, and localities are piloting innovative approaches to tackle problems associated with trespassing and grade crossings. While anecdotally these programs might be achieving their intended goals, data that quantify how much they cost and how much they reduced specific incidents are often not recorded or reported. Similarly, it was difficult to find any information about the standard costs of grade crossing gates, fencing, and other signals that have been deployed to reduce grade crossings.

5.0 Policy Recommendations

Congress should expand funding to multifaceted programs and organizations that support rail trespassing prevention.

Trespassing is an issue that spans multiple policy areas, and effective programs to reduce it needs to go beyond traditional railroad approaches. There is no ongoing multi-agency federal program devoted to rail trespass prevention, whereas there is such a program devoted to preventing grade crossing collisions (the Section 130 program). Expanded funding to organizations like Operation Lifesaver as well as engaging policy areas of homelessness, addiction, and mental health can create multifaceted strategies, including those involving new technologies to monitor and address problem areas, to address persistent problems. Such a program deserves substantial funding and attention since trespassing is the leading cause of fatalities on the rail network. Programs can be designed to allow flexibility to the local context and require reporting to better evaluate what strategies are the most effective so other states and railroads can learn best practices.

Policymakers and planners should address grade crossing and trespassing issues with targeted education efforts combined with targeted enforcement and better engineering at areas with persistent safety issues.

Education, engineering, and enforcement have to work in concert with each other and constantly refine their approaches based on feedback from each other. Safety policy can be more effective when there is more two-way dialogue between education-focused outfits like Operation Lifesaver and state programs like BeRailSafe and law enforcement. Engaging local police, railroad police, and private security at railroad-adjacent facilities can help, particularly when law enforcement takes on an educational, instead of punitive, approach. In places where there are persistent problems, roadway designs that force drivers to slow down, limit the ability to drive around gates, and enhance the visibility of oncoming trains can greatly reduce the risk for collisions. Further, engineering should also address ways to provide safer and more attractive places for people to bike and walk.

Amtrak, commuter railroads, and their freight railroad hosts need more funding to address persistent problems with grade crossing incidents.

Grade crossing incidents on passenger railroads and where passenger trains operate have increased 50 percent over the past decade. This problem will require more information to determine exactly when and where such issues are occurring, but federal and state dollars are needed to address the growing problem. Eligibility should include

engineering, education, and enforcement approaches and the statutory $7,500 per crossing maximum for federal assistance with grade crossing closure projects should be increased or eliminated.

States and localities, particularly those with higher grade crossing and trespassing incidents, need to spend more resources to tackling those localized issues.

States need to get more involved in cutting the rates of trespassing and grade crossing incidents in their jurisdiction. Alabama, California, Florida, Illinois, Indiana, Louisiana, Ohio, and Texas all have more than 80 grade crossing incidents per year *and* have seen incidents increase more than 10 percent over the past decade. With respect to trespassing, Georgia has the highest rate of injuries and fatalities adjusted for population, and California, Colorado, Florida, and Oregon have high rates and worsening trends. These states need targeted efforts and funding to address problems, along with transparent measurement of the outcomes of these initiatives.

The federal government should quantify the outcomes of specific initiatives and provide cost ranges for various safety treatments.

Particularly when it comes to innovative technologies and new approaches to education and enforcement, FRA needs to fund studies that evaluate experimental approaches and determine whether they achieved their intended outcomes. Similarly, the FRA and industry trade groups needs to publish a list of infrastructure and signaling treatments and their respective cost ranges. Without reliable or useful data associated with the range of costs for installing and maintaining crossing gates, fencing, or other treatments, it is difficult to determine how to effectively target scarce dollars to improve outcomes at grade crossings.

Congress should remove legal and procedural barriers to railroads' sharing of more trespasser data with FRA and other authorities.

Railroads are reluctant to share trespasser close call data with FRA as the agency lacks statutory authority to protect this data from disclosure and use in judicial and other actions to determine damages or liability. But this data can be invaluable to helping law enforcement, localities, and states address specific trespassing issues.

Endnotes

[1] Federal Railroad Administration, "About FRA," October 7, 2019.
[2] U.S. Department of Transportation, "Transforming Communities in the 21st Century," February 2016.
[3] Federal Railroad Administration, "Federal Railroad Administration (Organization Chart)," undated.
[4] Federal Railroad Administration, "Railroad Safety," February 12, 2021.
[5] Federal Railroad Administration, "Railroad Safety Inspection Programs," *Railroad Safety*, 1978.
[6] Federal Railroad Administration, "Divisions Overview," June 16, 2020.
[7] Federal Railroad Administration, "Positive Train Control (PTC)," January 4, 2021.
[8] Sheet Metal, Air, Rail and Transportation Workers - Transportation Division, "FRA's Policy on Jurisdiction over Light Rail Passenger Operations," undated. The main exception is the Port Authority Trans-Hudson rail transit system connecting New York City with New Jersey, which is subject to FRA regulation because its tracks are connected with the national rail network.
[9] Federal Railroad Administration, "Railroad Safety Inspection Programs," *Railroad Safety*, 1978.
[10] Congressional Research Service, "Positive Train Control (PTC): Overview and Policy Issues," *CRS Report R42637*, September 4, 2018, page 2.
[11] Cornell Law School, "Commerce Clause," *WEX*, undated.
[12] In July 2020, the U.S. Surface Transportation Board ruled that the Texas Central Railway is to be considered part of the national rail network and thus subject to FRA regulation, despite that it will not be physically connected to or interchange with any other railroad and will operate entirely within the state of Texas. Source: Peter LeCody, "Extraordinary STB Decision: Texas Central Railway is part of the interstate rail network," Texas Rail Advocates, *Texas Rail News*, July 16, 2020.
[13] County of Albemarle, Virginia, "Chapter 33: The Federal Laws Applicable to Railroads," *The Albemarle County Land Use Handbook*, March 2012.
[14] Arnold & Itkin Trial Lawyers, "The Federal Railroad Safety Act," undated.
[15] Ibid.
[16] County of Albemarle, Virginia, "Chapter 33: The Federal Laws Applicable to Railroads," *The Albemarle County Land Use Handbook*, March 2012.
[17] Ibid.
[18] Federal Railroad Administration, "Railroad Safety Inspection Programs," *Railroad Safety*, 1978.
[19] Good Jobs First, "Violation Tracker Agency Summary Page," 2020.
[20] Federal Railroad Administration, "Railroad Safety Inspection Programs," *Railroad Safety*, 1978.
[21] Ibid.
[22] It's worth noting that the 2015 FAST Act was the first law to include rail safety and passenger rail programs within a broader surface transportation authorization package. Previously, rail safety and passenger rail programs had been authorized separately from other surface transportation programs.
[23] Federal Railroad Administration, "Competitive Discretionary Grant Programs," March 3, 2021.
[24] Dani Arbuckle, "How Much Does a Train Driver Make a Year?" *Houston Chronicle*, undated.
[25] Federal Railroad Administration Office of Safety, Human Performance Division, "Training, Qualification and Oversight for Safety-Related Railroad Employees, 49 CFR Part 243 - Overview," undated.
[26] Federal Railroad Administration, "Research and Development Funding," November 17, 2019.
[27] Federal Railroad Administration, "Program Areas," October 22, 2019.
[28] Federal Railroad Administration, "Research and Development Funding," November 17, 2019.
[29] Progressive Railroading Editorial Staff, "Rail News - FRA to relaunch Railroad Safety Advisory Committee," *Progressive Railroading*, October 1, 2018.
[30] Railroad Safety Advisory Committee, "News & Events," undated.
[31] Federal Railroad Administration Office of Safety Analysis, Database, March 19, 2021.
[32] Federal Highway Administration, "Section 2- Components of a Highway-Rail Grade Crossing," *Railroad-Highway Grade Crossing Handbook - Revised Second Edition*, August 2007.
[33] NHTSA Media, "NHTSA and FRA Launch Rail Crossing Safety Campaign," *National Highway Traffic Safety Administration - Press Releases*, April 18, 2019.
[34] NHTSA Media, "U.S. Secretary of Transportation Elaine L. Chao Launches 'Stop. Trains Can't.' Awareness Campaign to Save Lives at Railroad Grade Crossings," *National Highway Traffic Safety Administration - Press Releases*, October 6, 2020.
[35] Traffic Safety Marketing, "Stop. Trains Can't." undated.

[36] Electronic Code of Federal Regulations, "Title 49: Transportation, Part 392 - Driving of Commercial Motor Vehicles," March 17, 2021.
[37] Federal Motor Carrier Safety Administration, "Highway-Rail Grade Crossing Safety Regulations," January 3, 2014.
[38] Ibid.
[39] National Transportation Safety Board, "About the National Transportation Safety Board," undated.
[40] National Transportation Safety Board, "What Is the National Transportation Safety Board?" *NTSB/SPC-05/02*, September 17, 2010, page 6.
[41] Robert L. Sumwalt, "PTC Must Not Go Into Double Overtime," National Transportation Safety Board, *NTSB Safety Compass*, February 3, 2016; Julie Sneider, "Rail Insider - Remembering the deadly Chatsworth train crash 10 years later," *Progressive Railroading*, October 2018; Jamie Rodriguez and Gary L. Halbert, "NTSB Challenges and Expectations for 2021," Hollad & Knight, *Holland & Knight Transportation Blog*, January 20, 2021.
[42] National Transportation Safety Board, "Fully Implement Positive Train Control," *Safety Advocacy - Most Wanted List*, undated.
[43] National Transportation Safety Board, "Ensure the Safe Shipment of Hazardous Materials," *Safety Advocacy - Most Wanted List*, undated.
[44] National Transportation Safety Board, "Eliminate Distractions," *Safety Advocacy - Most Wanted List*, undated.
[45] National Transportation Safety Board, "Require Medical Fitness - Screen for and Treat Obstructive Sleep Apnea," *Safety Advocacy - Most Wanted List*, undated.
[46] National Transportation Safety Board, "Strengthen Occupant Protection," *Safety Advocacy - Most Wanted List*, undated.
[47] Progressive Railroading Editorial Staff, "Rail News - NTSB checks off eight safety recommendations on 'Most Wanted List,'" *Progressive Railroading*, January 31, 2020.
[48] Ibid.
[49] Ibid.
[50] Ibid.
[51] Jamie Rodriguez and Gary L. Halbert, "" NTSB Challenges and Expectations for 2021," Hollad & Knight, *Holland & Knight Transportation Blog*, January 20, 2021.
[52] Progressive Railroading, "Rail News - NTSB recommends safety measures in light of CSX derailment," *Progressive Railroading*, December 11, 2020.
[53] Ibid.
[54] National Transportation Safety Board, "Safety Recommendation R-20-030," *Case Analysis and Reporting Online (CAROL)*, January 25, 2021.
[55] Ibid.
[56] Ibid.
[57] Ibid.
[58] Ibid.
[59] National Transportation Safety Board, "Safety Recommendation R-20-021," *Case Analysis and Reporting Online (CAROL)*, December 10, 2020, and National Transportation Safety Board, "Safety Recommendation R-20-025," *Case Analysis and Reporting Online (CAROL)*, December 10, 2020.
[60] National Transportation Safety Board, "Safety Recommendation R-20-019," *Case Analysis and Reporting Online (CAROL)*, October 19, 2020.
[61] Iowa Department of Transportation, "Federal and State Regulation of Railroads," *Rail Transportation - Frequently Asked Questions*, undated.
[62] Federal Railroad Administration, *Compilation of State Laws & Regulations Affecting Highway-Rail Grade Crossings - Digital Editio*n, undated; States with primarily local-level jurisdiction are CT, IL, KS, ME, MS, MT, NH and WI. States with shared state and local jurisdiction are IA, NE, OH, SC and WA.
[63] Federal Highway Administration, *Railroad-Highway Grade Crossing Handbook, Revised Second Edition*, Washington, DC: Government Printing Office, August 2007, pages 16-17.
[64] Ibid.
[65] Federal Highway Administration, *Railroad-Highway Grade Crossing Handbook, Revised Second Edition*, Washington, DC: Government Printing Office, August 2007, page 17.
[66] Federal Railroad Administration, "State Rail Safety Participation," October 9, 2020.
[67] California Public Utilities Commission, "Railroad Operations and Safety Branch," undated.

[68] Caroline Kieltyka, "Freight Rail - State Initiatives," American Association of State Highway and Transportation Officials - Rail Council, undated.
[69] Amtrak, "FY 2019 Company Profile," National Railroad Passenger Corporation, accessed March 19, 2020.
[70] Robert Barnes, "Supreme Court says Amtrak is more like a public entity than a private firm," *Washington Post*, March 9, 2015.
[71] Office of the Inspector General - National Railroad Passenger Corporation, "About Us," undated.
[72] Jim Blair, "Amtrak's Rights and Relationships with Host Railroads," National Railroad Passenger Corporation, September 21, 2017.
[73] Brian A. Reaves, "Federal Law Enforcement Officers, 2004," U.S. Department of Justice Office of Justice Programs, *Bureau of Justice Statistics Bulletin NCJ 212750*, July 2006.
[74] U.S. House of Representatives, Committee on Transportation and Infrastructure, "Rules Committee Print 116-54, Text of H.R. 2, the Moving Forward Act," June 22, 2020, 189-196.
[75] Congressional Research Service, "Should Railroads Help Pay for Grade Crossing Improvements?" *CRS Insight IN11434*, June 24, 2020.
[76] Ibid.
[77] 49 U.S. Code, Sect. 28101, "Rail police officers," Cornell Law School, Legal Information Institute, undated.
[78] Union Pacific Railroad, "Union Pacific Special Agents," undated; U.S. railroads have had their own police since shortly after the Civil War, and they played a major role in crushing organized labor activity and stopping pilferage by railroad employees in the early years.
[79] William T. Faricy, "Functions of the Railroad Police," *Journal of Criminal Law and Criminology* Vol. 42, No. 3, September-October 1951, page 386.
[80] Ibid.
[81] Operation Lifesaver, Inc., "Enforcement," undated.
[82] Federal Railroad Administration, "Regulations & Rulemaking," November 5, 2019.
[83] Examples: Norfolk Southern Corporation, "About NS - Government Relations," undated and Union Pacific Corporation, "Washington, D.C., Office Contacts," undated.
[84] Frank N. Wilner, "Labor Talks Include a Witches' Brew," *Railway Age*, October 3, 2019.
[85] U.S. Department of Labor, Occupational Safety and Health Administration, "Whistleblower Protection for Railroad Workers," *OSHA FactSheet DWPP FS-3945*, May 2018.
[86] Marybeth Luczak, "For Small Roads, Two New Safety Training Programs," *Railway Age*, March 12, 2021.
[87] Association of American Railroads, "AAR Members," undated.
[88] Association of American Railroads, "About Us," undated.
[89] Association of American Railroads / Transportation Technology Institute, Inc., "Welcome to AAR's Technical Services," undated.
[90] Association of American Railroads, "Prioritizing Safety Means Empowering Your Workforce," undated.
[91] Association of American Railroads, "Freight Rail and Operational Regulation," undated.
[92] American Short Line and Regional Railroad Association, "About ASLRRA," undated.
[93] American Short Line and Regional Railroad Association, "Safety & Compliance," undated.
[94] Marybeth Luczak, "For Small Roads, Two New Safety Training Programs," *Railway Age*, March 12, 2021.
[95] American Public Transportation Association, "About APTA," undated.
[96] American Public Transportation Association, "Delivering Products and Services that Advance the Industry," undated.
[97] American Public Transportation Association, "Commuter, Intercity and High-Speed Rail Standards (PRESS)," undated.
[98] Operation Lifesaver, Inc., "Mission, Impact and History," undated
[99] Ibid.
[100] Sheet Metal, Air, Rail and Transportation Workers, "About SMART Transportation Division," undated
[101] Sheet Metal, Air, Rail and Transportation Workers, "Transportation Safety," undated
[102] Brotherhood of Locomotive Engineers and Trainmen, "Brotherhood of Locomotive Engineers and Trainmen," undated
[103] Brotherhood of Locomotive Engineers and Trainmen, "Railroad Security News," undated.
[104] Brotherhood of Maintenance of Way Employes Division, "History," undated.
[105] Brotherhood of Maintenance of Way Employes Division, "Safety," undated.
[106] Brotherhood of Railroad Signalmen, "About the Brotherhood of Railroad Signalmen," undated.
[107] Brotherhood of Railroad Signalmen Local 56, "Safety," undated.
[108] American Short Line and Regional Railroad Association, "The FAMES Committee (Fatality Analysis of Maintenance of Way Employees and Signalmen)," undated.

[109] American Short Line and Regional Railroad Association, "The FAMES Committee (Fatality Analysis of Maintenance of Way Employees and Signalmen)," undated.
[110] "Monetary Threshold Notice," Federal Railroad Administration, December 22, 2020.
[111] Note that for this data, FTA categorizes Class I, II, and II railroads slightly differently than the Group 1, 2, and 3 for the purposes of safety reporting.
[112] Office of Railroad Safety, "FRA Guide for Preparing Accident/Incident Reports," Federal Railroad Administration, May 23, 2011.
[113] Suzanne Horton, Anya Carroll, Mina Chaudhary, et. al. "Success Factors in the Reduction of Highway-Rail Grade Crossing Incidents from 1994 to 2003." 2009. *Office of Research and Development, Federal Railroad Administration, U.S. Department of Transportation*. 1-127.
[114] "Evaluation of Cost-Effective Systems for Railway Level-Crossing Protection," 2000, United Nations Economic and Social Commission for Asia and the Pacific.
[115] Federal Highway Administration Office of Safety Programs, "Railway-Highway Grade Crossing (Section 130) Program: Program Overview," February 17, 2021.
[116] Changxi Ma, Wei Hao, Wang Xiang, Wei Yan, "The Impact of Aggressive Driving Behavior on Driver-Injury Severity at Highway-Rail Grade Crossings Accidents." 2018; *Hindawi, Journal of Advanced Transportation, Vol. 2018,* 6.
[117] Robert Raub, "Examination of Highway-Rail Grade Crossing Collisions Over 10 Years in Seven Midwestern States," 2006. *ITE Journal*. 16-26.
[118] "Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges." 2018. *Government Accountability Office*. 18-19.
[119] Ibid.
[120] Ibid.
[121] Ibid.
[122] Robert Raub, "Examination of Highway-Rail Grade Crossing Collisions Over 10 Years in Seven Midwestern States," 2006. *ITE Journal*. 16-26.
[123] "Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges." 2018. *Government Accountability Office*. 16.
[124] Payton Guion, "NJ: Why do pedestrians keep getting hit by trains? NJ Transit is trying to solve the mystery," March 22, 2021, *Mass Transit*.
[125] Robert Raub, "Examination of Highway-Rail Grade Crossing Collisions Over 10 Years in Seven Midwestern States," 2006. *ITE Journal*. 16-26.
[126] Wei Hao and Janice R. Daniel, "Severity of Injuries to Motor Vehicle Drivers at Highway-Rail Grade Crossings in the United States." 2013. *SAGE Journals*.
[127] Changxi Ma, Wei Hao, Wang Xiang, Wei Yan, "The Impact of Aggressive Driving Behavior on Driver-Injury Severity at Highway-Rail Grade Crossings Accidents." 2018; *Hindawi, Journal of Advanced Transportation, Vol. 2018*. 7-8.
[128] Christos Pyrgidis, Eleni Papacharitou, and Alexandros Eleftheriadis, "Risk Management at Railroad Grade Crossings: Proposal for a Decision Support System." 2016; *Science Direct, Transportation Research Procedia 14*. 1394 - 1402.
[129] E.C. Wigglesworth and C.B. Uber, "An Evaluation of the Railway Level Crossing Boom Barrier Program in Victoria, Australia," 1991, *Journal of Safety Research* Vol. 22, pp. 133-140.
[130] Adrian Hellman and Marco daSilva, "Low-Cost Warning Device Industry Assessment," U.S. Department of Transportation, Federal Railroad Administration, December 2011, RR 11-26.
[131] Richard P. Reiff, Scott E. Gage, Anya A. Carroll and Jeffrey E. Gordon, "Evaluation of Alternative Detection Technologies for Trains and Highway Vehicles at Highway Rail Intersections," February 2003, Office of Research and Development, Federal Railroad Administration, U.S. Department of Transportation.
[132] Adrian Hellman and Marco daSilva, "Low-Cost Warning Device Industry Assessment," U.S. Department of Transportation, Federal Railroad Administration, December 2011, RR 11-26.
[133] Jeffrey C. Peters and John Frittelli, "Positive Train Control (PTC): Overview and Policy Issues," 2012. *Congressional Research Service*.
[134] Justin Vonashek, Deidre Mitchell, Lori Ebbighausen, Karl Meyer and Linda Katz, "Safety Education and Community Outreach Initiatives for Trespasser Prevention," July-August 2019, *TR News*, 36-38.
[135] Jeffrey C. Peters and John Frittelli, "Positive Train Control (PTC): Overview and Policy Issues," 2012. *Congressional Research Service*.

[136] NHTSA Media, "NHTSA and FRA Launch Rail Crossing Safety Campaign," *National Highway Traffic Safety Administration - Press Releases*, April 18, 2019.
[137] "Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges." 2018. *Government Accountability Office*. 25-30.
[138] Karl Knoblauch, Wayne Hucke, and William Berg, "Rail Highway Crossing Accident Causation Study Vol. 1." 1982. *Office of Research and Development, Federal Highway Administration, United States Department of Transportation*. 1-32.
[139] Wei Hao and Janice R. Daniel, "Severity of Injuries to Motor Vehicle Drivers at Highway-Rail Grade Crossings in the United States." 2013. *SAGE Journals*.
[140] Karl Knoblauch, Wayne Hucke, and William Berg, "Rail Highway Crossing Accident Causation Study Vol. 1." 1982. *Office of Research and Development, Federal Highway Administration, United States Department of Transportation*. 1-32.
[141] Changxi Ma, Wei Hao, Wang Xiang, Wei Yan, "The Impact of Aggressive Driving Behavior on Driver-Injury Severity at Highway-Rail Grade Crossings Accidents." 2018. *Hindawi, Journal of Advanced Transportation, Vol. 2018*. 1.
[142] Wei Hao and Janice R. Daniel, "Severity of Injuries to Motor Vehicle Drivers at Highway-Rail Grade Crossings in the United States." 2013. *SAGE Journals*.
[143] Karl Knoblauch, Wayne Hucke, and William Berg, "Rail Highway Crossing Accident Causation Study Vol. 1." 1982. *Office of Research and Development, Federal Highway Administration, United States Department of Transportation*. 1-32.
[144] "Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges." 2018. *Government Accountability Office*. 25-30.
[145] Working Party on Rail Transport Group of Experts on Improving Safety at Level Crossings, "Assessment of safety at level crossings in UNECE member countries and other selected countries and strategic framework for improving safety at level crossings," 2016, United Nations Economic Commission for Europe.
[146] NCDOT BeRailSafe, "What Is BeRailSafe?" North Carolina Department of Transportation, undated.
[147] NCDOT BeRailSafe, "First-Responder Training," North Carolina Department of Transportation, undated.
[148] General Assembly of North Carolina, Session 2021, "House Bill 285, Committee Substitute Favorable 3/30/2021," March 15, 2021.
[149] "Grade Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges." 2018. *Government Accountability Office*. 25-30.
[150] Wei Hao and Janice R. Daniel, "Severity of Injuries to Motor Vehicle Drivers at Highway-Rail Grade Crossings in the United States." 2013. *SAGE Journals*.
[151] Robert Raub, "Examination of Highway-Rail Grade Crossing Collisions Over 10 Years in Seven Midwestern States," 2006. *ITE Journal*. 16-26.
[152] Changxi Ma, Wei Hao, Wang Xiang, Wei Yan, "The Impact of Aggressive Driving Behavior on Driver-Injury Severity at Highway-Rail Grade Crossings Accidents." 2018. *Hindawi, Journal of Advanced Transportation, Vol. 2018*. 1.
[153] Office of Safety Analysis "1.12 – Ten Year Accident/Incident Overview," Federal Railroad Administration, 2021.
[154] "Train Fatalities, Injuries and Accidents by Type of Accident," Bureau of Transportation Statistics, U.S. Department of Transportation.
[155] Jeffrey C. Peters and John Frittelli, "Positive Train Control (PTC): Overview and Policy Issues," *Congressional Research Service,* 2018.
[156] Ibid.
[157] Personal experience of author Kenton as a railroad passenger.
[158] Eileen Reilly, "PTC 2.0: Now Is the Time," January 4, 2021, *Railway Age*.
[159] Jeffrey C. Peters and John Frittelli, "Positive Train Control (PTC): Overview and Policy Issues," *Congressional Research Service,* 2018.
[160] Malcolm Kenton, "After PTC: After $10 billion and 12 years, the safety system is in place, but now railroads want more from it," February 2021, *Trains Magazine*, 34-41.
[161] Mark Hartong, Rajni Goel, and Duminda Wijesekera, "Positive Train Control (PTC) Failure Modes," 2011. *Science Direct, Volume 23, Issue 3*. 311-321.
[162] Ibid.
[163] Susan Fleming, "Positive Train Control: As Implementation Progresses, Focus Turns to the Complexities of Achieving System Interoperability," 2019. *Government Accountability Office,* Summary & 14.

[164] Malcolm Kenton, "After PTC: After $10 billion and 12 years, the safety system is in place, but now railroads want more from it," February 2021, *Trains Magazine*, 34-41.
[165] Eileen Reilly, "PTC 2.0: Now Is the Time," January 4, 2021, *Railway Age*.
[166] Jeffrey C. Peters and John Frittelli, "Positive Train Control (PTC): Overview and Policy Issues," *Congressional Research Service,* 2018.
[167] Eileen Reilly, "PTC 2.0: Now Is the Time," January 4, 2021, *Railway Age*.
[168] Joe Becker, "Taking Technology to the Next Level," 2018. *Railway Age*.
[169] Stephanie L. Morrow, Alyssa K. McGonagle, Megan L. Dove-Steinkamp, Curtis T. Walker Jr., Matthew Marmet and Janet L. Barnes-Farrell, "Relationships between psychological safety climate facets and safety behavior in the rail industry: A dominance analysis," August 15, 2009, *Accident Analysis and Prevention* vol. 42 (2010), 1460-1467.
[170] M.T. Baysari, A.S. McIntosh and J.R. Wilson, "Understanding the human factors contribution to railway accidents and incidents in Australia," 2008, *Accident Analysis and Prevention* vol. 40, 1750–1757.
[171] Trudi Farrington-Darby. Laura Pickup and John. R. Wilson, "Safety culture in railway maintenance," 2005, *Safety Science* vol. 43, 39-60.
[172] Eileen Reilly, "PTC 2.0: Now Is the Time," January 4, 2021, *Railway Age*.
[173] Ibid.
[174] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation*. 21.
[175] Ibid.
[176] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[177] Ibid.
[178] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation*. 21.
[179] Ibid.
[180] Ibid.
[181] "Rail Trespasser Fatalities," 2013. Federal Railroad Administration, U.S. Department of Transportation. 18.
[182] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[183] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[184] Josephine Au, "Suicide on Railroad Rights-of-Way: A Psychological Autopsy Study," June 2014, *Suicide and Life-Threatening Behavior* vol. 44, no. 6 (December 2014).
[185] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[186] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[187] Josephine Au, "Suicide on Railroad Rights-of-Way: A Psychological Autopsy Study," June 2014, *Suicide and Life-Threatening Behavior* vol. 44, no. 6 (December 2014).
[188] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[189] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation*. 21.
[190] Ibid.
[191] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[192] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[193] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[194] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[195] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[196] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).

[197] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[198] Ibid.
[199] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[200] Ibid.
[201] Ibid.
[202] Asim F. Zaman, Baozhang Ren and Xiang Liu, "Artificial Intelligence-Aided Automated Detection of Railroad Trespassing," July-August 2019, *TR News*, 30-35.
[203] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[204] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[205] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation.* 21
[206] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[207] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[208] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[209] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation.* 21
[210] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[211] NJ Transit, "Christie Administration Enhances Safety Along New Jersey's Rail System," Press Releases, June 27, 2013; Marni Pyke, "Metra steps up suicide prevention, mental health awareness," *The Daily Herald*, Oct. 2, 2017.
[212] U.S. Department of Transportation, Volpe Center, "Media Reporting of Railway Suicides," Transportation Human Factors, Oct. 14, 2020.
[213] OLI's newest campaign for individuals experiencing homelessness and their service providers is currently available via the website (OLI.org) or contacting the national office.
[214] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[215] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[216] "Analyzing Online Media Reporting of Rail Suicide and Trespass Incidents," June 20, 2017, *U.S. Department of Transportation Volpe Center*.
[217] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[218] Karoline Lukaschek, Jens Baumert, Marion Krawitz, Natalia Erazo, Hans Förstl and Karl-Heinz Ladwig, "Determinants of completed railway suicides by psychiatric in-patients: case-control study," January 2, 2018, *British Journal of Psychiatry* vol. 205, no. 5, 398-406.
[219] Metrolink, "Metrolink receives FRA grant to stem suicides on tracks," April 13, 2021, *Mass Transit*.
[220] Stephanie G. Chase, Danielle Hiltunen, and Scott H. Gabree, "Characteristics of Trespassing Incidents in the United States (2012-2014)," 2018. *The Office of Research, Development, and Technology, Federal Railroad Administration, U.S. Department of Transportation.* 21
[221] "Railroad Trespassing, Vandalism, and Highway-Rail Grade Crossing Warning Device Violation Prevention Strategies," 2010. *Office of Railroad Safety, Federal Railroad Administration, U.S. Department of Transportation.* 6-7.

[222] Associated Press, "CSX: Up to 700 more job cuts possible; CEO defends restructuring progress," *The Florida Times-Union*, July 19, 2017; John Walsh, Director of Hazmat Programs at the Short Line Safety Institute, personal correspondence, June 15, 2021.
[223] John Frittelli, "Trespassing: The Leading Cause of Rail-Related Fatalities," 2018. *Congressional Research Service*.
[224] Kurt Topel, "A Literature Review of Rail Trespassing and Suicide Prevention Research," February 28, 2018, Transportation Research Board, *Transportation Research Circular* No. E-C242 (January 2019).
[225] Ibid.
[226] Ian Savage, "Trespassing on the Railroad," 2007. *Department of Economics, Northwestern University*. 5.
[227] Kirrilly Thompson, Naomi Offler, Lily Hirsch, Danielle Every, Matthew J. Thomas and Drew Dawson, "From broken windows to a renovated research agenda: A review of the literature on vandalism and graffiti in the rail industry," April 18, 2012, *Transportation Research Part A* vol. 46 (2012), 1280-1290.
[228] Ibid.
[229] Ibid.
[230] Ibid.
[231] Ibid.
[232] Grigore M. Havarneanu, Jean-Marie Burkhardt and Francoise Paran, "A systematic review of the literature on safety measures to prevent railway suicides and trespassing accidents," May 2014, *Accident Analysis and Prevention* vol. 81 (2015), 30-50.
[233] Andre L. Taylor, "On dangerous ground: Deadly stretch of railway runs through Greensboro," *Greensboro News & Record*, June 29, 2018.
[234] Roger Smock, Rail Safety Consultant to North Carolina DOT Rail Division, personal correspondence, June 21, 2021.
[235] U.S. Department of Transportation, Federal Railroad Administration, "Federal Railroad Administration Announces More Than $500,000 To Deter Trespassing," Press Releases, July 7, 2020.
[236] Grigore M. Havarneanu and Kurt Topel, "Rail Trespassing and Suicide: What Can Be Done to Improve Safety?" July-August 2019, *TR News*, 23-29.
[237] John Frittelli, "Trespassing: The Leading Cause of Rail-Related Fatalities," 2018. *Congressional Research Service*.

Eno

Center for Transportation

www.enotrans.org

@EnoTrans

/EnoCenterForTransportation

bit.ly/EnoLinkedIn

/EnoTransportation

@EnoTrans

1629 K Street, NW
Suite 200
Washington, DC 20006

CONTACT US:
publicaffairs@enotrans.org