In-Service Evaluation of Railroad Signal and Stop Arm Pole Protection

tech transfer summary

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RESEARCH PROJECT TITLE
In-Service Evaluation of Railroad Signal and Stop Arm Pole Protection

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While active warning systems at railroad crossings have been found to be effective at reducing vehicle-train crashes, limited research and guidance is available on crashes involving warning system infrastructure.

Objective

The main objective of this study was to provide guidance on the design of railroad-highway at-grade crossings, specifically in terms of the location of railroad mast arms/poles and the viability of using guardrails to shield these devices from crashes with errant motor vehicles.

Background

Safety at railroad-highway at-grade crossings has been a longstanding concern for transportation agencies. Active warning devices, such as train-activated flashing lights, gates, and overhead cantilever beams, have been installed at crossings in the US and many other countries to reduce the risk of train-involved crashes.

While these treatments have been found to be effective, their presence introduces the risk of errant vehicles striking the signal masts, crossing gate mechanisms, cantilever supports, signal controller boxes, and related infrastructure. These structures are currently not designed to be crashworthy.

To mitigate the impacts of crashes involving railroad infrastructure, barriers such as guardrails or crash cushions are sometimes installed at or near at-grade crossings to protect motorists or to shield the infrastructure.

Justin Cyr 2018, CTRE

Longitudinal guardrail protecting a signal mast in Elkhart, Iowa

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Problem Statement

While significant efforts have been made to investigate crashes between motor vehicles and trains, limited research and guidance is available on crashes involving railroad infrastructure.

The Federal Railroad Administration (FRA) does not report crashes that only involve railroad infrastructure. Similarly, state and federal databases, such as the Iowa Crash Analysis Tool (ICAT) and the Fatality Analysis Reporting System (FARS), do not include fields to identify crashes involving rail infrastructure.

Moreover, guidance on placing and shielding railroad infrastructure is limited in sources such as the Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices for Streets and Highways* (commonly known as the MUTCD), the American Association of State Highway and Transportation Officials (AASHTO) *Roadside Design Guide* (RDG), and the FHWA *Railroad-Highway Grade Crossing Handbook*.

Research Description

The research involved a state-of-the-practice review, an analysis of crash rates and severities at railroad crossings in Iowa, and a benefit-cost comparison of simulated scenarios involving different infrastructure placement and shielding options.

The FHWA and AASHTO guidance publications were consulted to compile recommendations on the crashworthiness and placement of railroad-crossing warning devices and the use of barriers to protect this infrastructure. Design standards and guidance on the use of guardrails to shield railroad signals were identified for seven states, including Iowa.

Officials from various railroad and highway transportation agencies were also surveyed to explore the prevalence of crashes involving railroad infrastructure and the use of protective barriers.

An inventory of public at-grade railroad crossings with active warning signals, information on the corresponding roadways, and information on guardrail and barrier locations were compiled from Iowa Department of Transportation (DOT) and FRA sources. Ten years (2007 through 2016) of crash data were gathered from the Iowa DOT through the Traffic and Criminal Software (TraCS) reporting system and supplemented with crash report narratives.

A total of 1,853 railroad crossings and 156 railroad infrastructure-related crashes were identified, including 1 fatal crash and 4 major injury crashes. Most of the remaining crashes were of moderate to low severity. A negative binomial model was estimated to analyze crash rate, and an ordered logit model was used to estimate crash severity.

Scott Cyr 2018, used with permission

Signal mast damage from motor vehicle crash (top) and vehicle damage from striking signal mast (bottom) in Brimson, Minnesota

Simulations were run in the Roadside Safety Analysis Program (RSAP) Version 3.0.1 to further explore the impacts of various factors on the likelihood of railroad-related crashes. Five scenarios on a two-lane rural highway were compared that differed in terms of whether the railroad signal mast was breakaway, the mast's offset from the road, and the presence of a longitudinal guardrail.

RSAP was also used to perform a benefit-cost analysis of the different scenarios. Information on the installation, maintenance, and repair costs of railroad infrastructure and guardrails was obtained from the Iowa DOT.

Key Findings

- The FHWA and AASHTO documents recommend not to protect railroad crossing signals unless they are located in low-speed, industrial areas frequented by turning trucks.
- Sixty-one percent of respondents to the state-of-the-practice survey indicated that they had received reports or observed evidence of motorists striking railroad infrastructure. These respondents indicated that such incidents were very rare, and only one reported a fatality.
- Three-quarters of respondents indicated that at least one form of barrier was used to protect railroad signal equipment, with guardrails being the most common.
- Of the 156 identified crashes, crashes directly involving signal masts were the most common, followed by crashes involving guardrails.

- Crash rates were highest at crossings with flashing lights and gates only and lowest at crossings with flashing lights and a cantilever beam only.
- Although a larger number of crashes occurred at crossings without a guardrail or barrier, crossings with a guardrail or barrier had higher crash rates than crossings that did not. However, these differences were not statistically significant.
- Crash severity was slightly lower when a vehicle struck a guardrail versus a railroad signal mast, but this result was not statistically significant due to the small number of guardrail-involved crashes.
- None of the variables tested for their effects on crash severity, including roadway characteristics, driver characteristics, type of crash, and weather conditions, were found to be statistically significant.
- The RSAP results indicate that the two alternatives with guardrail present were less cost-effective than the other three alternatives. Providing an additional 4 feet of clearance (from a 6-foot to 10-foot offset) was found to be more economically viable.
- The optimal RSAP scenario in terms of cost-effectiveness was to locate the mast 10 feet from the edge of the traveled way without a guardrail.

Implementation Readiness and Benefits

The results of the RSAP simulations and the crash analyses suggest that a guardrail does not sufficiently reduce injury severity to warrant the installation costs. While guardrails tend to reduce crash severity and cost per crash, such crashes are infrequent and were not found to be substantially more severe than other crashes.

Providing more lateral space between the signal support and the edge of the traveled way could reduce the probability of a vehicular strike and eliminate the need for a guardrail. However, this may require changing the size and placement of the signs and lights and developing larger gates and cantilever beams, which could lead to higher installation costs.

The use of longitudinal guardrail systems did not appear to have a strong effect on crash rates at active at-grade crossings in Iowa, and placing guardrails at these locations was not found to be cost-effective in simulations.

Recommendations for Future Research

Several of the key findings from this study were not statistically significant due to the small sample size. Further research is needed to provide more confident recommendations.

To determine the most effective barrier designs for minimizing crash severity, the results of this study can be compared with those involving other barrier designs, and finite element analysis can be used to explore the crash dynamics for different barrier types.

Other ways to reduce crash rate and severity can be explored, including developing crashworthy signal assemblies and improving communication between the different agencies involved in railroad crossing construction to ensure the use of properly designed signals and appropriate clearances.