U.S. Department of Transportation
Federal Railroad Administration

RESEARCH RESULTS
FRA OFFICE OF RAILROAD POLICY & DEVELOPMENT

RR 15-16 | **May** 2015

FRA FUNDED GRADE CROSSING SAFETY & TRESPASS PREVENTION RESEARCH (JUNE 2007 – PRESENT)

SUMMARY

FRA's Office of R&D and Office of Railroad Safety have been actively supporting highway-rail grade crossing safety and trespass prevention research to improve safety. Below is a list of technical reports and research results from FRA-funded projects on these topics since 2007.

The research work has focused on both the benefits of new technology and improved understanding and altering of human behavior at highway-rail grade crossings and railroad right-of-way.

FRA sponsors grade crossing safety and trespass prevention workshops where a wide range of stakeholders are invited to participate including Federal, State, local agencies, academia, private industry, and community community-based organizations and advocates. The goal of these gatherings is to solicit ideas, identify innovative solutions to common problems, and share lessons learned nationally and internationally to drive both the safety oversight and research and development programs.

U.S. Department of Transportation
Federal Transit Administration

- August 14-16, 2012
- Keynote speaker FRA Administrator Joseph C. Szabo
- 175 Attendees
- 6 Technical Sessions
- Breakout groups developed research needs

2012 ROW FATALITY & TRESPASS PREVENTION WORKSHOP
AUG 14-16
ST. LOUIS, MISSOURI

Each year, FRA publishes a Broad Agency Announcement soliciting ideas for improving grade crossing safety improvements and trespass prevention programs and activities. Ideas are also generated through the Small Business Innovative Research program administered by the U.S. Department of Transportation.

FRA's grade crossing safety and trespass prevention research is conducted primarily by the Volpe Center and is supported by private contractors and universities.

The list below has links to on-line copies of the reports. The reports and other related materials can also be found by searching FRA's eLibrary at www.fra.dot.gov.

For further information:

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Date	Report Number and Title	Type	Brief Description
02/02/2015	DOT/FRA/ORD-15/02 Using Signal Detection Theory to Understand Grade Crossing Warning Time and Motorist Stopping Behavior	Technical Report	Signal detection theory was used to model motorists' stopping behavior at active grade crossings. The key factor in predicting motorist stopping behavior is treating the subjective probability that a train is in the grade crossing as a function of the expected arrival time of the train and this was modeled with Gaussian, Chi-squared and Poisson probability distributions.
11/24/2014	DOT/FRA/ORD-14/36 Countermeasures to Mitigate Intentional Deaths on Railroad Rights-of-Way: Lessons Learned and Next Steps	Technical Report	This report discusses the current information available on trespasser fatalities and the implementation of countermeasures in use internationally to prevent suicides on the railroad right-of-way. The report presents a discussion of each countermeasure according to various intervention points along the path to complete suicide on the railroad right-of-way.
11/12/2014	DOT/FRA/ORD-14/32 Trespass Event Risk Factors	Technical Report	This research investigated the common risk factors for railroad trespassing incidents. Risk factors found include (1) a disregard for grade crossing warning signs, (2) trespasser intoxication, (3) use of distracting electronic devices, and (4) right-of-way proximity to stations, bridges, and rail yards. This research report offers several suggestions for improved data availability to support future studies.

07/16/2014	DOT/FRA/ORD-14/21 Effect of an Active Another Train Coming Warning System on Pedestrian Behavior at a Highway-Rail Grade Crossing	Technical Report	The system chosen for this analysis, known as an Another Train Coming Warning System (ATCWS), consists of signage and an accompanying aural alert which is activated by the presence of multiple trains during gate activation. The ATCWS was installed at a crossing in Garfield, NJ, to assess the impacts of such a warning system on pedestrian behaviors during gate activations with multiple trains. Pedestrian violations were therefore tracked before and after the installation of the ATCWS.
07/16/2014	DOT/FRA/ORD-14/19 Trespass Prevention Research Study – West Palm Beach, FL	Technical Report	FRA's Office of Research and Development (ORD), conducted a Trespass Prevention Research Study (TPRS) in the city of West Palm Beach, FL. The main objective of this research was to demonstrate potential benefits, including best practices and lessons learned, of implementation and evaluation of trespass prevention strategies following FRA's and Transport Canada's existing trespassing prevention guidance on the rail network in West Palm Beach, FL, and all of its rights-of-way.
07/16/2014	RR 14-20 Driver Performance on Approach to Crossbuck and STOP Sign Equipped Crossings	Research Results	A research project, conducted at Volpe, to study driver behavior at or on approach to grade crossings.

04/15/2014	Compilation of State Laws and Regulations Affecting Highway-Rail Grade Crossings, 6th Edition	Technical Report	This 6th Edition is intended to provide an up-to-date look at the various state laws and regulations concerning the regulation of highway-rail grade crossings and driver behavior at those crossings. Laws and regulations of the 50 states and the District of Columbia that address highway-rail grade crossings have been compiled into one easy-to-use document.
04/04/2014	DOT/FRA/ORD-14/04 Effect of Dynamic Envelope Pavement Markings on Vehicle Driver Behavior at a Highway-Rail Grade Crossing	Technical Report	A research study to evaluate the effectiveness of roadway pavement markings placed within the dynamic envelope, the region between and immediately adjacent to the tracks at a highway-rail grade crossing, and new corresponding signage at the Commercial Boulevard grade crossing in Ft. Lauderdale, FL. The goal of the added markings and signage is to reduce the number of vehicles that come to a stop within the dynamic envelope, a violation of most applicable State highway traffic laws, thus reducing the possibility that a vehicle is present on the tracks when a train approaches.
04/04/2014	DOT/FRA/ORD-14/06 Proposed Key Elements of a Critical Incident Intervention Program for Reducing the Effects of Potentially Traumatic Exposure on Train Crews to Grade Crossing and Trespasser Incidents	Technical Report	This independent report presents work conducted regarding project FR-RDD-0024-11-01 to advise and support the formulation of regulations and supporting materials concerning “critical incident” response plans for rail carriers covered by the Rail Safety Improvement Act of 2008, Sec. 410.

12/30/2013	DOT/FRA/ORD-13/51 Effect of Gate Skirts on Pedestrian Behavior at Highway-Rail Grade Crossings	Technical Report	The purpose of this evaluation was to determine if the addition of gate skirting would result in fewer pedestrians attempting to violate the crossing on the sidewalk after the gates began to descend.
12/01/2013	DOT/FRA/ORD-14/09 Evaluation of Education and Outreach Methods and Strategies: A Case Study of a Web-Based Rail Safety Education Initiative	Technical Report	This research study was conducted to evaluate the impact of an education and awareness program on highway-rail grade crossing safety. The Volpe Center worked in collaboration with Operation Lifesaver, Inc., to evaluate the impact of the Web-based Rail Safety for Professional Drivers e-Learning Challenge (ProDriver Challenge). The evaluation was conducted using Federal safety data and information on the ProDriver Challenge collected from users about their experiences.
08/16/2013	RR 13-37 Public Education and Enforcement Research Study (PEERS)	Research Results	In 2001, the FRA and the Illinois Commerce Commission (ICC) established the Public Education and Enforcement Research Study (PEERS) to test the effectiveness of various education and enforcement (E&E) techniques to improve compliance with traffic safety laws at highway-rail grade crossings.
08/13/2013	RR 13-36 Demographic Profile of Intentional Fatalities on Railroad Rights-of-Way in the United States	Research Results	This project reviews available trespasser data to establish a baseline estimate of intentional trespasser fatalities that occur on railroad rights-of-way and to obtain a basic demographic profile of the individuals involved.

05/20/2013	DOT/FRA/ORD-13/28 Driver Behavior Analysis at Highway-Rail Grade Crossings using Field Operational Test Data—Light Vehicles	Technical Report	A research study focused on collecting and analyzing data related to driver behavior at or on approach to highway-rail grade crossings. Volpe Center reviewed and coded 4,215 grade crossing events involving light vehicle drivers collected during a recent field operational test of vehicle safety systems. The data collected for each grade crossing included information about drivers' activities, driver and vehicle performance, driving environment, and vehicle location at or on approach to highway-rail grade crossings.
05/09/2013	DOT/FRA/ORD-13/25 Defining Characteristics of Intentional Fatalities on Railway Rights-of-Way in the United States, 2007–2010	Technical Report	This report presents aggregate findings from 55 psychological autopsies of decedents who were identified as an intentional death (i.e., a suicide) on railroad rights-of-way between October 1, 2007, and September 30, 2010. The goal of this study was to assess whether there are unique characteristics of individuals involved in suicides on railroad rights-of-way compared with individuals who complete suicide by other means.
04/24/2013	DOT/FRA/ORD-13/18 2012 Right-of-Way Fatality and Trespass Prevention Workshop	Technical Report	FRA and the Federal Transit Administration (FTA) sponsored a national workshop, August 14–16, 2012, in St. Louis, MO. The workshop offered a varied program by rail/transit experts and safety professionals who shared their ideas on key issues, best practices, technical developments, human behavior, law enforcement, and public education and awareness outreach methods related to trespass prevention.

01/10/2013	DOT/FRA/ORD-12/24 A Radar Vehicle Detection System for Four-Quadrant Gate Warning Systems and Blocked Crossing Detection	Technical Report	A Radar-based detection system was adapted for use at four-quadrant gate railroad crossings for the purpose of influencing exit gate behavior upon the detection of vehicles, as an alternative to buried inductive loops. Two radar devices were utilized, operating collaboratively, in order to realize a fully redundant system.
01/09/2013	DOT/FRA/ORD-13/01 Understanding Driver Behavior at Grade Crossings through Signal Detection Theory	Technical Reports	This report uses signal detection theory (SDT) to model motorists' decision making strategies at grade crossings in order to understand the factors that influence such decisions and to establish a framework for evaluating the impact of proposed countermeasures.
12/31/2012	DOT/FRA/ORD-12/23 Highway-Rail Intersection GPS-Based In-Vehicle Warning Systems—Literature Review and Recommendations	Technical Reports	This research investigates the advancement of commercially available technology and equipment that create the environment for the development and deployment of a viable global-positioning system-based in-vehicle warning system for highway-rail intersections.
12/14/2012	DOT/FRA/ORD-12/22 Driver Behavior Analysis at Highway-Rail Grade Crossings using Field Operational Test Data – Heavy Trucks	Technical Reports	A research study focused on collecting and analyzing data related to driver characteristics at or on approach to highway-rail grade crossings. Volpe Center reviewed and coded 3,171 grade crossing events involving heavy vehicle drivers collected during a recent field operational test of vehicle safety systems. The data collected for each grade crossing included data about drivers' activities, driver and vehicle performance, driving environment, and vehicle location at or on approach to highway-rail grade crossings.

11/20/2012	DOT/FRA/ORD-06/03-1 Highway Rail-Grade Crossing Safety Research: Railroad Infrastructure Trespassing Detection Systems Research in Pittsford, New York	Technical Reports	In this research a 3-year demonstration of an automated prototype railroad infrastructure security system was conducted on a railroad bridge. Specifically, this commercial-off-the-shelf technology system was installed at a bridge in Pittsford, New York, where trespassing is commonplace and fatalities have occurred.
10/01/2012	Grade Crossing Evaluation Tools and Risk Assessment	Technical Reports	FRA develops tools to assist agencies, analysts and policymakers in assessing safety risks and potential improvements to highway-rail grade crossings. FRA has developed a GIS grade crossing viewer, a crossing improvement decision tool, and is working on a risk assessment methodology for high-speed grade crossings.
08/01/2012	DOT/FRA/ORD-12/11 Use of Traffic Channelization Devices at Highway-Rail Grade Crossings	Technical Reports	Traffic channelization devices have found new application at highway-rail grade crossings with active warning devices. When meeting certain requirements, traffic channelization devices and median barriers are an approved supplemental safety measure for the establishment of quiet zones. Traffic channelization devices are low cost and this makes them an attractive option for improving safety..

08/01/2012	RR 12-14 2012 ROW Fatality & Trespass Prevention Workshop	Research Results	FRA and FTA sponsored a national workshop, August 14–16, 2012, in St. Louis, MO. The workshop offered a varied program by rail/transit experts and safety professionals who shared their ideas on key issues, best practices, technical developments, human behavior, law enforcement, and public education and awareness outreach methods related to trespass prevention.
07/01/2012	DOT/FRA/ORD-12/12 North Carolina "Sealed Corridor" Phase IV Assessment – Private Crossings	Technical Report	This research, conducted from October 2008 to February 2010, assesses the potential safety benefits provided by the safety improvements at private highway-rail grade crossings in North Carolina along the Charlotte to Raleigh portion of the Southeast High-Speed Rail Corridor (SEHSR).
12/01/2011	RR 11-26 Low-Cost Warning Device Industry Assessment	Research Results	The purpose of this research was to present an objective assessment of the available low-cost advance warning device technologies and to recommend a migration path that could be implemented in the United States.
12/01/2011	RR 11-27 Data Analysis of Grade Crossing Incidents	Research Results	To provide a more realistic comparison of safety performance over the years, it is important to include both train and vehicle traffic when calculating incident rates at highway-rail grade crossings. The FRA tasked the Volpe Center to review an exposure metric called traffic moment (TM), which is currently used by European nations, and to apply it to U.S. data.

04/01/2011	DOT/FRA/ORD-11/09 Railroad Right-of-Way Incident Analysis Research	Technical Report	This project categorizes grade crossing and trespass incident hotspots. Mathematical models and theories are researched to see which ones may be used in identifying locations along rail right-of-ways where the risk of collisions or trespassing is high and intervention is justified. For the analysis of grade crossing incident hotspots, the Transport Canada model is modified to accommodate U.S. data and is applied to a sample of grade crossing incidents from 2003 to 2007 in the San Joaquin corridor in California.
03/01/2011	DOT/FRA/ORD-11/07 Public Education and Enforcement Research Study (PEERS) - Macomb, Illinois, Analysis	Technical Report	The PEERS program was a collaborative effort between the FRA, the Illinois Commerce Commission, and local communities in the State of Illinois. This project was designed to promote safety at highway-rail grade crossings. The role of the Volpe Center was to monitor and evaluate highway-rail grade crossings in the communities using video data collection, while the communities conducted education and enforcement campaigns.

03/01/2011	DOT/FRA/ORD-09/06 Effects of Active Warning Reliability on Motorist Compliance at Highway-Railroad Grade Crossings	Technical Report	In this project, two studies were conducted to examine motorist behavior as a consequence of warning signal failure. Experiment one measured motorist behavior in response to false alarms (i.e., the presentation of a warning when no train was approaching). Experiment two examined how motorist responses to grade crossing warning signals were influenced by false alarms and missed signals (i.e., the failure of the warning system to signal an approaching train).
01/01/2011	DOT/FRA/ORD-11/01 Railroad Infrastructure Trespass Detection Performance Guidelines	Technical Report	In this project, FRA conducted a 3-year demonstration of an automated prototype railroad infrastructure security system on a railroad bridge in the town of Pittsford, NY. The main objective was to demonstrate a stand-alone, video-based trespass monitoring and deterrent system for railroad infrastructure applications using commercial off-the-shelf technology.
12/01/2010	ACPD 2010 Accident Prediction and Resource Allocation Procedure Normalizing Constants – 2010	Technical Report	DOT/FRA/OS-87/10 uses three “normalizing constants” in the accident prediction formula. These constants need to be periodically adjusted in order to keep the procedure matched with the current accident trends, the current number of open crossings, and the changes in the warning devices.

02/01/2010	DOT/FRA/ORD-10/02.I Private Highway-Rail Grade Crossing Safety Research and Inquiry, Volume I	Technical Report	Summarizes a private highway-rail grade crossing safety inquiry conducted by the FRA and the Volpe Center. The safety inquiry consisted of a series of public meetings to solicit oral commentary on the safety of the nation's private highway-rail grade crossings, a docket for electronic comment submission, a panel discussion at the Transportation Research Board's annual meeting, and other activities as described in the report.
02/01/2010	DOT/FRA/ORD-10/02.II Private Highway-Rail Grade Crossing Safety Research and Inquiry, Volume II – Appendices	Technical Report	Appendices to the above report.
01/01/2010	DOT/FRA/ORD-10/01.I USDOT Federal Railroad Administration's Third Research Needs Workshop on Highway-Rail Grade Crossing Safety and Trespass Prevention: Volume I - Summary of Results	Technical Report	The primary purpose of this workshop was to bring together nationally and internationally recognized subject matter experts to collaborate, identify and prioritize specific research needs to facilitate the reduction of highway-rail grade crossing and trespass incidents and fatalities for incorporation into the strategic vision of FRA, other USDOT modes and their stakeholders.
01/01/2010	DOT/FRA/ORD-10/01.II USDOT Federal Railroad Administration's Third Research Needs Workshop on Highway-Rail Grade Crossing Safety and Trespass Prevention: Volume II – Appendices	Technical Report	Appendices to the above report.

11/01/2009	RR 09-21 North Carolina Department of Transportation's "Sealed Corridor" Assessment - Phase IV	Research Results	The FRA's Office of R&D tasked the Volpe Center to document the success of the Sealed Corridor project through Phase IV—the implementation of safety strategies at private crossings.
10/31/2009	Compilation of State Laws and Regulations Affecting Highway-Rail Grade Crossings 5th Edition	Technical Report	The Compilation of State Laws and Regulations Affecting Highway-Rail Grade Crossings, Fifth Edition makes a unique contribution to the highway-rail grade crossing safety literature.
04/12/2009	Summary of Inventory Data Crossing Counts	Technical Report	Data Source: US DOT National Highway-Rail Crossing Inventory File Data Date: as of December 31, 2008.
04/02/2009	The Highway-Rail Crossing Inventory Number	Technical Report	This report is extracted from the FRA National Highway-Rail Crossing Inventory Instructions and Procedures Manual dated December 1996 and updated.
04/01/2009	DOT/FRA/ORD-09/09-I 2003 Highway-Rail Grade Crossing Safety Research Needs Workshop: Volume I - Summary of Results	Technical Report	The purposes of the workshop were to provide up-to-date information and research reports from selected organizations, analyze a number of safety research topics by a selected group of delegates from all areas of technology and government organizations associated with the rail industry, and define a new practical list of research needs for the Highway-Rail at Grade Crossing Safety Program of the FRA's Office of R&D and Office of Safety in coordination with other organizations having similar needs.

04/01/2009	DOT/FRA/ORD-09/09-II 2003 Highway-Rail Grade Crossing Safety Research Needs Workshop: Volume II - Appendices	Technical Report	Appendices to the above report.
07/01/2009	RR 09-12 Crossing Consolidation Guidelines	Research Results	The Volpe Center conducted literature and regulation reviews and solicited information from states about their crossing consolidation programs. The information and experiences were compiled into key subject areas for state and local officials to consider during the crossing consolidation process. Best practices and lessons learned are provided as examples.
04/01/2009	DOT/FRA/ORD-09/05 Success Factors in the Reduction of Highway-Rail Grade Crossing Incidents from 1994 to 2003	Technical Report	Between the years 1994 and 2003, incidents at highway-rail grade crossings declined by 41.2 percent. The reasons for this decline were unknown. The Volpe Center was tasked by the FRA to identify the salient success factors in highway-rail grade crossing incident reduction. The success factors were analyzed and investigated using various qualitative and quantitative methods. Ten factors were identified as the most influential.
03/25/2009	Assignment of Crossing Inventory Numbers	Technical Report	All crossings in the United States, public, private and pedestrian, both at-grade and grade separated (underpasses and overpasses) are required by Law (RSIA of 2008) to have a DOT Crossing Inventory Number assigned and the number should be posted at the crossing.

02/01/2009	DOT/FRA/ORS-09/001 ROW Fatality and Trespass Reduction Workshop 2008, Summary of Results	Technical Report	This report documents the activities and results of the first Right-of-Way (ROW) Fatality and Trespass Prevention Workshop which was held April 1 & 2, 2008 at Caltrain headquarters in San Carlos, California.
11/01/2007	DOT/FRA/ORD-09/06 Effects of Active Warning Reliability on Motorist Compliance at Highway-Railroad Grade Crossings	Technical Report	Two studies were conducted to examine motorist behavior as a consequence of warning signal failure. Experiment one measured motorist behavior in response to false alarms (i.e., the presentation of a warning when no train was approaching). Experiment two examined how motorist responses to grade crossing warning signals were influenced by false alarms and missed signals (i.e., the failure of the warning system to signal an approaching train).
10/01/2007	DOT/FRA/ORD-07/24 Passenger Cab Car Grade Crossing Impact Test Report: Rail Passenger Equipment Impact Tests	Technical Report	Two full-scale oblique grade crossing impact tests were conducted in June 2002 to compare the crashworthiness performance of alternative corner post designs on rail passenger cab cars. On June 4, 2002, a cab car fitted with an end frame built to pre-1999 requirements impacted a steel coil at approximately 14 mph. Following on June 7, 2002, a cab car fitted with an end frame built to current requirements also impacted a steel coil at approximately 14 mph.

08/01/2007	RR 07-21 Alternative Rail Intruder and Obstacle Detection Systems	Research Results	The main objective of rail intruder and obstacle detection systems (IODS) is to provide train engineers, railroad dispatchers, and security organizations timely information on the status of sections of railroad track and crossings. The intent is to allow them sufficient time to perform the appropriate emergency actions to decrease train speed or stop a train to avoid or mitigate the effects of a collision or security breach.
07/01/2007	RR 07-17 Alerting Lights on Locomotives	Research Results	The results of controlled field tests indicated that the triangular lighting pattern used with each type of auxiliary lights (crossing, ditch, and strobe) increased detectability of the locomotive compared with the use of the standard headlights alone. Each system provided a distinctive, uniform light pattern that motorists could recognize as signifying a locomotive.
06/01/2007	RR 07-19 Trespass on Railroad Rights-of-Way	Research Results	The main objectives of this project were to demonstrate a stand-alone video-based trespass monitoring and deterrent system for railroad infrastructure applications using Commercial Off-The-Shelf (COTS) technology.