



U.S. Department
of Transportation
**Federal Railroad
Administration**

Office of Research,
Development and Technology
Washington, DC 20590

Railroad Information Sharing Environment Data Steward: Phase II



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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE (DD-MM-YYYY) 30 September 2026			2. REPORT TYPE Technical Report		3. DATES COVERED (From - To) Sept 2021- Feb 2025	
4. TITLE AND SUBTITLE Railroad Information Sharing Environment Data Steward: Phase II					5a. CONTRACT NUMBER 69A36521403060RRDMD	
					5b. GRANT NUMBER	
					5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Mark L. Franz, Ph.D.: ORCID # 0000-0002-3985-691X Tahsin Emtenan, Ph.D.: ORCID # 0000-0002-7001-6724 Rohan Aras, Ph.D.: ORCID # 0000-0002-9674-2708 Sara Zahedian, Ph.D.: ORCID # 0000-0002-6927-1189 Przemyslaw Sekula, Ph.D.: ORCID # 0000-0002-4599-1077 Ateet Maharjan: ORCID # 0000-0002-7450-6237					5d. PROJECT NUMBER	
					5e. TASK NUMBER	
					5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) University of Maryland – Center for Advanced Transportation Technology Laboratory 5000 College Avenue College Park, MD 20740					8. PERFORMING ORGANIZATION REPORT NUMBER If Any	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Department of Transportation Federal Railroad Administration 1200 New Jersey Ave. SE Washington, DC 20590					10. SPONSOR/MONITOR'S ACRONYM(S)	
					11. SPONSOR/MONITOR'S REPORT NUMBER(S) DOT/FRA/ORD-26/27	
12. DISTRIBUTION/AVAILABILITY STATEMENT This document is available to the public through the FRA website .						
13. SUPPLEMENTARY NOTES COR: Jason Wornoff, Ph.D.						
14. ABSTRACT Building on the success of Phase I, Phase II of the FRA sponsored Railroad Information Sharing Environment (RISE) established collaborative relationships among rail stakeholders in class I freight, passenger and short line railroads, in addition to labor groups, state DOTs and railroad safety special interests groups with support from the Volpe Transportation Systems Center and RISE third-party data steward, the University of Maryland – Center for Advanced Transportation Technology Laboratory (CATT Lab). This Phase, conducted between September 2021 and February 2025, developed Issue Analysis Teams (IAT) to pursue railroad safety topics identified by FRA, Volpe, and railroad stakeholders, with the goal of improving railroad safety. Two IATs were established around the topics of rail property trespassing and vertical profiles of highway-rail grade crossings. This report will discuss the development of these IATs and three RISE products, a Grade Crossing Planar Deviation Dashboard, Grade Crossing Vehicle Simulation Model, and a Non- Injury Railroad Property Trespassing Collection Form that were developed with the direction of RISE stakeholders.						
15. SUBJECT TERMS Safety, Grade Crossings, Data Sharing, Simulation						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES 40	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER (Include area code)	

Acknowledgements [Optional]

The University of Maryland – Center for Advanced Transportation Technology Laboratory would like to thank Neeraj Koul (FRA), Francesco Bedini Jacobini (FRA), Jordan Multer (Volpe), and Scott Gabree (Volpe) for their technical guidance on this project.

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Executive Summary

Building on the success of Phase I, Phase II of the Railroad Information Sharing Environment (RISE) established collaborative relationships between the Federal Railroad Administration (FRA), Volpe, railroad safety stakeholders, and the third-party data steward, the University of Maryland — Center for Advanced Transportation Technology Laboratory (CATT Lab). This project, conducted between September 2021 and February 2025, developed issue analysis teams (IATs) around pressing railroad safety topics identified by FRA, Volpe, and railroad stakeholders, including railroad operators and railroad safety special interest groups. In this phase of the project, two IATs were established around the topics of rail property trespassing and vertical profiles of highway-rail grade crossings. Each IAT included representatives from FRA, Volpe, and railroad stakeholders, including railroad operators and railroad safety special interest groups.

The Vertical Profiles of Highway-Rail Grade Crossings IAT identified the need for data and analytical tools to determine potentially high-risk grade crossings for commercial vehicles. Specifically, the IAT expressed interest in discovering grade crossings with the risk of commercial vehicles making contact with the roadway surface, causing the vehicle to become stuck or “hung-up”, thus increasing exposure to a train-to-road vehicle collision. To address this critical safety need, the team used open-sourced United States Geological Survey (USGS) data to estimate vertical profiles at every grade crossing in the US. The team also analyzed commercial motor vehicles traversing target grade crossings. This analysis provided insights into which type of design vehicles may make contact with the grade crossing infrastructure.

Next, this project developed a secure online non-injury railroad property trespassing data collection form and database to support the FRA Railroad Trespassing Enforcement Grant Program. All grantees used this form to enter and submit trespassing observations to FRA. As of February 12, 2025, grantees submitted 3,993 trespassing events that include observations on 4,975 individuals. This database provided FRA and grantees valuable information on trespassing hot spots and characteristics of individuals engaging in trespassing activities.

1. Introduction

Phase II of the Railroad Information Sharing Environment (RISE) project continued to foster collaborative relationships across the railroad safety industry. Upon gathering information on the critical safety challenges from the railroad stakeholders, two issue analysis teams (IATs) were established. While the Railroad Trespassing IAT was paused due to a lack of data sharing, the team established a framework for collaboratively identifying challenges around trespassing data collection and sharing. The Highway-Rail Grade Crossings IAT developed a user-friendly dashboard to identify and investigate the vertical profile of any highway-rail grade crossing (GX) in the US based on elevation data from the United States Geological Survey (USGS). These estimates were fused with GX information from the FRA Grade Crossing Inventory to give users deeper insights into GX environments. The GX dashboard was supplemented with the development of a commercial motor vehicle simulation tool. This tool allows users to select a design vehicle, alter its parameters as needed, and simulate the vehicle traversing a target grade crossing profile.

This project also developed a secure online non-injury trespassing data collection form for the FRA [Railroad Trespassing Enforcement Grant Program](#). This form enables grantees to efficiently document trespassing enforcement activities. These submissions are used to populate a database to support FRA trespassing safety analysts.

1.1 Background

Building on the success of Phase I, Phase II of the RISE project re-engaged railroad safety stakeholders to identify and address critical railroad safety issues. Upon identifying the topics of trespassing and vertical GX profiles, the RISE team worked with stakeholders to document the needs and challenges that stakeholders face in addressing safety concerns about these topics.

A separate task was to develop, operate, and maintain a secure online non-injury rail property trespassing form and database. This form was developed under the guidance of several previous grantees.

The outcome of the discussions with stakeholders on each of these topics defined the objectives, approach, and scope as described in the following sections.

1.2 Objectives

The objectives of the research were to work with railroad safety stakeholders to identify critical safety challenges and strategies to address these challenges. Based on the discussions with stakeholders, the following objectives were identified:

1. Assess the state of practice in non-injury railroad property trespassing data collection and analysis.
2. Develop a product to enable the secure and efficient collection of non-injury railroad property trespassing data collection.
3. Develop a national database of vertical profiles of every GX in the US.
4. Develop tools to identify potentially high-risk GX.

1.3 Overall Approach

To meet the project objectives, the team participated in several stakeholder outreach activities, including in-person and virtual meetings with each IAT and one-on-one meetings with individual stakeholders. These meetings were used to define a research plan that addressed stakeholders' needs around the topics of trespassing and vertical profiles of highway-rail grade crossings.

Though the Railroad Trespassing IAT was ultimately paused, the team used stakeholder insights to develop a secure online non-injury railroad property trespassing data collection form and associated database. Developed under the guidance of previous trespassing enforcement grantees, this form is being used by all of FRA's Railroad Trespassing Enforcement Grant Program grantees and is available for any interested railroad agency to use.

The Vertical Profiles of Highway-Rail Grade Crossings IAT identified the lack of data and tools to support grade crossing risk assessment. The team discovered that vertical profile data is often collected by state or local highway departments and is not frequently shared with outside entities. To overcome this challenge, the team explored national-level elevation data sources and ultimately leveraged the United States Geological Survey (USGS) database. The North American Rail Network (NARN) was conflated with the OpenStreetMap (OSM) road network to establish an updated grade crossing location inventory to overcome inaccurate grade crossing locations in the FRA Grade Crossing Inventory. The locations of these grade crossings and the road geometry were then used to estimate the change in road elevation at locations 30 feet away from each end rail, as defined in the American Association of State Highway and Transportation Officials ([AASHTO guidance on planar deviation](#)). These elevation changes were fused with the FRA Grade Crossing Inventory to create a national database of grade crossing elevation profiles with associated data on each grade crossing environment. This data was then used to create a Tableau dashboard that allows users to explore the database with an intuitive interface and data visualizations.

Recognizing that the vertical profile is not the only component in grade crossing risk assessment, a commercial motor vehicle simulation model was also developed. This simulation tool leveraged design vehicles from a study conducted by West Virginia University (WVU). The tool allows users to select the vertical profile for the USGS-based method and various design vehicles. Users can then simulate the design vehicle traversing the target grade crossing to determine if the vehicle safely crosses the grade crossing or if the design vehicle makes contact with the grade crossing surface.

1.4 Scope

This research leveraged stakeholder engagement to identify critical railroad safety challenges and products to address those challenges. To do so, the team developed products to address stakeholder challenges in collecting and analyzing data around the topics of non-injury railroad property trespassing and vertical profiles of highway-rail grade crossings. The non-injury railroad property trespassing database only includes submissions from FRA's Railroad Trespassing Enforcement Grant Program grantees. The data leveraged by the vertical profiles of the highway-rail grade crossings dashboard is based on information derived from the USGS, NARN, OSM road network, and the FRA Grade Crossing Inventory.

1.5 Organization of the Report

The remainder of this report is organized as follows. The next section describes the data used to analyze vertical profiles at grade crossings. Section 3 presents the details of the methods used in the analysis. Section 4 presents the results of the analysis, and the products developed for the Vertical Profiles of Highway-Rail Grade Crossings IAT. Section 5 describes the effort to develop a secure online non-injury rail property trespassing data collection form and database. The final section of the report presents the conclusions of this research.

2. Data

The first step in developing the dashboard was to identify and evaluate data sources that provide insights into the safety risks of high vertical profile GXs. Additional data sources beyond the GX Inventory were used to evaluate the accuracy of GX locations. The team also developed a method to discover “ground truth” data to validate the accuracy of planar deviation estimates derived from USGS elevation data. As described in the following subsections, the development of the planar deviation dashboard leveraged data from diverse sources, including the FRA Grade Crossing Inventory, GX Incident Data, North American Rail Network (NARN), United States Geological Survey (USGS), OpenStreetMap (OSM), and the Illinois Height Modernization (ILHMP) LiDAR dataset. The following subsections describe each dataset and how each was integrated into the dashboard.

2.1 Highway-Rail Crossing Inventory Data

FRA Grade Crossing Inventory [data](#) are a comprehensive database maintained by FRA. It includes detailed information about each highway-rail crossing in the United States, reported by each state's Department of Transportation and railroads. The data is reported using Form 71 and encompasses various aspects such as location, classification, railroad details (e.g., train speed and volume), highway characteristics (e.g., annual average daily traffic, number of lanes, posted speed limits), and traffic control information. Both States and railroads contribute to this inventory to ensure it contains information on every grade crossing in the country. Railroads are required to update their information in the inventory every three years, or sooner—as in specific circumstances such as the installation of new warning devices or the closure of a grade crossing [1]. This systematic data collection helps maintain up-to-date records and enhances safety at railroad crossings. As of June 1, 2024, the database includes information on 242,621 active highway-rail crossings across the US, each identified by a unique crossing ID and featuring 255 distinct attributes. [Table 1](#) illustrates the percentage distribution of key attributes within the dataset.

Table 1. Percentage distribution of key attributes within the Highway-Rail Crossings Inventory Dataset

Attribute	Categories	Percentage of records
Ownership	Public	67%
	Private	32.8%
	NA	0.2%
Crossing position	At Grade	84%
	RR Over	7%
	RR Under	9%
Development	Commercial	14%
	Farm	19%
	Industrial	17%
	Institutional	1%
	Open Space	24.3%
	Recreational	1%
	Residential	20%

Attribute	Categories	Percentage of records
	RR Yard	0.7%
	NA	3%
Road at crossing	Rural	34%
	Urban	24%
	NA	42%
Presence of low ground clearance sign	Yes	9%
	No	56%
	NA	35%

2.2 Highway-Rail Crossing Accident Data

The Highway-Rail Grade Crossing Accident database is a comprehensive repository containing information on collisions between railroad on-track equipment and highway users at public and private crossing sites. All grade crossing collisions, regardless of severity or monetary damage, are reported using Form 57, ensuring a standardized data collection method. Railroads are required to submit immediate reports for fatal crashes and accident reports within 30 days of the accident [1]. The database includes information on crossing conditions, the type of highway vehicle involved, train speed at collision, environmental factors like time of day and weather conditions, demographic details of the driver involved, and so on. FRA's Office of Railroad Safety maintains this database as a national resource to improve safety at railroad crossings. The database contains records from 1975 to 2024, documenting 246,129 incidents as of June 1, 2024. The data reveals that 176,507 incidents involved vehicles moving over the crossing, 42,126 incidents due to vehicles stopping on the crossing, and 25,689 incidents due to vehicles becoming stalled or stuck on the crossing. Texas reported the highest number of incidents among states, followed by Illinois and Ohio.

2.3 United States Geological Survey

The primary dataset leveraged to determine planar deviations was the United States Geological Survey (USGS) Elevation [2]. The USGS Elevation dataset is available as a set of downloadable files as well as through the API — Elevation Point Query Service (EPQS). The EPQS returns elevations that are interpolated from the 3DEP dynamic elevation service. This web coverage service (WCS) includes multiple resolutions of digital elevation models (DEMs), including 1-meter resolution LiDAR-based DEMs where available and 1/3 arc-second seamless DEMs. According to the USGS website [3], the accuracy of the elevations returned by EPQS varies based on the source data for each location. The overall accuracy of the elevation service currently has an RMSE (root mean square error) of 0.53 meters. Moreover, it was discovered that the data available through the EPQS differs from the downloadable data, and based on our tests, the EPQS-based data are more accurate.

2.4 OpenStreetMap

OpenStreetMap (OSM) is an initiative to create and provide free, editable world maps using a crowdsourced approach. The quality and completeness of OSM data vary in different areas, but the studies that analyze their accuracy generally say the number of absolute and relative errors is falling [4]. OSM street data was leveraged to determine the exact location of grade crossings.

This dataset was chosen due to its completeness, which—in our experience—exceeds other publicly available sources.

2.5 Illinois Height Modernization LiDAR

The Illinois Height Modernization (ILHMP) LiDAR dataset [5] was used to validate the accuracy of the planar deviations we determined. ILHMP data have been acquired using LiDAR and are based on a contour resolution of 2 feet to 6 inches. The dataset covers almost the entire state of Illinois and is publicly available. This data is also relatively new—the oldest data dates back to 2004, and for over 61% of counties, the data were collected between 2014 and 2022. Due to the high accuracy of this dataset, it was considered ground truth and used to verify the accuracy of the planar deviation determining process.

2.6 West Virginia Commercial Vehicle Designs

Specifications for design vehicles were borrowed from Clawson [6]. This work provides the worst-case clearance profiles for four classes of vehicles: single-unit trucks with no hitch, buses, hitched trucks, and recreational vehicles. The design vehicles are split into each class as follows:

Single Unit Trucks:

- Single Unit Beverage Truck
- Articulated Beverage Truck
- Rear-Load Garbage Truck
- Aerial Fire Truck
- Pumper Fire Truck

Buses:

- Mini-bus
- School Bus
- Single Unit Transit Bus
- Articulated Transit Bus
- Motorcoach

Trucks:

- Low-Boy Trailers
- Double-Drop Trailer
- Car Carrier Trailer
- Belly Dump Trailer

Recreation Vehicles:

- Passenger Vehicle and Trailer – Private Use
- Passenger Vehicle and Trailer – Commercial Use
- Recreational Vehicle

Clearance profiles for all vehicle classes are specified by the length of each portion of the vehicle's undercarriage and the minimum clearance of that portion. For example, vehicles without a hitch or other articulation will have measurements for the length and clearance of the front overhang, wheelbase, and rear overhang. Vehicles with a hitch have measurements specified solely for the trailer component of the vehicle. An example design vehicle is shown in [Figure 1](#).

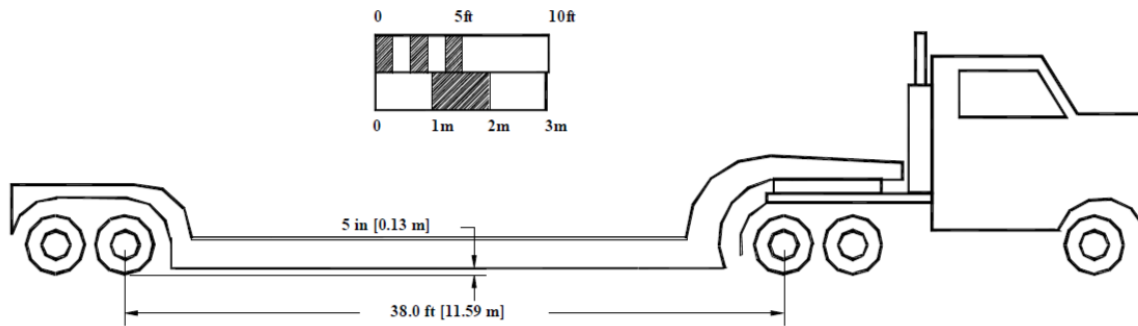


Figure 1: Worst case clearance for a Low Boy Trailer [\[6\]](#)

3. Methodology

3.1 Conflation Process

To accurately calculate planar deviation at grade crossings (GX), it is essential to pinpoint the exact locations of both the crossings and the geometry of the crossing highways. This study used OpenStreetMap (OSM) for the highway network and the North American Rail Network (NARN) for the rail network. The initial step involved overlaying these two maps to identify intersections between highways and railroads. Once intersections were identified, the next task was to match these locations with corresponding crossing IDs from FRA's Grade Crossing Inventory. To achieve this, a search radius of 100 meters was implemented around each identified intersection point. Within this radius, the closest GX from the FRA inventory was selected as the matching crossing. The selection of a 100-meter search radius was determined through manual verification of GX locations provided by the FRA inventory against observations from Google satellite view. This process ensured that most observed GX locations were within this distance. Moreover, extending the search radius beyond 100 meters increases the risk of incorrectly matching crossings IDs. Figure 2 presents an example of rail-highway conflation.

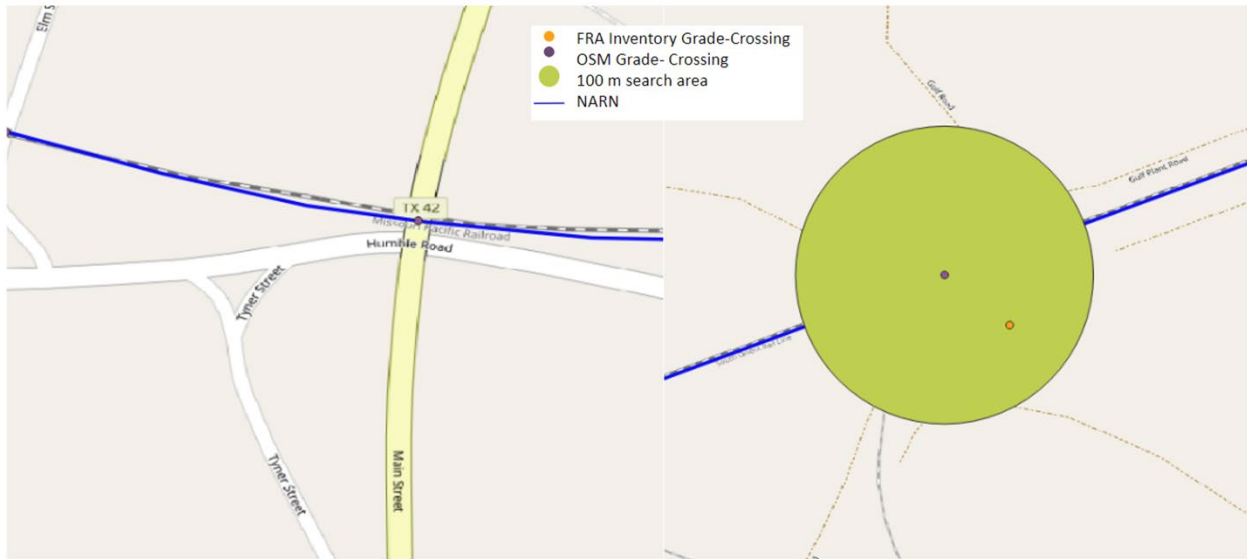


Figure 2: Rail-Highway conflation example

Validating the quality of the conflation process was done manually. First, it was assumed that if the distance between the FRA inventory and the conflation-based location is less than or equal to 10 meters, the conflation process provided a more accurate location. This assumption was based on the relatively high quality of the OSM dataset, especially if it is compared to the unclear way the original location data was collected. Secondly, for the locations with distances greater than 10 meters, we selected the subset of 243 locations with greater distances. Then, this subset was analyzed manually, comparing the original and conflation-based locations with OSM and NARN maps and Google satellite imagery and determining whether and why the conflation process was inaccurate. The following error categories were considered:

- No error: the conflation process returned the correct location; the original location was accurate.

- Missing OSM: the error was caused by a missing OSM segment.
- NARN data problems: the error was caused by missing or inaccurate NARN data.
- Other / cannot determine: All other errors, including these where we cannot determine the source of the error.

3.2 Planar Deviation Calculation

Given the geocoordinates of the GX locations, the USGS dataset was leveraged to determine the elevations at and around the GX. Specifically, the elevations of five locations were determined: in addition to querying the elevation of the GX, we also queried the elevations of the locations on the road, 15ft and 30ft away from the intersection in both directions. The 30ft distance was used to be consistent with the planar deviation definition. In contrast, the 15ft distance helped capture cases where the slope was steeper in the immediate vicinity of the GX. This logic was confirmed by initial tests, in which we discovered that using both 15ft and 30ft away locations increased the accuracy compared to the case when only the 30ft away points were used. Given these elevations, the planar deviation was determined for each direction separately, as shown in Equation 1:

$$Planar\ deviation = \max \left(\frac{|elevation_{point} - elevation_{midpoint}|}{distance} \right) \quad (1)$$

The slope types (ascending/descending) for the maximum elevations were also determined.

The ILHMP LiDAR dataset was used to validate the quality of planar deviation estimations. For all the GXs in Illinois, this dataset was used to determine the elevations and, as a result, the ground truth planar deviations. Then, the ground truth planar deviations were compared with corresponding USGS Elevation dataset-based results. Finally, four planar deviation thresholds of 3, 6, 9, and 12 inches were defined, which may be meaningful for practitioners. For each threshold separately, the task was redefined as a classification task, e.g., “determine whether a planar deviation is greater than 6 inches.” Then, the ground truth ILHMP LiDAR-based data was leveraged to analyze the performance of this classification. For the performance analysis, three metrics were used: accuracy, precision, and recall.

3.3 Physics Modeling

The commercial motor vehicle simulation tool models both the vehicle and the vertical profile of the crossing as simple rigid bodies using the Python Pymunk library. Pymunk is a 2D physics library used to simulate rigid body physics. It is built on Chipmunk2D, a 2D rigid physics library written in C.

In the model, the vertical profile of the crossing is abstracted to a set of joined line segments. The vehicle is similar, but the abstraction includes circles to model the wheels.

3.3.1 Vertical Profile Model

The vertical profile of a GX was modeled as a set of five segments: approach, entry slope, crossing, exit slope, and departure. The middle three segments modeling the vertical profile (entry slope, crossing, exit slope) correspond to the model underlying AASHTO's Vertical Alignment Design Criteria for Railroad-Highway Grade Crossings. These three segments are parametrized by three values:

- **Approach planar deviation (D1):** the difference in elevation between the crossing and the approach segments.
- **Departure planar deviation (D2):** the difference in elevation between the departure and crossing segments.
- **Crossing Length (CL):** the length from the first rail in the crossing to the end of the last rail. This length is the length of the crossing segment minus 4 feet. The 4-foot added length comes from the AASHTO model.

For both D1 and D2, a positive number indicates a positive slope from the vehicle's perspective. The canonical crossing would have a *positive* D1 and a *negative* D2 (up to the tracks; down the other side).

3.3.2 Vehicle Models

Vehicles are modeled as a set of at least two circles (representing a front and back set of wheels) and several segments. The exact number of segments and circles depends on the vehicle configuration. These shapes are also split between multiple vehicle components: a *cab* and (when relevant) a *trailer*. The connection between the components is modeled with a simple pin joint—the cab and trailer can only rotate with respect to the other along a singular axis. Please note that no other joints are modeled—*both the cab and trailer models are perfectly rigid*. Again, this model does not attempt to model suspensions as this could vary wildly between vehicle models and conditions.

All of the base cab models have the following pattern: a front overhang segment, followed by a wheel/axle, followed by a wheelbase segment, followed by 1-2 wheel/axles, followed by a rear overhang segment. These shapes are parameterized as follows:

- **Front overhang length:** The distance between the front bumper and the front axle.
- **Wheelbase length:** The distance between the front axle and the (first, if applicable) rear axle.
- **Rear overhang length:** The distance between the (second, if applicable) rear axle and the rear bumper.
- **Front overhang clearance:** The minimum clearance of the front overhang.
- **Wheelbase clearance:** The minimum clearance of the wheelbase.
- **Rear overhang clearance:** The minimum clearance of the rear overhang.
- **Wheel diameter:** The diameter of the wheels.
- **Wheel spacing:** The distance between the rear axles.

The base trailers have a similar pattern: a trailer overhang segment, followed by a "wheelbase" segment, followed by 1-3 wheel/axles, followed by a rear overhang segment. These segments are parameterized similarly to their base cab counterparts. The parameterization is as follows:

- **Trailer overhang length:** The length of the segment overhanging the cab.

- **Wheelbase length:** the distance between the first rear axle and the trailer overhang segment.
- **Rear overhang length:** The distance between the (second or third, if applicable) rear axle and the rear bumper.
- **Trailer overhang clearance:** The height of the trailer overhang above the ground.
- **Wheelbase clearance:** The minimum clearance of the wheelbase.
- **Rear overhang clearance:** The minimum clearance of the rear overhang.
- **Wheel diameter:** The diameter of the wheels.
- **Wheel spacing:** The distance between the rear axles.

4. Results and Final Products

4.1 Planar Deviation Dashboard

As part of this research, a dashboard was developed to identify high vertical profile GX in the U.S. where approach grade profiles might pose safety issues. It includes a detailed data visualization interface featuring filters, interactive maps, and tables. Figure 3 shows a screenshot of the planar deviation dashboard.

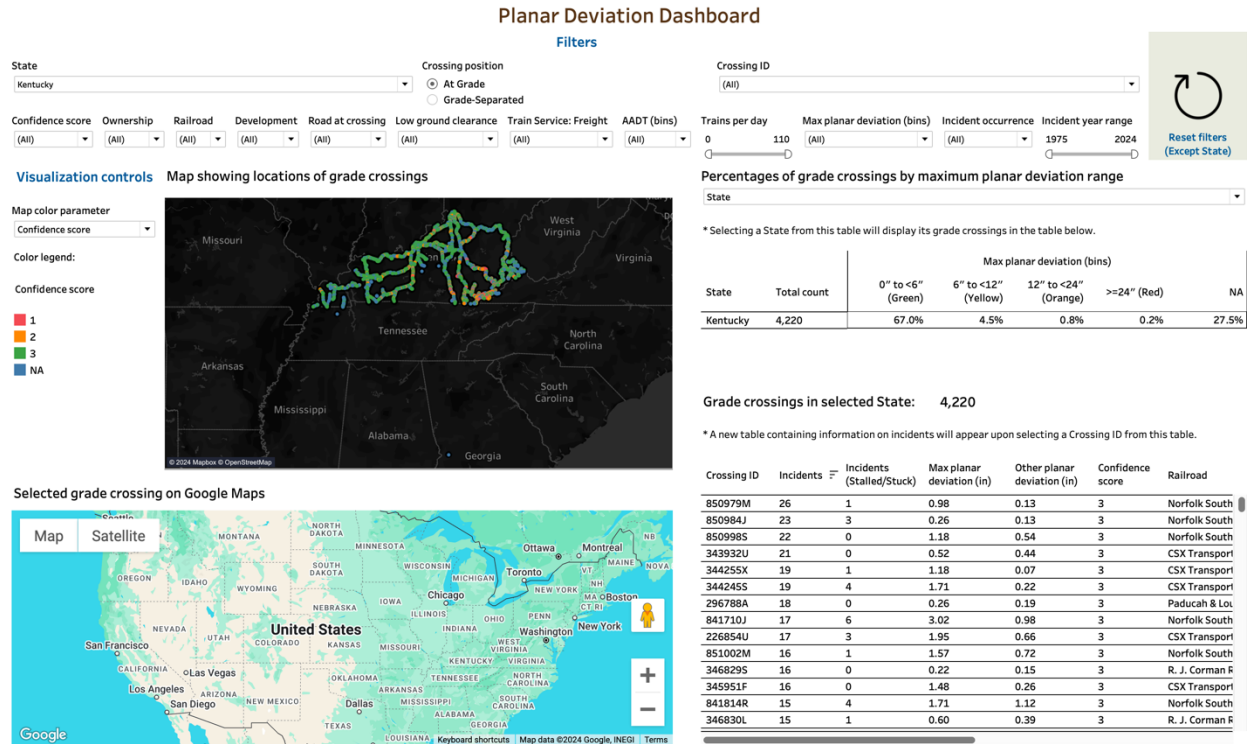


Figure 3: Planar deviation dashboard

4.1.1 Interface Design and Functionality

Filters

Users can apply various filters to customize the dashboard according to specific criteria. Once applied, the dashboard automatically updates all the calculations and displays to show the filtered results. A reset button allows users to clear all selected filters, enhancing flexibility. Table 2 provides definitions and example field values for the variables used in filtering.

Table 2. Variables used in the dashboard for filtering

Variable	Definition	Field values
State	Name of the state where the crossing is located	50 states and the District of Columbia

Variable	Definition	Field values
Crossing position	Indicates whether a crossing is at grade or if the railroad passes under or over the roadway or pathway.	At grade, Grade-Separated
Crossing ID	Unique ID to locate each crossing	850979M, 344255X, 735682T etc.
Confidence score	Level of confidence on the calculated planar deviation where 3 corresponds to the highest and 1 to the lowest confidence	1, 2, 3, NA
Ownership	Indicates whether a crossing is public or private	Public, Private
Railroad	Name of the parent railroad	Alameda Belt Line, Alan Wood Steel, etc.
Development	Predominant type of land development in the vicinity of the crossing	Commercial, Industrial, Residential, etc.
Road at crossing	Rural or urban classification of the road at the crossing	Rural, Urban, NA
Low ground clearance	Presence of low ground clearance signs	Yes, No
Train service: Freight	Use of the crossing by freight	Yes, No
AADT (bins)	Estimated AADT through the crossing (total in both directions) categorized into bins	0 to <500, 500 to <1000, 1000 to <1500, 1500 to < 5000, 5000 to <10000, >= 10000
Trains per day	Total number of trains that operate through the crossing per day during normal railroad operating periods	0 to 856
Max planar deviation (bins)	Maximum planar deviations calculated using the USGS dataset categorized into bins	0" to <6", 6" to <12", 12" to <24", >= 24"
Incident occurrence	Indicates whether an incident between on-track railroad equipment and a highway user occurred at a crossing.	Yes, No
Incident year range	Year of the incident	1975 to 2024

Interactive Maps

The dashboard includes two interactive maps. The first map, as shown in Figure 4, displays GX nationwide using color-coded markers based on selected parameters, such as confidence score, maximum planar deviation (categorized into bins), development type, AADT (categorized into bins), and estimated truck AADT (categorized into bins). Users can choose a specific parameter to color-code the markers on the map according to that parameter.

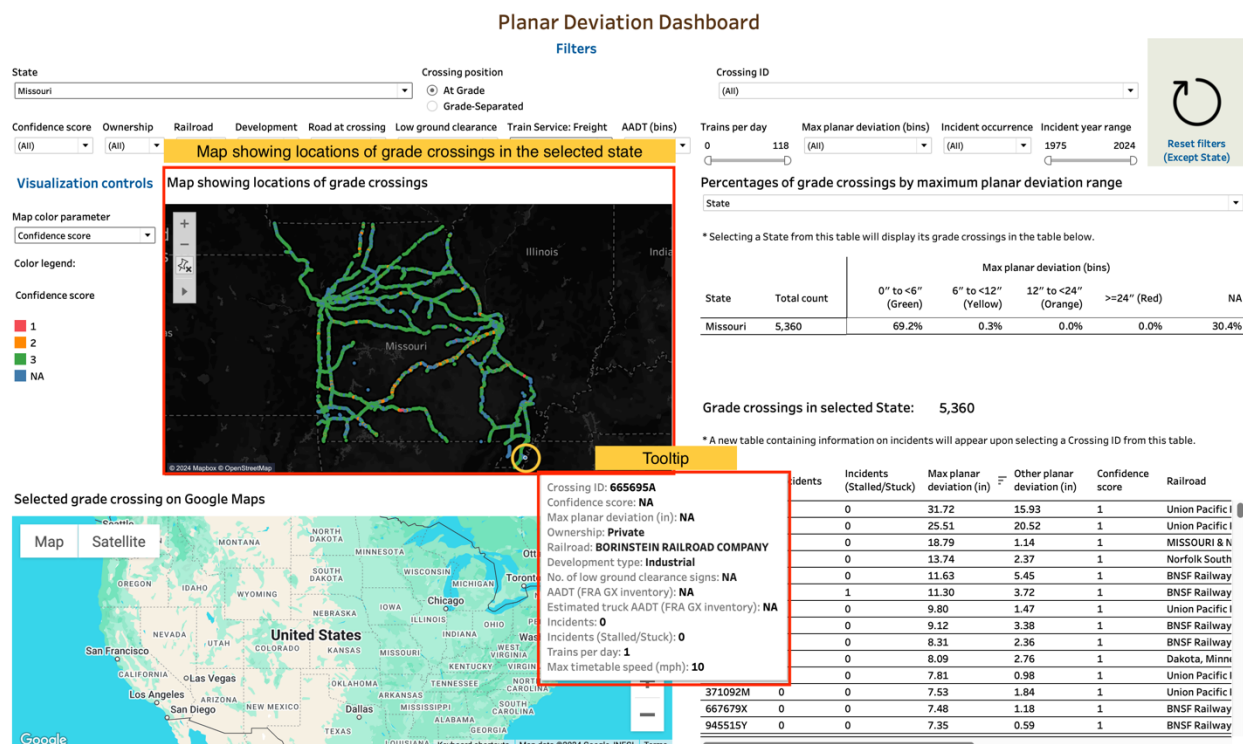


Figure 4: Map displaying grade crossing locations in Missouri, color-coded by confidence score

Another map on the dashboard displays a Google Maps view of the selected GX with the option to explore street view imagery for further exploration. Users can select a crossing from either the national map or from the table listing detailed grade crossing data to view the location of the crossing on Google Maps. Figure 5 and Figure 6, respectively, show the satellite and street views of a selected grade crossing on Google Maps.

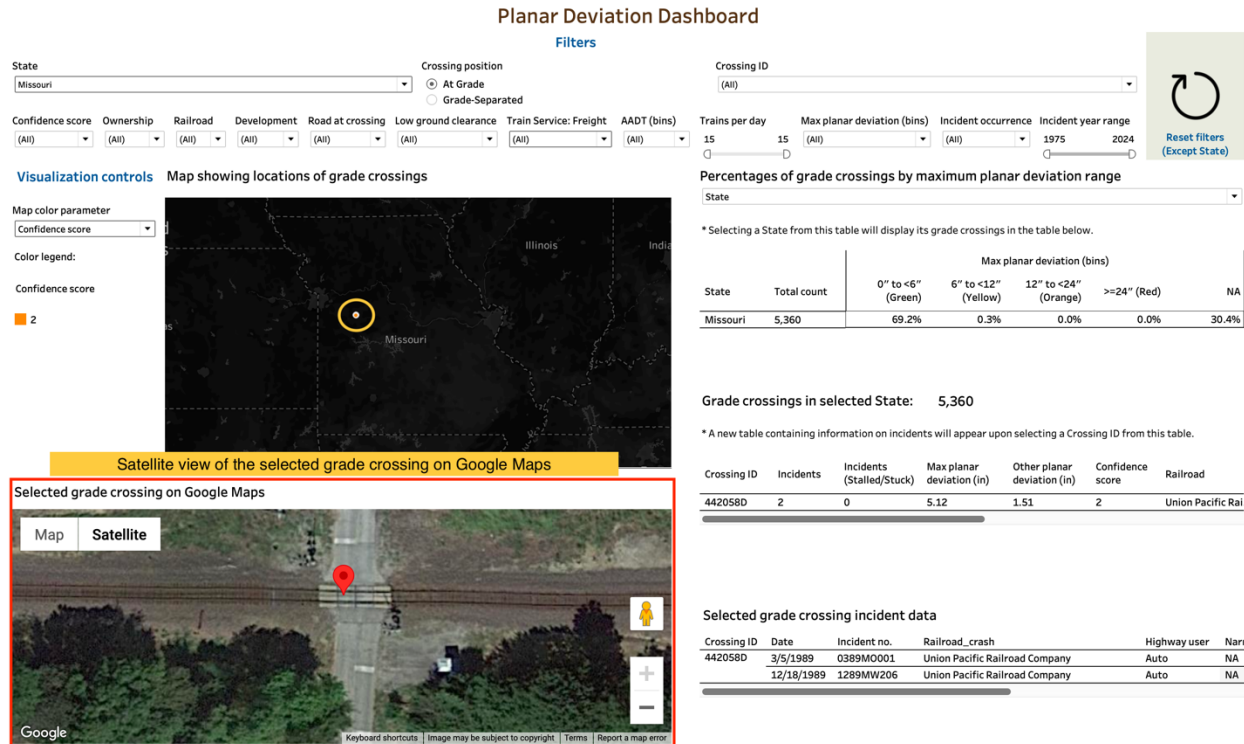


Figure 5: Map displaying the satellite view of the selected grade crossing on Google Maps

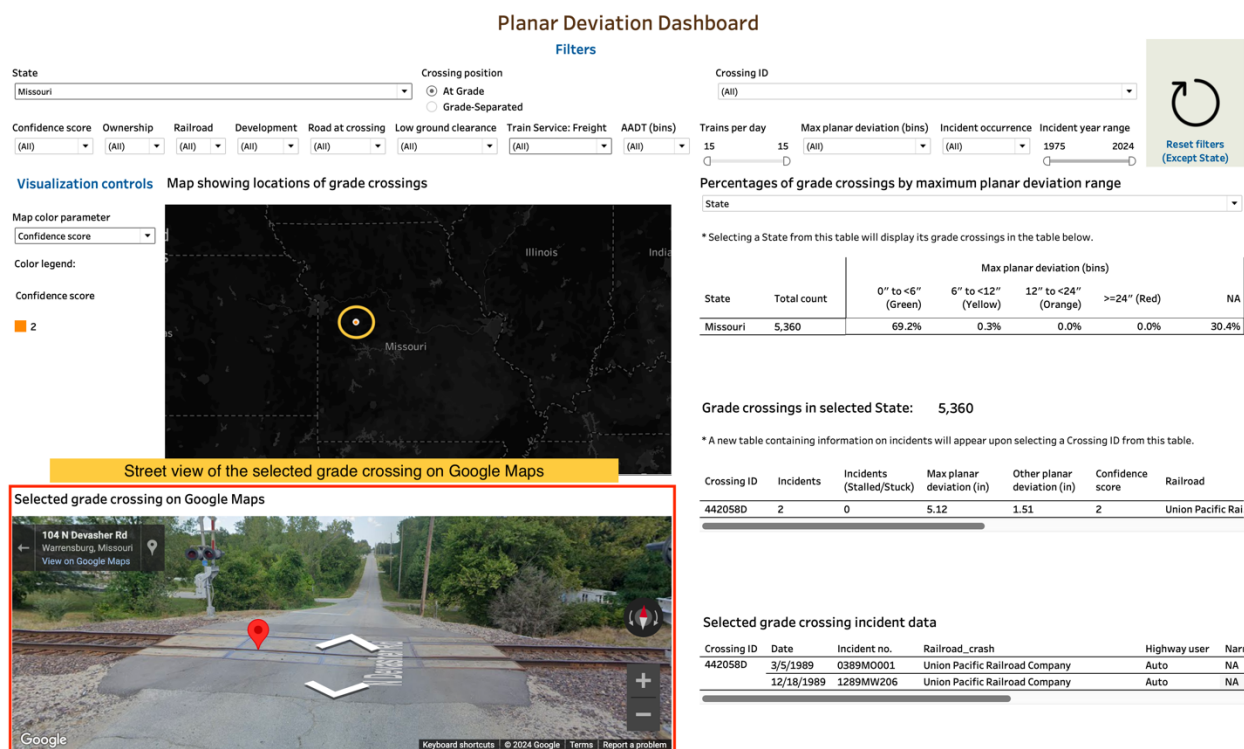


Figure 6: Map displaying the street view of the selected grade crossing on Google Maps

Tables

On the right side of the dashboard, there are three tables. The first table, as shown in Figure 7, presents the percentage of crossings within each maximum planar deviation range at either the state or county level based on user selection via a parameter at the top of the table.

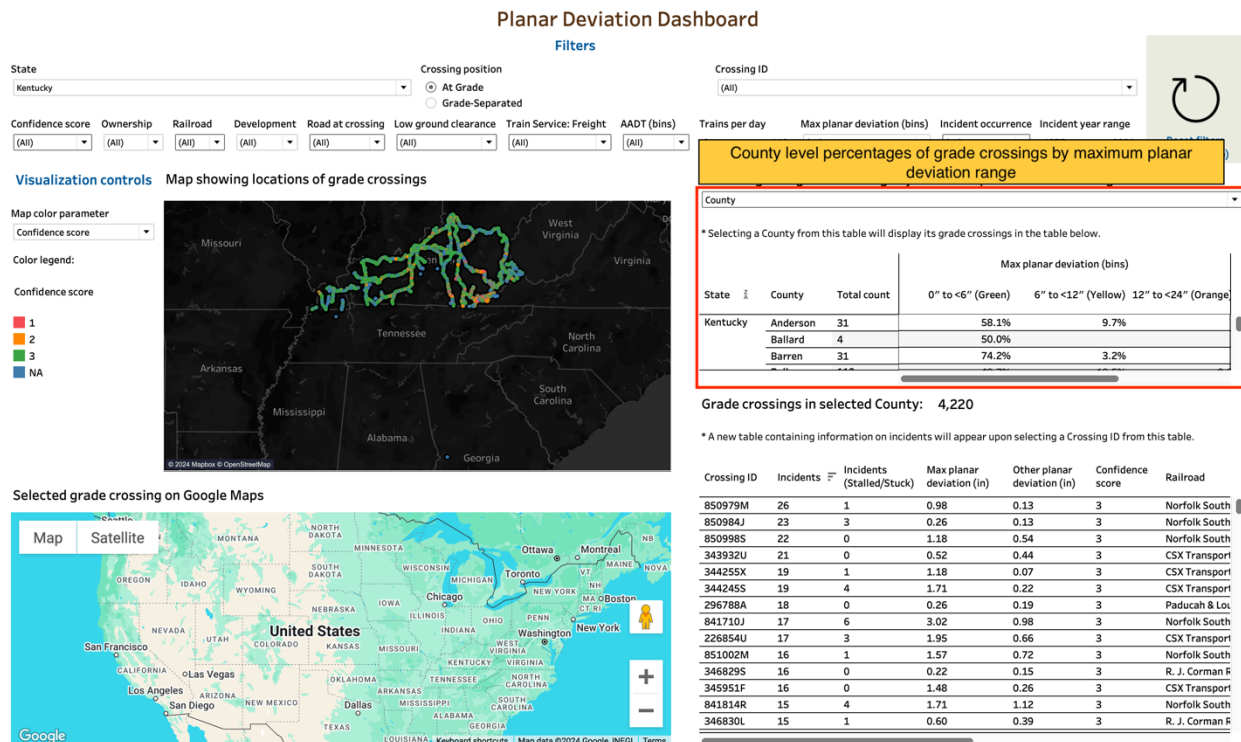


Figure 7: Table showing county level percentages of grade crossings by maximum planar deviation range

The second table, as shown in Figure 8, lists the GX in the selected state or county along with relevant attributes, such as the number of incidents, incidents involving vehicles getting stuck or stalled on the crossing, maximum planar deviation, confidence score, the presence of low ground clearance signs, and so on.

When a crossing ID is selected from this table, a third table, as shown in Figure 9 appears with detailed incident information, including highway user position and incident narratives.

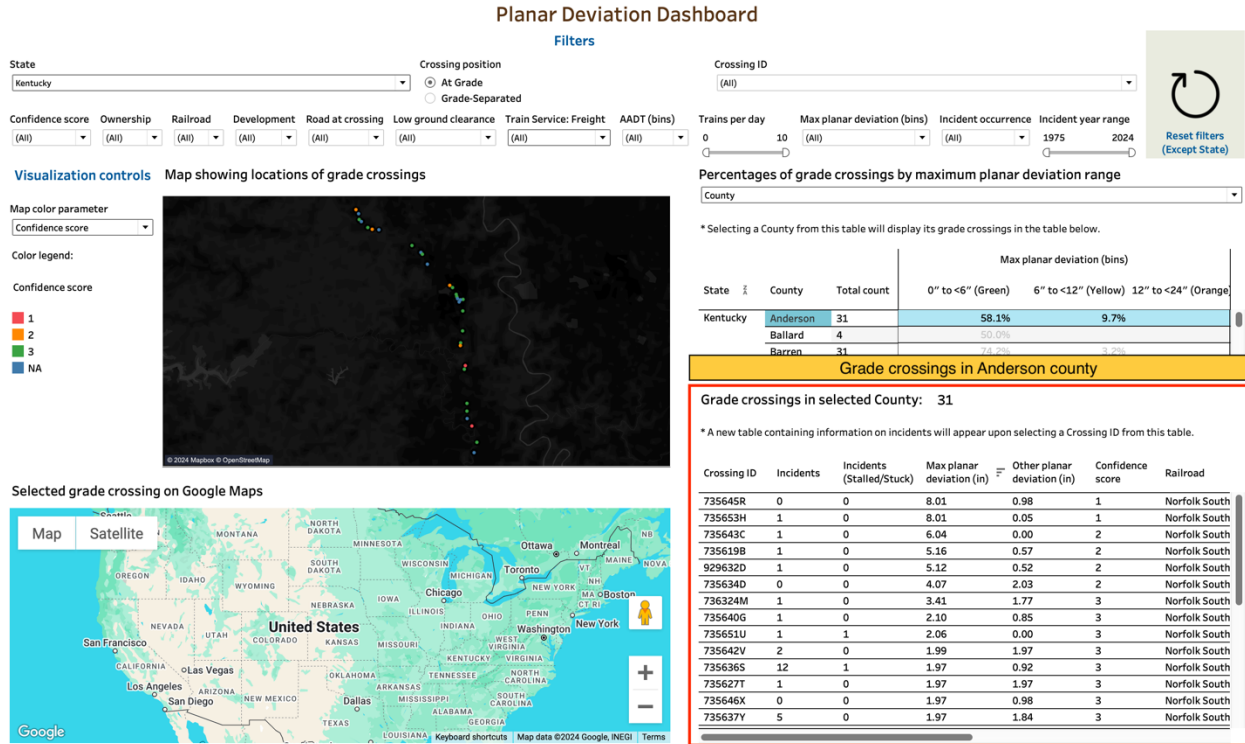


Figure 8: Table showing grade crossings in the Anderson County, along with relevant attributes

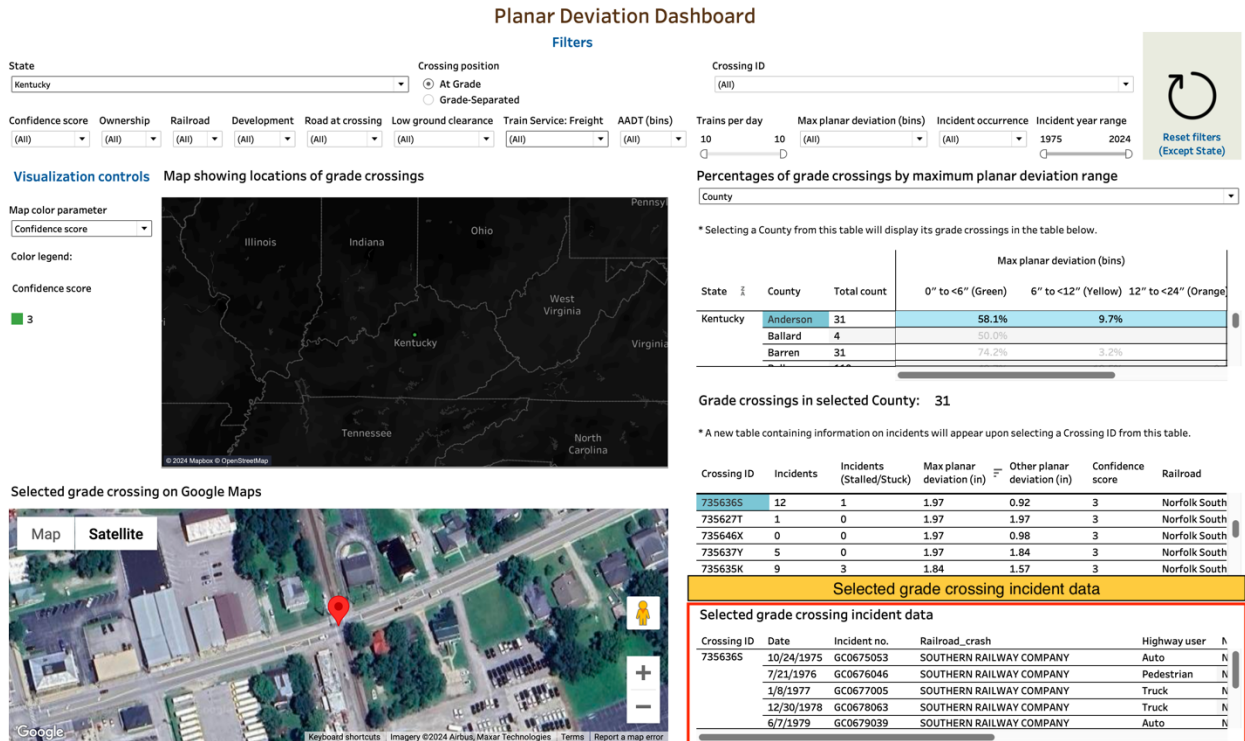


Figure 9: Table showing information on incidents on the selected grade crossing

4.1.2 Real-World Application

The dashboard can be used for different purposes. One of the primary use cases of the dashboard is to identify GX with high planar deviations within a state. By integrating this information with the presence of low ground clearance signs and the number of incidents related to vehicles getting stalled or stuck on the crossing, users can identify and prioritize grade crossings with a high risk of hangups. The dashboard allows users to utilize Google Maps Street View to verify the approach grade profile, providing a practical tool for assessing and addressing potential safety issues at these crossings.

Figure 10, Figure 11, and Figure 12 illustrate such a use case of the dashboard. First, the user can filter for public grade crossings with confidence scores of 2 or 3 and incidents involving vehicles getting stalled or stuck within the last 10 years. The table on the bottom right displays the crossings that meet these criteria, as shown in Figure 10.

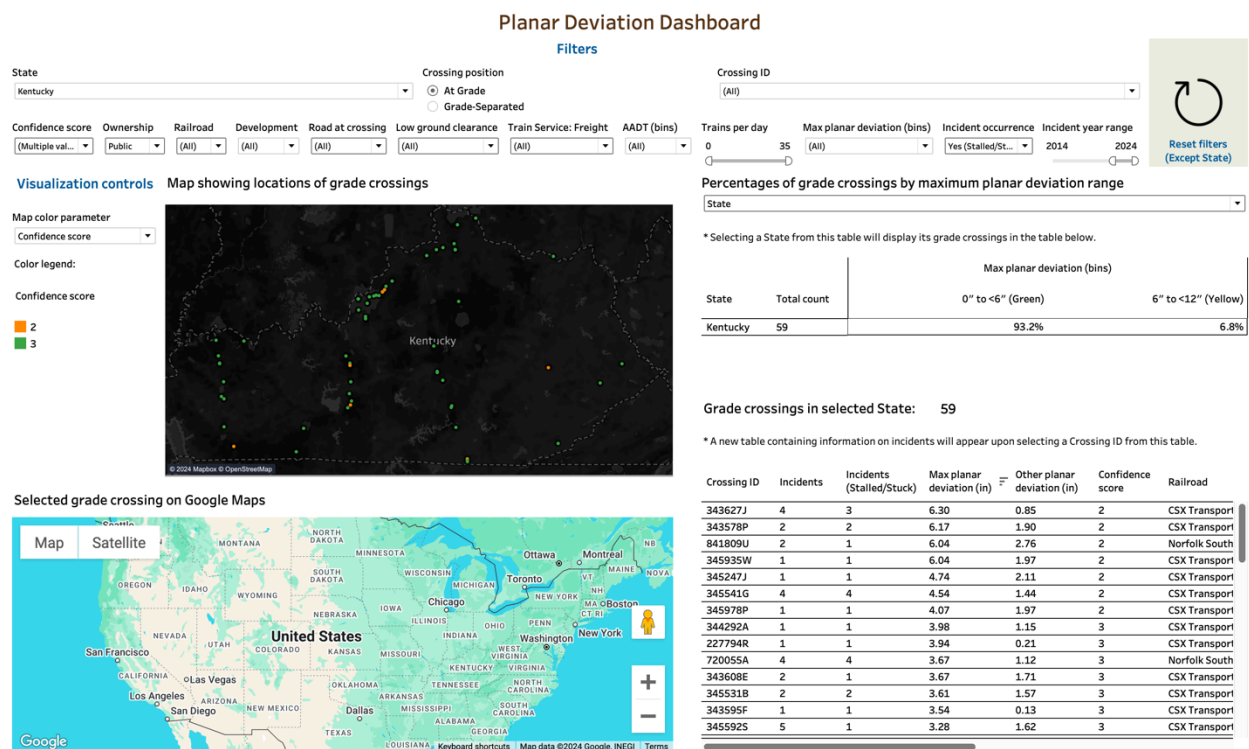


Figure 10: Dashboard displaying at-grade crossings in Kentucky with applied filters

Next, the user can sort the table in ascending order of maximum planar deviations. Figure 11 shows that four incidents occurred at the crossing with Crossing ID 343627J, three of which were due to vehicles getting stalled or stuck on the crossing. This crossing has a maximum planar deviation of 6.3 inches and lacks a low ground clearance sign. Additionally, the table provides detailed information on the incidents at the crossing.

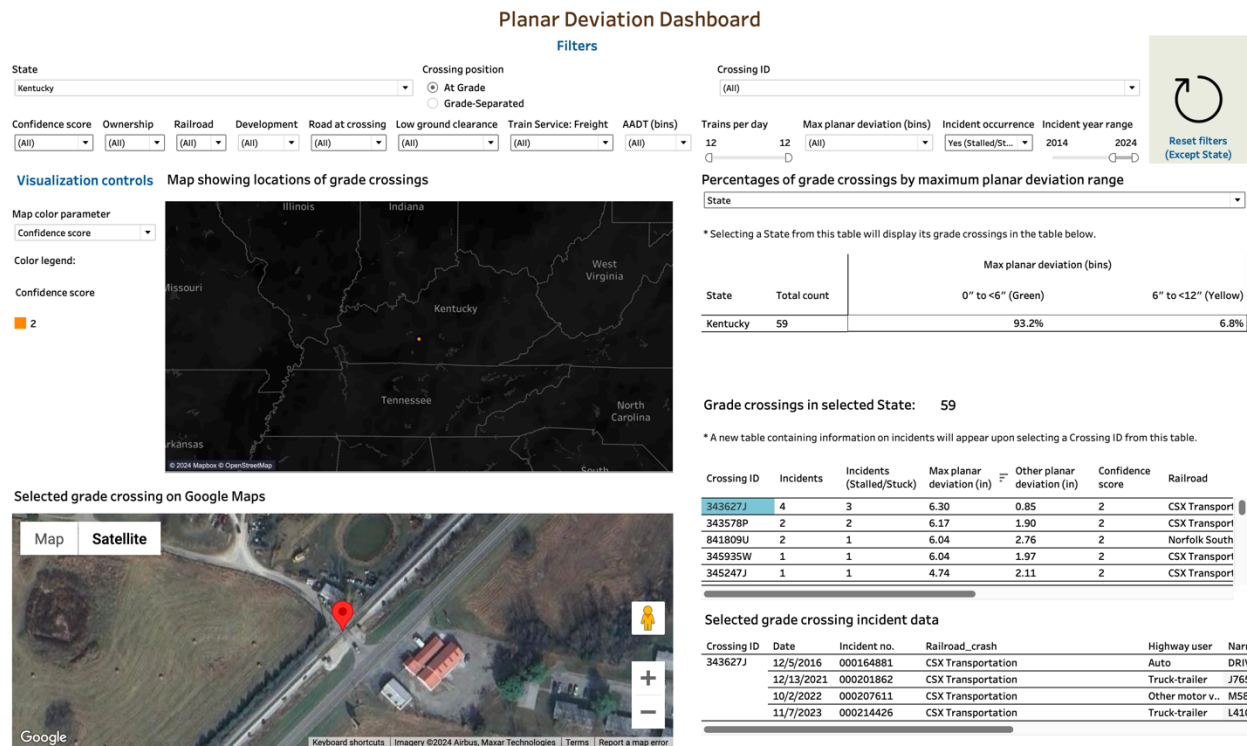


Figure 11: Dashboard with table showing no. of stalled/stuck vehicle-related incidents at Crossing ID 343627J

By selecting the grade crossing on the map, the user can view the street-level image of the crossing on Google Maps, as demonstrated in Figure 12. This functionality enables thorough assessment and prioritization of potential safety issues.

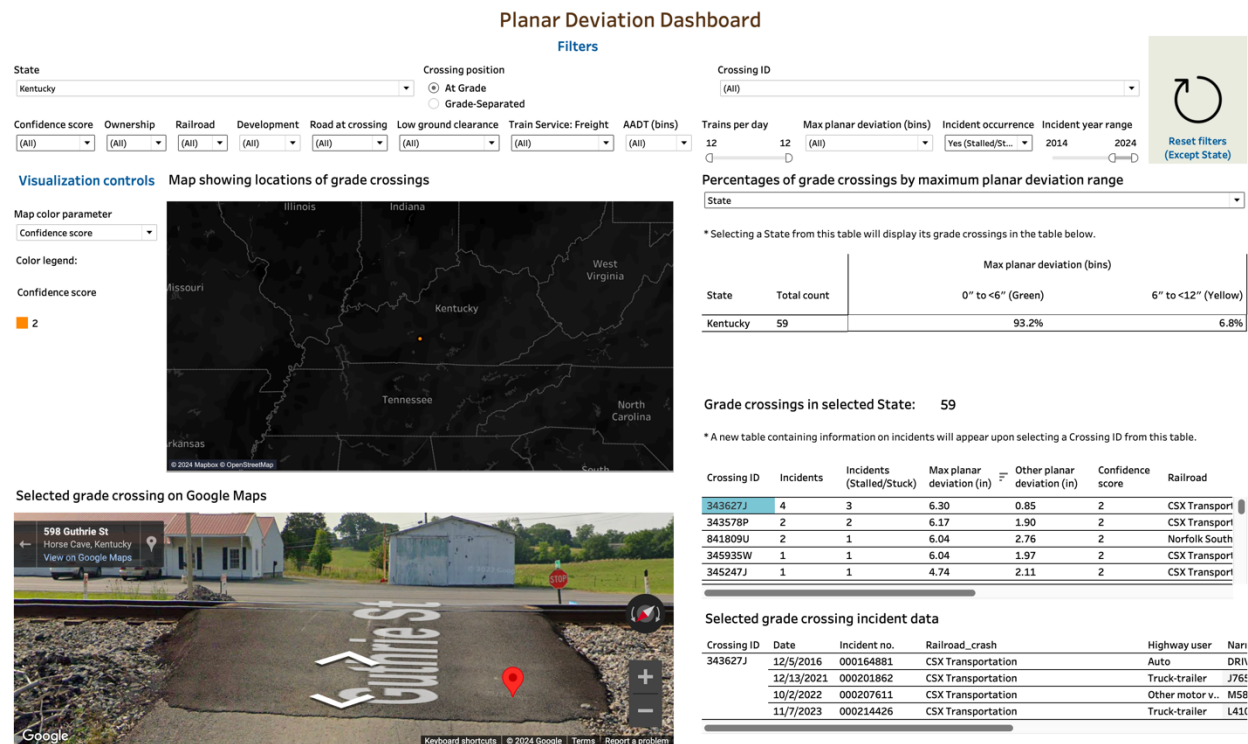


Figure 12: Dashboard displaying Google Street View image of the selected grade crossing

Another potential use case of the dashboard is validating the locations of GXs in FRA’s Grade Crossing Inventory. The confidence score filter in the dashboard provides four options, including the ability to display only those grade crossings for which a confidence score could not be derived based on our methodology. These crossings may have incorrect locations in FRA’s Grade Crossing Inventory. By viewing these crossings on Google Maps, the user can determine if location corrections are necessary, thereby ensuring the accuracy and reliability of the grade crossing data.

The following example illustrates this use case. By selecting “NA” from the dropdown filter, the map updates to display only those crossings that lack a confidence score. The user can then choose a specific crossing from the map to view its street-level imagery via Google Maps. As illustrated in Figure 13, there is a discrepancy between the grade crossing inventory's recorded location and the actual location of the crossing. This indicates that the recorded location of this crossing needs to be revised in the inventory.

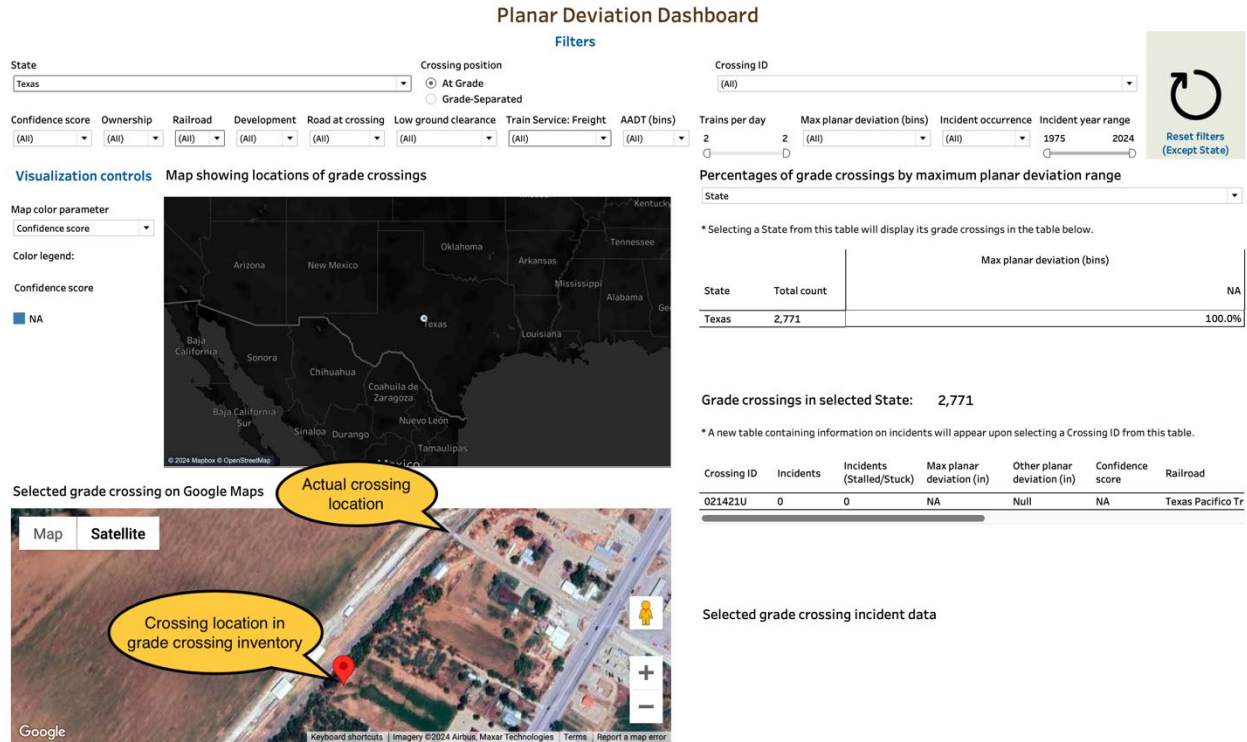


Figure 13: Dashboard showing a grade crossing in Texas with an inaccurate location in the inventory

4.2 Vehicle Simulation Model

The commercial motor vehicle simulation tool is an application designed to provide a simplified model of the interaction between various vehicle types and road-rail grade crossings. This tool allows users to identify potential collisions between vehicles and the crossing and assess crossings for safety considerations. This tool is designed to be used in conjunction with the Planar Deviation Dashboard described in Section 5.1.

4.2.1 Interface Design

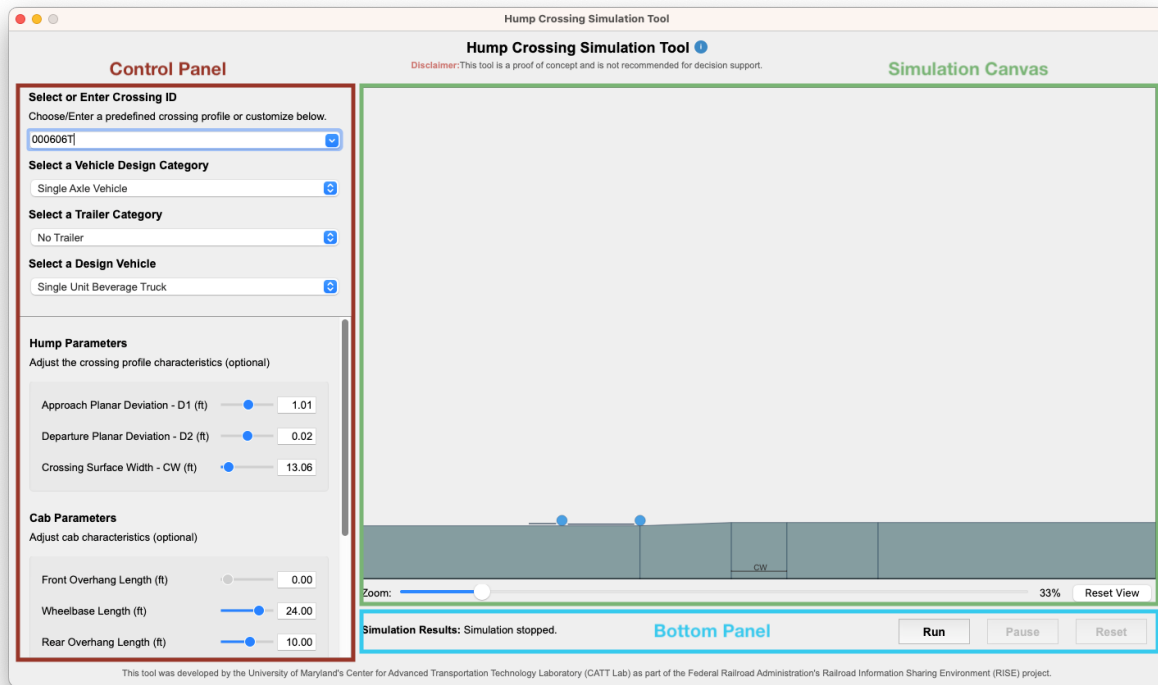


Figure 14: Simulation tool interface

The main window of the simulation Tool consists of three primary components:

Control Panel (Left)

This component houses dropdowns and sliders to adjust the parameters of the vertical profile and the vehicle. At the top of the component are four dropdown menus. The first allows the user to set the parameters of the vertical profile using the values of a specific crossing ID. This dropdown also functions as a textbox to facilitate the entry of crossing IDs found using the planar deviation dashboard.

The subsequent three dropdowns allow the user to drill down to the specific design vehicle that they would like to use. First, the user can select a specific cab type: one with a single rear axle or one with a dual rear axle. Next, they can choose one of the available trailer types. This dropdown has already been narrowed to a list of trailers that form a viable design vehicle with the selected cab. Finally, the user can select one of the available design vehicles for that cab and trailer combination.

Several standard design vehicles are provided across six different combinations of cab and trailer configurations:

- Single rear axle cab with:
 - No trailer
 - Single rear-axle trailer
 - Dual rear-axle trailer

- Tri rear-axle trailer
- Dual rear-axle cab with:
 - No trailer
 - Dual rear-axle trailer

The design vehicles utilize measurements provided by Clawson in [Establishing Design Vehicles for the Hang-Up Problem](#).

Below the four dropdown menus are two to three sets of sliders that the user can manually use to adjust the parameters of the vertical profile, vehicle cab, and vehicle trailer (if applicable). The section encompassing all three sets of sliders will become scrollable if the number of sliders needed to manipulate the vehicle makes it necessary.

The vertical profile sliders—controlling D1, D2, and CL—will be preset with values if the user selects a specific crossing using the dropdown menu at the top of the control panel. Similarly, the cab and trailer parameters will be preset using values for the selected design vehicle.

Simulation Canvas (Center)

This component displays a 2D cross-sectional view of the crossing and a traversing vehicle. It provides a visual representation of the simulation in real time. The five segments of the vertical profile (approach, entry slope, crossing, exit slope, and departure), with delineations between the different sections, form the base of the visualization. The parameters for the vertical profile, D1, D2, and CL, are labeled on the canvas to provide visual feedback to the user's inputs. The user-selected vehicle is shown as a simplified model, highlighting the wheels and the bottom of the chassis. The vehicle moves across the crossing during the simulation.

The canvas also contains a few controls to adjust the user's view of the simulation. At the bottom of the canvas, there is a slider that changes the zoom level of the simulation. When zoomed in, the user can also click and drag the viewport to pan the view. When used in conjunction, these two features allow the user to more closely inspect the vertical profile, vehicle, or collision.

Bottom panel

This component displays information and contains controls:

- **Results Panel:** This component displays information on the progress of the simulation. When a collision occurs, this panel will detail the part of the vehicle and the part of the vertical profile that was involved.
- **Simulation Controls:** This component contains controls to [Run](#), [Pause](#), and [Reset](#) the simulation.

4.2.2 Real-world application

One can extend the real-world application presented in Section 5.1 to show how the planar deviation dashboard and commercial motor vehicle simulation tool can be used together. After starting the Simulation tool, we can input the Crossing ID from Figure 15, **343627J**, in the appropriate dropdown in the top left of the tool. The cross-section of this crossing will appear on the Simulation Canvas at the center, as seen in [Figure 15](#).

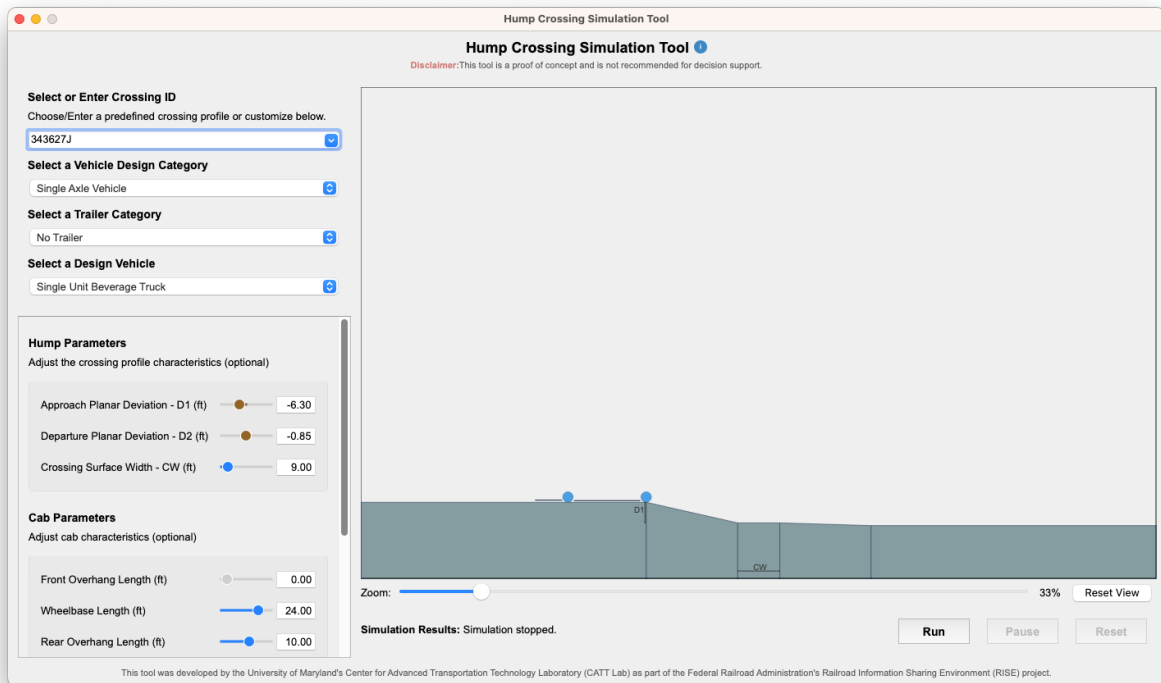


Figure 15. Cross section of Crossing ID 343627J

Now, suppose there is a high probability of a car carrier truck at this intersection. It is known that the prototypical car carrier contains a cab with two rear axles and a trailer with two rear axles. Hence one may drill down to this vehicle type using the bottom three dropdown menus in the control panel to the left.

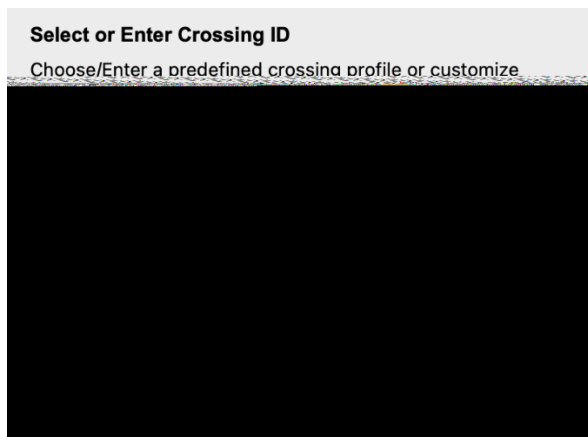


Figure 16 Dropdown options for trailer categories

We can then hit run to start the simulation:

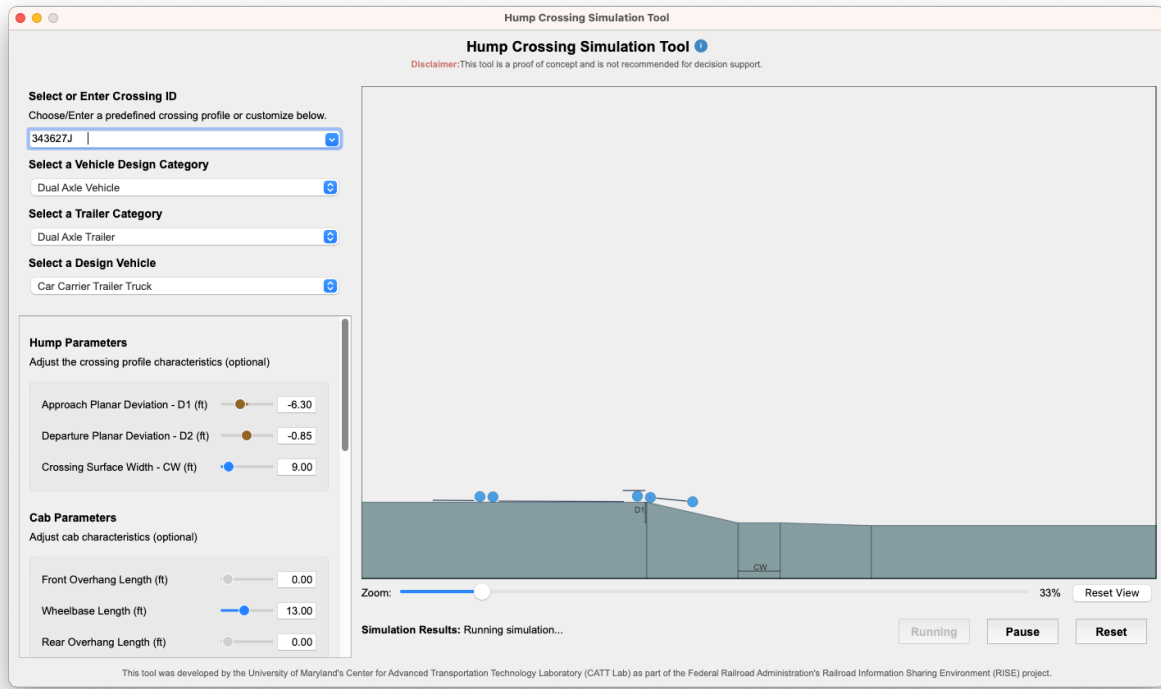


Figure 17. Running the simulation

It is clear that, for this parameterization, the vehicle quickly comes into contact with the roadway surface. As is visually apparent in the Simulation Canvas and described textually in the Results Panel in [Figure 18](#), the wheelbase of the trailer struck the approach to the vertical profile almost immediately.

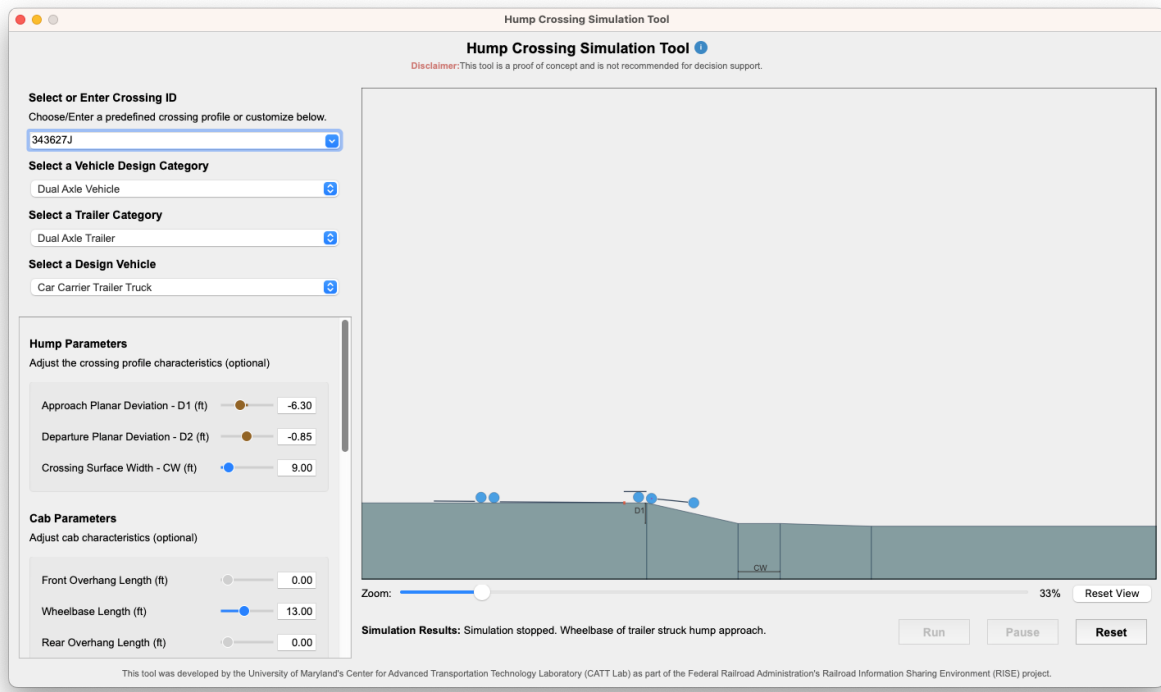


Figure 18. Simulation results display

5. Secure Online Non-Injury Railroad Property Trespassing Data Collection Form and Database

5.1 Form Development

The secure online non-injury railroad property trespassing data collection form and database were developed to support FRA's [Railroad Trespassing Enforcement Grant Program](#). Under the program, FRA provides grants for law enforcement to assist communities at risk for rail trespassing-related incidents and fatalities. Through the meetings and review of data samples provided by the Railroad Trespassing IAT, our team observed significant variation in how non-injury trespassing data was collected and documented. These observations motivated the team to contact potential end-users of the trespassing data collection form. To meet this need, FRA assisted with outreach to previous trespassing enforcement grantees to create an ad-hoc steering committee that provided feedback on the data fields to collect and the design of the data collection form. The committee met several times over the course of the form development to provide feedback on the steps in entering observations and the overall interface designs. The outcomes of these conversations were used to refine and enhance the form, as described in the next section.

5.2 Form Design

The secure online data collection form offers two levels of user permissions. The first permission level is titled "Officer." Officer permissions allow users to enter, edit, and submit trespassing observations to their supervisor. Officers can only view the observations that they have submitted. The second permission level is "Supervisor." Supervisors can enter and edit trespassing observations and approve submissions by their officers. Supervisors can view submissions by all officers in their agency. In both permission levels, the secure online data collection form walks users through a four-step process to enter the details of non-injury trespassing observations. The first step of the process asks users to enter information on the agency submitting the data. As shown in [Figure 19](#), users enter the agency name and location, as well as the name of the person submitting the data.

FRA Railroad Trespassing Report

1. Reporting Agency

2. Date & Location

3. Incident Details

4. Confirmation

Reporting Agency

Reporting agency name

Submitted By

City

State

Reporting Officer*
The person who made the in-field observation.

NEXT

Figure 19. Reporting agency page

Upon entering the agency information, users are then taken to the Date and Location page, shown in [Figure 20](#). Here, users enter the details of the date, time, and location of the trespassing observations. Users can automatically populate fields using the current time and location. Users can also interact with the map by typing the name or address of a known point of interest, zooming and panning the map, and updating the pinpoint location by clicking on the exact location of the trespassing observation. Users must also enter the name of the railroad owning the track. Optional fields include the railroad subdivision, nearest milepost, and nearest grade-crossing.

FRA Railroad Trespassing Report

1. Reporting Agency

2. Date & Location

3. Incident Details

4. Confirmation

Date & Location

Date of Encounter*
02/05/2025

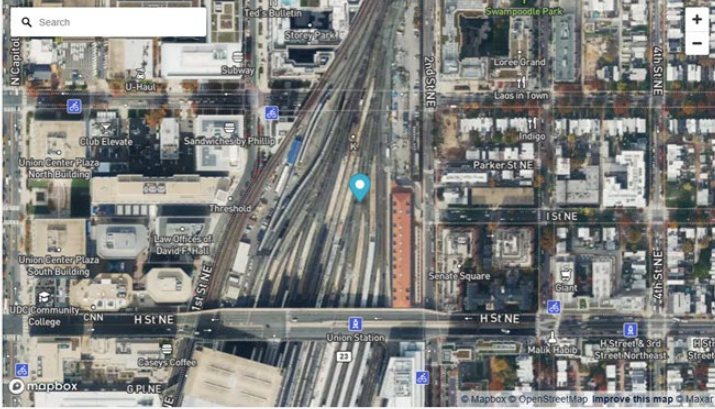
Time of Encounter
12 : 57 AM ET

Use Current Date/Time

Use Current Location

Click on the map or search for an address to autofill location information.

Search



Latitude and Longitude

38.90146342817192, -77.00448892238416

Location of Encounter*

900 2nd Street Northeast

Washington District of Columbia

District of Columbia USA 20002

Railroad*

Amtrak (ATK)

Railroad Subdivision

Nearest Milepost

Nearest GX Crossing (US DOT # or Street)

PREVIOUS

NEXT

* Entry is required

Figure 20. Date and location page

Next, users are sent to the Incident Details page (Figure 21) where detailed information on the trespassers is entered. Information such as the age, gender, and race of the trespassers can be provided. The form also documents what enforcement action was taken and if the trespasser was a repeat offender. If the officer interviewed the trespasser(s), detailed information on the reason for trespassing, awareness of illegal trespassing, and how the trespasser accessed the rail property could be entered. This process is repeated for each trespasser involved in the trespassing event.

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FRA Railroad Trespassing Report

1. Reporting Agency

2. Date & Location

3. Incident Details

4. Confirmation

Incident Details

Trespasser 1 [+ Add Trespasser](#)

Trespasser 1

Was trespasser interviewed?*
☒ Yes ☐ No

Incident Details
Trespasser Action*
Choose here
Trespassing Reason*
Choose here
How did the individual access the right of way?*
Choose here
Enforcement Actions Taken*
Check all that apply
☐ Warning
☐ Issued summons/citation and release
☐ Arrested for trespassing
☐ Arrested for non-trespassing crime that is discovered while interviewing subject
☐ Referred for mental health evaluation
☐ Referred to social services
☐ Unable to locate or make contact
☐ Provided education on the dangers of trespassing
☐ None
☐ Unknown/Not gathered
☐ Other
Awareness of Illegal Action Taken*
☐ Complete ☐ Somewhat ☐ Not at all ☐ Unknown/Not gathered

Figure 21: Incident details page

The final page of the form is the Confirmation page (Figure 22). This page allows users to review and edit entries before submitting them for approval by the agency supervisor.

1. Reporting Agency
2. Date & Location
3. Incident Details
4. Confirmation

Confirmation

Reporting Agency

Submitted By

Grant Grantee (grantee@dot.gov)

Reporting Officer

John Smith

Reporting Agency Name

Hanford Police Department (CA)

City

College Park

State

Maryland

Location

Date of Incident

02/05/2025 12:57 PM ET

Latitude & Longitude

38.90146342817192, -77.00448892238416

Nearest Road/Rail Intersection

900 2nd Street Northeast

City

Washington

State

District of Columbia

County

District of Columbia

Postal Code

20002

Railroad

Amtrak (ATK)

Railroad Subdivision

Nearest Milepost

Nearest GX Crossing (US DOT # or Street)

Incident Details

Trespasser 1

Was trespasser interviewed?

Yes

Trespasser Action

Recreational activities

Trespassing Reason

Unknown/Not gathered

How did the individual access the right of way?

Accessed at a legal crossing

Enforcement Actions Taken

Warning

Figure 22. Confirmation page

5.3 Non-Injury Trespassing Observation Database

Once the agency supervisor submits and approves trespassing observations, the data is sent to the master FRA database. As shown in Figure 23, the database allows analysts to view the details of trespassing observations. Here, users can view trespassing reports or details on individuals. Trespassing reports provide the information for each trespassing incident, while the individuals view shows the details of each person involved in the trespassing incident. PDFs of the reports, CSV files of the report, and individual data tables can be downloaded directly from the database view page.

FRA Railroad Trespassing Report

Report from: All Data

Date Range

Manage Your Reports

Showing 10 of 100 reports

View: Results Individuals

APPROVAL STATUS	REPORTING AGENCY	STATUS	REPORT ID	ADDRESS	CITY	STATE	TRAIL NAME	# OF VIOLATIONS	INCIDENT DATE	LAST UPDATED	SELECT ALL	
Type to filter	Type to filter	Filter by status	Type to filter	Type to filter	Type to filter	Type to filter	Type to filter	Type to filter			Export Selected	
1	clm@brunswick.org	Brunswick Police Department (ME)	Approved	30	23 Maple Street	Brunswick	Maine	Ambase (JFK)	3	04/05/2023 2:00 PM ET	04/05/2023 4:30 PM	
2	clm@brunswick.org	Brunswick Police Department (ME)	Approved	33	240 Bath Road	Brunswick	Maine	Ambase (JFK)	1	04/05/2023 1:30 PM ET	04/05/2023 4:30 PM	
3	clm@brunswick.org	Brunswick Police Department (ME)	Approved	34	Fairfax Road	Brunswick	Maine	Ambase (JFK)	1	04/05/2023 1:30 PM ET	04/05/2023 4:30 PM	
4	clm@brunswick.org	Brunswick Police Department (ME)	Approved	35	Fairfax Road	Brunswick	Maine	Ambase (JFK)	2	04/05/2023 2:00 PM ET	04/05/2023 4:30 PM	
5	deni.carlin@concordnc.org	Concord Police Department (NC)	Approved	36	621 South Spring Street	Concord	North Carolina	North/Southern (NS)	1	04/05/2023 11:15 AM ET	04/05/2023 2:30 PM	
6	deni.carlin@concordnc.org	Concord Police Department (NC)	Approved	37	130 Wood Lanes Street	Concord	North Carolina	North/Southern (NS)	2	04/05/2023 10:30 AM ET	04/05/2023 2:40 PM	
7	Arnell@billingsmt.gov	Billings Police Department (MT)	Approved	38	3115 1st Avenue South	Billings	Montana	Montana Rail Link	2	04/05/2023 9:30 PM MDT	04/05/2023 4:30 PM	
8	clm@brunswick.org	Brunswick Police Department (ME)	Approved	39	208 Pleasant Street	Brunswick	Maine	Ambase (JFK)	1	04/10/2023 12:00 PM ET	04/10/2023 4:30 PM	
9	clm@brunswick.org	Brunswick Police Department (ME)	Approved	40	34 Church Road	Brunswick	Maine	Ambase (JFK)	1	04/10/2023 12:00 PM ET	04/10/2023 4:30 PM	
10	clm@brunswick.org	Brunswick Police Department (ME)	Approved	41	27 Bath Road	Brunswick	Maine	Ambase (JFK)	1	04/10/2023 12:00 PM ET	04/10/2023 4:40 PM	

Figure 23. Database view page

6. Conclusion

Following the recommendations and lessons learned in Phase I, RISE Phase II continued to foster collaborative relationships with the US railroad safety community, which resulted in the development of stakeholder driven IATs and new safety tools for stakeholder use. The success of the Vertical Profiles of Highway-Rail Grade Crossings IAT has attracted new stakeholders, including AASHTO. This group continues to discuss the needs and challenges in improving safety at highway-railroad grade crossings.

The work with the Railroad Trespassing IAT enabled an initial assessment of non-injury trespassing data collection practices, gaps, and challenges. While many railroads attempt to collect trespassing data, the lack of standardization and concerns with sharing this data limited an empirical analysis. However, the RISE team used these findings to structure a secure online non-injury trespassing data collection form and database that was utilized by the FRA's Railroad Trespassing Enforcement Grant Program. The form and database were developed under the guidance of FRA, Volpe, and previous volunteer grantees. The tool was launched in March 2023 and has documented ~4,000 trespassing events on ~5,000 individuals. This first-of-its-kind database is being used by FRA analysts to discover trespassing hotspots, analyze patterns in trespassing environments, and assess details on the individuals engaging in trespassing activities.

The Vertical Profiles of Highway-Rail Grade Crossings IAT identified a need to develop databases and automated analytical tools to assess the risk of vehicles getting stuck or “hung up” at GX. To address this need, the team pursued two critical components of the hang-up risk problem. First, the team explored several data sources to estimate the vertical profiles of every grade crossing in the US. To overcome the challenge of erroneous grade crossing location information in the FRA Grade Crossing Inventory, the team developed an algorithm to discover the locations where the NARN network intersected the OpenStreetMap road network. Next, the team utilized USGS data to estimate the vertical profile of the roads approaching all US grade crossings. These profile estimates were fused with the FRA Grade Crossing Inventory to build a user-friendly vertical profile dashboard.

The second component of the risk assessment that was pursued was the assessment of commercial vehicles traversing a grade crossing. To meet this need, we developed a simulation tool that leveraged the USGS-based profile estimates with design vehicles from previous studies. Users can select a grade crossing and design vehicle of interest within the simulation tool and run simulations to evaluate if the design vehicle makes contact with the grade crossing surface. Within the tool, users can alter the profiles and vertical clearance parameters of the design vehicles to enable custom simulations. The simulation tool was designed to be used in coordination with the vertical profile dashboard so users can discover potentially high-risk grade crossings and then simulate various design vehicles traversing the target locations.

7. References

- [1] U.S. Government Accountability Office. (2018). [Grade-Crossing Safety: DOT Should Evaluate Whether Program Provides States Flexibility to Address Ongoing Challenges](#). Washington, DC: GAO-19-80.
- [2] U.S. Geological Survey. [Elevation Point Query Service \(EPQS\)](#).
- [3] U.S. Geological Survey. [How accurate are elevations generated by the Elevation Point Query Service in The National Map?](#) |
- [4] S. S. Sehra, J. Singh, and H. S. Rai. (2013) Assessment of OpenStreetMap Data - A Review. *Int. J. Comput. Appl.*, vol. 76, no. 16, pp. 17–20.
- [5] [Illinois Height Modernization \(ILHMP\): LiDAR Data](#).
- [6] A. L. Clawson. (2002). Establishing design vehicles for the hang-up problem. MS Thesis, West Virginia University Libraries. doi: 10.33915/etd.1222.

Abbreviations and Acronyms

ACRONYM	DEFINITION
AASHTO	American Association of State Highway and Transportation Officials
CL	Crossing Length
DEM	Digital Elevation Models
EPQS	Elevation Point Query Service
FRA	Federal Railroad Administration
GX	Grade Crossing
IAT	Issue Analysis Team
ILHMP	Illinois Height Modernization
NARN	North American Rail Network
OSM	OpenStreetMap
RISE	Railroad Information Sharing Environment
RMSE	Root Mean Square Error
USGS	United States Geological Survey
WCS	Web Coverage Service