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Federal Railroad Administration

Office of Research, Development and Technology
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Railroad Information Sharing Environment (RISE)

RISE

Railroad Information Sharing Environment

DOT/FRA/ORD-21/31

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NOTICE

NOTICE

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14. ABSTRACT
Despite tremendous progress in railroad safety over the last 30 years, many safety statistics have plateaued. Thus, additional insights on the complex interaction between people, trains, infrastructure, and the operating environment are needed. While the Federal Railroad Administration (FRA) requires railroad agencies to regularly report on key safety metrics, there is additional data that agencies collect, but rarely share. Following similar successful data sharing projects in the aviation and motor vehicle industries, this FRA project established a secure, data-sharing and analysis platform titled the Railroad Information Sharing Environment (RISE). The RISE pilot project demonstrated the ability for FRA, railroads, and a trusted third-party data steward to share and analyze safety-sensitive data to improve railroad safety. This report documents the effort, challenges, lessons learned, and recommendations for building future phases of RISE as a data trust for the railroad industry.

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METRIC/ENGLISH CONVERSION FACTORS

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

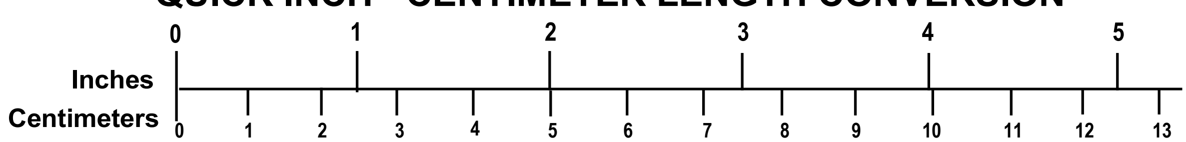
VOLUME (APPROXIMATE)

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)

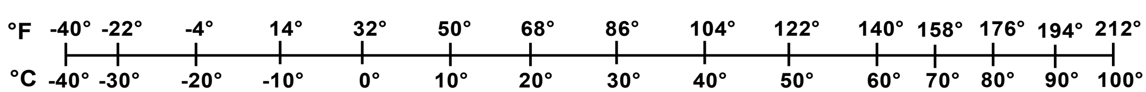
TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO



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

Despite tremendous progress in railroad safety over the last 30 years, many safety statistics have plateaued. Thus, additional insights on the complex interaction between people, trains, infrastructure, and the operating environment are needed. While the Federal Railroad Administration (FRA) requires railroads to regularly report on key safety metrics, there is additional data that railroads collect, but rarely share.

Following similar successful data sharing projects in the aviation and motor vehicle industries, this FRA project established a pilot, secure, data sharing and analysis platform titled the Railroad Information Sharing Environment (RISE).

The RISE team included partners from FRA, the Volpe National Transportation Systems Center (Volpe), five passenger railroads, and the University of Maryland's (UMD) Center for Advanced Transportation Technology (CATT Lab). The identities of the participating passenger railroads are kept anonymous as part of this project's data trust.[1] The team worked together to achieve the following project objectives:

- Promote trust in the rail community.
- Develop secure data capture processes.
- Define and produce key analytic outputs.

The team worked collaboratively to accomplish these objectives by:

- Identifying critical railroad safety topics
- Beginning to develop a non-punitive data trust
- Establishing a data security plan
- Creating a secure, online, data sharing and analysis platform
- Demonstrating the platform on real-world safety issues of personal injuries and rule violations
- Documenting the lessons learned

The RISE pilot project demonstrated the ability for FRA, Volpe, railroads, and a trusted third-party vendor, UMD's CATT Lab, to share and analyze safety-sensitive data to improve railroad safety. This report documents the effort, challenges, lessons learned, and recommendations for building future phases of RISE as a data trust for the railroad industry.

[1] https://www.transportation.gov/orders/data-trust-policy-guidelines-and-principles

1. Introduction

The Federal Railroad Administration (FRA), in collaboration with the Volpe National Transportation Systems Center (Volpe), the University of Maryland's Center for Advanced Transportation Technology Laboratory (CATT Lab), and five passenger railroad stakeholders, conducted a proof-of-concept pilot project called the Railroad Information Sharing Environment (RISE) to test the feasibility of developing a data trust for the railroad industry. The first task in developing a data trust was to develop a secure railroad safety data sharing and analysis platform. This report documents the effort, lessons learned from this first task, and recommendations for future paths related to developing the RISE data trust.

1.1 Background

Safety is the most important performance measure of any transportation system. To monitor and understand safety performance, the U.S. Department of Transportation and its modal administrations collect data on the movement of people and goods. While this data has enabled tremendous improvement in U.S. transportation system safety, many modes have observed plateaus in safety performance. For railroad safety, FRA has noted that both accident rates (Figure 1) and injury rates (Figure 2) have flatlined.

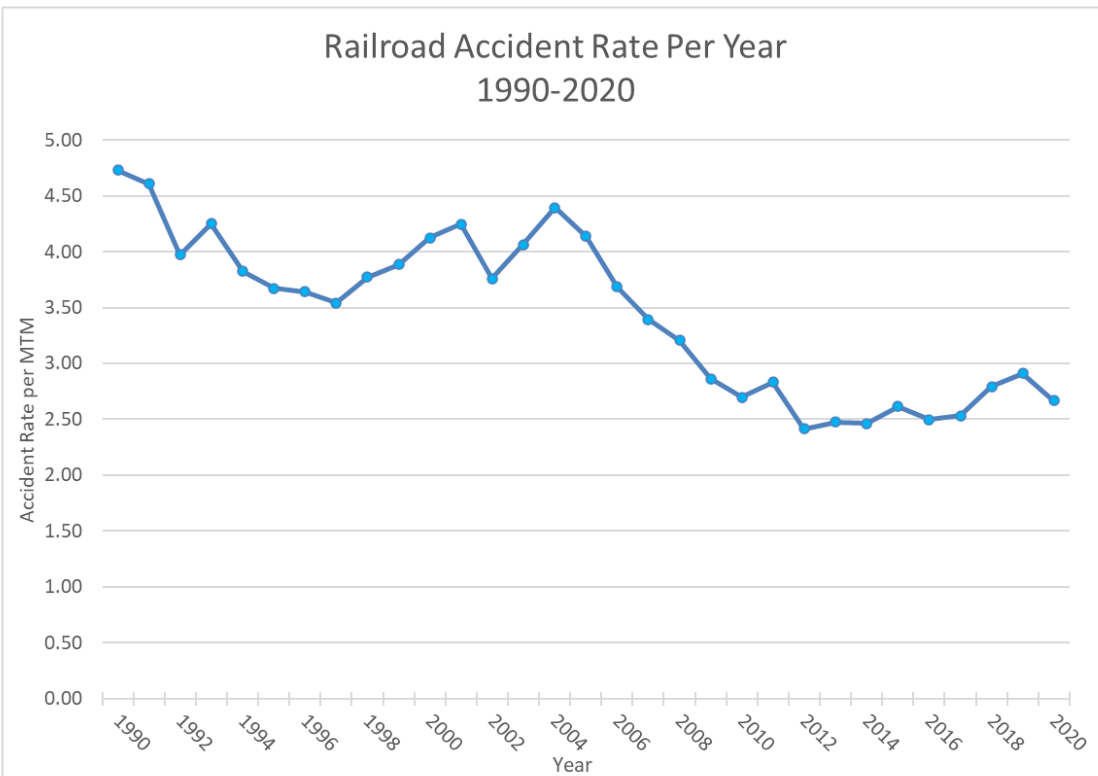

Figure 1. Railroad Employee Injury Rate by Year (1990–2020)

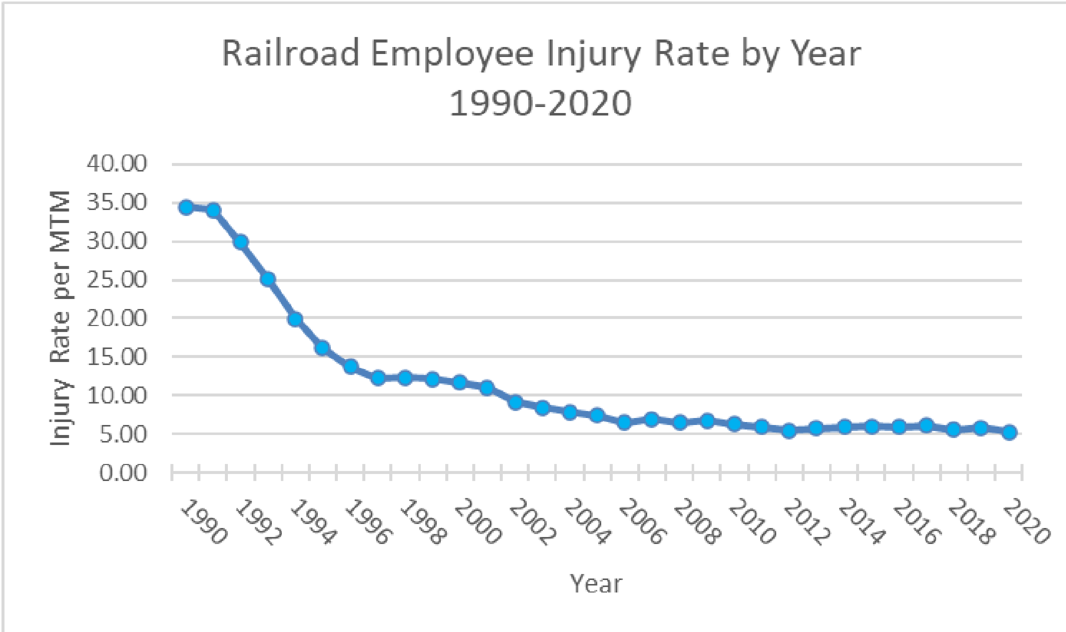

Figure 2. Railroad Accident Rate by Year (1990–2020)

To address the challenge of further improving transportation safety, several modes have established data sharing initiatives, called *data trusts,* to securely gather additional safety data from stakeholders. Examples of successful transportation safety data trusts include the Federal Aviation Administration's Aviation Safety Information Analysis and Sharing, and the National Highway Transportation Safety Administration's Partnership for Analytics Research in Traffic Safety. FRA has created several data sharing programs to break down the barriers preventing secure data sharing. Examples of successful FRA data trusts include its Confidential Close Call Reporting System (C^3RS) and an ongoing project with the Short Line Safety Institute.

In a similar fashion, RISE was established to assess the feasibility of a stakeholder-driven, secure, safety data sharing and analysis platform. In the RISE pilot project, FRA worked with Volpe to engage five passenger railroad stakeholders and an impartial, third-party vendor to provide a secure data sharing and analysis environment. The University of Maryland's CATT Lab was selected to serve as the data vendor that led the development of the RISE data sharing and analysis platform.

1.2 Objectives

The RISE pilot project was established to assess the challenges, lessons learned, and overall feasibility of a stakeholder-driven secure safety data sharing and analysis environment for the railroad industry. The objectives of this research were to:

- Promote trust in the rail community.
- Develop secure data capture processes.
- Define and produce key analytic outputs.

1.3 Overall Approach

1.3.1 RISE Team Members and Roles

The RISE pilot team was comprised of members from FRA's Office of Railroad Safety (RRS) and FRA's Office of Research, Development, and Technology (RD&T) teams, Volpe, five passenger railroad stakeholders, and the CATT Lab. Each had specific roles to fulfill:

FRA: The RRS and RD&T teams assisted in project management, provided formatted data and data reporting documentation, assisted in the design of the analysis dashboards, and provided general technical assistance on rail safety data analysis.

Volpe: The Volpe team assisted in stakeholder engagement and data acquisition, provided technical assistance on rail safety data analysis, and assisted in the design of the data protection plan and design of the analysis dashboards.

Railroad stakeholders: The five participating passenger railroads provided valuable industry perspectives by identifying and ranking safety issues of interest, sharing data to support the down-selected issues, providing information on how they collect and analyze safety data, and sharing feedback on the analysis dashboards and overall project experience.

CATT Lab: The CATT Lab served as the third-party vendor that led the overall development of RISE, including project management and documentation, stakeholder engagement, secure data acquisition and storage, data cleaning and analysis, and dashboard development.

1.3.2 RISE Development Process

A brief summary of the RISE development activities are provided below and are discussed in further detail throughout this report.

Pre-project stakeholder engagement: Prior to CATT Lab's involvement, Volpe and FRA worked with five passenger railroad stakeholders to identify and prioritize potential safety topics. The FRA report on that task, Lessons from the Railroad Information Sharing Environment (RISE) Pilot Project, is now available on the FRA eLibrary.

CATT Lab joins RISE team: CATT Lab joined the team and revisited the short list of topics with the RISE team.

Data assessment and determination of final safety topics: CATT Lab worked with FRA, Volpe, and railroad stakeholders to determine final safety topics by independently evaluating the data available to support the analysis of each topic.

Data acquisition: CATT Lab, with Volpe's assistance, held several meetings with the railroad stakeholders to discuss the data available to support this project and how it was collected. Options for sharing the data were also discussed to ensure stakeholders were comfortable with at least one of the sharing mechanisms. The secure data sharing mechanism was one component of the overall data security plan. During this process, the team learned about the state of railroad safety data collection.

Data cleaning and fusion: Upon receiving data from the railroad stakeholders, CATT Lab began developing the anonymized database that removed any personally identifiable information (PII) as well as the exact time and physical location of each observation. The anonymization of the data was another component of the data security plan. During this process, CATT Lab had several follow-up meetings with the railroad stakeholders to resolve data formatting issues and erroneous data entries.

Develop secure analytical dashboards: Once the anonymized database was created, the team developed a secure data analysis platform. The team used Tableau online software to create interactive dashboards using the anonymized database

Share dashboards with RISE team: The completed secure analyses were shared with RISE stakeholders via Tableau online licenses. Within the dashboards, each participating railroad user could switch between the aggregate dataset of all participating railroads and the data provided by the user's railroad. This functionality enabled peer benchmarking assessments. For data security purposes, FRA and Volpe users had access to only the aggregate dataset.

Gather feedback: After each RISE team member explored the dashboards, follow-up meetings were conducted to document end user experiences, suggestions, and next steps for RISE. The railroad stakeholders were also asked to complete a brief questionnaire that is included in the appendix of this report.

1.4 Scope

This report describes the effort to develop the pilot version of RISE. The report also includes documentation on the state-of-the-practice of railroad safety data collection, lessons learned in establishing a secure data sharing and analysis platform, end-user feedback on the data sharing and analysis platform, and recommendations for the next steps. This project included data provided by five commuter railroad stakeholders, from January 2018 through June 2019.

1.5 Organization of the Report

Section 2 presents the process of selecting the topics for the pilot RISE demonstration. Section 3 describes the data acquisition and cleaning process. Section 4 discusses the background on the safety data analysis. Section 5 presents the findings of the safety analysis. Section 6 documents the lessons learned in developing the pilot version of RISE. And Section 7 provides concluding remarks and recommendations for next steps.

2. Pilot Safety Topic Selection Process

2.1 Pre-project Stakeholder Engagement

Before CATT Lab joined the project, Volpe and FRA worked with five passenger railroad stakeholders to identify and prioritize potential safety topics. During this process, 35 safety topics and 34 supporting data types were identified.[2] To focus the discussion, the topics were consolidated to nine topics:

1. Personal Injuries
2. Operating Rules Violations
3. Passenger Station Misses/Off Platform
4. Technology Overreliance
5. PTC System Status
6. Equipment Safety
7. Employee Training
8. Operator Errors
9. Post-Incident Actions

To further down-select these topics, each railroad stakeholder was asked to rank each topic for its value, feasibility, and duration on a scale of from 1 to 5 (with 1 indicating low interest and 5 indicating highest interest). The result of this ranking created a shortlist of three potential topics:

1. Personal Injuries (PI)
2. Operating Rule Violations (RV)
3. Passenger Station Misses/Off Platform

2.2 Data Assessment and Final Safety Topic Selection

CATT Lab joined the RISE team in September 2019 and revisited the shortlist of topics with the RISE team. CATT lab recommended revisiting at-grade rail crossings as a potential topic for consideration, and the team agreed to replace the Passenger Station Misses/Off Platform topic with At-Grade Rail Crossings.

CATT Lab worked with FRA, Volpe, and railroad stakeholders to determine final safety topics by independently evaluating the data available to support the analysis of each topic. The team decided to use data covering January 2018 through June 2019 in this pilot study. CATT Lab's evaluation considered:

1. Data availability and accessibility
2. Data consistency
3. Pre-analysis data cleaning/processing

[2] See the FRA Technical Report, Lessons from the Railroad Information Sharing Environment (RISE) Pilot Project.

4. Ability to anonymize data.
5. Perceived ability to support deeper safety insights for all stakeholders.

These considerations were scored 1, 2, or 3 (with 3 being the highest score) for each of the potential topics. CATT Lab recommended the inclusion of PI as well as RV as the topics for the pilot study. Each railroad stakeholder agreed with this recommendation.

Table 1. Summary of Safety Topic Assessment

Use Case	Data Availability*	Data Consistency	Data Cleaning and Processing	Ability to Anonymize Data*	Ability to Support Deeper Analysis	TOTAL
Personal Injury	2.5	3	3	2.5	3	14
At-Grade Crossings	1	1	1	1	1	5
Rules Violation	2.5	2	2	2.5	2	11

3 = Highest score for RISE implementation

1 = Lowest score for RISE implementation

* Indicates tie for highest score

3. Data Security, Acquisition, and Pre-Processing

3.1 Data Security Plan

To ensure that the data and associated analysis tool were made available only to the appropriate parties, data security and anonymization aimed to:

1. Block unauthorized users from RISE data and analysis tool.
2. Mitigate PII concerns by removing the exact date and physical location of injuries and violations.
3. Protect stakeholder data within the aggregate dataset.
4. Protect stakeholder specific datasets.

3.1.1 Secure Data Sharing and Storage

Stakeholder-provided data in the original and/or redacted format was sent to CATT Lab via email, secure CATT Lab FTP, or directly to an encrypted data storage environment where the data cleaning, storage, and analysis took place. The Controlled Unclassified Information Environment (CUIE) provided by the University of Maryland's Division of Information Technology is NIST 800-171-compliant.[3]

3.1.2 Data Anonymization

The data anonymization strategy removed all obvious PII such as employee name, ID number, and date of birth. Additional data scrubbing removed temporal (date and time) and spatial (physical location) details for each injury and violation record. Temporal data resolution was restricted to hour of day within a given day. Next, the spatial details were transformed and only FRA location codes and county information were retained. Injuries could not be geographically mapped to a physical location.

3.1.3 User Permissions

A multi-tiered permissions structure was employed to restrict access and control what data was available to specific registered users. Only approved RISE participants could access the RISE platform. Accounts were requested and approved by the account administrator for each stakeholder. In this phase of the RISE project, a representative from each participating stakeholder acted as the account administrator. Each administrator coordinated directly with CATT Lab to identify personnel with access to the RISE dashboards provided via Tableau online licenses. Once approved, the users accessed the RISE platform using a user ID and password within the Tableau login page, as shown in Figure 3.

[3] University of Maryland, Division of Information Technology. CUI Environment.

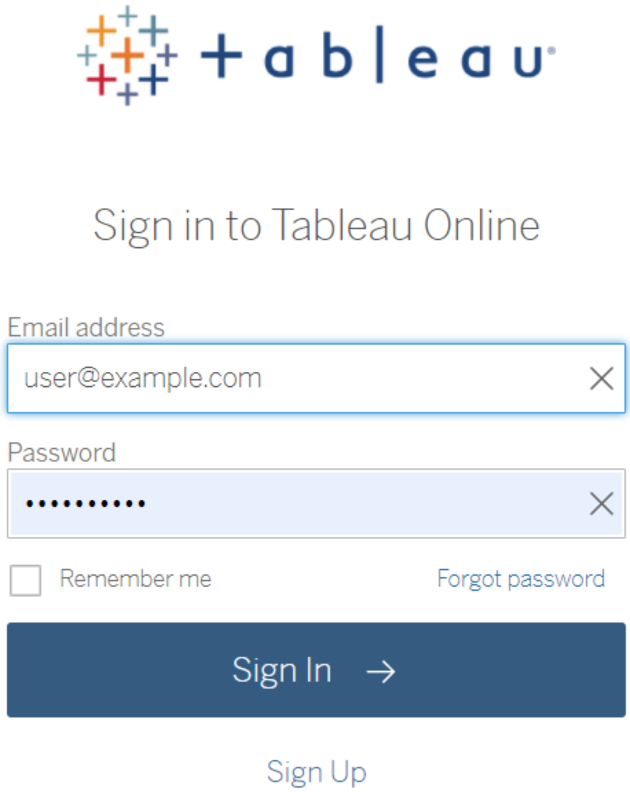

Figure 3: Tableau Online Account Login Page

Once a user is logged in, the platform controls access to specific datasets based on railroad affiliation. All RISE partners have access to the anonymized aggregate datasets. However, access to railroad-specific data and analytical tools are controlled by each railroad. For example, a user from railroad A can see and analyze the aggregate data and the data from railroad A. No other data is available to this user.

Lastly, to mitigate the unapproved sharing of RISE data, only aggregate dataset visualizations were available for download. The individual-level observations were not available for download. In addition, no individual stakeholder downloads were available – as this data was provided by the stakeholders, and it was assumed that such functionality was not necessary for this project.

A summary of the proposed data security and anonymization plan is described in Figure 4.

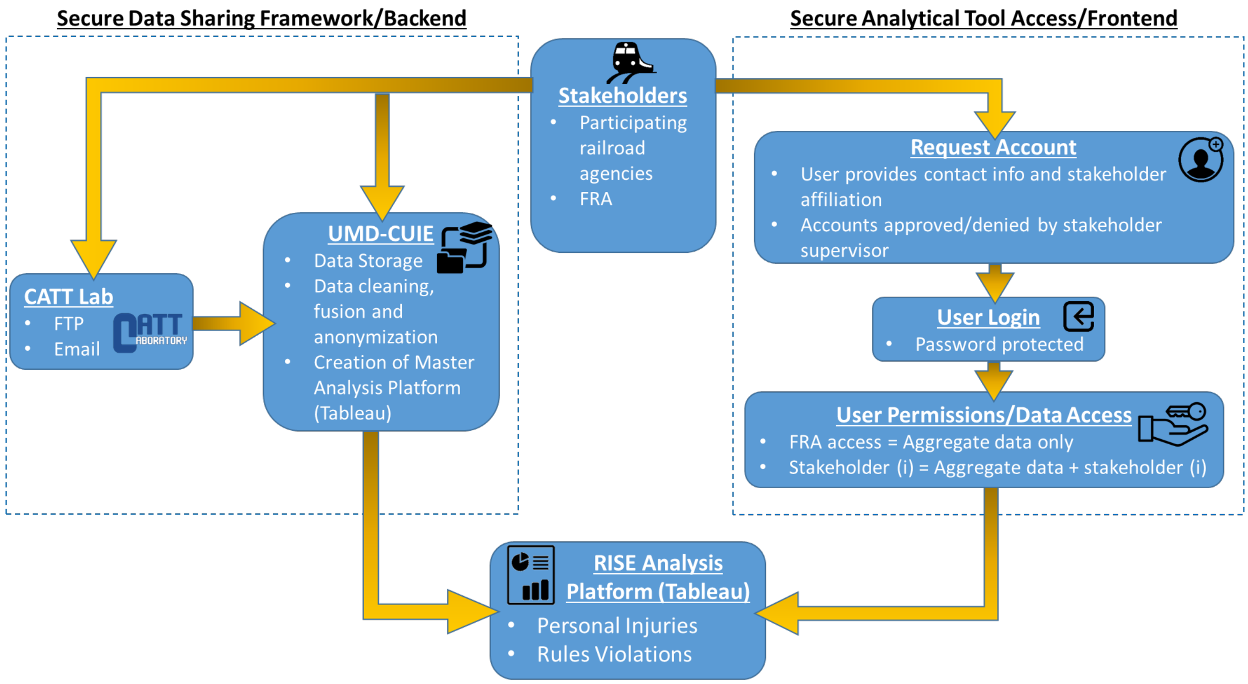

Figure 4: RISE Data Protection Framework

3.2 Data Requests and Stakeholder Discussions

With the data security plan in place, the team began the process of making formal data requests from the railroad stakeholders. CATT Lab and Volpe held several virtual meetings with each participating railroad stakeholder to discuss the details of the available data and how the data was collected. To document the availability of data across all participating railroad stakeholders, the team developed data matrices for both the PI and RV topics. These matrices were ultimately used to determine what data items were consistently collected and available to share for this study for the PI and RV analysis, respectively. To protect the actual data shared in this project, a hypothetical data matrix is provided in Figure 5.

Data Item	Stakeholder 1	Stakeholder 2	Stakeholder 3	Stakeholder 4	Stakeholder 5	# of Stakeholders with Data Item
Injury Date and Time	✓	✓	✓	✓	✓	5
Injury Type	✓	✓	✓	✓	✓	5
Age	✓	✓	✓	✓	✓	5
Years of Service	✓	✓	✓	✓	✓	5
Hours into Shift		✓		✓		2
Drugs-Alcohol	✓	✓	✓		✓	4
Lost Days	✓	✓	✓	✓	✓	5
Weather	✓				✓	2

Figure 5. Hypothetical Data Matrix

3.3 Rail Safety Data Collection State-of-Practice Snapshot

In the data acquisition discussions with the railroad stakeholders, CATT Lab and Volpe also asked about safety data collection practices. These discussions shed light on the differences and similarities between railroad safety data collection processes. To honor the anonymity of the participating railroad stakeholders, this section will only discuss generalized findings.

Though each participating railroad stakeholder had unique protocols on how safety data was collected and archived, all had recently or are in the process of transitioning to electronic-based data collection via commercial off-the-shelf software. Before this transition, a majority of data collection was performed using manual processes, such as manual entry into a spreadsheet or by calling in events to record observations, that increased the possibility of human error. Furthermore, these data entry methods often created segregated databases that prevented efficient and comprehensive safety analysis. For example, a single employee may be responsible for documenting RV observations and if that person leaves the railroad, that data may not be easily discoverable to conduct trend analysis. The commercial software solutions have tremendous potential to improve the efficiency and quality of data collection. In addition, commercial software solutions make archiving and sharing data easier by storing data in a centralized database that can be populated by multiple authorized users.

Other challenges in rail safety data collection and sharing stem from siloed departments within a given railroad. For example, detailed employee work logs are needed to conduct fatigue analysis. However, such data may be difficult for the safety department to acquire if the human resources department is unwilling to share this valuable data. This challenge can only be overcome if departmental siloes are broken down to allow for comprehensive safety analysis. Most railroads are now building centralized databases so that all relevant data can be made available to authorized personnel across all departments.

3.4 Data Cleaning and Fusion

CATT Lab performed data cleaning and fusion across the PI and RV datasets using a standardized process for storage, aggregation, normalization, and analysis. Railroad stakeholder feedback and an understanding of the potential uses of the data was essential to standardizing and processing. The RV dataset was more limited than the PI dataset, as it currently is not submitted to FRA. This resulted in different levels of data maturity among the stakeholders, and a smaller analysis that could be conducted on the RV dataset.

As discussed in the previous section, the first step of this process was to extract and obtain the MS Excel files with the required data elements from the railroad stakeholders. Next, the research team identified incomplete data submissions. Once the submission was deemed complete, the team standardized and cleaned the dataset using automated scripts for each stakeholder. The scripts anonymized the railroad stakeholder data by removing PII and enriched the dataset by deriving new data fields, such as binning continuous variables, creating grouped categorical variables that combined lower frequency levels, and creating date part elements. The scripts also integrated employee hours worked and abbreviated injury scale (AIS)/value of statistical life (VSL) data into the PI dataset. Due to the varying of employee hours worked provided by the railroad stakeholders, the day of week distribution from two stakeholders was applied to the other stakeholders that only had monthly granularity for this analysis. The overall level of effort for cleaning and standardizing the datasets was much higher than originally anticipated due to the challenges associated with the manual compilation process described below. In future analyses, the team recommends automating the data ingestion process and using data already provided to FRA.

- Variations in the data format:
  - Discrepancies caused by category description abbreviations and special character usage.
  - Inconsistent usage of category codes versus category descriptions across railroad stakeholders
- Differences in the data fields provided:
  - Different interpretation of the data requests, such as stakeholders providing FRA job title as opposed to FRA occupation.
  - Inconsistent data fields provided by railroad stakeholders when there was a combined category code for a data field, such as Location, that was equivalent to multiple sub-attributes, such as Location1, Location2 and Location3.
- Invalid and incomplete data:
  - Missing data fields in non-reportable incidents
  - Category levels that did not exist.
  - Invalid values, such as years of service values greater than an individual's age and non-reportable incidents with lost days greater than 0
- Duplicate entries:
  - Some PI incidents were recorded as both non-reportable[4] and reportable.
- Multiple files that were not intuitively linked:
  - Multiple iterations and requests needed to obtain all originally requested fields.
  - New data elements, such as weather, AIS, and inspection locations, were requested from the railroad stakeholders as the project progressed.

Once each dataset was cleaned, the team fused them into a master database that was used for the data analysis.

[4] Non-reportable injuries refer to injuries below FRA minimum reporting thresholds and are also called accountable injuries.

4. Data Analysis and Methodology

This section provides an overview of the data analysis and methodology, including:

- Exploratory Data Analysis
- Dashboard Development
- Statistical Tests
- C^3RS and Inspections Data

4.1 Exploratory Data Analysis

CATT Lab performed an exploratory data analysis once the initial master database was created. This was an iterative process, as data discrepancies were identified through the exploratory data analysis which resulted in minor updates to the master database. The process involved the development of descriptive statistics, word clouds, charts, and graphs to understand the data fields within the PI and RV datasets. The exploratory data analysis helped test the master database by identifying, collecting, aggregating, and analyzing the PI and RV data. This exploratory analysis was essential to the development of the dashboards and provided information such as:

- Completeness of data fields
- Removal of data fields with insufficient data
- Distribution of data fields
- Differences between PI reportable and non-reportable incidents
- Outliers in data that required action
- Initial potential relationships between the variables
- Appropriate types of visualizations
- Identification of new data fields of interest

4.2 Dashboard Development

CATT Lab designed and implemented the RISE platform once the exploratory data analysis was complete. The research team recognized the need for dashboards with different objectives and developed the RISE platform to include six dashboards: five focused on PI and one focused on RV. The development approach involved building and vetting a set of mock-ups to select the types of charts, views, and pivots that best accomplish the purpose and objectives of each dashboard. These mock-ups were vetted in both internal meetings with FRA as well as external meetings with railroad stakeholders. In addition, once the dashboards were built, pilot access to the dashboards was provided to further obtain feedback and changes.

The RISE platform was developed using Tableau Online and allowed users to navigate and explore the datasets using deep-dive, trend, and sensitivity techniques. The dashboards were built to be interactive and easy to navigate, with users able to click on charts and drop-downs to zoom and filter across the data fields. The dashboards were developed with data protection and railroad stakeholder anonymity at the forefront, which was a key emphasis of the of the data protection plan with the railroad stakeholders. Data protection was accomplished through establishing user roles and permissions within Tableau Online to control the access of users and protect the underlying dataset. Furthermore, the visualizations focused on providing general trends, relationships, and distributions. To protect the data, the visualizations did not allow users to drill -down to individual records. Lastly, the dashboards permitted railroad stakeholders to toggle between an aggregate view of the data that included all stakeholder data as well as a specific view for each respective stakeholder. This allowed individual stakeholders to benchmark their data against their railroad peers while protecting the identity of specific railroad stakeholder groups. A high-level overview of each of the dashboards is provided below:

PI – Univariate

The PI Univariate dashboard (Figure 6) enabled users to explore the differences between FRA reportable and non-reportable incidents. Users could investigate temporal relationships across month-year, hour of day, and day of week. In addition, within the dashboard users could select a categorical variable and explore the injury distribution as well as the average lost days, age, and years of service associated with that categorical variable. Lastly, the dashboard allowed users to select a desired reportable versus non-reportable view including stacked, side-by-side, ungrouped, reportable incidents only, and non-reportable incidents only.

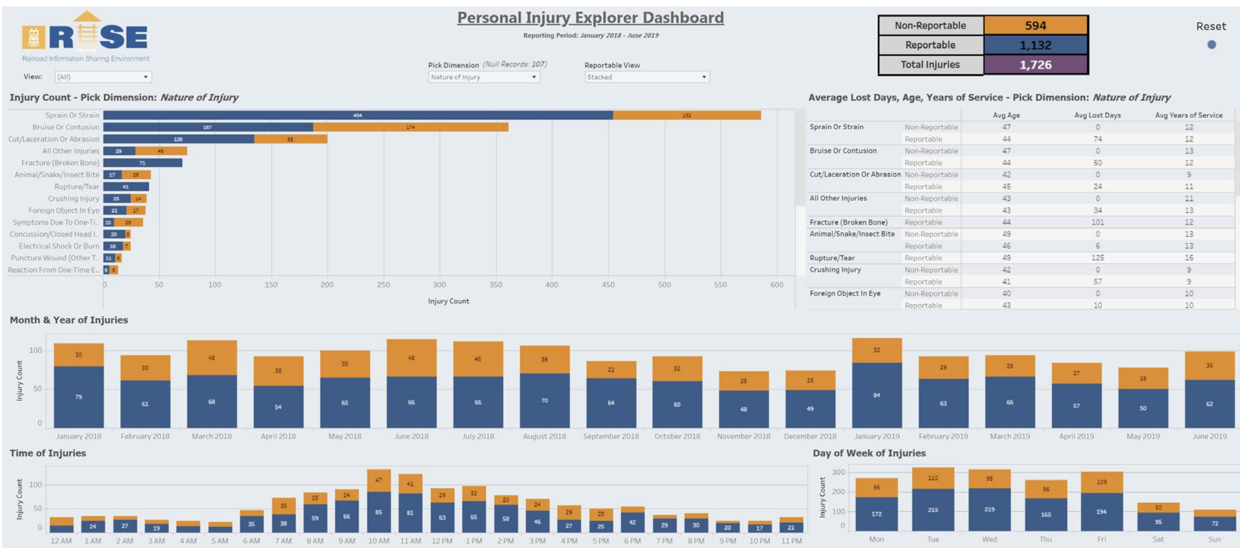

Figure 6. PI Univariate Dashboard

PI – Univariate Normalized

The PI Univariate Normalized dashboard (Figure 7) had a similar focus, look, and feel as the PI Univariate dashboard. The main difference was that it allowed users to normalize the reportable and non-reportable injury count by employee hours worked for the day of week and month-year categorical variables. Both the day of week and month-year charts allowed users to see injury counts and employee hours worked to understand how the normalization works. As with the PI Univariate dashboard, it also allowed users to select a desired reportable versus non-reportable view.

Figure 7. PI Univariate Normalized Dashboard

PI – Multivariate Numeric

The focus of the PI Multivariate Continuous dashboard (Figure 8) was to enable users to explore relationships between the continuous variables. This dashboard consisted of the following three charts and allowed users to select two continuous and one categorical variable:[5]

- Bubble plot: allowed users to explore two continuous variables on the x and y axis and one categorical variable that sized the bubble.
- Scatter plot: allowed users to explore two continuous variables on the x and y axis.
- Box and whisker plot: allowed users to explore the distribution of a continuous variable across one categorical variable.

In addition to the charts, three temporal filters could also be applied, including day of week, hour of day (binned), and month-year.

[5] To facilitate interpretation of visualizations in the multivariate dashboards, for variables with more than 12 levels, the dashboard used grouped categorical variables limited to the 11 highest frequency variable levels with the remaining categories grouped in an “other” group. These variables are designated with an asterisk in the dashboards.

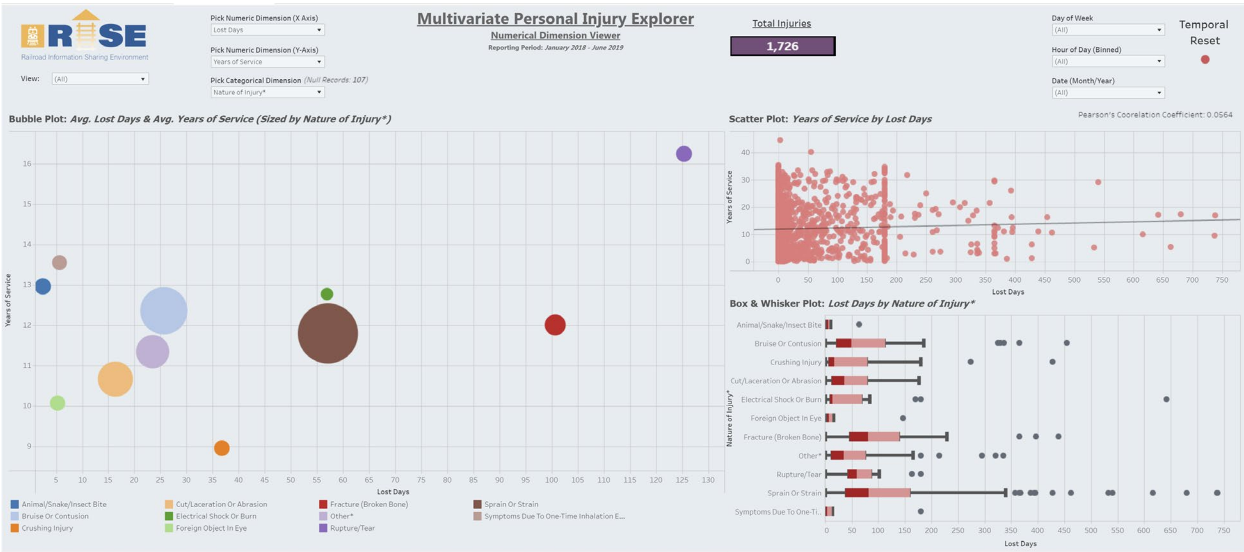

Figure 8. PI Multivariate Continuous Dashboard

PI – Multivariate Categorical

The PI Multivariate Categorical dashboard (Figure 9) enabled users to explore relationships between the categorical variables. This dashboard allowed users to explore two-way categorical variable[5] relationships within seven different charts, including side-by-side bar charts, stacked bar charts, heat maps, circle charts, tree maps, Marimekko charts, and Sankey charts. The different chart options allowed users the flexibility to approach their exploration with different views of the data and ultimately select the chart with which they were most comfortable. As with the PI Multivariate Continuous dashboard, there were three temporal filters that could be applied.

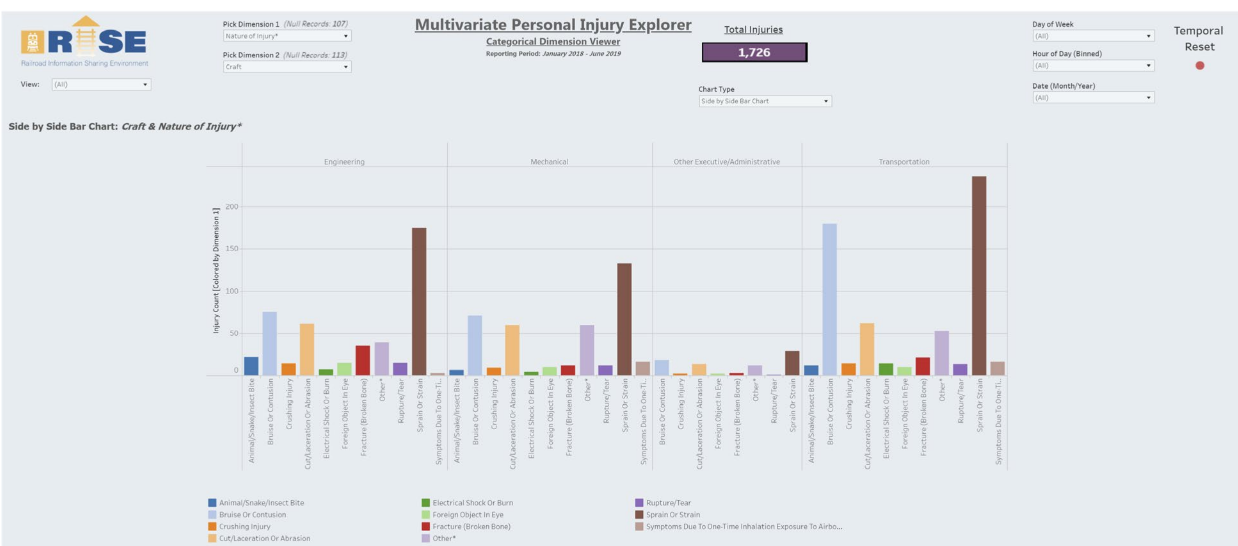

Figure 9. PI Multivariate Categorical Dashboard

PI – Risk Matrix

The PI Risk Matrix dashboard (Figure 10) enabled users to analyze and understand the average lost days and estimated injury cost associated with rail incidents. This dashboard consisted of two risk matrix plots that allowed users to select a categorical variable and analyze the frequency and associated average lost days and average estimated injury cost. The estimated injury cost was based on a preliminary mapping of the AIS and the VSL currently being finalized by FRA.

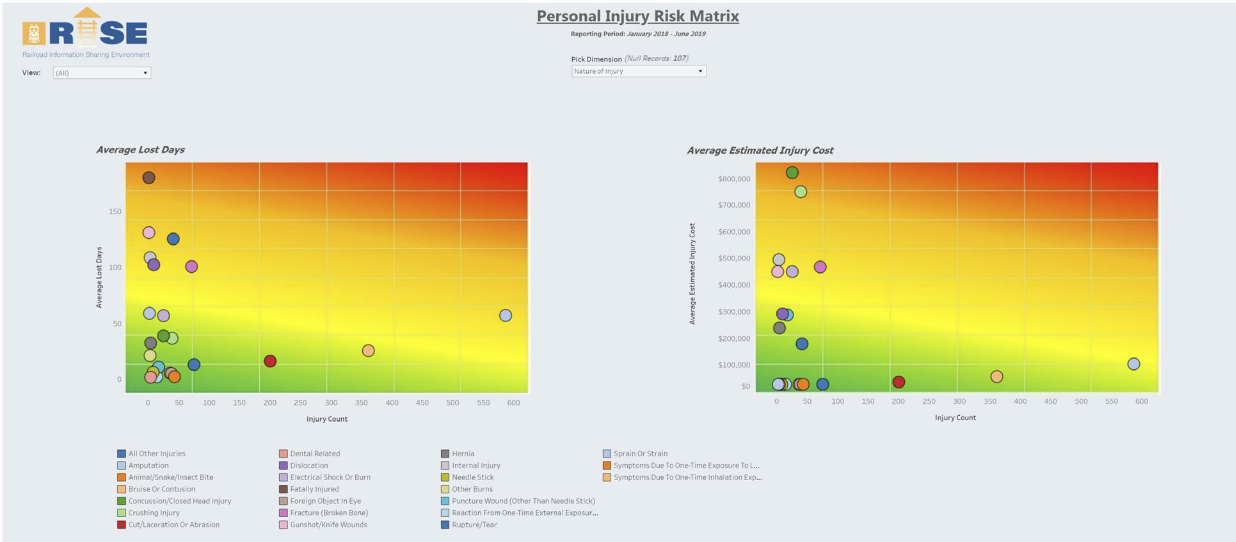

Figure 10. PI Risk Matrix Dashboard

RV – Univariate

The RV Univariate dashboard (Figure 11) enabled users to explore the RVs. The dashboard had a similar look and feel as the PI Univariate dashboard and allowed users to investigate temporal relationships across month-year, hour of day, and day of week. The dashboard was limited in exploring categorical variables due to data availability and focused solely on the distribution, average count, and years of service associated with the violation type and the occupation category. In the RV dashboard, some of the participating railroad stakeholders indicated multiple individuals involved in a single violation event. In such cases, researchers assigned a portion of the violation to each employee involved.

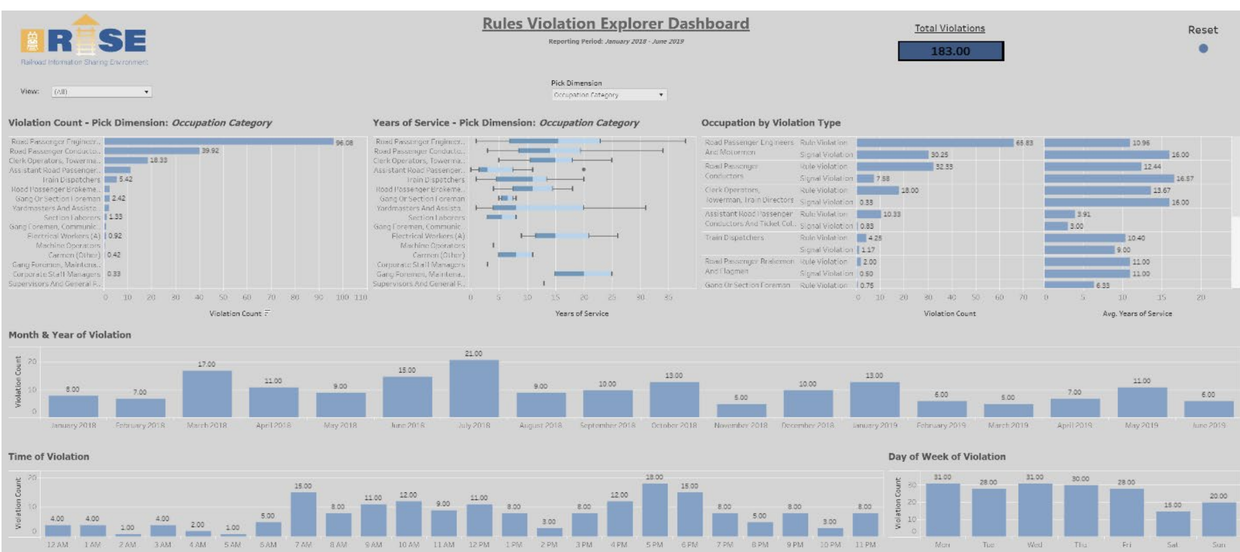

Figure 11. RV Univariate Dashboard

4.3 Statistical Tests

The following sections provide an overview of the statistical and modeling techniques performed on the PI Data. Note that no statistical modeling was performed on the RV data due to its limited size. This analysis served as a representative sample of the type of statistical analysis that can be performed using PI data and is focused on several areas:

1. Statistical differences – temporal variables
2. Statistical differences – injury rate of railroad stakeholders
3. Statistical differences – reportable versus non-reportable incidents
4. Statistical differences – two-way categorical variables of interest
5. Correlation fit – continuous variables

4.3.1 Statistical Differences – Temporal Variables

CATT Lab performed statistical tests and modeling on three temporal variables: day of week, hour of day, and month-year. The analysis focused on the non-normalized frequency count data and normalized frequency count data per employee hours worked each month. An overview of the analysis performed for temporal variables is summarized below.

Frequency Count Data Statistical Tests and Modeling:

- Chi-square test of goodness of fit:
  - Chi-square tests of goodness of fit were performed to establish whether an observed frequency distribution differed from a theoretical distribution. For the theoretical distributions the research team assumed an equal probability of each temporal category. In terms of day of week, this meant that the chance of an injury on a Monday is the same as the chance of an injury on a Tuesday. Next, if the result of the chi-square test was significant with a p-value less than 0.05, the team performed a post-hoc paired chi-square with a Bonferroni correction to determine the actual levels that were different.
- General linear model (GLM) Poisson regression:
  - GLM Poisson regression models were developed to examine the relationship between the temporal variable and the observed count of injuries. The Poisson Regression model z-tests performed on the independent variables determined the statistical significance of the temporal variable levels.

Injury Rate per Employee Hours Worked Data Statistical Tests:

- Analysis of variance (ANOVA)
  - ANOVA tests were performed to determine whether there were any statistically significant differences between the means of the temporal variable level groups. Next, if the result of the ANOVA test was significant with a p-value less than 0.05, the team performed a post-hoc Tukey-Kramer honestly Significant difference (HSD) test to determine the actual levels that were different.

4.3.2 Statistical Differences – Injury Rate of Railroad Stakeholders

CATT Lab performed statistical tests on the injury rate per employee hours worked across the railroad stakeholders. As with the temporal variable analysis, the normalized frequency count data per employee hours worked each month was analyzed using an ANOVA test.

4.3.3 Statistical Differences – Reportable Versus Non-Reportable Incidents

CATT Lab performed statistical tests and modeling on variables related to reportable and non-reportable incidents, including nature of injury, injured body region, occupation title, occupation category, and Location 3: specific location of incident and cause/reason for incident. An overview of the analysis performed for reportable and non-reportable incidents is summarized below.

- Chi-square test of independence:
  - Chi-square tests of independence were performed to examine whether the variables were independent of one another. The null hypothesis of this chi-square test was that no relationship exists between the variables (independent) while the alternative hypothesis was that the variables were in fact related. Next, if the result of the chi-square test was significant with a p-value less than 0.05, the research team performed a post-hoc paired chi-square with a Bonferroni correction to determine the actual levels that were different.
    - Note that simulation of the sampling distribution of the test statistic was used to derive the p-value when expected counts were low. The team did not anticipate that simulation would be needed for a larger dataset beyond this pilot, which included an 18-month sample of the five railroads data.
- Inference and variable importance based on predictive models:
  - Inference models were developed to predict whether an incident was reportable or non-reportable. The purpose of these models was to better understand the variables contributing to the predictions. The following five types of interpretable models were used: logistic regression, grouped lasso, decision trees, random forests, and boosted trees. The logistic regression performed z-tests on the model parameter coefficients to identify variable importance utilizing p-values under 0.05. The grouped lasso performed feature selection by identifying features that did not contribute to the model. Random forest, decision trees, and boosted trees approximated variable importance by calculating the relative contribution of the corresponding feature to the model calculated by taking each feature’s contribution in the model.
    - All models were based on a 75 percent training and 25 percent test dataset split. In terms of model tuning, a 10-fold cross-validation was then performed on the training sets to determine the optimal parameters.

4.3.4 Statistical Differences – Two-Way Categorical Variables of Interest

CATT Lab performed two-way statistical analysis on two pairs of variables of interest: nature of injury versus occupation title and severity of injury versus occupation title. Note that for future analyses, any pairs of variables could be analyzed. As with the reportable versus non-reportable incidents, chi-square tests of independence were performed to determine whether the variables were independent of one another.

4.3.5 Correlation – Continuous Variables

CATT Lab performed correlation analysis on the continuous variables within this dataset including age, years of service, and lost days. Pearson correlation coefficients were calculated for each pair to determine whether there was a relationship between the variables.

4.4 C^{3}RS and Inspection Data

CATT Lab integrated the C^{3}RS and county inspections with the PI and RV datasets. An overview of the analysis is summarized below:

- C^{3}RS:
  - C^{3}RS was examined to identify the fields in common with the PI and RV datasets. Based on the two temporal fields in common, an analysis was conducted on the three datasets to identify distribution and trends across hour of day bin and month-year.
- Inspections:
  - County inspection data was integrated with PI incidents to identify the date of the last county inspection prior to an incident occurring. The distribution of days since last inspection and the relationship with personal injuries were then analyzed.

5. Analysis Findings

This section provides an overview of the findings from the PI Analysis, including:

- Use Case with Dashboards
- Overall Findings and Trends
- Statistical Analysis Findings
- C^3RS and Inspection Findings

5.1 Use Cases with Dashboards

This sub-section provides an overview of the findings based on the use cases that were developed and analyzed. CATT Lab developed the first two use cases and railroad stakeholders recommended the third use case. The first use case – PI Reportable versus Non-Reportable incidents – was presented in the stakeholder meeting and included more in-depth analysis and output as opposed the rest of the use cases, summarized at a high level. All use cases were analyzed using the RISE platform dashboards and demonstrate the ability to help users gain insights on rail safety.

Use Case 1: PI Reportable Versus Non-Reportable Incidents

This pilot study provided the opportunity to analyze PI non-reportable incidents, which, because they were less severe, did not meet FRA reporting requirements. The goal of this use case was to gain insights from incorporating both reportable and non-reportable incidents to understand what circumstances contribute to an injury being more serious and hence reportable to FRA.

PI-Univariate, PI-Multivariate Numeric, and PI-Multivariate Categorical dashboards were used to identify notable differences. PI-Univariate and PI-Multivariate Categorical were used to analyze FRA reportable and non-reportable incidents versus the other categorical variables, while PI-Multivariate Numeric was used to analyze FRA reportable and non-reportable incidents versus continuous variables. Appendix A provides a representative sample of the types of visualizations across the three dashboards used in this analysis.

Overall, the trends and distributions of the PI variables across reportable versus non-reportable incidents were very similar, indicating that additional information on the incidents may be required to determine the circumstances that led to a more severe reportable incident. There were, however, some differences noted across several variables that are summarized below. Note that "NR" stands for non-reportable incidents and "R" stands for reportable incidents.

- Nature of Injury:
    - Sprain and strain injuries were more prominent in reportable incidents (25 percent of NR/42 percent of R) while bruise or contusion injuries were more prominent in non-reportable incidents (32 percent of NR/17 percent of R).
    - Fracture (broken bones and rupture/tear injuries were only found in reportable incidents – they tended to be more severe injuries, as demonstrated by their considerable number of lost days. These injuries made up about 7 percent of the overall data.
- Occupation Title:

- Maintenance of way (MOW) and structures staff injuries were more prominent in reportable injuries (19 percent of NR/34 percent of R), while maintenance of equipment and stores staff were more prominent in non-reportable injuries (30 percent of NR/22 percent of R).
- Injured Body Region:
  - Head or face injuries were more prominent in non-reportable incidents (20 percent of NR/14 percent of R), while torso injuries were more prominent in reportable incidents (23 percent of NR/29 percent of R).
  - Other injuries were also more prominent in non-reportable incidents (6 percent of NR/1 percent of R).
- Cause/Reason for Incident:
  - Following procedures for operating equipment injuries were more prominent for reportables (2 percent of NR/10 percent of R).

Use Case 2: PI Highest Injury Rate by 200k Hours Worked

The goal of this use case was to compare the June 2018 period to the overall dataset to identify circumstances that could have contributed to the highest injury rate. This case focused on June 2018, which had the highest rate of 6.31 injuries per 200k hours worked, demonstrating the value of incorporating both reportable and non-reportable incidents to understand the highest injury rate. Overall, there were only slight differences in the June 2018 period compared to the overall dataset.

Use Case 3: PI Railroad Stakeholder Results Versus Aggregate Dataset

The goal of this use case was for each railroad to benchmark its results against the aggregate FRA RISE platform data. All railroads were encouraged to conduct this use case.

5.2 Overall Findings and Trends

The following summarizes the more notable overall trends found in FRA RISE PI dataset.

- Occupation Category:
  - Most incidents involved road passenger conductors and engineers:
    - Road passenger conductors (21 percent of total injuries)
    - Assistant road passenger conductors and ticket collectors (7 percent of total injuries)
    - Road passenger engineers and motormen (7 percent of total injuries)
- Occupation Title:
  - Most incidents involved transportation and mechanical staff:
    - Transportation train and engine and transportation other than train and engine (41 percent of total injuries)
    - MOW and structures (30 percent of total injuries)
- Nature of Injury:

  - Most incidents involved sprains and strains and bruises or contusions:
    - Sprains and strains (36 percent of total injured)
    - Bruises or contusions (22 percent of total injured)
- Injured Body Region:
  - Most incident injuries were equally dispersed across torso, arm or hand, and leg or foot body regions:
    - Torso (27 percent of total injured)
    - Arm or hand (26 percent of total injured)
    - Leg or foot (25 percent of total injured)
- Location1: General Location of Incident:
  - Most incidents took place in the main/branch and yard:
    - Main/branch (40 percent of total injuries)
    - Yard (22 percent of total injuries)
- Location2: Equipment Type Involved:
  - Most incidents were not associated with on-track equipment and involved combinations of standing/moving on a passenger train/passenger car:
    - The A/I not associated with on track equipment (51 percent of total injuries)
    - Combinations of standing/moving on passenger train/passenger car (35 percent of total injuries)
- Physical Act:
  - Most incidents occurred while staff was walking or standing:
    - Walking (19 percent of total injuries)
    - Standing (9 percent of total injuries)
- Cause/Reason for Incident:
  - Most incidents resulted from a human factor, an environmental factor and undetermined circumstances:
    - Human factor (42 percent of total injuries)
    - Environmental (14 percent of total injuries)
    - Undetermined (14 percent of total injuries)
- Event Circumstance:
  - The event circumstance was disbursed across many categories, and the top event circumstance cause was overexertion:
    - Overexertion (17 percent of total injuries)

- AIS Severity:
    - Almost all injuries were minor or moderate in severity:
        - Minor (80 percent of total injuries)
        - Moderate (12 percent of total injuries)
- Estimated VSL:
    - Almost all incidents were estimated to be in the two lowest cost tiers:
        - Tier 1 – $28,800 (85 percent of total injuries)
        - Tier 2 – $451,200 (12 percent of total injuries)
- Hour of Day and Daylight:
    - Most injuries occurred between 9 a.m.–12 p.m. (25 percent of total injuries) and most injuries occurred during daylight hours (86 percent of total injuries).
- Weather:
    - Poor weather conditions during outdoor incidents were present in about 11 percent of total injuries and in 17 percent of the outdoor injuries (excluding the indoor incidents).
- Binned Years of Service:
    - Service personnel with fewer years of service were more susceptible to injuries; 31 percent of total injuries were associated with 5 years of service or less.
- Highest Rate of Injuries:
    - June 2018 had the highest injury rate, 6.31, per 200k hours worked, .

5.3 Statistical Analysis Findings

The following section details the results of the statistical tests performed on the PI data discussed in Section 4.3.

5.3.1 Temporal Variables

CATT Lab performed chi-square tests, GLM Poisson models and ANOVA tests to determine significant relationships across the temporal variables. Overall, there were significant differences in the observed versus theoretical distribution across all three variables. However, when normalizing the day of week and the month-year by employee hours worked, there were not significant differences in the injury rates. The research team also performed some sensitivity analysis with filtering solely reportable and non-reportable incidents to see whether the relationship held true or changed. Other filtering across occupation types or locations could be considered in future analyses.

- Day of Week:
    - Frequency count: There was a significant difference in the number of injuries based on the day of week. Weekdays had a higher number of injuries than the weekend.

    - Normalized rate: When normalizing the number of injuries by employee hours worked, there was no longer a significant difference, as employee hours worked were lower on the weekends.
    - Filter reportable and non-reportable incidents: Both the frequency count and normalized rate findings held true.
- Month-Year:
    - Frequency count: There was a slightly significant difference in the number of injuries based on the month-year. The number of injuries in November 2018, December 2018, and May 2019 were less than the other 15 months in the pilot analysis.
    - Normalized rate: When normalizing the number of injuries by employee hours worked, there was no longer a significant difference as the employee hours worked.
    - Filter reportable and non-reportable incidents: The frequency count was no longer significant for reportables and non-reportables, while the normalized rate findings held true.
- Hour of Day:
    - Frequency count: There was a significant difference in the number of injuries based on the hour of day. Most injures occurred during daytime shifts, from 7:00 a.m.–3:00 p.m.
    - Normalized rate: N/A, as employee hours worked were not available at this level of granularity.
    - Filter reportable and non-reportable incidents: The frequency count findings held true.

5.3.2 Injury Rate of Railroad Stakeholders

CATT Lab performed ANOVA tests to identify a significant difference in the injury rate across railroad stakeholders. Overall, there were significant differences in the injury rates between the railroad stakeholder groups. Due to anonymity concerns, this finding will not be discussed in this report.

5.3.3 Reportable Versus Non-Reportable Incidents:

CATT Lab analyzed inference models and chi-square tests to determine variable importance and significant relationships between FRA reportable and non-reportable incidents. Overall, the inference models and chi-square tests revealed only slight differences and confirmed that reportable and non-reportable incidents were very similar.

Inference Models

Overall, the inference models had difficulty differentiating between reportable and non-reportable incidents and performed marginally better in accuracy than the no information rate. The following variables were identified as influential based on the various inference models analyzed:

- Nature of Injury
- Occupation Title
- Injured Body Region
- Cause or Reason Occupation Category
- Location3: Specific Location of Incident

Chi-Square Tests

CATT Lab further explored the influential variables from the inference models for significant relationships with FRA reportable and non-reportable incidents. All the variables were found to be significant across chi-square tests, indicating there was a relationship between the variables. As a result, post-hoc, paired, chi-square tests were run to identify the actual levels of the variables that were different. Note the underlined levels correspond back to the Use Case 1: Reportable Versus Non-Reportable incidents findings discussed in Section 5.1. Overall, the chi-square post-hoc tests showed significant relationship across a small number of variables levels, as summarized below.

- Nature of Injury:
    - Bruise or contusion: significantly more prevalent in non-reportable incidents
    - Fracture (broken bone): only present in reportable incidents
    - Rupture/tear: only present in reportable incidents
    - Sprain or strain: significantly more prevalent in reportable incidents
    - Animal/snake/insect bite: significantly more prevalent in non-reportable incidents
    - Symptoms due to one-time inhalation exposure to airborne contamination: significantly more prevalent in non-reportable incidents
- Occupation Title:
    - Maintenance of equipment and stores: significantly more prevalent in non-reportable incidents.
    - MOW and structures: significantly more prevalent in reportable incidents.
- Injured Body Region:
    - Other: significantly more prevalent in non-reportable incidents
- Cause or Reason:
    - Procedures for operating/using equipment not followed: significantly more prevalent in reportable incidents
    - Undetermined: significantly more prevalent in non-reportable incidents
- Occupation Category:
    - Stationary engineers: significantly more prevalent in non-reportable incidents
- Location3:
    - Specific Location of Injury: No differences in levels identified.

5.3.4 Two-Way Categorical Variables of Interest

CATT Lab analyzed the nature of injury and severity of injury relationships with occupation title. Overall, the severity of injury chi-square test was not significant, while the nature of injury chi-square test was significant. The actual levels of occupation title that were different based on post-hoc paired chi-square tests are listed below.

- Occupation Type Versus Nature of Injury:
  - Maintenance of way and structures: significantly more injuries with fractures (broken bones) and animal/snake/insect bites
  - Maintenance of equipment and stores: significantly more injuries with symptoms due to one-time exposure to loud noises
  - Transportation, train and engine: significantly more injuries with bruises or contusions

5.3.5 Continuous Variables

CATT Lab analyzed the correlation relationship between lost days and the age and years of service of the injured employee. Overall, neither variable had a strong relationship with lost days, as summarized below.

- Age was not correlated with lost days. Higher ages of injured employees did not result in a higher number of lost days (correlation ~0.02).
- Years of service was not correlated with lost days. Higher years of service of injured employees did not result in a higher number of lost days (correlation ~0.06).

5.4 C^3RS and Inspection Findings

There were no noteworthy findings regarding the integration of C^3RS and county inspections with the PI and RV datasets. For future analyses, the research team recommends that railroads:

- Obtain more detailed inspection data, such as the specific location of inspection and the reason for the inspection, to better correlate it against the PI dataset.
- Invest in mapping the C^3RS data fields more closely to the PI and RV datasets to analyze additional features beyond temporal variables.

6. Lessons Learned and Recommendations

Throughout this project, the team gained valuable insight on needs and challenges that passenger railroads face in collecting, archiving, and sharing data. These challenges ultimately affected the effort required to establish the pilot version of RISE that will be used to guide future, related development of the data trust. Below are the primary lessons learned in overcoming challenges faced in this project, as well as recommendations for the next phase of RISE.

Lesson 1: Variability in how data is collected, especially the data not directly shared with FRA, required significant effort in the data cleaning and fusion process. As mentioned in Section 2.2 (data assessment and final safety topic selection), differences between data shared by railroad stakeholders required some data to be excluded to protect the identity of the railroads.

Recommendation: The RISE team should work closely with FRA RRS to better utilize data collection forms and guidelines. Such information may have reduced the effort in requesting and cleaning data sent by railroad stakeholders.

Lesson 2: Significant time was spent building options for a comprehensive data security plan to ensure the data of all participants was safeguarded. Some of these options, such as CUIE, were not fully utilized.

Recommendation: Future changes to the data security plan should involve both technical and legal representative from all stakeholders. These parties should come to an agreement on a security plan that meets everyone's needs to avoid the effort required to modify the security options based on individual stakeholder needs.

Lesson 3: Stakeholder engagement and buy-in is required for RISE to be successful. In addition to the usual resource challenges faced by railroads, this project was delayed by COVID-19. Changes in personnel and shifting priorities under constrained budgets presented additional challenges in developing the pilot version of RISE. Despite these challenges, participants from FRA, Volpe, and the participating railroads saw the potential for RISE to lay the framework for addressing critical rail safety issues.

Recommendation: The RISE team should continue to grow RISE by inviting safety-driven stakeholders to join the team. Sharing data, expertise, and experiences are needed to break through the rail safety plateau.

After the dashboards were shared, the RISE team asked the railroad stakeholders to provide feedback on their experience with the dashboards and the project in general using the feedback form shown in Appendix B. The responses provided a framework for final discussions with each stakeholder. In addition, the team also met with FRA safety analysts to document their experience with the dashboards. During these discussions, the team discovered that the railroad stakeholders found the dashboards to be useful not only for automating the analysis process but also for communicating findings to a broad audience. For example, the PI Univariate dashboards provide charts and visualizations that are commonly shared with upper management to communicate general safety trends. There was also interest in using the multivariate dashboards to investigate deeper insights and communicating findings within the data analysis community. In addition, nearly every stakeholder appreciated the PI risk matrix, as converting injuries to monetary values was of great interest to every railroad stakeholder.

For the next RISE phase, the team is considering the following enhancements:

1. Extend RISE to include additional railroad stakeholders, including freight rail partners and labor unions.
2. Streamlined selection of additional safety topics to assist railroad agencies tackle difficult safety issues.
3. Automate the secure data sharing process.
4. Providing additional tools to support efficient safety data analysis and benchmarking.

7. Conclusion

The successful completion of the pilot RISE project has set a framework for continued secure railroad safety data sharing and analysis. In doing so, the RISE team made the following key contributions to the realm of railroad safety:

Engaged railroad stakeholders: This project was driven by the desire of five passenger railroads to address challenging safety issues. These stakeholders provided invaluable industry insights on safety topics, data collection procedures, data analysis practices, and potential future paths for RISE.

Began establishing a railroad safety data trust: Following examples from other modes, RISE began to establish a data trust among passenger railroad stakeholders, FRA, Volpe and CATT Lab. This data trust formed the foundation for voluntary, non-punitive, secure data sharing – solely to better understand challenging safety topics.

Created a data security plan: The RISE data security plan anonymized data and controlled access to the aggregate and railroad-specific data. This plan was designed to apply to any safety-sensitive data.

Developed a secure data sharing and analysis platform: The end product of this project was the creation of the secure online data sharing and analysis tool. This streamlined the process of PI and RV data analysis and benchmarking.

Demonstrated the ability of RISE to address a critical safety issue: Data provided by railroad stakeholders was used to demonstrate the analysis of the PI and RV topics. Further statistical analyses were conducted to illustrate the formal process of comparing safety statistics.

Documented lessons learned: Throughout the process of establishing RISE, the team documented the challenges faced and lessons learned. These lessons will provide the team with valuable experience in the future phases of developing the RISE data trust.

8. Appendix

8.1 Appendix A: Use Case 1 Representative Sample of Visualizations

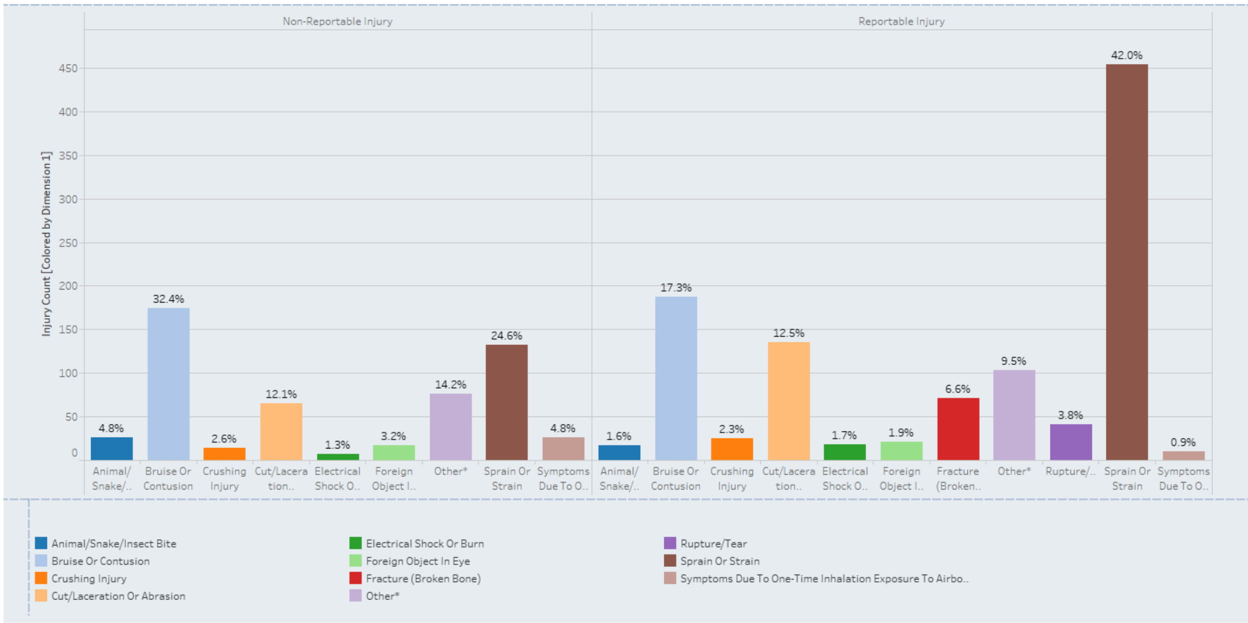

Figure A1. FRA Reportable Versus Nature of Injury

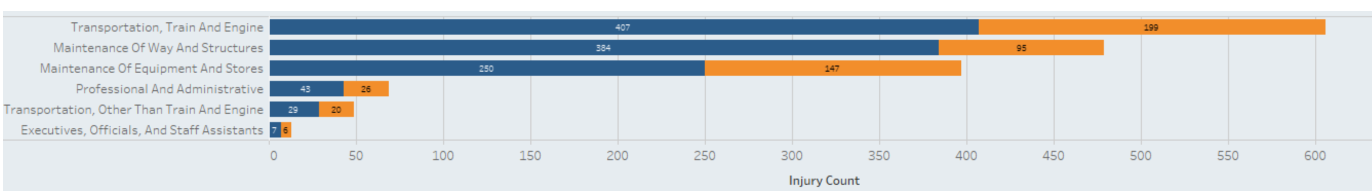

Figure A2. FRA Reportable Versus Occupation Title

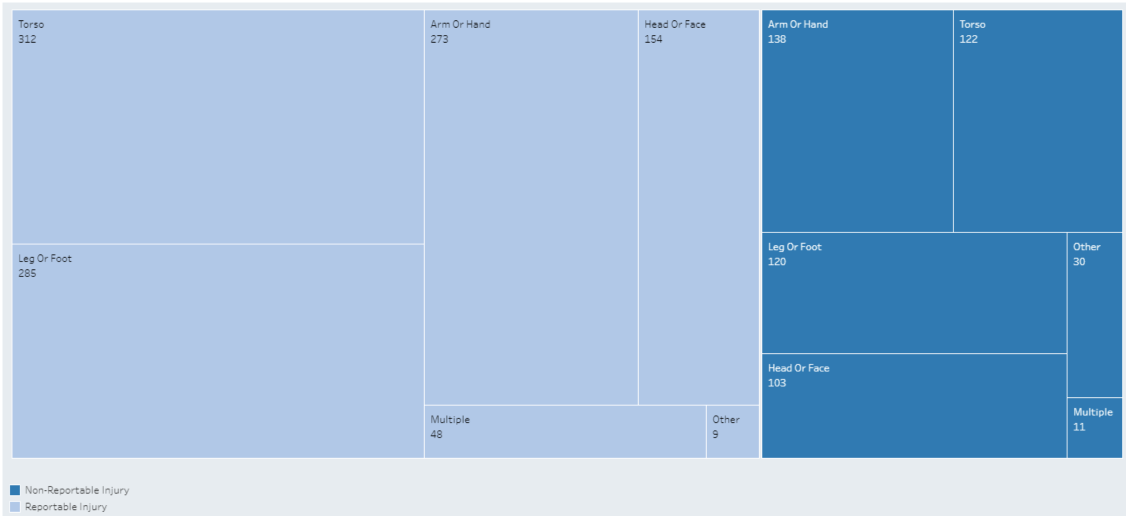

Figure A3. FRA Reportable Versus Injured Body Region

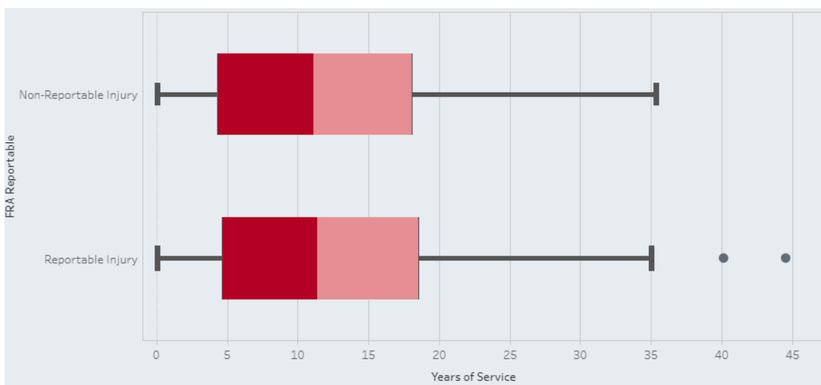

Figure A4. FRA Reportable Versus Years of Service

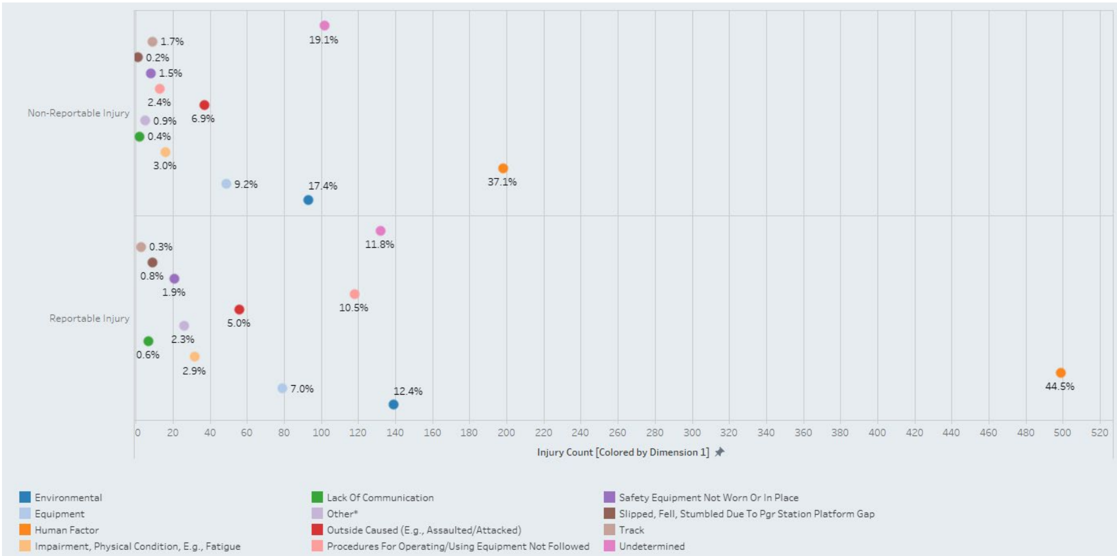

Figure A5. FRA Reportable Versus Cause or Reason for Incident

8.2 Appendix B: Stakeholder Project Feedback Form

Railroad Information Sharing Environment

Stakeholder Analysis Dashboard Feedback

Context: The Center for Advanced Transportation Technology Laboratory (CATT Lab) seeks feedback on your agency's initial experience with the Railroad Information Sharing Environment (RISE) analysis dashboards and the RISE project, itself. As you and your colleagues explore the Tableau dashboards, please review and answer the questions listed below.

Your responses to the questions below will be used to document end user experiences, prioritize dashboard improvements, and inform future paths for this project. Please add your feedback directly to this Word document and provide screenshots of the dashboard as needed to supplement your responses.

A follow-up meeting will be coordinated to review your responses. Any questions about the survey can be directed to:

Mark Franz
email:mfranz1@umd.edu

Thank you for your valuable feedback,

Mark

General Use of Dashboard

- Did the dashboards meet your expectations for how to investigate the study topics identified by the group?
- Who will be the primary users (job titles, not names of individuals) accessing and exploring the dashboards? Will any other employees be providing direction about how to explore the dashboards?
- How would you like to make use of these dashboards over the next 6 months? Do you intend/expect to use the dashboards for data exploration, presentations/data visualizations?
- Did the data in the dashboards provide any insights on how your agency may better collect and manage data on personal injuries and/or rules violations? For example, is there a data field that your agency is not currently collecting but may consider after this project?

Data Aggregation

- Does the aggregated data on the dashboards help you understand things you could not understand with your data alone? Yes/No (please provide examples)

- What insights have you uncovered by reviewing the aggregated data?
- If you chose to benchmark your data against the aggregated data, did this comparison provide useful information? Yes/No (please provide examples)

Interface Design and Data Presentation

- Is it easy to navigate the dashboards and filter/drill down to events of interest? Why or why not?
- Do the dashboards support your agency's data visualization and reporting needs?
    - If not, what functions and/or visualizations are needed?

Use Cases and Findings

- Have the charts and tables in the Tableau dashboard provided any insights that you have not observed from the ways that your data are currently analyzed and presented? Yes/No (please provide examples)
- What insights have you uncovered from this new presentation of this data?
    - What contributed to those new insights? Were there particular charts or information displays that were particularly helpful?
- After going through the data sharing process, does your agency have or desire to collect any additional data fields to support personal injury and/or rules violation analysis? If so, please list those data fields.

Data Collection/Maintenance

- Has the process, to date, demonstrated that this is a mechanism by which you feel comfortable sharing data?
- Would you feel comfortable sharing additional data in a similar manner?
- Do you have suggestions for ways to enhance the data collection process?

Topic Selection

- The stakeholders decided to pursue *personal injuries* and *rules violations* as the initial use cases for the demonstration. Please consider the following:
    - Did these use cases demonstrate the ability to stand up a functioning data trust?
    - Did these use cases show the potential benefits of RISE?
    - Do you have suggestions for how to select topics as this demonstration continues?
    - Do you have any recommendations for topics to pursue?
    - Do you have any suggestions for how to improve RISE going forward?

Abbreviations and Acronyms

ACRONYMS	EXPLANATION
CATT Lab	Center for Advanced Transportation Technology
FRA	Federal Rail Administration
PI	Personal Injury
RISE	Railroad Information Sharing Environment
RV	Rule Violation
UMD	University of Maryland