An FRA study examined the causes behind an approximately 65 percent drop in injuries, fatalities, and collisions at highway–rail grade crossings.

Railroads and Research Sharing Track

Success Factors in the Reduction of Highway–Rail Grade Crossing Incidents

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In the past 20 years, safety at public highway–rail grade crossings has improved significantly. Despite increases in motor vehicle and train traffic, collisions at grade crossings have declined by approximately 65 percent, fatalities by approximately 63 percent, and injuries by approximately 65 percent (*1*).

The collaboration of many agencies and organizations that share the goal of reducing grade crossing incidents, fatalities, and injuries has driven these trends. In addition, major research initiatives by the Federal Railroad Administration (FRA) have provided the information to support implementation of industry guidance, policies, and rules, which have provided a significant safety benefit.

The improvements in grade crossing safety were evident, but the factors and initiatives that contributed to the successes had not been identified. FRA therefore funded a two-phase study to determine the safety factors that had an impact on the reduction of highway–rail grade crossing incidents from 1994 to 2007 (*2, 3*). The study identified possible factors in grade crossing incident reduction and applied data from the FRA Railroad Accident–Incident Reporting System (RAIRS) to estimate the impact of each factor. A similar study by Mok and Savage focused on the reduction in grade crossing incidents and fatalities from 1975 to 2001 and credited highway safety improvements as the greatest influence on safety (*4*).

Identifying Success Factors

Extensive reviews of the literature and discussions with subject matter experts identified 11 factors as likely contributors to the improvement in grade crossing safety. The factors included rulemakings, changes or advances in the grade crossing and transportation environment, and political, societal, and economic changes. Most of the 11 factors were associated with a significant FRA research effort.

Commercial Driver Safety

During the period of study, national legislation placed a greater emphasis on commercial driver safety. The Motor Carrier Safety Improvement Act of 1999 established the Federal Motor Carrier Safety Administration, with the primary mission of reducing crashes, injuries, and fatalities involving large trucks and buses. In October 1999, the law on Commercial Driver Disqualification stated that the licenses of commercial drivers convicted of violating warning devices at a highway–rail grade crossing would be suspended.[1]

Locomotive Conspicuity

Making locomotives more conspicuous aids drivers not only in seeing an oncoming train, but in judging its distance and speed. The Locomotive Safety Standards, effective December 1997, stated that all locomotives that exceed 20 mph at a crossing must have auxiliary alerting lights in addition to the headlights.[2]

[1] 69 Code of Federal Regulations (CFR) 48104.

[2] 49 CFR 229.

Before the rulemaking, FRA undertook research to evaluate the effects of various locomotive headlight configurations on motorists' decision making and published the results (*5*).

More Reliable Motor Vehicles

Automobiles manufactured during the period of study increased in safety and reliability. A more reliable vehicle reduces the possibility of breaking down or stalling while crossing railroad tracks and being struck by an oncoming train.

Sight Lines Clearance

The clearing of vegetation and the removal of obstructions at grade crossings enables highway users to observe the tracks and any oncoming trains at farther distances from the crossing. Adequate sight distance allows highway users to stop safely, reducing the risk of collision with an unexpected or undetected train. The U.S. Department of Transportation established a technical working group in 2002 to determine calculations for adequate sight distance (*6*).

Grade Crossing Maintenance Rule

The final rule on Grade Crossing Signal System Safety, issued in 1995, stated that railroads must implement specific maintenance, inspection, and testing requirements for active crossing warning systems.[3] Regular maintenance and inspection were intended to reduce the risk of warning device malfunction.

[3] 49 CFR 234.

Photo: TRB Staff

FRA requires all locomotives exceeding 20 mph at a crossing to have auxiliary alerting lights—which increase perceptibility for drivers—as well as headlights.

Photo: Brett VA

Street markings and flashing lights at a Washington State rail crossing protect pedestrian traffic.

Freight Car Reflectorization

The final rule on Reflectorization of Rail Freight Rolling Stock, effective March 2005, mandated the application of retroreflective sheeting to the sides of freight cars and locomotives in a specified color and pattern. FRA conducted extensive research to determine the value of adhering reflectors to freight rail cars and the optimal size and pattern for the application.[4] The full research report was published in 1999 (7).

Pedestrian Safety

New devices and technologies installed at grade crossings protect pedestrian traffic. The FRA Office of Safety has worked with states, railroads, and other stakeholders to identify and catalogue pedestrian-specific treatments at highway–rail grade crossings (*8*).

[4] 49 CFR 224.

Photo: Andrew Bossi

Construction crews build a bridge to grade-separate a CSX crossing in Bladensburg, Maryland. U.S. Congress appropriated funds to improve highway–rail grade crossings under Section 130, Title 23, of the U.S. Code.

Crossing Closure and Grade Separation

In 1991, the FRA Administrator recommended the closing of 25 percent of all crossings. Of the 292,839 public and private at-grade crossings at the end of 1990, 70,004 had been closed as of 2008. Closures and grade separations reduce the risk of a collision to nearly zero.

Warning Device Upgrades

Upgrading to crossing warning devices that have a higher effectiveness value reduces the risk of a collision. States and communities routinely evaluate warning devices at crossings for upgrades and safety improvements.

Education and Enforcement

Communities are taking a proactive approach by educating the public on the dangers of highway–rail grade crossings and by discouraging risky behavior at crossings with active enforcement. Operation Lifesaver is an international organization that provides education and awareness programs to prevent tragic collisions, fatalities, and injuries at highway–rail grade crossings and on railroad rights-of-way. The FRA-sponsored Public Education and Enforcement Research Study traced the effects of the initiatives on reducing risky behavior at highway–rail grade crossings (*9*).

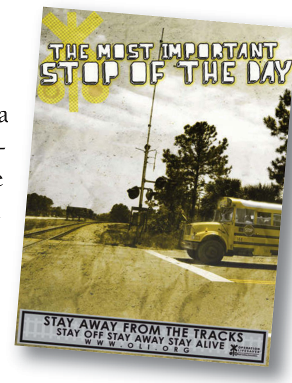

Image: Operation Lifesaver

Operation Lifesaver posters and other safety resources bring public awareness to safety at rail crossings and railroad rights-of-way.

Crossing Improvement Programs

Congress appropriates highway funds for safety improvements to highway–rail grade crossings under Section 130, Title 23, of the U.S. Code. States apply the funds, and each state implements its own crossing improvement plan. The Section 130 program overlaps other success factors, since the funds are used also to close, separate, and upgrade crossings.

Research Methodology

The first phase of the research on success factors analyzed the reduction in highway–rail grade crossing incidents from 1994 to 2003. The second phase analyzed the continued decline in incidents from 2003 to 2007.

Seven of the 11 factors considered in the study were estimated with data from the RAIRS: commercial driver safety, locomotive conspicuity, grade crossing maintenance, more reliable motor vehicles, sight lines clearance, freight car reflectorization, and pedestrian safety. The remaining four were analyzed qualitatively and with data from outside RAIRS: warning device upgrades, education and enforcement, crossing improvement programs, and crossing consolidation–grade separation.

The RAIRS data fields indicated that the incident characteristics implied the influence of one or more of the factors. For example, an incident with a commercial vehicle would be influenced by the commercial driver safety factor. Assigning incidents to the success factors made it possible to analyze the factors' impacts.

The impact of the factors analyzed with grade crossing data from RAIRS was estimated with two metrics—percent impact and percent reduction. The percent impact is the percentage of incidents attributable to behaviors that the factor was attempting to change. The percent reduction is the percentage of incidents reduced that can be attributed to the safety countermeasures. Together, these two metrics provided a complete estimate of the factors' impact on the reduction of incidents.

To estimate each factor's contribution to improving highway–rail grade crossing safety, each incident during the study period was assigned to an individual factor, to a combination of factors, or to no identified factor. The assignment was made based on the RAIRS data fields for each incident. If the characteristics of the incident indicated multiple factors, it was assigned to a combination of factors; if none of the factor characteristics was present in the incident, it was assigned to no identified factor. This ensured that the incidents were not counted multiple times for different factors, inflating the factors' impacts.

The contributions of the factors that were not analyzed with RAIRS data were investigated through other relevant studies and with data available from other sources, such as the National Highway–Rail Grade Crossing Inventory.

Results and Analyses

The percent impact and percent reduction were calculated for the factors in each phase of the study. The results are shown in Table 1 (below).

During the first phase, from 1994 to 2003, improvements in commercial driver safety and locomotive conspicuity made the largest contributions to the reduction in incidents. The analysis during the second phase revealed that the safety benefits from regulations and measures introduced during the 1990s had been fully realized by 2007.

The study from 2003 to 2007 was a shorter period, with fewer incidents included in the analysis, which magnified any variability in the annual data. Negative values in the results table do not imply that the factor caused an increase in incidents, but that no further benefits were derived from those factors after the first phase.

Two additional factors were included in the second phase of the study: pedestrian safety and freight car reflectorization. Neither the RAIRS Grade Crossing database nor the Crossing Inventory indicates the type of pedestrian warning device or treatment at a crossing. Therefore, evaluating the effects of pedestrian warning devices was not possible; the data show the trend of pedestrian incidents as a whole.

The increase in pedestrian incidents from 2003 to 2007 did not reflect the effectiveness of any particular warning device or safety program. This could be a result of variability and fluctuations from year to year because of fewer incidents during the second phase of the study. The finding also could indicate that the installation of new pedestrian devices should be more widespread.

PHOTO: MICHAEL HICKS

Warning device upgrades were among the success factors considered in the FRA study.

TABLE 1 Percent Impact and Percent Reduction for Identified Success Factors

	Percent Impact		Percent Reduction	
	1994–2003	2003–2007	1994–2003	2003–2007
Commercial driver safety	21.8	18.7	34.6	1.02
Locomotive conspicuity	15.0	15.5	15.6	–5.1
Grade crossing maintenance	1.2	1.4	3.1	4.6
More reliable motor vehicles	1.9	1.6	3.1	3.1
Sight lines clearance	2.6	1.8	3.7	4.6
Freight car reflectorization	-	1.0	-	5.1
Pedestrian safety	-	1.8	-	–8.7

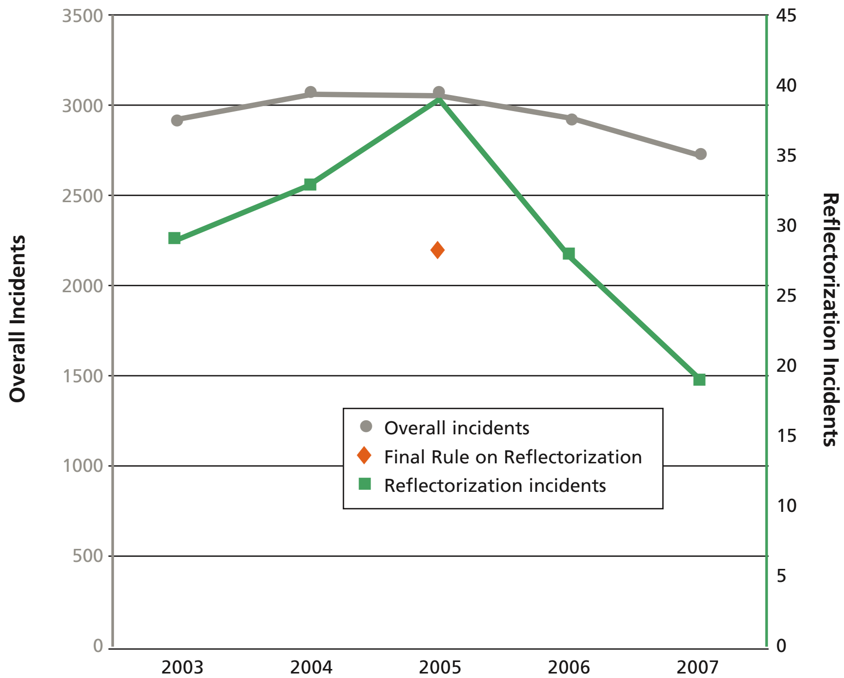

FIGURE 1 Reflectorization incidents and overall incidents, 2003–2007.

Although the time period for the second phase was shorter and the data set therefore less extensive, the improvements from making freight cars more visible with reflectorization were evident after the passage of the 2005 rule. Figure 1 (above) presents the impact of the improvements.

Although analyzed with a different methodology and additional data sources, warning device upgrades and crossing closures were effective strategies in improving safety at grade crossings. Crossing closures eliminate nearly all risk of incidents, injuries, and fatalities at that location; crossing closures showed one of the strongest impacts on the reduction in incidents. The effects of education and enforcement and of crossing improvements were difficult to analyze quantitatively, but other studies and reports have indicated the effectiveness of these factors in improving highway–rail grade crossing safety.

Value of Research Investments

These findings highlight the value of several major research initiatives undertaken by the federal government and industry to improve highway–rail grade crossing safety. During the study of success factors for 1994 to 2003, commercial driver safety and locomotive conspicuity were the two greatest successes in reducing incidents. Although the number of incidents related to freight car reflectorization was relatively small during the 2003 to 2007 study period, the data showed a discernible downturn after the final rule went into effect in 2005. Crossing closures also showed a significant impact on the reduction of incidents.

Many of the factors identified were the result of major research initiatives by the federal government, industry, or other stakeholders. The research investment in highway–rail grade crossing safety has provided significant safety improvement. The implementation of the research investments, particularly for locomotive conspicuity and freight car reflectorization, has yielded real-world safety benefits. The study results also revealed factors that did not have an impact on the reduction in incidents or that have not fully realized the benefits. These results highlight areas for new safety research efforts.

Investing in highway–rail grade crossing safety research has reduced the number of incidents between highway users and trains. FRA continues to improve highway–rail grade crossing safety with research and development.

This study underscores the value of investing in safety-related research and using the results in regulatory, policy, or technological changes and advances. The differing results from the two phases of the study also show the need for research to evolve and to identify and explore new means to improve safety at highway–rail grade crossings.

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