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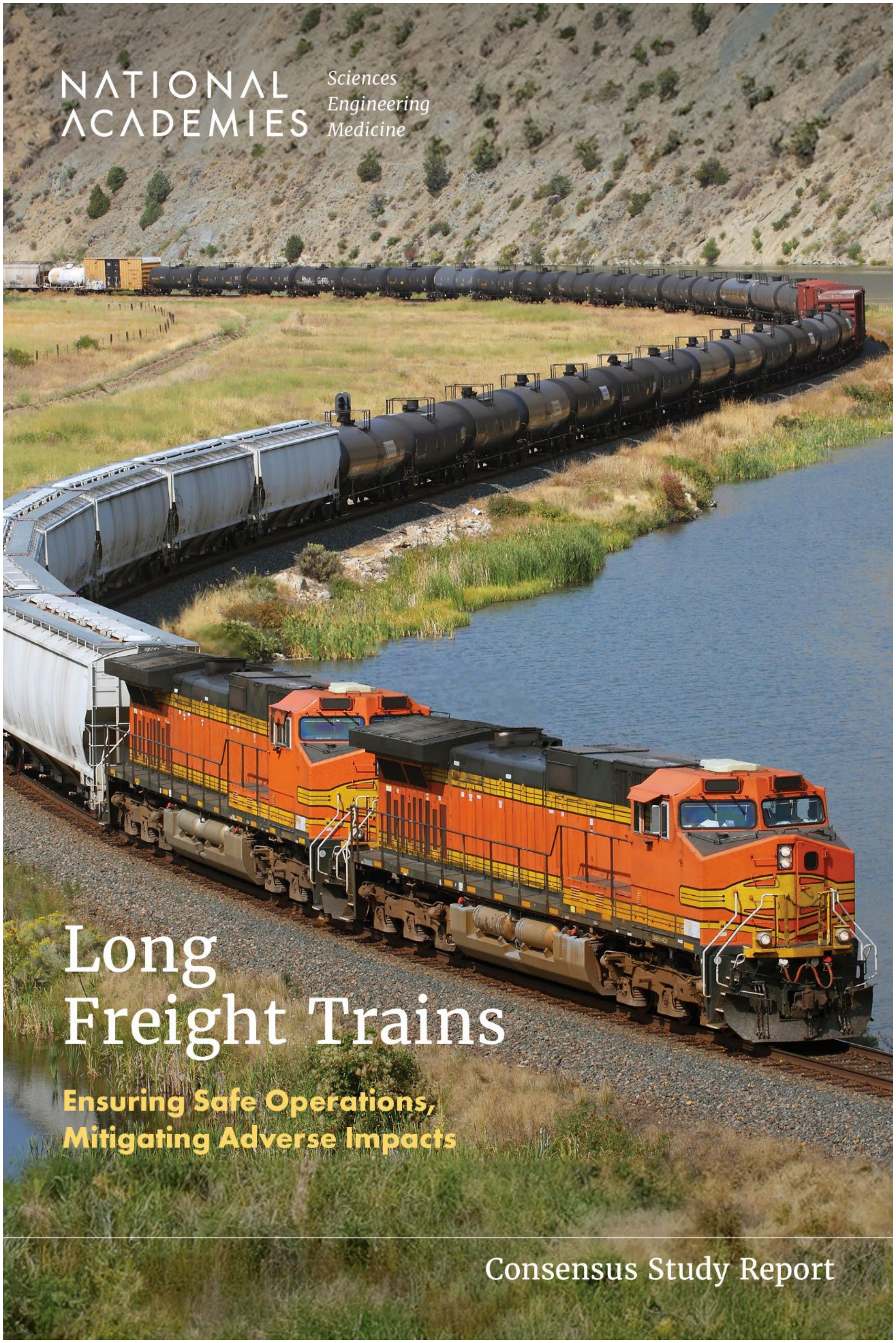

NATIONAL ACADEMIES Sciences Engineering Medicine

Long Freight Trains

Ensuring Safe Operations, Mitigating Adverse Impacts

Consensus Study Report

NATIONAL ACADEMIES *Sciences Engineering Medicine*

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Washington, DC

Long Freight Trains

Ensuring Safe Operations, Mitigating Adverse Impacts

Committee on the Impact of Trains
Longer Than 7,500 Feet

Consensus and Advisory Studies
Division

Transportation Research Board

Consensus Study Report

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[1] Venetta Keefe, then with the Indiana Department of Transportation, served on the committee from September 2022 to March 2024.

Reviewers

This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following individuals for their review of this report:

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report, nor did they see the final draft before its release. The review of this report was overseen by **CHRIS HENDRICKSON (NAE),** Carnegie Mellon University, and **CRAIG PHILIP (NAE),** Vanderbilt University. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

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David O. Willauer directed the study and assisted the study committee in preparation of the report along with Brittany P. Bishop, Sarah Jo Peterson, and Dylan Rebstock. Thomas R. Menzies, Jr., provided oversight management, and Timothy B. Marflak, Claudia Sauls, and

Myah Stroman provided administrative and logistical support in addition to assisting with preparing the report for publication. Karen Febey, Senior Report Review Officer, managed the report review process. Garreth Rempel, President and Chief Executive Officer of Trainfo, Inc., provided consulting services.

Contents

Preface

In 2021, Congress directed the Secretary of Transportation to enter into an agreement with the National Academies of Sciences, Engineering, and Medicine "to conduct a study on the operation of freight trains that are longer than 7,500 feet." Under sponsorship from the Federal Railroad Administration, the Transportation Research Board convened a 12-member committee, with experience in freight and passenger railroad operations, state rail transportation, national rail safety oversight, and freight and passenger rail research. The committee met 16 times, 6 in person to examine impacts of long trains based on the Statement of Task. To inform the study, the committee invited presentations from individuals and organizations, as listed in the Acknowledgments section of this report. In addition, the committee dedicated meetings to train technology, highway rail grade crossings, and traveled to Chicago, where all Class I railroad operations intersect daily.

Debra L. Miller, *Chair*
Committee on the Impact of Trains Longer Than 7,500 Feet

Acronyms and Abbreviations

AAR	Association of American Railroads
ATDA	American Train Dispatchers Association
BLE&T	Brotherhood of Locomotive Engineers and Trainmen
BNSF	BNSF Railway Company
CN	Canadian National Railway
CPKC	Canadian Pacific Kansas City Railway
CSX	CSX Transportation Inc.
DG	dangerous goods
DP	distributed power (unit, locomotive)
ECP	electronically controlled pneumatic (brakes)
EOCC	end-of-car cushioning (devices)
EOT	end of train (device)
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
GAO	U.S. Government Accountability Office
GHG	greenhouse gas
LEADER	Locomotive Engineer Assist/Display & Event Recorder
NS	Norfolk Southern Railway
NTSB	National Transportation Safety Board
PSR	Precision Scheduled Railroading
PTC	Positive Train Control
REA	Rail Equipment Accident/Incident Database
RRP	Risk Reduction Program
RSAC	Railroad Safety Advisory Committee
RSIA	Rail Safety Improvement Act
SMART	Sheet Metal, Air and Rail Transportation
SMS	safety management system

SOT	Statement of Task
SSP	safety system program
STB	Surface Transportation Board
T&E	train and engine
TO	Trip Optimizer
TRB	Transportation Research Board
TSB	Transportation Safety Board (of Canada)
UDE	undesired emergency (brake application)
UP	Union Pacific Railroad Company
VLT	very long train

Executive Summary

In response to a congressional mandate, this report examines the safety challenges arising from the operation of longer freight trains, and particularly from the increased use of longer manifest trains that transport a mix of freight in many different types of rail cars. The report also examines the impacts of increasing freight train length on the frequency and duration of blocked highway-rail grade crossings and the scheduling and efficient operations of Amtrak intercity passenger trains. The following is a summary of the report's key findings and assessments for each of these three impact areas, followed by a note on other potential impacts. Recommendations are offered on actions to address impacts that would benefit the most from policy interventions.

LONGER MANIFEST TRAINS CAN CREATE NEW AND HEIGHTENED SAFETY RISKS REQUIRING ACTIVE CONTROL

As the length of a manifest train increases, safe handling can be more challenging to manage relative to the handling of a shorter manifest train or a unit train (a train consisting of the same general car types) of comparable length. As a general matter, manifest trains create operational challenges due to the mixture of rail car types, designs, sizes, and weights. All rail cars in a train are subject to longitudinal forces that create draft and buff load conditions and to lateral forces, especially at curves. These in-train forces can lead to broken equipment, including drawbars and couplers, and cause the wheels of a car to leave the rail when negotiating curves. The magnitude of these forces will differ among cars that vary in size and weight, and the movement and mitigation of the forces will differ among cars having different drawbars and coupling devices with or without cushioning units.

Railroads must therefore pay close attention during the makeup of manifest trains to the placement of cars of different types, designs, sizes, and weights to manage in-train forces, reduce risks of derailment, and preserve train integrity. In particular, they must make choices about the placement of light cars, short cars, heavy cars, and cars with and without cushioning devices to facilitate safe handling as well as efficient operations. They must also pay attention to the placement of locomotives for distributed power (DP), as these units help control in-train forces through adjustments to power and activation of brakes, or they can add to the operational challenge if poorly positioned.

As the length of a manifest train increases, so too will the complexity of accounting for these in-train forces through train makeup decisions. Longer trains have more cars, possibly a greater variety of car types and sizes, and more requirements for power distributed across the train in comparison with shorter manifest trains. Moreover, the rail cars in a long train can be experiencing a wider range of grade and curvature conditions as the train spans more terrain. As a practical matter too, long trains can create more challenges for proper train makeup because they are so long and are constructed from blocks of rail cars that are switched to and from other trains and yards enroute. The placement of these blocks requires planning and can take time to execute. While assembling short trains also takes planning and time, assembling long trains can present additional challenges and opportunities for errors in car placement due to limited yard space, insufficient track lengths, and added demands on labor.

Train makeup decisions and train length must be made with ample consideration of the capabilities and performance of the crews that operate the trains. To this end, railroads have introduced engineer-assist systems to control trains by calculating the best operating profile for both lead and DP locomotives, while considering factors such as the route's grade and curvature and the train's length, weight, and composition. The availability of these engineer-assist systems, however, does not reduce the importance of crew readiness and performance in managing the handling requirements of long manifest trains in the varied environments and territories in which they are being used. Yardmasters and dispatchers must also account for these handling challenges when constructing and routing trains.

The operational demands of long manifest trains, therefore, require a combination of responses by railroads that includes well-designed and consistently applied train makeup rules, the deployment of appropriate technology (e.g., DP units, brakes, engineer-assist programs), and assurance of crew readiness and competency. To assess railroad claims about the effectiveness of these responses, the committee examined Federal Railroad Administration (FRA) accident records, which contain causal information that can be used to observe trends in derailments from the kinds of train handling and equipment issues characteristic of in-train forces not being adequately controlled. Having observed an increase in the rate of occurrence of these types of derailments, the committee asked the Class I railroads, through the Association of American Railroads (AAR), to provide data on their train operations with sufficient detail to ascertain train type and length for the purpose of more granular assessments of the derailment records. However, restrictive conditions on the data's availability and use, including a high degree of data aggregation and preapproval of the analytic methods to be used, foreclosed this option. Nevertheless, a review of publicly available data on train traffic indicates that the average length of manifest trains has been increasing coincidental with an increase in the rate of derailments of interest. Absent more detailed data, the committee was not able to verify that the operational demands created by longer manifest trains are being fully controlled, and indeed the limited analyses that could be performed suggest that more targeted safety assurance measures may be needed.

The report also documents the committee's consultations with railroad employees, who raised concerns about the amount and quality of training they receive for safely handling long manifest trains and about the challenges they face assembling the trains correctly. Concerns included the problems crew members can face maintaining communications with one another while maneuvering long trains at yards and during train inspections and repairs, which take more time to perform as train length increases. The potential for error from crew member miscommunication and fatigue was also raised as a concern when the time required to walk the train increases.

These heightened operational challenges and risks arising from increasing the length of manifest trains need to be recognized and addressed in a deliberate and systematic manner. Following direction from Congress for railroads to put in place safety management systems for the purpose of controlling risks deliberately and systematically, FRA required each Class I railroad to develop and implement Risk Reduction Programs (RRPs). However, the RRP rule was written to allow "streamlined" safety management systems that do not obligate railroads to anticipate and account for risks arising from all major planned operational changes, including the expanded use of longer manifest trains. To rectify this problematic shortcoming in the RRP rule, and to ensure that railroads are indeed being proactive in their treatment of the risks from longer trains, the committee recommends the following.

Recommendation 1: The Federal Railroad Administration should revise the Risk Reduction Program (RRP) rule to require railroads to address all major operational changes in their RRPs in an explicit and comprehensive manner. Current RRP requirements do not obligate railroads to address planned operational changes that can affect safety. To the contrary, railroads should be required—consistent with the principals of safety management systems—to identify and analyze the risks associated with all planned significant operational changes and to explain and justify the procedural, technological, and human-systems means that will be used to eliminate or reduce the risks.

Recommendation 1a: The revisions to the Risk Reduction Program (RRP) rule should be written in such a way as to make it clear to railroads that an operational change that is known to increase and add new train integrity and handling challenges, as lengthening manifest trains can do, constitutes an operational change that should be addressed in an RRP. Compliant railroads should be expected to have an RRP that is thorough in describing any operational and handling challenges, assessing their safety risks, explaining how the risks will be managed through procedural and technological means, and describing how those risk reduction means will be monitored and assessed for effectiveness.

Recommendation 1b: The Federal Railroad Administration (FRA) should seek from Congress the resources required to hire and train a team of auditors skilled in reviewing safety management systems to regularly and critically assess the completeness and quality of each railroad's Risk Reduction Program (RRP) and its key components. The auditors in turn should enlist FRA inspectors to verify that a railroad's risk reduction measures are implemented in the field. For trains whose length creates new and increased operational and handling challenges, the FRA auditors and safety inspectors should expect to find that compliant railroads, at a minimum, have

- **Train makeup rules and procedures for implementing them that are well justified and informed by best practices applicable to train types and a range of operating conditions and terrains encountered.**
- **Descriptions of the technologies to be deployed to control operational risks, including the use of distributed power, engineer-assist programs, and braking systems, and explanations of how their effectiveness will be monitored and evaluated.**
- **Assessments of the skills and competencies needed by crew members to perform safely when encountering the operational and handling challenges and how these needs will be met through crew training programs and other means.**
- **Explanations of any other challenges that added train length can create and that could have a bearing on safety, such as from the added work and complexity of train assembly and disassembly, added inspection times, and maintaining crew radio communications. Measures to address these safety-related challenges should be described and justified.**

Recommendation 1c: To aid railroads in the development of increasingly effective measures for reducing risks associated with long trains and to aid auditors in obtaining the requisite knowledge for critically assessing a railroad's risk reduction measures and their justifications, the Federal Railroad Administration should survey and synthesize industry protocols and best practices on train makeup, crew training, and communications capabilities pertinent to addressing the operational and handling challenges arising from increases in train length under different operating and environmental conditions.

The evidence in this report about the added challenges that train crews face when operating and handling manifest trains as they increase in length, including difficulties maintaining radio communications while inspecting and riding equipment, suggests that the time is right for FRA to also take a closer look at the coverage and adequacy of the regulations, FRA standards, industry guidance, and railroad operating procedures and practices for crew training and radio communications. With these interests in mind, the committee recommends the following.

Recommendation 2: The Federal Railroad Administration should stand up separate working groups under the Railroad Safety Advisory Committee that are tasked with evaluating and providing advice on the following:

2a. Methods and technologies that can be implemented to improve the capabilities, competencies, and training that train crews and other railroad employees require for the safe operation, assembly, and inspection of trains as they become longer; and

2b. Technological means and performance standards for ensuring that train crew members have the capability to communicate, including while inspecting and riding equipment, in a manner that can be continuously maintained and does not create personal safety hazards.

COMMUNITIES EXPERIENCING CHRONIC BLOCKED HIGHWAY-RAIL GRADE CROSSINGS NEED REAL SOLUTIONS

Trains frequently block pedestrian and motor vehicle traffic as they travel though, and sometimes stand idle in, highway-rail grade crossings. To the extent that the trend toward longer freight trains leads to fewer trains in the aggregate, one would expect potentially fewer blocked crossings. However, a transiting longer train will block a single crossing for a longer period than a shorter train and is more likely to block multiple crossings at the same time. Train transit times through crossings may be slowed further by speed restrictions that all freight trains must abide by but that will impact long trains over a greater distance and for a longer time. It is not clear whether a long train is more likely than a short train to be stationary on a grade crossing for a longer period; however, when trains are being assembled and disassembled in rail yards, longer trains, due to their length, are more likely to exceed the capacity of rail yards built for shorter trains operated in the past and therefore spill out from yards to block grade crossings in the vicinity of the facility.

Apart from the logical inference that a long train will take more time than a short train to transit a grade crossing simply because of its added length, the evidence to suggest that long trains block grade crossings more often, whether idle or moving, is largely anecdotal. The committee heard from leaders of communities impacted by chronic grade crossing blockages who maintain that train length is a factor in both the frequency and duration of blockages. Some of the communities are in proximity to rail yards where trains frequently stand idle for long periods awaiting entry to the yard and where train assembly and disassembly operations can lead to trains moving back and forth over one or more crossings multiple times. The community leaders complained about the resulting increased response time for emergency responders and the lengthy and recurrent delays incurred by motorists and pedestrians. Examples of interrupted access to neighborhoods, schools, and recreational facilities were given along with instances where impeded pedestrians, including students, maneuvered through stopped trains at considerable personal risk. Such problems are also reported on a regular basis by the media and in a database maintained by FRA for the public to report blocked crossings.

While state and local laws once gave communities leverage with railroads in seeking remedies to chronic blocked crossings, federal preemption, upheld in the courts based on the Constitution's interstate commerce clause, has eliminated this leverage. Today, there are no federal laws or regulations pertaining to blocked crossings to replace the vacated state and local laws. Accordingly, FRA and the Federal Highway Administration, as well as state and local jurisdictions, do not possess direct means to compel railroads to limit the frequency and duration of blocked crossings. State and local governments can make public investments in grade separations, sometimes with federal aid, or they can choose to close some low-volume crossings to motor vehicle and pedestrian traffic. However, both options can be expensive to the public and/or disruptive such that they are not applicable to many instances where blocked crossings are problematic.

The absence of network-level data from grade-crossing monitoring systems and reliance on anecdotal reports makes it difficult to assess trends in blocked crossings, including impacts from long trains. Inasmuch as frequent and lengthy blocked crossings are a general concern of railroad operations, such monitoring and data gathering would be valuable for finding solutions to blockages that are especially problematic. In short, the committee cannot confirm whether a trend toward long trains is positively or negatively impacting the frequency and duration of blocked grade crossings. However, what is clear is that operating long trains is not necessarily a solution for resolving chronic blocked crossings and may be making the problem worse in some locations. For this reason, the committee recommends the following:

Recommendation 3: Congress should authorize and direct the Federal Railroad Administration to obtain data on an ongoing basis from railroads on blocked highway-rail grade crossings. The railroads should be obligated to deploy automated means for efficiently collecting and reporting the data on a regular and expeditious basis. Data collection should focus first on crossings with gates and other active warning devices that are indicative of higher traffic locations where blockages are likely to be the most disruptive; then data collection should expand to more public highway-rail grade crossings. Individual blockage incidents that exceed defined thresholds of duration should be prioritized for reporting, such as when a crossing is occupied for more than 10 minutes.

Recommendation 3a: The Federal Railroad Administration (FRA) should use these grade-crossing reports to gain a better understanding of the incidence, magnitude, and scope of the blockage problem. For this purpose, FRA should make the reports available to states and their transportation agencies, regional and metropolitan planning organizations, local communities, and the public through means such as portals and other self-service data retrieval tools. FRA should seek from these stakeholders contextual information about

problem sites experiencing frequent and lengthy blockages such as by requesting data on the affected roadway's traffic volumes, emergency response activity, and significance for accessing neighborhoods, schools, hospitals, and other essential facilities and services during times when crossings were blocked.

Recommendation 3b: Informed by the reports of blockages, the Federal Railroad Administration should negotiate with the railroads individually and collectively to find solutions to the most problematic blockage sites, reduce the incidence and severity of the problem generally, and determine whether the trend toward increasing train length is creating special problems such as more blocked crossings near rail yards that require targeted remedies.

Recommendation 3c: Congress should give the Federal Railroad Administration authority to impose financial penalties on railroads for problematic blocked crossings. The penalties should be sufficient in magnitude to prompt good faith negotiations to resolve problematic crossing blockages.

FREIGHT RAILROADS SHOULD BE DETERRED FROM USING LONG TRAINS WHERE THEY WILL IMPEDE AMTRAK TRAINS

The report considers the impacts of longer freight trains on the passenger trains operated by Amtrak. Many of Amtrak's intercity passenger trains operate over the track of other railroads (called "host railroads") that were relieved of their common carrier obligation to provide passenger service when Amtrak was created. Federal statute grants Amtrak trains preference over a host railroad's trains, and thus if operational conflicts arise due to the increasing length of freight trains, this can be a clear public policy matter.

Amtrak maintains and has marshaled evidence that it incurs lengthy service delays when its passenger trains meet or follow freight trains that are too long to pass using available sidings on mainline single-track route segments. A host railroad that is aware of a mismatch between the length of freight trains being operated and the infrastructure available on the route to accommodate the passenger trains operated by Amtrak would seem to conflict with the latter's statutory right to run ahead of freight trains. To address this problem, the committee recommends the following.

Recommendation 4: Congress should direct and empower the Federal Railroad Administration (FRA) to enforce the performance of host freight railroads in giving preference to Amtrak passenger trains on single-track route segments where there is a mismatch between the length of freight trains being operated and the infrastructure available on the route segment to accommodate them without delaying Amtrak trains. Under these circumstances, when an Amtrak train experiences delays because of an inability to meet or pass a freight train, the host railroad should be subject to financial penalties. The penalties should be substantial and certain enough to deter this practice and to motivate solutions, including the rightsizing of freight trains to sidings and investments by host railroads in longer sidings. This FRA function would need to be allied with the Surface Transportation Board's jurisdiction over railroad practices and service.

Finally, the report considers, but does not make policy recommendations about, certain impacts from longer trains, including their effects on greenhouse gas (GHG) emissions and the operational fluidity of freight trains. GHG emissions are a major public policy concern, but on a national scale freight trains are not intense emitters of these pollutants. Estimating the marginal emissions impacts from longer trains would require many uncertain assumptions about whether and by how much longer freight trains are replacing shorter trains or diverting freight to or from trucks and other modes. With regard to freight train operational fluidity, some of the operational impacts from using longer trains are described, such as on rail car cycle times; however, the railroads must account directly for the choices they make about when and how to use long trains, including impacts on their paying customers.

1
Introduction

During the past two decades, U.S. freight railroads have been operating increasingly longer trains. Nearly all of these long trains are operated by the six Class I railroads.[2] Based on data provided by two Class I railroads, the U.S. Government Accountability Office (GAO) reported in 2019 that average train length had increased by about 25% from 2008 to 2017.[3] By 2021 some trains had reached a length of almost 14,000 ft (~2.6 mi) and the length of about 25% of all trains exceeded 7,500 ft (~1.5 mi).[4] Railroads began adopting long trains out of interest in reducing costs and increasing operating efficiency. By making trains longer—and especially by lengthening manifest trains that consist of different types of rail cars—railroads could reduce the number of train starts, crews, and locomotives to move the same amount of tonnage as moved by more shorter trains.[5]

The derailment of a 178-car freight train in Bedford County, Pennsylvania,[6] during August 2017, which led to the release of hazardous materials and a fire, brought attention to potential safety challenges from operating longer trains. Notably, in its investigation of the derailment, the National Transportation Safety Board (NTSB) raised concerns about how the 10,612-ft-long (~2-mile-long) train had been composed and how hand brakes were used to control speeds on descending grade. NTSB questioned the railroad's decision to place at the front of the train blocks of empty rail cars, which were derailed by the heavier, loaded cars pushing from behind as the train descended a grade. In its review of the safety and other impacts of longer freight trains, GAO pointed to this incident as indicative of the complexities that can arise in properly constructing trains as they become longer and contain a mix of rail car types and weights.[7]

As part of its charge, GAO also considered whether the trend toward longer trains was affecting the frequency and duration of blocked highway-rail grade crossings. The Federal Railroad Administration (FRA) had reported that complaints about blocked crossings had been increasing coincident with the increases in train lengths generally. The agency was receiving more complaints about delayed emergency responses at blocked crossings and high-risk motorist

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[2] BNSF Railway, Canadian National, Canadian Pacific Kansas City, CSX Transportation, Norfolk Southern, and Union Pacific.

[3] GAO (U.S. Government Accountability Office). n.d. Rail Safety: Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact." GAO-19-443. https://www.gao.gov/assets/gao-19-443.pdf.

[4] AAR (Association of American Railroads). "Freight Rail & Train Length." https://www.aar.org/issue/freight-train-length (accessed May 20, 2024).

[5] AAR presentation to committee, January 2023.

[6] "CSX Train Derailment with Hazardous Materials Release, Hyndman, Pennsylvania, August 2, 2017." Accident Report NTSB/RAR-20/04 PB2020-101012.

[7] "Rail Safety: Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact." GAO-19-443. https://www.gao.gov/assets/gao-19-443.pdf, p. 2.

and pedestrian behaviors, such as racing to cross tracks in advance of a train, and, in the case of impatient pedestrians, crawling over and under trains stopped at crossings. Although it did not reach a conclusion about whether longer trains have been a factor in the increase in complaints about grade-crossing blockages, GAO reported concerns raised by local communities that longer trains prolong the duration of a blockage and can block more crossings concurrently to make it harder for vehicles to route around the train.

STUDY ORIGINS AND APPROACH

In November 2021, Congress directed the Secretary of Transportation to enter into an agreement with the National Academies of Sciences, Engineering, and Medicine "to conduct a study on the operation of freight trains that are longer than 7,500 feet."[8] Under sponsorship from FRA, the Transportation Research Board convened the Committee on the Impact of Trains Longer Than 7,500 Feet in September 2022. The 12-member committee, with experience in freight and passenger railroad operations, state rail transportation, national rail safety oversight, and freight and passenger rail research, was charged with fulfilling the Statement of Task (SOT) found in Box 1-1.

BOX 1-1
Statement of Task

An ad hoc committee will conduct a study of freight trains that are longer than 7,500 feet. The study will examine potential safety risks from the operation of these trains relative to the operation of shorter trains. Consideration will be given to whether there is a changed potential for (a) loss of communications between the end-of-train device and the locomotive cab when taking into account differing terrains and conditions; (b) loss of radio communications between crew members when a crew member alights from the train, including communications over differing terrains and conditions; (c) derailments, including incidents that may be associated with in-train compressive forces and slack action or other operational factors in differing terrains and conditions; (d) adverse impacts from the deployment of multiple distributed power units; and (e) adverse impacts on braking, locomotive performance, and track wear.

As part of its review, the committee will consider the role of locomotive electronics, signal systems, train length, and trailing tonnage with regard to how railroads build longer trains (including the number and placement of loaded and empty freight cars and distributed power locomotives). The committee will review how engineers and conductors are trained and their service readiness to operate longer trains. If warranted from its findings, the committee may examine safety margins and human factors and make recommendations on whether additional engineer and conductor training is required for safely operating longer trains. The committee will also assess the potential impacts of operating longer trains relative to shorter trains on greenhouse gas emissions and other environmental concerns, the scheduling and efficiency of passenger and freight train operations, and the frequency and amount of time that highway-rail grade crossings are occupied by trains.

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[8] "Section 22422: National Academies study on trains longer than 7,500 feet"; Infrastructure Investment and Jobs Act, P.L. 117-58, Infrastructure Investment and Jobs Act, November 15, 2021. https://www.congress.gov/bill/117th-congress/house-bill/3684/text.

The committee may also make other recommendations, including to Congress and the U.S. Department of Transportation, on steps needed to better understand and reduce any adverse impacts of longer trains.

In considering the SOT, the study committee had to make several decisions, including about the meaning of terms in the charge and how to orient the study toward salient public policy interests.

Defining Long Trains

The SOT calls for an examination of trains that are longer than 7,500 ft—equivalent to about 1.5 mi—but this value is not uniformly viewed as the threshold for defining a long train.[9] As a result, and because the impacts from freight trains do not change abruptly when a train reaches or drops below 7,500 ft in length, the committee decided that this value was specified in the SOT and in the legislation calling for the study to signify an interest in the upper portion of the train length range, rather than to define a "long" train precisely.[10]

Emphasis on Impacts with Policy Relevance

The committee wanted its report and recommendations to be relevant by addressing the most salient public policy issues. In this regard, it is important to emphasize that current policy interests pertaining to long trains stem largely from recent trends within the rail industry to build and operate increasingly longer manifest trains, which haul a mix of freight in many different types of rail cars. In addition to manifest trains, railroads operate unit trains and intermodal trains. A unit train consists of cars of uniform type and weight, such as a train made up of coal cars only. An intermodal train carries only intermodal cars, but these trains can have characteristics similar to manifest trains inasmuch as the intermodal cars can be of varying lengths and weights.

Railroads first began operating long unit trains (up to 200 cars) to transport iron ore and coal during the 1940s, but it was not until recent decades that railroads began operating longer manifest trains.[11] Longer manifest trains have spawned public policy interest because they present different operational challenges than the more uniform unit and intermodal trains. Manifest train handling and operations can be more complicated because of their diverse car types and weights. In addition, as blocks of rail cars are picked up and set out en route, the consists of manifest trains may change during a single trip such that the train's handling demands will also change.

In asking for a review of the impacts of increasing freight train lengths, the SOT calls out four interests in particular: rail safety, highway-rail grade-crossing blockages, the operational efficiency of passenger and freight trains, and greenhouse gas (GHG) emissions. Of these impacts, safety is a foremost public concern, and thus treated extensively in the report. Likewise, significant attention is paid to highway-rail grade crossings, where trains have a direct impact on

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[9] AAR Standard S-462 is based on extensive testing of the valve portions on a 150-car test rack, comprising of 50-ft long cars, for a total train length of 7,500 feet.

[10] FRA defines a very long train as a train with more than 200 cars. Because rail cars may be of different lengths, there is not a one-to-one relationship between the number of cars and the length of the train.

[11] AAR presentation to committee, January 2023.

the public. With regard to the impacts of longer freight trains on passenger trains, the report pays the most attention to impacts on intercity trains operated by Amtrak. Many of Amtrak's trains run over the track of freight railroads (called "host railroads") that were relieved of their common carrier obligation to provide passenger service when Amtrak was created.[12] Federal law grants Amtrak trains preference over a host railroad's trains,[13] and thus if conflicts arise due to the increasing length of freight trains, this can be a clear public policy matter.

While GHG emissions are a major public policy concern, freight trains are not intense emitters of these pollutants relative to other modes, and therefore the impact of longer trains on GHG emissions is not treated as extensively in this report as impacts on rail safety, grade crossings, and Amtrak passenger service. The report also gives less attention to the impacts of long trains on the operational efficiency of local commuter trains because, unlike Amtrak, commuter railroads are not afforded preference over freight service by statute, and they can address operational issues related to long freight trains through their individual track usage agreements negotiated with host railroads.

With regard to the impacts of long freight trains on the operational fluidity of other freight trains, some of these impacts are discussed in the report, such as on rail car cycle times, but with recognition that this is not a significant public policy matter because railroads must account for these impacts on their own operations and on their shipper customers when they make choices about when and how to use longer trains.

Methodology

To inform its work, the committee invited presentations from dozens of individuals and organizations, as listed in the Acknowledgments section above. They included presentations from all six Class I railroads and the Association of American Railroads (AAR), three railroad labor unions (Brotherhood of Locomotive Engineers and Trainmen; American Train Dispatchers Association; and Sheet Metal, Air and Rail Transportation), Amtrak and commuter passenger railroads, shippers, and members of the public and their locally elected officials.

The committee reviewed the academic literature pertaining to all study subject matter and sought data from publicly available sources and from the freight and passenger railroad industries directly. To assess safety impacts, the committee consulted FRA safety advisories and evaluated train derailment records from FRA and train traffic data from the Surface Transportation Board (STB). For this purpose, the committee also asked AAR to provide various data needed to document the extent of long train operations and to better align train derailment records with train movements and types; however, restrictive conditions on the supply of this proprietary information, including preapproval of the analytic methods used and a high degree of data aggregation, foreclosed this option.

To examine the role of technology in train operations and communications between locomotives, the committee held a meeting to learn about in-train telemetry. To understand the radio communication requirements of crew members when operating long trains over differing terrains and under different operating conditions, the committee invited presentations from officials and members of railroad labor unions. They explained how train engineers and

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[12] P.L. 91-518. Rail Passenger Service Act of 1970. The act authorized Amtrak to assume by contract the intercity rail passenger service obligations of railroads who wished to be relieved of these obligations as common carriers.

[13] P.L. 93-146, § 10(2), 87 Stat. 548.

conductors are trained and otherwise prepared to operate longer trains and how long trains can affect rail yard and dispatching operations.

To understand the impacts on communities from longer trains, including at highway-rail grade crossings, the committee met with members of the public and officials from local communities, including emergency responders from the Chicago area and other parts of Illinois, as well as from Indiana, Maryland, and Iowa. To further evaluate how long trains can affect the functioning of highway-rail grade crossings, a panel of federal, state, and local officials was convened for input, and the committee commissioned an analysis of data recorded from devices located at grade crossings to detect trains in selected locations. To understand how long trains can affect passenger trains, the committee invited presentations from Amtrak and Metra, the commuter railroad of northern Illinois.

To observe the functioning of the largest freight railroad center in North America, the committee held one of its meetings in Chicago, where all Class I railroad operations intersect daily. The visit included tours of the Belt Railway of Chicago, Metra operations, and several area sites that have experienced persistent blocked grade crossings. On this visit, the committee also heard from officials in local communities impacted by long trains, the chair of STB, and officials from the Chicago Metropolitan Agency for Planning.

REPORT ORGANIZATION

Chapter 2 describes the operational and safety challenges of long trains and examines why these challenges are particularly acute for long manifest trains. Chapter 3 examines the technologies used to control long trains and ensure operational safety, including engineer-assist systems, braking systems, and distributed power locomotives. Chapter 4 examines issues related to crew and railroad employees and their preparedness and experience in operating, inspecting, and maintaining long trains. Chapter 5 examines the safety impacts of long trains on the public, namely on the functioning of highway-rail grade crossings and on Amtrak intercity passenger rail service. Chapter 6 reviews the ways long trains can affect greenhouse gas emissions from rail transportation and from other modes and have other environmental impacts. Chapter 7 is a summary assessment of the report’s findings and contains the committee’s recommendations and their rationale.

2

Overview of Long Train Safety Challenges and Performance

While long trains are not new to the freight railroad industry, this chapter explains the significance of recent changes in the type and operation of long trains, and particularly the increasing length of manifest trains. Previously, the longest trains operated by railroads were disproportionately unit trains, and hence past research on the safety performance of long trains did not address manifest trains explicitly. The chapter therefore begins with a brief history of long trains and the recent technological developments that have enabled railroads to operate longer manifest trains.

The Federal Railroad Administration (FRA) of the United States and the Transportation Safety Board (TSB) of Canada have raised concerns in safety advisories about the safe operations of longer manifest trains.[14,15] The chapter explains the reasons for these concerns and then presents analysis of FRA derailment data to see if there is evidence of these concerns affecting rail safety. Because the handling challenges associated with long trains is called out in FRA safety advisories, consideration is given to railroad practices for train makeup, which is critical for managing in-train forces.

The chapter concludes by reviewing the role of safety management systems (SMSs) in addressing new or heightened safety challenges that longer trains may present. FRA requires that railroads institute Risk Reduction Programs (RRPs), which if consistent with the standard elements of a fully developed SMS program would be expected to address such safety-related challenges in a deliberate and systematic manner. However, FRA's RRP requirements and compliance audits are (in FRA's words) "streamlined," and as a result, it is unclear whether railroads are being deliberate and systematic in controlling the risks from longer trains. [16]

TREND TOWARD LONGER MANIFEST TRAINS

According to the Association of American Railroads (AAR), long unit trains have been operating in some fashion for more than 80 years, as trains with 180 or more cars were being used on a limited set of routes to move iron ore and coal as early as the 1940s.[17] The placement of locomotives at intervals throughout the train to provide distributed power (DP) helped to mitigate high in-train draft forces, which, along with the development of stronger coupler

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[14] FRA (Federal Railroad Administration). 2023. "Safety Advisory 2023-03; Accident Mitigation and Train Length." *Federal Register*, May 2. https://railroads.dot.gov/sites/fra.dot.gov/files/2023-05/Safety%20Advisory%202023-03.pdf. See also FRA. 2023. "Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns." *Federal Register*, April 11. https://railroads.dot.gov/elibrary/safety-advisory-2023-02-train-makeup-and-operational-safety-concerns.

[15] Transportation Safety Board of Canada. 2020. "Managing In-Train Forces." Rail Safety Advisory Letter 617-06/20.forces. Ottawa, ON: Transport Canada.

[16] Federal Register, Vol. 85, No. 32, 9273, February 18, 2020.

[17] AAR presentation to committee, January 2023.

systems, allowed railroads to operate 120-car (or more) unit trains on a more widespread basis as early as the 1960s. The DP units were controlled remotely by the crew in the lead locomotive. More recently, the introduction of alternating current (AC) traction locomotives allowed trains to high throttle indefinitely without overheating (in contrast to locomotives equipped with direct current [DC] traction motors). Because AC traction increases adhesion and low-speed tractive effort, the use of these motors allowed railroads to operate longer and heavier trains in more locations, especially on mountain grades.[18] Although most of these technological advances were applied to increase the length of unit trains, AAR reports that even by the 1960s some railroads were experimenting with longer manifest trains, notably the Southern Railway.[19]

During the 1990s, some railroads began implementing Precision Scheduled Railroading (PSR) that emphasizes freight trains in point-to-point service operating on fixed schedules, instead of being dispatched whenever sufficient loaded cars are available. While it is pursued and defined differently by the Class I railroads, PSR's aim, as a general matter, is to increase operating efficiency and reduce labor and fuel costs.[20,21]

As shown in Table 2-1, during the past two decades PSR has been adopted by all but one (BNSF) of the major railroads. A 2023 study by the U.S. Government Accountability Office (GAO) found that the adoption of PSR has consistently led to longer trains, decreases in the number of assets such as locomotives, and reductions in the railroad workforce.[22] According to GAO, between 2011 and 2021, the number of Class I service locomotives decreased by 5%, the number of service rail cars decreased by 32%, and the number of railroad workers decreased by 28%.[23]

TABLE 2-1 Origins of Precision Scheduled Railroading by Railroad

Railroad	Year
CN	1998
CP	2012
CSX	2017
UP	2018
KCS	2019
NS	2019

SOURCE: GAO Analysis of Class I Freight Railroad materials, data from the Bureau of Transportation Statistics on freight volumes, and analysis by Council of Economic Advisors – GAO-23-105420.

Although PSR does not necessarily require long trains, most Class I railroads began to show a substantial increase in the average length of their long-distance "through" trains as they shifted to PSR. Through trains operate between two or more major concentration or distribution points (i.e., rail yards and terminals), as opposed to trains used for local services or unit trains.

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[18] PRC Rail Consulting Ltd. "Electric Traction Control." http://www.railway-technical.com/trains/rolling-stock-index-l/train-equipment/electric-traction-control-d.html (accessed June 4, 2024).

[19] AAR presentation to committee, January 2023.

[20] Dick, C.T. 2021. "Precision Scheduled Railroading and the Need for Improved Estimates of Yard Capacity and Performance Considering Traffic Complexity." *Transportation Research Record* 2675(10):411–424.

[21] GAO (U.S. Government Accountability Office). 2023. "Freight Rail: Information on Precision-Scheduled Railroading." https://www.gao.gov/products/gao-23-105420.

[22] Ibid.

[23] Ibid.

Whether PSR is the main cause of longer manifest trains is unclear; however, Figure 2-1, which is derived from annual reports (R-1) submitted by railroads to the Surface Transportation Board (STB), shows that the average size of through trains, measured by number of cars, has increased in recent years among the four largest Class I railroads.[24] The STB R-1 data do not allow for direct estimates of average train length, and thus the number of railcars per train is used as a proxy for train length. While average rail cars per through train remained fairly stable from 2005 to 2019, ranging from 56 to 65 cars, the average grew to 89 in 2021 and 77 in 2022.

It merits noting that while STB's definition of through trains excludes local and unit trains, it does include both manifest and intermodal trains and the data cannot be disaggregated further. While manifest and intermodal trains differ in a number of respects, they do share the same characteristic of having cars of different lengths, weights (empty, loaded), and configurations. Moreover, some intermodal trains are filled out with automobile carriers and other conventional rail cars, making them a type of manifest train in these cases.

For the purposes of observing trends in average cars per through train as a proxy for average length of through trains, the aggregation of manifest and intermodal trains is problematic only in the sense that it is likely to lower the average and suggest that through trains are shorter than they really are. This is because intermodal trains are usually composed of a relatively small number of long, multi-platform articulated railcars (i.e., 5-unit well cars). Accordingly, a 25-car intermodal train consisting of 5-unit well cars can be the same length as a 125-car manifest train. Thus, if intermodal trains could be removed from the STB data for through trains, this would likely increase the average number of cars (as shown in Figure 2-1), but it would not affect the overall pattern of change unless the proportion of intermodal and manifest trains was changing significantly.

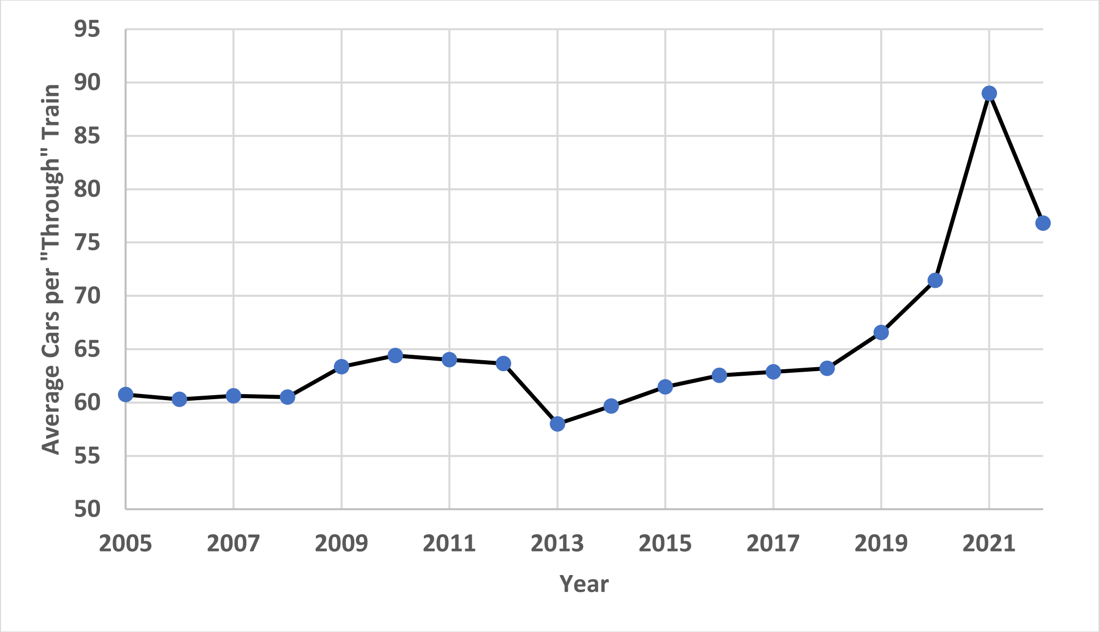

FIGURE 2-1 Average cars per through train (manifest and intermodal), four largest Class I railroads combined, 2005–2022.

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[24] Average number of railcars for a specific year is calculated from dividing annual through car-miles by annual through train-miles from the STB R-1 annual report for an individual railroad during a given year

NOTE: Data are for Union Pacific Railway, Burlington Northern Santa Fe Railway (BNSF), Norfolk Southern Railway, and CSX Transportation Railway (CSX).
SOURCE: Surface Transportation Board (STB) R-1 reports.

INDICATIONS OF THE SAFETY PERFORMANCE OF LONGER TRAINS FROM DERAILMENT DATA

All six Class I railroads presenting to the committee maintained that the operation of longer trains should result in safer train operations and fewer derailments overall. The six railroads maintained that longer trains result in fewer trains in total, and therefore fewer opportunities for derailments.[25] Furthermore, the railroads maintained that the frequency of equipment-caused and track-caused derailments should be unaffected by train length.[26]

Despite these assertions, both FRA and TSB have raised concerns in safety advisories about operational and handling challenges associated with longer manifest trains.[27,28] During March and April 2023, FRA issued advisories on accident mitigation and train length, train makeup, and operational safety. The advisories followed the initial investigations of the derailment of a 9,300-ft-long manifest train in East Palestine, Ohio, and subsequent derailments in Springfield, Ohio; Ravenna, Ohio; and Rockwell, Iowa, all of which involved trains that were more than 12,000 ft long.

According to FRA's advisory, these manifest train derailments "demonstrate the need for railroads and railroad employees to be particularly mindful of the complexities of operating longer trains, which include, but are not limited to: (1) train makeup and handling; (2) railroad braking and train handling rules, policies, and procedures; (3) protecting against the loss of end-of-train (EOT) device communications; and (4) where applicable, protecting against the loss of radio communications among crew members."[29]

The TSB advisory raised similar concerns related to the length and weight of longer trains by stating that

> with the increase in average train length and weight, there have been increases in the associated in-train forces. Longer trains in particular can generate significant longitudinal draft/buff forces due to the slack action of the train. To minimize these draft/buff forces requires more critical management of freight car placement (train marshalling) within the trains to reduce in-train forces and maintain safe operations.[30]

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[25] Class I railroad presentations to committee, January, March, and April 2023.

[26] Ibid.

[27] FRA. 2023. "Safety Advisory 2023-03; Accident Mitigation and Train Length." *Federal Register*, May 2. https://railroads.dot.gov/sites/fra.dot.gov/files/2023-05/Safety%20Advisory%202023-03.pdf. See also FRA. 2023. "Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns." *Federal Register*, April 11. https://railroads.dot.gov/elibrary/safety-advisory-2023-02-train-makeup-and-operational-safety-concerns.

[28] Transportation Safety Board of Canada. 2020. "Managing In-Train Forces. Rail Safety Advisory Letter 617-06/20. Ottawa, ON: Transport Canada.

[29] FRA. 2023. "Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns." *Federal Register*, April 11. https://railroads.dot.gov/elibrary/safety-advisory-2023-02-train-makeup-and-operational-safety-concerns.

[30] Transportation Safety Board of Canada. 2020. "Managing In-Train Forces. Rail Safety Advisory Letter 617-06/20. Ottawa, ON: Transport Canada..

In these safety advisories, FRA and TSB identified a number of operational concerns related to longer manifest trains, including concerns about the effects of greater in-train forces and the importance of sound train makeup procedures to account for these forces. The advisories also raised issues pertaining to train handling and braking, communications among crew members, and communications between the locomotive cab and end-of-train device.

Before considering these specific matters, the next section reviews train derailment data and evidence from the literature for insights on how increases in manifest train length may be affecting derailment frequency and severity. Consideration is given first to the derailment performance of manifest trains generally when compared to unit trains. This is followed by references to past studies that have examined how train length correlates with the frequency and severity of derailments. As noted above, FRA's advisories have pointed to the handing challenges that longer manifest trains can create because of the mix of rail cars in the consist. With these concerns in mind, FRA accident data are examined to see if rates of derailments (per ton-mile) involving train makeup and handling deficiencies have been changing in relation to upward trends in average train size (i.e., number of cars per train).

Derailment Performance of Manifest Trains Generally

Although train type is not always cited in aggregate statistics of derailment patterns and trends, it is important to assess and understand. For instance, Zhang et al. determined that, for the years 1996 to 2018, manifest trains exhibited a mainline derailment rate per ton-mile that was 40% higher than the derailment rate for loaded unit trains.[31] A major reason for this higher rate appears to be differences in the propensity for train handling errors. Although manifest trains and loaded unit trains exhibited similar rates of derailments for both equipment-caused and track-caused incidents, the derailment rate from human factor causes was more than four times higher for manifest trains.[32] This result suggests that manifest trains may pose greater operational and handling challenges for crew members than units trains, despite the latter trains being heavier on average than manifest trains.

The specific reasons for the handling challenges are discussed more below, but they stem from differences in how manifest and unit trains are constructed. The former contain a mix of rail car types, sizes, and weights, while the latter are more uniformly constructed, usually consisting of the same types of cars (i.e., tank car, hopper car), each having similar sizes and weights. As a result, the weight, length, truck-center spacing, center of gravity, and coupler draft gear cushioning for individual rail cars can vary greatly in manifest trains compared to the more homogeneous unit trains. The distribution of power will also differ from train to train. Manifest trains will therefore exhibit more variability in their handling requirements, which train crews must be able to recognize and accommodate. By comparison, unit trains are typically a consistent length and locomotive configuration, which allows crews to use consistent and repeatable control methods.

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[31] Zhang, Z., C.-Y. Lin, X. Liu, Z. Bian, C.T. Dick, J. Zhao, and S.W. Kirkpatrick. 2022. "An Empirical Analysis of Freight Train Derailment Rates for Unit Trains and Manifest Trains." *Journal of Rail and Rapid Transit* 236(10):1168–1178. https://doi.org/10.1177/09544097221080615.

[32] Ibid.

Long Trains and Derailment Frequency and Severity

If train miles and derailment potential are correlated, then the transportation of a fixed amount of freight by long manifest trains displacing shorter manifest trains should reduce total derailments, as maintained by the Class I railroads. However, because longer manifest trains have more cars, the derailments that do occur may be more consequential. The consequences of a train derailment can be characterized by descriptors of the derailment itself, such as the number of rail cars derailed and damaged, and by measures of impacts on railroad workers, local communities, and emergency responders, including people evacuated due to concerns about hazardous materials.

Research on train derailments caused by equipment and mechanical failures shows that the number of cars derailed is correlated to the length of the derailed train.[33] Furthermore, the literature shows that the number of cars derailed is highly correlated with the likelihood of hazardous materials being released and other severe outcomes.[34,35,36]

Trends in Derailment Rates and Average Train Size

The following is an analysis of derailments of freight trains occurring from 2005 to 2022 focusing on the experience of the four largest Class I railroads (BNSF, CSX, NS, and UP). The aim of the analysis is to see if there is an association between the average size of through trains, as defined earlier for Figure 2-1, and rates of freight train derailments attributed to train makeup and handling issues as identified in FRA accident records.[37] The analysis uses STB data (from annual R-1 reports) on the annual gross ton-miles of the four Class I railroads to calculate derailment rates.[38]

To focus on derailments that can be attributed to train makeup and handling issues, only mainline derailments with the FRA causal codes listed in Table 2-2 were selected. These codes include a preponderance of human-related causes, such as excessive buff and draft forces due to improper train handling, and some equipment-related causes, such as broken knuckles and drawbars. FRA and TSB have pointed to such issues in their safety advisories pertaining to longer manifest trains, as noted above.

TABLE 2-2 Freight Train Derailment Causes Considered in the Analysis

Codes	Description
E30-E34	Broken or defective knuckles, couplers, drawbars and draft gear
H018-H022	Improper hand brake application to secure engines and cars

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[33] Schafer, D.H., and C.P.L. Barkan. 2008. “Relationship Between Train Length and Accident Causes and Rates.” *Transportation Research Record* 2043(1):73–82. https://doi.org/10.3141/2043-09.

[34] Nayak, P.R., and D.W. Palmer. 1980. “Issues and Dimensions of Freight Car Size: A Compendium.” Report No. FRA-ORD-79/56. Washington, DC: U.S. Department of Transportation, Federal Railroad Administration.

[35] Barkan, C.P.L., C.T. Dick, and R.T. Anderson. 2003. “Analysis of Railroad Derailment Factors Affecting Hazardous Materials Transportation Risk.” *Transportation Research Record* 1825:64–74.

[36] Wang, B.Z. 2019. “Quantitative Analyses of Freight Train Derailments.” Ph.D. dissertation, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL.

[37] FRA Train Accident Database. 2023. https://data.transportation.gov/Railroads/Rail-Equipment-Accident-Incident-Data-Form-54-Subs/byy5-w977/about_data.

[38] STB (Surface Transportation Board). 2023. *R-1 Annual Reports: 1996–2022*. https://www.stb.gov/reports-data/economic-data/annual-report-financial-data.

H501-H502	Improper train make up at and between terminals
H503-H504	Excessive Buff or slack action due to train handling, train makeup
H505-H507	Improper train handling on curves
H510-H514	Improper automatic brake application
H517-H521	Improper dynamic brake application
H522-H524	Improper throttle application
H599	Other causes relating to train handling or makeup

SOURCES: FRA Derailment Cause Codes: Train Operation, Human Factors. https://railroads.dot.gov/forms-guides-publications/guides/appendix-c-train-operation-human-factor. Mechanical and Electrical Failures. https://railroads.dot.gov/forms-guides-publications/guides/appendix-c-mechanical-and-electrical-failures.

Figure 2-2 shows the annual derailment rates from 2005 to 2022 calculated by combining mainline derailments caused by train makeup and handling issues and then dividing their sum by the total gross ton-miles for the four Class I railroads combined. The trendline shows marked increases in the annual rate of these derailments starting in 2019.

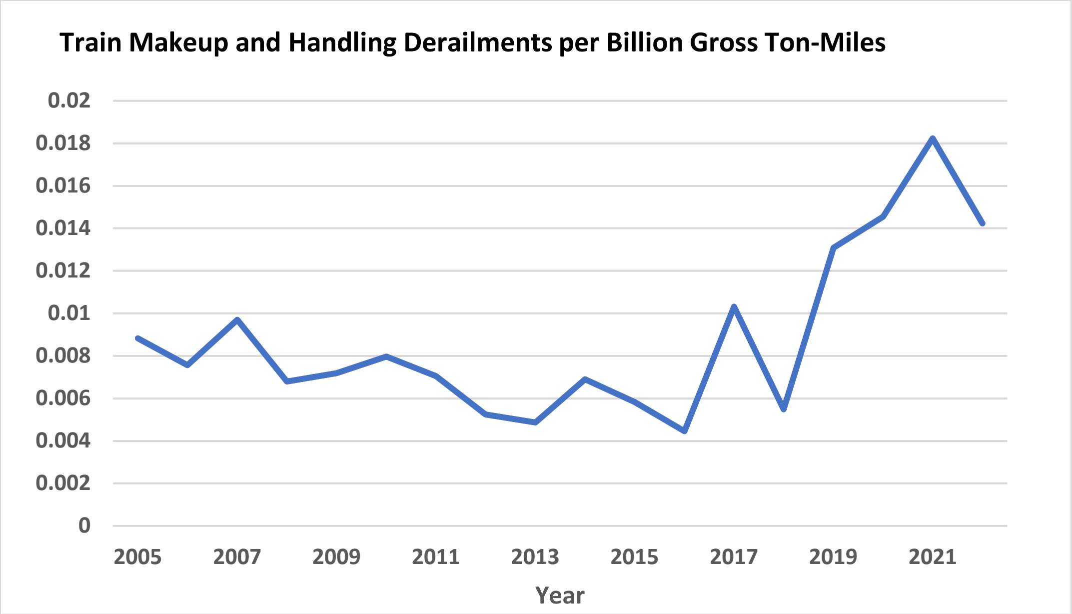

FIGURE 2-2 Train makeup and handling derailments per billion gross-ton mile (GTM) for the four largest Class I railroads combined, 2005–2022.
SOURCE: STB R-1 reports and FRA derailment reports.

Having observed an increase in the rate of occurrence of derailments associated with train makeup and handing issues, a matter of interest is whether this pattern aligns with changes in average through train size. Thus, to take the analyses a step further, Figure 2-3 plots the annual train derailment rates (from makeup and handling issues) for each of the four Class I railroads against each railroad's average number of cars per through train during 2005 to 2022. Each plotted point represents a Class I railroad for a given year (18 years × 4 Class I railroads = 72 points). The average number of cars per through train is calculated in the same manner as described in Figure 2-1. For reasons explained in discussing that figure, the through train data include intermodal trains in addition to manifest trains, but this aggregation should not be problematic because the inclusion of intermodal trains is likely to depress the calculated average number of cars per train.

A linear regression trendline of the plotted values reveals a positive relationship between increasing rates of derailments (from handling and makeup issues) and average number of cars per through train. The chances of there not being a positive relationship, after testing for the p-value of the linear equation's slope coefficient, is much less than 1%.[39]

Figure 2-4 shows the same plotted points but identifies the railroads and separates them for trend analysis. While a positive relationship between derailment rates (from train makeup and handling issues) and average through train size is observed for all four railroads, one railroad (NS) stands out as accounting for most of the highest annual derailment rates (11 of the 16 highest rates) while exhibiting the strongest relationship between average through train size and derailment rates. This suggests that railroads may differ in the degree to which they are controlling for the operational challenges associated with increases in manifest train length. These controls, however, may not be fully effective, as the likelihood of train size and derailment rates not having a positive relationship is less than 1% for the regressions performed on data for all four railroads (based on the p-value for the coefficient of the dependent variable in each regression equation).[40] The next section describes in more detail the operational challenges that railroads operating longer trains need to address.

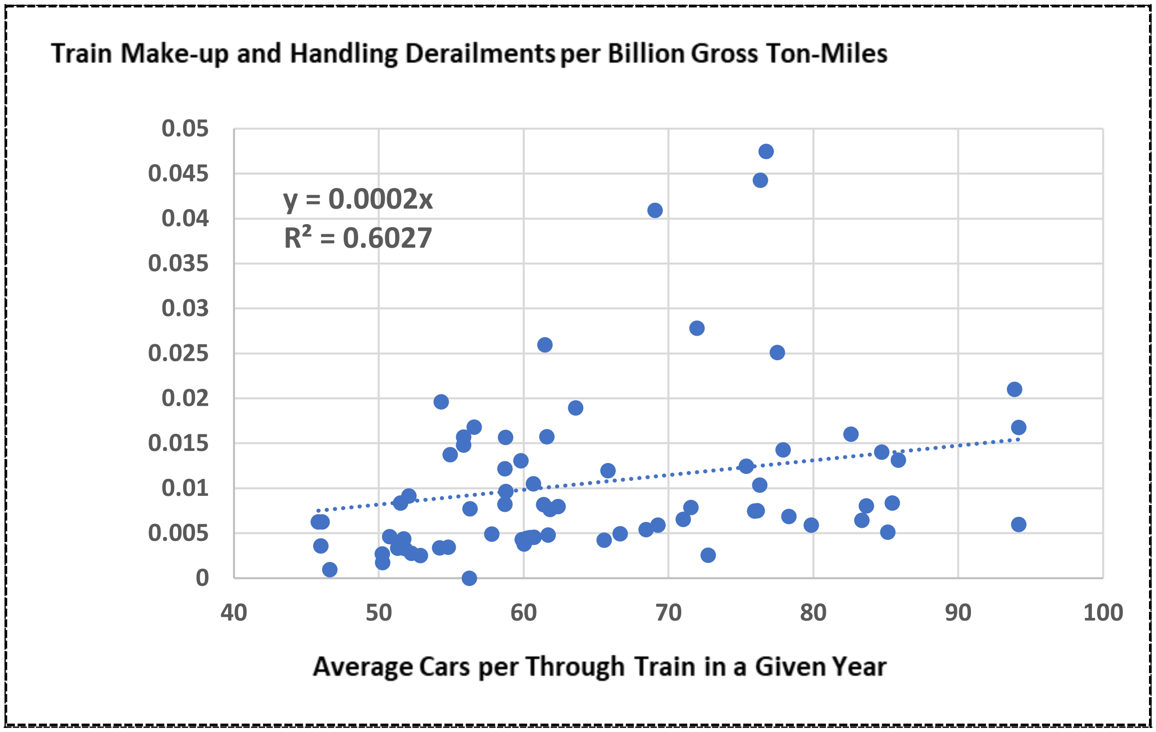

FIGURE 2-3 Train makeup and handling derailment rates in relation to average cars per through train for the four largest Class I railroads combined, 2005–2022.

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[39] The x coefficient p-value is 7.07e-16. A p-value of less than 0.05 is typically indicative of statistically significant relationship.

[40] The x coefficient p-values are as follows: NS (4.95e-7), CSX (1.82e-6), UP (2.41e-6), and BN (2.60e-7).

NOTE: Each of the 72 plotted points is for one of the four major Class I railroads for a given year, 2005 to 2022.
SOURCE: STB R-1 reports and FRA accident reports.

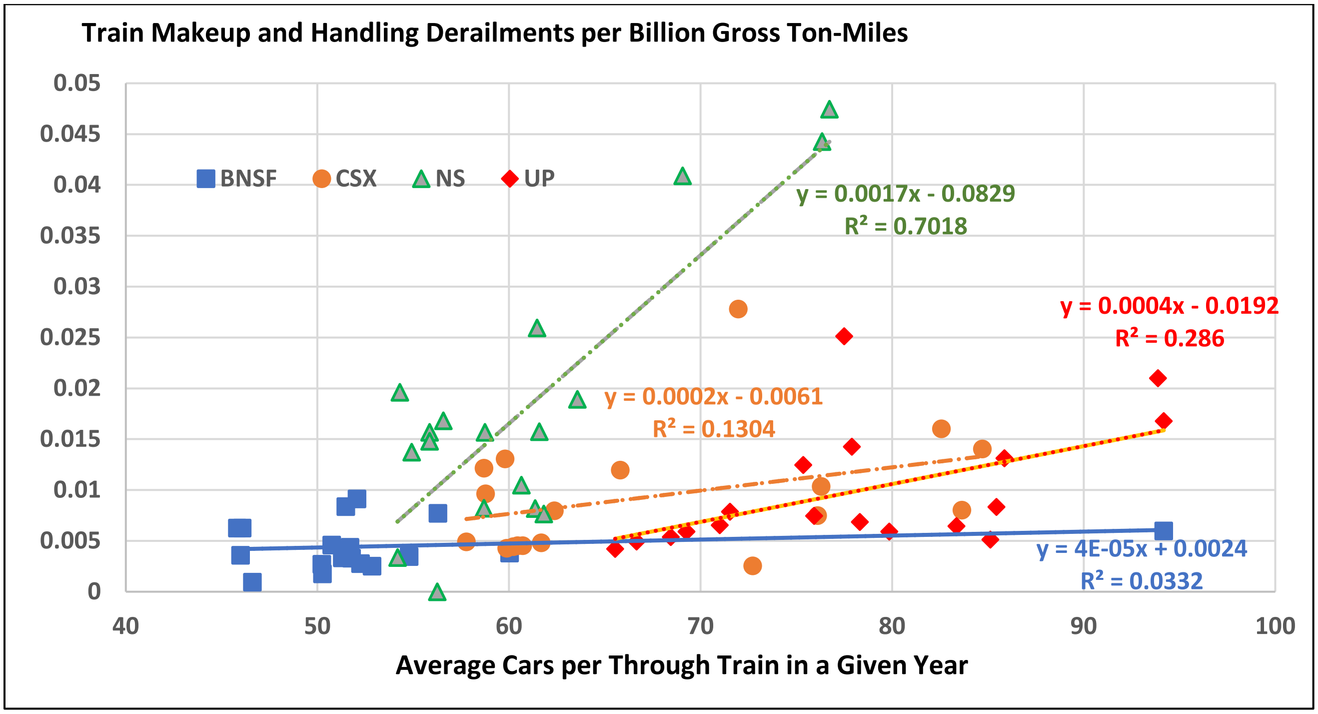

FIGURE 2-4 Train makeup and handling derailment rates in relation to average cars per through train for each of the four largest Class I railroads, 2005–2022.
NOTE: Each of the 72 plotted points is for one of the four major Class I railroads for a given year, 2005 to 2022.
SOURCE: STB R-1 reports and FRA accident reports.

IN-TRAIN FORCES AND TRAIN MAKEUP PRACTICES

This section explains how in-train forces create handling challenges for manifest trains and why proper train makeup can be critical to ensuring safe operations. The guidance available to railroads for train makeup is then reviewed.

In-Train Forces

In-train forces are created by compressive and stretching forces applied to the cars and their components. Forces that act longitudinally are referred to as "buff" and "draft" forces. Trains traveling on straight track generate steady-state longitudinal in-train forces.[41] Buff forces compress cars while draft forces stretch the train. On ascending track, trains generate draft forces, with the magnitude determined in part by trailing tonnage, locomotive tractive effort, and the ascending grade percent. On descending grades, buff forces are generated, with the

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[41] FRA. 2005. "Safe Placement of Train Cars: A Report." June. https://railroads.dot.gov/elibrary/safe-placement-train-cars-report.

magnitude determined by the use of dynamic and air brakes, trailing tonnage, and grade of the track. On undulating track, a train may experience both forces at the same time in different locations on the train.[42]

Buff forces create the potential for derailments from cars jackknifing while draft forces create the potential for derailments from cars stringlining in curves. Jackknifing occurs when high buff forces push cars against one another, causing wheels on the affected cars to climb the rail (usually on the outside rail on a curve) or the force may cause a rail to roll over if the track is not sufficiently anchored. Stringlining occurs when a train under draft conditions straightens out on a curve, causing lateral forces on two ends of a car to pull the car toward the low rail, which can cause the wheel on the high rail to derail. Additionally, if these longitudinal forces applied to couplers and their components are too high, a train will pull apart (usually as a result of a knuckle failure) and may also cause a derailment.[43]

Often the effects of these in-train forces are most severe on curved track, with tight curves being the most affected. On curved track, the in-train forces are transferred tangentially to the curve; each coupler forms an angle, and the in-train forces are partially transferred laterally. Coupler lateral forces are transferred to the car bodies and into the trucks and wheelsets, which causes wheels to apply lateral forces to the rail.

In a train with head-end locomotive power only, in-train forces will increase with train length and trailing tonnage.[44] High trailing tonnage creates higher in-train forces when locomotives are pulling (draft) and when brakes are not applied uniformly (buff or draft).[45,46] Thus, to help mitigate in-train forces, railroads operate DP locomotive units, or locomotives distributed at multiple locations in the train.[47] The DP locomotives apply tractive and braking forces through commands sent by radio signal from the lead controlling locomotive. The DP units also help control in-train forces through additional power and dynamic braking.[48]

Proper train makeup, or marshalling, can help control the magnitude of in-train forces. While train makeup for the purpose of controlling in-train forces is less of a factor for unit and intermodal trains whose cars have uniform cargoes, sizes, and weights,[49] it is critical for manifest trains.[50] Manifest trains have cars and blocks of cars that vary greatly in weight, length, and other characteristics, such as coupler and cushioning arrangements, that can make train handling more difficult.[51] In particular, poor placement of empty cars and cars with end-of-car cushioning

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[42] Ibid.

[43] Knuckles are designed to be the weak link in a train that breaks when forces are too high. This prevents more serious damage to cars. However, such breaks often result in undesired emergency air brake applications (explained later in Chapter 5) that can cause derailments.

[44] Government of Canada National Research Council. March 31, 2015. “Industry Review of Long Train Operation and In-Train Force Limit - NRC Publications Archive.” https://nrc-publications.canada.ca/eng/view/object/?id=bcc92202-14a8-476b-9500-5a384c4ff003.

[45] House Transportation and Infrastructure Subcommittee on Railroads, Pipelines, and Hazardous Materials. 2022. “Examining Freight Rail Safety.” June 14. https://www.congress.gov/event/117th-congress/house-event/114882.

[46] Serajian, R., S. Mohammadi, and A. Nasr. 2019. “Influence of Train Length on In-Train Longitudinal Forces During Brake Application.” *Vehicle System Dynamics* 57(2):192–206.

[47] AAR (Association of American Railroads). 2023. “Train Makeup Guidance.” Memo. September.

[48] Ibid.

[49] Train makeup can nevertheless be important for unit trains to separate specific hazardous materials.

[50] Ibata, D. 2019. “Train Make-Up 101: Or How to Not Let This Happen to You.” TrainsMag.com, July.

[51] FRA. 2023. Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns. D. FRA. Federal Record, GPO. 88:21736.

(EOCC) devices can cause in-train forces that are excessive enough to cause a derailment.[52] Here again, the placement of DP locomotives is critical to mitigate in-train forces by reducing the trailing tonnage for each locomotive. Even though DP locomotives distribute pulling and braking forces throughout the train, they can still create dangerous forces for empty cars immediately ahead of or behind them, which calls for careful placement of the units.[53]

Train Makeup Protocols and Guidance

When railroads assemble manifest trains, they must consider many factors for managing in-train forces, including

- Limiting trailing tonnage,
- Number of driving (and dynamic braking) axles and total train tonnage,
- Minimum weight requirements for head-end cars,
- Number and placement of empty cars,
- Number and placement of cars equipped with EOCC devices,
- Force limits adjacent to remote locomotives,
- Train length and radio communication, and
- Distributed power unit configuration.[54,55]

In addition, other factors to be considered include the subdivision (grades and curves), number of and placement of hazardous materials cars, and long-car/short-car combinations.[56] When railroads create trip plans for trains, individual cars are usually assembled in blocks by destination, which are then assembled into trains. Some railroads use the position of blocks in a train to control train makeup, whereas others have rules that transcend the placement of blocks, such as positioning heavy cars closer to the front of the consist and lighter cars, cars with EOCC devices, and empty cars toward the rear.[57]

Locomotive capacity and power capabilities must also be taken into consideration during train makeup. Locomotive power requirements are generally defined by ruling grade in certain locations.[58] Railroads either calculate the horsepower per ton required to maintain desired speed or calculate the minimum locomotives necessary to haul trains at a minimum continuous speed using either tons per axle[59] or some other measure such as haulage capacity factors or locomotive tonnage ratings.

While each railroad has its own rules and instructions to manage in-train forces, they all use industry and internal software to model train operations to create an optimal transportation

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[52] Government of Canada National Research Council. 2024. “Industry Review of Long Train Operation and In-Train Force Limit - NRC Publications Archive.” May 3. https://nrc-publications.canada.ca/eng/view/object/?id=bcc92202-14a8-476b-9500-5a384c4ff003.

[53] Ibid.

[54] Transport Canada. 2016. “Marshalling Guidelines for Safe Operations of Freight Trains.” September.

[55] Ibata, D. 2019. “Train Make-Up 101: Or How to Not Let This Happen to You.” TrainsMag.com, July.

[56] Long cars have long draw bars (couplers) that create excessive lateral forces when coupled to short cars when moving through tight curves or switches.

[57] CSX presentation to committee, March 2023.

[58] AAR. 2023. Association of American Railroads. “Train Makeup Guidance.” Memo. September.

[59] Tons per axle (TPA) is calculated by estimating the trailing tonnage divided by the equivalent powered axles (EPA), or TPA = TT / EPA. For a good reference for train makeup see Ibata, D. 2019. “Train Make-Up 101: Or How to Not Let This Happen to You.” TrainsMag.com, July.

plan and determine when a particular train or blocking plan may result in excessive in-train forces.[60] Certain capacity restraints are estimated based on train rules, subdivision restrictions, available crews, and number of locomotives. The software is used to adjust departure times, align train meets and passes en route, and adjust train sizes accordingly.[61] Further adjustments are made along the route to account for changes in schedules, weather conditions, passenger operations, and equipment changes.[62] Class I railroads further develop train plans to manage how trains are made up and then operated.[63] Some onboard train artificial intelligence technologies "learn" about any changes to the plan en route, while others do not. If train crews receive makeup data that do not match what is in their train order, they notify dispatch to rectify any discrepancies.[64]

Table 2-3 presents selected rules for CSX, CN, and BNSF, showing how train makeup rules can differ by railroad.

TABLE 2-3 Selected Train Makeup Rules by Railroad

Situation	Rule	Railroad
Manifest trains with single lead locomotive	Must place 5 loaded cars directly ahead of any DP locomotive	CSX
	First 5 cars in train must not weigh 45 tons or less	CN
Manifest trains with more than one locomotive	Must have 10 loaded cars placed directly ahead of a DP locomotive	CSX
	First 10 cars in train must not weigh 45 tons or less	CN
DP locomotives	Must have 10 loads placed directly ahead of a DP locomotive	CSX
Auto-racks or other cars with end-of-car cushioning devices[65]	Must not be placed directly ahead of or behind DP locomotives	CSX
DP locomotives	Maximum of 120 cushioned cars in a train	CN
	Must be placed a minimum of 1,250 ft behind or ahead of any other operating locomotive	CSX
Weight distribution	Maximum of 33% of train weight in rear quarter of train	CN

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[60] Union Pacific presentation to committee, March 2023.

[61] This software is used for train composition and is different from other software and models that railroads use to determine train makeup and in-train forces.

[62] Union Pacific presentation to committee, March 2023.

[63] Most/all railroads use some tool to examine existing or future train consists. It was not clear from presentations to the committee that all consists are tested on a real-time basis by all railroads before trains depart yards. The FRA safety advisory of 2023 (previously cited) indicates that current efforts to police train makeup are not universally working.

[64] BNSF presentation to committee, May 22, 2023.

[65] To prevent damage to shipments, some cars are equipped draft gear (couplers) that cushion sudden draft or buff forces for the car. The devices can be hydraulic, or spring loaded. Although the devices cushion the shipment, trains with many of these cars can behave like a giant "Slinky."

	Trains without DP locomotives weighing more than 8,000 tons must not have more than 33% of weight in the rear quarter of the train	CSX
Train length and weight restrictions	Maximum of 12,000 ft and 20,000 tons with DP locomotives	CN
	Maximum of 10,000 ft and 14,000 tons without DP locomotives	CN
	Manifest trains longer than 10,000 ft or more than 14,000 tons must not operate without an additional DP locomotive	BNSF

SOURCES: CSX, presentation to committee, March 2023; Canadian National Railway (CN), presentation to committee, April 2023; BNSF, presentation to committee, May 2023.

In addition to having different train makeup rules, each railroad has different processes for implementing the rules. Yard and train crews are ultimately responsible for ensuring compliance with the appropriate train makeup protocols for the territory to be traversed prior to the train departing a terminal. On certain railroads, crews are assisted by computer systems that automatically compare the train consist against relevant makeup rules to flag problems. On some railroads these automated checks only take place at the initial departure terminal, whereas other railroads have implemented systems that check the consist for compliance each time a rail car is added to or set out from the train along the route.

Canadian Pacific Kansas City Railway (CPKC) described a proprietary electronic train area simulation marshalling suite that has been in service for more than 20 years. The software calculates maximum draft and buff forces based on the number, placement, and characteristics of locomotives and location of cars placed in the train. It also evaluates trailing tonnage restrictions behind long and empty cars and ensures L/V (longitudinal over vertical forces) ratios remain below predetermined levels for safe operations.[66]

Even when utilizing modern freight equipment, draft or buff forces greater than 325,000 to 400,000 lbs. can cause damage to cars such as broken knuckles or couplers in addition to derailments (see Table 2-4).[67] Coupler knuckles are designed to be the weak link in a car that will fail before more serious damage results from excessive in-train forces. Knuckles can be replaced by crew members, but a broken knuckle will cause a train separation (and an undesired emergency brake application). CPKC reported that it uses automated train analytics machine learning tools to predict the potential for train separations resulting in undesired emergency brake applications.[68]

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[66] CPKC presentation to the committee, April 2023.

[67] Canada, Government of Canada National Research Council. "Industry Review of Long Train Operation and In-Train Force Limit - NRC Publications Archive," March 31, 2015. https://nrc-publications.canada.ca/eng/view/object/?id=bcc92202-14a8-476b-9500-5a384c4ff003.

[68] CPKC presentation to committee, April 2023.

TABLE 2-4 Maximum Knuckle Working Limits

Knuckle Material Grade	Load at Maximum Permanent Set (lbs.)	Ultimate Strength (lbs.)
Grade C (1992)	250,000	300,000
Grade E (1992)	300,000	400,000
AAR MSRP 2010	400,000	650,000

SOURCES: Canada, Government of Canada National Research Council. "Industry Review of Long Train Operation and In-Train Force Limit - NRC Publications Archive," March 31, 2015. https://nrc-publications.canada.ca/eng/view/object/?id=bcc92202-14a8-476b-9500-5a384c4ff003.

Some areas in North America have mountain grades and challenging terrain. In these locations, several railroads have territory-specific marshalling rules that limit train length and tonnage and marshalling restrictions for problematic car types, including short cars, empty bulkhead flatcars, and cars with EOCC devices such as auto-rack cars.[69] Some railroads deploy distributed braking cars, which are modified box cars with air compressors and associated equipment to supplement the train air brake system.[70] This can be particularly important in areas with frequent cold temperatures such as in the northern United States and in Canada.

Effectiveness of Train Makeup Rules and Policies

The only industry standards for marshalling trains that apply across the North American railroad industry are AAR's Train Makeup Manual, published in 1992,[71] and the Marshalling Guidelines for Safe Operation of Freight Trains, published by Transport Canada in 2016.[72] The AAR Train Makeup Manual was one of the first industrywide train makeup manuals that was written to help railroads manage in-train forces through the control of trailing tonnage, the use of head-end and DP locomotives, and the proper placement of critical car combinations in the train. The Transport Canada marshalling guidelines improved and expanded upon the trailing tonnage method of the AAR Train Makeup Manual by providing more robust in-train force limits.

The degree to which the railroad train makeup practices are consistent with this guidance and how faithfully the railroads follow their own train makeup procedures is unclear. The derailment trends presented above, and concerns raised in FRA safety advisories, suggest that either more effective rules or more consistent compliance may be needed.[73] In Canada, a TSB

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[69] CN presentation to committee, April 2023.

[70] Ibid. See also CN (Canadian National Railway). 2022. "Distributed Braking Cars Help Keep Our Network Running Safely, Efficiently in Winter." February 1. https://www.cn.ca/en/stories/20220201-air-cars.

[71] AAR. 1992. "Train Make-up Manual." Report No. R-802. January.

[72] Transport Canada. 2016. "Marshalling Guidelines for the Safe Operation of Freight Trains." https://tc.canada.ca/en/rail-transportation/publications/marshalling-guidelines-safe-operation-freight-trains.

[73] FRA. 2023. "Safety Advisory 2023-01, Evaluation of Policies and Procedures Related to the Use and Maintenance of Hot Bearing Wayside Detectors." *Federal Register* 88:14494–14497. https://railroads.dot.gov/sites/fra.dot.gov/files/2023-03/Safety%20Advisory%202023-01.pdf; FRA. 2023. "Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns." *Federal Register* 88:21736. https://www.govinfo.gov/content/pkg/FR-2023-04-11/pdf/2023-07579.pdf; FRA. 2023. "Safety Advisory 2023–03; Accident Mitigation and Train Length." *Federal Register* 88:27570–27573. https://www.govinfo.gov/content/pkg/FR-2023-05-02/pdf/2023-09239.pdf; National Transportation Safety Board. 2020. "CSX Train Derailment with Hazardous Materials Release, Hyndman, Pennsylvania, August 2, 2017." https://www.ntsb.gov/investigations/AccidentReports/Reports/RAR2004.pdf.

Safety Advisory Letter from 2020[74] reported differences in how train makeup is managed by major railroads in the country. For instance, TSB reported one of the two major Canadian railroads performs simulations of every train to minimize in-train forces, while the other uses only general rules of train makeup and has no policies for placement of cars with EOCC devices in a train. The advisory raised concern about the absence in Canada of regulatory requirements for managing in-train forces. Similarly, FRA does not have regulatory standards for managing in-train forces through train makeup formulas or other means.[75]

Long Trains and Maintaining Safe Track Condition

As discussed above, higher in-train forces create lateral forces on the rails. These forces can increase rail wear. Lateral forces have the greatest effect on curves. Ideally, the track in curves will be installed to provide superelevation for the track, where one rail is higher than the other to balance the effect of the lateral forces needed to move through a curve at a given speed. Curved track usually has its superelevation set to produce equal wear to the outside and inside rail and to put even load on the high and low rails when the train is traveling at balanced speed. The design assumes a target train speed. When trains are slower than the target speed, the wear of the inside rail will be increased. When trains are faster, the outside rail will experience more wear.[76] While both long and short trains will have these wear impacts, keeping a longer train at the target speed can be more difficult, in part because the train may span multiple curves. Also, longer unit trains with equal truck spacing will put more load for a longer period of time on the curves. Moreover, as train length increases, speed adjustments take longer, and speed restrictions may affect train speed over a longer length of track.[77] Except on tangent track, longer trains will have more impacts on condition of rail infrastructure because train speeds cannot be adjusted to account for the simultaneous and varied impacts of the long trains on the different rail geometries.

LONG TRAINS AND SAFETY MANAGEMENT SYSTEMS

The increased use of longer trains during the past decade has coincided with FRA's efforts to ensure that railroads are taking proactive steps, through the use of safety management systems (SMSs), to reduce the risks of their specific operations and conditions, and not simply following the minimum and industrywide standards in FRA regulations and in industry guidance. It is notable that in 2020, after investigating the August 2017 derailment of a long train in Bedford County, Pennsylvania, the National Transportation Safety Board (NTSB) observed the following:[78]

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[74] Transportation Safety Board of Canada. 2020. "Managing In-Train Forces: Rail Safety Advisory Letter 617-06/20." October 1. https://www.tsb.gc.ca/eng/securite-safety/rail/2020/r19t0107/r19t0107-617-06-20.html.

[75] "Railroad Operating Rules." 49 C.F.R. Part 217. https://www.ecfr.gov/current/title-49/part-217 (accessed May 3, 2024); FRA presentation to committee, January 2023.

[76] FRA. n.d. "Mixed Freight and Higher-Speed Passenger Trains: Framework for Superelevation Design." https://railroads.dot.gov/elibrary/mixed-freight-and-higher-speed-passenger-trains-framework-superelevation-design (accessed May 14, 2024).

[77] Dick, C.T., L. Sehgal, C.J. Ruppert, Jr., and S. Gujaran. 2016. "Superelevation Optimization for Mixed Freight and Higher-Speed Passenger Trains." In *Proceedings of the American Railway Engineering and Maintenance-of-Way Association Annual Conference*. Orlando, FL.

[78] "CSX Train Derailment with Hazardous Materials Release, Hyndman, Pennsylvania, August 2, 2017." Accident Report NTSB/RAR-20/04 PB2020-101012, p. 34.

> At the time of the accident, the FRA did not require that each railroad have a risk reduction program (RRP) or system safety program in place. That changed on February 18, 2020, when the FRA published a final rule requiring Class I railroads and railroads with inadequate safety performance to submit a written railroad safety RRP to the FRA for review and approval by August 16, 2021 (FR 2020, 9262). Both the first crew and relief crew members expressed concern with operating heavy loads with multiple empty rail cars in the front of the train consist. Although the train makeup was in accordance with CSX rules, NTSB has determined this rule to be insufficient to manage elevated longitudinal forces imparted on blocks of empty rail cars in the front of the train consist.

FRA issued the RRP rule in February 2020, with a staged implementation, to satisfy a statutory mandate in sections 103 and 109 of the Rail Safety Improvement Act of 2008 (RSIA).[79] NTSB was aware of the new RRP rule and recognized that it did not apply in 2017 when the Bedford County derailment of a long train occurred. Nevertheless, NTSB called on FRA to take active steps to implement the rule in accordance with the RSIA's emphasis on railroads having deliberate and systematic risk reduction programs for all operational risks. NTSB stated:[80]

> The FRA's final rule requiring all Class I railroads to develop and implement RRPs represents a departure from the historic approach used by the FRA for oversight and safety management. For example, rather than monitoring rules compliance, an SMS approach seeks to further improve safety through identification and control of potential safety hazards that may not technically violate prescriptive FRA regulations. Transitioning to an RRP regulation will take time to mature for the FRA and industry. The FRA has traditionally had clear minimum safety standards and limited ability to examine the effectiveness of railroad safety programs for hazard identification and management. To date, the FRA has not published guidance for the industry on how to develop and implement the requirements for RRPs and SSPs [safety system programs]. This lack of guidance on what is needed to comply with the FRA's requirements may result in different levels of RRP and SSP program development and implementation, potentially limiting the safety benefits anticipated from the FRA's RRP requirement. It is also unclear how the FRA and the industry will measure the success of the required RRPs and SSPs.

NTSB went on to conclude that FRA had not provided sufficient guidance to railroads on how to develop and implement the requirements for an RRP. NTSB recommended that FRA develop and issue guidance for railroads to use in developing the RRPs that they were required to submit to FRA for approval.

Historically, most FRA requirements for the rail industry can be characterized as minimum standards and their compliance is verified and enforced by FRA inspection personnel. For instance, regulations place limits on the wear on an individual component that can be measured by inspectors (i.e., allowable wear on a track component before it must be replaced), or they prescribe certain requirements such as hours of work and rest, or training intervals for safety-critical employees or required inspection intervals for tracks and wheels.[81] While such

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[79] P.L. 110-432, Division A, 122 Stat. 4848 et seq., codified at 49 U.S.C. 20156 and 20118–20119.

[80] "CSX Train Derailment with Hazardous Materials Release, Hyndman, Pennsylvania, August 2, 2017." Accident Report NTSB/RAR-20/04 PB2020-101012.

[81] "Federal Railroad Administration, Department of Transportation." 49 C.F.R. Chapter II. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-II (accessed May 3, 2024).

prescriptive and minimum standards are common for safety regulation across all transportation modes, during the past three decades regulators in many modes and other domains have recognized the importance of supplementing their traditional regulatory regimes with requirements for regulated entities to develop customized SMSs to control the diverse and specific risks arising from the design and operation of their facilities and activities.[82,83,84]

The four pillars of an SMS are the development and faithful execution of (1) safety policies (including management commitment, accountability, responsibilities, and documentation), (2) safety risk management (including hazard identification, risk assessment, and mitigation), (3) safety assurance (monitoring/measuring, managing change, and continuous improvement), and (4) safety promotion (training, education, and safety communication).[85] The idea behind the promotion of these systems is that the regulated entities are in the best position to know the hazards and risks associated with their specific operations, and are therefore in the best position to target means for reducing those risks. Managers are expected to develop plans, practices, or procedures to address both technological and human risk factors and then to keep track of compliance with those procedures, report on progress, and periodically reevaluate and improve risk management efforts. The job of the regulator in this case is to verify that the plans are sound and well justified, being consistently followed, and are regularly reviewed by the operator for effectiveness. The regulator may also offer guidance on developing a high-quality SMS.

The RSIA mandates that each railroad establishes an RRP that “systematically evaluates railroad safety risks on its system and manages those risks in order to reduce the number and rates of railroad accidents, incidents, injuries, and fatalities.” The mandate is suggestive of congressional interest in railroads instituting SMSs. The committee observes, however, that when FRA required RRPs it did so in a “streamlined” fashion that, as FRA acknowledged, does not mandate many elements that are typically part of an SMS.[86] According to the rule, an RRP is acceptable if it simply concentrates on managing risks arising from changes in (1) operating rules, (2) the implementation of new technology, and (3) reductions in crew staffing levels.

This limited set of RRP elements was criticized by safety management experts commenting on the RRP rule as it was being proposed by FRA.[87] The commenters noted that an important element that was excluded from the rule was “processes and procedures for a railroad to manage changes that have a significant effect on railroad safety.”[88] Accordingly, the rule does not require a railroad to preemptively address a major change in its operations in a deliberate manner by identifying the associated hazards, analyzing the potential risks arising from those hazards, and evaluating and explaining how the risks will be managed. FRA’s reasoning for streamlining RRPs in this manner is unclear given that the agency’s rule that governs SSPs for

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[82] National Academies of Sciences, Engineering, and Medicine. 2018. *Designing Safety Regulations for High-Hazard Industries*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24907.

[83] International Civil Aviation Organization. 2016. “Annex 19: Safety Management.” July.

[84] “The International Safety Management (ISM) Code.” https://www.imo.org/en/ourwork/humanelement/pages/ISMCode.aspx (accessed May 3, 2024).

[85] National Academies of Sciences, Engineering, and Medicine. 2018. *Designing Safety Regulations for High-Hazard Industries*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24907.

[86] *Federal Register* 85(32). February 18, 2020.

[87] Ibid.

[88] FRA. 2024. “Risk Reduction.” 49 C.F.R. Part 271, Subtitle B, Chapter IIhttps://www.ecfr.gov/current/title-49/subtitle-B/chapter-II/part-271.

passenger railroads (also mandated in RSIA) do stipulate that SSPs should have processes and procedures to manage significant operational changes.[89]

The trend toward longer manifest trains would seem, by any measure, to represent a major operational change that could create or heighten train operational and handling challenges such as for managing in-train forces, ensuring proper train makeup, and maintaining crew communications. Accordingly, in a typical, fully developed SMS this change would be called out by assessing all potential hazards and risks and by describing the methods and means that will be used to eliminate or manage those risks. In this instance, an RRP patterned after an SMS would be expected to explain, among other things, the train makeup protocols that will be employed; the skills, readiness levels, and competencies required for crew members and how they will be met through means such as scheduling and training; and how technologies will be deployed (e.g., DP units, brakes, radio systems, engineer-assist programs) and verified for effectiveness. In turn, if an SMS process was being followed, FRA would be expected to confirm, through critical reviews and audits, that each railroad's risk reduction program does indeed cover such interests, is well reasoned and well justified, and is being followed faithfully and evaluated regularly by the railroad for effectiveness.

RSIA requires railroads to submit their RRP plans to FRA for approval, and in early 2022 FRA approved the plans of all the Class I railroads. To verify that railroads have followed the plans by implementing programs, FRA has been auditing railroad RRPs. The first program audited was for the Norfolk Southern Railway, completed in May 2024.[90] While the auditors found that the railroad was generally in compliance with the RRP rule's requirements, they identified a number of deficits.[91] For example, the railroad did not demonstrate that it had followed the planned processes for identifying and analyzing hazards and mitigating associated risks. As a general matter, however, the audit's focus was on verifying that the railroad's program was in place and following the written plan and that all administrative requirements were being met. The audit did not include critical evaluations of the quality and thoroughness of the RRP risk evaluations, analyses, and promised mitigation actions.

Because RRPs are proprietary to individual railroads and do not require all elements of a traditional SMS, it is not possible for external parties, including this committee, to ascertain whether and how railroads are identifying and controlling the hazards and risks arising from their major operational changes, including their decisions to use longer manifest trains.

After issuing the RRP rule in 2020, FRA has conducted multiple training sessions for railroads and labor organizations representing many directly affected employees. During those training sessions, FRA explained the requirements of the rule, FRA's expectations on the content of RRP plans, and the RRP approval process.[92] To date, the training and guidance have not focused specifically on key elements of an SMS, such as on how to conduct a high-quality, quantitative risk assessment or by covering best practices for managing specific types of hazards and risks. It merits noting that Transport Canada first issued an SMS regulation in 2001. That regulation has since been updated periodically as the railroads and safety agency have gained more experience with these systems.

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[89] 49 C.F.R. Part 270.

[90] FRA. 2024. Audit Report, Norfolk Southern Railway (NS), Class I. FRA Audit No. 2024-NS271-10-1. May 15.

[91] FRA. n.d. "NS Risk Reduction Program (Part 271) Audit Report." https://railroads.dot.gov/elibrary/ns-risk-reduction-program-part-271-audit-report (accessed June 4, 2024).

[92] Letter from FRA Administrator Amit Bose to Senator Chuck Schumer, reported in *Railway Age*, June 2023.

3

Technology for Controlling Long Trains

This chapter explains the role of locomotive technology and operations in the evolution of the systems used to control trains, including long trains. Class I railroads now rely on engineer-assist systems to operate all freight trains in North America. These systems use the locomotive dynamic brakes as the primary method for train braking. However, air brakes are also used in steep terrain and slow-speed maneuvers and are still the primary emergency braking requirement. The chapter also describes results of the Federal Railroad Administration (FRA) very long train technical reports to test air brakes and dynamic brakes on trains with more than 200 cars and a discussion regarding electronically controlled pneumatic (ECP) brakes. The chapter concludes with a discussion of the continuing crew member communication challenges presented by long trains as well as brief consideration of Positive Train Control (PTC).

LOCOMOTIVE TECHNOLOGY

Technology has and is playing a major role in enabling the operation of longer trains. The key technology that helps to control long trains is the use of distributed power (DP) locomotives with multiple sets of locomotives spread throughout the train. These groups of locomotives can be separately controlled to minimize in-train forces. To make this task easier, engineer-assist systems either coach engineers on how to control all engines or automatically control all locomotives as a modern cruise control. However, as with many technologies, engineer-assist systems still have problems and engineer training is critical for maintaining safe operations. Due to the reliance on engineer-assist systems, the committee learned that engineers may not be getting as much experience manually operating trains with DP locomotives.

Distributed Power

As noted in Chapter 2, distributing locomotives throughout a train reduces both pulling (draft) and pushing (buff) forces within the train. DP locomotives can reduce these forces when spaced appropriately throughout the train to separately apply power, apply air brakes, and/or apply dynamic brakes. Their application can make a single long train handle like several smaller trains.[93] A train operating with DP may be configured with mid-consist locomotives (sometimes at two places) and/or one or more locomotives at the rear of the train. Some railroads prefer using locomotives at the back of the train for more pushing power in certain terrains.[94] DP units also provide additional air compressor capacity by charging the brake pipe from several locations

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[93] Ibata, D. 2019. “Train Make-Up 101: Or How to Not Let This Happen to You.” TrainsMag.com, July.

[94] BNSF presentation to committee, April 2023.

along the length of the train and by providing additional locations for train air brake applications, thereby further enhancing braking performance.[95,96]

Without DP locomotives (all engines at the front of the train), the buff and draft forces immediately behind the locomotives will increase with train length and weight. This results from the entire train pushing on the first car of the train when using dynamic brakes and from the entire train being pulled from the first car in a train without DP locomotives. For sufficiently long and heavy trains without DP locomotives, these draft forces may approach the force limits of the couplers between rail cars. Longer trains without DP locomotives will also require more time for propagation of air brake applications.[97]

Communication technology used to control DP locomotives in the train is known as LOCOTROL (an abbreviation of "locomotive" and "control").[98] This merits mentioning because, in the past, tunnels and rough terrain created impediments for maintaining communications between the controlling locomotive at the front of the train and the DP locomotives and end-of-train (EOT) devices. Although many technological solutions were tried, including repeaters spaced out along the right-of-way and inside tunnels,[99] the problem led the Federal Communications Commission (FCC) in 2010 to authorize an increase in EOT power output from 2 to 8 W.[100] Concurrent with the advent of PTC, the changes led to a more robust and dependable communications protocol, LOCOTROL Expanded Architecture or LXA,[101] to be introduced.[102,103] All Class II railroads are now in the process of updating locomotives with this new communications protocol, which will increase the reliability of LOCOTROL communications and allow railroads to place DP locomotives in up to four locations throughout a train. This development should be beneficial for control of longer train.[104]

While distributed power can reduce in-train forces and improve train handling and braking performance on longer trains that are properly constructed, the magnitude of its effect on train safety, including the safe operations of longer trains, is an ongoing area of research. Researchers at the University of Illinois at Urbana-Champaign (UIUC) have conducted statistical analyses of accident records to investigate the effect of DP on derailment frequency and severity for various train types. The analyses are possible because FRA accident records indicate the number of locomotives at the front, middle, and rear of the train, allowing incidents to be classified as conventional trains with all locomotives at the front or DP trains with locomotives at intervals. For all FRA-reportable mainline and siding derailments from 2001 to 2022, the

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[95] Vantuono, W.C. 2011. "The Long and the Short of Distributed Power." *Railway Age*, August 1. https://www.railwayage.com/cs/the-long-and-the-short-of-distributed-power.

[96] Aronian, A., K. Wachs, S. Bell, and D. Peltz. 2011. "Long Train Testing and Validation at Canadian Pacific." International Heavy Haul Association Conference, June, Calgary, Canada.

[97] Vantuono, W.C. 2011. "The Long and the Short of Distributed Power." *Railway Age*, August 1. https://www.railwayage.com/cs/the-long-and-the-short-of-distributed-power.

[98] LOCOTROL was developed by Wabtec but is used on both GE/Wabtec and EMD/Progress locomotives. Wabtec presentation to committee, May 2023.

[99] Some railways initially installed radio repeaters on long trains to mitigate signal loss, especially in tunnels and mountainous areas. Federal Railroad Administration (FRA). n.d. "Stakeholder Perceptions of Longer Trains." https://railroads.dot.gov/elibrary/stakeholder-perceptions-longer-trains (accessed May 3, 2024).

[100] CN presentation to committee, April 2023.

[101] For more information, see https://www.wabteccorp.com/digital-intelligence/next-generation-distributed-power-activating-the-future-of-freight-rail-through-enhanced-communications.

[102] Wabtec presentation to committee, May 2023.

[103] Class I railroads, presentations to committee, March and April 2023.

[104] Ibid.

UIUC researchers found that 81% involved conventional trains with locomotives only at the front, while the remaining 19% involved DP trains.[105] Note, the traffic data required to normalize derailment counts by train-miles of DP and non-DP trains were not available.

The UIUC researchers examined the relative severity of derailments involving DP and non-DP trains. They found that the median train length and weight of DP trains was greater than that of non-DP trains. They also found that DP trains derail at a higher speed than non-DP trains. Based on these differences in train length and weight and speed at the time of derailment, one would expect that derailments involving DP trains will be more severe on average (i.e., derailing more cars). However, when the researchers compared the median number of cars derailed per derailment, they did not find a statistically significant difference in derailment severity among accidents involving DP and non-DP trains. These results suggest that, even though DP trains tend to be heavier and longer than non-DP trains, they may be helping reduce derailment severity by helping to manage in-train forces and handling challenges of longer trains.

Engineer-Assist Systems

To save fuel and maintenance costs, railroads have relied on greater use of dynamic brakes through engineer-assist systems. LEADER (New York Air Brake)[106] and TripOptimizer (Wabtec)[107] are two competing "engineer-assist" systems. Initially these systems were designed for energy use management because of their reliance on dynamic brakes as opposed to air brakes to reduce fuel consumption. Such systems advise, or even control, throttle and dynamic brake actions and recommend selected air brake applications depending on the grade, train speed, train makeup and the territory ahead.[108] Both systems are used on conventional and distributed power trains and provide engineers information about the train so they can mitigate the potential excessive forces involved. With more widespread implementation of DP locomotives and longer trains, the engineer-assist systems have taken on an additional objective of managing the use of DP units to minimize in-train forces.[109] These systems are also evolving into "cruise control" or "autopilot" systems and fully automatic operations are being tested in the United States.[110] Certain lines in Australia already support fully autonomous freight train operations.[111]

The use of engineer-assist systems does have some limitations. Current U.S. systems can recommend but not control air brake applications, so the engineer-assist systems either rely on dynamic brakes alone or signal the engineer to initiate train air brake applications as necessary.[112] Distributed power locomotives can either be set up to duplicate the setting on the lead locomotives (synchronous) or can be controlled separately (asynchronous or "fenced"). However, DP units are not allowed to apply dynamic brakes when the head-end units are in power. The opposite asynchronous scenario is allowed (lead units in braking or idle while DP

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[105] Christopher P.L. Barkan et al., presentation to committee, May 22, 2023.

[106] Products, New York Air Brake, and milosms2015. "LEADER." NYAB Products, March 13, 2015. https://www.nyabproducts.com/leader.

[107] Wabtec Corporation. n.d. "Trip Optimizer™." https://www.wabteccorp.com/digital-intelligence/energy-management/trip-optimizer (accessed May 3, 2024).

[108] New York Air Brake and Wabtec presentation to committee, May 2023.

[109] Ibid.

[110] Luczak, M. 2022. "Watch: Testing New Wabtec Trip Optimizer Feature." Railway Age, September 8. https://www.railwayage.com/freight/class-i/watch-csx-testing-new-wabtec-trip-optimizer-feature.

[111] "Self-Driving Trains: The World's Heaviest Robot." June 23, 2023. https://www.knorr-bremse.com/en/magazine/self-driving-trains-the-worlds-heaviest-robot.json.

[112] New York Air Brake and Wabtec presentations to committee, May 2023.

units in traction) and is frequently used by train crews to keep the slack in the couplers between rail cars bunched in undulating territory.[113]

Although DP units and engineer-assist systems reduce in-train forces, it should be noted that FRA has advised railroads that their use alone is not enough to avoid derailments. FRA's April 2023 advisory emphasizes that using DP units "should not be considered a replacement for proper train car placement and makeup," and notes that several in-train force derailments occurred even when DP unit power was used. In some cases, the engineer-assist system was in control of the train.[114]

Engineer-assist systems have proven so useful that many railroads encourage—and some require—that engineers rely on them whenever possible.[115] Engineers are sometimes required to take manual control when engineer-assist systems are not operating properly, the train is moving at low speeds, or when urgent braking action is needed.[116] The increasing reliance on autonomous systems may have some effect on engineers' skill level for handling long manifest trains without the aid of engineer-assist systems. Engineer training is discussed in Chapter 5.

BRAKING SYSTEMS

Controlling freight trains before the advent of air brakes was a dangerous business. Trains were slowed using manual brakes requiring brakemen to move from car to car while the train was moving to apply hand brakes on each car with unreliable results and much loss of life. The invention of the air brake system, first patented by George Westinghouse in 1869, helped to control train speed and is still in use today.[117] Locomotive dynamic brakes came into use with the shift from steam to diesel-electric locomotives. Their first widespread adoption was for moving trains in mountainous areas.[118] Today, the majority of trains run by the Class I railroads are operated by engineer-assist systems that use locomotive dynamic brakes supplemented by the use of air brakes as needed.

Train Air Brakes

Train engineers use train air brakes to apply brakes on each locomotive and on each car in the train to slow or stop the train. Each freight car contains the necessary equipment to stop itself using compressed air stored on the car in air reservoirs.[119] The air in each car is supplied by the locomotives. When all the cars are connected (through the connecting couplers known as glad hands), the brake pipes on each car are connected to a continuous air line (or "trainline") from

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[113] T. Dick, background for technology questions, May 16, 2023.

[114] FRA. 2023. "Safety Advisory 2023-02; Train Makeup and Operational Safety Concerns." *Federal Register* 88:21736. https://www.govinfo.gov/content/pkg/FR-2023-04-11/pdf/2023-07579.pdf.

[115] Committee members heard conflicting reports from Class I railroads on the use of air brakes in conjunction with TO and LEADER. Some railroads encourage engineers to manually control trains when needed, while others reprimand engineers for switching from automatic to manual operation because it increases fuel costs.

[116] SMART and BLE-T presentations to committee, January 19, 2023.

[117] Humphrey, A.L. 1914. "Forty-Five Years of Air-Brake Evolution." *Scientific American* 110(25):498–511. Although train air brakes are often referred to as automatic brakes, the term "train air brakes" or simply "air brakes" is used here to avoid confusion with actual automatic systems.

[118] McGonigal, R.S. 2024. "Dynamic Braking 101." *Trains*, February 6. https://www.trains.com/trn/train-basics/abcs-of-railroading/dynamic-braking-101.

[119] Transportation Safety Board of Canada. 2022. "Locomotive and Freight Car Brakes." March 31. https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r19c0015/r19c0015-20220331-3.html, p. 209.

the leading locomotive to the end of the train. For typical freight operations, air compressors on the locomotives charge the train air brakes through the air brake pipe to a pressure of 90 psi.[120]

To release the train brakes, the engineer raises the pressure in the trainline, which is sensed by each car's control valve and the compressed air in the brake cylinder is released and the reservoirs are recharged back to operating pressure. Should the brake pipe have a sudden and rapid drop in pressure (such as when a coupler breaks and the brake pipe connection is broken), the control valves on each car sense this and initiate an emergency brake application where compressed air from a larger emergency reservoir tank on each car is directed to the brake cylinder, creating the maximum braking force possible for each car on the train.[121]

One drawback with this system is that although the engineer can gradually apply brake force using successive air pressure reductions, the system does not allow for the gradual release of the brakes. There is no way to ease off the brake; only a full brake release can occur. As a result, once brakes are applied, releasing them and then reapplying them before the air reservoirs on each car have had time to refill reduces the effectiveness of the train air brakes.[122] To control train speed on a descending grade, the engineer may have to apply the air brakes and locomotive dynamic brakes to keep control of the train.[123]

Locomotive Independent Brakes

Locomotives are also equipped with an independent air brake system, which is separate from the normal train air brakes.[124] Although the independent direct air systems allow for faster braking operations, they are typically used for situations involving locomotives, such as parking maneuvers, rather than those with entire freight trains.[125] Locomotive dynamic brakes provide greater overall braking power than the locomotive independent brakes. However, locomotive independent brakes may be used in emergency situations.

Locomotive Dynamic Brakes

Locomotive dynamic brakes are powered by the electricity generated by the kinetic energy of the train in motion. Locomotive dynamic brakes can be gradually applied and released. Because no mechanical friction is used to impede the rolling of locomotive wheels, there is little wear on the wheels and no wear of the brake shoes.[126]

However, while dynamic brakes are useful to control train speed, their braking power declines at speeds below 9 mph. Engineers can use dynamic brakes in emergency brake

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[120] Ibid.

[121] PRC Rail Consulting Inc. n.d. "North American Freight Train Brakes." The Railway Technical Website. http://www.railway-technical.com/trains/rolling-stock-index-l/train-equipment/brakes/north-american-freight.html (accessed May 3, 2024).

[122] Transportation Safety Board of Canada. 2022. "Locomotive and Freight Car Brakes." March 31. https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r19c0015/r19c0015-20220331-3.html, p. 209.

[123] This problem is somewhat alleviated in passenger cars, which can have graduated release that lets engineers reduce brake action without completely releasing the train brakes.

[124] Transportation Safety Board of Canada. 2022. "Locomotive and Freight Car Brakes." March 31. https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r19c0015/r19c0015-20220331-3.html, p. 209.

[125] Ibid.

[126] One exception is where excess braking force results in wheel sliding, but modern systems prevent wheel slip from happening. Also, using dynamic brakes results in less wear on brake shoes of cars than does the use of train air brakes.

application aboard the locomotive in the lead position; however, remote locomotives in the consist default to 45 psi brake cylinder pressure when in emergency and lose dynamic braking effort. Train air brakes will usually stop trains quicker than dynamic brakes under emergency situations.[127] In addition, because the braking action takes place only on the locomotives, dynamic braking affects in-train forces differently than air brakes. Dynamic braking force is concentrated on the cars immediately behind locomotives. As trains have grown longer, the effect of dynamic brake use on in-train forces has increased.[128] Using DP locomotives can transfer some of the dynamic braking forces to other parts of the train, but braking effort is still concentrated immediately behind both the lead and the DP locomotives.[129] This concentration of braking power is based on how many cars are being held back by locomotives with the cars nearest the locomotive having the highest buff forces acting on them.[130]

Train Brake Applications

Although dynamic brakes are the primary method of train braking, air brakes are still needed for extra braking power on steep grades, low-speed braking, and for stopping trains in an emergency. This is because train air brakes provide a "fail-safe" braking mechanism, because dynamic brakes lose braking power at slower speeds and because dynamic braking power is limited by the number of locomotive axles on a train. For these reasons, air brakes are required on all freight trains. They are fail-safe because any severing of the trainline will result in an emergency brake application. Such separations can result from a broken knuckle or a derailment.

Serial Application

A serious problem with the use of train air brakes is the amount of time it takes for the air signal initiated by the engineer at the locomotive to travel through the brake line from the front to the rear of the train. The delay between brakes applying on the front of the train and the rear of the train naturally increases with train length and can result in extreme buff (compressive) forces at the front of the train.[131] This has been mitigated by the introduction of the EOT device, which allows engineers to release air from both ends of the train in an emergency, thereby reducing in-train forces caused by braking from the front end only.[132] The use of DP locomotives (with LXA communications) has also improved this situation by controlling brake pipe reductions at remote locomotive locations, decreasing the time taken for the entire train to reach full braking.[133][134]

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[127] PRC Rail Consulting Inc. n.d. "North American Freight Train Brakes." The Railway Technical Website. http://www.railway-technical.com/trains/rolling-stock-index-l/train-equipment/brakes/north-american-freight.html (accessed May 3, 2024).

[128] Ibata, D. 2019. "Train Make-Up 101: Or How to Not Let This Happen to You." TrainsMag.com, July.

[129] Ibid.

[130] Ibid.

[131] Vantuono, W.C. 2011. "The Long and the Short of Distributed Power." *Railway Age*, August 1. https://www.railwayage.com/cs/the-long-and-the-short-of-distributed-power.

[132] "End-of-Train Devices." 49 C.F.R. Part 232, Subpart E. https://www.ecfr.gov/current/title-49/part-232/subpart-E (accessed May 14, 2024).

[133] Distributed power is the placement of additional locomotives at the rear and/or interior of the train that are controlled by the engineer in the leading locomotive.

[134] Aronian, A., K. Wachs, S. Bell, and D. Peltz. 2011. "Long Train Testing and Validation at Canadian Pacific." International Heavy Haul Association Conference, June, Calgary, Canada.

This is especially important for quickly and safely stopping a train with an emergency brake application.

No Partial Release

While most passenger cars are equipped for partial (or "graduated") release of train air brakes, freight train cars are not. In situations where brakes must be released and reapplied, retaining valves ("retainers") on each car can be adjusted to retain a limited amount of braking power while train air brakes are recharged.[135] Retainers were used frequently prior to the adoption of very effective dynamic brakes, but they are seldom used by railroads today.[136] The time to set and release retainers has become prohibitive with today's longer trains. In situations where train air brakes are needed to hold a train on a hill, a release of brakes must often be followed by an emergency application and setting of hand brakes until the entire train air brake system can be fully recharged.

Recharge Time

With longer trains, the time needed to completely recharge train air brakes has increased as much of the air supplied to the system may potentially leak out before it reaches the end of the train. Cold weather can also increase rechange time due to increased leakage.[137] DP locomotives placed strategically throughout the train may not reduce leakage but can help to recharge the air in the train.[138]

Emergency Brake Applications

In emergency situations, engineers can initiate a "desired" emergency air brake application that will cause each car to exert the maximum braking pressure available.[139] Emergency brake application can be needed because of unforeseen obstructions, grade-crossing accidents, and so on and will result in the serial application of brakes as described above. Emergency brake applications are more complex in long trains because long trains are likely to have multiple DP units.[140] During emergency braking, emergency brake application will cause power knockdown and idle the DP locomotives. DB effort would be retained, but power (throttle) cannot be adjusted.

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[135] Krug, A. 2019. "North American Freight Train Brakes." The Railway Technical Website. 2019. http://www.railway-technical.com/trains/rolling-stock-index-l/train-equipment/brakes/north-american-freight.html.

[136] Ibid.

[137] CN presentation to committee, April 2023.

[138] In addition to DP locomotives, some railroads have used "distributed braking box cars" with air compressors to help charge train air brakes.

[139] Transportation Safety Board of Canada. 2022. "Locomotive and Freight Car Brakes." March 31. https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r19c0015/r19c0015-20220331-3.html, p. 209.

[140] Emergency brake applications (especially undesired ones) can create severe in-train forces due to lags in brake applications and variation in car braking forces. As a result, engineers often release locomotive independent brakes and apply power to keep the train stretched out while it is stopping to prevent cars from piling up in a derailment. If stopping as quickly as possible is more important, engineers can use dynamic brakes in addition to the train air brakes. DP can be used similarly as deemed appropriate (added power or dynamic brake) by the engineer.

Undesired Emergency Brake Application

Train air brake systems are designed so that broken equipment, derailments, malfunctioning brake valves, broken trainlines, and so forth that independently reduce trainline brake pressure rapidly to zero will cause an undesired emergency (UDE) brake application.[141] The unintended (undesired) application of train emergency air brakes is a high-risk situation. During an UDE brake application (such as in the case of a train separation due to a broken knuckle or a malfunctioning brake valve), the engineer is not in full control of the train air brake system because the cars are automatically applying their emergency brakes for a brief time before the engineer is aware an emergency brake application has occurred. In addition, the train is at increased risk for high buff or draft forces during an UDE brake application, potentially high enough to cause a broken coupler knuckle or a derailment.

Longer Trains and Emergency Brake Applications

Longer trains are more at risk of experiencing a prolonged information gap between UDE brake application and engineer awareness because the incident initiating the brake pipe pressure drop may occur at any position in the train. In addition, UDEs are especially problematic for four reasons, as highlighted in a 2022 FRA Safety Advisory. First, even if the train remains intact and undamaged, recharging the train air system can be time consuming. Second, if a train has an emergency application on a grade (desired or undesired), hand brakes must be tied down to hold the train while the brake system is being recharged.[142] There is also a Canadian Rail Operating Rule “Securing equipment after an emergency brake application on grade” which requires applying hand brakes to secure and recharge the train after an emergency brake application.[143] Third, as the train is braking under maximum braking force, high in-train forces may be generated between cars, increasing the risk of derailment of the train. Finally, after an UDE brake application, a train must be thoroughly inspected to find the cause of the UDE, to identify any damage or derailment caused by the UDE, and to make necessary repairs. The latter two problems are made more difficult and time consuming by longer trains, because train crews must travel greater distances to complete the inspections and manually apply the hand brakes.[144] The increased risk for a long train is that the crew must have sufficient time to apply the necessary hand brakes to hold the train in case the air brakes release or there is a depletion of average brake cylinder pressures, sufficient to hold the train on the descending grade. A long train on a grade will require more hand brakes to be applied to secure the train, requiring more time from the crew. Environmental conditions, such as heavy snow, wind, or rain, may also increase the time needed to apply the hand brakes.

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[141] Carlson, F.G. 1990. “Undesired Emergency Brake Applications: Transportation Test Center UDE Tests.” Report No. R-761. Association of American Railroads. https://railroads.dot.gov/elibrary/undesired-emergency-brake-applications-transportation-test-center-ude-tests.

[142] FRA. 2022. “Safety Advisory 2022-02; Addressing Unintended Train Brake Release.” *Federal Register* 87:80256. December 29. https://www.federalregister.gov/documents/2022/12/29/2022-28336/safety-advisory-2022-02-addressing-unintended-train-brake-release.

[143] Canadian Rail Operating Rule (CROR) Rule 66

[144] GAO (U.S. Government Accountability Office). 2023. “Rail Safety: Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact.” June 1. https://www.gao.gov/products/gao-19-443.

Unintended Brake Release

In certain circumstances, train air brakes can release on their own with no action from the engineer. This can result in a high-risk situation for trains stopped on a grade. When this happens an emergency brake application should be made, and enough hand brakes should be applied to hold the train on the grade.[145] An FRA safety directive also states that train crews should not expect a service or emergency brake application to be indefinitely maintained because air eventually leaks out of the brake system.[146]

Train Brakes in Operation

Application of train air brakes has a significant impact on in-train forces. During regular braking, the engineer applies a combination of dynamic brakes and train air brakes to control the speed of the train or, if needed, to bring a train to a stop. Ideally, engineers endeavor to keep trains either completely stretched[147] or completely bunched.[148]

Today most railroads employ engineer-assist programs that rely primarily on dynamic brakes (and bunching trains) to control speed. This saves fuel by not having to drag a train with brakes applied and reduces wear and tear on car brake components and wheels. The expanded use of dynamic brakes was initially a fuel-saving practice, as evidenced in the early engineer-assist systems for dynamic braking that focused on saving costs. However, because dynamic brakes concentrate braking power in the locomotives as opposed to the whole train as with train air brakes, it is not clear that dynamic braking should be the preferred or primary method of train control in all situations. In 2023, the NTSB required FRA to ensure that railways have proper procedure in place to ensure that train speed could be maintained by automatic brakes alone in case DP is unavailable or suddenly lost en-route. [149] The committee found no guidance on when or if using train air brakes should be prioritized overusing dynamic brakes and how train length affects this decision.

FRA Studies of Air Brake Systems in Long Trains

FRA conducted a series of tests between 2020 and 2024 on air brakes on very long trains. The final technical reports for Phases II-IV were publicly released in May 2024.[150] Phase II's rack tests simulated the air brakes on trains of up to 200 cars.[151] Phase III's tests were conducted on a

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[145] FRA. 2022. "Safety Advisory 2022-02; Addressing Unintended Train Brake Release." *Federal Register* 87:80256. December 29. https://www.federalregister.gov/documents/2022/12/29/2022-28336/safety-advisory-2022-02-addressing-unintended-train-brake-release.

[146] Ibid.

[147] Harvey, W.T. 2023. *High Iron & Big Boys: The Life and Times of a Union Pacific Steam Engineer*. South Platte Press.

[148] Today engineers are taught to rely more on dynamic brakes to keep trains "bunched" to control in-train forces and to save fuel by not pulling and braking simultaneously.

[149] NTSB Safety Recommendation Report on Train Emergency Brake Communication, September 2019, https://www.ntsb.gov/investigations/AccidentReports/Reports/RSR1902.pdf.

[150] Representatives of FRA briefed the committee on the progress of these very long train studies in March 2023 and March 2024.

[151] FRA. 2024. "Very Long Trains—Phase II: Rack Tests." DOT/FRA/ORD-24/18. May. https://railroads.dot.gov/sites/fra.dot.gov/files/2024-05/VLT%20Phase%20II%20Report.pdf.

stationary train of 200 cars.[152] Phase IV's tests took place on a moving train in a DP configuration with 228 cars as it traveled 1,300 miles over plains, mountains, and rolling hills.[153] FRA's key findings are summarized in Box 3-1.

BOX 3-1
FRA's Key Findings from Its Very Long Train Studies of Air Brake Systems

The following are FRA's key findings from its series of studies conducted between July 2020 and May 2024 on the air brakes of very long trains:

- Phase II of testing, using only head-end power, found that the likelihood of unintended brake releases was higher with longer trains and that increased train lengths led to slightly slower brake response times.
- Phase III of testing found that distributed power train configurations achieve better braking capability than only head-end power on long train operations.
- Phase IV of testing found that when long trains climbed a grade, certain sections of the train consist experienced elevated buff forces and coupler forces, which can influence how a train behaves and impact the safe handling of trains with distributed power.
- Phase IV of testing concluded that further testing is needed to identify potential safety gaps when operating long trains in nonideal operating conditions.
- The research team also made clear in Phase IV, the final phase of testing, that additional research, testing and analysis is recommended to provide a better understanding of how long trains impact the durability of rolling stock mechanical components.

SOURCE: FRA. 2024. "FRA Rigorously Examines Safety and Quality of Life Implications of Long Trains." https://railroads.dot.gov/about-fra/communications/newsroom/press-releases/fra-rigorously-examines-safety-and-quality-life-0.

A key finding from the rack tests (head-end power only) was that air brake recharge time for a 200-car train took three times longer than a 100-car train,[154] while the static rail tests further confirmed that longer air brake propagation time increases with train/car length.[155]

Even with the expansion of test elements during the fourth stage, FRA officials indicated that "no unusual events" occurred during the monitored trip.[156] Peak coupler forces measured were about ±400 kips;[157] while trains do routinely experience comparable levels, especially during periods of elevation change where climbing front cars push against trailing accelerating downslope cars, in-train forces have occasionally been the primary cause of derailments in as

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[152] FRA. 2024. "Very Long Trains—Phase III: Stationary Train Tests." DOT/FRA/ORD-24/19. May. https://railroads.dot.gov/sites/fra.dot.gov/files/2024-05/VLT%20Phase%20III%20Report.pdf.

[153] FRA. 2024. "Very Long Trains—Phase IV: Moving Train Tests." DOT/FRA/ORD-24/20. May. https://railroads.dot.gov/sites/fra.dot.gov/files/2024-05/VLT%20Phase%20IV%20Report.pdf.

[154] FRA. "Very Long Trains Brake Study—Phase II Rack Tests."

[155] FRA. "Very Long Trains Brake Study—Phase III Stationary Train Tests."

[156] FRA presentation to committee, March 2024.

[157] A kip is an American unit of measurement equal to 1,000 pound-force. FRA. "Very Long Trains Brake Study—Phase IV Moving Train Tests."

low amounts as ±135 kips.[158] The reported coupler forces were significant enough for FRA to highlight as a core goal of its next phase of research to "more thoroughly investigate factors contributing to the elevated coupler forces observed during the tests."[159]

This first moving train test occurred with a uniform unit makeup and under ideal weather conditions (although the route did traverse mountainous terrain). However, FRA aims to conduct additional monitored runs to test long train brake performance under more complex situations.[160] Such tests could prove instrumental in updating industry guidelines for train makeup for longer manifest trains with DP locomotives.

Electronically Controlled Pneumatic Brakes

The National Transportation Safety Board (NTSB) has recommended that certain freight trains be equipped with ECP brakes.[161] In ECP brakes, brake applications are triggered via an electronic signal sent through wires that produce a simultaneous application of air brakes throughout the entire train. Compared to conventional air brakes that gradually traverse the train, the simultaneous application of ECP brakes could be advantageous for longer trains. In addition, because the brake application signal does not require reducing air pressure in the train line, a full release or a partial release of train air brakes would not subsequently require the train air brake system to be recharged. ECP brakes' potential advantages include improved safety, reduced stopping distances, and less wear on train wheels and brake shoes.[162] The main limitations for current freight train air brakes are that time is required for braking commands to propagate along the length of a train, and braking action cannot be reduced without releasing the air brakes entirely. Both of these limitations could be eliminated with the use of ECP brakes that are more flexible and faster acting; however, ECP brake use is not supported by Class I railroads due to reliability problems in earlier tests and the cost of equipping the entire fleet of freight cars for ECP operation. Finally, because ECP brakes are incompatible with conventional air brakes (without extensive technical modifications), other disadvantages include time and operational challenges of outfitting the entire North American interchange rail car fleet and locomotives, the cost of maintaining the new system, and the ongoing time and cost of recoupling wires after cars are separated for switching (in addition to reconnecting the train air line).[163]

Although the industry has previously tested ECP brake systems, no freight railroad currently uses ECP brakes in the United States. In addition, there is currently no consensus on next steps for widespread ECP brake adoption. The Association of American Railroads (AAR) contends that ECP brakes suffer from an unacceptable failure rate while offering inconsequential

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[158] Government of Canada National Research Council. 2024. "Industry Review of Long Train Operation and In-Train Force Limit—NRC Publications Archive." May 3. https://nrc-publications.canada.ca/eng/view/object/?id=bcc92202-14a8-476b-9500-5a384c4ff003.

[159] FRA. "Very Long Trains Brake Study—Phase IV Moving Train Tests."

[160] Ibid.

[161] For an overview of NTSB's recommendations on ECP brakes and the railroads' reactions, refer to Chapman, T.B., and NTSB. 2022. "Testimony Before the Railroads, Pipelines, and Hazardous Materials Subcommittee Committee on Transportation and Infrastructure on Examining Freight Rail Safety." June 14. https://www.ntsb.gov/news/Testimony/Pages/Chapman-20220614.aspx.

[162] National Academies of Sciences, Engineering, and Medicine. 2017. *A Review of the Department of Transportation Plan for Analyzing and Testing Electronically Controlled Pneumatic Brakes*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24698.

[163] FRA. n.d. "Accelerating Implementation of ECP Emulator Technology." https://railroads.dot.gov/elibrary/accelerating-implementation-ecp-emulator-technology (accessed May 3, 2024).

safety improvements.[164] Two Class I railroads that tested ECP brakes on coal trains found the technology too unreliable to be adopted.[165] At the Railroad Safety Advisory Committee (RSAC) meeting held in March 2023, FRA created a working group to "consider and identify potential methods of modernizing train brake equipment and brake-related processes and procedures to improve train braking effectiveness, including consideration of the use of locomotive distributive power (DP) or ECP brake systems, or a combination of those systems."[166] It should be noted, however, that both New York Air Brake and Wabtec, the two manufacturers of ECP brake systems available in North America, indicated to the committee that they have continued to do research and development to improve ECP braking system reliability and lower ECP braking system costs.[167]

Despite the railroads' concerns about the technology, ECP brake systems could someday provide another layer of safety for two reasons. First, train air brakes could be partially released without releasing brakes entirely. Second, accidents resulting from air brakes bleeding off could be prevented as train lines could be charged continuously.

Positive Train Control

The use of PTC was mandated by Congress as part of the 2008 Rail Safety Improvement Act and all affected railroads were in compliance by December 29, 2020.[168] PTC systems are backup systems that use train monitoring and control technologies to automatically stop a train if unsafe conditions (such as excessive speed) are detected and thereby prevent train collisions, derailments, and certain train switching movements.[169] While challenges exist with the use of PTC,[170] including the addition of another information screen needing to be monitored by the train crew, the committee did not find examples of the use of PTC increased problems with long train derailments. Regarding safety and community impacts, one railroad uses PTC to notify dispatchers when trains are stopped on road crossings for more than 10 minutes.[171] However, overall train length is currently represented in PTC systems as an estimate based on the GPS coordinates of the lead locomotive plus the number of cars listed in the railway's manifest. Increased certainty with regard to the location of the end of a train could assist with research on a number of safety issues, such as the duration of time spent in grade crossings.[172]

CREW COMMUNICATIONS TECHNOLOGY

Maintaining effective crew communication is a crucial aspect of a safely operating train, and federal regulations require that all occupied locomotives have a working radio along with a

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[164] AAR. 2023. "Electronically Controlled Pneumatic (ECP) Brakes Fact Sheet." March. https://www.aar.org/wp-content/uploads/2023/02/AAR-ECP-Brakes-Fact-Sheet.pdf.

[165] BNSF presentation to committee, April 2023; Norfolk Southern presentation to committee, January 2023.

[166] RSAC Meeting, March 2023. https://rsac.fra.dot.gov/meetings?id=63.

[167] New York Air Brake and Wabtec presentations to committee, May 2023.

[168] FRA. 2023. "Positive Train Control (PTC)." October 10. https://railroads.dot.gov/research-development/program-areas/train-control/ptc/positive-train-control-ptc.

[169] AAR. n.d. "Freight Rail & Positive Train Control." https://www.aar.org/issue/positive-train-control (accessed May 3, 2024).

[170] FRA. 2021. "Positive Train Control Interface Design Issue with Locomotive and Cab Car Braking Systems." *Federal Register* 86:49410–49411. Washington, DC: Government Printing Office.

[171] Union Pacific presentation to committee, March 2023.

[172] FRA. n.d. "Positive Train Location: Final Report." DOT/FRA/ORD-18/17. June 20, 2018.

backup wireless system.[173] Roadway and onboard crew communicate with central dispatchers and supervisors to navigate track occupation, coordinate maintenance schedules, and report problems (both onboard and trackside).[174] Onboard crews also need an unconstrained ability to coordinate with each other in order to maintain optimal train operations. These communications, which were originally made using hand signals, now occur using radios. These two-way, short-range, very high frequency radios have a limited range based on "line of sight," which naturally creates more problems for longer trains, especially those moving through rugged terrain. A crew member who is walking the train looking for broken air hoses, derailments, sticking brakes, and hot bearings or is walking back to cut the train into multiple sections to clear road crossings will be equipped with a handheld radio.[175] On long trains, the power limits of the individual radio systems may detrimentally affect communications. Radios in the cab of the locomotive typically have more power (e.g., 35 W) and range than the handheld radios commonly used by conductors (e.g., 5 W). As a result, engineers can transmit to conductors, but not always vice versa. The primary train dispatcher's union believes long trains have also increased the difficulty of switching operations and inspections, because radio instructions with downrange crew often must be relayed through the locomotive. Besides creating problems with communications, this situation can create a hazard for crews riding equipment to make a coupling, fix a broken knuckle or switch an industry. Maintaining communications through line of sight may become more hazardous when crew members are riding moving equipment and must use one hand to hold radio the handset aloft (called the statue of liberty position).[176]

Current regulations require that trains have one working radio in the controlling locomotive and a backup radio somewhere.[177] Railroads are currently experimenting with roving conductors or utility people who can drive to where they are needed quicker than if they had to walk from the front of the train.[178] It should be noted that, when communication is lost between crew members, these rules require the train crew to stop further movements of all rolling railroad equipment until communication is reestablished, which can often result in lengthy delays.

Although technology has improved communication overall between locomotives, communication among crew members potentially becomes more difficult as train size increases. However, there are currently limited data to fully analyze the risk.[179] A focus-group-based study of railroad stakeholders found that the perception of long train communication challenges varied among FRA staff, representatives of labor unions, and railroad managers.[180] Both FRA staff and labor representatives agreed that the loss of radio communication on long trains is a safety issue, but only the latter directly asserted that long trains consistently exceed radio communication

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[173] "Railroad Communications." 49 C.F.R. Part 220. https://www.ecfr.gov/current/title-49/part-220 (accessed May 3, 2024).

[174] "Communication and Coordination Demands of Railroad Roadway Worker Activities and Implications for New Technology." FRA Office of Research and Development, November 2007. https://railroads.dot.gov/sites/fra.dot.gov/files/fra_net/389/ord0728.pdf.

[175] GAO (U.S. Government Accountability Office). 2023. "Rail Safety: Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact." June 1. https://www.gao.gov/products/gao-19-443.

[176] BLE&T presentation to committee, January 2023.

[177] "Railroad Communications." 2024. 49 C.F.R. Subtitle B, Chapter II, Part 220. Washington, DC: DOT, FRA. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-II/part-220.

[178] BLE&T presentation to committee, January 2023.

[179] FRA. 2022. "Stakeholder Perceptions of Longer Trains." DOT/FRA/ORD-22/43. December. https://railroads.dot.gov/elibrary/stakeholder-perceptions-longer-trains.

[180] Ibid.

limits.[181] While there was no consensus among FRA staff over the extent to which long trains experience radio problems in comparison to shorter trains, FRA representatives agreed that train length is one of several variables that can negatively impact communications.[182] Furthermore, the identified communication issues haves been impacted by the lack of bandwidth available from the FCC.[183]

Representatives from the railroads countered concerns about disrupted radio communication by stating that communication problems in the field are a longstanding issue but long trains have operated without incident over the past 80 years.[184] In addition, loss of radio communications should not result in an accident as long as railroad staff are following railroad communication rules.[185]

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[181] SMART and BLE-T presentations to committee, January 19, 2023.

[182] FRA. 2022. "Stakeholder Perceptions of Longer Trains." DOT/FRA/ORD-22/43. December. https://railroads.dot.gov/elibrary/stakeholder-perceptions-longer-trains.

[183] Willauer interview with Bruce Marcheschi, December 14, 2023.

[184] AAR presentation to committee, January 20, 2023.

[185] Both widely used books of rules require engineers to stop trains at half the distance last requested if radio communications are interrupted.

4

Long Trains and Crew Operations

The challenges associated with operating long trains, as described in Chapters 2 and 3, have implications for how engineers and conductors are trained and their service readiness. In addition, the advent of long trains has coincided with reductions in the railroad labor force that are especially concentrated in trains crews and maintenance of equipment personnel. This chapter outlines the impacts of long trains on labor and their training needs. The chapter begins with a brief overview of employment trends in the Class I railroads. The chapter then presents an extended discussion of impacts on train and engine employees, followed by a briefer examination of maintenance of equipment employees. This chapter examines how training has or has not been adapted to the operational challenges of long trains. While engineer-assist systems make some engineer tasks easier, they do not replace the need for additional training inasmuch as engineer-assist systems are not always available. In addition, long trains may lead to increased crew fatigue. The chapter concludes with a comparison of training in the railroad industry with other industries.

RAILROAD EMPLOYMENT TRENDS GENERALLY

For a given tonnage of freight, running longer trains means running fewer trains. Therefore, long trains can reduce the need for labor. Federal data on employment in the Class I railroads (see Figure 4-1) show that train and engine employees and maintenance of equipment employees have declined since 2015. The number of maintenance of way employees has seen a smaller decline, while the numbers of employees in other employment categories have remained relatively flat.[186] This decrease in train and engine employees and maintenance of equipment employees coincides with the increasing train length, which as described in Chapter 2 dates to around 2017.

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[186] FRA (Federal Railroad Administration). 2024. "Labor and Employment." Updated May 24. https://railroads.dot.gov/rail-network-development/labor-and-employment.

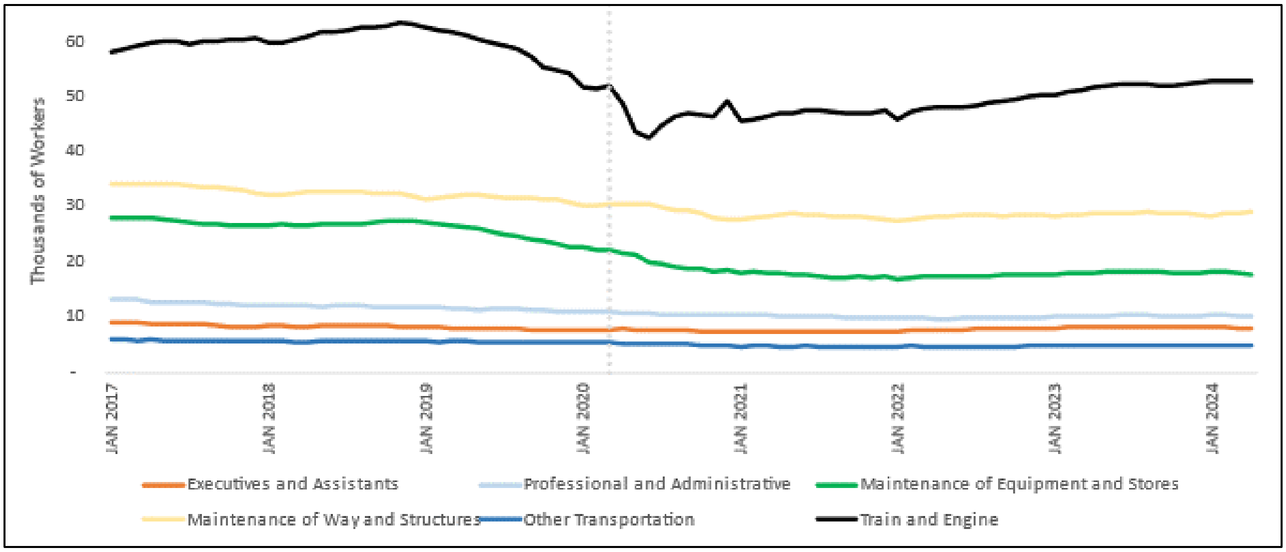

FIGURE 4-1 Railroad employment by job category, 2017–2024.
SOURCE: Surface Transportation Board. 2024. Quarterly Wage A and B data. https://www.stb.gov/reports-data/economic-date/quarterly-wage-ab-data.

TRAIN AND ENGINE EMPLOYEES

Long trains are operated by an engineer and a conductor who share the responsibility for safe train operation. The engineer is responsible for operating the locomotive engine while the conductor supervises the operation and administration of the train and is responsible for the cargo and train equipment. This includes making sure that the cars and their systems are in good operating condition, and that train makeup is sound. The conductor and engineer are jointly responsible for the safe operation of the train in accordance with all rules and regulations.[187] As described in Chapters 2 and 3, long trains can be more difficult to operate and add to the responsibilities of the engineer and the conductor.

Figure 4-2 shows the recent decline in the number of train and engine employees accompanied by an increase in the gross ton-miles per employees for the four largest Class I railroads.[188] Although the total number of train and engine (T&E) employees has fluctuated since 2005, gross ton-miles per T&E employee stayed relatively flat until it began an increasing trend in 2015. Between 2018 and 2022, total T&E employees decreased by 23%, while gross ton-miles per employee increased by 15%. Although T&E employees have reportedly not been working more miles per year, union leaders contend longer trains have led to increasing the need to recrew trains before they reach their destination, resulting in a longer workday for T&E employees.[189] This increased length of the workday comes from waiting for transport and traveling to their destination terminal, which are often in addition to their 12-hour maximum allowed work time.

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[187] Sperandeo, A. 2023. "The People Who Work on Trains." *Trains*, December 20. https://www.trains.com/trn/train-basics/abcs-of-railroading/the-people-who-work-on-trains.

[188] STB R1 data and STB Wage A and B reports.

[189] SMART, BLE-T, and ATDA union presentations to committee, January 2023.

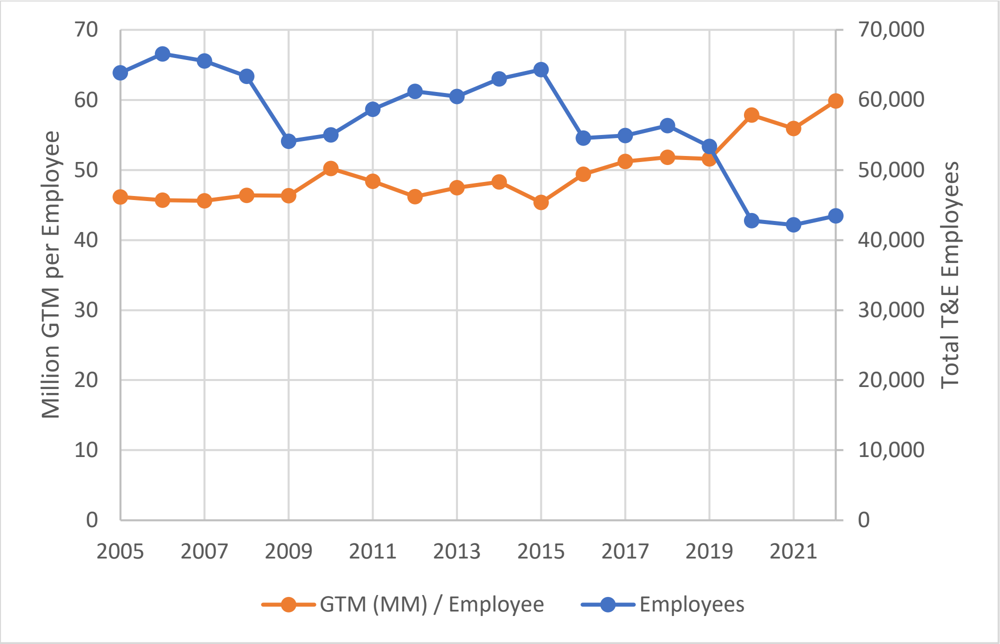

FIGURE 4-2 Train and engine (T&E) employment and million gross ton miles (GTM) per T&E employee for the four largest Class I railroads, 2005–2022.
SOURCE: STB R1 data and STB Wage A and B reports.

Crew Preparedness and Training

As described in Chapters 2 and 3, long manifest trains, with their complicated makeup and multiple groups of DP locomotives, can create situations where controlling train speed while minimizing in-train forces will be challenging even for a well-trained and experienced crew.

Federal Railroad Administration (FRA) regulations require railroads to train and certify their train crews.[190] Qualified locomotive engineers must demonstrate proficiency in operating trains in the most demanding type of service they are permitted to perform, which includes operating longer trains with or without DP locomotives.[191] There is an initial period of classroom training; however, the bulk of most training programs for new employees takes place in the field during normal operations. For the most part, this training for locomotive engineers and conductors is done via mentoring, with an experienced engineer riding with a new student and conductor trainees working under the direct supervision of a more experienced conductor. Locomotive engineers and conductors are required to be recertified for train service once every 3 years, with annual training in between.[192] Railroads are required to conduct annual performance

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[190] "Chapter II—Federal Railroad Administration, Department of Transportation." 49 C.F.R. Parts 240, 242, and 243. https://www.ecfr.gov/current/title-49/subtitle-B/chapter-II (accessed May 6, 2024).

[191] 49 C.F.R. § 240.213. FRA regulations require that each railroad shall determine that the person has the knowledge and skills to safely operate a locomotive or train in the most demanding class or type of service that the person will be permitted to perform. Specific topics for training programs include personal safety, railroad operating rules, handling trains over the railroad's territory, federal regulations, and operating the different train types normally used by the railroad.

[192] At some railroads this is done utilizing simulator technology, and at some railroads it is done in the field with a check ride performed during a regular train operation.

evaluations of engineers to ensure that they can safely operate trains according to federal railroad safety requirements.[193]

Unusual and/or emergency situations cannot be specifically addressed during the training that takes place in the field during normal operations. To prepare for such situations, representatives of Class I railroads stated that they train their crews on trains and "simulators" that cover various routes, scenarios, and train lengths.[194] Each railroad develops its own program of initial and recurrent training for its train crew members. Although these programs are similar for each railroad, they are not identical. While one Class I railroad does require annual engineer simulator testing for trains up to 12,000 ft in length, several others operating in the United States indicated that they had not changed anything in their respective training curricula to specifically address the operation of long trains.[195] Instead, they stated that train length was not an important factor in a crew member's ability to successfully complete their job requirements and that there were no issues that would require any modifications to the training that employees receive.[196]

However, representatives of railroad workers did not concur with the railroads' position on the need for additional or modified training.[197] Union representatives expressed concern that some railroads do not provide sufficient training for crews to operate longer trains, resulting in locomotive engineers and conductors that lack the necessary training and experience to handle longer trains.[198]

Derailments Caused by Improper Train Handling

Chapter 2 provided evidence that train derailments with makeup and handling issues have increased coincident with the increasing length of manifest trains. As an example of this problem, an FRA accident report on a 2023 derailment concluded that handling was a primary cause, noting the engineer's improper use of dynamic brakes.[199] In the report, FRA stated that the engineer's last annual check ride did not test the engineer's ability to handle a train of the size of the derailed train. The train that derailed consisted of 15,519 tons, 11,374 ft, with both a mid and a rear DP consist. The report stated:

> Analysis-Certification Process: During the investigation the FRA reviewed the engineers operational performance exam (annual ride) and the engineers skills performance exam (certification ride) which revealed the following: Federal Regulation listed under 49 CFR 240.127(b) requires the evaluation to consist of "being evaluated for qualification as a locomotive engineer in either train or locomotive service to determine whether the person has the skills to safely operate locomotives and/or trains, including the proper application of the railroad's rules and practices for the safe operation of locomotives or trains, in the

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[193] 3549 C.F.R. § 240.129. In addition, FRA regulations require that FRA review new and materially modified railroad-crew-training programs and also meet with railroads to discuss strategies to reduce instances of poor safety conduct by train crews. See 49 C.F.R. § 240.103 and 49 C.F.R. § 240.309, respectively. According to FRA, the agency may audit training programs and require railroads to update deficient training programs to comply with regulations.

[194] FRA. 2024. "Stakeholder Perceptions of Longer Trains." February 16. https://railroads.dot.gov/elibrary/stakeholder-perceptions-longer-trains.

[195] Class I presentation to committee, March 2023.

[196] Class I railroads presentation to committee, April 2023.

[197] SMART presentation to committee, January 2023.

[198] SMART, BLE-T, and ATDA union presentations to committee, January 2023.

[199] BNSF derailment near Williams, Arizona, on June 8, 2023, FRA file No. HQ-2023-1863. The cause of the derailment was "[H503] Buffing or slack action excessive resulting from improper use of dynamic brakes."

> most demanding class or type of service that the person will be permitted to perform." However, the train used for the engineer's certification ride composed of a simulated 55 car intermodal train with only 4,086 tons and 5,462 feet (including locomotives).

FRA concluded that the smaller train used in the simulation was not equivalent to the regulation's requirement that training be on the most demanding class of service for the subdivision.

Increasing Reliance on Control Technology

Class II railroads are also increasingly relying on technology to guide crew members, especially locomotive engineers, on the operation of trains over their assigned territory. As described in Chapter 3, engineer-assist systems direct both power and braking decision making for trains.[200] Not only are train crew members increasingly tasked with relying on these systems, but also, they are often required to comply with the system's recommended control inputs. One reason for the reliance on engineer-assist systems is the difficulty in separately controlling all locomotives in a train (mid-train distributed power [DP] locomotives and end-of-train DP locomotives) to minimize in-train forces has increased greatly as trains extend over multiple uphill and downhill grades simultaneously.

However, one notable limitation of the engineer-assist technologies that are currently being used is that these systems primarily use dynamic braking for controlling the speed of the train.[201] As covered in Chapter 3, overreliance on dynamic brakes can be problematic in trains that are not properly marshalled. According to one railroad, their engineers were trained to not use air brakes unless the engineer-assist system recommends doing so.[202] Another railroad discourages their engineers from using air brakes, but they had the prerogative to do so if they concluded that it was necessary to safely control their train.[203] It should be noted that there are some mountain grades in the country where the use of both air brakes and dynamic brakes are required as dynamic brakes alone are not adequate to control the train on very steep grades and/or moving at slow speeds.[204]

The problem with the increasing dependence on engineer-assist systems, especially as trains have grown longer, is that they are not yet reliable enough to work all the time in all situations.[205] As such they are not a substitute for effective training and their use does not negate the need for training as required by FRA.

Given that running trains with less horsepower per gross ton-mile is proven to reduce fuel burn,[206] the 22% increase appears to come more from reduced horsepower per gross ton. Another railroad presented a study comparing winter operations using shorter trains to operations over the rest of the year using longer trains. The study showed fuel savings for running longer trains.[207] The study attributed all the increase in fuel consumption during the winter to running shorter

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[200] Wabtec and LEADER presentations to committee, May 2023.

[201] Ibid.

[202] UP and CSX railroads presentations to committee, March 2023.

[203] Ibid.

[204] Transportation Safety Board of Canada. 2022. "Locomotive and Freight Car Brakes." March 31. https://www.tsb.gc.ca/eng/medias-media/fiches-facts/r19c0015/r19c0015-20220331-3.html, p. 209.

[205] BLE&T presentation to the committee, January 2023.

[206] Cetinich, J. 1975. *Fuel Efficiency Improvement in Rail Freight Transportation: United States*. FRA.

[207] CN presentation to committee, April 2023.

trains; however, it did not account for the impact that cold weather operations could have on fuel burn.

Research on Train Size and Fuel Economy

Railroads have made changes to operations that can and have resulted in decreased fuel use over recent decades. Engines have become more efficient and therefore more cost effective.[208] Rail cars are built to carry heavier loads, reducing the number of cars needed to move the same amount of tonnage. Wayside detectors have reduced flat spots on wheels and therefore rolling resistance.[209] Reducing train speeds to below 40 mph also saves fuel.[210] As described in Chapter 3, the Class I railroads introduced a greater reliance on dynamic brakes, and the subsequent adoption of engineer-assist systems to speed the adoption of dynamic brakes, in part to increase fuel efficiency.[211] All railroads have implemented or are implementing anti-idling policies to provide additional fuel savings and therefore reduce emissions.[212]

On the other hand, long trains have led to fewer locomotives in service. Running trains with less horsepower per gross ton, which reduces the ratio of horsepower to gross train weight, while maintaining maximum speed levels, produces the greatest savings relative to increases in minimum over-the-road train running times.[213] In addition, having fewer locomotives in service will reduce idling, further increasing overall fuel economy.

Therefore, although railroads have clearly reduced fuel usage since the advent of long manifest trains, it is not clear that such savings are from running longer trains as opposed to other locomotive operating policies. In addition, GHG emissions can be reduced through other means. Several railroads are increasing their utilization rates of low-carbon fuels and testing hydrogen-powered locomotives to provide even cleaner locomotive operations.[214]

Train Crew Fatigue and Long Trains

Train crew fatigue may increase as train length increases.[215] For example, according to union representatives, if a train stops unexpectedly because of a mechanical or other issue, a train crew member must typically walk the length of the train. For a 2-mile train, walking from the lead locomotive to the end and back would require walking 4 miles, a journey made substantially more difficult during inclement weather or at night. Additionally, a recent FRA safety advisory requires that any unattended train must have a sufficient number of hand brakes applied to

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[208] Lustig, D. 2010. “AC vs. DC: What’s the Difference?” *Trains* 70(5):18–19.

[209] Ernest Robl, E. 2006. “Smarter Detectors, Less Talking.” *Trains*.

[210] Hopkins, J.B. 1975. *Railroads and the Environment: Estimation of Fuel Consumption in Rail Transportation: Volume 1. Analytical Model*. Federal Railroad Administration.

[211] See Trip Optimizer and LEADER section in Chapter 3.

[212] AAR presentation to committee, March 16, 2023.

[213] Efficiency can be further optimized by shutting down locomotives in a consist when they are not needed to power the train, especially if idling specific locomotives permits the remaining locomotives to operate at full throttle. For more information, see Cetinich, J. 1975. *Fuel Efficiency Improvement in Rail Freight Transportation*. Federal Railroad Administration.

[214] “Freight Shipping and Its Impact on Climate Change.” February 7, 2024. http://www.up.com/up/customers/track-record/tr021522-impact-of-freight-shipping-on-climate-change.htm.

[215] FRA. 2024. “Stakeholder Perceptions of Longer Trains.” February 16. https://railroads.dot.gov/elibrary/stakeholder-perceptions-longer-trains.

prevent unintended movement.[216] As train length has grown, both the number of hand brakes required to secure a train and the distance that conductors must walk to set the hand brakes has increased significantly. According to union representatives, such physically demanding tasks can increase crew fatigue.[217] Labor reported that crews often have long days due to not getting to destinations before they run out of time on the hours of service and have to wait for replacement crews before resting.[218]

EQUIPMENT MAINTENANCE EMPLOYEES

The long-term drop in railway employment has been seen in every employee category (as shown in Figure 4-1) but the percentage decline is highest for maintenance of equipment (MOE), which has experienced declines of approximately 43% from 2015 to 2023.[219] This reduction of MOE personnel has coincided with increased train length, requiring that more cars be managed, inspected, and maintained per train. Some of the reasons for MOE workforce reductions include (1) increasing reliance on sophisticated sensor suites and artificial intelligence to find mechanical problems quickly and without human inspection, (2) reduced number of yards and therefore places to inspect trains, (3) increased use of modern locomotives, (4) increased use of subcontractors for a variety of tasks, and (5) greater locomotive productivity.

Locomotive Maintenance

Increased locomotive productivity is measured here as gross ton-miles per locomotive mile, which has increased greatly from 2015 to 2022 (see Figures 4-3 and 4-4). It is not known whether this improved productivity comes from increasing reliance on modern locomotives or from using fewer locomotives per gross ton-mile.[220] However, improved locomotive productivity results in needing fewer locomotives, which reduces the numbers of locomotives maintained and, therefore, the need for MOE personnel.

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[216] FRA. 2022. “Safety Advisory 2022-02; Addressing Unintended Train Brake Release.” *Federal Register* 87:80256. December 29. https://www.federalregister.gov/documents/2022/12/29/2022-28336/safety-advisory-2022-02-addressing-unintended-train-brake-release.

[217] SMART and BLE-T presentations to committee, January 2023.

[218] Ibid.

[219] STB Quarterly Wage A and B data, https://www.stb.gov/reports-data/economic-data/quarterly-wage-ab-data.

[220] In addition to being more powerful and having better traction control, modern locomotives are more reliable. They use alternating current traction motors which do not overheat when used at maximum power. Older direct current traction motors would overheat when used at maximum power for too long. For more information see Lustig, D. 2010. “AC vs. DC: What’s the Difference?” *Trains* 70:18–19. Milwaukee, WI: Kalmbach Publishing Company.

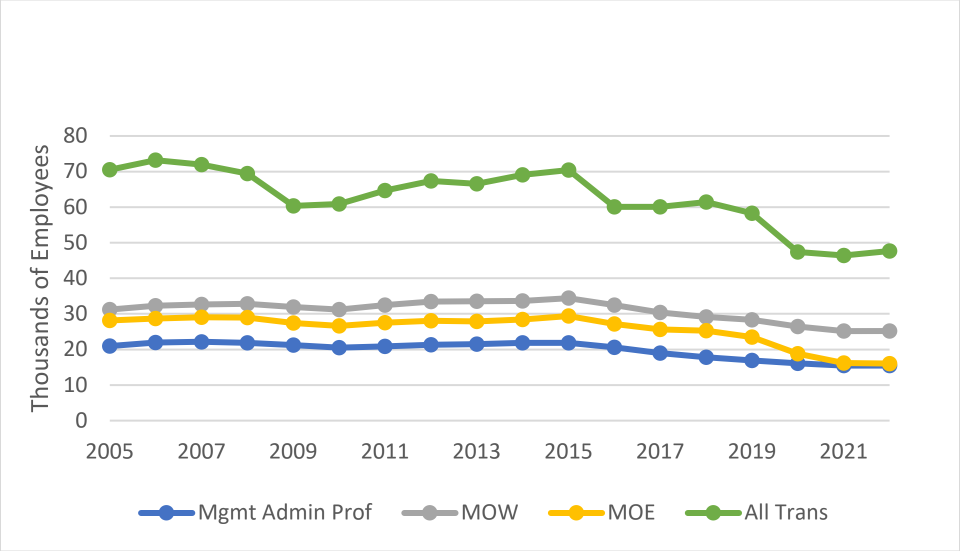

FIGURE 4-3 Employment by area for the four largest Class I railroads, 2005–2022.
SOURCE: STB Wage A and B reports.

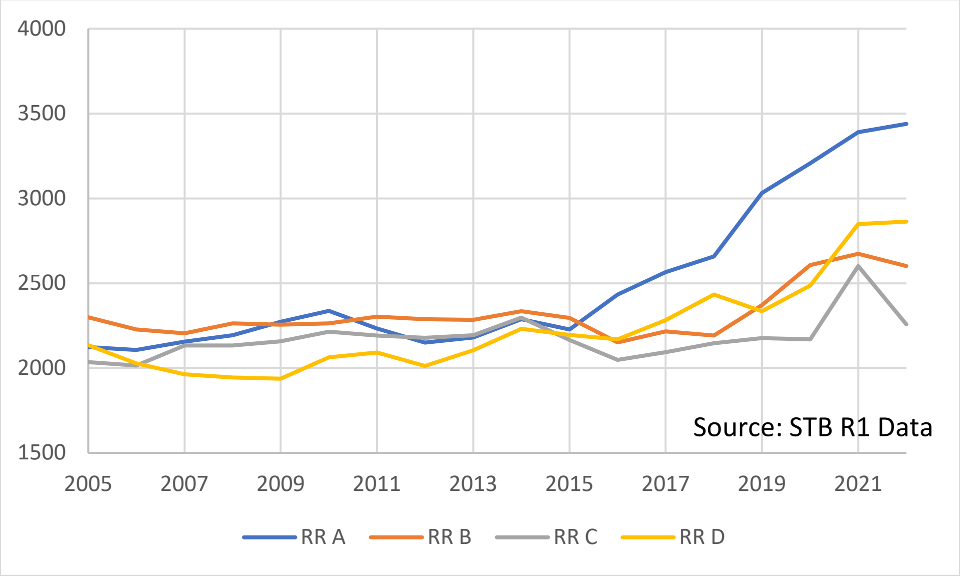

FIGURE 4-4 Gross ton-miles per locomotive mile for the four largest Class I railroads, 2005–2022.
SOURCE: STB R1 data.

Equipment Inspection

Longer trains require that more cars be managed, inspected, and maintained per train. This has occurred at the same time that carmen have raised concerns[221] about increasing pressure to inspect and release trains quickly, which has also been reported in recent investigative

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[221] BLE-T and SMART presentations to committee, January 2023.

journalism.[222] The time needed to inspect a single car is independent of train length. Because there are more cars in a long train, the total inspection time for the entire train—and therefore each car in that train—is also longer. However, railroad presentations confirm there has been an increase in the use of technology to perform car inspections across railroad networks. For example, acoustic bearing detectors are the "first line of defense," followed by hot bearing and axle detectors, wheel impact load detectors, portal detectors, wheel impact load detectors, high and wide load detectors and dragging equipment detectors.[223]

Implementing such technology systems and the use of inbound inspections performed on arrival of the car at the terminal has advantages in getting defective cars set aside for repair. In summary, while wayside detectors have reduced the need for car inspections in yards, long trains still require more time to inspect arriving and departing manifest train yards.

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[222] Fung, E., K. Maher, and P. Berger. 2023. "'Hurry Up and Get It Done': Norfolk Southern Set Railcar Safety Checks at One Minute." *The Wall Street Journal*; Sanders, T., J. Lussenhop, D. Morton, and G. Sandoval. 2023. "Do Your Job: How the Railroad Industry Intimidates Employees into Putting Speed Before Safety." *Probublica*; Sanders, T., D. Schwartz, and J. Sterman. 2023. "As Rail Profits Soar, Blocked Crossings Force Kids to Crawl Under Trains to Get to School." *Propublica*.

[223] CN presentation to committee, April 2023.

5
Impacts on the Public

This chapter considers whether long trains may be adversely impacting the public by occupying highway-rail grade crossings more often or for longer periods and by contributing to delays in Amtrak passenger trains. Highly relevant to both kinds of impacts is whether the rail infrastructure is able to accommodate longer trains. The first part of the chapter considers how long trains can affect the functioning of grade crossings and how chronic blocked crossings can be problematic for affected communities. The second part of the chapter considers how long trains can affect the operation of the passenger trains operated by Amtrak, which is legally afforded dispatching preference when using the track of host freight railroads.

HIGHWAY-RAIL GRADE CROSSINGS

Highway-rail grade crossings are locations where roadways and rail lines intersect at the same "grade" or level. At these grade crossings, a traveler on the road can be delayed by, or even collide with, a train. When the train, moving or stopped, occupies the crossing, road travel cannot—or should not—take place and the crossing is considered blocked. There are currently more than 212,000 highway-rail grade crossings on approximately 140,000 route-miles of track in the U.S. railroad system.[224]

The consequences of blocked grade crossings for communities vary by factors related to rail operations and the community's road system and location of critical land uses. Rail operation factors include the frequency and duration of blocked crossings, as well as time of day. For example, three blocked crossing events during 3:00 p.m. to 5:00 p.m. pm on a weekday will have different impacts than the same three events that take place between 8:00 p.m. and 6:00 a.m. during the weekend. Across communities, the consequences of blocked grade crossings will differ depending on such factors as the availability of alternative routes for motor vehicles and pedestrians, the lengths of the detours, and the impacts of any resulting vehicle congestion. The consequences of delayed or rerouted road travel also vary. Trips for which time is of the essence, such as emergency services, have high consequences, as do trips that are time dependent, such as arriving on time for school, work, or a medical appointment. Blocked crossings may also induce risky behaviors, such as drivers trying to "beat the train" or people on foot crawling over or under a stopped train at considerable personal risk.

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[224] Federal Railroad Administration (FRA). 2024. All States Crossing Data. https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/DownloadCrossingInventoryData.aspx.

Train Length and Blocked Crossings

It is possible that longer trains result in fewer trains and therefore fewer blocked crossing events in the rail network overall and in specific communities.[225] However, the duration of each blocked crossing event will increase, because it takes the longer train more time to pass through the crossing. Apart from the logical inference that a long train will take more time than a short train to transit a grade crossing simply because of its added length, the evidence to suggest that long trains block grade crossings more often, whether idle or moving, is largely anecdotal. Nevertheless, as the length of time any particular crossing is blocked increases, the number of complaints about it increases significantly. The committee heard from leaders of communities impacted by chronic grade crossing blockages who maintain that train length is a factor in both the frequency and duration of blockages. The relationship between community impacts and the frequency versus duration of blocked crossing events still requires research.

For a given number of rail cars distributed in a fewer number of long trains versus a greater number of shorter trains, it is not clear whether the *total duration* of blocked crossing events favors the long trains. Because the duration of a blocked crossing event includes the time it takes for the gates to lower and raise, which is a fixed interval per train, fewer gate cycles would slightly reduce the total duration of blocked crossings. However, in many situations long trains do not run at the same average speed as shorter trains. Rail lines have speed restrictions (such as for curves, bridges, traveling in urban areas, track maintenance crews, etc.) where trains are required to slow down to pass through the point or area. For a given point, a 1-mile-long train traveling at a speed-restricted 20 mph would require a minimum of 1/20 of an hour, or 3 minutes, for its entire train to pass a given point. A 2-mile-long train would require a minimum of 2/20 of an hour, or 6 minutes, for its entire train to pass the same given point at 20 mph. This means that the 1-mile-long train must slow its travel to 20 mph for 3 minutes, but the 2-mile-long train must travel at 20 mph for 6 minutes before both trains can accelerate to normal speed. [226]

In addition, as the long train passes through a community with numerous grade crossings, it is more likely to simultaneously block multiple crossings, and therefore potentially disrupt road travel patterns more severely for a longer period of time than for the same number of cars in shorter trains.[227]

For long trains that must stop, there will be fewer locations where they can be stopped without blocking crossings. Long trains may be stopped and blocking crossings—or cause other trains to be stopped and blocking crossings—because they are waiting for a meet with another train, being held out of yards, or running out of time under the crew's maximum hours of service.[228,229]

If a blocked crossing is unavoidable, the practice had been to "cut" the train, which involves breaking the connection between rail cars and moving a section of the train to open a gap at the crossing, which then allows vehicle and pedestrian travel. The longer the train, the more difficult cutting the train becomes. It may be more time consuming for the crew to walk the

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[225] This is the hypothesis of several railroads and the Association of American Railroads (AAR), as presented to the committee.

[226] Stephens, B. 2023. "The Shortsighted View of Long Trains." *Trains* 83:8. https://www.trains.com/wp-content/uploads/2022/12/MAG-TRN-FEB23.pdf.

[227] Reports from local officials from Bensenville, Illinois, and Bushnell, Illinois, June 2023.

[228] Stephens, B. 2023. "The Shortsighted View of Long Trains." *Trains* 83:8. https://www.trains.com/wp-content/uploads/2022/12/MAG-TRN-FEB23.pdf.

[229] BLE-T presentation to committee, January 2023.

long train to reach the crossing to disassemble the train and then return later to put it back together. It will also take longer to restore the train's air brakes (see Chapter 3) to prepare for departure, lengthening the time the fully reassembled train is again blocking the crossing. For long trains stopped at crossings, the practice of cutting may become impractical.

Yard Constraints and Blocked Crossings

Representatives from the railroad labor unions who briefed the committee indicated that their members have observed long train operations resulting in blocked highway-rail grade crossings, especially in urban areas and near large rail yards.[230] In particular, they have observed that assembling blocks of cars prior to departure and distributing blocks of cars upon arrival is leading to trains extended outside of yards to block nearby crossings.[231] For example, when a yard does not have tracks long enough to hold a train that is being assembled or disassembled, the train may extend out onto the mainline, potentially blocking rail traffic and highway-rail grade crossings for extended periods.[232] This is more likely to be the case where the rail yards that assemble and disassemble manifest trains are many decades old and were not designed to accommodate long trains. Such a situation can lead to yard congestion, delays to freight trains in the vicinity of the yard, and blocked highway-rail grade crossings from waiting trains and from trains spilling out to tracks outside the yard.[233] While the focus of this section is on how these yard constraints can affect blocked crossings and the public, Box 5-1 discusses the potential for adverse impacts on freight train operational fluidity and the railroads' shipper customers.

Under Precision Scheduled Railroading (PSR), Class I railroads decreased reliance on their networks of hump classification yards to sort cars.[234] In 2017, CSX reduced the number of hump yards it operated by either closing them or converting them to flat switching facilities.[235] Other Class I railroads have followed suit, with the number of active hump yards in the United States decreasing from 57 in 1996 to 35 in 2018.[236] A result of this trend is increased use intensity of the remaining hump yards and increased manifest train size due to the concentration of more activity in fewer yards.

The building of long trains at originating yards can tie up the yard by blocking the switching lead (and sometimes the mainline) for longer periods of time due to the increased size of trains, a problem recognized by the railroads who devote significant amounts of their network capacity investments toward siding extensions, new longer sidings, and overall yard expansions.[237] The lack of sufficiently long departure tracks exacerbates the situation for many

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[230] American Train Dispatchers Association (ATDA) presentation to committee, January 2023.

[231] BLET (Brotherhood of Locomotive Engineers and Trainmen), SMART (Sheet Metal, Air and Rail Transportation), and ATDA.

[232] SMART presentation to committee, January 2023.

[233] ATDA presentation to committee, January 2023.

[234] A "hump" yard is a facility that utilizes gravity, usually a hill, to more efficiently reorganize and assemble rail cars. For an example, see https://www.bnsf.com/news-media/railtalk/service/hump-yards.html.

[235] Stephens, B. 2017. "CSX Hump Yards Are Targets." *Trains* 77:8.

[236] Zhao, J., and C.T. Dick. 2022. "Quantitative Derailment Rate Comparison of Unit Trains at Transload Terminals and Manifest Trains at Railroad Switching and Hump Classification Yards." *Transportation Research Record* 2677(1):311–325. https://doi.org/10.1177/03611981221099287.

[237] CPKC presentation to committee, April 2023. Harwell, J.A. 2023. "CPKC's Shreveport Dilemma." *Trains* 83:14–23.

yards with track lengths designed for considerably shorter trains.[238,239] The situation may be repeated at destination yards due to increased difficulty in receiving longer trains that exceed the length of receiving tracks. Operating longer trains often requires outbound crews to combine several trains together from tracks that used to fit entire shorter trains. Inbound trains are often required to switch blocks of cars to several tracks for the same reason. The additional effort to dispatch and receive long trains can consume a disproportionate amount time blocking yard leads and sometimes mainline track.[240] For these reasons, other yard operations are often affected or delayed as long trains are dispatched or received.[241]

Chief among these effects is decreased dependability of industrial switching because yard resources have been reduced to increase efficiency and remaining resources may be committed to handling inbound and outbound trains before first mile and last mile movements can be addressed. Furthermore, the elimination of some major classification yards required much rail car sorting work to be shifted to smaller local and industrial yards where crews now spend more time pre-blocking outbound rail cars for different network destinations instead of preparing local trains or servicing nearby rail customers.[242] Additional long train impacts on shippers are described in Box 5-1.

BOX 5-1
Short and Long Train Impacts on Shippers of Rail Freight

Yard-related issues have the potential to affect the quality of service provided to freight rail shippers. Because longer trains take more time to process, switch, assemble, and inspect at a classification yard, longer minimum connection times between arriving and departing trains must be planned at each classification yard in the rail car trip plan. This extra yard connection time may extend the average origin-to-destination transit time of freight shipments through the network. In addition, because they transport more freight at once, longer trains may necessitate reduced departure frequencies in order for a sufficient “train load” of freight to accumulate for a given destination or departure block. Reduced departure frequencies of longer trains increase the average rail car waiting time in classification yards, further extending rail car transit times in the network and potentially diminishing the level of service provided to freight shippers.

Multiple studies have demonstrated the service and rail car transit time benefits of operating more frequent, shorter trains that connect a greater number of origin-destination terminals with direct service, as opposed to a smaller number of longer trains between a limited set of terminals.[243,244] The result was that each type of traffic departed each yard for a

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[238] SMART presentation to committee, January 2023.

[239] Stephens, B. 2023. “The Shortsighted View of Long Trains.” *Trains* 83:8. https://www.trains.com/wp-content/uploads/2022/12/MAG-TRN-FEB23.pdf

[240] Time spent arriving and departing is also increased due to requirements of trains to obey yard and other speed restrictions for the entire train.

[241] ATDA presentation to committee, January 2023.

[242] Dick, C.T. 2021. “Precision Scheduled Railroading and the Need for Improved Estimates of Yard Capacity and Performance Considering Traffic Complexity.” *Transportation Research Record* 2675(10):411–424. https://doi.org/10.1177/03611981211011486.

[243] Leilich, R.H. 1974. *Study of the Economics of Short Trains*. Washington, DC: Peat, Marwick, Mitchell & Co.

[244] Diaz de Rivera, A., C.T. Dick, and M.M. Parkes. 2021. “Balancing the Service Benefits and Mainline Delay Disbenefits of Operating Shorter Freight Trains.” *Transportation Research Record* 2675(10):303–316. https://doi.org/10.1177/03611981211011484.

given destination multiple times per day, greatly reducing yard dwell and decreasing rail car transit time while still accruing the economic and efficiency benefits of longer trains[245] During the implementation of PSR railroads operated longer trains between two or more major concentration or distribution points (i.e., rail yards and terminals), as opposed to trains used for local services or unit trains) One of the disadvantages of PSR from a customer service standpoint is that it reduced the possibilities to forward traffic more expeditiously, rather than having it wait for a single ride. The service benefit of short train operations has largely been lost as current long train operating strategies place more emphasis on increasing train length for single types of traffic, and less on train and blocking plans that leverage long trains to generate multiple departures per day between each pair of yards. These are decisions railroads must make and work out with their paying customers.

Information on Blocked Crossings

The committee was told by Class I railroads that they monitor grade crossings as part of their overall freight train operations and safety. Railroads have dashboards depicting the location and number of blocked crossings by city, state, time of day, and time of week to help dispatchers monitor blocked crossings and monitor and assess community concerns. One railroad reported that it has recently added crossing locations to dispatcher dashboards in addition to dashboards at control centers. [246] Another railroad reported that, based on its monitoring, it has not found any correlation between train length, the duration of blocked crossings, and the quantity of blocked crossing notifications they receive.[247]

To analyze the impacts of long trains on the functioning of highway-rail grade crossings the committee posed two questions:

1. Are the community impacts related to blocked crossings increasing?
2. Are long trains responsible for any increased impacts?

On the first question, the qualitative information and limited quantitative data that are discussed in more detail below indicate that chronically blocked crossings are a problem in some communities. On the second question, long trains appear to be a factor in some locations experiencing chronic crossing problems. The quantitative data required to definitively answer both questions, however, are not publicly available.

FRA Data

Public data on the extent of blocked crossings in the United States are limited, and much of what exists is qualitative or not suitable for quantitative analyses. Even if suitable data on the extent of blocked crossings existed, causal analysis would also require appropriate data on train length. During the course of this study, FRA began requiring Class I railroads to report train length in accident reports, starting in 2023.

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[245] Dick, C.T. 2021. "Precision Scheduled Railroading and the Need for Improved Estimates of Yard Capacity and Performance Considering Traffic Complexity." *Transportation Research Record* 2675(10):411–424. https://doi.org/10.1177/03611981211011486.

[246] CSX presentation to committee, March 2023.

[247] Union Pacific Railway presentation to committee, March 2023.

FRA has been collecting crowd-sourced information on blocked crossings since 2019. Since then, more than 91,800 blocked crossing incidents have been identified by members of the public, including the reported date, time, and duration of the reported blocked crossings. The information has been reported in all 50 states, with the highest number of incidents in Texas, Ohio, and Illinois. Figure 5-1 illustrates reported incidents across the nation. Among the limits of this database is that the results may be skewed for various reasons such as geographic variability in and public knowledge of the reporting system. In addition, there is no process for correlating the reports with train length.

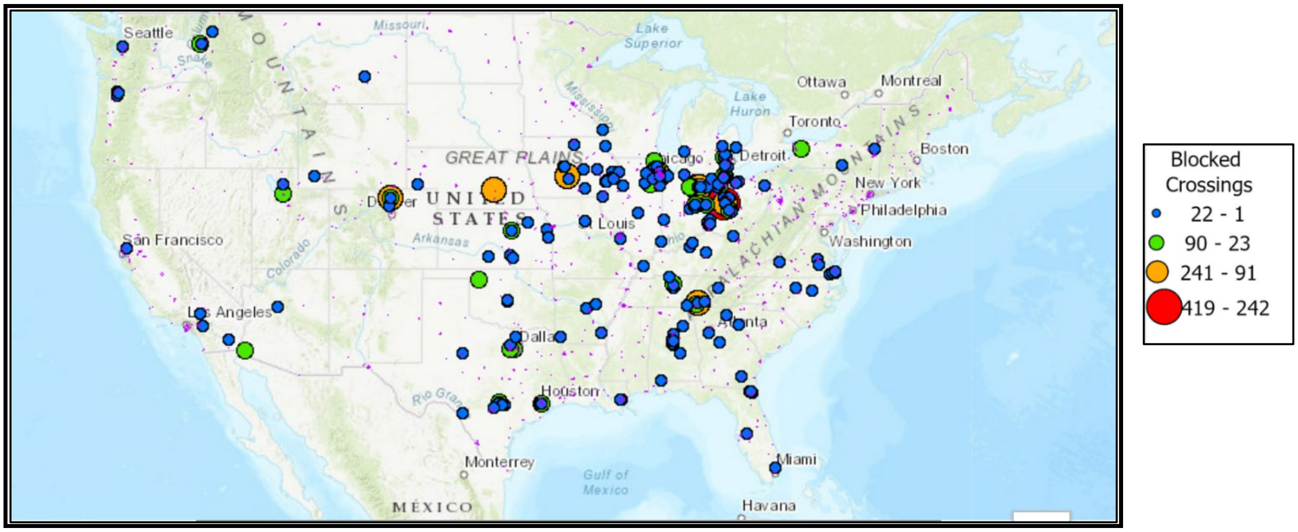

FIGURE 5-1 Reported incidents of blocked highway-rail crossings, 2019–2024.
SOURCE: FRA. "Public Blocked Crossing Incident Reporter." https://www.fra.dot.gov/blockedcrossings/incidents (accessed May 31, 2024).

Sensor Data

Proprietary acoustical sensors can capture the date, time, and duration of blocked crossings and other information. To date, approximately 150 jurisdictions in North America have employed such sensors to alert first responders and motorists regarding blocked crossings and to provide data to support applications for government funding of grade crossing improvements or removals.

A consultant was retained as part of this study to gain a better understanding of how sensor technology could be used to identify and assess blocked crossings, including for monitoring blockage times. The study area included three highway rail grade crossings in Jacksonville, Florida, and seven in Houston, Texas.[248] The locations were selected based on proximity to rail yards at which manifest trains are assembled and dissembled. Between June 1 and August 31, 2023, the sensors used by the consultant recorded 3,440 events at three crossings in Jacksonville, 6% of which were longer than 10 minutes. During the same time period, sensors recorded 11,700 blocked crossing events in Houston, 20% of which were longer than 10 minutes.

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[248] Florida Department of Transportation and the City of Houston allowed the committee to view data from these locations in support of this study.

An "event" is defined as when a moving or stationary train blocks a crossing for a period of time.[249]

While these results confirm that lengthy blocked crossings can indeed be problematic in some locations, the effects of longer trains could not be determined. Data limitations from this detection source include unknown train type, unknown presence of distributed power locomotives, and limited data on train speed and train length.

Community Impacts

In the absence of quantitative data, the committee sought to gauge the significance of the community impacts from blocked crossings by consulting media reports and meeting with affected communities.

The committee heard from leaders of communities impacted by chronic grade crossing blockages who maintain that train length is a factor in both the frequency and duration of blockages. Some of the communities are in proximity to rail yards where trains frequently stand idle for long periods waiting entry to the yard and where train assembly and disassembly operations can lead to trains moving back and forth over one or more crossings multiple times., As the length of time any particular crossing is blocked increases, the number of complaints about it increases exponentially. The community leaders complained about the resulting increased response time for emergency responders and the lengthy and recurrent delays incurred by motorists and pedestrians. Examples of interrupted access to neighborhoods, schools, and recreational facilities were given along with instances where impeded pedestrians, including students, maneuvered through stopped trains at considerable personal risk. These consultations suggest that, as might be expected, the impacts on emergency response times raise some of the most significant public interest concerns due to their safety ramifications. Fire trucks, ambulances, and police vehicles rerouted because of a blocked crossing or delayed by the ensuing traffic congestion can be a matter of life or death. Deploying duplicative emergency response assets so neighborhoods do not get isolated by blocked crossings is expensive.

The following are specific examples of disruption related to blocked crossings from communities in Illinois, Indiana, and Maryland.

Barrington, Illinois

The Mayor of the City of Barrington, Illinois, described blocked crossings that created delays for emergency responders that have lasted hours.[250]

Bensenville, Illinois

The Village Manager of Bensenville described persistent blocked crossings (at York Road, Center Street, Addison Street, and Church Street) because of a Class I railroad's yard operations. The official maintained that long trains are blocking more crossings concurrently, making it more difficult for drivers to find an alternate route.[251] The fire chief described impacts of long train operations, including the need to build a second fire station to improve response times. Today, when there are fire stations on both sides of the tracks, fire truck response times using

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[249] Trainfo, Inc., presentation to committee, November 2023.

[250] Mayor of Barrington, Illinois, June 15, 2023.

[251] Local officials from Bensenville, Illinois, June 16, 2023.

York Road are less than 4 minutes but previously, with a fire station on only one side of the tracks, being forced by blocked crossings to use Route 83 delayed units by 8 to 12 minutes.[252]

Bensenville is part of the Coalition of Nine Communities Opposed to the CPKC Merger that has documented the increased freight rail traffic and related impacts. Railroad actions in one community can spill into another. Several crossings in Franklin Park, Illinois, are routinely blocked by assembling or disassembling trains in the Canadian Pacific Kansas City Railway (CPKC) yard at Bensenville.[253] This is corroborated by cameras installed by local officials. In response to the coalition's concerns, the Surface Transportation Board (STB) required CPKC to report grade crossing blockages caused by increased traffic associated with the merger including in the Chicago area. To date, CPKC has reported no blockages in the area of Bensenville. However, this appears to be due to CPKC's reporting method, which excludes these tracks because they are used by CPKC trains but owned by Metra, the commuter rail agency. CPKC has not been reporting blockages on rail lines it does not own.[254]

Hammond, Indiana

In Hammond, Indiana, video recordings of students climbing between and under stopped freight rail cars to get to school garnered national attention. The trains, which can stretch across five or six intersections at a time in the working-class suburb of 77,000, routinely blocked the paths of students and teachers going to and from school.[255] After the media attention in April 2023, Norfolk Southern took action to address the situation,[256] but such actions proved to be temporary.[257]

New Berlin, Illinois

Railroads position trains awaiting room in a rail yard, blocking travel in the entire town sometimes for hours.[258] A business owner described how long trains parked at his private crossing, sometimes for days, have delayed shipments and prevented patrons from accessing his family business.[259]

East Dubuque, Illinois

Train operations have blocked numerous crossings for extended periods. This has affected farmers transporting loads of produce. In particular, trains blocking the one road into the

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[252] Fire Chief, Village of Bensenville, Illinois, June 16, 2023.

[253] Local officials from Bensenville, June 2023.

[254] Provisions in the CPKC merger include documenting blocked crossings and assigning a community liaison to facilitate communication between CPKC and Chicago Area Officials and members of the public.

[255] Sanders, T., et al. 2023. "As Rail Profits Soar, Blocked Crossings Force Kids to Crawl Under Trains to Get to School." *Propublica*, April 26. https://www.propublica.org/article/trains-crossing-blocked-kids-norfolk-southern.

[256] Sanders, T. 2023. "How Norfolk Sourthern Is Addressing Blocked Train Crissings in Hammond, Indiana." *Propublica*, August 25. https://www.propublica.org/article/how-norfolk-southern-is-addressing-blocked-train-crossings-hammond-indiana.

[257] Sterman, J., S. Smith, and T. Sanders. 2023. "New Video of Child Jumping from Moving Train Puts Spotlight Back on Blocked Crossings." WTOC, December 12. https://www.wtoc.com/2023/12/12/new-video-child-jumping-moving-train-puts-spotlight-back-blocked-crossings.

[258] The committee heard from local officials and farmers whose communities and businesses were impacted by blocked public and private crossings (New Berlin, Illinois, and East Dubuque, Iowa).

[259] Doug Danenberger, Danenberger Family Vineyard, New Berlin, Illinois, June 14, 2023.

Frentress Lake area prevent people from leaving to get to their jobs or entering to open their businesses and people have missed doctor appointments. In addition, the blocked crossing can cause a backup of vehicles all the way through the exit ramp and onto Highway 20, a major arterial. During a recent blockage, people crawled over a coupling and under a rail car. The issues stemmed from operational issues between Canadian National Railway (CN) and Burlington Northern Santa Fe Railway (BNSF).[260]

Brunswick, Maryland

In Brunswick, Maryland, a major Class I rail yard sits between the city and the Potomac River. The blocked crossing due to long train yard operations has delayed commuters accessing the MARC commuter train park-and-ride lot, people in vehicles and on foot from accessing the river park, and trucks from accessing a lumber yard.[261] The geography of the town makes grade separation impossible, and the railroad and local officials are still discussing a solution.

Federal Oversight

The federal government has long recognized its responsibility for ensuring safety at highway-rail grade crossings through funding infrastructure improvements and requiring states to develop grade crossing safety plans. Fatalities and injuries at highway-rail grade crossings have reduced approximately 60% from 425 fatalities in 2000 to 247 in 2023.[262] However, the federal government has not exercised its authority to enforce blocked crossings.

Historically, federal investments in grade crossings have focused almost exclusively on improving safety by reducing vehicle-train crashes and related fatalities and injuries. The Federal-Aid Road Act of 1916 provided federal funds to states for the construction of rural post roads.[263] Although federal aid funds could be spent on highway-rail grade crossings, early development of grade separations and active crossing warning devices were shared by the public sector and the railroads.[264] Federal programs dedicated to grade crossing safety began in 1935, and Congress authorized the first categorical funding program for crossing safety improvements in the 1973 Highway Act, with subsequent programs in 1978 and 1982 surface transportation authorizations. The Surface Transportation Assistance Act of 1987 established a federal grade crossing safety program permanently in statute.[265]

States use federal grade crossing safety funds to add passive and active grade crossing warning devices to grade crossings using risk-based allocation formulas and models. Federal and state grade crossing improvement projects take place on railroad right of way through agreements with applicable railroads, and railroads are generally responsible for maintenance of active crossing devices.

The U.S. Department of Transportation produced a Grade Crossing Safety Action Plan in 1994. A 2004 audit of the plan's results, requested by a member of Congress, found that "some

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[260] Don Zillig, Jo Daviess County Councilor, East Dubuque, Illinois, June 14, 2023.

[261] Julie Martorana, City Administrator, City of Brunswick, Maryland, May 2023.

[262] Operation Lifesaver. n.d. "Collisions & Casualties by Year." Updated June 6, 2024. https://oli.org/track-statistics/collisions-casualties-year.

[263] Appendix A in *Highway-Rail Grade Crossing Handbook*, 3rd Edition. FHWA Report FHWA-SA-18-040, FRA Report FRA-RRS-18-001, July 2019, p. 181.

[264] Ibid, p. 179.

[265] 23 U.S.C. § 130. Railway-Highway Crossing. https://www.law.cornell.edu/uscode/text/23/130.

states continued to have a large number of public grade crossing accidents" and recommended that the seven identified states "should develop an action plan that identifies specific solutions for improving safety at those crossings that continue to have accidents."[266] Subsequently, the Rail Safety Improvement Act of 2008 (RSIA) required that the 10 states with the highest number of grade crossing collisions over a 3-year period prepare State Action Plans to "identify specific solutions for improving safety at crossings, including highway-railway grade crossing closures or grade separations; focus on crossings that have experienced multiple accidents or that were at high risk for such accidents; and cover a period of five years."[267]

In 2012, the National Transportation Safety Board (NTSB) recommended that the Federal Highway Administration (FHWA) and FRA develop a model grade crossing action plan as a resource for states interested in producing an action plan similar to those required for the 10 states in the RSIA.[268] FRA and FHWA jointly developed the *Noteworthy Practices Guide: Highway-Railway Grade Crossing Action Plan and Project Prioritization* in 2016 to provide guidance for states to prepare highway-rail grade crossing state action plans. In 2015, the Fixing America's Surface Transportation Act required the remaining 40 states and the District of Columbia to develop state action plans.[269] The Infrastructure Investments and Jobs Act (2021) added the Railroad Grade Crossing Elimination Program, which is providing more than $500 million annually for 5 years in discretionary grant funding for eliminating grade crossings and providing grade separations. The first round of grants issued in June 2023 for fiscal year 2022 totaled more than $570 million to projects in 32 states.[270]

Limits on State and Local Interventions

Railroad operations that cause trains, moving or stopped, to occupy or block highway-rail grade crossings had been the subject of state and local regulation, but not federal oversight. However, recent court rulings have reaffirmed that only the federal government has oversight authority over blocked crossings.

In the past, state and local governments had the power to force or incentivize railroads to alter their operations or provide infrastructure to remedy blocked crossings. An example from the late 19th and early 20th centuries: many cities were able to require rail-roadway grade separations, paid for in part or entirely by the railroads.[271] In addition, many states had laws limiting the time that grade crossing could be blocked to 20 minutes,[272] and some states limited

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[266] U.S. Department of Transportation. 2004. "Report on the Audit of the Highway-Rail Grade Crossing Safety Program." Office of Inspector General Report No. MH-2004-065, June 16. https://www4.oig.dot.gov/sites/default/files/mh2004065.pdf.

[267] P.L. 110-432, Rail Safety Improvement Act of 2008, October 16, 2008. https://railroads.dot.gov/elibrary/public-law-110-432-rail-safety-improvement-act-2008.

[268] National Transportation Safety Board (NTSB). 2012. "Highway–Railroad Grade Crossing Collision, US Highway 95, Miriam, Nevada, June 24, 2011." Highway Accident Report NTSB/HAR-12/03, December 11. https://www.ntsb.gov/investigations/AccidentReports/Reports/HAR1203.pdf.

[269] FRA's State Highway-Rail Grade Crossing Action Plan (SAP) regulations can be found in 49 C.F.R. § 234.11.

[270] FRA. n.d. "Railroad Crossing Elimination Grant Program." Updated April 10, 2024. https://railroads.dot.gov/grants-loans/railroad-crossing-elimination-grant-program.

[271] Sennstrom, B.H. 2001. *Erie Lackawanna West End: Volume 1*. Avoca, NY: Erie Lackawanna Historical Society.

[272] McEowen, R.A. 2016. "How Long Can a Train Block a Crossing?" *Agricultural Law and Taxation BLOG*. LPB Network. https://lawprofessors.typepad.com/agriculturallaw/2018/11/how-long-can-a-train-block-a-crossing.html.

maximum blocked crossing time to 10 minutes.[273] Many local communities fined railroads for blocking road crossings according to specified lengths of time.[274]

Highway-rail crossings exist at the intersection of two different regulatory regimes. Passage of the Federal Railroad Safety Act of 1970 (FRSA) and the Interstate Commerce Commission Termination Act of 1995 (ICCTA) reaffirmed federal primacy over railroad regulation, which is based in the federal government's constitutional authority over interstate commerce.[275] Notably, The ICCTA applied only to railroad economic regulation rates, not to safety. Authority to regulate roadways, for the most part, belongs to state governments. Jurisdiction over most aspects of highway-rail grade crossings also falls with the states.[276] However, the courts have sided with the rail industry on blocked crossings and assigned authority to the federal government.[277]

Exclusive federal authority to regulate blocked crossings has been recently affirmed in *State of Ohio v. CSX Transportation, Inc*. The Ohio Revised Code states that no railroad may block a public street, road, or highway for longer than 5 minutes.[278] In 2018, CSX was charged with crossing blockage violations associated with moving trains in and out of the Honda auto plant near Marysville, Ohio. CSX contended that the FRSA and the ICCTA preempted Ohio law.[279] In 2022, the Ohio Supreme Court agreed with CSX, and ruled that "the regulation of railroad transportation is a matter of federal law, and the federal government alone has the power to address the threat to public safety caused by blocked crossings."[280]

The state of Ohio appealed this decision to the U.S. Supreme Court, and 19 states and the District of Columbia filed a legal brief in support of Ohio's position on the state's authority to regulate blocked crossings. The states wanted the Supreme Court to determine whether the STB has sole jurisdiction over regulating crossings. While the STB does not typically handle blocked crossings, the states argued that it is unclear based on past court cases who at the federal level has the authority to regulate blocked crossings.[281] On January 8, 2024, the Supreme Court declined to hear the Ohio case.[282]

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[273] Iowa Department of Transportation. 2023. "Railroad Rights-of-Way, Crossings, Tracks, and Fencing." § 327G.32. https://www.legis.iowa.gov/docs/ico/chapter/327G.32.pdf; Iowa & Nebraska Legislature. "Railroads; Blocking Crossings; Penalty." 17-225. https://nebraskalegislature.gov/laws/statutes.php?statute=17-225.

[274] Slaughter, K. 2005. "Runaway Train? Federal Preemption of State and Local Laws." University of Minnesota. https://conservancy.umn.edu/server/api/core/bitstreams/42a0f0de-cd7e-403e-81e1-b6106da0361f/content.

[275] Ibid.

[276] Within some states, responsibility of highway-rail crossings is divided between several public agencies. In other states, jurisdiction over highway-rail grade crossings is assigned to a regulatory agency such as the public utility commission, public service commission, or state corporation commission. FRA. 2021. *Compilation of State Laws and Regulations Affecting Highway-Rail Grade Crossings*, 7th Edition. https://railroads.dot.gov/sites/fra.dot.gov/files/2021-08/Compilation%20of%20State%20Laws-7th%20Edition.pdf.

[277] Gianvito, N. 1991. "Preemption Under the Federal Railway Safety Act: Death of a Plaintiff's Cause of Action." *Duquesne Law Review* 30.

[278] Ohio Revised Code § 5589.21. https://codes.ohio.gov/ohio-revised-code/section-5589.21.

[279] The *Ohio v. CSX* case presents two overlapping questions: (1) Does 49 U.S.C. § 101501(b) preempt state laws that regulate the amount of time a stopped train may block a grade crossing? (2) Does 49 U.S.C. § 20106(a)(2) save from preemption state laws that regulate the amount of time a stopped train may block a grade crossing?

[280] "State Cannot Enforce Law Against Trains Blocking Railroad Crossings." August 17, 2022. http://www.courtnewsohio.gov/cases/2022/SCO/0817/200608.asp.

[281] Ibid.

[282] Chism, L. 2024. "Justices Pass on Ohio Train-Crossing Law Despute." *LAW360*: Portfolio MNedia, Inc. https://www.shumaker.com/Templates/media/files/pdf/news/Justices%20Pass%20On%20Ohio%20Train-Crossing%20Law%20Dispute%20-%20Law360.pdf.

Search for Remedies

The community impacts of blocked crossings are a type of economic externality, whereby railroad companies' operating choices are levying additional costs on the communities through which their trains pass.[283] Without interventions that encourage or obligate the railroads to address community impacts, the railroads may have limited motivation to minimize blocking crossings. The current regulatory approach permits railroads to make decisions in their own best interest without regard to impacts on the affected communities.[284] Railroads monitor blocked crossings and provide grade crossing information for dispatchers; respond to concerns from communities; and train their engineers to minimize blocked crossings during railroad operations.[285]

Community solutions to blocked crossings include grade separations, road closures, and relocating community facilities. Grade separations are very expensive, only suitable to specific locations, disrupt areas around the ramps leading to and from the overpasses, and are often difficult or unattractive for pedestrians to use. Road closure trades an unpredictable disruption in travel patterns and access for a permanent and therefore predictable disruption, which will have its own community impacts. In addition, places where grade separations or road closures were an easy solution have probably already taken these steps. Relocating facilities such as firehouses or schools is another expensive solution that will have costs and other impacts on the affected communities.

The absence of network-level data from grade-crossing monitoring and reliance on anecdotal reports makes it difficult to assess trends in blocked crossings, including impacts from long trains. Inasmuch as frequent and lengthy blocked crossings are a general concern of railroad operations, such monitoring may be valuable for finding solutions to blockages that are especially problematic. In short, the committee cannot confirm whether a trend toward long trains is positively or negatively impacting the frequency and duration of blocked grade crossings. However, what is clear is that operating long trains is not necessarily a solution to blocked crossings and may be making the problem worse in some locations.

LONG TRAIN IMPACTS ON AMTRAK TRAINS AND SERVICE

As described above for yards and their arrival and departure tracks, long trains have outgrown some existing infrastructure on some mainline track. Like rail yards, many existing passing sidings were built in an era when trains were much shorter. Some Class I railroads have therefore made infrastructure improvements to accommodate long trains, and they assert that they plan to continue to make additional improvements in the future.[286] However, [recent examples of increased Amtrak delays suggest] infrastructure investments to lengthen sidings or add long sidings may not have kept pace with the increase in long trains. Infrastructure investments can take time, resulting in situations where long trains are being operated that cannot fit into passing sidings. Where train lengths exceed the existing infrastructure or track capacity, the operation of other trains can be negatively affected in ways discussed next.

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[283] Swan, P.F. 2011. "Market-Based Regulation of Freight Transportation: A Primer." *Tranportation Journal* 50(1).

[284] Class I railroad presentations to committee, March 2023

[285] Ibid.

[286] CPKC presentation to committee, April 2023. Harwell, J.A. 2023. "CPKC's Shreveport Dilemma." *Trains* 83:14–23.

Mainline Meets and Passes

Inadequate rail infrastructure for meets and passes with long trains can impact the operation of other trains. On mainlines, opposing direction trains must "meet" each other and for same direction trains traveling at different speeds or with different priorities the faster train must "pass" (or overtake) the slower train across the rail network. Meets between opposing trains are most readily handled on corridors with more than one main track (also referred to as "multiple track") where each track handles a predominant direction of traffic and even long trains can meet each other unimpeded.[287] Where multiple track sections are congested, however, it may be difficult for one train to overtake the other.

Approximately 70% of the North American mainline rail network consists of single-track operations.[288] Short sections of track known as "passing sidings" or "loops" are used to execute meets and passes. Because one train must stop in the passing siding while another train passes by on the mainline, in order to execute a meet or pass efficiently, at least one of the trains involved must be shorter than the clearance distance between the turnouts at either end of the passing sidings.[289] Thus, planning and coordination of these meets and passes at sidings of appropriate length for the trains involved is critical to maintaining the operational fluidity of single-track portions of the system. However, even on multiple-track line segments, long trains cause delay when they cross from one track to another due to speed restrictions and the length of the train that must pass through the speed restriction before the train can accelerate back to normal speed.[290]

Train dispatchers coordinate meets and passes by subdivision across the network and communicate requirements to train operating crews.[291] Because siding length by subdivision defines maximum practical train lengths for meeting other trains, railroads codify train length capability by route as part of the planning process. Most individual railroad subdivisions contain a range of passing siding lengths due to engineering constraints on siding length and the age of the siding; the target design length for passing sidings has increased over time so many legacy passing sidings do not have the capacity to store long trains.[292]

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[287] Sogin, S.L., Y.-C. (Rex) Lai, C.T. Dick, and C.P.L. Barkan. 2013. "Comparison of Capacity of Single- and Double-Track Rail Lines." *Transportation Research Record* 2374(1):111–118. https://doi.org/10.3141/2374-13.

[288] Association of American Railroads (AAR). 2007. *National Rail Freight Infrastructure Capacity and Investment Study*. Washington, DC: Association of American Railroads.

[289] Dick, C.T., I. Atanassov, F.B. Kippen, and D. Mussanov. 2019. "Relative Train Length and the Infrastructure Required to Mitigate Delays from Operating Combinations of Normal and Over-Length Freight Trains on Single-Track Railway Lines in North America." *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*. 233(7):731–742. https://doi.org/10.1177/0954409718809204.

[290] Stephens, B. 2023. "The Shortsighted View of Long Trains." *Trains* 83:8. https://www.trains.com/wp-content/uploads/2022/12/MAG-TRN-FEB23.pdf.

[291] Borraz-Sánchez, C., D. Klabjan, and A. Uygur. 2020. "An Approach for the Railway Multiterritory Dispatching Problem." *Transportation Science* 54(3):721–739. https://doi.org/10.1287/trsc.2019.0895.

[292] Dick, C.T., I. Atanassov, F.B. Kippen, and D. Mussanov. 2019. "Relative Train Length and the Infrastructure Required to Mitigate Delays from Operating Combinations of Normal and Over-Length Freight Trains on Single-Track Railway Lines in North America." *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit* 233(7):731–742. https://doi.org/10.1177/0954409718809204.

Long trains that exceed available siding lengths in a subdivision require managers and/or dispatchers to employ special techniques to operate trains. Known techniques include the following:[293,294]

- Running trains longer than passing sidings in one direction only.
- Fleeting trains so the entire subdivision is used by trains traveling in the same direction and by trains in the opposite direction when all opposing trains have cleared.
- Utilizing "saw-bys" and "shuffle moves," where long trains are broken into multiple pieces to facilitate passing.
- Timing the running of longer trains to minimize conflicts with other trains; and
- Forcing smaller trains (including passenger trains) to wait for longer trains to pass by while they wait in sidings.

A longer-term solution to one problem of operating longer trains is to expand passing sidings to better accommodate long trains. While this can be expensive, expanding selected sidings can provide significant relief. Atanassov and Dick[295] and Dick et al.[296] used simulation to investigate the operational impacts of overlength trains on single-track mainline corridors. For a constant volume of rail cars, the simulations determined the train delay arising from different combinations of long train length, percent of traffic carried in long trains, and percent of sidings along the corridor able to hold long trains. The general conclusions of these simulation experiments related to long train operations are as follows:

- Introducing even a small number of long trains on a corridor without any long sidings creates a significant amount of additional train delay that negatively impacts average train speed and shipment transit times. In such a scenario, the long trains effectively become prioritized and run across the corridor nonstop while short trains must wait in passing sidings for extended periods while a long train is traversing the corridor.
- When a small number of passing sidings are extended to handle long trains, the delays to shorter trains are somewhat mitigated. However, the long trains tend to spend additional time waiting in the few mid-route long sidings for meets with other long trains. Unless the timing of opposing long trains is carefully planned and executed, corridors with few long sidings lack operational flexibility and create large train delays.
- When additional sidings on a corridor are extended to handle long trains, overall train delay actually decreases relative to the baseline operations with short trains. Since fewer long trains than short trains are required to transport the same amount of traffic, operation of long trains reduces train count and requires fewer meets (and associated delays) along the corridor. When the corridor has a sufficient number of long sidings

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[293] Sogin, S.L., Y.-C. (Rex) Lai, C.T. Dick, and C.P.L. Barkan. 2013. "Comparison of Capacity of Single- and Double-Track Rail Lines." *Transportation Research Record* 2374(1):111–118. https://doi.org/10.3141/2374-13.

[294] ATDA presentation to committee, January 2023.

[295] Atanassov, I., and C.T. Dick. 2015. "Capacity of Single-Track Railway Lines with Short Sidings to Support Operation of Long Freight Trains." *Transportation Research Record* 2475:95–101. https://doi.org/10.3141/2475-12.

[296] Dick, C.T., I. Atanassov, F.B. Kippen, and D. Mussanov. 2019. "Relative Train Length and the Infrastructure Required to Mitigate Delays from Operating Combinations of Normal and Over-Length Freight Trains on Single-Track Railway Lines in North America." *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit* 233(7):731–742. https://doi.org/10.1177/0954409718809204.

to provide operational flexibility, long trains can reduce mainline train delay and improve mainline transit times.

- The exact number of long sidings required to mitigate the delay impacts of long trains is a function of the relative size of the short and long trains, and the traffic level along the corridor. In all simulated cases, it was not necessary to extend every passing siding along the corridor in order to handle long trains without increasing train delay. A number of short sidings can still remain, reducing the capital expense of introducing long train operations, and providing additional flexibility for meets with passenger trains or shorter local freight trains. Thus, train length is not governed by the shortest siding length along a corridor, but the predominant siding length along the corridor.

Passenger rail operations, especially Amtrak and certain commuter rail services, often share tracks with freight trains. Amtrak, as discussed below, differs from commuter railroads in that it was afforded dispatching preference on the tracks of host railroads. Under statute, Amtrak collects data on the extent of delays and which railroads are causing them. Amtrak officials attribute delays to long train operations and contend that delays have increased since 2018 and the advent of long trains.[297] Box 5-2 describes how long trains can impact commuter railroads, exemplified by Metra in Chicago.

BOX 5-2
Impacts on Commuter Railroads: The Case of Metra in Chicago

The Chicago metropolitan area is one of the busiest train hubs in the country for both freight and passenger rail. In addition to around 56 daily Amtrak trains in service,[298] Metra provides commuter rail service on more than 1,100 miles of track distributed over 11 main lines, 4 branch lines, and 242 stations. In 2019, before the pandemic's disruption to commuting, Metra trains completed more than 74 million passenger trips.[299] Like Amtrak but unlike other commuter rail services, Metra shares track with all Class I freight train operators. Also, like Amtrak, when Metra operates on track owned by other railroads (and vice versa), those host railroads control the dispatching of all trains on their lines. Unlike Amtrak's situation, gaining preference over freight trains can only be accomplished by commuter railroads through negotiated agreements with host railroads. Metra lines with shared track and therefore increased freight interference include the BNSF, UP-Northwest, UP-North, UP-West, North Central Service (on CN, CPKC, Metra), Southwest Service (on NS), Heritage Corridor (on CN), and Milwaukee District North (MD-N) and Milwaukee District West (MD-W) (CPKC trains on Metra, dispatched by CPKC) lines.[300]

When long manifest trains do not fit in the freight rail yards assembly and disassembly of these trains can spill out onto main lines, this can interfere with Metra operations.[301] However, the most significant source of interference with Metra's passenger rail operations is rail-rail crossings. Rail-rail crossings, of which there are 34 on Metra's service lines, require significant coordination and planning with the Class I railroads. Often called interlockings or

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[297] Jim Amtrak presentation to committee, February 2023.

[298] Amtrak presentation to committee, January 2024.

[299] Metra presentation to committee, February 22, 2023.

[300] Metra. n.d. "How Metra Handles Service Disruptions." https://metra.com/how-metra-handles-service-disruptions (accessed May 6, 2024).

[301] Metra presentation to committee, February 2023.

“diamonds” (for the shape of the intersecting rails),[302] the signals and switches are interconnected (“interlocked”) with one another so that it is impossible to route one train into the path of another. Only one train can occupy an interlocked route at a time. Similar to a traffic intersection of motor vehicles, there are only bi-directional green (or red) lights for one axis at a time. Because these rail-rail crossings are sometimes positioned close together, longer trains block multiple crossings. During the course of just one weekday, 662 passenger trains in 2023 contended with these cross-traffic points.

Amtrak Operations and Long Trains

Amtrak operates a nationwide intercity passenger rail network on more than 20,000 route-miles of rail lines owned by 30 host railroads[303] and on 924 route-miles owned or controlled by Amtrak. Host railroads make all dispatching decisions regarding which trains are allowed to go first and which trains must wait. However, in a return to relieving freight railroads of the common carrier obligation to provide passenger service more than 50 years ago, Congress gave Amtrak the right of dispatching preference over host freight transportation.[304] Despite its statutory preference, Amtrak experiences delays caused by freight trains and dispatching decisions made by host railroads. In 2022, freight trains caused more than 1 million minutes of delay to Amtrak passengers,[305] and for Amtrak trains operating on Class I host railroads during 2022, two-thirds (67%) of train delay minutes were because of freight railroad operations.[306] It is not known what percentage of such delays can be attributed to trains longer than 7,500 ft.

Amtrak’s Analysis of Delays

Amtrak operates trains on all six Class II railroads. The passenger railroad keeps records of its train delays and their proximate causes while operating on host railroads.[307] Amtrak provided its analyses of these delay data for its trains operating on host railroads for a period of 9 years, from 2014 through 2022. Amtrak identified 2018 as the year of transition to long freight trains and 2019 as the beginning of more long freight trains on routes where Amtrak operates. Accordingly, Amtrak used analysis periods of the 4 years (2014-2017) prior to the advent of long manifest

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[302] Ibid.

[303] Railroads other than Amtrak that own rail lines over which Amtrak trains operate are known as host railroads.

[304] Amtrak was given a statutory right of preference over freight transportation by Congress shortly after Amtrak was created in response to the many delays being incurred by Amtrak trains on host railroads; see 49 U.S.C. § 24308(c).

[305] Amtrak. n.d. “Amtrak Host Railroad Report Card: CY 2022.” https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/HostRailroadReports/Amtrak-2022-Host-Railroad-Report-Card.pdf. Host railroads performed slightly better in 2023, Amtrak. n.d. “CY 2023 Host Railroad Report Card & Route On-Time Performance.” https://www.amtrak.com/content/dam/projects/dotcom/english/public/documents/corporate/HostRailroadReports/Amtrak-2023-Host-Railroad-Report-Card.pdf.

[306] Amtrak Senior Host Railroad Specialist, January 9, 2024.

[307] Amtrak’s Electronic Delay Reporting (eDR) system records minutes of delay automatically using computers which note the time that Amtrak trains pass points along their routes. To ensure accuracy, these delay minutes and cause codings are shared with the host railroads at the end of the train’s journey (Jim Blair, Senior Host Railroad Specialist, January 9, 2024).

trains, a 1-year transition (2018), and 4 years after long trains had become prevalent (2019–2022).

Amtrak officials contend increases in train delays may be attributed to the increase in long freight trains during this study period. It is important to point out, however, that Amtrak does not define and record freight train length, so in most cases the trends in delays are coincidental to the increased use of longer freight trains. What follows then is Amtrak's analysis of delays and attribution to longer trains. Amtrak contends that increases in passenger train delays from freight trains experiencing issues such as broken knuckles, train repairing and recrewing, and meeting, passing, and routing conflicts are not just coincident with the increase in longer trains but adversely impacted by this development. Amtrak officials maintain that such delays can be a violation of Amtrak's statutory right of preference over freight transportation while using host railroad rail lines. However, Class I railroad representatives who briefed the committee contend that long train operations result in fewer freight trains and therefore will create fewer conflicts between passenger and freight trains. Amtrak officials maintain that they have not experienced this reduction in delays due to conflicts between passenger and freight trains.

While Amtrak attributes increased delays from multiple causes as being attributable to long train operations, absent data on train length and a uniform definition of what constitutes a "long" train, the validity of some of Amtrak's claims about the adverse impact of long trains cannot be thoroughly vetted. In the case of delays from conflicts during meets and passes, however, Amtrak's concerns are easier to support. Conflicts that arise between Amtrak trains and freight trains during meets and passes that are caused by passing sidings being too short for long trains is indicative of a railroad operating a freight train that is too long to fit in the existing sidings along the route. A host railroad that is aware of such a mismatch between the length of its freight trains and the infrastructure available on the route segment to accommodate meets and passes with Amtrak trains would seem to conflict with the passenger railroad's statutory right for dispatching preference. Data on delays from meets and passes, and how conflicts are sometimes addressed through "saw-by" and "shuffle" maneuvers, are discussed below.

Broken Knuckles

As discussed in Chapter 2, in-train forces can be exacerbated by long trains. These forces can rise to the level of breaking a knuckle in the couplers that hold adjacent cars of a train together. Total minutes of delay to Amtrak trains due to broken coupler knuckles on freight trains have increased more than 45% in the study period post-2018 versus the study period pre-2018. The average duration of a delay incident—when the Amtrak train waits for the freight train's broken knuckle to be repaired—has increased by more than 20% during the same study periods (see Table 5-1). Amtrak delay data on broken knuckles do not include train length. Therefore, broken knuckles could be attributed to short or long trains.

TABLE 5-1 Amtrak Delay, in Total Minutes and Average Minutes per Incident, Caused by Broken Knuckles on Freight Trains, 2014-2022

Year	Total Delays (minutes)	Delay Length (minutes)
Pre-2018	3,590	88
2018	3,900	92
Post-2018	5,261	107

SOURCE: Amtrak presentation to committee, February 23, 2023.

Repairing or Recrewing Stopped Freight Trains

Since long trains have been implemented on a widespread basis, delays to Amtrak trains due to repairing or recrewing freight trains have increased. These delays include freight crews reaching the maximum number of hours they are allowed to work under federal law. In these instances, the crew must be replaced ("rescued") by a fresh crew. This occurs at over-the-road locations, in addition to designated crew change locations at the end of subdivisions. In some cases, the freight train may block or delay the passage of other trains on the line, including Amtrak. The average delay per such occurrence experienced by Amtrak trains has increased from 39.1 minutes during the study period pre-2018 to 65.3 minutes during the study period post-2018 (see Table 5-2 and Figure 5-2). Much of the increase between the two study periods was caused by a spike in delay in 2022.

TABLE 5-2 Amtrak Delays Due to Freight Train Breakdown Recovery Time, 2014–2022

Year	Delays per Instance (minutes)
Pre-2018	39.1
2018	47.2
Post-2018	65.3

SOURCE: Amtrak presentation to committee, February 23, 2023.

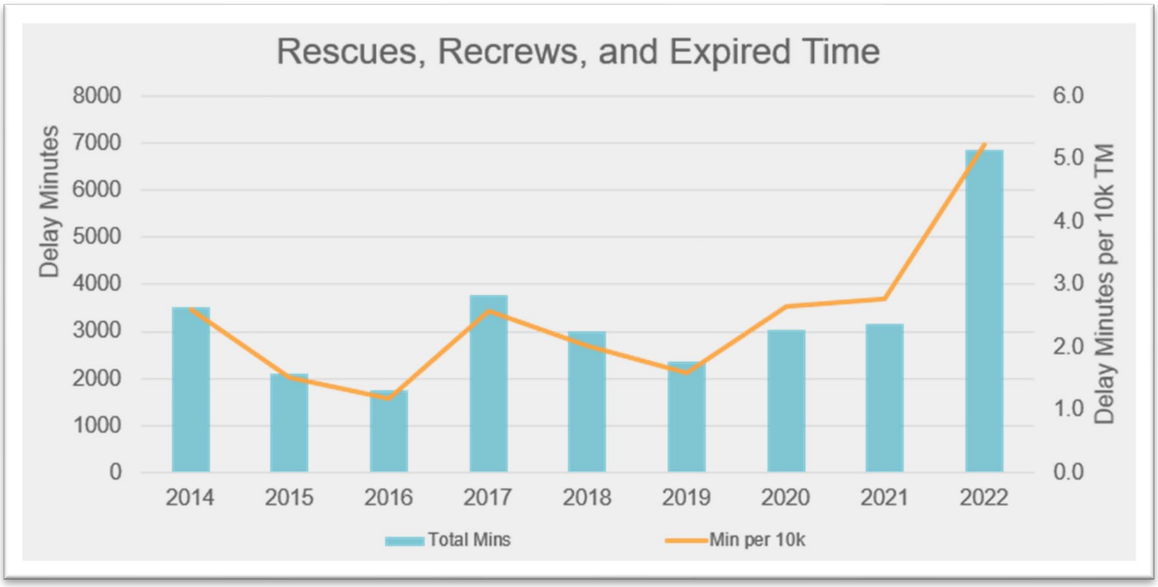

FIGURE 5-2 Freight train rescues, recrews, and expired time, 2014–2022.
SOURCE: Amtrak presentation to committee, February 23, 2023.

Meeting and Following Long Freight Trains

Long trains traveling slower for longer can compound delays for Amtrak trains caused by inadequate infrastructure for passing slower long trains. Long freight trains that do not fit in passing sidings can prevent an Amtrak train from passing a slower freight train until the freight train reaches a siding or yard with tracks long enough to accommodate it. It can take a long time before a long freight train can move out of the way of a following Amtrak train. Since 2015, Amtrak train delays from following long[308] freight trains nearly doubled, from an average of 32 minutes per 10,000 Amtrak train miles[309] during the study period pre-2018 to 61 minutes per 10,000 Amtrak train miles during the study period post-2018 (see Figure 5-3).

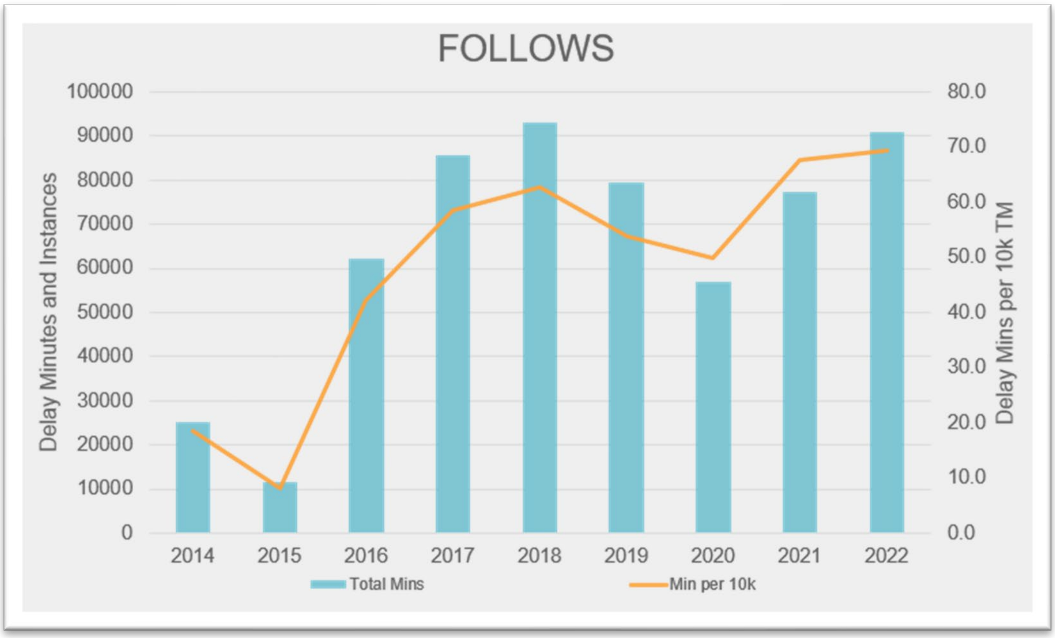

FIGURE 5-3 Amtrak delays due to following long freight trains, 2014–2022.
SOURCE: Amtrak presentation to committee, February 23, 2023.

In addition, long freight trains can require complex train meets, also known as "saw-by" or "shuffle" maneuvers, so that an Amtrak train can pass.[310] These complex maneuvers require Amtrak to stop while a freight train slows down and performs a reverse movement into a nearby siding or adjacent track. Figure 5-4 depicts Amtrak train delays during the study period due to such saw-by and shuffle moves, which shows a marked increase in total minutes of delay and minutes of delay per 10,000 train miles for the period of long trains.

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[308] Amtrak identified delays caused by "long" trains using applicable words and phrases as filters in their database (e.g., "non-fitter," "too long for siding," "no sidings long enough," "10k/12k/15k footer").

[309] To compare delay data across routes and host railroads, Amtrak often normalizes delay minutes per 10,000 train miles ("10K TM").

[310] Described more in Chapter 2.

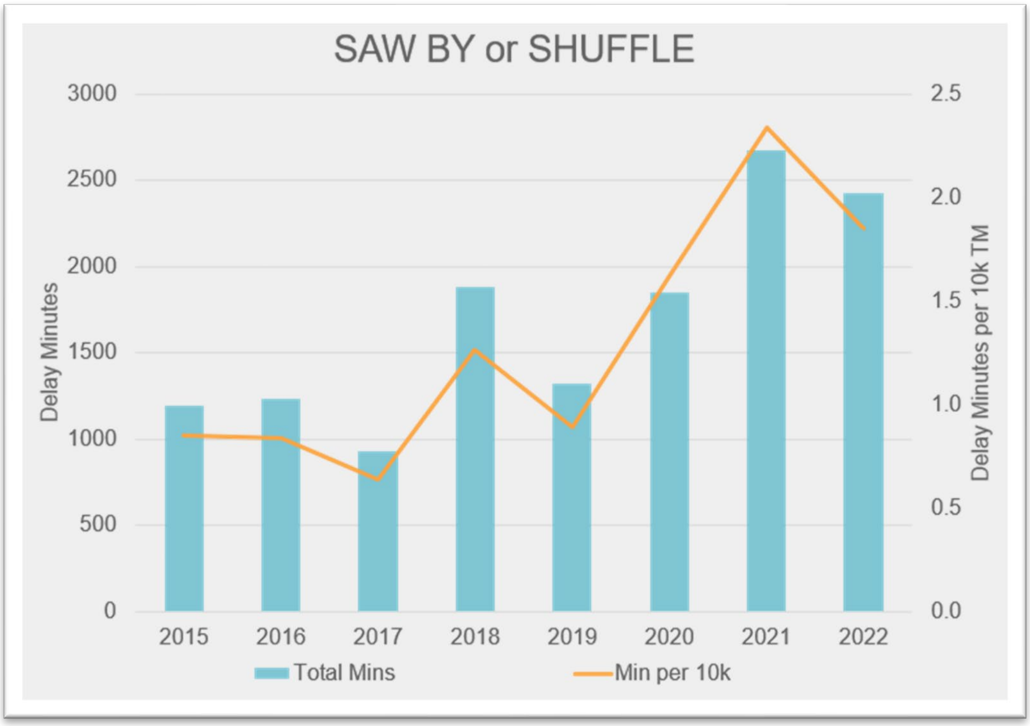

FIGURE 5-4 Amtrak delays due to saw-by or shuffle maneuvers, 2015–2022.
SOURCE: Presentation to committee, February 22, 2023.

Slower Routing of Amtrak Trains

In addition to not fitting in sidings, long trains may also not fit into freight train yards. In situations where a long freight train is holding the mainline outside a freight yard, the host railroad dispatcher may route an Amtrak train around the freight train by sending it through the freight yard. Freight yards are not designed for passenger trains and often include slow speeds, many switches, tight curves, and narrow spaces. Operating an Amtrak train through a yard requires more time than operating on the adjacent mainline, but the host dispatcher may judge that directing an Amtrak train past a long train by sending the passenger train through the freight yard is the lesser of evils. Average annual delay in minutes of Amtrak trains from operating through freight yards has increased from 4,179 minutes during the study period pre-2018 to 6,864 minutes during the study period post-2018 (see Table 5-3).

TABLE 5-3 Amtrak Delays Due to Slower Routing through Yards, 2014-2022

Year	Total Delays (minutes)	Delay Length (minutes)
Pre-2018	4,179	11
2018	4,091	15
Post-2018	6,864	17

SOURCE: Amtrak presentation to committee, February 23, 2023.

6

Environmental Impacts

This chapter reviews the railroad industry's contention that long trains reduce fuel consumption and therefore greenhouse gas (GHG) emissions and describes the limitations of current research on the matter. The chapter then covers potential increases in motor vehicle emissions, building on the analysis of highway-rail grade crossings in Chapter 5. The chapter closes with a brief discussion of changes in freight rail service and the likelihood of a shift in freight to or from trucks.

Potential environmental benefits of long trains are based on their ability to reduce the industry's consumption of diesel fuel by reducing the number of trains. However, it is possible that long trains have indirect effects that worsen environmental conditions by increasing the pollutants emitted from motor vehicles if, for instance, long trains increase motor vehicle congestion and disrupt travel at highway-rail grade crossings or if changes in rail service patterns associated with long trains encourage shifts of freight to trucks. Conversely, if long trains reduce crossing blockage and increase rail efficiency to lower shipping rates (such that freight is attracted from trucks), the net result could be reduction in fuel use and emissions.

LONG TRAINS AND LOCOMOTIVE FUEL CONSUMPTION

Rail transport, whether for passengers or freight, is one of the most fuel-efficient and therefore climate-friendly transport modes, producing only 2% of the U.S. transportation sector's greenhouse gas emissions in 2022. GHG emissions from the rail sector have also been decreasing, falling 16% between 2018 and 2022.[311] The Class I railroads maintain that operating longer trains reduces fuel burn and therefore reduces GHG emissions.[312] While railroads have substantially increased fuel efficiency, the role of long trains in the reduction of fuel consumed is not clear.

Industry Position on Train Size and Fuel Consumption

To support the position that running longer trains reduces fuel usage and thus GHG emissions, two railroads presented analysis based on their own operations. One railroad used a Fuel Burn Report in which fuel efficiency was calculated based on the impact of a train with a restricted length of 7,500 feet.[313] The estimated increased fuel use from running longer trains amounted to 22%. Given that running trains with less horsepower per gross ton-mile is proven to reduce fuel

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[311] EPA (U.S. Environmental Protection Agency). 2024. "Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions 1990–2022." EPA-420-F-24-022. May. https://www.epa.gov/system/files/documents/2024-05/420f24022.pdf.

[312] Class I presentations to the committee, January, March, and April 2023.

[313] Norfolk Southern used 70-day waybills from November 22, 2020, to January 30, 2021, and an Operating Plan Developer (OPD) tool to conduct the analysis.

burn,[314] the 22% increase appears to come more from reduced horsepower per gross-ton. Another railroad presented a study comparing winter operations using shorter trains to operations over the rest of the year using longer trains.

LONG TRAINS AND MOTOR VEHICLE EMMISIONS

If long trains do affect the frequency and duration of highway-rail grade crossing blockages, they can have an indirect effect on the air pollution emitted from motor vehicles.[315] Cars and trucks increase their GHG emissions when they idle while waiting for a crossing and any associated motor vehicle congestion to clear. GHG emissions may also increase if motor vehicles travel farther to avoid a grade crossing or if people switch from walking to biking to an automobile because blocked crossings disrupt the pedestrian or bicycle network. Other pollutants, such as particulate matter and nitrogen oxides, can also be associated with increased motor vehicle fuel consumption.[316]

As described in Chapter 4, the railroads maintain that long trains reduce the frequency and total daily duration of blocked crossings, but there are no publicly available data to confirm this claim. In addition, the impact of long trains on blocked crossings and motor vehicle congestion will be location specific. Therefore, it is possible that long trains may reduce motor vehicle congestion, idling, and emissions for one railroad,[317] but the opposite may be the case for another railroad. For example, in a study of the environmental impacts of constructing grade separations at highway-rail crossings, Caltrans analyzed 18 crossings and found that a grade separation would reduce the annual metric tons of carbon dioxide emitted by motor vehicles from, depending on the crossing, 107 to 5,059 tons.[318]

Impacts on motor vehicle emissions can also happen when railroads shift the location of operations or utilize infrastructure differently. Concentrating activity in one location or shifting it away from a location that already suffers from motor vehicle congestion will also have localized impacts on motor vehicle emissions.[319] A study of the environmental impacts of the merger that formed CPKC found increased rail traffic would also increase motor vehicle emissions from idled vehicles at blocked crossings and from increased local truck traffic accessing the rail terminal.[320]

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[314] Cetinich, J. 1975. *Fuel Efficiency Improvement in Rail Freight Transportation: United States*. Federal Railroad Administration.

[315] Ibid.

[316] California Air Resources Board. 2020. “Truck Versus Train Emission Analysis.” September 23. https://ww2.arb.ca.gov/resources/fact-sheets/truck-vs-train-emissions-analysis.

[317] Norfolk Southern presentation to committee, January 20, 2023.

[318] Caltrans. 2016. “Railroad Grade Crossings Report to the Legislature.” https://dot.ca.gov/-/media/dot-media/programs/legislative-affairs/documents/railroad-grade-crossing-evaluation-report-v9-6-14-2016-a11y.pdf. Analysis assumptions included the following: Passenger trains are 700 ft, freight trains are 5,000 ft, freight speed is 15 mph, frequency between 5 a.m. and 11 p.m. was evenly distributed, gates are in down position 30 seconds before and 10 seconds after trains clear the crossing, used current passenger timetables.

[319] See, for example, AECOM. 2015. “Technical Memorandum: Benefit Cost Analysis of the Willmar Rail Connector and Industrial Access Project.” May 28. https://www.dot.state.mn.us/ofrw/willmar/15docs/04BCATechM.pdf.

[320] Surface Transportation Board (STB). 2023. “STB Issues Final Environmental Impact Statement for Proposed CP/KCS Merger.” January 27. https://www.stb.gov/news-communications/latest-news/pr-23-02.

LONG TRAINS AND FREIGHT MOVED BY TRUCK

According to the Association of American Railroads (AAR), transporting freight by rail instead of truck reduces GHG emissions by up to 75%.[321] Therefore, it is important to ascertain whether the Class I railroads are operating in a way to encourage or discourage freight traffic to shift from truck to rail. The evidence is mixed.

The 2023 merger of CP and KCS to create CPKC could result in an overall decrease in emissions due to the expected diversion of freight from truck to rail transportation and the resulting removal of projected 64,000 trucks per year from the highways.[322] Despite increases in emissions from blocked highway-rail grade crossings and local truck traffic accessing rail terminals, STB concluded that the merger would result in a net reduction in emissions.[323]

On the other hand, since 2019 and the advent of long trains and Precision Scheduled Railroading, STB has intervened twice to require the Class II railroads to meet their common carrier obligations.[324] There have also been concerns that the Class I railroads are reducing service.[325] In addition, moving freight by long train implies reduced service frequency, because certain locations will receive fewer trains per day or week.

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[321] AAR. n.d. “Freight Rail & Climate Change.” Updated February 2024. https://www.aar.org/wp-content/uploads/2023/06/AAR-Climate-Change-Fact-Sheet.pdf.

[322] STB. 2023. “STB Issues Final Environmental Impact Statement for Proposed CP/KCS Merger.” January 27. https://www.stb.gov/news-communications/latest-news/pr-23-02.

[323] Ibid.

[324] STB. 2022. “STB Continues Emergency Service Period for Foster Farms; Directs Service Commitments and Reporting.” July 1. https://www.stb.gov/news-communications/latest-news/pr-22-35; STB. 2023. “STB Grants Preliminary Injunction; Orders BNSF Railway Company to Transport 4.2 Million Tons of Coal for Navajo Transitional Energy Company, LLC.” June 23. https://www.stb.gov/news-communications/latest-news/pr-23-11.

[325] STB. 2019. “Oversight Hearing on Demurrage and Accessorial Charges.” Docket No. EP 754 (Day 1). Washington, DC: Surface Transportation Board. https://www.stb.gov/audio-meeting/oversight-hearing-on-demurrage-and-accessorial-charges-docket-no-ep-754-day-1; STB. 2019b. “Oversight Hearing on Demurrage and Accessorial Charges.” Docket No. EP 754 (Day 2). Washington, DC: Surface Transportation Board. https://www.stb.gov/audio-meeting/oversight-hearing-on-demurrage-and-accessorial-charges-docket-no-ep-754-day-2.

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Summary Assessment and Recommendations

In response to a congressional mandate, this report examines the potential safety risks from the operation of freight trains longer than 7,500 ft relative to the operation of shorter freight trains. Safety issues that are called out for study include the potential for derailments and other safety-related incidents associated with in-train forces, the performance and distribution of locomotives, train braking capabilities, and crew performance and human factor issues. Other safety issues identified are the potential for loss of communication between the end-of-train device and the locomotive cab and among crew members reliant on radio systems as trains become longer and encounter differing terrains. In considering these safety issues and how they can be eliminated or controlled, the committee is charged with examining the role of locomotive electronics, signal systems, the placement of rail cars and locomotives in the train, and how crew members are trained and otherwise prepared to operate long trains. Additionally, the committee is asked to examine the impacts of increasing train length on the frequency and duration of highway-rail grade crossing blockages, the scheduling and efficient operations of passenger trains and freight trains, and greenhouse gas emissions. If supported by the study findings, the committee is asked to make recommendations, including to Congress and the Federal Railroad Administration (FRA), on steps needed to better understand and reduce any adverse effects of long trains.

In contemplating the study charge and how best to fulfill it, the study committee had to make several decisions, including about the meaning of terms in the charge and how to orient the study toward salient public policy interests. Because the impacts from freight trains do not change abruptly when a train reaches or drops below 7,500 ft in length, the committee decided that this train length—equivalent to about 1.5 miles—was specified to signify an interest in the upper portion of the train length range, rather than to define a "long" train precisely. Furthermore, because train length is associated with changes in other variables, such as train weight (i.e., trailing tonnage) and configuration of cars within a train (i.e., train makeup)—and that these variables themselves will depend on train type (e.g., manifest, unit)—the committee recognized the importance of examining train length in the context of train types and by considering characteristics in addition to length.

The committee also wanted its report and recommendations to be relevant by addressing the most pressing public policy issues. In this regard, it is important to emphasize that current policy interests pertaining to long trains stem largely from recent trends within the rail industry to build and operate increasingly longer *manifest* trains, which haul a mix of freight in many different types of rail cars (some loaded and some empty), as opposed to *unit* trains, which consist of cars having similar designs and weights (usually all are loaded or all are empty). The committee's analysis of train derailment data suggested that longer manifest trains are creating new handling and operational challenges for railroads that warrant a closer examination of industry practices and public policies to address them.

Regarding long manifest trains, four specific impacts are called out in the study charge: (1) safe operations, (2) highway-rail grade crossing blockages, (3) efficient passenger and freight train operations, and (4) greenhouse gas emissions. Here too, the committee had to make some distinctions to ensure the study's policy relevance. Safety is a foremost public concern, and thus treated extensively in the report from the standpoint of train handling and operational challenges that can arise from increasing train length, the procedures and technologies used to manage them, and implications on crew performance and training requirements. Likewise, the report gives significant attention to highway-rail grade crossings, where trains of all lengths have a direct impact on the public when they block roads to impede motor vehicle and pedestrian movements. Greenhouse gas (GHG) emissions are a major public policy concern, but on a national scale freight trains are not intense emitters of these pollutants. The committee concluded that to estimate marginal emissions impacts from longer trains would require many uncertain assumptions about whether and by how much long freight trains are replacing shorter trains or diverting freight to or from trucks and other modes. Finally, there are secondary emissions effects caused by motor vehicles emitting GHGs when backed up behind blocked crossings. Given these complexities and uncertainties, and the low rate of GHG emissions from freight trains compared to other modes of freight transportation, this impact area is not treated to the same degree as other impacts in this report.

The report also gives varying treatment to the impacts of long manifest trains on the scheduling and operational efficiency of passenger trains and freight trains. The report pays the most attention to impacts on passenger trains operated by Amtrak. Many of Amtrak's intercity passenger trains operate over the track of other railroads (called "host railroads") that were relieved of their common carrier obligation to provide passenger service when Amtrak was created.[326] Federal statute grants Amtrak trains dispatching preference over a host railroad's trains,[327] and thus if conflicts arise due to the increasing length of freight trains, this can be a clear public policy matter. By comparison, local and regional commuter passenger railroads negotiate track use terms with their host railroads and must therefore address operational issues related to long trains through these negotiations. Because the public policy leverage in this instance is limited, especially at the federal level, this report focuses primarily on the impacts of long trains on Amtrak's services.

Likewise, only limited attention is given to the impacts of long manifest trains on the operations of the freight railroad themselves and the shippers that use their service. Freight railroads must account directly for the operational impacts of the choices they make about when and how to use long trains. Some of these operational impacts are described, such as on car cycle times; however, the committee is not in a position to judge the advisability of these choices or to assess ultimate impacts on shippers, especially without knowing how privately negotiated shipping rates and service contracts are affected by the use of longer trains.

The committee's assessment, therefore, focuses on long manifest trains and concentrates on impacts on rail safety, the functioning of highway-rail grade crossings, and Amtrak passenger train service. The following is a synopsis of the report's assessments for each impact area. Recommendations are offered on actions to address impacts the committee believes would benefit most from policy interventions.

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[326] Rail Passenger Service Act of 1970, P.L. 91-518. The Act authorized Amtrak to assume by contract the intercity rail passenger service obligations of railroads who wished to be relieved of these obligations as common carriers.

[327] P.L. 93-146, § 10(2), 87 Stat. 548.

LONGER MANIFEST TRAINS CAN CREATE NEW AND HEIGHTENED SAFETY RISKS REQUIRING ACTIVE CONTROL

As the length of a manifest train increases, safe handling can be more challenging to manage relative to the handling of a shorter manifest train or a unit train (a train consisting of the same general car types) of comparable length. As a general matter, manifest trains create operational challenges due to the mixture of rail car types, designs, sizes, and weights. All rail cars in a train are subject to longitudinal forces that create draft and buff load conditions and to lateral forces, especially at curves. These in-train forces can lead to broken equipment, including drawbars and couplers, and cause the wheels of a car to leave the Rail when negotiating curves. The magnitude of these forces will differ among cars that vary in size and weight, and the movement and mitigation of the forces will differ among cars having different drawbars and coupling devices with or without cushioning units.

Railroads must therefore pay close attention during the makeup of manifest to the placement of cars of different types, sizes and weights to manage in-train forces, reduce risks of derailments and to preserve train integrity. In particular, they must make choices about the placement of light cars, short cars, heavy cars, and cars with and without cushioning devices to facilitate safe handling as well as efficient operations. They must also pay attention to the placement of locomotives for distributed power (DP), as these units can help control in-train forces through adjustments to power and activation of air brakes and dynamic brakes, or they can add to the operational challenge if poorly positioned.

As the length of a manifest train increases, so too will the complexity of accounting for these longitudinal and lateral forces through train makeup decisions. Longer trains have more cars, possibly a greater variety of car types and sizes, and more requirements for power distributed across the train in comparison with shorter manifest trains. Moreover, the rail cars in a long train can be experiencing a wider range of grade and curvature conditions as the train spans more terrain. As a practical matter too, long trains can create more challenges for proper train makeup because they are so long and are constructed from blocks of rail cars that are switched to and from other trains and yards enroute. The placement of these blocks requires planning and can take time to execute. While assembling shorter trains also takes planning and time, assembling long trains can present additional challenges and opportunities for errors in car placement due to limited yard space, insufficient track lengths, and added demands on labor.

Regarding train makeup, each railroad has its own placement rules that apply to manifest trains. FRA and Transport Canada do not prescribe train makeup practices or monitor and assess each railroad’s rules and their consistent application. Guidance for marshalling trains across the North American railroad industry is contained in the Association of American Railroads (AAR) Train Make Up Manual published in 1992[328] and the Marshalling Guidelines for Safe Operation of Freight Trains published by Transport Canada in 2016.[329] The AAR Train Makeup Manual was one of the first industrywide train makeup manuals that was written to help railroads manage in-train forces through the control of trailing tonnage, the use of head-end and DP locomotives, and the proper placement of critical car combinations in the train. The Transport Canada

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[328] Association of American Railroads (AAR). 1992. “Train Make-Up Manual.” Report No. R-802. Chicago: AAR Technical Center.

[329] Transport Canada. 2016. “Marshalling Guidelines for the Safe Operation of Freight Trains.” https://tc.canada.ca/en/rail-transportation/publications/marshalling-guidelines-safe-operation-freight-trains.

marshalling guidelines improved and expanded upon the trailing tonnage method of AAR's Train Makeup Manual, by providing more robust in-train force limits.

Train makeup decisions and train length must be made with ample consideration of the capabilities and performance of the crews that operate the trains. To this end, railroads have introduced engineer-assist systems to control trains by calculating the best operating profile for both lead and DP locomotives, while considering factors such as the route's grade and curvature and the train's length, weight, and composition. The availability of these engineer-assist systems, however, does not reduce the importance of crew readiness and performance in managing the handling requirements of long manifest trains in the varied environments and territories in which they are being used. Yardmaster and dispatchers must also account for these handling challenges when constructing and routing trains.

The operational demands of long manifest trains, therefore, require a combination of responses by railroads that includes well-designed and consistently applied train makeup rules, the deployment of appropriate technology (e.g., DP units, brakes, engineer-assist programs), and assurance of crew readiness and competency. To assess railroad claims about the effectiveness of the responses, aid in its examination of the safety outcomes of these responses the committee examined FRA accident records, which contain causal information that can be used to observe trends in derailment from the kinds of train handling and equipment issues characteristic of in-train forces not being adequately controlled. Having observed an increase in the rate of occurrence of these types of derailments, the committee asked the Class I railroads, through AAR, to provide data on their train operations with sufficient detail to ascertain train type and length for the purpose of more granular assessments of the derailment records. However, restrictive conditions on the data's availability and use, including a high degree of data aggregation, and preapproval of the analytic methods to be used, foreclosed this option. Nevertheless, a review of publicly available data on train traffic indicates that the average length of manifest trains has been increasing coincidental with an increase in the rate of derailments of interest. Absent more detailed data, the committee was not able to verify that the operational demands created by longer manifest trains are being fully controlled, and indeed the limited analyses that could be performed suggest that more targeted safety assurance measures may be needed.

The report also documents the committee's consultations with railroad employees, who raised concerns about the amount and quality of training they receive for safely operating long manifest trains and about the challenges they face assembling the trains correctly. Concerns included the problems crew members can face maintaining communications with one another while maneuvering long trains at yards and during train inspections and repairs, which take more time to perform as train length increases. The potential for error from crew member miscommunication and fatigue was also raised as a concern when the time to walk the train increases.

Risk Reduction Programs Should Target Long Train Risks

The need for railroads to address new and heightened operational challenges created by long manifest trains through systematic, multifaceted means reinforces the importance of provisions in the Rail Safety Improvement Act of 2008 that require Class I railroads to develop and faithfully implement Risk Reduction Programs (RRPs). Specifically, the act requires that each railroad establish an RRP that "systematically evaluates railroad safety risks on its system and manages those risks in order to reduce the numbers and rates of railroad accidents, incidents, injuries, and fatalities." As written in the legislation, the provision is suggestive of congressional interest in railroads instituting the kind of safety management systems (SMSs) that are now used widely to ensure high levels of safety in numerous other transportation industries, including aviation, passenger rail, and pipelines.

In fulfillment of this legislative requirement, FRA issued a final rule in 2020 requiring Class I railroads to institute RRPs but in a "streamlined" fashion that does not include many of the components typical of an SMS.[330] According to the rule, an RRP is acceptable if it concentrates on managing risks arising from changes in (1) operating rules, (2) the implementation of new technology, and (3) reductions in crew staffing levels. Notably, the rule does not require a railroad to preemptively address a major change to its operations in an explicit and deliberate manner by identifying the associated hazards, analyzing the potential risks arising from those hazards, and evaluating and explaining how the risks will be managed. Consequently, whether and how railroads are identifying and controlling the hazards and risks arising from their decisions to use long manifest trains is unclear and difficult to ascertain because each railroad's RRP is proprietary. While the Railroad Safety Improvement Act requires railroads to submit the RRPs to FRA for approval, the agency interprets the law's provisions to imply that railroads must demonstrate that they have a written plan with the requisite minimum elements; however, FRA does not verify the quality and thoroughness of the RRP's evaluations, analyses, and promised mitigation actions. In summary, the RRP rule was written to allow "streamlined" safety management systems that do not obligate railroads to anticipate and account for risks arising from all major planned operational changes, including the expanded use of longer manifest trains.

In the committee's view, the heightened operational challenges and risks from increasing the length of manifest trains, need to be recognized and addressed in a deliberate and systematic manner. A high-quality RRP should be expected to explain, among other things, the train makeup protocols that will be employed; the skills, readiness levels, and competencies required for crew members and how they will be met through means such as scheduling and training; and how technologies will be deployed (e.g., DP units, brakes, radio systems, engineer-assist programs) and verified for effectiveness. In turn, FRA should be expected to confirm that each railroad's Risk Reduction Program does indeed cover such interests, is well reasoned and well justified, and is being faithfully followed and evaluated regularly for effectiveness.

To rectify this problematic shortcoming in the RRP rule, and to ensure that railroads are indeed being proactive in their treatment of the risks from longer trains, the committee recommends the following.

Recommendation 1: The Federal Railroad Administration should revise the Risk Reduction Program (RRP) rule to require railroads to address all major operational changes in their RRPs in an explicit and comprehensive manner. Current RRP requirements do not obligate railroads to address planned operational changes that can affect safety. To the contrary, railroads should be required—consistent with the principals of safety management systems—to identify and analyze the risks associated with all planned significant operational changes and to explain and justify the procedural, technological, and human-systems means that will be used to eliminate or reduce the risks.

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[330] *Federal Register* 85(32), February 18, 2020.

Recommendation 1a: The revisions to the RRP rule should be written in such a way as to make it clear to railroads that an operational change that is known to increase and add new train integrity and handling challenges, as lengthening manifest trains can do, constitutes an operational change that should be addressed in an RRP. Compliant railroads should be expected to have an RRP that is thorough in describing any operational and handling challenges, assessing their safety risks, explaining how the risks will be managed through procedural and technological means, and describing how those risk reduction means will be monitored and assessed for effectiveness.

Recommendation 1b: The Federal Railroad Administration (FRA) should seek from Congress the resources required to hire and train a team of auditors skilled in reviewing safety management systems to regularly and critically assess the completeness and quality of each railroad's Risk Reduction Program (RRP) and its key components. The auditors in turn should enlist FRA inspectors to verify that a railroad's risk reduction measures are implemented in the field. For trains whose length creates new and increased operational and handling challenges, the FRA auditors and safety inspectors should expect to find that compliant railroads, at a minimum, have:

- **Train makeup rules and procedures for implementing them that are well justified and informed by best practices applicable to train types and a range of operating conditions and terrains encountered.**
- **Descriptions of the technologies to be deployed to control operational risks, including the use of distributed power, engineer-assist programs, and braking systems, and explanations of how their effectiveness will be monitored and evaluated.**
- **Assessments of the skills and competencies needed by crew members to perform safely when encountering the operational and handling challenges and how these needs will be met through crew training programs and other means.**
- **Explanations of any other challenges that added train length can create and that could have a bearing on safety, such as from the added work and complexity of train assembly and disassembly, added inspection times, and maintaining crew radio communications. Measures to address these safety-related challenges should be described and justified.**

The committee recognizes that individual railroads will differ in the particulars of the operational challenges and risks they face when increasing the length of trains due in part to differences in operating conditions and environments. As a result, the specific measures used by railroads to mitigate risks, as documented in their RRPs, are likely to vary. Indeed, the safety challenges introduced by longer trains are exemplary of why Congress called for a rule requiring RRPs, which can be used by FRA to ensure that railroads are addressing safety risks in a deliberate, proactive, and systematic manner, and not just following the minimum requirements in regulation.

FRA auditors will be responsible for critically reviewing the programs and plans to ensure they are well developed and well justified, consistently executed, and regularly evaluated for effectiveness; the plans should not be paper exercises implemented in a "check-the-box" manner. Through learning and experience, railroads should be expected to evolve their RRPs with risk reduction measures that are increasingly effective. It will also take time and learning for auditors to develop the knowledge and competencies required to fulfill their responsibilities for critical verification.

Recommendation 1c: To aid railroads in the development of increasingly effective measures for reducing risks associated with long trains and to aid auditors in obtaining the requisite knowledge for critically assessing a railroad's risk reduction measures and their justifications, the Federal Railroad Administration should survey and synthesize industry protocols and best practices on train makeup, crew training, and communications capabilities pertinent to addressing the operational and handling challenges arising from increases in train length under different operating and environmental conditions.

For the reasons given above, it is the committee's view that when any change in railroad operations, such as increasing train length, creates new or heightened challenges for safety assurance, railroads should be required to assess those challenges and respond to them in a manner that is well reasoned and well documented in an RPP verified by FRA. While some of those responses, such as establishing train makeup rules, may not be subject to the requirements of a specific FRA safety regulation, many of them will. FRA has requirements for crew training and for radio communications among crew members that are intended to be sufficiently robust to address a range of safety assurance challenges. Their applicability and robustness, however, cannot be taken as a given and should be periodically reviewed to determine if modifications are warranted to address changes in railroad operations, practices, and technologies that are introduced abruptly and that also accumulate over time.

Crew Training and Radio Communications Practices Should Support the Safe Operations of Long Trains

The evidence in this report about the added challenges that train crews face when operating and handling manifest trains as they increase in length, including difficulties maintaining radio communications while inspecting and riding equipment, suggest that the time is right for FRA to take a closer look at the coverage and adequacy of the regulations, FRA standards, AAR guidance, and railroad operating procedures and practices for crew training and radio communications. With these interests in mind, the committee recommends the following.

Recommendation 2: The Federal Railroad Administration should stand up separate working groups under the Railroad Safety Advisory Committee that are tasked with evaluating and providing advice on the following:

- **2a. Methods and technologies that can be implemented to improve the capabilities, competencies, and training that train crews and other railroad employees require for the safe operation, assembly, and inspection of trains as they become longer; and**
- **2b. Technological means and performance standards for ensuring that train crew members have the capability to communicate, including while inspecting and riding equipment, in a manner that can be continuously maintained and does not create personal safety hazards.**

As is typical of Railroad Safety Advisory Committee (RSAC) activities, the working groups should include representatives from railroads and labor organizations and have other members who possess the appropriate technical expertise and representation of interests needed for objective and thorough evaluations that can support consensus advice to FRA and industry about regulations, standards, and guidance. When evaluating crew competency and training requirements for safely managing the operational challenges associated with increasing train length, the working group should consider, for instance, whether existing training standards, guidance, and practices are sufficient for scenarios involving the handling of long trains, taking into account considerations such as variabilities in terrain and track geometries, in-train forces arising from different train makeups, and conditions that can create and occur during emergencies. A review of how visual- and motion-based simulator technologies could provide additional realism for training could be part of this effort, informed by their uses in other domains such as aviation and maritime transportation. Likewise, it would behoove the working group on radio communications to evaluate the adequacy of existing regulations, standards, technologies, and practices for ensuring uninterrupted radio communications among crew members operating long trains under different contexts and to consider options for addressing any inadequacies through enhancements in practice and technologies.

RSAC working groups will often recommend changes to FRA regulations and industry standards. While such advice may be forthcoming from the RSAC activities recommended here, the results from the evaluations should inform railroads directly as they address the challenges of long trains in their RRPs.

COMMUNITIES EXPERIENCING CHRONIC BLOCKED HIGHWAY-RAIL GRADE CROSSINGS NEED REAL SOLUTIONS

Trains frequently block pedestrian and motor vehicle traffic as they travel through, and sometimes stand idle in, highway-rail grade crossings. To the extent that the trend toward longer freight trains leads to fewer trains in the aggregate, one would expect potentially fewer blocked crossings. However, a transiting longer train will block a single crossing for a longer period than a shorter train and is more likely to block multiple crossings at the same time. Train transit times through crossings may be slowed further by speed restrictions that all freight trains must abide by but that will impact long trains over a greater distance and for a longer time. It is not clear whether a long train is more likely than a short train to be stationary on a grade crossing for a longer period; however, when trains are being assembled and disassembled in rail yards, longer trains, due to their length, are more likely to exceed the capacity of rail yards built for shorter trains operated in the past and therefore spill out from yards to block grade crossings in the vicinity of the facility.

Apart from the logical inference that a long train will take more time than a short train to transit a grade crossing simply because of its added length, the evidence to suggest that long trains block grade crossings more often, whether idle or moving, is largely anecdotal. The committee heard from leaders of communities impacted by chronic grade crossing blockages who maintain that train length is a factor in both the frequency and duration of blockages. Some of the communities are in proximity to rail yards where trains frequently stand idle for long periods waiting entry to the yard and where train assembly and disassembly operations can lead to trains moving back and forth over one or more crossings multiple times. The community leaders complained about the resulting increased response time for emergency responders and the lengthy and recurrent delays incurred by motorists and pedestrians. Examples of interrupted access to neighborhoods, schools, and recreational facilities were given along with instances where impeded pedestrians, including students, maneuvered through stopped trains at considerable personal risk. Such problems are also reported on a regular basis by the media and in a database maintained by FRA for the public to report blocked crossings.[331]

While state and local laws once gave communities leverage with railroads in seeking remedies to chronic blocked crossings, federal preemption, upheld in the courts based on the Constitution's interstate commerce clause, has eliminated this leverage. Today, there are no federal laws or regulations pertaining to blocked crossings to replace the vacated state and local laws**.** Accordingly, FRA and the Federal Highway Administration, as well as state and local jurisdictions, do not possess direct means to compel railroads to limit the frequency and duration of blocked crossings. State and local governments can make public investments in grade separations, sometimes with federal aid, or they can choose to close some low-volume crossings to motor vehicle and pedestrian traffic. However, both options can be expensive to the public and/or disruptive such that they are not applicable to many instances where blocked crossings are problematic.

The absence of network-level data from grade-crossing monitoring systems and reliance on anecdotal reports makes it difficult to assess trends in blocked crossings, including impacts from long trains. Inasmuch as frequent and lengthy blocked crossings are a general concern of railroad operations, such monitoring and data gathering would be valuable for finding solutions to blockages that are especially problematic. In short, the committee cannot confirm whether a trend toward long trains is positively or negatively impacting the frequency and duration of blocked grade crossings. However, what is clear is that operating long trains is not necessarily a solution for resolving chronic blocked crossings and may be making the problem worse in some locations. For this reason, the committee recommends the following.

Recommendation 3: Congress should authorize and direct the Federal Railroad Administration to obtain data on an ongoing basis from railroads on blocked highway-rail grade crossings. The railroads should be obligated to deploy automated means for efficiently collecting and reporting the data on a regular and expeditious basis. Data collection should focus first on crossings with gates and other active warning devices that are indicative of higher traffic locations where blockages are likely to be the most disruptive; then data collection should expand to more public highway-rail grade crossings. Individual blockage incidents that exceed defined thresholds of duration should be prioritized for reporting, such as when a crossing is occupied for more than 10 minutes.

Recommendation 3a: The Federal Railroad Administration (FRA) should use these grade-crossing reports to gain a better understanding of the incidence, magnitude, and scope of the blockage problem. For this purpose, FRA should make the reports available to states and their transportation agencies, regional and metropolitan planning organizations, local communities, and the public through means such as portals and other self-service data retrieval tools. FRA should seek from these stakeholders contextual information about problem sites experiencing frequent and lengthy blockages such as by requesting data on the affected roadway's traffic volumes, emergency response activity, and significance for accessing neighborhoods, schools, hospitals, and other essential facilities and services during times when crossings were blocked.

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[331] See https://www.fra.dot.gov/blockedcrossings.

Recommendation 3b: Informed by the reports of blockages, the Federal Railroad Administration, should negotiate with the railroads individually and collectively to find solutions to the most problematic blockage sites, reduce the incidence and severity of the problem generally, and determine whether the trend toward increasing train length is creating special problems such as more blocked crossings near rail yards that require targeted remedies.

Recommendation 3c: Congress should give the Federal Railroad Administration authority to impose financial penalties on railroads for problematic blocked crossings. The penalties should be sufficient in magnitude to prompt good faith negotiations to resolve problematic crossing blockages.

FREIGHT RAILROADS SHOULD BE DETTERED FROM USING LONG TRAINS WHERE THEY WILL IMPEDE AMTRAK TRAINS

The report considers the impacts of longer freight trains on the passenger trains operated by Amtrak. Many of Amtrak's intercity passenger trains operate over the track of other railroads (called "host railroads") that were relieved of their common carrier obligation to provide passenger service when Amtrak was created. Federal statute grants Amtrak trains preference over a host railroad's trains, and thus if operational conflicts arise due to the increasing length of freight trains, this can be a clear public policy matter.

Amtrak maintains and has marshaled evidence that it incurs lengthy service delays when its passenger trains meet or follow freight trains that are too long to pass using available sidings on mainline single-track route segments. A host railroad that is aware of a mismatch between the length of freight trains being operated and the infrastructure available on the route to accommodate the passenger trains operated by Amtrak would seem to conflict with the latter's statutory right to run ahead of freight trains. To address this problem, the committee recommends the following.

Recommendation 4: Congress should direct and empower the Federal Railroad Administration (FRA) to enforce the performance of host freight railroads in giving preference to Amtrak passenger trains on single-track route segments where there is a mismatch between the length of freight trains being operated and the infrastructure available on the route segment to accommodate them without delaying Amtrak trains. Under these circumstances, when an Amtrak train experiences delays because of an inability to meet or pass a freight train, the host railroad should be subject to financial penalties. The penalties should be substantial and certain enough to deter this practice and to motivate solutions, including the rightsizing of freight trains to sidings and investments by host railroads in longer sidings. This FRA function would need to be allied with the Surface Transportation Board's jurisdiction over railroad practices and service. This FRA function would need to be allied with the Surface Transportation Board's jurisdiction over railroads practices and service.

Appendix
Study Committee Biographical Information

Debra L. Miller (*Chair*) is the chair of the Kansas Turnpike Authority, before which she was the director of the Kansas University Public Management Center. She served as a member of the Surface Transportation Board (STB) from 2014 to 2019. Prior to joining STB, Ms. Miller served as a senior consultant with Cambridge Systematics, Inc. From 2003 to 2011, she was the Secretary of the Kansas Department of Transportation (KDOT) with the distinction of being the longest-serving Secretary of Transportation in Kansas history. Prior to serving as the Secretary of KDOT, Ms. Miller was a consultant at HNTB. Previously, Ms. Miller served as the director of KDOT's Division of Planning and Development, the special assistant to the Secretary of Transportation, and as a policy assistant to the Governor of Kansas. Ms. Miller has been active with the Transportation Research Board (TRB) and was a member of TRB's Executive Committee for 5 years, including a year serving as the chair. She also was active with the American Association of Highway and Transportation Officials, where she headed numerous task forces and workgroups and served for 9 years as the chair of the Standing Committee on Planning. She also served on the Eno Foundation's Board of Advisors. Ms. Miller graduated magna cum laude from Kansas State University with a B.S. in sociology.

Faye Ackermans was appointed as a board member to the Transportation Safety Board of Canada on July 2, 2014. She has more than 25 years of rail experience, working at Canadian Pacific Railway from 1982 to 2008, with more than 15 of those years in senior positions where she was responsible for corporatewide oversight for safety management, security planning, operations regulatory compliance, and occurrence investigations. Ms. Ackermans has held several rail industry committee memberships over her career, including the Safety & Operations Management Committees of both the Railway Association of Canada and the American Association of Railroads. She received an M.B.A. from Concordia University in Montreal and an honors B.A. in psychology from Carleton University in Ottawa.

C. Tyler Dick is an assistant professor in the Department of Civil, Architectural, and Environmental Engineering at The University of Texas at Austin (UT). Prior to joining UT in 2022, Dr. Dick spent 10 years as a research engineer and lecturer with the Rail Transportation and Engineering Center at the University of Illinois at Urbana-Champaign. He previously spent 11 years as a railway design engineer with HDR Engineering where he attained the title of professional associate in recognition of his expertise in railway yard and terminal design. His current research is focused on railway capacity, network design, yard and terminal operations, operations potential of advanced railway traffic control systems with virtual and moving blocks, and railway applications of alternative energy and automation. Dr. Dick is a licensed professional engineer and is actively involved in American Railway Engineering and Maintenance-of-Way Association committees 16, 24, and 14, Transportation Research Board

Committees AR030 and AR040, the American Society of Civil Engineers Rail Transportation Committee, and the INFORMS Railway Applications Section. He is also on the board of the International Association of Railway Operations Research. Dr. Dick holds a B.Sc. in civil engineering from the University of Manitoba and an M.S. and a Ph.D. in civil engineering from the University of Illinois.

Theresa M. Impastato currently serves as the executive vice president and the chief safety officer for the Washington Metropolitan Area Transit Authority, where she has primary responsibility for the oversight and implementation of a multimodal safety management system. Over the course of her 25 years in the transportation industry, Ms. Impastato has held roles in operations, engineering, project management, and safety at Amtrak, the New Jersey Transit RiverLINE, and in private industry. With a background in science and systems engineering, Ms. Impastato has served as a voting member on federal advisory committees and industry working groups dedicated the development of minimum safety standards in rail transportation. She is a member of the New York Academy of Sciences. She holds an M.Sc. in data and systems analysis from the University of Oxford and a B.A. in applied sciences from the University of Pennsylvania.

Gary F. Knudsen is a retired locomotive engineer/conductor from Burlington Northern Santa Fe Railway (BNSF), where he was employed from 2004 to 2013. At BNSF he worked in the Northern California, Kansas, Nebraska, and Springfield Divisions, operating all varieties of freight trains, including those of more than 7,500 feet in length. His work experience included the operation of trains equipped with various technologies, including distributed power, electronically controlled pneumatic brakes, and both New York Air Brake locomotive engineer assist/display and event recorder and Wabtec trip optimizer systems. Prior to his experience in rail transportation, he spent more than 25 years in the aviation industry in a variety of roles. He was formerly employed as a senior vice president in charge of all North American airline and aviation products liability underwriting for XL Capital. He was also employed as an aviation safety consultant for the Aeronautics Division of the California Department of Transportation. He has additional experience as a corporate pilot and holds an airline transport pilot rating. He holds an M.B.A. from the University of Michigan and a B.S. in aeronautical studies from Embry-Riddle Aeronautical University.

Dennis S. Mogan is a railroad inspector/safety specialist III with the Illinois Commerce Commission. He is retired from the railroad industry, at the Chief level, with more than 50 years of continuous service in both the passenger and freight operations. This included 20 years with the Metra Passenger Rail Service, retiring as the chief safety, rules and regulatory officer and 20 years with the Milwaukee Road, Soo Line, and Canadian Pacific Railroads in positions up to acting division manager administration. Mr. Mogan was a member of the negotiated rulemaking committee of the Federal Railroad Administration for 49 C.F.R. Part 214. He has completed many training courses offered by the National Safety Council, American Red Cross, and the American Public Transit Administration. Mr. Mogan was a member of the General Code of Operating Rules for many years and assisted in the writing of the 2020 rule book.

J. Allan Rutter has been involved in transportation policy for the past 38 years and currently serves as the division head for the Division of Freight and Investment Analysis at the Texas

A&M Transportation Institute, where he has worked for the past 8 years. Previously, he was a senior associate for Cambridge Systematics, before which he was the executive director of the North Texas Tollway Authority. Mr. Rutter was appointed by President Bush to serve as the Federal Railroad Administration administrator in 2001. Previously, Mr. Rutter served President Bush in Texas as the director of transportation policy, before which he was the deputy executive director of the Texas High-Speed Rail Authority. From 1984 to 1990, Rutter served Texas Governors Bill Clements and Mark White, and worked for the Texas House Transportation Committee and later developed transportation policy for Texas Governor Rick Perry. Mr. Rutter holds an M.P.A. from the Lyndon B. Johnson School of Public Affairs and a B.A. in political science from The University of Texas at Austin.

John M. Samuels is the president of Revenue Variable Engineering, LLC. Prior to retiring from Norfolk Southern Corporation in March 2006, he was the senior vice president operations planning and support, the position he had held since March 2000. He joined Norfolk Southern in January 1998, as the vice president operations planning and budget after spending 22 years at Conrail, the major northeastern freight railroad in the United States. During his career at Conrail, he held successive positions of the assistant vice president of industrial engineer-transportation, the vice president of continuous quality improvement, the vice president of engineering, the vice president mechanical, and the vice president operating assets, in charge of the planning and maintenance of Conrail's 1,800 locomotives, 64,000 rail cars, and 18,000 miles of right-of-way. Prior to joining the railroad industry in 1978, he worked 8 years for General Motors Corporation as a co-op student and then a production engineer, and 10 years as a college professor at The Pennsylvania State University, during which time he earned a Ph.D. in industrial engineering. While at Penn State he had a joint appointment as a materials research scientist specializing in the manufacture of stainless steel and alloy steel products. He was elected to the National Academy of Engineering in 1996.

Peter F. Swan recently retired as an associate professor of logistics and operations management at The Pennsylvania State University, where he taught undergraduate and graduate courses. Prior to his professorship, he worked for 7 years at Chessie System (now CSX) in operations and automotive marketing. He also consulted for several railroads after leaving CSX, including Iowa Northern Railway Company, Chicago Rail Link, and R.J. Corman Railroad Group. Dr. Swan has written several papers relating to carrier operations and/or economics. His expertise covers operations management, safety, economics, logistics, marketing, and information systems. More recently, Dr. Swan has focused his research on issues of productivity, operations, and transportation markets. Dr. Swan has chaired the Transportation Research Board (TRB) Freight Systems Group and the TRB standing committee for Freight Transportation Economics and Regulation. He is currently a member of the TRB Trucking Industry Research Committee and the Freight Transportation Economic and Regulation Committee. He has also served for 6 years on the TRB Committee on Freight Rail Transportation and remains very active with that committee as a friend. While at the University of Michigan (UM), Dr. Swan participated in both the UM Truckload Driver Survey and the UM LTL Case Study. Dr. Swan holds a Ph.D. in operations management from UM, an M.B.A. in transportation from the University of Tennessee, and a B.G.S. in computer science from UM.

Elton E. Toma is a senior engineer at the National Research Council Canada (NRC), where he leads a team of researchers conducting rail and road vehicle testing and simulation. He has led and been active in NRC studies related to freight and passenger rail operations concerning in-train forces, marshalling of freight cars, derailment causes, curving behavior, and vibration and noise. He is currently leading a research team investigating the performance of freight car air brake systems in cold climates and also leading a team conducting a risk assessment of hydrogen fuel cell locomotives for freight use. He is a licensed professional engineer in the province of Ontario. He was a member of the 2016 Transportation Research Board's committee performing a review of U.S. Department of Transportation testing of electronically controlled pneumatic brakes. He holds a Ph.D. and an M.Sc. in mechanical engineering from Queen's University at Kingston (Ontario, Canada) and a B.Sc. in mechanical engineering from the University of Alberta.

Paul E. Vilter is retired from Amtrak, where he worked from 1999 to 2022. He most recently led Amtrak's Planning, Commercial Services and Sustainability Department, and previously led Amtrak's Host Railroad Group for 15 years. He also worked in Amtrak's Finance Department. From 1989 to 1999, Mr. Vilter worked at Conrail in its intermodal marketing, short line relations, and carload sales and marketing functions. Mr. Vilter started his railroad career in 1984 as a management trainee at the Chessie System Railroads where he subsequently worked in market research, metals marketing, and, after the merger that formed CSX, in intermodal planning. He worked closely with the Federal Railroad Administration, the Surface Transportation Board, and freight and passenger railroads around the nation during his tenure at Amtrak. He has spoken at the Transportation Research Board, the Transportation Research Forum, and most recently moderated a panel at the 2022 American Public Transit Association conference. Mr. Vilter holds a B.A. in materials and logistics management from Michigan State University and an M.B.A. from the J.L. Kellogg Graduate School of Management at Northwestern University.