New England University Transportation Center
77 Massachusetts Avenue, E40-279
Cambridge, MA 02139
utc.mit.edu

Year 25 Final Report

Grant Number: DTRT13-G-UTC31

Project Title:

A Driving Simulator Evaluation of Driver Distraction and Traffic Control Device Comprehension for At-Grade Railroad Crossings

Project Number:	Project End Date:	Submission Date:
UMAR25-28	01/31/2018	11/08/2017

Principal Investigator:	Michael A. Knodler Jr.	**Co-Principal Investigator:**	Donald L. Fisher
Title:	Associate Professor	**Title:**	Professor Emeritus
University:	University of Massachusetts/Amherst	**University:**	University of Massachusetts/Amherst
Email:	Mknodler@engin.umass.edu	**Email:**	fisher@ecs.umass.edu
Phone:	413-330-2662	**Phone:**	

U.S. Federal statistics show a downward trend in the number of incidents at railway-highway at-grade crossings (herein referred to as grade crossings), yet the number of fatalities at these crossings remains appalling. A total of 2,075 railroad-highway grade crossing vehicle-train collisions occurred in 2015, resulting in 244 deaths and more than 1000 injuries (FRA Database, 2015 Statistics). The U.S. Federal Railroad Administration (FRA) statistics show that close to 94 percent of these train-vehicle collisions can be attributed to driver behavior and poor judgement, and thus preventable (FRA RR 16-10, 2016). The National Highway Traffic Safety Administration (NHTSA) reports that a motorist is almost 20 times more likely to die in a crash involving a train than in a collision involving another motor vehicle (NHTSA, 2012).

Although driver inattention has been widely cited as a contributing factor in train-vehicle collisions (Horton et al., 2006) ;(OLI, 2009), historical policy-making has almost always placed the motorists as the villain frontrunner. In 1877, the United States Supreme Court Case of *Continental Improvement Company v. Stead,* 95 U.S. 161, 5 Otto 161, 24 L.Ed. 403 (1877) addressed the responsibilities of motorist and the railroad industry as "mutual and reciprocal" (Pottroff, 1998), except trains are heavy – thousands of tons heavy and thus have a hard time coming to a complete stop, which as a result almost always gives the train the right of way.

It wasn't until 1973 when the debate over who had the responsibility to stop led to the creation of the Federal-Aid Rail Highway Crossing Program (present day Railway-Highway Crossings -Section 130) Program as part of the Federal Highway Act of 1973. Section 130 was the result of political debate spearheaded by the Interstate Commerce Commission (ICC) in which the ICC argued that *"the solution to the grade crossing problem was to transfer the financial burden and planning of crossing improvements to the highway authority."* According to the ICC *"highway users are the principal recipients of the benefits"* (Mok & Savage, 2005). Section 130 apportions funds to the States by formula; these funds are provided for the elimination of hazards at railway-highway crossings at a 90% federal share – the remaining 10% comes from the railroads, the state highway authority, the municipality or a combination of the three.

Fifty percent of a State's apportionment under 23 USC 130(e) is dedicated for the installation of protective devices at crossings, yet according to the FRA, only half of the 127,862 public grade crossings have automatic-warning systems and only one-third have gates and flashing lights (FRA,2015) – meaning that the vast majority of public grade crossings are just one step above meeting the Federal standard which requires the placement of one crossbuck in each direction of travel, at a minimum (MUTCD, 2009). Most importantly, just because these crossings meet the minimum standards does not imply these standards are adequate.

In addition to understanding the policies that created the dynamic we see today in grade crossing safety, it is important to understand the underlying decision-making that provided the basis for the creation and use of the Traffic Control Devices (TCD's) which are present today at grade crossings.

The precursor of the present-day flashing lights was installed in 1930, by the Central Railroad of New Jersey in Sewaren, New Jersey (Fisher, 1951). By 1930, with over 60 different warning devices being used by different railroads, the American Association of Railroads (AAR) decided that the two *"most widely favored devices"* become the national standard; the two alternately-flashing horizontal lights we see today being one of the favorites (Fambro et al., 1990). In the 1978 edition of the Manual on Uniform Traffic Control Devices (MUTCD) highway-rail grade crossing TCD needs were officially addressed by including a new section which provided engineers with guidance on addressing grade crossing safety. Since then, the MUTCD has dictated the size, application, placement, and need for TCD's at grade crossings.

At-grade crossings (grade crossings) are those crossings in which any part of a roadway intersects with railroad tracks. Safety at these railroad-highway grade crossings is a major concern, with traffic control warning devices serving as the main mechanisms for improving safety.

There are three factors that influence a driver's behavior at a given crossing. First, traffic control devices, including warning devices at the railroad-highway grade crossings, provide the driver with information whose impact will depend in part on the likelihood that the driver knows whether to glance in the direction of the device based on prior experience, and in part on what the driver understands the warning device to mean. Second, assuming that the driver identifies the warning, the driver's prior knowledge influences his or her expectancy regarding various railroad-highway grade crossing situations and, therefore, the way in which the driver responds to the hazard presented by the crossing. Finally, the driver's own physiological (e.g., impaired) and psychological (e.g., distracted) state will modify the role that conspicuity and expectancy have on the driver's behavior.

For any given level of, expectancy and driver state, crashes can and do occur at crossings. These crashes typically occur because: 1) a driver never sees the railroad-highway grade crossing, 2) a driver does not select an appropriate speed and/or path through the crossing or 3) a driver does not successfully execute an appropriate decision. Distraction can be an element in all three types of causes of crashes. This dissertation centers on the impact of distraction and the effect of traffic control and warning devices have on stopping behavior and glance behaviors at non-gated railroad-highway grade crossings and studies a possible countermeasure which when combined with traffic control and warning devices can mitigate the effects of distraction due to less than optimal glance patterns.

In order to address the gap that exists in our understanding of driver distraction at railroad-highway grade crossings, two driving simulator experiments were conducted that arguably targeted the most critical need, in particular the need to identify the role that distraction has on the effectiveness of traffic control and warning devices at grade crossings. Ninety-nine participants were evaluated across the two driving simulator experiments. For the first experiment, the role distraction plays in reducing the benefit of crossbuck and flashing lights was analyzed. Participants either engaged in a distracting task or did not engage. The secondary tasks included a mock cell phone conversation or an in-vehicle task where the participant driver was asked to change the radio station. Eye movement and stopping behavior was collected for all participants in both studies. The first experiment showed participants in all groups had trouble navigating the grade crossing environment thus pointing to the need to evaluate supplementary treatments which may benefit driver behavior at these crossings. The second simulator experiment evaluated the impact of the dynamic envelope pavement markings on driver glance pattern and behavior as they approached grade crossings while drivers also performed a distracting or non-distracting task. The dynamic envelope is painted on the region between and immediately adjacent to the tracks. Results show that the addition of these markings can alert drivers of the presence of a grade crossing with anticipation, and as a result induce drivers to glance more and potentially stop in higher proportions than when the markings are not present.

The objectives of this dissertation were to address the role that distraction has on the effectiveness of warning devices (crossbuck with flashing lights) when the driver is performing a distracting task; and based on the evaluation of the warning configuration, determine a potential improvement to the current warning devices configuration which can provide a greater level of awareness to the road user of the potential presence of a train. Both objectives were accomplished and important lessons were learned.

A key takeaway from this research is that even when the flashers are properly working, if there is an obstruction (whether by vegetation or other factor) the driver may be in danger. Road geometry also plays a big part in driver safety, as crossings located on curves or multi-lane roads create complex situations for the driver to navigate.

The dynamic envelope pavement markings provide a cost effective, and feasible alternative for alerting drivers of a grade crossing ahead. Even in situations where the driver does not look at the warning sign, and misses the flashers, the markings can add a layer of safety, particularly when a driver is distracted.

Distraction is widely known to be a top contender for the number one cause of crashes in the U.S. While statistics have improved, the numbers are appalling. Given the poor behavior of drivers on approach a grade crossing, the presence of markings can help drivers texting and driving to look up and detect the lights. Of course, driver comprehension is at play in all these scenarios.

References:

Fambro, D.B., Heathington, K.W., Richards, S.H., “Level of Service Criteria for Active Warning Devices at Railroad-Highway Crossings” Presented at the International Symposium on Railroad-Highway Grade Crossing Research and Safety (1990) Knoxville, TN.

Fisher, A W. *"A History of Flashing Light Crossing Signals - What They Are and Why*." Paper presented at the Cincinnati Regional Meeting of the SignalSection, Association of American Railroad, January 25, 1951.

Horton, S., Carroll, A., Chaudhary, M.,Ngamdung,T.,Mozenter, J., (2006). *Success Factors in the Reduction of Railroad-highway Grade Crossing Incidents from 1994 to 2003* (Report No. FRA/ORD-09/05) .Cambridge, Massachusetts: U.S. Department of Transportation, Transportation Systems Center.

Mok S., Savage, I., *Why has Safety Improved at Rail-Highway Grade Crossings?.* Risk Analysis, Volume 25(4), August 2005, pages 867- 881.

Operation Lifesaver, Inc. (OLI,) Operation Lifesaver Says Distracted Driving a Factor in Railroad Crossing Crashes WASHINGTON, DC, September 28, 2009. Retrieved from: http://www.oli.org.

Pottroff, Robert, *Who Is Responsible.* Fifth International Symposium on Highway-Railway Research and Safety, Knoxville Tennessee, (October 1998), 1.

U.S. Department of Transportation; Federal Highway Administration. *Manual of Uniform Traffic Control Devices* (MUTCD). 2009 Edition.

U.S. Department of Transportation; Federal Railroad Administration *Federal Railroad Administration Ramps up Campaign to Enhance Safety at Nation’s Grade Crossings* (2015) [FRA 03-15]. Retrieved from https://www.fra.dot.gov/eLib/details/L16245.

U.S. Department of Transportation; National Highway Traffic Safety Administration. *Traffic Safety Facts 2012* https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812032.