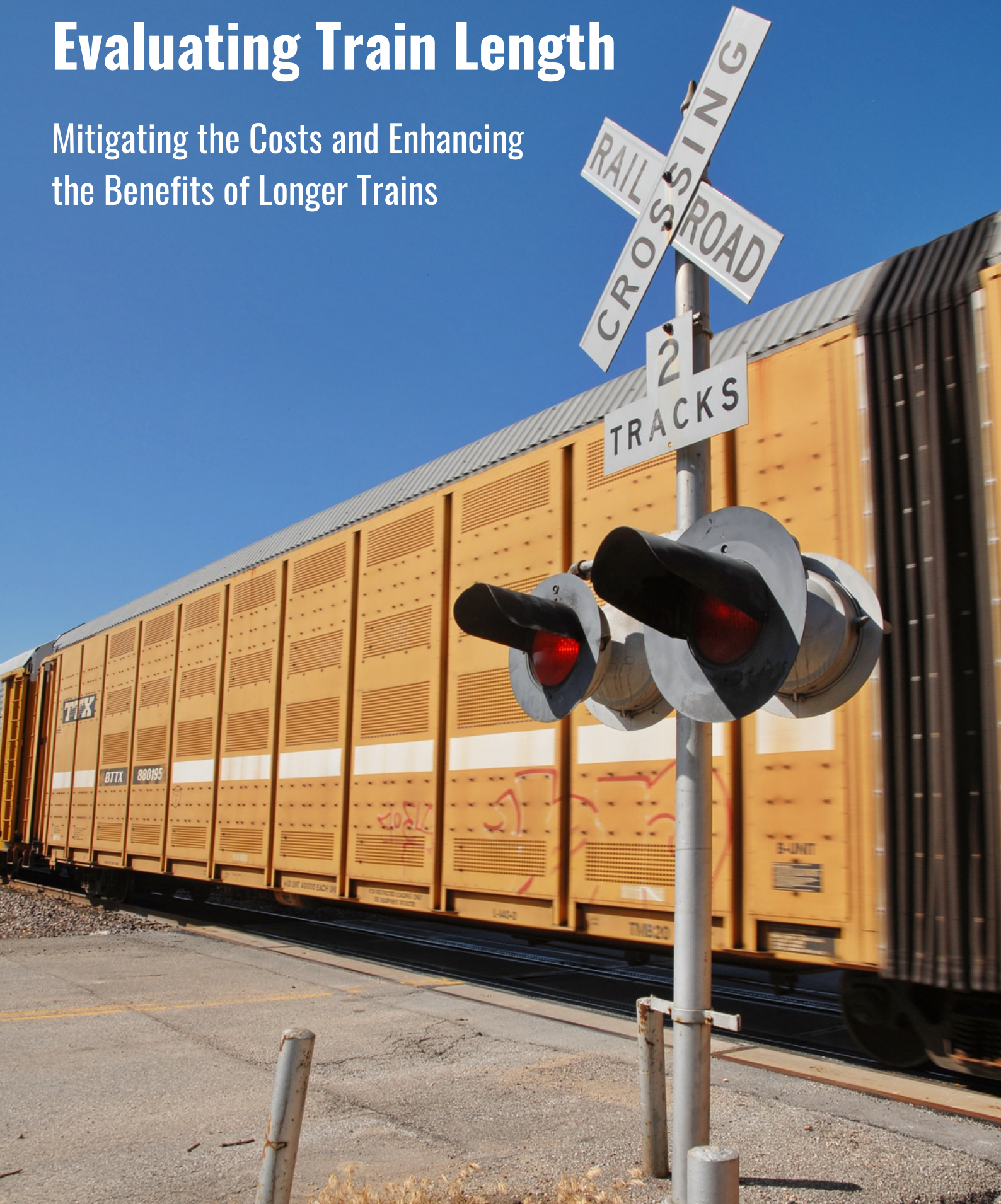


# Evaluating Train Length

Mitigating the Costs and Enhancing the Benefits of Longer Trains





### **Executive Summary**

Trains are getting longer in the United States. This fact alone does not obviously portend problems nor benefits. But there are policy issues that stem from this fact that implicate public safety, the economy, and the environment. To effectively evaluate train length across these issue areas, we must consult available data and theory. Balanced public policy must properly weigh the costs and benefits of train length. Once this analysis is completed, policymakers can be better equipped with data in hand to implement targeted reforms that will mitigate the costs of longer trains while enhancing the benefits they can provide.

The available data up to this point does not provide strong evidence that increasing train lengths correlate with safety concerns as measured by train accidents. There may even be weak evidence to the contrary, as accidents continue to decline as train length increases. The alternative to long trains is more trains, which may increase the probability of certain train incidents. Capping train length may also shift marginal freight loads to other transportation methods, namely trucks. The added freight on public roadways would cause a net increase in safety risks, and perhaps ironically may lead to highway-rail crossing incidents.

The various factors reveal different positive and negative effects. Some point to longer trains as favorable for safety or environmental concerns, while other indicate that there are consequences of longer trains that the industry or government should address. No element is purely advantageous, and none is purely negative. Finally, no accepted definition exists for when a train is “long” making any legislation or regulation that asserts a definitive definition potentially disruptive.

### **Introduction**

Many people today have a well-formed opinion on trains. Whether it is from the media or their personal experience sitting at a blocked crossing, this opinion likely has emotional weight and personal relevance. In particular, an often gut-level reaction to train length has led many to assume it is a problem. But what does a more wholistic assessment of longer trains reveal? Does the frustration outweigh the benefits, or are longer trains a key to solving some of the nation’s and the world’s largest problems?

These answers are not settled. In fact, reports from the Government Accountability Office (GAO) and Federal Railroad Administration (FRA) have concluded that “additional information is needed to assess their impact” and that “research is ongoing” into the operational effects of train length and any externalities. Such is the need for public data demonstrating a problem<sup>1</sup> that the FRA recently announced a proposed information collection action, whereby the agency would collect monthly reports from Class I railroads. While more data is always helpful, this action may impose compliance costs without resulting in actionable data that justifies a new rulemaking.

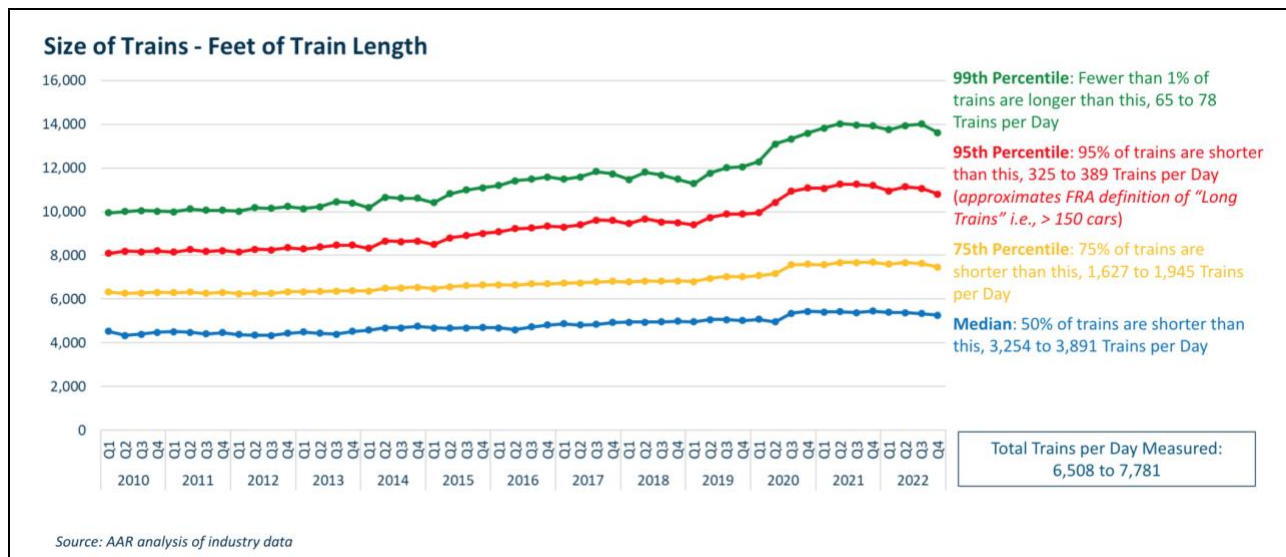
Fortunately, there is enough data already available to make meaningful assessments of the industry and its impacts, and to provide policymakers with nuanced background as they evaluate longer trains. The three lenses through which to view longer trains will be safety, economic costs and benefits, and environmental impact. These each offer a rich and deep level of analysis. The bottom line may be unexpected. Before getting to this analysis, some context is important.

Freight rail is part of the vital transportation network in the United States that allows for modern life, hauling around 1.7 billion tons of raw material and finished goods each year.<sup>2</sup> Among those are approximately 3 million carloads of construction-related material needed to build and maintain our nation’s critical infrastructure.<sup>3</sup> While trains can strike some people as a 19th or 20th century industry, rail in the 21<sup>st</sup> century is highly advanced and integrates technology at comparable rates to businesses around the world, including those in high-tech sectors.

The freight rail industry also has a few distinctions relative to other major American industries. It stands out as an efficient and safe industry that is economically *deregulated*, making nationally economy-defining decisions without significant, burdensome government oversight or enforcement around rates and other issues. Additionally, it is privately funded, yet competes with publicly funded roads and economically successful pipelines to transport hazardous materials and payloads of raw resources and commercial goods. If and where negative externalities arise, they must be evaluated against the benefits accrued by this industry that is in many ways facilitating modern life, upholding our supply chains, and advancing the development and deployment of innovative technology.

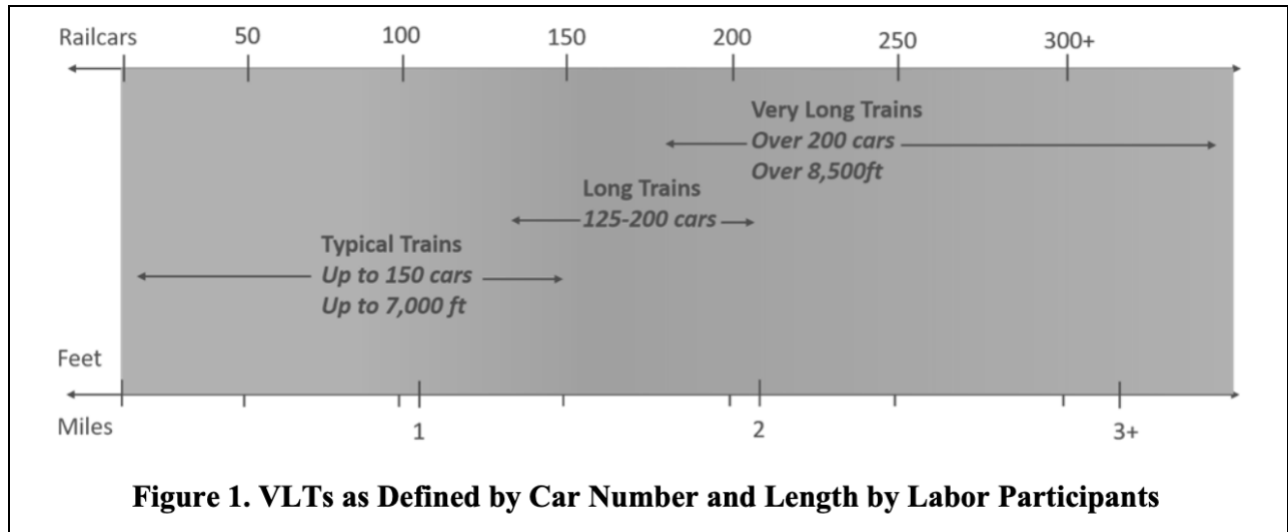
In light of these factors, as we look through the lenses of safety, cost, and environmental impact, we must also evaluate the industry trends and public policy frameworks that have led us here. In so doing, we necessarily assess what impacts changes to law or policy would have.

Recent history makes it clear that trains are increasing in length. While virtually all trains have increased in size, the majority remain well below what may be considered a “long train.”<sup>4</sup>



Aii Figure 1: Train length percentiles

Recent government and industry research has also been conducted into the perception of train length.<sup>5</sup> What emerges clearly is that even among stakeholders, there is no definition for a “long train” or a “very long train.” Some use total train length (such as linear feet or miles) while others use car count, and within each category, there are ranges for what constitutes a “typical,” “long,” and “very long” train.



Aii Figure 2: FRA stakeholder perception research.<sup>6</sup>

While the recent trend clearly demonstrates an increase in length, a broader historical context is interesting to note. Pulling the timeline back to the 1980s reveals two factors: first, the average *train car number* is actually consistent with the latest available numbers for 2022. Second, the *train car length* is relatively longer today.<sup>7</sup> This contributes to the above visible trend in train length while providing context for car numbers.

This means to some extent, train length has increased due to the long-term investment – by railroad companies and the logistics industry – in railcars and platforms to service intermodal containers, higher capacity for cargo, and more payloads of various kinds. The growth is not explained solely by railroad companies linking greater numbers of train cars to locomotives.

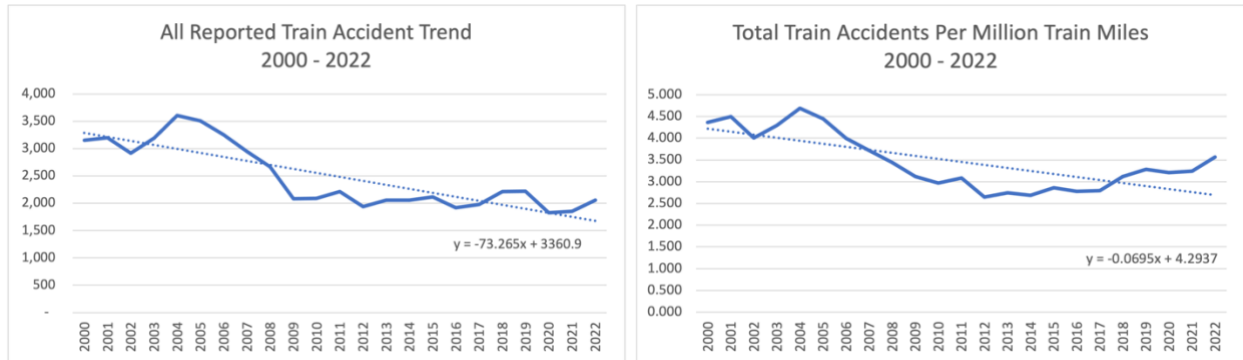
With demand projected to grow for freight transport by as much as 30 percent in less than 20 years, it may be an economic necessity to the nation’s well-being to move more cars. Whether that is done on fewer or more train may depend in part on this analysis.



While virtually all trains have increased in size, the majority remain well below what may be considered a “long train.”

## Safety

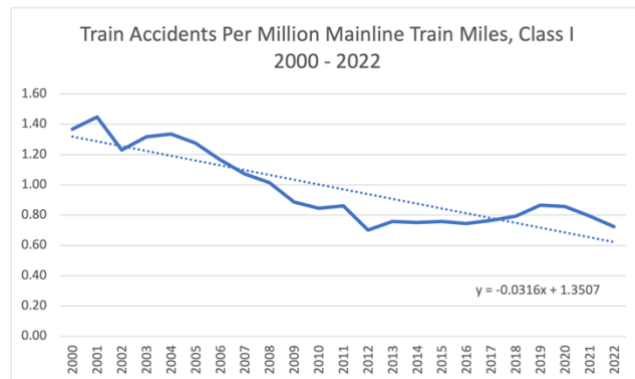
Accident data is the best first context for evaluating the safety of the railroad industry. Whether evaluating total reported train accidents across the entire sector or train accidents per million train miles traveled, accidents are on a downward trend since 2000. The prima facie case when approaching this issue is that there is no obvious safety concern. It will take clear and convincing evidence to demonstrate that train length not only correlates with but has a causal relationship to safety concerns, accidents, or other incidents. The alternative to long trains is more trains, which may actually increase the probability of train accidents and crossing issues.



Aii Figure 3: Train Accident Trend (Source: FRA Form 54)

When viewing the above graphs in light of increasing train length, the visible correlation is that as trains grow in length (per Aii Figure 1), total train accidents decline. In fact, for total accidents (left), from 2010 to 2022, there remains a very slight negative slope of around minus 15 train accidents per year. Since 2012, there has been upward movement in train accidents per million train miles (right), which may require further analysis. When isolating this to mainline<sup>8</sup> accidents per million mainline train miles, this uptick becomes a statistical plateau. Narrowing further to Class I railroads, the past decade is also flat, but most recently has resumed a downward trend, with 2022 almost matching an all-time low in train accidents per million train miles for Class Is on mainline track.

This 10-year statistical plateau against increasing train length may indicate that the industry is nearing a natural cap in train length as measured against train accidents. Policymakers should assess this closely so as not to impose regulatory compliance costs unnecessarily on an equilibrium industry practice. Fortunately, much more data analysis can be conducted from here.

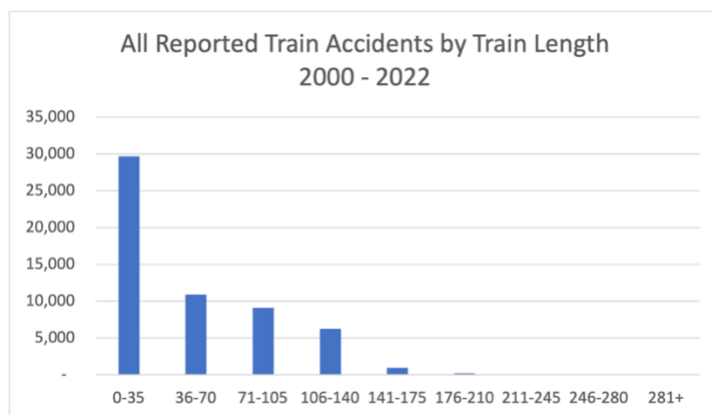


Aii Figure 4: Rate of Mainline Train Accidents for Class I Railroads

While correlation does not imply causation, a lack of correlation is strong evidence that a hypothesis is not supported. In this case, the hypothesis that longer trains are inherently less safe is contradicted by train length increasing over the same period that train accident numbers are remaining flat or in some cases decreasing.

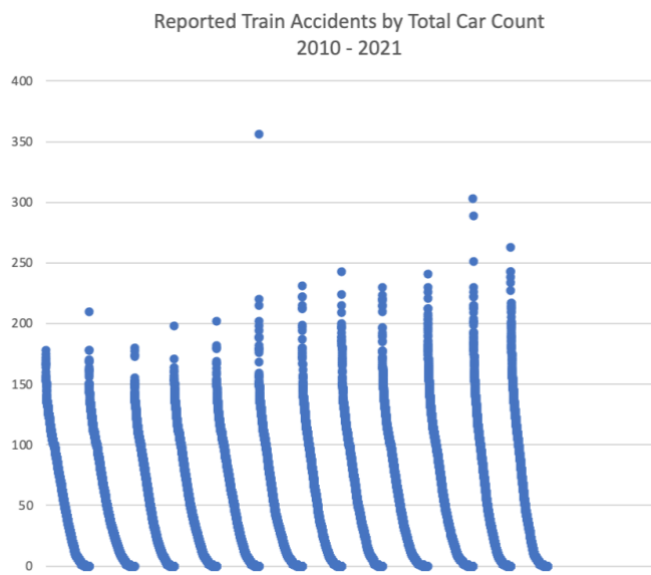
From train accident data, we can also seek train length to assess the potential correlation between longer trains and accidents another way. By adding total cars for each report (i.e., the sum of loaded freight, unloaded freight, loaded passenger, unloaded passenger, and cabooses<sup>9</sup>) we can filter the data by number of cars. When we do this, we find that out of approximately 24,400 reported train accidents from 2010 to 2021, only around 4,400 (or 18 percent) included total train of 100 or more cars. We can assume, then, that more than 80 percent of trains involved in accidents from 2010 to 2021 were less than a mile long.

Broadening by a decade, it is clear that most accidents involve shorter trains (as the majority of operating trains are this below what may be considered a “long train”). In fact, since 2000, nearly 30,000 train accidents involved between zero and 35 train cars (zero meaning only locomotives),<sup>10</sup> while only 15 train accidents involved more than 245 cars.



Aii Figure 5: Train Length by Car Count

Plotting the train accidents by year with train car totals reveals an interesting visualization. Each string below represents years from 2010 through 2021 (left to right). The dots align with the y-axis to represent total train cars, and every data point reflects a reported accident. While we can see the dots are trending higher as time goes on – consistent with known train length increases over time – the density of train accidents remains concentrated in the lower train lengths as measured by train car counts. For longer trains to correlate with more accidents, we would expect to see greater concentration of dots toward the top of each string, rather than tightly packed toward the lower car counts at the bottom of each string. There are more accidents when total car counts are higher, but this offers an unclear picture and says nothing yet about causation. Further, note that because every dot represents an accident, definitive safety conclusions cannot be drawn from this chart because it does not display long or short trains that did *not* experience an accident. This chart merely displays of the set of those trains that did have accidents, the distribution of train cars.



Aii Figure 6: Density map of accidents by train car count and year



The available data up to this point does not provide strong evidence that increasing train lengths correlate with safety concerns as measured by train accidents. There may even be weak evidence to the contrary, that accidents continue to decline as trains increase in length. That may suggest that running fewer trains decreases the statistical incidence of train accidents. It does not tell us whether other kinds of safety issue arise, even if it is true that lowering the total number of trains reduces train accident numbers.

A vital safety statistic after viewing accident numbers and rates is casualties. Is train length correlated in any way with injuries or death amongst the public or railroad employees? The clear answer seems to be no. Overwhelmingly, accident casualties group around shorter or “typical” length trains. This is true whether viewing the casualties as a total number or the average casualty rates per accident.

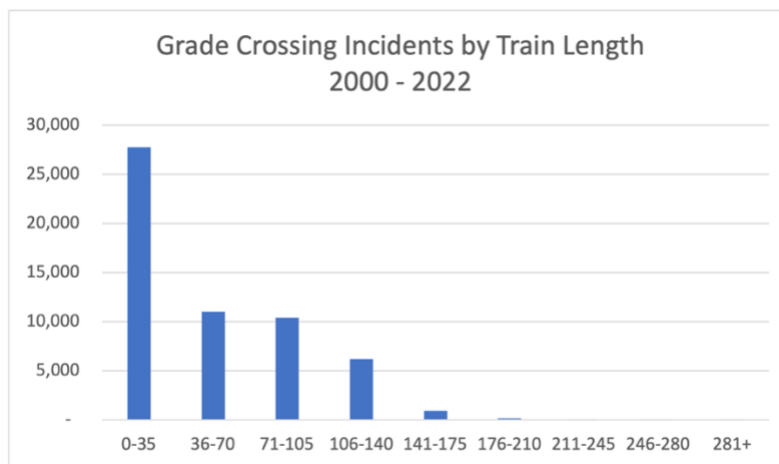


Aii Figure 7: All Reported Casualties by train length<sup>11</sup>

The next and possibly most common concern for longer trains is the impact to highway-grade crossings. These are the railroad crossings that pedestrians and drivers face every day and often wait for a passing train to clear the intersection. We will consult FRA data for incidents occurring at crossings and analyze that against train length to discern any relationships. Each incident reported here (1) involves on-track equipment, (2) involves a highway user, and (3) the accident occurred at a designated crossing.<sup>12</sup>

Of particular concern are crossings where drivers on public roadways interact with trains at highway-grade crossings. Crossing incidents such as train-truck collisions can be devastating and are critical to address – both from a rail standpoint and driver (driver behavior can contribute to risks, such as attempts to “beat the train”). Longer trains may contribute in some ways, but not materially. When a truck driver decides to pass over a crossing, he does not know whether the train is 50 cars or 100 cars. What is relevant to him is the distance of the locomotive, not how many cars are lined up behind – except to the extent media has conditioned drivers to attempt

beating a train due to the perception that not beating the train means waiting for a long train to cross. And when an engineer and conductor approach a crossing, the key factors are the distance between them and the crossing. The length of the train is relevant to how long the train will take to complete its crossing, but as soon as the locomotive enters the crossing it is no longer relevant to crossing safety – whether the train is long or short. In other words, vehicles cannot move through the intersection once the train has entered it, so only accidents involving a vehicle driving directly into the side of a train would be irrelevant, and those could not be correlated to the train’s length.

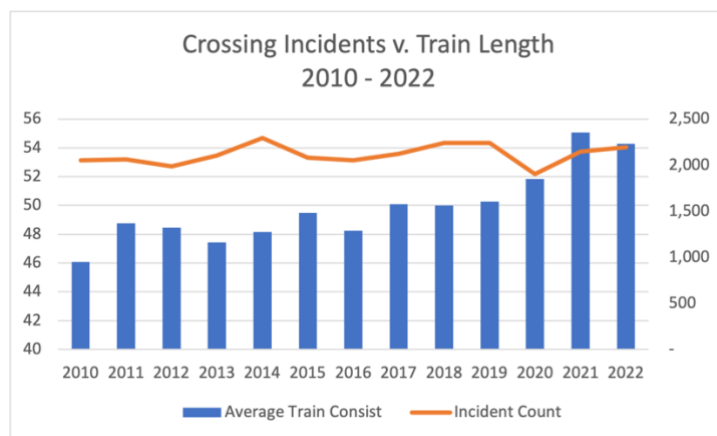


Aii Figure 8: All Reported Highway Grade Crossings by Train Length

Similar to train accidents reported above, the clear majority of incidents occurring at crossings involve shorter trains. Over 87 percent of crossing incidents since 2000 have involved “typical” train length.<sup>13</sup> Less than one percent would be considered “very long trains.” The graph above shows the overwhelming number of crossing incidents involve shorter or “typical” train lengths. Since we know train length has increased in the last decade, we can plot that here to avoid earlier years where shorter trains were more common from biasing the data.

Assessing Aii Figure 9, we look at data from crossing accidents only since 2010. While train consists have grown by car count (left axis) since 2010, the annual highway-rail crossing incident counts (right axis) have not correlated.

Engineers and conductors do need to be keenly aware of their payload and train length and weight. These are relevant to the distance it will take a train to stop and are relevant for calculating the speed, distance, and time before entering an intersection/crossing. Longer and heavier trains with more momentum will take longer to stop and more data is needed to assess the safety risks associated and the incidence of making emergency stops.



Aii Figure 9: Crossing Incidents by Time and Train Length



Once a train has entered a crossing and stopped, new risks arise. In particular, longer trains are more likely to block crossings, as even if the locomotive has moved well past the crossing, the numerous cars behind it may linger. As mentioned, vehicles are unlikely to ram into the side of a train – although some do, and the ultimate liability would rest with the driver not the train (from 2010-2020, a total of 4,326 incidents are recorded as a train *struck by* a highway user, while the same period records 19,608 incidents recorded that a train struck a highway user).

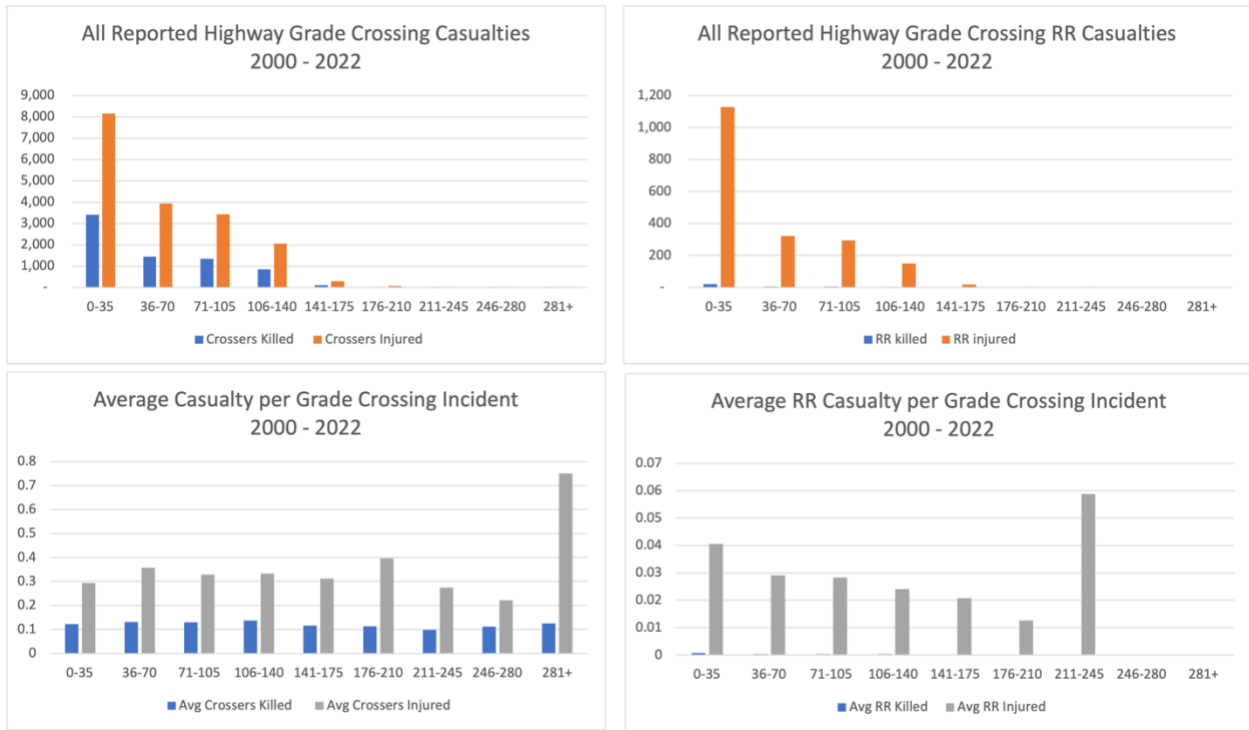


**While train consists have grown by car count since 2010, the annual highway-rail crossing incident counts have not correlated.**

Vehicle movement and driver judgement aside, the primary risk is to pedestrians who (unlawfully) cross the track or climb between rail cars to pass through a stationary train. Many children, teens, and adults (including many under the influence of substances) make this decision and harm themselves. The risks can include small scrapes and bruises, falling or becoming pinned by the industrial equipment, or at worst being in between cars or near the wheels as the train begins to move. These obviously range from somewhat innocuous to lethal, and these risks are not present when a train is moving through a crossing, but seemingly unique to trains that stop and block crossings.

What the available data demonstrates is that train length does not correlate with crossing injuries or death. Casualties are concentrated toward shorter train lengths, and when controlled for the number of accidents, the average injuries and deaths do not demonstrate a relationship with train length. For railroad employees, no deaths were reported since 2000 for “long” or “very long” trains. Railroad workers injured since 2000 include 21 injuries on “long” trains and three injuries on “very long” trains.

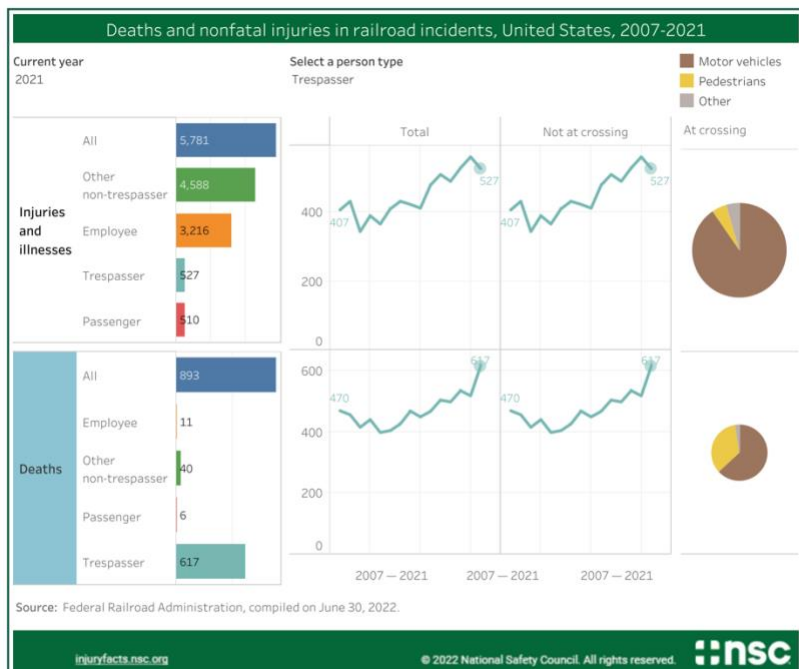
Among the public, approximately 121 fatalities were reported with respect to “long” trains at crossings, and around seven deaths involving “very long” trains since 2000. There is no correlation between train length and fatalities at crossing incidents that can be perceived across over two decades of data. The only appearance of correlation for crosser injuries and “very long” trains is because of how rare the events are: eight total crossing accidents and six total injuries reported involving trains longer than 280 cars over 23 years (see Average Casualty per Grade Crossing Incident, lower left in *Aii Figure 10*).



Aii Figure 10: Casualties by train length in total and average per incident since 2000.

The data displayed above comes from FRA crossing incident form, where nuanced detail is not always available. Consulting other sources may shed light on crosser casualties and whether train length is a meaningful factor.

Trespasser injury, illness, and fatalities have all been rising in the last decade. This seems like an obvious correlation with longer trains (although not causation), but these do not seem to be taking place at crossings. It may call into question whether longer trains give trespassers more potential to interact with a train – such as a long train stopped and a trespasser passing through it at a point other than a crossing/intersection. If the train is sufficiently long that a pedestrian cannot walk around it, the train length may be a factor in their decision to pass through it. This is not established through data, however. It is noted here as useful context on background trends.



Aii Figure 11: Trespasser trends from 2007 to 2021.

| Train Length by Share of Accidents and Casualties, 2000-2022 |                 |                |                  |                 |
|--|-----------------|----------------|------------------|-----------------|
| Car Count  | Total Accidents | % of Accidents | Total Casualties | % of Casualties |
| 0-35   | 27,787          | 49.15%         | 12,715           | 46.96%          |
| 36-70  | 11,015          | 19.48%         | 5,716            | 21.11%          |
| 71-105   | 10,411          | 18.41%         | 5,065            | 18.70%          |
| 106-140  | 6,187           | 10.94%         | 3,058            | 11.29%          |
| 141-175  | 913             | 1.61%          | 410              | 1.51%           |
| 176-210  | 159             | 0.28%          | 83               | 0.31%           |
| 211-245  | 51              | 0.09%          | 22               | 0.08%           |
| 246-280  | 9               | 0.02%          | 3                | 0.01%           |
| 281+   | 8               | 0.01%          | 7                | 0.03%           |
| <b>Total</b>   | <b>56,540</b>   |                | <b>27,079</b>    |                 |

| Train Length by Share of Accidents and Casualties, 2010-2022 |                 |                |                  |                 |
|--|-----------------|----------------|------------------|-----------------|
| Car Count  | Total Accidents | % of Accidents | Total Casualties | % of Casualties |
| 0-35   | 13,512          | 49.17%         | 6,612            | 48.45%          |
| 36-70  | 4,867           | 17.71%         | 2,515            | 18.43%          |
| 71-105   | 4,862           | 17.69%         | 2,394            | 17.54%          |
| 106-140  | 3,360           | 12.23%         | 1,704            | 12.49%          |
| 141-175  | 669             | 2.43%          | 313              | 2.29%           |
| 176-210  | 145             | 0.53%          | 76               | 0.56%           |
| 211-245  | 51              | 0.19%          | 22               | 0.16%           |
| 246-280  | 9               | 0.03%          | 3                | 0.02%           |
| 281+   | 7               | 0.03%          | 7                | 0.05%           |
| <b>Total</b>   | <b>27,482</b>   |                | <b>13,646</b>    |                 |

*Aii Figure 12: Accident and casualty proportions by train length*

Returning to recent data, regardless of train length, the number of casualties associated with crossing accidents is what the proportion of accidents predicts. For instance, for all highway-rail incidents from 2010 to 2022, there were 3,698 total fatalities reported. For trains over 100 cars, which represent 17.87 percent of all trains involved in such accidents, a similar proportion of fatalities occurred at 644 deaths, or 17.41 percent.

The trains longer than 150 cars represent only 1.96 percent of accidents while representing 1.78 percent of the fatalities. This proportionate share of accidents and casualties holds across train length and across time. We see the percentage of casualties we would expect to see given the percentage of train accidents per train length.

A secondary risk and concern are blocked crossings thwarting emergency response vehicles from passing through a crossing. If a mile-long train is blocking a crossing, an ambulance responding to a local emergency or with a patient onboard will either wait at the crossing for an indeterminate period of time until the train clears or is split or will seek a less efficient route to their destination. This theoretical yet intuitive concern is yet to be established in data.

The FRA is currently collecting submissions from the public and from law enforcement officials through a blocked crossing incident reporter,<sup>14</sup> but few safeguards exist to prevent false information, low quality submissions, repeated submissions, or a combination or confluence of these and other data quality concerns. When this data is known, it should be incorporated into a holistic view.

A final safety consideration that may have train length implications involve the basic everyday tasks that rail employees undertake, namely slips, trips, falls, and fatigue. Long trains mean more to inspect, more train cars that may have bad wheel bearings, or greater potential for some issue to trip a sensor. Whether they have these problems in reality is unclear, but the potentiality for them is unquestionably increased in proportion to train length.

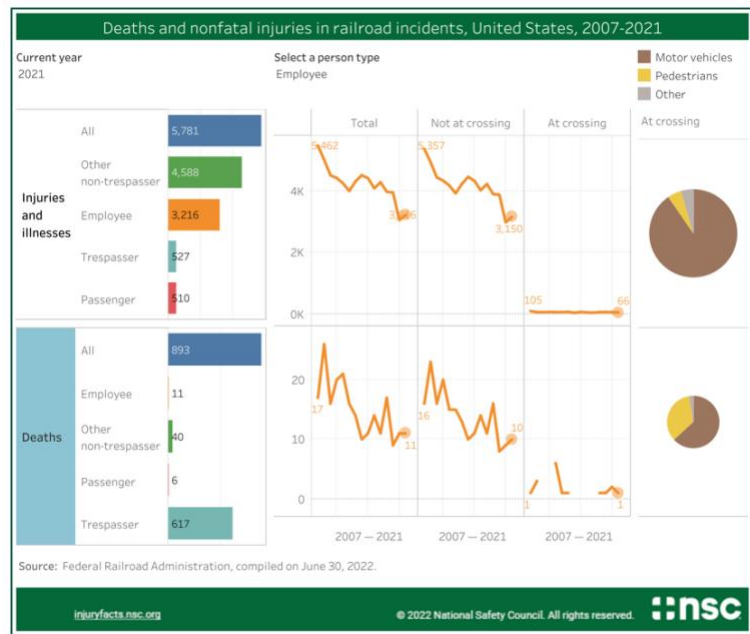
If and when these issues do arise, it means the engineer and/or conductor may be responsible for stopping the train and walking its length to inspect or address an issue. The longer the train, the longer the round trip back to the locomotive, which again increases the potential for issues.



These can interact with a secondary rail issue of train crew size. One alternative is roving or ground-based conductors, who can arrive on scene or help reduce engineer/conductor fatigue from the locomotive. As it stands, a two-mile train could require a conductor to walk a four-mile roundtrip if the relevant issue were at the back of the train. This maximal distance is incredibly rare and unlikely. In part, because even with the general train length increasing, still 95 percent of Class I trains are less than 11,000 feet (2.08 miles), with the median length around 5,300 feet (one mile). The likelihood of an issue requiring the conductor to walk from head locomotive to caboose (or final car or rear locomotive) is also highly unlikely.

It is also the case that over the same period that train length has grown, railroad employee safety has improved, with the number of injuries, illnesses, and death declining significantly. Railroads also have comparable or better safety record for death, injury, and illness relative to similar and a broad cross section of industry across most metrics, according to data from the Bureau of Labor Statistics.

One relevant and concerning metric where railroads outpace the transportation sector broadly and all industry is in sprains and fractures. The data here is railroad industry-wide and would include everyone from inspectors to fabricators and people in trains, rail yards, and elsewhere, making a definitive correlation with train length very difficult to surmise. It is also the case that this higher rate of sprains and fractures appears to be a natural consequence of the railroad industry, not that it increases with train length. Nevertheless, as train length increases and more walking is required, this is a natural statistic to explore in greater depth.



Aii Figure 13: Railroad employee trend.

After considering general accident statistics, public risks at crossings, and railroad employee safety, a broader community and environmental risk is worth raising. While hazardous material is addressed below, it is worth noting hazmat as a safety issue here. Since 2000, fewer than one percent (0.85 percent) of train accidents have identified a release of hazardous materials. Narrowing to the past decade, while train length has been notably increasing, the same statistic holds (0.71 percent). The past 10 years have seen the accident rate for hazmat fall by 55 percent, even while the general trend in train accidents has seen a roughly 10 percent decline in all train accidents. Over this period, federal rules have also taken effect requiring stronger tank car design for many hazardous material commodities. At this time, data is not sufficient to establish reason for concern that train length and hazardous material releases are positively correlated.

As a final framing on the safety risks or benefits associated with train length, it is useful to apply more theoretical lens. To the extent that data is incomplete, we can also contemplate based on intuition. The most basic intuition is that by running longer trains, there are fewer trains needed. By reducing the number of trains, there is a natural reduction in the probability of an incident.

Other intuition tells us that while fewer incidents may arise from running fewer trains, the lower number of incidents could be more severe with longer trains, as there are more train cars or tankers in the equation. This could apply to derailment and to trains lingering longer in intersections and crossings. Longer trains also mean greater weight and momentum, which translates into longer time needed to slow and stop. This would all but guarantee an incident if the engineer or conductor visually identifies an issue on the track, even at the edge of their vision, because the train could not stop in time.

Conversely, by limiting train length, there are likely to be more trains needed to move raw materials and finished goods. The greater number of trains will interact more with the public at crossings and on track. More trains may also block crossings as they wait for the signal to enter rail yards or for another train ahead to clear the track or siding. In fact, FRA explicitly notes that some blocked crossings are proper, stating, “There may be legitimate operating and/or safety-related reasons for a crossing to be occupied by a slow or idling train.”<sup>15</sup> This would apply to shorter trains as much or more than long ones.

Finally, by capping train length, another consequence may be the shifting of the marginal freight loads to other transportation methods, namely trucks. The added freight on public roadways would cause a net increase in safety risks, and perhaps ironically may lead to highway-rail crossing incidents, as trucks are larger and take longer to clear crossing intersections and tracks.

Where we must return is the data. These intuitive exercises are critically important, and they fill much of the dialogue between unions and carriers during collective bargaining. The problem is that the public lacks robust, reliable, and high-quality data to support the case that any of these eventualities are occurring at all, much less that they are systemic rather than anecdotal.

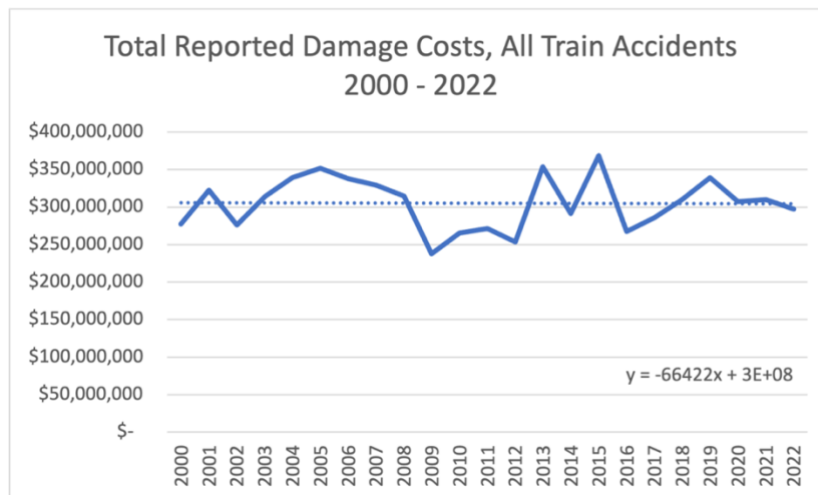
The intuitive analysis ends up with many points counteracting one another, leaving only a few possible concerns measured up against volumes of data that the general safety trend has been fewer incidents even while train length has grown. Certainly, this cannot establish a causal relationship that longer trains are improving safety, but it is enough to establish a rebuttable presumption that longer trains are safe.



**The general safety trend has been fewer incidents even while train length has grown. . . . it is enough to establish a rebuttable presumption that longer trains are safe.**

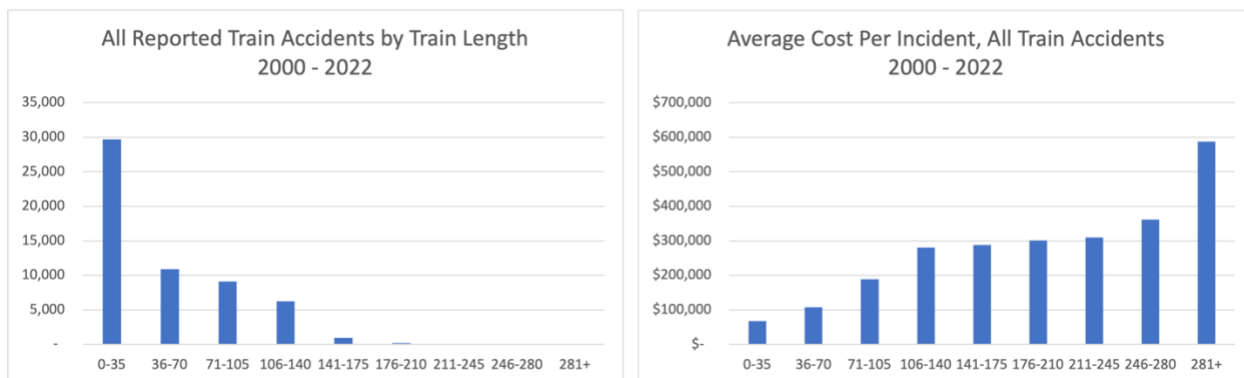
## Economic Costs and Benefits

Railroads underpin much of the nation’s economy. It is natural, then, to frame the question of the implication of train length with respect to economics. This will include both costs and benefits and their relationship to train length. We begin with background trends.



Aii Figure 14: All Train Accident Reported Costs Trend

While train accidents are a function of safety previously assessed, the economic costs shed light on whether incidents from the past two decades demonstrate any correlation to train length. There is no discernable trend, and while train length has grown more in the last 10 years, the reported costs from train accidents remain slightly downward, but statistically flat.



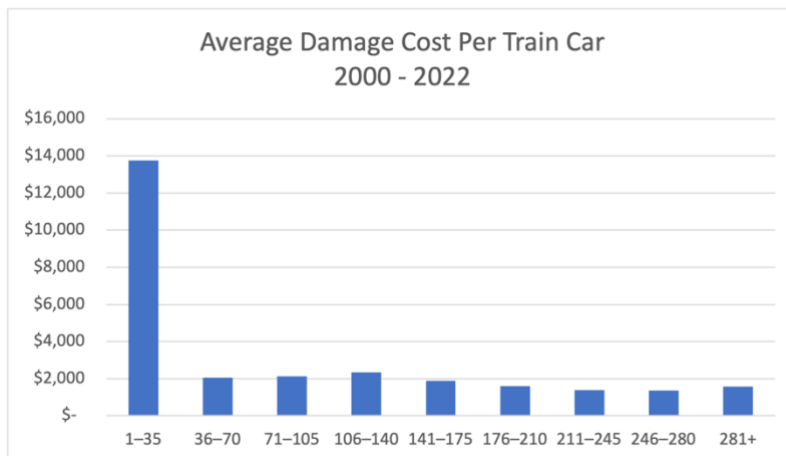
Aii Figure 15: Train Accidents by Train Length and by Average Cost Per Accident

Looking at the data by train length, more accidents occur with lower train car numbers, but the average cost per accident trends inversely. That is likely because many more lower-impact incidents occur, where a small amount of equipment is damaged, while longer trains on mainline track may be struck by a vehicle, collide with another train, derail, or experience another significant issue.<sup>16</sup> It is not surprising then to find the average cost per incident trends this way and is important to note these figures are reported costs to equipment and track, not public negative economic externalities. They are often internalized costs the railroads themselves bear but are nevertheless important context for evaluating.



The average cost per accident can still be evaluated further by assessing these costs per train car. Given that a train car is involved in an accident, what is the expected damage for cars in longer trains versus cars in shorter trains? The data demonstrates that a car in a longer train may have a lower expected damage than one in a shorter train accident.

Evaluating average total reported damage costs by the number of cars in accidents shows that per car, there is an insulating effect for being in a longer train. The downward cost trend as train length increases is worth noting because it shows that when the unit of analysis is train cars rather than whole trains, the economic impact of a longer train is less significant. This is also relevant to externalities. As noted, railroads own or fund most of their own infrastructure and equipment, including locomotives, but as much as two-thirds of train cars are owned by shippers and other parties. Accordingly, with the average per-car analysis of train length, we can see that, given an accident, the railroad imposes fewer negative externalities on others the longer the train.



Aii Figure 16: Average Cost Per Car, All Train Accidents

### Public Costs

The reported costs associated with train accidents is merely a tool for assessing where the industry is already trending. With these costs primarily being absorbed by the railroad companies themselves, the next task is to explore the cost imposed on others, and from there the cost to transport goods, and the economic efficiency of moving more goods in a single train. While no resources can comprehensively tackle every dimension of this issue, we provide a useful analysis of economic (or financial) costs directly and some indirectly associated with train length.

Costs may be imposed on the public in a few ways, primarily accident casualties, damage to infrastructure, lost productivity, and environmental and health risks. From the safety analysis, we see that while each injury and death is truly tragic, casualties do not correlate with train length from accident data. This cost is therefore a feature of transportation, and while more can and likely should be done to mitigate needless injury and loss of life, the length of trains is unlikely to contribute, thus making new rules an exercise in regulatory compliance costs without lifesaving effect.

Likewise for infrastructure costs, the main (or direct) costs that accrue during a rail accident are to the locomotive and train cars as well as the track – much of which are owned or funded by railroad companies. Where public roads and utilities are damaged, there are real negative externalities arising from train accidents, but it is unclear that any relationship exists between these and the length of the train.

Researcher in Europe attempted to identify a relationship for determining total cost of the direct and indirect effects of train derailments, estimating 1.5 to 2. Providing a liberal cost estimate, these researchers conclude, “Reasonable practice would be to assume that the indirect costs, if unknown, are equal to the direct costs.”<sup>17</sup> There is good reason to view this estimate as overly liberal, in part because we have shown that per car, average damage costs trend downward, reducing the indirect costs faced by shippers and third parties resulting from an incident.

The most obvious additional considerations are that this estimate is over a decade old, when train accidents and their impacts were at higher levels than today, positive train control technology was not in place (and now exceeds implementation levels required by Congress), and the research applies primarily to Europe. Lastly, the analysis assumes this direct-indirect cost relationship for *derailments* (a type of accident with abnormally high damage costs), not *all train accidents* or other incidents. In fact, in the U.S., since 2000, derailments cost on average 15 percent more in direct costs than all train accidents (inclusive of derailments) and 52 percent more than all other train accidents (exclusive of derailments).

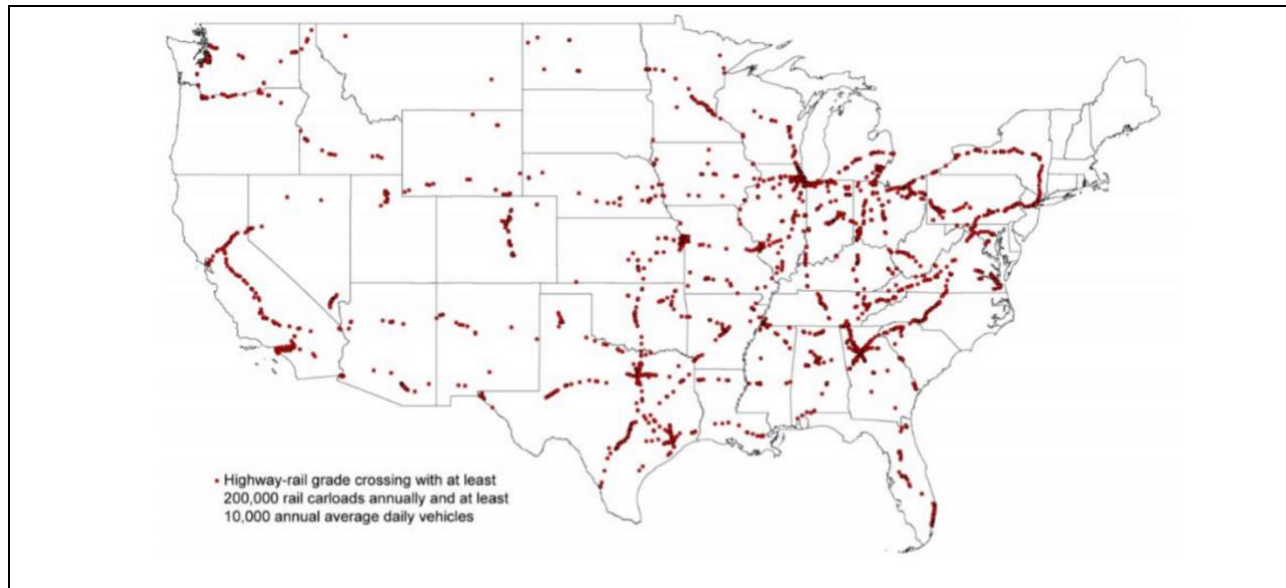
Accordingly, we reject this cost prediction as overly inflated, but do posit that some indirect cost exists that is greater than zero and less than the cost faced by the railroad directly for the average train incident.<sup>18</sup>

With respect to train length, while the statistical incidence of “very long” trains derailing is very low, they do result in higher costs due to more potential cars derailing compared with a shorter train. Still, the paucity of data makes it difficult to assess these costs and to determine if a multiplier for direct and indirect costs should be fixed or slide with train length.

### Costs at Crossings

Lost productivity, like grade crossings assessed in the context of safety, occupy a large portion of the train length discourse. This is a cost imposed on the public, but only when they are at a crossing. The problem with train length is that the same problem of blocked crossings may arise by capping train length because simply more trains would be on the tracks, increasing the likelihood of a crossing being occupied at any given time and location. In either case, a blocked crossing represents a cost to the community by preventing traffic from flowing and thereby delaying commerce, commutes, and other activities.





*Aii Figure 17: High-Volume Highway-Rail Crossing Locations (Source: U.S. Senate)<sup>19</sup>*

When it comes to blocked crossings – the primary complaint and concern among the public relating to longer trains – not only do we lack the data, but we are completely unable to collect it. The blocked crossing incident reporter makes clear that,

FRA does not confirm the accuracy of the blocked crossing reports submitted to this portal. This collection is not designed to provide a representative sample or create generalizable statistics. The data gathered from this collection is not suitable for use in budgetary requests, nor regulatory proposals. The agency shall not utilize the data for these purposes.<sup>20</sup>

The accuracy cannot be guaranteed because it is a public reporting form that allows duplicates and does not require any geolocating or other type of location confirmation. Even if we assume good faith submissions only – and even take the estimated blocked/waiting time of drivers as accurate – we still would have no basis for attributing these reports to train length. Driver reports would not be reliable to provide car counts, and when a train is stationary, not all cars are visible. Unless every report were accurate enough to be traced to the railroad company and the given train's consist is recorded and associated with each report, there is no way to link train length and blocked crossings. Moreover, as FRA notes, there are many legitimate and safety-related reasons for trains to slow or stop, which apply equally to longer and shorter trains.

As for costs associated with blocked crossings, they are legitimate but unknown. That is in part because little research has been conducted to differentiate the costs from general traffic (e.g., a train constantly moving through the crossing on a daily/weekly basis) from blocked crossings (e.g., a train not moving and thus preventing drivers and pedestrians from passing for an indeterminate time).<sup>21</sup> The costs can be huge, but without differentiating them, railroads may be punished for simply conducting commerce. In some cases, they may also be penalized for land-use policies and housing development that is established near existing track. In such cases, even if trains block crossings, it is population density and other public policy that contribute – this should be evaluated at a local and state level amidst the greater blocked crossing debate.



In Miami, one study placed the annual delay costs associated with traffic at crossings to total \$2.4 million.<sup>22</sup> In Chicago, delays from rail crossings are alleged to amount to as much as \$58 million each year.<sup>23</sup> Not only are these unclear with respect to moving or idling trains, but they shed no light on the length of a train. The primary correlation seems to be population density.

After blocked crossings, we turn to the rail operations and look at the costs associated with longer trains in at least four lenses: cost of goods, cost of fuel, productivity, and monetized expected value of accidents. These can be evaluated from multiple perspectives, so “productivity” includes both the railroad’s productivity and the community at-large that may gain or lose based on how they interact with long trains.

The question of costs is a particularly important element for cost-benefit analyses that must precede any law or regulation. Because existing literature is sparse or does not evaluate costs,<sup>24</sup> much of this analysis is based on theory and available information, and will require more research.

### **Cost of Goods**

When we filter out all variables besides train length, the question of the cost of goods is determined by whether more goods can be moved and how efficiently they are moved. The price of goods at the store, for instance, are determined by a number of things, including supply and demand, but also the cost of raw materials, manufacture of the good, and transportation to get it to the store. Within this equation, it is the transportation question at issue.

The cost of transporting goods is itself dependent on a number of factors, namely time, personnel, and fuel. If more goods are placed on a single train that is efficiently run to a destination, the cost of goods will be cheaper than if half are placed on a second train that comes later. In other words, trains keep the cost of each good low based on having a high capacity.<sup>25</sup> A second train requires a second crew, fuel for additional locomotives, and more time. Limiting train length may also increase diversions to trucks for the additional freight, which is less cost effective than trains because a single railcar can carry as much freight as four truckloads.<sup>26</sup> By the same reasoning, however, many goods do move on trucks. If longer trains block crossings, it could also add to the time it takes goods to move by truck. At present, there is little to no data to suggest this is the case – nor to evaluate the impact. Trucks blocked at railroad crossings are most similar to general traffic in terms of time and costs.

### **Cost of Fuel**

Another measure of financial impact is the cost of fuel to power the train. Freight trains are capable of moving a ton of freight approximately 500 miles on a single gallon of diesel fuel. This is roughly four times more fuel efficient than moving similar loads by truck. This fuel efficiency helps keep the cost of shipping down and is partially attributable to the fact that trains can connect many railcars. Additional cars added to the same train take less marginal fuel than running multiple trains. One practical impact of limiting train length to 7,500 feet, for instance, is an approximate 13 percent increase in fuel consumption annually, according to the Association for American Railroads. That would require railroads to utilize over 420 million more gallons of fuel than present levels.

At an average per gallon price of diesel of four dollars, that would equate to \$1.69 billion in added cost every year. This cost is ultimately incorporated into the cost of goods, and also strains the market for fuel, which drives up the cost of fuel for truck drivers, commercial operators, and even the general public.

The fuel question can be illustrated most simply by visualizing the impact of additional rail cars. One additional rail car does not require an additional locomotive and only diminishes the fuel efficiency by a small margin. By contrast, splitting a train or truck diversions directly require more engines to move the freight. For diversions, the difference between 100 train cars and 150 train cars moving intermodal containers between Abilene, Texas and Kansas City, Missouri would be a difference of 245 trucks to 367 trucks, or 122 new trucks. The same 50 train cars can run on one train. This has added implications for carbon emissions, which we will evaluate in the next section.

### **Cost of Lost Productivity**

While previous discussion of blocked crossings focused on the productivity of the public who must wait for a train to move or find a detour, here we add another element – that the train itself is not moving.

Taking these in turn, the longer a train is, the greater likelihood of a blocked crossing at certain grade crossings. This will depend on both the train itself and any issues it may face, but also local track infrastructure and whether sidings or rail yards are nearby. One common occurrence is a train awaiting clearance to enter a rail yard and stopping short. This situation can result in blocked crossings if there are roads near the rail yard. Train length is related to this, because longer trains are more likely to block these nearby roads – but also longer trains may need longer sections of open track within the rail yard to enter, which may mean waiting longer for clearance. These delays have economic costs for the railroads, and by extension for the consumers of the materials and goods being transported.

Some delays are inevitable and uncorrelated to train length. Research finds that shorter trains experience disproportionate costs from delay relative to longer trains.<sup>27</sup> This means that long trains generate some cost immunity from unexpected delays and also that rules capping train length may result in more short trains moving that would then be penalized by market forces beyond control of the railroad, shipper, or other stakeholder.

Evaluating the cost of productivity must balance the increased efficiency of moving more goods on a single train – making the railroad more productive<sup>28</sup> – with the potential lost productivity associated with longer trains taking more time to get to their destination or blocking/delaying others from reaching their destination.

### **Expected Value**

A final consideration when it comes to costs is the expected value of something going wrong. Statistically, the likelihood of an accident is a calculable expected cost. If a derailment is predicted to occur once for every million train miles and will cost a million dollars in damage (both numbers being arbitrarily selected here) then the expected value in cost can be calculated based on how many trains are moving and how far they go.



As we explored previously, there are reasons to believe that safety is positively correlated with train length for certain issues. In that case, the expected costs would actually decrease with train length to an extent. However, for any risks that are increased by longer trains, such as worker fatigue or injury associated with walking a train length, the expected cost would increase with train length.

Other research has modeled train accident rates by differentiating between car-miles and train-miles;<sup>29</sup> “The concept of car-mile versus train-mile accident causes leads to the premise that, although longer trains are expected to experience more accidents than shorter trains, operation of longer trains results in a lower system-level accident rate.” This interesting finding helps explain the expected costs to individual carriers and to the general economy. Readers should note that this model and data predate key technologies and safety improvements made in the ensuing 15 years.

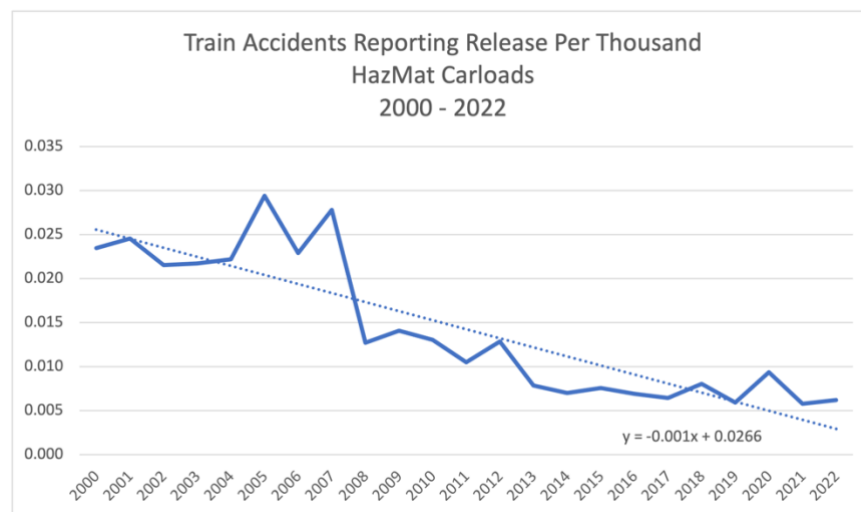
It is worth noting that if or where states prevent long trains, there may be additional economic impositions, such as trains stopping and offloading cars ahead of state borders. That may include splitting trains and running two trains through the state or moving cargo onto trucks. It may also mean railroad companies simply run multiple shorter trains from the beginning if they will move through states with this type of law or regulation. In each case, there are associated costs.

## Environmental Impacts

Contextualizing the relationship between trains and the environment is important. There are at least two main ways that trains interact with the environment. The most significant issue is the through release of hazardous materials during an incident, while fuel efficiency and carbon intensity follows.

### Hazardous Material Safety

Exploring hazardous material releases, we look to all reported train accidents and grade crossing incidents, each of which include collisions and derailments of the most serious nature. In each case, not only is no clear correlation between train length and hazardous material release noted, but the overall safety record is continually improving over time. As with previous analysis, the downward accident trend viewed in light of the upward train length trend creates a strong rebuttable presumption that even long and growing trains do not pose a safety or environmental risk.



Aii Figure 18: Rate of Hazardous Material Accidents<sup>30</sup>

The graph expressed above presents the rate of hazardous material release per thousand hazmat carloads. It is near its lowest level in decades, having fallen over 70 percent since 2000. In fact, between just 2008 and 2017, this hazmat release rate fell by 50 percent<sup>31</sup> despite train length increasing by 25 percent.<sup>32</sup>

While we take known train length increases as a background condition when viewing this declining rate of train accidents with a release of hazardous material, we can also break train accidents down by train length. Similar to train accidents themselves, casualty numbers, and costs, the clear majority of incidents involving a hazardous material release skew toward lower car counts. In fact, from 2000 to 2022, only three “very long train” were involved in a train accident that reported cars releasing hazardous materials. Those incidents involved trains of 201 cars, 209 cars, and 225 cars, and combined, they had six total cars releasing hazardous materials. No reported releases were associated with trains longer than 225 cars.



From the FRA data available, less than one percent of train accidents involve a release of hazardous materials, and when evaluated by train length, most involve “typical” train lengths.

| Train Accidents With Reported Release of Hazardous Materials, 2000 - 2022 |                                     |                      |                            |
|---|-------------------------------------|----------------------|----------------------------|
| Car Count   | Train Accidents With HazMat Release | % of HazMat Releases | % of Total Train Accidents |
| 0-35  | 98                                  | 20.21%               | 0.17%                      |
| 36-70   | 109                                 | 22.47%               | 0.19%                      |
| 71-105  | 159                                 | 32.78%               | 0.28%                      |
| 106-140   | 87                                  | 17.94%               | 0.15%                      |
| 141-175   | 25                                  | 5.15%                | 0.04%                      |
| 176-210   | 6                                   | 1.24%                | 0.01%                      |
| 211-245   | 1                                   | 0.21%                | 0.00%                      |
| 246-280   | -                                   | 0.00%                | 0.00%                      |
| 281+  | -                                   | 0.00%                | 0.00%                      |
|   |                                     |                      |                            |
| <b>Total with HazMat Release</b>  | <b>485</b>                          |                      |                            |
| <b>Total Train Accidents</b>  | <b>57,198</b>                       |                      |                            |

*Aii Figure 19: Release of Hazardous Material by Car Count and Percentage*

There is also no correlation between longer trains and hazardous material releases with respect to incidents at highway grade crossings. The overwhelming majority of gallons of hazardous materials lost have occurred with train consists of less than 140 cars. Trains with 141 to 210 cars only reported a total of 550 gallons of hazardous materials lost in the 23 years between 2000 and 2022. Only a single crossing incident since 2000 reported a release of hazardous materials in a “very long” train. For trains longer than 225 cars, zero incidents reported a release of hazardous materials from a crossing incident.

Overall, data supports a 99.99 percent effectiveness rate for moving hazardous material by rail to its destination without incident:

Hazardous products transported by rail tanker car arrive at the destination over 99.99 percent of the time without a release caused by a train accident. The leak, spill, or accident rate below 0.01 percent makes rail the second safest in-land transportation method with rail spilling the least volume of hazardous material of any in-land method. Overall, in comparison to other forms of transportation, oil is spilled from railroad transports more frequently than pipelines, however rail loses significantly less oil from accidents in comparison to pipelines, given the larger volumes moved by pipe. Rail effectively transports between 100 million and 200 million barrels of crude and petroleum products each year.<sup>33</sup>

In line with analysis around safety and costs, it is important to assess the impact of running multiple trains and diversion of hazardous material onto trucks. While the risk of derailment is statistically small on a modern freight train, the risk is theoretically increased by running two trains with hazardous material loads relative to running a single longer train. Similarly, trucks move hazardous materials safely over 99 percent of the time, but move on much more dynamic and unpredictable roadways relative to track-bound rail infrastructure. The risk of a roadway

accident is much higher than a rail accident, making the marginal shift from train to truck for hazardous materials a greater risk to the environment.

Finally, it is true that regardless of the contributing cause (i.e. even if train length does not cause the accident), for derailments that do occur, the longer the train, the more train cars and tankers there are that may derail or release hazardous materials. If a long train derails because of a human error or equipment malfunction that can definitively be separated from the length, the great number of cars may still generate environmental risk.

Similarly, there is a marginal impact of train length on other accident types simply by prolonging the stopping time of a train. Longer trains are heavier and have more momentum than shorter trains (depending in part on the cargo and consist) meaning that potential issues like overheated wheel bearings may be more difficult to slow and stop to address. In that event, the precise relationship between train length and any resulting derailment and release of hazardous material must be rigorously and precisely investigated. Law and regulation should not be made on broad assumptions.

### **Climate Impact**

Outside of rare hazardous material releases, the primary environmental impact of rail is operational emissions, which do not have the type of acute and local impact, but a much more marginal, diffuse, and global one. These emissions come from diesel fuel combustion to power locomotives.

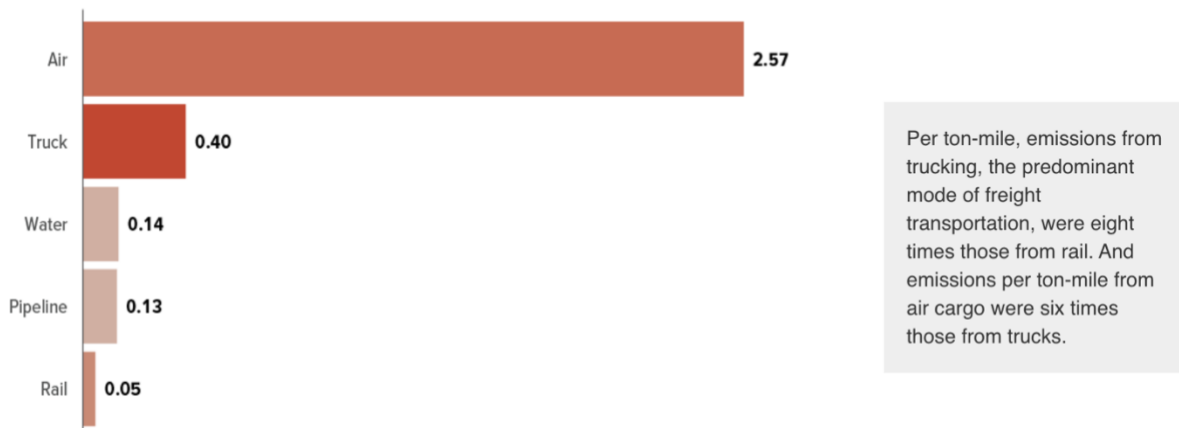
Within the transportation sector, rail accounted for only 1.7 percent of greenhouse gas emissions in 2021, lower than any freight-moving alternative.<sup>34</sup> What's more, companies are advancing their fuel efficiency and reducing emissions by blending renewable fuels and deploying battery-electric locomotives.<sup>35</sup> Over time, in part due to increasing train length as well as more efficient consists, logistics, and technology, freight rail has reduced its fuel consumption. On this front, train length is almost exclusively correlated with climate impact in a positive way – meaning beneficial.



**Within the transportation sector, rail accounted for only 1.7 percent of greenhouse gas emissions in 2021, lower than any freight-moving alternative.**

## Average Carbon Dioxide Emissions per Ton-Mile of Freight, by Mode of Transportation, 2019

Pounds of Carbon Dioxide per Ton-Mile



*Aii Figure 20: Carbon Dioxide Emissions Rate for Freight Transport<sup>36</sup>*

Trains are one of the most fuel efficient ways to move freight and cargo, and over land are unmatched for moving these loads long distances. By nature, linking train cars allows more freight to be attached to the same locomotive(s) with minimal reduction in fuel efficiency. It requires less fuel to add marginal train cars to the consist than to add those same additional cars to a separate, second train. According to the Association of American Railroads, limiting train length to 7,500 feet, for instance, would result in an approximate 13 percent increase in fuel consumption annually. That would require railroads to utilize over 420 million more gallons of fuel than present levels. This has a direct impact of emissions coming from the diesel-powered locomotives.

Another alternative to running multiple trains – a direct and natural consequence of any rule setting a cap on train length – is to divert freight to trucking. On average, a freight train can move a ton of freight nearly 500 miles on a single gallon of diesel, while the average truck moves this same ton just over 100 miles on one gallon of diesel. On top of trucks having only a quarter of the fuel efficiency, a train car can carry more than twice the freight load of trucks. For example, 100 rail cars of intermodal cargo moving from Charleston, SC to Washington, D.C. is the equivalent to 245 trucks. That load moving by train rather than truck prevents over 160 tons of carbon dioxide emissions.<sup>37</sup> This means that where possible, diversions from truck to (longer) train result in a net reduction in emissions – which is also likely larger than just the difference between truck and train emissions, because it may reduce traffic and congestion on public roadways.

### Externalities

The costs and impacts that are created by longer trains but not fully internalized by the rail industry may include certain environmental impacts. With blocked crossings being the primary consideration for long trains, the main externality is traffic and idling of road vehicles. These contribute to emissions, as vehicles burn fuel and stay on the road longer than they would if no crossing was blocked. The overall impact of this is unknown, as the federal government is still collecting data on blocked crossings and among the variables at play are population density, road

architecture, time of day, proximity to rail yard, number of trains moving, train length, and many more. If the data demonstrates that there is a statistically significant increase in blocked crossings that is causally connected to train length, it must still be evaluated in net terms against the emissions avoided or prevented by using a longer train. The data is not available at this time.

A final externality is once again a possible consequence of long trains that is not necessarily causally related. If a train derails for whatever reason, the greater number of cars may also require more emergency vehicles to respond, lead to more emissions or releases of hazardous materials, and impact communities for weeks as clean up and remediation is undertaken. These risks can be mitigated through improved inspections and maintenance along with technology.

More research by the federal government is underway. With this report providing some considerations and frameworks for analysis, we conclude that train length is not fully understood and while it may impose costs, it also has clear benefits. Regulators and lawmakers must understand and balance these costs and benefits before altering the rules and regulations of this critical component of the supply chain. Regulating based on costs without appropriately factoring in the benefits will create its own negative externalities.

## Balanced Policy Opportunities

In fulfilling a directive from Congress, FRA has issued a proposed information collection request for industry data on train length.<sup>38,39</sup> While the only way to get public data on train length is to use accident reporting forms, the new collection plan appears to solicit monthly operational reports from Class I railroads. This would go toward establishing a baseline of data and settling definitively any correlation – positive or negative – between train length and a range of impacts such as safety, economic costs and benefits, and environmental impact. As the FRA notes, this action may merely “justify the status quo” rather than find any issues:

This data collection is necessary to allow objective findings to be made that can be used to either justify the status quo or to provide justification for further recommendations or agency action. Of note, FRA is seeking to collect data on train length on an ongoing basis, as opposed to this being a one-time study.<sup>40</sup>

This would show the overall safety rate. Current data allows the public to view accident numbers, but by collecting “on a monthly basis...data regarding the total number of trains operated, the total number of cars in those trains, as well as the total trailing tonnage in specified train length categories,”<sup>41</sup> FRA will have a clear and conclusive view of operational safety and accident rate by train length – particularly data on trains that are *not* involved in an accident, something that until now has had to be inferred from accidents per million train miles and similar statistics. The proposed collection does have feasibility concerns given the level of detail sought.

The proposed collection also seeks train length not merely in car count but in feet. This appears to be in ranges rather than precise measurements “(e.g., less than or equal to 7,500 feet, greater than 7,500 feet),”<sup>42</sup> however it is somewhat unclear. Providing more clear and precise instructions would reduce compliance costs – which are expected to be substantial and burdensome – that are certain to accrue for railroads soon to be under regulatory obligation to collect and submit new information. Car counts are already collected, including locomotives,



loaded freight, unloaded freight, loaded passenger, unloaded passenger, and caboose, but as noted previously, car length has changed over time.

With respect to the proposed collection, the excerpted quote above demonstrates FRA's ambition to collect this "on an ongoing basis" rather than "one-time study." This presumably means for a number of years. In July, the FRA published its latest notice<sup>43</sup> stating no reference to duration. In pursuit of good public policy, this should be construed conservatively to exactly the timeframe Congress instructed from the date of the first monthly collection. Clear and abundant data is good, but indefinite collection may have diminishing marginal returns while continuing to impose compliance costs.

States should consider waiting until this federal study is complete and refrain from implementing train length rules and restrictions unless or until regionally specific factors and copious data make clear that an issue is present, and a well-tailored policy can effectively address it. As FRA stakeholder research demonstrates, there is consensus among companies, labor, and regulators that "The safety of a given train was dependent on contextual factors that go beyond train length."<sup>44</sup> They went on, stating that "According to stakeholders, contextual factors that can increase safety risk include the territory characteristics over which the train operates, track infrastructure, equipment and technology, train makeup, and operational practices."

Should any length restriction on freight trains be applied – though none is warranted from existing data – it should not be a fixed and general rule. It should be as narrowly tailored as possible to avoid imposing costs on railroads and their customers. For example, a train running through a densely populated and highly trafficked metropolitan area with numerous crossings is entirely different from a long-haul route that spans hundreds of miles with few or no crossings. Likewise, a train carrying mixed cargo in intermodal containers is vastly different from a single-commodity train of coal or one with certain hazardous materials.

A rule that applies to both dissimilar trains without distinction is inefficient. Additional considerations should be applied based on factors such as<sup>45</sup> traffic mix, region/terrain, population density, presence and volume of hazardous materials, train makeup, gross weight, integration of positive train control technology and similar tools, crew size, ground-based crew availability, automatic track inspection technology, season, and economic value.

## **Conclusion**

The federal government is proceeding to collect more information on train length. Congress has instructed the Federal Railroad Administration to undertake such a collection to acquire what should be definitive answers to the question of train length and its effect on safety, the economy, and the environment. In the meantime, an adequate volume of data is available to assess these factors, and the results should be considered by all in a policymaking or regulatory role.

The purpose of this independent study is to survey the impacts and implications of longer trains to the U.S. public safety, the economy, and the environment. Because railroads are so central to the nation's supply chain and transportation network, it is essential that the public and policymakers know and weigh both the costs and benefits of train activity. With the recent attention on longer trains, it is important to lay out a framework for evaluation.

While available data does demonstrate benefits, we do not assert a causal link between longer trains and safer movement, better economic conditions, or less environmental impact. There is data to support these claims, counter to the popular belief that train length correlates solely with negative externalities. The available data does not show that longer trains are unsafe, costly, or that they pose novel environmental risks. Such conclusions are simply precluded by the available data.

Over the past two decades, rail has seen safety improvements even while train length has increased. In turn, the increase in train length has other implications for the public. Given the projected increase in demand for moving cargo in the future, we will have to move more freight. If that is done on longer trains, it may block crossings or lead to other externalities. However, if it is done on a greater number of shorter trains, it will likely also block crossings. These tradeoffs must be accepted by policymakers before making new rules or regulations. Further, a thorough understanding of the benefits from trains of all lengths is essential to weigh against any known or future-discovered costs.

Finally, the advent of positive train control (PTC) technology, improved track inspection technology, equipment inspection technology, and related innovative solutions<sup>46</sup> has been linked to improved rail safety. The use of PTC and related technology can be expected to maintain rail safety even on longer trains. New rules and regulations that impose any costs should carefully evaluate the effects they may have on diminishing investment in research, development, and deployment of innovative technology that has proven to unlock substantial gains in safety and efficiency.

## Citations and Notes

<sup>1</sup> “However, we were not able to verify increases more broadly because FRA, STB, and AAR do not collect comprehensive data on train length in feet, and while such data are collected by Class I railroads, they are not publicly available.” See, U.S. Government Accountability Office. (May, 2019). *Rail Safety, Freight Trains Are Getting Longer, and Additional Information Is Needed to Assess Their Impact*. <https://www.gao.gov/assets/gao-19-443.pdf>.

<sup>2</sup> Association of American Railroads. (2023). <https://www.aar.org/topic/industries-we-support/>.

<sup>3</sup> *Id.*

<sup>4</sup> There is not a standard federal definition of “long train” but given reports and proposed legislation, consistent with Association of American Railroads in Figure 1 below, greater than 150 cars is a useful metric.

<sup>5</sup> Multer, J., et al. (2023). *Stakeholder Perceptions of Longer Trains*. U.S. Department of Transportation, Federal Railroad Administration. [https://railroads.dot.gov/sites/fra.dot.gov/files/2023-02/Stakeholder%20Perceptions%20of%20Longer%20Trains\\_Final\\_-A.pdf](https://railroads.dot.gov/sites/fra.dot.gov/files/2023-02/Stakeholder%20Perceptions%20of%20Longer%20Trains_Final_-A.pdf).

<sup>6</sup> *Id.*

<sup>7</sup> “According to the 2022 Railroad Fact Book, the average number of cars on a train on the East Coast for 2020 and 2021 (avg. around 73 cars) was similar to the number in 1985-1990 (avg around 74 cars). For the West Coast, which is not as populated their 2021-2020 avg is similar to their avg in 2010-2011 (lower 80’s). Yes, cars have gotten a little bigger but seems avg # cars on a train is what they were decades ago. Which of course equates to about 220 trucks on the East Coast and 250 trucks on the West per train.”

<sup>8</sup> Thus, cutting out yard, industry, or unspecified track.

<sup>9</sup> While cabooses are largely phased out of the industry or used in switching, they remain listed on accident reporting forms and are included in the analysis here, despite most total train car counts not including a caboose.

<sup>10</sup> This does not count locomotives.

<sup>11</sup> “Others” in *Aii Figure 6* are reported casualties that are not railroad employees or passengers.

<sup>12</sup> Form FRA F 6180.57.

<sup>13</sup> See *Aii Figure 2*.

<sup>14</sup> <https://www.fra.dot.gov/blockedcrossings/>.

<sup>15</sup> *Id.*

<sup>16</sup> Train accidents involving 0-35 train cars divided over \$2 billion in reported costs across nearly 30,000 incidents over this time period, while for trains longer than 280 cars, due to the rarity of their accidents, approximately \$4 million was divided by only 7 accidents since 2000.

<sup>17</sup> Vasic, G., et al. (2012). *Development of the Future Rail Freight System to Reduce the Occurrences and Impact of Derailment, Report on Derailment Economic Impact Assessment*. [https://d-rail-project.eu/IMG/pdf/DR-D1-2-Report\\_on\\_Derailment\\_Economic\\_Impact\\_AssessmentFinal-v1.pdf](https://d-rail-project.eu/IMG/pdf/DR-D1-2-Report_on_Derailment_Economic_Impact_AssessmentFinal-v1.pdf).

<sup>18</sup> We emphasize “**average**” train incident because there will certainly be incidents in densely populated environments and at crossings, in which the public faces costs comparable to and exceeding that of the damage to the railroad’s own costs. However, many train incidents that result in direct equipment and track damage costs occur in remote areas, within rail yards, or are limited to track and siding, leaving little or no public damage at all. In such instances, the direct and indirect costs would be 1, that is, only the damage costs, while in some, there exists a multiplier higher than 2. The most likely **average** is between 1 and 1:5.

<sup>19</sup> Cantwell, M. (2021). *Railroad Crossing Congestion and its Impact on Safety and Efficiency*. United States Senate. <https://www.commerce.senate.gov/services/files/E475D567-4922-4C1C-806A-77BBCF8592FC>.

<sup>20</sup> *Supra* note 14.

<sup>21</sup> With respect to traffic congestion – whether caused by slow-moving trains or extended idling occupying a crossing – ongoing research and experimentation between the Federal Railroad Administration and other public agencies seeks to provide real-time traffic updates to drivers. Such a concept may look like smart phone map applications providing alternative routes. For an industry example of this innovation still being developed, see Canadian company, TRAINFO (<https://trainfo.ca/>).

<sup>22</sup> *Id.*

<sup>23</sup> *Id.*

<sup>24</sup> See for example, note 1.

<sup>25</sup> Union Pacific. (2023). *Pros & Cons of Rail: Shipping Cost, Speed, Capacity and More*. <https://www.up.com/customers/track-record/tr082019-rail-pros-cons.htm>.

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- <sup>26</sup> RSI. (2020). *Comparing the Costs of Rail Shipping vs Truck*. <https://www.rsilogistics.com/blog/comparing-the-costs-of-rail-shipping-vs-truck/>.
- <sup>27</sup> Lovett, A., et al. (2015). *Determining Freight Train Delay Costs on Railroad Lines in North America*. Rail Transportation and Engineering Center, University of Illinois at Urbana-Champaign. <https://railtec.illinois.edu/wp/wp-content/uploads/2019/01/Lovett-et-al-2015-IAROR.pdf>.
- <sup>28</sup> Stagl, J. (2018). *Class I railroads continue the longer-train trend*. Progressive Railroading. [https://www.progressiverailroading.com/bnsf\\_railway/article/Class-I-railroads-continue-the-longer-train-trend--55035](https://www.progressiverailroading.com/bnsf_railway/article/Class-I-railroads-continue-the-longer-train-trend--55035).
- <sup>29</sup> Schafer, D. (2008). *Effect of Train Length on Railroad Accidents and Quantitative Analysis of Factors Affecting Broken Rails*. University of Illinois at Urbana-Champaign. <https://railtec.illinois.edu/wp/wp-content/uploads/pdf-archive/DarwinSchaferThesis.pdf>
- <sup>30</sup> Data from analysis of FRA, PHMSA, and Bureau of Explosives databases. Consistent with information published by the Association of American Railroads.
- <sup>31</sup> See Aii Figure 18.
- <sup>32</sup> *Supra* note 1.
- <sup>33</sup> Dierker, B. (2020). *How the U.S. Moves Hazardous Materials: A side-by-side comparison of transportation methods for critically needed materials*. Alliance for Innovation and Infrastructure. <https://www.aii.org/wp-content/uploads/2023/01/How-the-U.S.-Moves-Hazardous-Materials.pdf>
- <sup>34</sup> Environmental Protection Agency. (2023). *U.S. Transportation Sector Greenhouse Gas Emissions 1990-2021*. <https://www.epa.gov/system/files/documents/2023-06/420f23016.pdf>.
- <sup>35</sup> BNSF. (2022). *Annual Report, Carrying Out Our Commitment To Protect The Environment*. BNSF Railway. <https://www.bnsf.com/about-bnsf/bnsf-review/2022/environment.html>.
- <sup>36</sup> Swagel, P. (2022). *Emissions of Carbon Dioxide in the Transportation Sector*. U.S. Congressional Budget Office. <https://www.cbo.gov/publication/58861#:~:text=In%202019%2C%20CO2%20emissions,all%20lower%20per%20passenger%2Dmile>.
- <sup>37</sup> Association of American Railroads. (2023). *Carbon Calculator*. <https://www.aar.org/carbon-calculator/#charleston-sc/washington-dc/consumer-goods-intermodal/100>.
- <sup>38</sup> 88 FR 47233. Retrieved from: <https://www.federalregister.gov/documents/2023/07/21/2023-15437/proposed-agency-information-collection-activities-comment-request>
- <sup>39</sup> <https://www.regulations.gov/docket/FRA-2023-0002/comments>
- <sup>40</sup> *Supra* note 38.
- <sup>41</sup> *Id.*
- <sup>42</sup> *Id.*
- <sup>43</sup> *Supra* note 38.
- <sup>44</sup> *Supra* note 5.
- <sup>45</sup> Although not necessarily, and among others
- <sup>46</sup> Other recent innovations include widespread use of AC locomotives (which are cost and energy efficient and can reduce overheating concerns), increased adoption and reliability of on-board and wayside digital and voice communications systems, more sophisticated distributed power systems, energy management systems, two-way end-of-train devices, higher strength coupling systems, end-of-car cushioning, automated single car air brake tests, and more.





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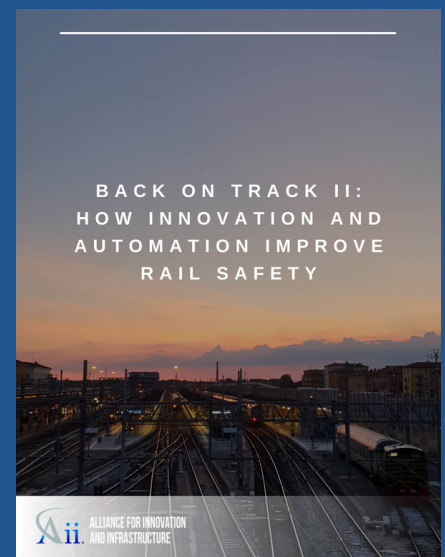
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