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Driver Behavior at Malfunctioning Crossing and Emergency Notification System Sign Awareness

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13. ABSTRACT
The Federal Railroad Administration wants to better understand driver knowledge of and expectations for finding Emergency Notification System (ENS) signs at highway-rail grade crossings. A simulator study was designed where participants were exposed to ENS signs of different orientations (parallel and perpendicular to the tracks) and various crossing malfunctions (activation failure, false activation, and vehicle stuck on tracks). Experimenters recorded eye glance patterns and participant indications that they would have called the ENS sign number. The study revealed that drivers were more likely to glance at the ENS sign for both types of gate malfunction when the sign was positioned parallel to the tracks. Conversely, drivers were more likely to glance at the ENS sign when it was perpendicular to the tracks when they were in the Stuck on the Tracks condition. Drivers were most likely to indicate that they would call the ENS sign number in the Stuck condition with a track-perpendicular sign orientation. These findings indicate that drivers may be likely to look for the ENS sign in different locations depending on the crossing challenge encountered.

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ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] □F = y □C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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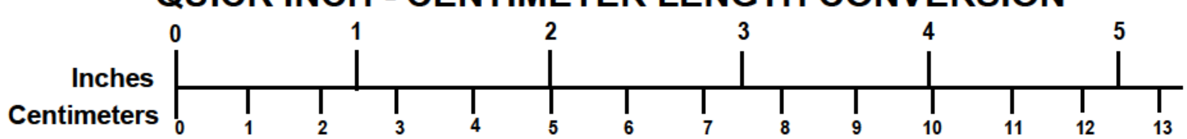

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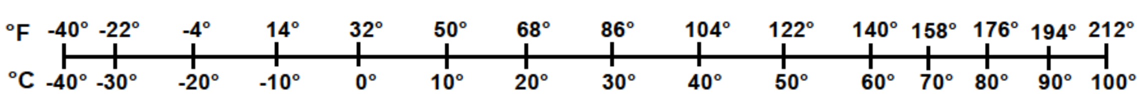

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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Executive Summary

A research team at the John A. Volpe National Transportation Systems Center (Volpe) developed an experimental procedure to understand driver behavior at malfunctioning highway-rail grade crossings (HRGC) and to assess Emergency Notification System (ENS) sign awareness by using the Federal Railroad Administration (FRA) driving simulator, which is housed at Volpe. The study took place in 2019 and 2020

On roadways across the U.S., ENS signs are placed at nearly every crossing so that if a driver encounters a malfunctioning crossing, or if they become stuck on the tracks, they can call the number on the sign and use the posted crossing ID to report the issue. If a driver were to become stuck on the tracks, calling the ENS would put the driver in direct contact with the railroad to slow or stop any approaching train and to arrange for the safe removal of the stuck vehicle. Roadway users may also choose to call the ENS if they feel that the warning systems are not functioning properly or if there are any other unsafe conditions at the crossing. The following work investigates the potential role of a driver's expectations and experience of the emergency notification system.

In some situations, a driver approaching a malfunctioning crossing may quickly realize that a problem exists, while other malfunction situations may require prolonged exposure. (And in some cases drivers may never become aware of a malfunction.) Regardless, the driver must make a decision about how to react based on the information that is available to them at the crossing in that moment. Poor decisions may occasionally be made, and unsafe actions may be more common when the information provided by the safety infrastructure is incomplete or inaccurate.

Volpe recruited 40 licensed drivers from the greater Boston area to participate in this study. Participants drove through six virtual worlds that contained a number of HRGCs. Drivers saw a series of working and malfunctioning active warning devices at HRGCs. The Volpe research team counterbalanced ENS sign orientation between two orientations – signs that faced the roadway (Track Parallel) and signs that faced down the rail track (Track Perpendicular). The order in which the participants saw each of these drives, malfunctions, and sign positions was counterbalanced such that each possible condition was seen an equal number of times and at various times during the scenario.

Researchers recorded eye glance behaviors during the data collection. In particular, they coded the location of a participant's glance as they approached and proceeded through the grade crossing. The dependent variable ("Glance") was binary. A driver received a score of 1 if the eye tracker cursor overlaid the target zone (anywhere on the ENS sign) while the driver was in the launch zone (approximately 20 feet before the HRGC until the gate arms) for longer than 0.5 second. Otherwise, the driver received a score of 0. Researchers coded a second dependent variable in a binary fashion as well. The driver received a score of 1 if they indicated they would call the number on the ENS sign to report a problem or emergency. If the driver did not indicate they would take this action they received a score of 0.

Generally, drivers were more likely to glance at and use ENS signs that were parallel to the track (i.e., facing the driver as they approached the crossing) in every scenario except for when the driver was stuck on the tracks. In the scenario when the driver was stuck on the tracks, the ENS signs perpendicular to the tracks were glanced at and called with more frequency. This study

found that drivers who were stuck were likely to look for one sign orientation (Track Perpendicular), and drivers who experienced a malfunction were likely to look for another sign orientation (Track Parallel). Using a single sign for both purposes may prove ineffective, even if drivers know about the signs uses.

1. Introduction

The Federal Railroad Administration (FRA) is interested in understanding more about drivers' awareness and understanding of the Emergency Notification System (ENS) signs posted at highway-rail grade crossings. The following work investigates the potential role of a driver's expectations and experience of the emergency notification system on their ability to locate the sign or know what the sign is intended to convey.

1.1 Background

ENS signs are placed at nearly every crossing so that if a driver encounters a malfunctioning crossing, or if they become stuck on the tracks, they can call the number on the sign and use the posted crossing ID to report the issue. If a driver were to become stuck on the tracks, calling the ENS would help to initiate a process to slow or stop an oncoming train and dispatch individuals who could help safely remove the stuck vehicle. Drivers may also choose to call the ENS number if they feel that the warning systems are not functioning properly or if the signage is damaged or obstructed.

One situation in which a driver may consider calling the number on an ENS sign is if the warning devices at the crossing are malfunctioning. While warning devices, especially those present at active crossings, are designed with safeguards to minimize the occurrence of errors, these safeguards cannot completely eliminate this issue. An active crossing may malfunction in one of three ways (from Code of Federal Regulations 392 Part 234):

- *Activation Failure*: The failure of the active crossing warning system to indicate the approach of a train at least 20 seconds prior to the train's arrival (or to indicate the presence of a train occupying the crossing).
- *Partial Activation*: The warning system activates incompletely, such as the gates not fully descending or the gates not descending while the lights flashed.
- *False Activation*: The activation of a warning system caused by something other than an approaching train (e.g., a condition that requires correction or repair of the system).

Each of these types of malfunctions creates an abnormal situation and the driver must decide how to react. Another scenario is how a driver may react if their vehicle becomes stuck while traversing the crossing. Where will the driver look? Would they attempt to contact anyone?

In some situations, a driver approaching a malfunctioning crossing may quickly realize that an error has occurred, while other malfunction situations may require prolonged exposure. (And some drivers may never become aware of a malfunction). Regardless, the driver must make a decision about how to act based on the information that is available to them. Poor decisions may occasionally be made, and unsafe actions may be more common when the information provided by the safety infrastructure is incomplete or inaccurate. For example, the preliminary National Transportation Safety Board report[1] from the January 31, 2018 Amtrak collision in Crozet, Virginia, includes witness statements that the refuse truck struck by the train in the incident went around the crossing gates after the crossing gates were down. Additional media reports have

[1] https://www.ntsb.gov/investigations/AccidentReports/Reports/HWY18MH005-prelim.pdf

indicated that the gates at this crossing were prone to malfunction and had done so in the days before the incident.[2]

These reports of prior malfunctions raise two serious questions about safety at highway rail grade crossings: 1) why did the driver go around the lowered gates, and more generally, how do drivers behave when approaching an active crossing that they believe to be malfunctioning, and 2) why had no one reported this crossing – by calling the number on the posted ENS sign – as needing maintenance? One way to address the second issue is to investigate current ENS sign placement and use of the numbers on those public signs.

1.2 Objectives

The objective of this experiment was to better understand drivers' awareness and understanding of ENS signs posted at highway-rail grade crossings. This study uncovered how drivers react when the crossing infrastructure appears to be malfunctioning or they become stuck on the tracks, including whether they look for or attempt to make use of the information on an ENS sign.

Specifically, the intention of this study was to help FRA determine if a particular orientation of the ENS sign was more successful in getting participants to notice the signage, or to call in problems or emergencies.

1.3 Overall Approach

This experiment was conducted in a driving simulator and included two phases: a simulator study and a post-study discussion. During the simulator study, participants drove through a variety of scenarios where they encountered functioning and malfunctioning crossing warning systems, as well as a scenario where the driver became stuck on the tracks. These scenarios included ENS signs in varied positions. Following the simulator study, experimenters interviewed the participants about their experience with the crossing warning systems and ENS signs. The research team then examined participants' eye glance behavior and use of the ENS signs.

1.4 Scope

This effort focuses on furthering knowledge about where drivers look in abnormal situations at crossings and if they seek out or claim that they would make use of the information on ENS signs at every crossing. The specific placement of an ENS sign may vary from crossing to crossing, and this experiment only examines two such placements: one representing signs facing the approaching driver and one perpendicular to that orientation. While other variations in placement are possible in practice, the goal of this effort was to identify if glance patterns differed for these two categories of placement. Additionally, while this study does include some insight about driver knowledge of the purpose of the information on the ENS sign, it was not intended to be representative of driver knowledge generally. Further research will be required to understand driver knowledge and understanding of ENS signage.

[2] See: https://nypost.com/2018/02/01/drivers-experienced-crossing-malfunction-before-gop-train-crash/ or https://www.sltrib.com/news/nation-world/2018/02/02/safety-arms-at-gop-train-garbage-truck-crash-site-seemed-to-malfunction-drivers-say/

1.5 Organization of the Report

The remainder of this report is organized into the following sections:

2. Methods: How the study was designed and why.
3. Results: What was discovered after completing the study.
4. Conclusion and Discussion: What do those results tell us and where can we go from here.

2. Methods

The study used FRA's Driving Simulator (simulator), housed at the Volpe National Transportation Systems Center (Volpe), to study driver behavior, including their interaction with the ENS signs, at a variety of crossing types and ENS sign orientations. Additionally, the study included discussions with participants after the simulator portion to better understand drivers' awareness and understanding of an ENS sign at crossings.

2.1 Data Collection

This section describes the data collected during the simulator study and post-study discussion. The methodology for each of these phases is described in greater detail below.

I. *Simulator Study:* Experimenters collected the following data while participants drove through six simulated scenarios:

   a. Information on a driver's eye fixation locations – to determine whether the driver noticed an ENS sign or if they fixated long enough to read it.

   b. Information on a driver's response to an ENS sign – to determine whether the driver would make use of the information on the signage to address the issue.

II. *Post-Study Discussion:* Experimenters asked about the participants' knowledge of and experience with malfunctioning gates. Specifically, these discussions probed participants' awareness of the ENS sign and how to use it (and for what reasons), and whether they saw an ENS sign at any of the crossings in the study. This discussion was open-ended and based upon participants' decisions in the simulator portion.

2.2 Simulator Study

Participants completed a series of six drives. The first drive was a practice drive to help participants become accustomed to driving in the simulator, which lasted about 7 minutes. The remainder of the drives were data collection drives. Drives 2 through 5 lasted approximately 7 minutes each and contained three highway-rail grade crossing scenarios. One crossing for each drive (2 through 5) had a malfunction, one crossing worked correctly, and one crossing was not activated. Experimenters counterbalanced ENS sign orientation between two orientations, Track Parallel (Figure 1) and Track Perpendicular (Figure 2), as well as the order in which the participants saw each of these drives, malfunctions, and sign positions. During the final drive, drive six, the participant experienced being stuck on the tracks. The following sections discuss each of these drives and scenarios in detail.

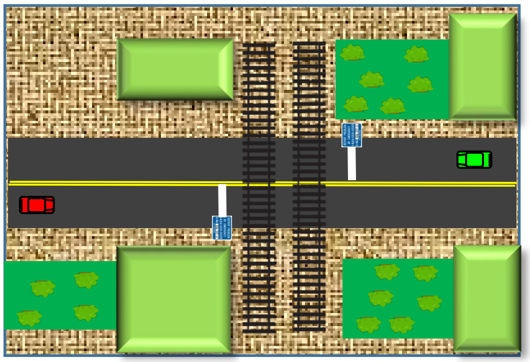

Figure 1. ENS Signs Parallel to Train Tracks

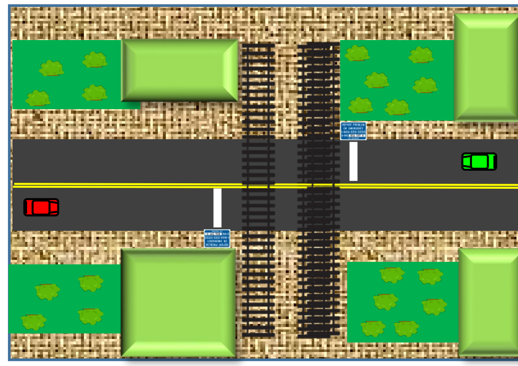

Figure 2. ENS Signs Perpendicular to Train Tracks

2.2.1 Scenarios

Each scenario took place in a simulated world that contained functioning and malfunctioning highway-railroad grade crossings.

The crossing malfunctions included a false activation and an activation failure. The properly working crossing scenarios included correct activations or crossings without activation. Drivers also encountered a stalled vehicle scenario. Table 1 below summarizes these conditions, which are described in the following sections.

Table 1. Overview of Crossing Scenarios

	Train present?	Gate active?
Correct activation	Yes	Yes
Crossing without activation	No	No
False activation	No	Yes
Activation failure	Yes	No

False Activation Scenario

The driver approached an active, gated crossing that had been activated, but no train would ever come. Only the gate for the opposing traffic was down – and the gate in front of the participant was still up (despite the bells/lights being active).

Figure 3. False Activation Scenario

Activation Failure Scenario

As the driver approached an active crossing with gates, but before they arrived at the crossing, a train arrived without the warning systems ever activating.

Figure 4. Activation Failure Scenario

Correct Activation Scenario

The warning systems at a crossing functioned as intended. Bells/lights and gates activated 20 seconds prior to a train arrival.

Figure 5. Correct Activation Scenario

Crossing without Activation Scenario

The warning system did not activate and no train arrived. Drivers could traverse the crossing normally.

Figure 6. Crossing without Activation

Stalled Vehicle Scenario

In the final scenario tested, the driver started out on the tracks and their vehicle could not move. After a short while they heard a train horn in the distance, but the crossing did not activate. The driver had to communicate with the experimenter about what they would do in this situation.

Figure 7. Stalled Vehicle Scenario with ENS Sign Perpendicular

Each of the scenarios described above represent the locations where data were collected to better understand driver behavior. It is worth noting, however, that there were other scenarios throughout the drives that were intended to attract attention. These included construction zones with oncoming traffic, mid-block crosswalks, and law enforcement vehicles positioned away from the roadway. The hope was that this mix of scenarios might make the grade crossing scenarios being studied less obvious to the drivers.

2.2.2 Participants

Volpe recruited a total of 40 participants, licensed drivers from the greater Boston area. The experimenters' assigned participants randomly to either see the ENS sign in a Track Perpendicular or Track Parallel position first, subject to the constraint that 20 drivers be in each group. The drivers in the Track Perpendicular group (12 males, 6 females, and 2 Transgender and Gender Nonconforming [TGNC] participants) had a mean age of 33.75 (SD 12.86). The drivers in the Track Parallel group (11 males, 9 females, and 0 TGNC participants) had a mean age of 48.24 (SD 15.42).

2.2.3 Equipment

This experiment used a fixed-base driving simulator and a head-mounted eye tracker to collect the data.

Driving Simulator

The driving simulator, manufactured by Realtime Technologies Inc. consisted of a quarter cab (Ford Fusion) placed in front of five screens subtending 210 degrees horizontally and 23 degrees vertically (Figure 8). The virtual environment was displayed on each screen at a resolution of 1920 x 1080 pixels and at a frequency of 60 Hz. Participants sat in the cab and operated the controls, moving through the virtual world according to their inputs to the car (Figure 9). The dedicated audio system consisted of 4 mid/high-frequency speakers located at the left and right side of the cab (1 far left, 1 left center, 1 right center, 1 far right) and 3 subwoofers (1 left center, 1 center, and 1 right center). This system provided realistic road, train, and other vehicle noises with appropriate direction, intensity, and Doppler shift.

Figure 8. RTI Driving Simulator

Figure 9. View of RTI Driving Simulator from Experimental Workstation

Eye Tracker

This experiment used a portable, lightweight eye tracker (Applied Science Laboratories' Mobile Eye-XG) to collect eye movement data. It has an optical system consisting of an eye camera and a color scene camera mounted on a pair of safety goggles. The eye movement data were converted to a crosshair, representing the driver's point of gaze. A video was also taken from a forward facing camera mounted on the optical system. After a subject completed their drives, the crosshair was superimposed on the video recording of the scene to show where in the scene the driver was looking at any given moment in time and enabled experimenters to review this data for later manual analysis.

Figure 10. Head-Mounted Applied Science Laboratories Mobile Eye-XG Eye Tracker

2.2.4 Experimental Procedures

Volpe recruited participants from the Greater Boston Area. All participants signed an informed consent form and provided demographic information and a driving history. The experimenter then outfitted each participant with the eye tracker, gave them a practice drive, and participated in data collection drives on the driving simulator. The calibration of the eye tracker took between 2 and 5 minutes, and the data collection drives took 20 minutes, on average. Once the data collection drives were complete, the experimenter asked each participant a series of five open-ended questions and recorded their responses.

2.2.5 Dependent Variables

The eye tracker recorded eye glance behaviors during the data collection drives. In particular, the location of a participant's glance as they approached and proceeded through the highway grade crossing was coded by the experimenter. As for glances while approaching and navigating through the grade crossing, experimenters defined the target zone as an area toward the ENS signs. The experimenters defined the launch zone as a continuous stretch of roadway upstream of the grade crossing where the driver could see the ENS sign. The launch zone included a location where the drivers might stop prior to the train tracks to wait for a train to go through. The dependent variable ("Glance") was binary. The experimenter gave the driver a score of 1 if the eye tracker cursor overlaid the target zone while the driver was in the launch zone for longer than

0.5 second. Otherwise, the experimenter gave the driver a score of 0. Participants' voices and conversations were also recorded. These recordings were stored in compliance with Volpe's approved Institutional Review Board protocol. A second dependent variable was coded in a binary fashion as well. The driver received a score of 1 if they indicated that they would call the number on the ENS sign to report a problem or emergency. If the driver did not indicate they would take this action they received a score of 0.

3. Results

The purpose of this study was to better understand driver behavior, including eye glance behavior, relative to an ENS sign when they are presented with abnormal situations at a highway-rail grade crossing. The analyses below examined eye glance behavior from participants who drove through five simulated worlds that contained highway-railroad grade crossings. Each participant experienced one combination of each possible crossing scenario (Correct Activation; No Activation; Gate, No Train; and Train, No Gate) with each ENS sign orientation (Track Parallel and Track Perpendicular) as well as one condition where their vehicle was stuck on the tracks.

3.1 Overview

Generally, drivers were more likely to glance at and use ENS signs that were parallel to the track (i.e., facing the driver as they approach the crossing) in every scenario except for when the driver was stuck on the tracks. In the latter scenario, the ENS signs perpendicular to the tracks were more effective. Table 2 below shows the number of participants who glanced at the ENS sign, and who indicated that they would call the number on the ENS sign, for each of the scenarios and each sign orientation.

Table 2. Glance and Call Behavior by Failure Type and Sign Position

Failure Type	Sign Position	Total	# Glanced	% Glanced	# Called	% Called
Gate; No Train	Track Parallel	41	29	70.7%	5	12.2%
Gate; No Train	Track Perpendicular	40	7	17.5%	3	7.5%
Train; No Gate	Track Parallel	41	30	73.2%	10	24.4%
Train; No Gate	Track Perpendicular	40	8	20%	5	12.5%
Stuck on Xing	Track Parallel	20	2	10%	2	10%
Stuck on Xing	Track Perpendicular	20	10	50%	10	50%

Over 70 percent of participants in the two gate malfunction scenarios, false activation (Gate, No Train) and activation failure (Train, No Gate), glanced at the sign when it was facing them as they approached the crossing. When the ENS sign was in the perpendicular position, the percent of drivers who glanced was far lower: 17.5 percent for the false activation and 20 percent for the activation failure. In the scenario when the driver started on the tracks and was stuck, the opposite pattern was found, with 20 percent of drivers glancing at the perpendicular ENS sign and only 10 percent glancing at the parallel ENS sign. Fewer participants indicated that they would call the number on the sign than simply glanced at the sign for both gate malfunction conditions. Still, in both cases, more participants indicated that they would call the number on the ENS sing for the condition when the sign was parallel to the roadway. For the stuck on tracks condition, every participant who glanced at the sign indicated they would call the number on the sign.

Volpe conducted a more robust statistical analysis of the full dataset to reveal any meaningful patterns, both related to the failure type and sign position, but also related to age and gender. Because a participant could, and often did, glance at the sign without indicating they would call it, this analysis treated glance and call behavior separately.

$$\text{Glanced} = \beta 1 \times \text{ErrorType} + \beta 2 \times \text{SignPosition} + \beta 3 \times \text{Age} + \beta 4 \times \text{Gender} + \epsilon$$

And

$$\text{Called} = \beta 1 \times \text{ErrorType} + \beta 2 \times \text{SignPosition} + \beta 3 \times \text{Age} + \beta 4 \times \text{Gender} + \epsilon$$

The statistical models chosen for analysis were logistic models, since the outcome variable in each case is binary. The research team used model selection to decide if the mediating variables of age and gender were useful. This statistical model works by determining the likelihood for a certain type of event as a baseline and then compares other types of events relative to that baseline. For this model, the baseline event was glance behavior in the Gate, No Train condition with a parallel sign. The odds ratio of this baseline scenario was calculated, with a value above 1 meaning the correct glance or call behavior was more likely than the null hypothesis of no difference. The other scenarios were compared to that baseline. If a scenario neither added nor subtracted from the likelihood of a correct glance or call, then there was no significant change in the odds ratio, so those other scenarios would have an odds ratio of 1. Odds ratios below 1 representing situations where the scenario led to less correct glance or call behavior, and odds ratios above 1 representing situations where the scenario led to more correct glance or call behavior.

3.2 Glance Analysis

First, this analysis examined driver glance patterns to investigate if drivers were more or less likely to glance at the ENS sign in certain scenarios. Overall, drivers glanced at the ENS sign in 42.5 percent of the times when they had an opportunity to do so. Drivers were much more likely to glance at the sign for both the Train, No Gate and the Gate, No Train conditions when the sign was parallel to the tracks, e.g., facing the driver as they approached (odds ratio: 0.08; $p \leq 0.001$). There was no significant difference between glances for the Train, No Gate and the Gate, No Train conditions. When a sign was perpendicular to the tracks, drivers were much less likely to glance at it.

This was not the case, however, for the final scenario when the driver was stuck on the tracks when the scenario started. When stuck on the tracks, drivers were much more likely (over 100 times more likely) to glance at the sign when it was in the Track Perpendicular orientation (odds ratio: 96.69; $p \leq 0.001$). Track Parallel signage in the stuck condition was the least likely signage to be glanced at.

The addition of age to the model helped to better predict glance behavior, but age alone was not meaningful (odds ratio: 0.98; $p = 0.072$). Additionally, males were less than half as likely to correctly glance at the ENS sign as females – but this was not statistically significant due to the sample size available (odds ratio for males: 0.52; $p = 0.074$).

3.3 Call Analysis

While glances at a sign are helpful to understand the potential for a driver to notice it, noticing the signage alone is not helpful; the driver must also know how and when to make use of the information on the sign. The next portion of this analysis explored whether participants indicated they would call the number on the sign. As expected, far more participants glanced at the signs than those who indicated that they would call the number on the sign. The overall odds of correct call behavior was only 0.25, far less than the null hypothesis of 1 (p=0.007), and corresponds to the small percentage of participants indicating they would correctly make a call. Overall, across all sign orientations and activation scenarios, there was no meaningful difference in call behavior for malfunction type (odds ratio for Stuck: 0.81; p=0.814; odds ratio for Train, No Gate: 2.49; p=0.144) or for sign orientation (odds ratio: 0.58; p=0.487). However, there was one scenario where calls were far more likely: when the driver was stuck on the tracks with the sign in the perpendicular position, they were 20 times more likely to call than in the baseline scenario (odds ratio: 20.02; p=0.013).

In assessing the influence of gender on call behavior, males were far less likely to indicate they would call the number on the sign than females or TGNC participants (odds ratio: 0.23; p=0.001).

3.4 Driver Interviews

After each participant completed the simulated drives, the experimenter interviewed them to learn more about their experience with ENS signs, both in the study as well as prior to the study. None of the participants had ever called the number on an ENS sign in the past and no one reported having known that there was an ENS sign at every highway-rail crossing. Only one participant indicated that they had heard about the ENS and had possibly seen educational material about the ENS.

While these interviews did not provide a tremendous amount of detailed insight, they did indicate that knowledge about the ENS signs was quite low among this study's limited sample size. A few participants did note that they wished they had known about these signs and agreed that they were valuable. Some of these participants expressed that they wished the signs were more conspicuous or that their existence were made known more clearly.

4. Conclusion

FRA would like to know more about drivers' understanding of the ENS signage at highway-rail grade crossings. Do drivers know that these signs are there? Do they know where to look for them? If they do see a sign, do they know when they should consider making use of the information on the sign? While not all of these answers can be gleaned from a simulator study, the goals of this initial effort were to better understand driver behavior, including driver glance patterns, as they approach a crossing with an ENS sign.

This simulator-based study found that in gate malfunction scenarios (Gate, No Train and Train, No Gate) drivers were more likely to glance at the ENS sign when it was positioned parallel to the tracks. This was not the case for the situation where the driver was stuck on the tracks; here the drivers were much more likely to glance at the sign when it was in the Track Perpendicular orientation. Experimenters also noted times when drivers indicated they would call the number on the ENS sign. Individuals were generally less likely to indicate that they would call the number on the ENS, with one exception being for the Stuck on Tracks condition with the Track Perpendicular signage. When stuck on the tracks, drivers seemed most confident that they could call the number on the sign to help remedy their situation.

There were a few other significant findings revealed by this study as well. Males were far less likely than females to indicate that they would actually call the number on the sign. If campaigns are developed to help educate the public about ENS signs and their use, this information may be helpful.

When interviewed, participants indicated they generally did not know about ENS signs before coming into the study. Many participants intuited what the ENS sign was for, especially for contacting the railroad when they were stuck on the tracks, but almost no one was aware that these signs existed at nearly every public rail crossing. While the sample size was limited, the lack of awareness among the study participants indicates that FRA may want to more fully explore driver knowledge of ENS signage. That said, it is also clear from this study's findings that knowledge alone will not necessarily solve these issues, as the orientation of the signage may play a critical role.

None of the findings about glance behavior are all that surprising; they indicate drivers are more likely to glance at signs that are facing them. However, this does point out a challenge of the way that ENS signs are intended to be used by the public. Drivers are asked to use ENS signs for multiple uses: to report when they or a car they see are stuck on the tracks *and* when the warning devices are not working properly. This study found that drivers who are stuck are likely to look for one sign orientation (Track Perpendicular) and drivers who experience a malfunction are likely to look for another sign orientation (Track Parallel). Using a single sign for both purposes may prove ineffective, even if drivers know about the signs uses.

While there is certainly more to understand about driver knowledge and understanding of the ENS sign, this initial study provides some insight into where additional effort may be focused. With a more detailed understanding of what drivers know and what they expect to find at crossings, FRA may be better able to recommend strategies to improve safety, including education campaigns or recommended signage placements.

5. References

Brown, H. (2018, February 1). Safety arms at GOP train-garbage truck crash site seemed to malfunction, drivers say. *The Salt Lake Tribune*.

NTSB. (2018). *Preliminary Report Highway HWY18MH005* . NTSB.

Steinbuch, Y. (2018, February 1). Drivers experienced crossing malfunction before GOP train crash. *New York Post*.

Appendix A.
Experimental Script (Full)

Before the Study Begins:

You will be driving this car. You have two side mirrors; here [point] and here [point] and a rear view mirror at the top, here [point]. Your seat can be adjusted using the controls here [point] on the side of your seat and we can adjust the steering wheel if you would like. We will be asking you to drive through a simulated town. Please follow the road forward unless the simulation instructs you to make a turn, which it will at certain points during the experiment. If you start to feel motion sick, please stop the vehicle and let us know.

It may take a few minutes to get used to the feel of this vehicle, but we ask that you try to drive as you would in the real world. If you ever encounter a situation where you would do something in the real world that you don't think is possible in the simulator, please let the experimenter know and we can provide guidance.

Possible Questions from Participants:

Below are possible times when the participant may engage with the experimenter and how the experimenter may respond:

- **Participant**: Is this supposed to be happening (e.g., with traffic light or with a gate malfunction)?
  - **Response**: Please continue as you would if you experienced this while driving in a normal vehicle.

- **Participant**: If I encountered this while driving a normal vehicle, I think I would call the police.
  - **Response (chain)**
    - **Experimenter**: Ok, you have just called the local police. They asked you to explain what is happening.
    - **Participant**: Explains the malfunction.
    - **Experimenter**: The police thank you for calling and ask where you are located.
    - **Participant**: Provides information from the sign or says they don't know.
    - **Experimenter**: The police inform you that they will call the railroad carrier. You are on hold for 5 more minutes. The police then inform you that they railroad carrier has said that all train traffic through that crossing is now temporarily stopped and you can proceed forward safely, but to be sure to obey all other railroad crossings in your travels.

- **Participant**: If I encountered this while driving a normal vehicle, I think I would call the number on that blue sign.
  - **Response (chain)**

        - **Experimenter**: Ok, you have just called the number on that sign. They asked you for the crossing ID.
        - **Participant**: Says the number on the sign
        - **Experimenter**: They thank you for calling and tell you that they are contacting the railroad to fix the problem and ensure it is safe to crossing. They then inform you that they railroad carrier has said that all train traffic through that crossing is now temporarily stopped and you can proceed forward safely, but to be sure to obey all other railroad crossings in your travels. They will send out a crew to fix the issue ASAP. Please remember that in the future you want to continue to obey all Grade Crossing warning devices. Please do not assume that because this one is broken that all crossings are broken.

- **Participant:** If I encountered this situation in my vehicle I would turn around and find another route.
    - **Experimenter:** Unfortunately, you can only get to the location you are travelling to by going this way – there is not another option. Please decide how you would continue along this path in a way that you feel safe.

- **Participant (stuck on tracks)**: My car won't move. What should I do?
    - **Experimenter**: Please do what you would do if this were to happen while you were driving your vehicle.
        - **Participant**: I would definitely get out of the car if it were stuck on the tracks like this.
        - **Experimenter**: Ok, stand up and exit the vehicle. [pause] Ok, now that you are out of the vehicle, what would you do