NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

# TRB Webinar: Deter Trespassing on Rail Rights of Way and Improve Grade Crossing Safety

*January 28, 2025*

*11:00AM – 12:30 PM*

# PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

***The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.***

ENGINEERING
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REGISTERED CONTINUING EDUCATION PROGRAM

# AICP Credit Information

1.5 American Institute of Certified Planners Certification Maintenance Credits

You must attend the entire webinar

Log into the American Planning Association website to claim your credits

Contact AICP, not TRB, with questions

# Purpose Statement

This webinar will share techniques and treatments to employ to deter trespassing, ranging from physical barriers to public outreach and education. Presenters will discuss deployment of electronic surveillance through rail crossing cameras and other devices to monitor grade crossing activity and provide alerts for actions.

# Learning Objectives

At the end of this webinar, you will be able to:

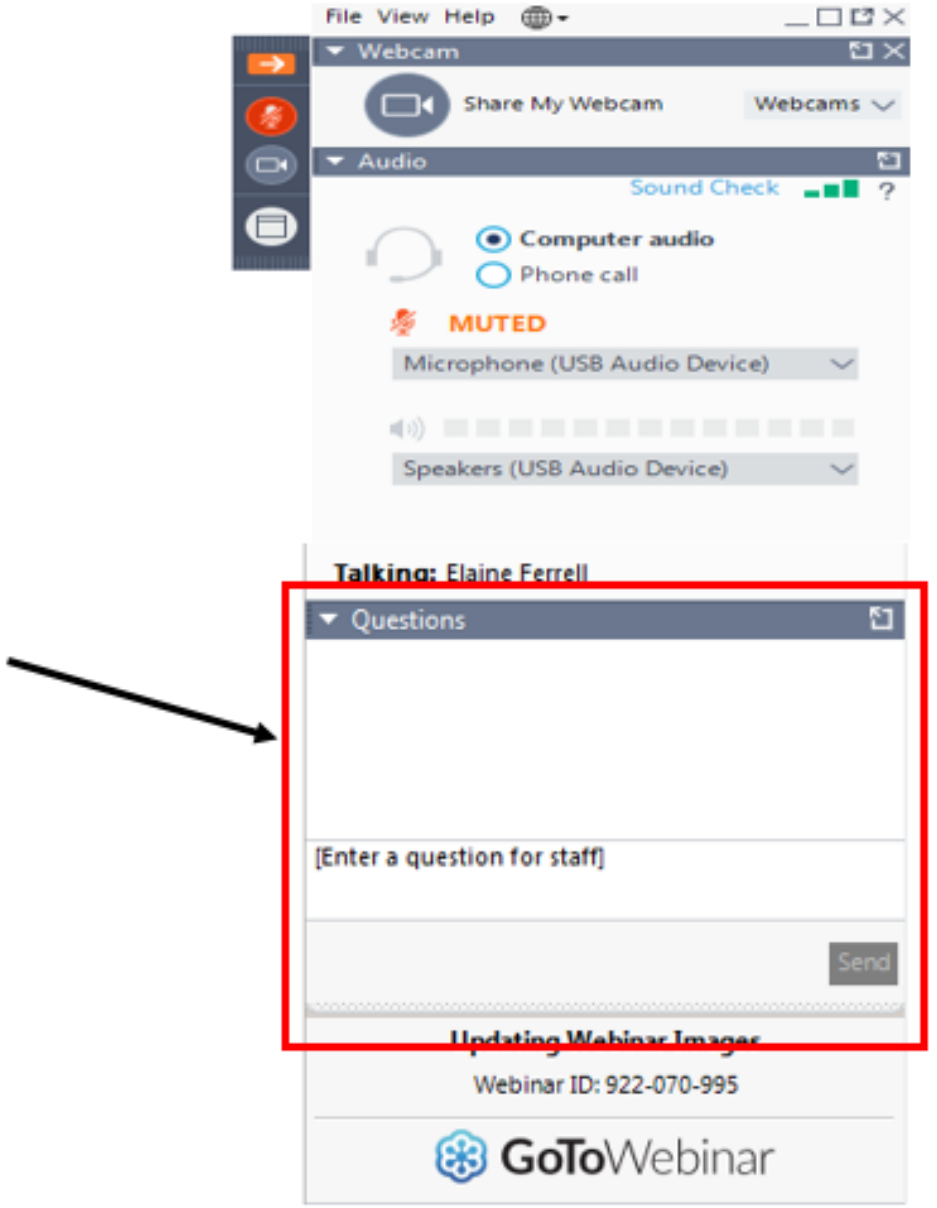
(1) Understand the most effective methods and techniques to deploy to deter trespassing on rail rights of way

(2) Analyze surveillance data collected from rail crossing cameras to enhance engineering, education, and enforcement efforts

(3) Recognize the vital role grade crossing surveillance and trespasser deterrence plays in the safe operation of rail systems

# Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



# Today's presenters

**David C. Wilcock**
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NATIONAL ACADEMIES *Sciences Engineering Medicine*

Texas A&M Transportation Institute

# Strategies for Deterring Trespassing on Rail Transit and Commuter Rail Rights-of-Way

*TRB Webinar: Deter Trespassing on Rail Rights-of-Way and Improve Grade Crossing Safety*

**January 28, 2025**

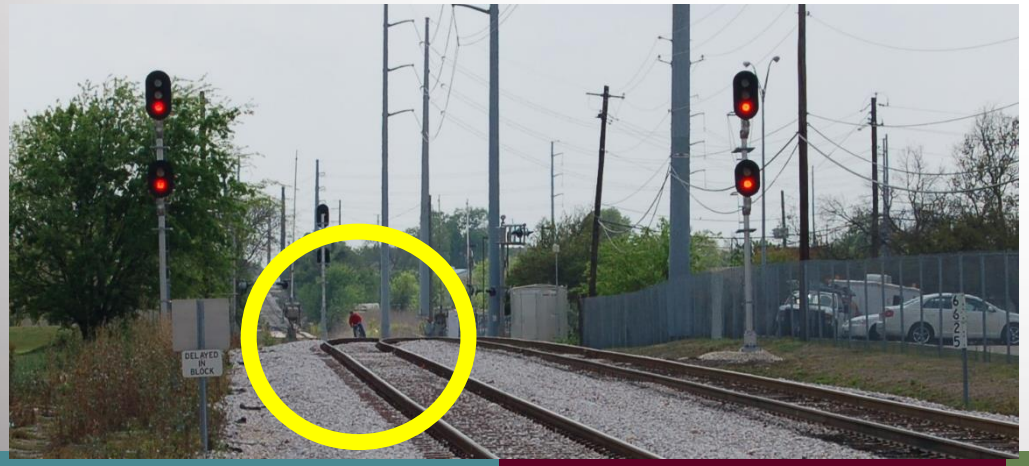
**Jeff Warner**

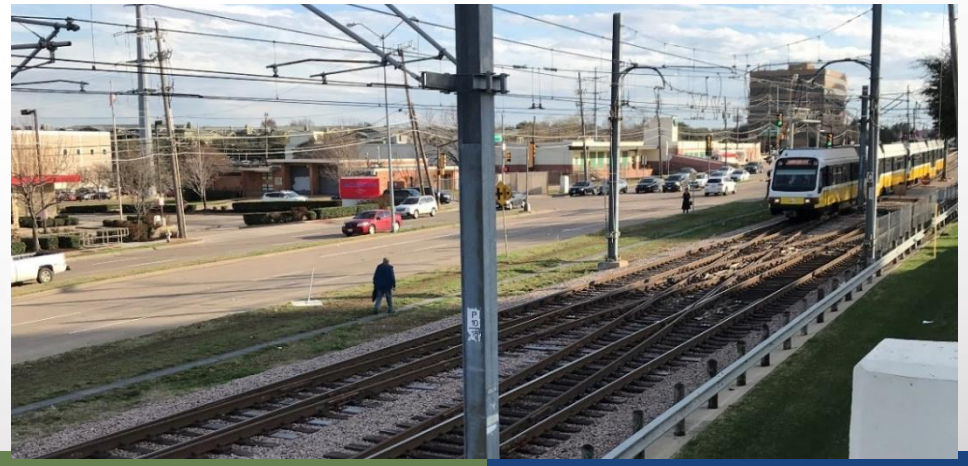
# Presentation Agenda

- **What is the trespassing problem?**
- How did we address the trespassing problem?
- What can be done to mitigate trespassing?

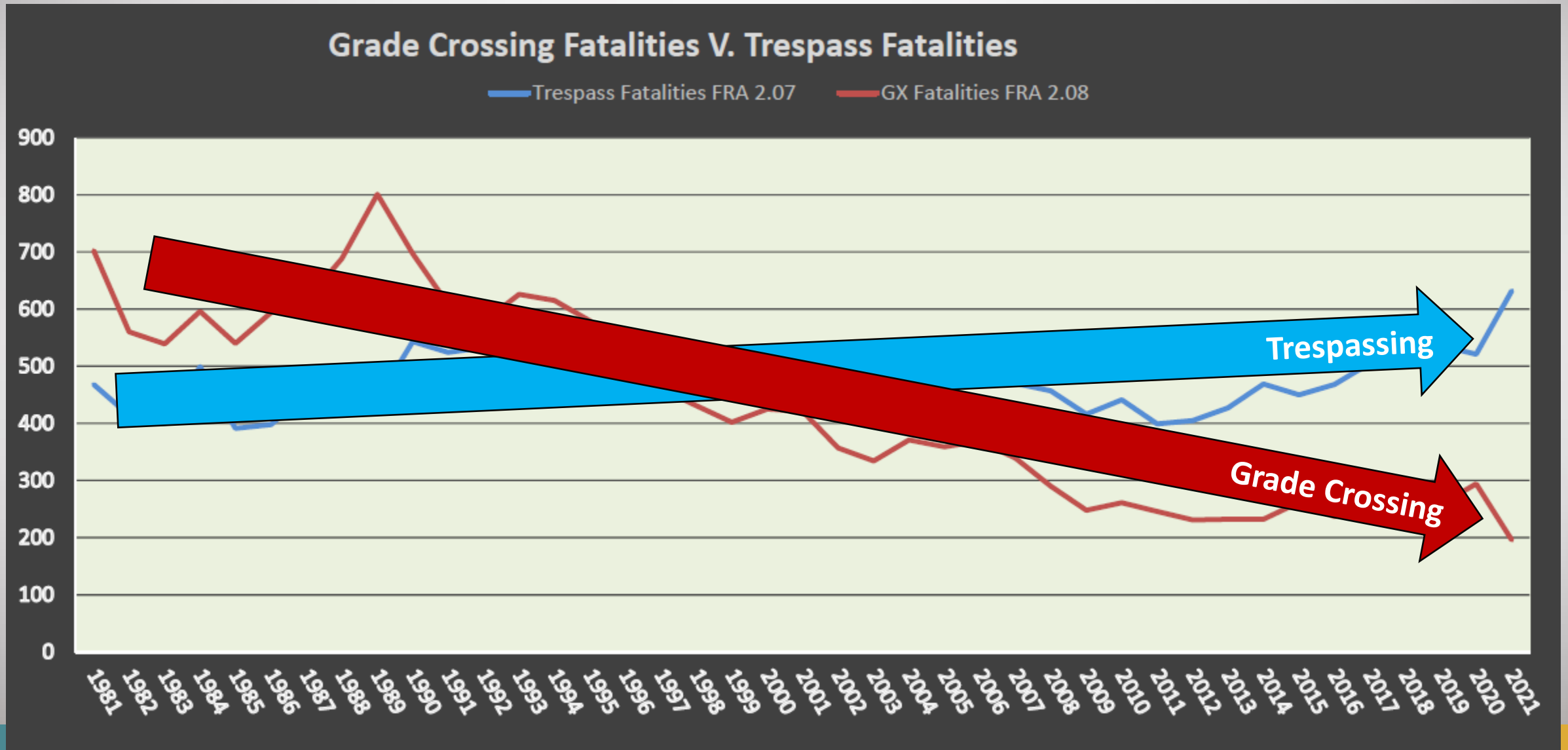
# What is Rail Trespassing?

- There's a surprising (or not surprising) number of official definitions
  - FRA – "Trespasser is someone who is on the part of railroad property used in railroad operation and whose presence is prohibited, forbidden, or unlawful."
  - FTA – "Trespasser is a person in an area of transit property not intended for public use (i.e., an unauthorized area)."
- Also includes suicides

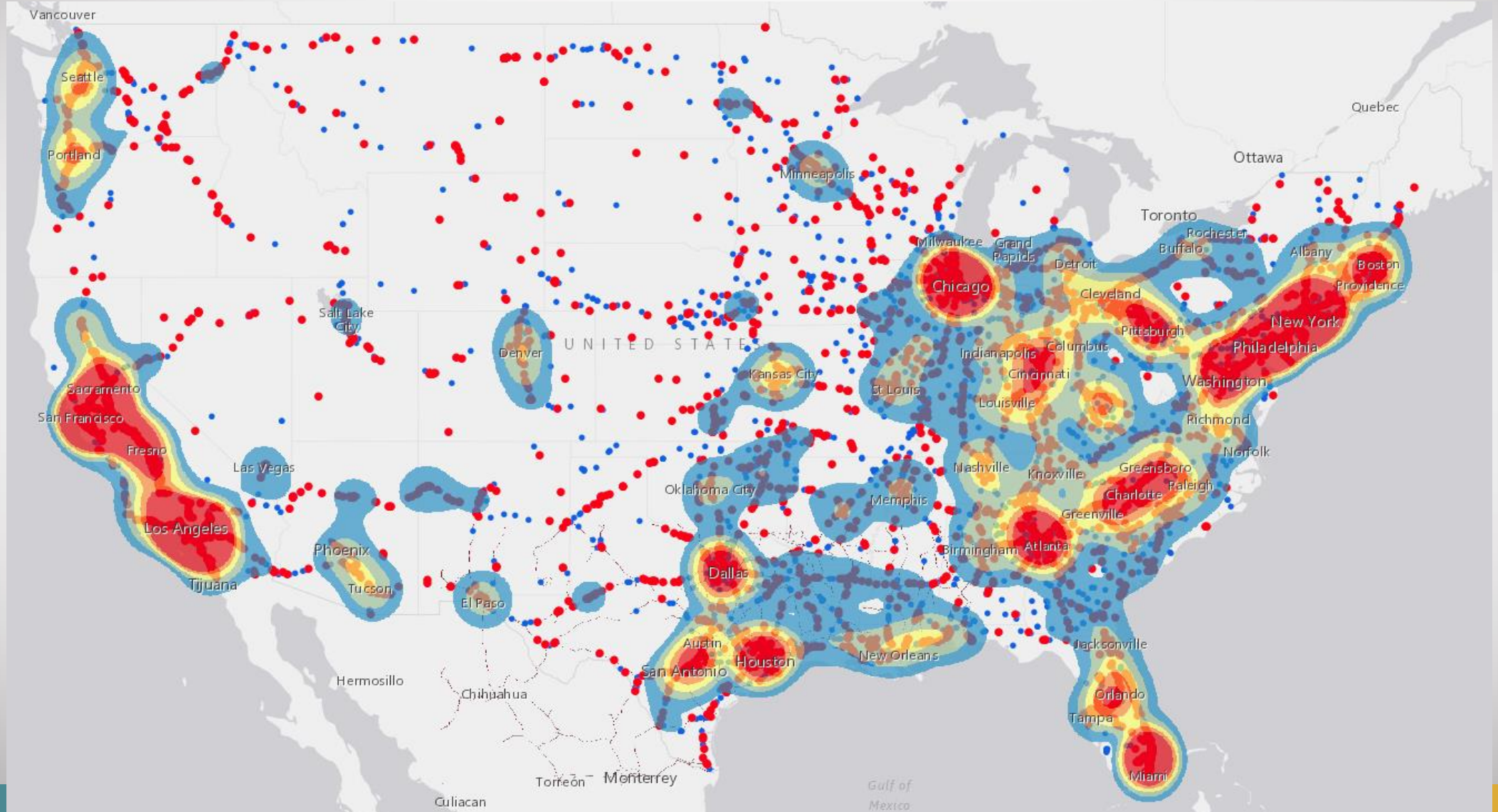




# How Bad is Trespassing? – FRA



# How Bad is Trespassing? – FRA



# Why Are People Trespassing?

- Living/loitering in the rail right-of-way (homeless encampments)
- Shortcut/route convenience
- Criminal behavior
- Dropped/lost items
- Recreational activities, such as hiking or fishing
- Intoxication
- Distraction
- Self-harm intent
- Photography and selfies


Photo credit: Carolyn Cook, FRA

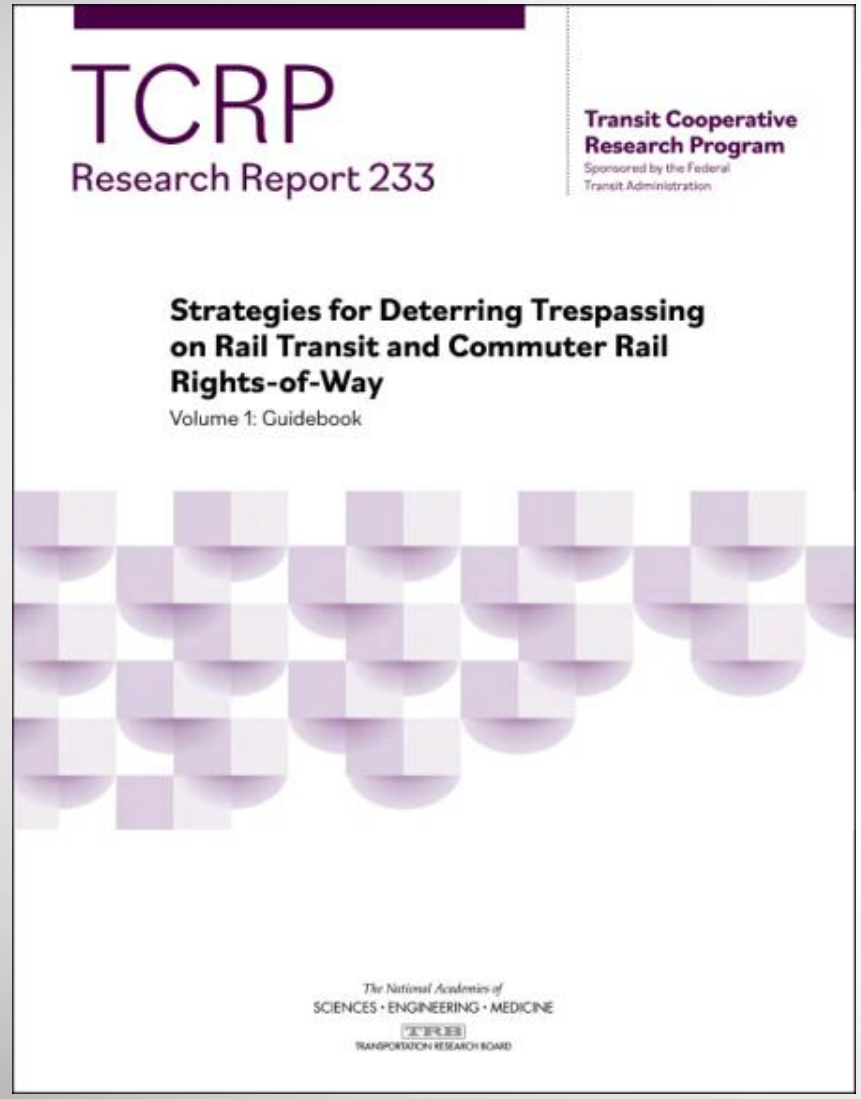
# Where Are They Trespassing?

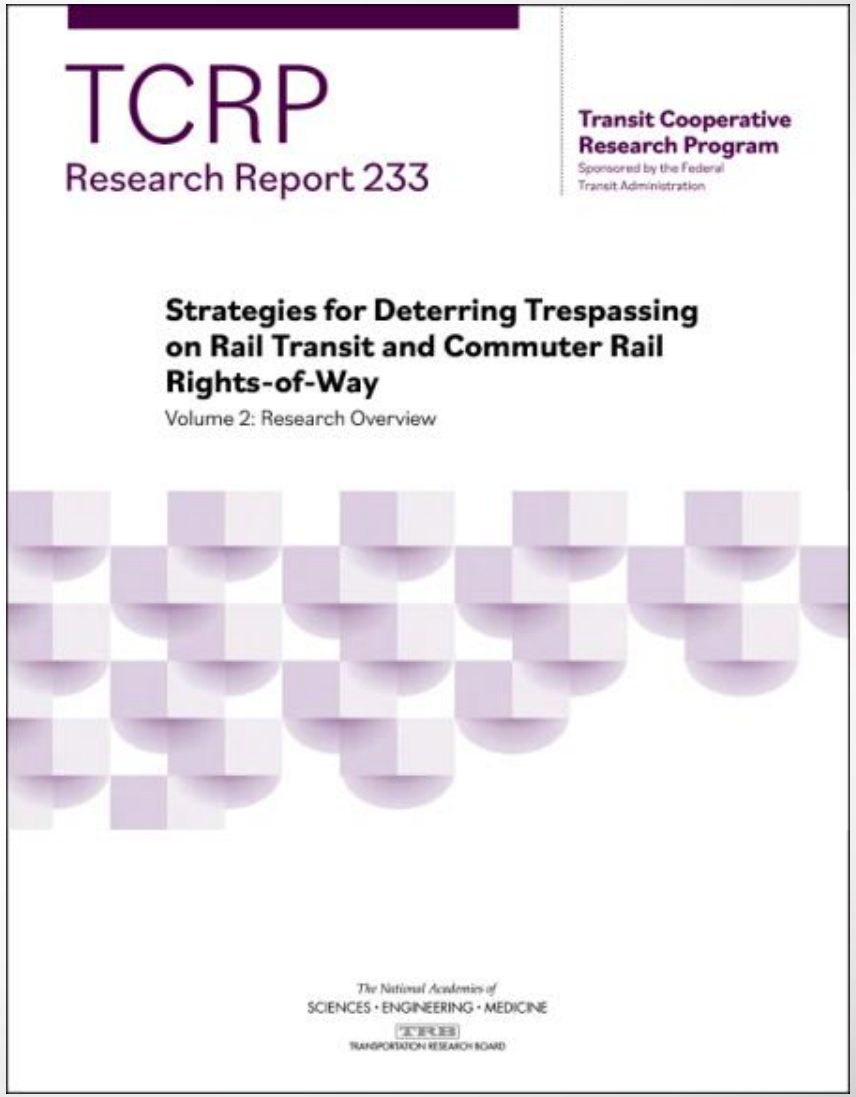
- Grade crossings
- Stations and platforms
- Along and across rights-of-way
- Equipment and maintenance yards
- Bridges


# Presentation Agenda

- What is the trespassing problem?
- **How did we address the trespassing problem?**
- What can be done to mitigate trespassing?

# TCRP Research Report 233 – Vol. 1 & 2



# Project Objective

**To provide guidance on strategies to deter trespassing on rail transit and commuter rail rights-of way in exclusive and semi-exclusive rights-of-way, including within station areas outside designated pedestrian crossings.**

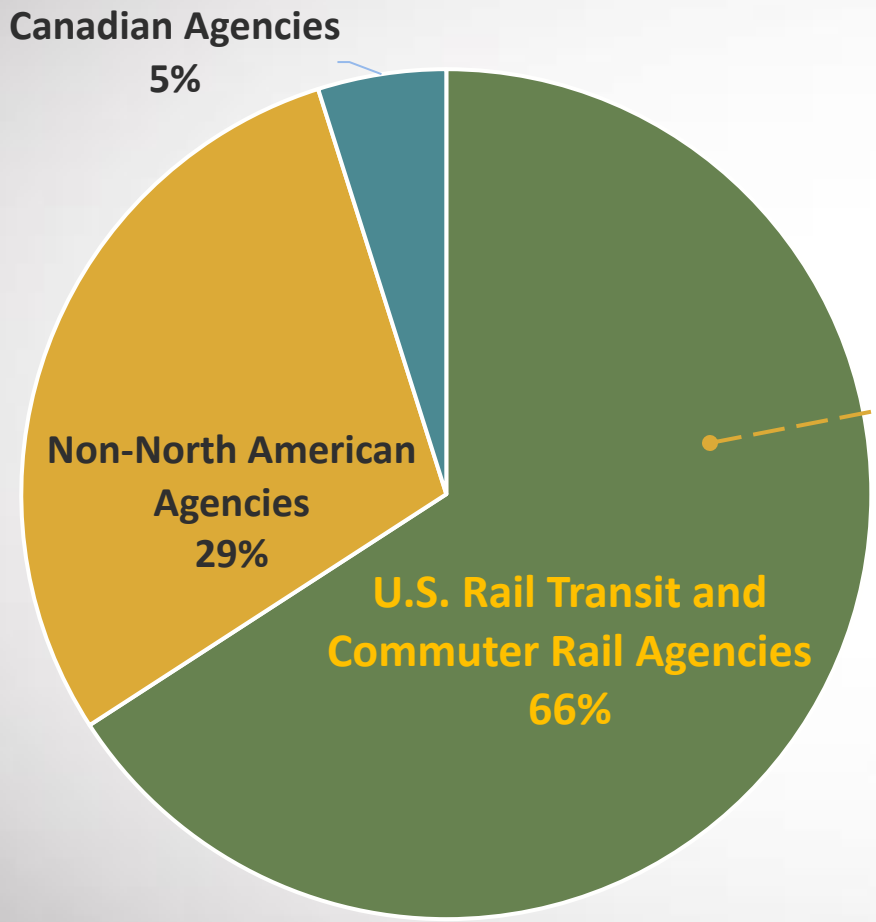


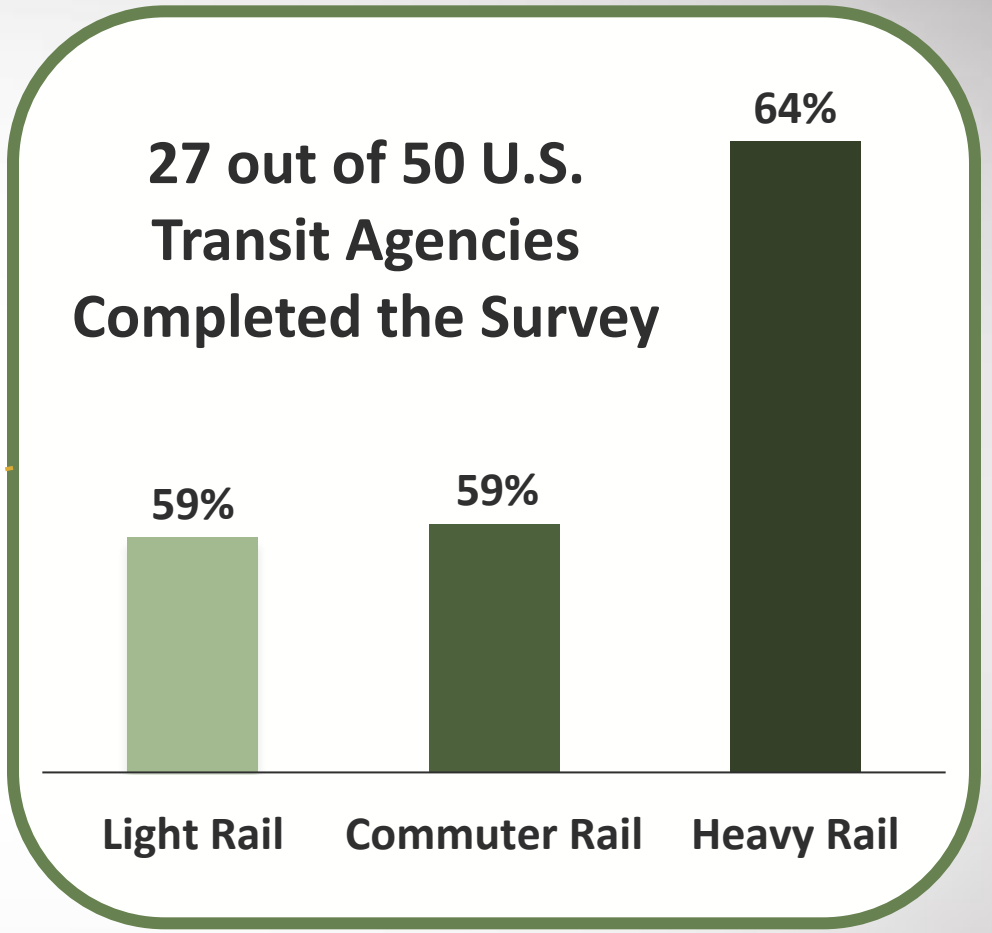
# Project Activities Overview

# Literature Review and Survey of Practitioners

- **Literature Review & Current Practices**
  - Main objectives to capture strategies to deter trespassing and document current applications of these strategies
- **Survey of Practitioners**
  - Main objectives to catalog practices to mitigate trespassing and understand trespassing concerns and issues

# Survey Respondents




* 41 Unique Agencies or Locations Identified from the Survey Responses

# Case Studies

- **U.S. Case Studies**
  1. **MTA – Baltimore, MD** → Light Rail, Heavy Rail and Commuter Rail
  2. **MTA Metro North – New York, NY** → Commuter Rail
  3. **UTA – Salt Lake City, UT** → Light Rail and Commuter Rail
  4. **DART – Dallas, TX** → Light Rail and Commuter Rail
  5. **LA Metro – Los Angeles, CA** → Light Rail and Heavy Rail

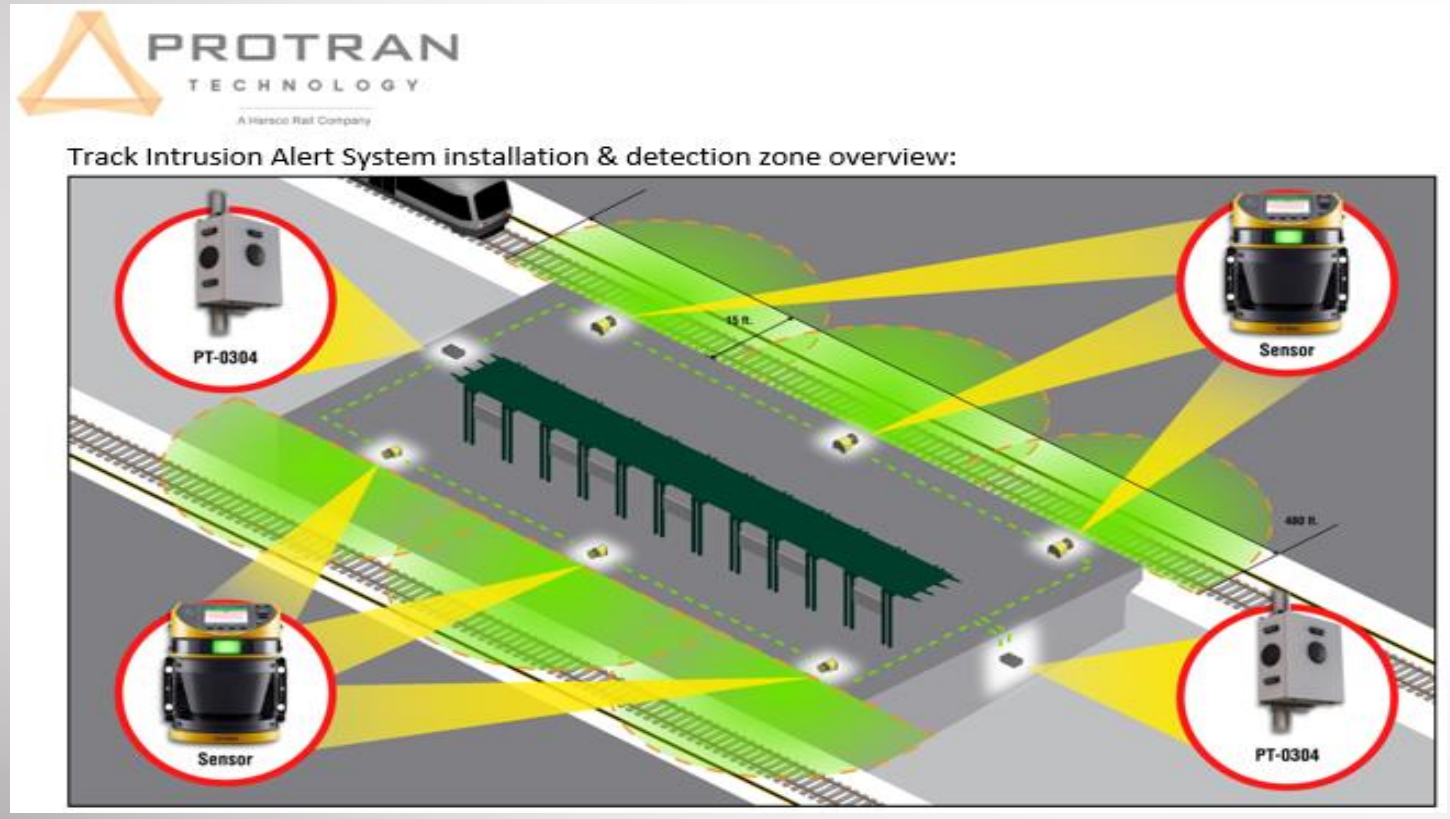
- **Non-North American Case Studies**
  1. **ProRail – The Netherlands** → Commuter Rail
  2. **London Underground – United Kingdom** → Heavy Rail

# Case Study Findings

- Several new countermeasures identified during case studies not found in literature review or surveys
- False positives are a major hinderance to technology implementation
  - Several noted removal of applications due to false positives
- Much stronger belief that agencies have role in reducing suicides
- Significant effort training employees to recognize suicidal behavior

# Technology – Trespasser Detection

- **MTA – Baltimore**




# Technology – Asset Management

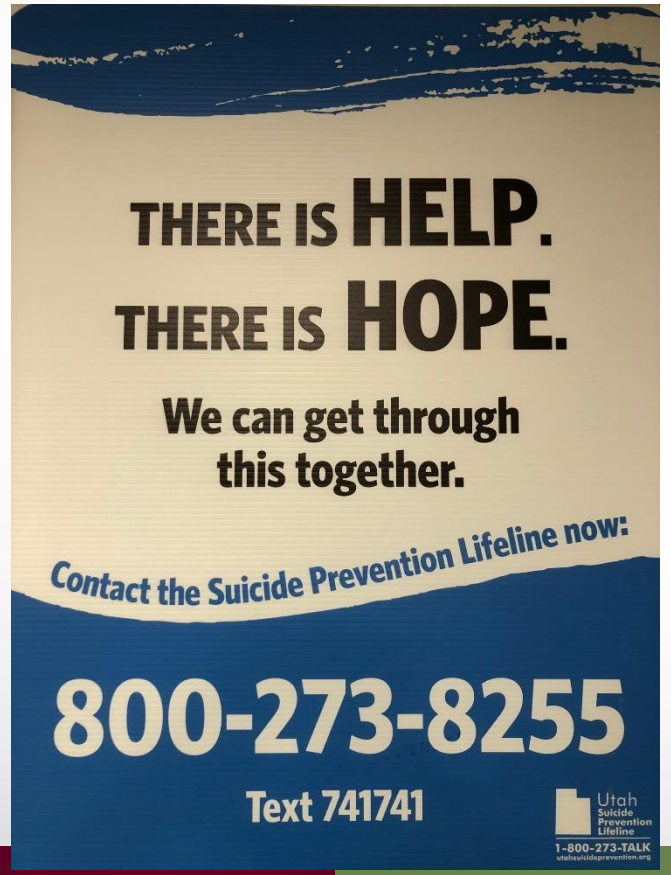
- **DART – Dallas-Fort Worth**

# Suicide Crisis Lines and Messaging



## "I'm Listening"

# Utah – Hope Poles


# National 988 Suicide & Crisis Lifeline

- Suicide & Crisis Lifeline Website – https://988lifeline.org/
- Substance Abuse and Mental Health Services Administration (SAMHSA) 988 Partner Toolkit – https://www.samhsa.gov/find-help/988

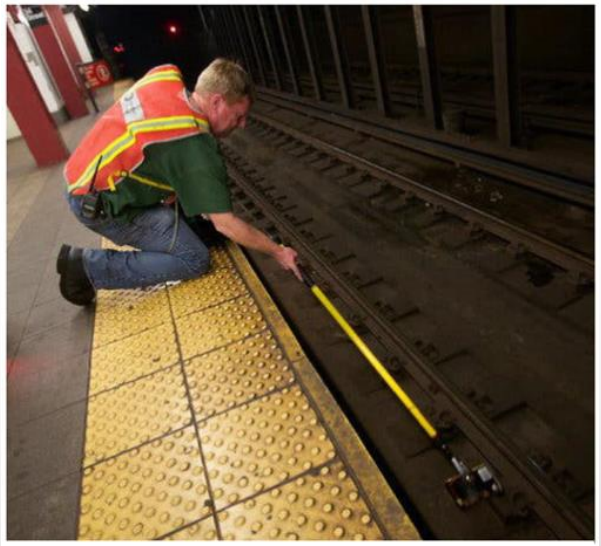

# Presentation Agenda

- What is the trespassing problem?
- How did we address the trespassing problem?
- **What can be done to mitigate trespassing?**

# Countermeasure Strategies and Selection Guidance

## 14 Countermeasure Strategies Grouped into Three Categories:

1. **Engineering and Physical Measures**
   - Fencing, channelization, and barriers
   - Landscaping
   - Anti-trespassing guard panels
   - Platform screen doors
   - Surveillance and detection
   - Lighting
   - Approaching train alerts
   - Track retrieval device



# Trespassing Countermeasure Strategies

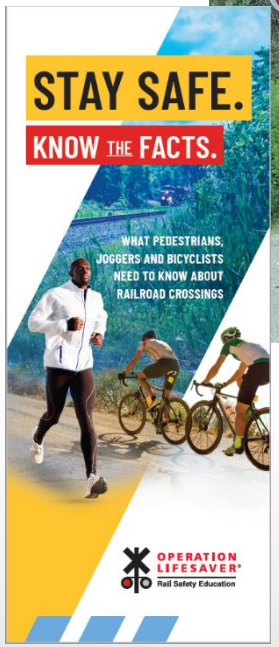
## 14 Countermeasure Strategies Grouped into Three Categories:

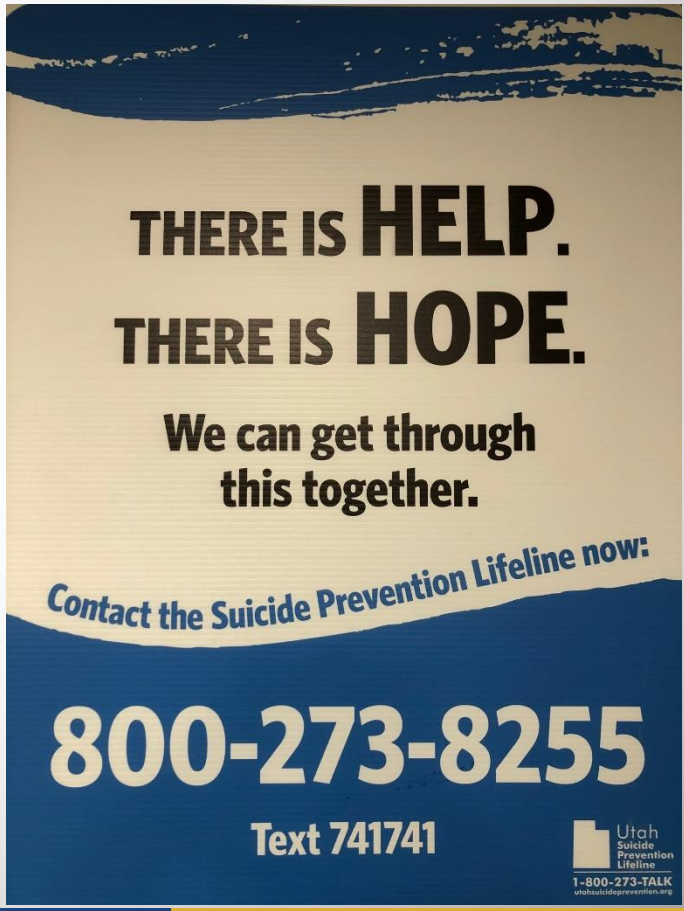
### 2. Education and Engagement

- Signage
- Community-based collaboration
- Public and industry events/campaigns
- Employee intervention training
- Hope poles

### 3. Enforcement

- Law enforcement and patrol

# Ease of Implementation Table

| |
|---|
| **Tier 1—Strategies that are easiest and fastest to implement at low operating and capital costs** |
| • Track retrieval device |
| • Signage |
| • Hope Poles |
| **Tier 2—Strategies that are easiest to implement but typically involve some operating costs or coordination with outside entities (often administrative)** |
| • Community-based collaboration |
| • Public and industry events/campaigns |
| • Employee intervention training |
| • Law enforcement and patrol |
| **Tier 3—Strategies that require longer lead time and typically involve higher operating costs and/or capital costs** |
| • Fencing, channelization, and barriers |
| • Landscaping |
| • Anti-trespass guard panels |
| • Lighting |
| **Tier 4—Strategies that require complex implementation, highest costs, and complex maintenance activities** |
| • Platform screen doors (typically considered for heavy rail only) |
| • Surveillance and detection |
| • Approaching train alerts |

# Countermeasure Summary Matrix

| Category | Countermeasure | Rail System Type | Problem Location | Costs | Type of Trespassing Addressed | Target Root Cause | Companion Countermeasure | Ease of Implementation | Benefit-Cost Tradeoffs |
|---|---|---|---|---|---|---|---|---|---|
| **Engineering and Physical Measures** | Fencing, Channelization, and Barriers | Light (L), Heavy (H), Commuter (C) | • Rights-of-way<br>• Equipment and maintenance yards<br>• Stations and platforms | $–$$$ | Trespassing (T), Suicide (S) | • Living/Loitering in Right-of-Way (ROW)<br>• Self-Harm Intent<br>• Shortcut/Route Convenience<br>• Criminal Behavior<br>• Other | • Landscaping<br>• Anti-trespass Guard Panels<br>• Surveillance and Detection<br>• Approaching Train Alerts<br>• Signage<br>• Community-Based Collaboration<br>• Law Enforcement and Patrol | Tier 3 | • May not have issues with cutting or scaling if made with the heavy metal of smaller mesh size.<br>• Can be installed at most of the rights-of-way, but some areas are not designed for fencing.<br>• Regular inspection and maintenance are needed, especially for regular fencing systems. |
| **Engineering and Physical Measures** | Landscaping | L, H, C | • Rights-of-way<br>• Stations and platforms | $ | T | • Shortcut/Route Convenience<br>• Other | • Fencing, Channelization, and Barriers | Tier 3 | • Visibility can be improved with vegetation management and removal.<br>• However, removing vegetation could increase the need to install fencing or other barriers. |
| **Engineering and Physical Measures** | Anti-trespass Guard Panels | L, H, C | • Rights-of-way<br>• Equipment and maintenance yards<br>• Stations and platforms | $ | T | • Living/Loitering in ROW<br>• Shortcut/Route Convenience<br>• Criminal Behavior<br>• Other | • Fencing, Channelization, and Barriers<br>• Surveillance and Detection<br>• Lighting<br>• Signage | Tier 3 | • Provides a ground-level physical barrier that can deter trespassing.<br>• Panels could prevent railroad employees from accessing the rights-of-way or trap trespassers on the right-of-way. |

# Interactive Spreadsheet

| Rail System Type | Problem Location | Type of Trespassing Addressed | Target Root Cause | Ease of Implementation |
|---|---|---|---|---|
| Commuter Rail | Equipment and maintenance yards | Suicide | Criminal Behavior | Tier 1 |
| Heavy Rail | Non-specific | Trespassing | Living/Loitering in ROW | Tier 2 |
| Light Rail | Rights-of-way | | Lost/Dropped Items | Tier 3 |
| | Stations and platforms | | Other | Tier 4 |
| | | | Self-harm Intent | |
| | | | Shortcut/Route Convenience | |

| Category | Countermeasure | Costs | Companion Countermeasure | Ease of Implementation |
|---|---|---|---|---|
| Engineering and Physical Measures | Fencing, Channelization, and Barriers | $-$$$ | Landscaping;Anti-Trespass Guard Panels;Surveillance and Detection;Approaching Train Alerts;Signage;Community-based Collaboration;Law Enforcement and Patrol | Tier 3 |
| | Landscaping | $ | Fencing, Channelization, and Barriers | Tier 3 |
| | Anti-trespass guard panels | $ | Fencing, Channelization, and Barriers;Surveillance and Detection;Lighting;Signage | Tier 3 |
| | Platform Screen Doors (PSDs) | $$$ | Surveillance and Detection;Approaching Train Alerts | Tier 4 |
| | Surveillance and Detection | $$-$$$ | Fencing, Channelization, and Barriers;Anti-Trespass Guard Panels;Platform Screen Doors;Lighting;Employee Intervention Training;Hope Poles;Law Enforcement and Patrol | Tier 4 |
| | Lighting | $ | Anti-Trespass Guard Panels;Surveillance and Detection;Hope Poles | Tier 3 |
| | Approaching Train Alerts | $$ | Fencing, Channelization, and Barriers;Platform Screen Doors | Tier 4 |
| | Track Retrieval Device | $ | Signage;Community-based Collaboration;Public and Industry Events/Campaign | Tier 1 |
| Education and Engagement | Signage | $ | Fencing, Channelization, and Barriers;Anti-Trespass Guard Panels;Track Retrieval Device;Community-based Collaboration;Public and Industry Events/Campaigns;Hope Poles;Law Enforcement and Patrol | Tier 1 |
| | Community-Based Collaboration | $ | Fencing, Channelization, and Barriers;Track Retrieval Device;Signage;Public and Industry Events/Campaigns;Law Enforcement and Patrol | Tier 2 |
| | Public and Industry Events/Campaigns | $ | Track Retrieval Device;Signage;Community-based Collaboration;Law Enforcement and Patrol | Tier 2 |
| | Employee Intervention Training | $ | Surveillance and Detection | Tier 2 |
| | Hope Poles | $ | Surveillance and Detection;Lighting;Signage | Tier 1 |
| Enforcement | Law Enforcement and Patrol | $ | Fencing, Channelization, and Barriers;Surveillance and Detection;Signage;Community-based Collaboration;Public and Industry Events/Campaigns | Tier 2 |

# Interactive Spreadsheet – Scenario A

| Rail System Type | Problem Location | Type of Trespassing Addressed | Target Root Cause | Ease of Implementation |
|---|---|---|---|---|
| Commuter Rail | Equipment and maintenance yards | Suicide | Criminal Behavior | Tier 1 |
| Heavy Rail | Non-specific | Trespassing | Living/Loitering in ROW | Tier 2 |
| Light Rail | Rights-of-way | | Lost/Dropped Items | Tier 3 |
| | Stations and platforms | | Other | Tier 4 |
| | | | Self-harm Intent | |
| | | | Shortcut/Route Convenience | |

| Category | Countermeasure | Costs | Companion Countermeasure | Ease of Implementation |
|---|---|---|---|---|
| Engineering and Physical Measures | Fencing, Channelization, and Barriers | $-$$$ | Landscaping;Anti-Trespass Guard Panels;Surveillance and Detection;Approaching Train Alerts;Signage;Community-based Collaboration;Law Enforcement and Patrol | Tier 3 |
| | Landscaping | $ | Fencing, Channelization, and Barriers | Tier 3 |
| | Anti-trespass guard panels | $ | Fencing, Channelization, and Barriers;Surveillance and Detection;Lighting;Signage | Tier 3 |
| | Surveillance and Detection | $$-$$$ | Fencing, Channelization, and Barriers;Anti-Trespass Guard Panels;Platform Screen Doors;Lighting;Employee Intervention Training;Hope Poles;Law Enforcement and Patrol | Tier 4 |
| | Lighting | $ | Anti-Trespass Guard Panels;Surveillance and Detection;Hope Poles | Tier 3 |
| | Approaching Train Alerts | $$ | Fencing, Channelization, and Barriers;Platform Screen Doors | Tier 4 |
| Education and Engagement | Signage | $ | Fencing, Channelization, and Barriers;Anti-Trespass Guard Panels;Track Retrieval Device;Community-based Collaboration;Public and Industry Events/Campaigns;Hope Poles;Law Enforcement and Patrol | Tier 1 |
| | Community-Based Collaboration | $ | Fencing, Channelization, and Barriers;Track Retrieval Device;Signage;Public and Industry Events/Campaigns;Law Enforcement and Patrol | Tier 2 |
| | Public and Industry Events/Campaigns | $ | Track Retrieval Device;Signage;Community-based Collaboration;Law Enforcement and Patrol | Tier 2 |
| Enforcement | Law Enforcement and Patrol | $ | Fencing, Channelization, and Barriers;Surveillance and Detection;Signage;Community-based Collaboration;Public and Industry Events/Campaigns | Tier 2 |

# Final Project Products

- **TCRP Research Report 233**
  - **Strategies for Deterring Trespassing on Rail Transit and Commuter Rail Rights-of-Way, Volume 1: Guidebook** (https://www.trb.org/Publications/Blurbs/182672.aspx)
    - Interactive Spreadsheet
    - Video https://vimeo.com/672388271

  - **Strategies for Deterring Trespassing on Rail Transit and Commuter Rail Rights-of-Way, Volume 2: Research Overview** (https://www.trb.org/main/blurbs/182671.aspx)


## Thank You!

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# Electronic Surveillance of Railroad-Highway Crossings for Collision Avoidance: State of the Practice

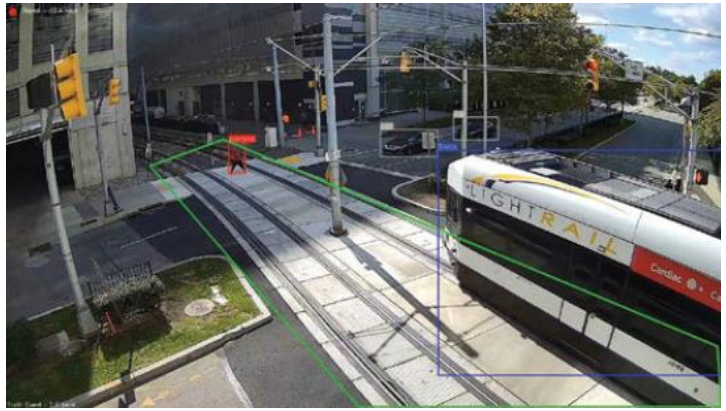
*Amiy Varma, Ph.D., PE, AICP, PTOE*
*AAAJ LLC*
*Fargo, ND*

**TRB Webinar: Deter Trespassing on Rail Rights-of-Way and Improve Grade Crossing Safety**
**January 28, 2025**

# Outline

- Type of Crossings
- Issues
- Survey Results
- Case Examples
- Lessons Learned

# Crossings




LRT

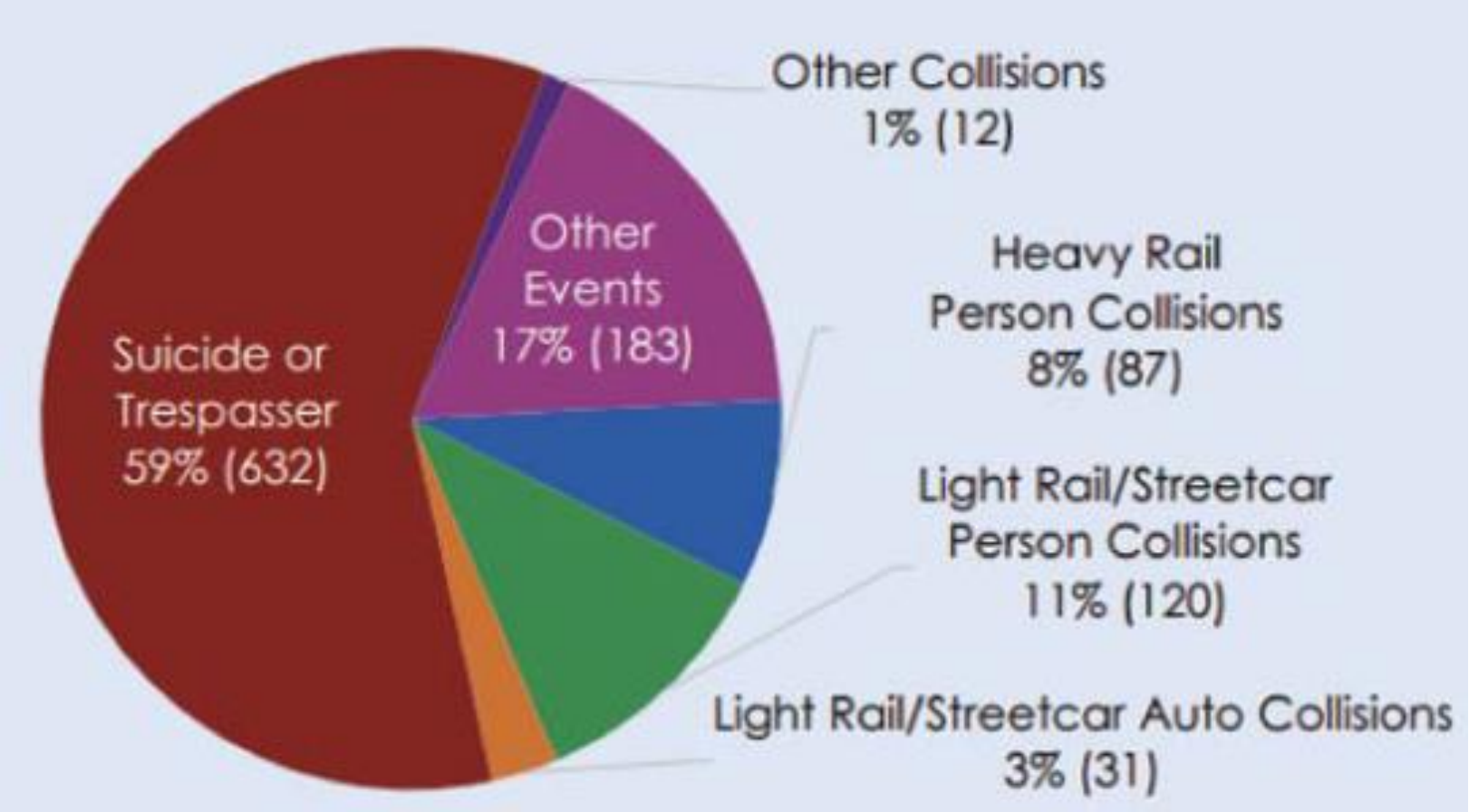
Commuter Rail

Railroad

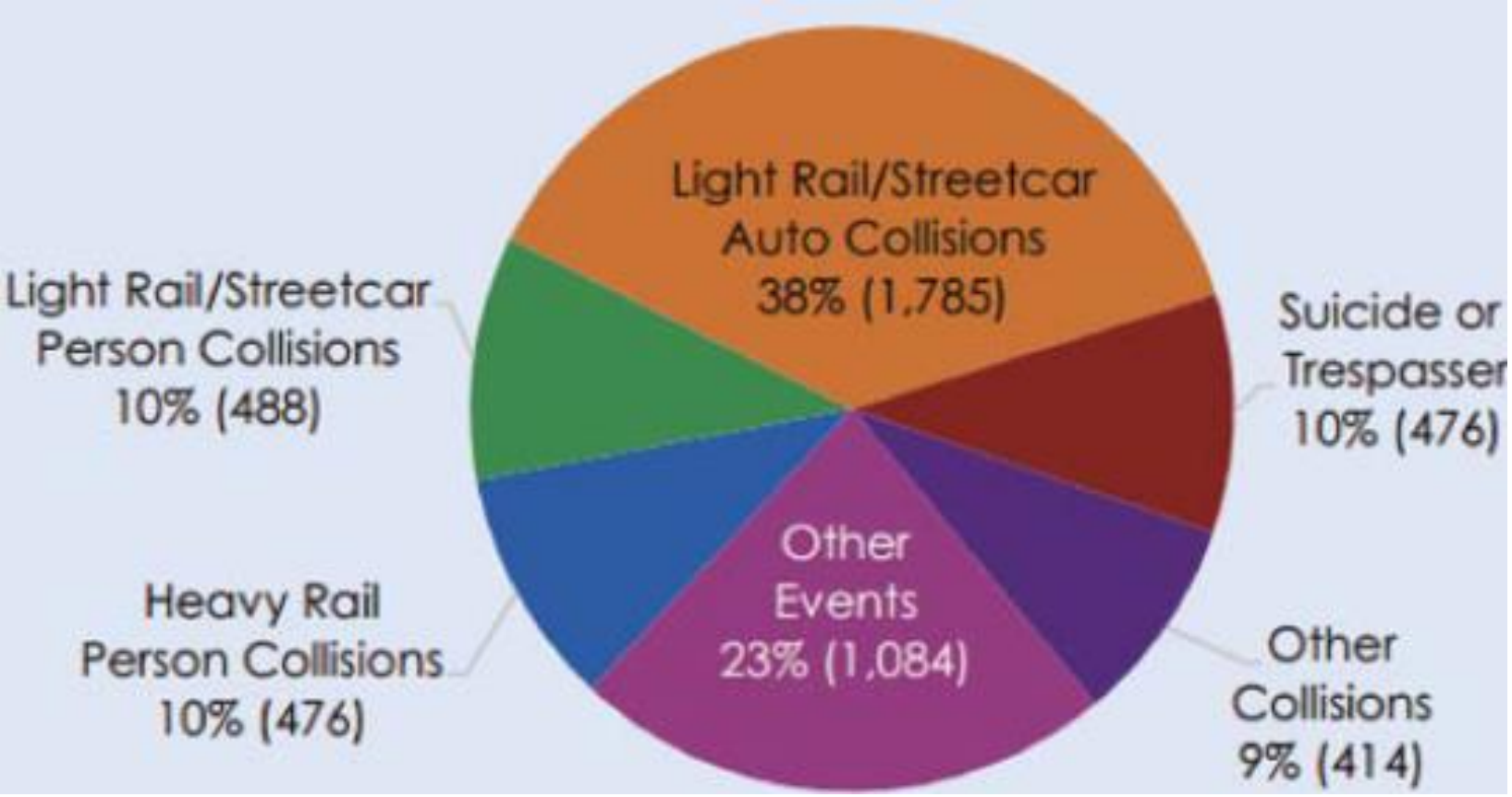
# Issues

- Traffic blockage
- Control and warning devices
- Physical security
- Fatalities and injuries
- Device malfunction
- Distracted drivers and pedestrians
- Trespassers

# Fatalities


Other Collisions
1% (12)
Other
Events
17% (183)
Heavy Rail
Person Collisions
8% (87)
Suicide or
Trespasser
59% (632)
Light Rail/Streetcar
Person Collisions
11% (120)
Light Rail/Streetcar Auto Collisions
3% (31)

# Injuries


Light Rail/Streetcar
Auto Collisions
38% (1,785)
Suicide or
Trespasser
10% (476)
Other
Collisions
9% (414)
Other
Events
23% (1,084)
Heavy Rail
Person Collisions
10% (476)
Light Rail/Streetcar
Person Collisions
10% (488)

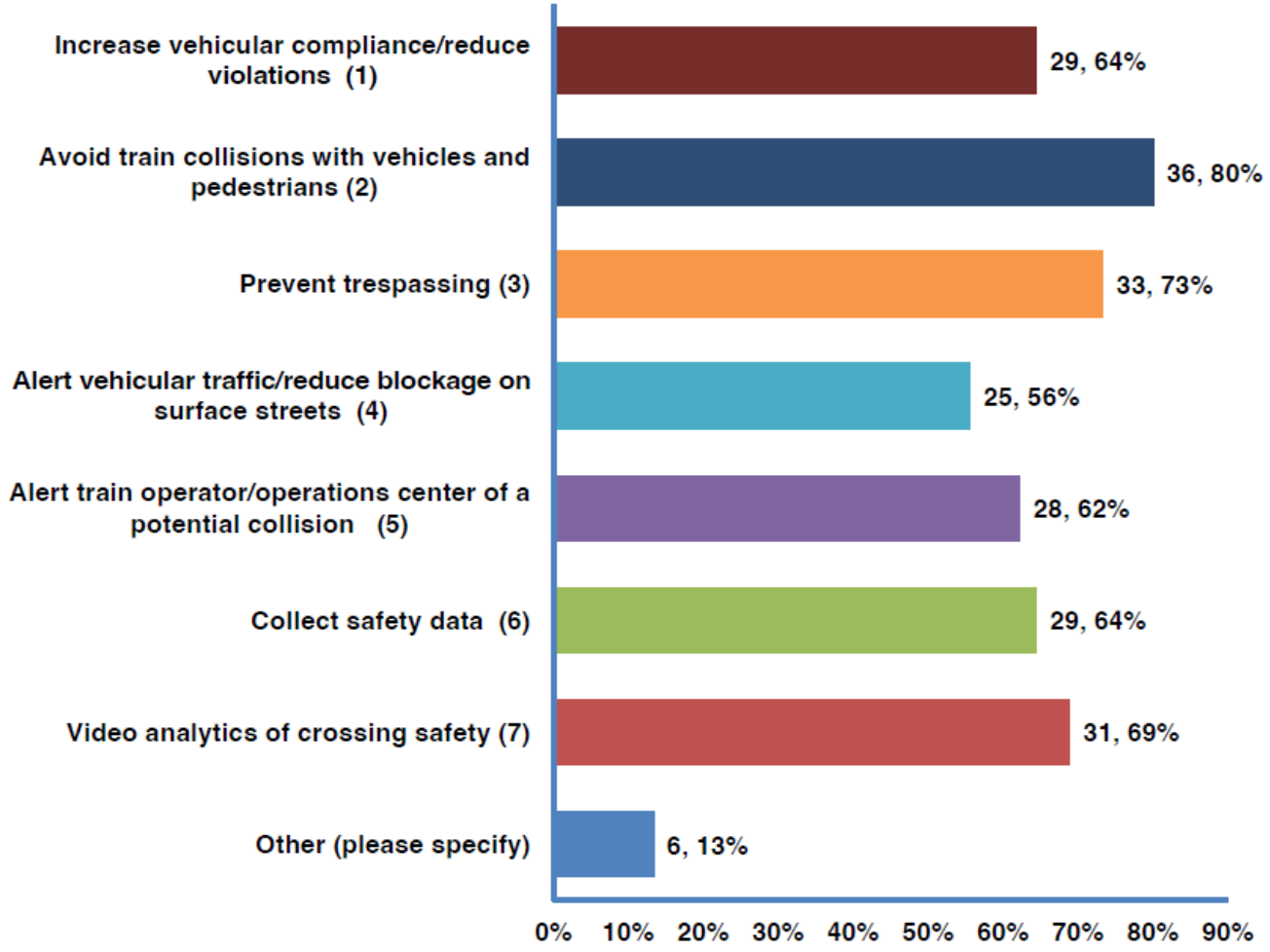
# Emerging Technologies

- Technology for cameras
- Fiber optics
- Cloud storage
- Artificial Intelligence & Machine Learning
- Video Analytics

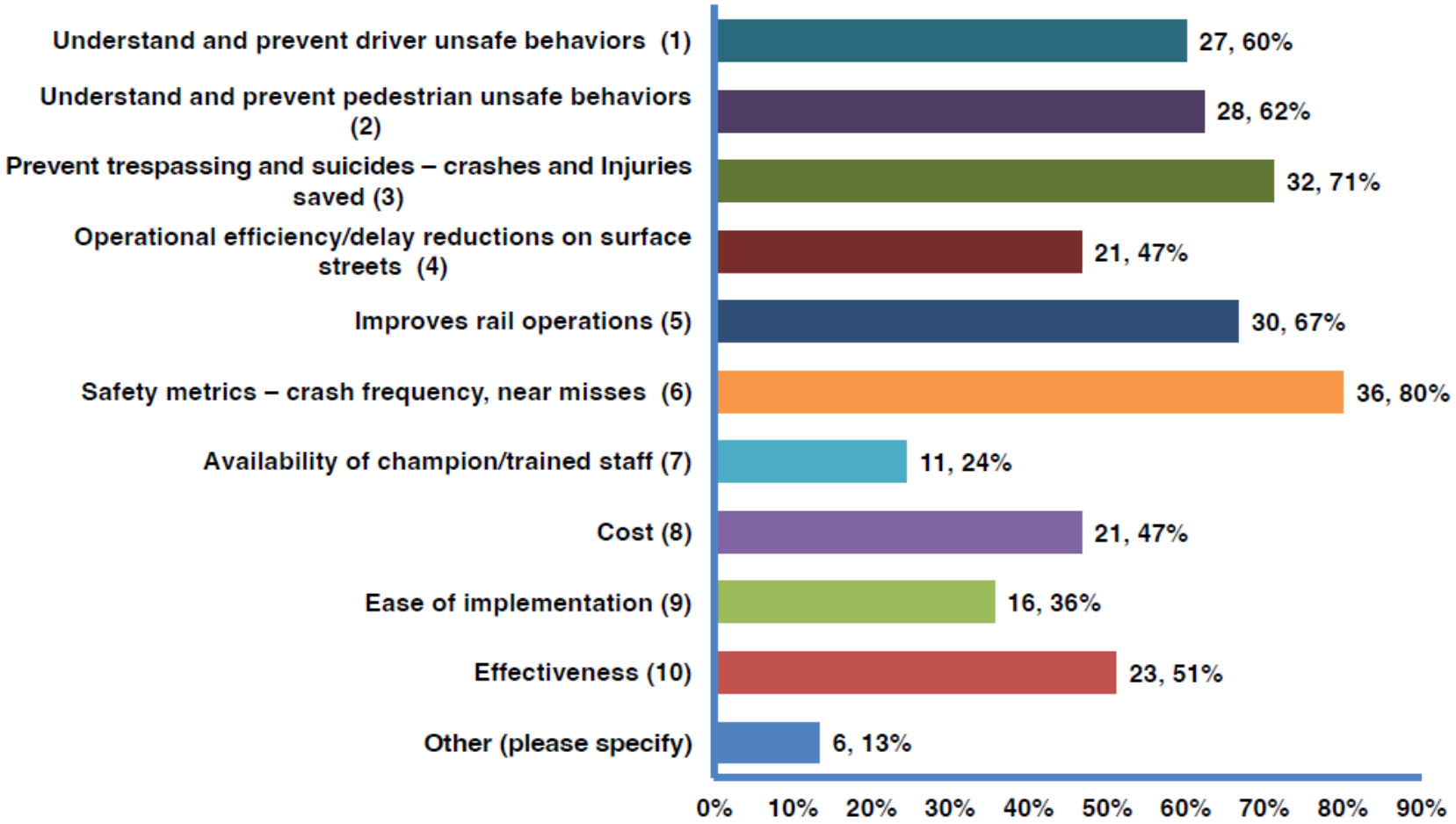
# Survey

- Part 1 – 8 Questions
- Part 2 – 15 Qs
- 45 survey responses
- 35 complete responses

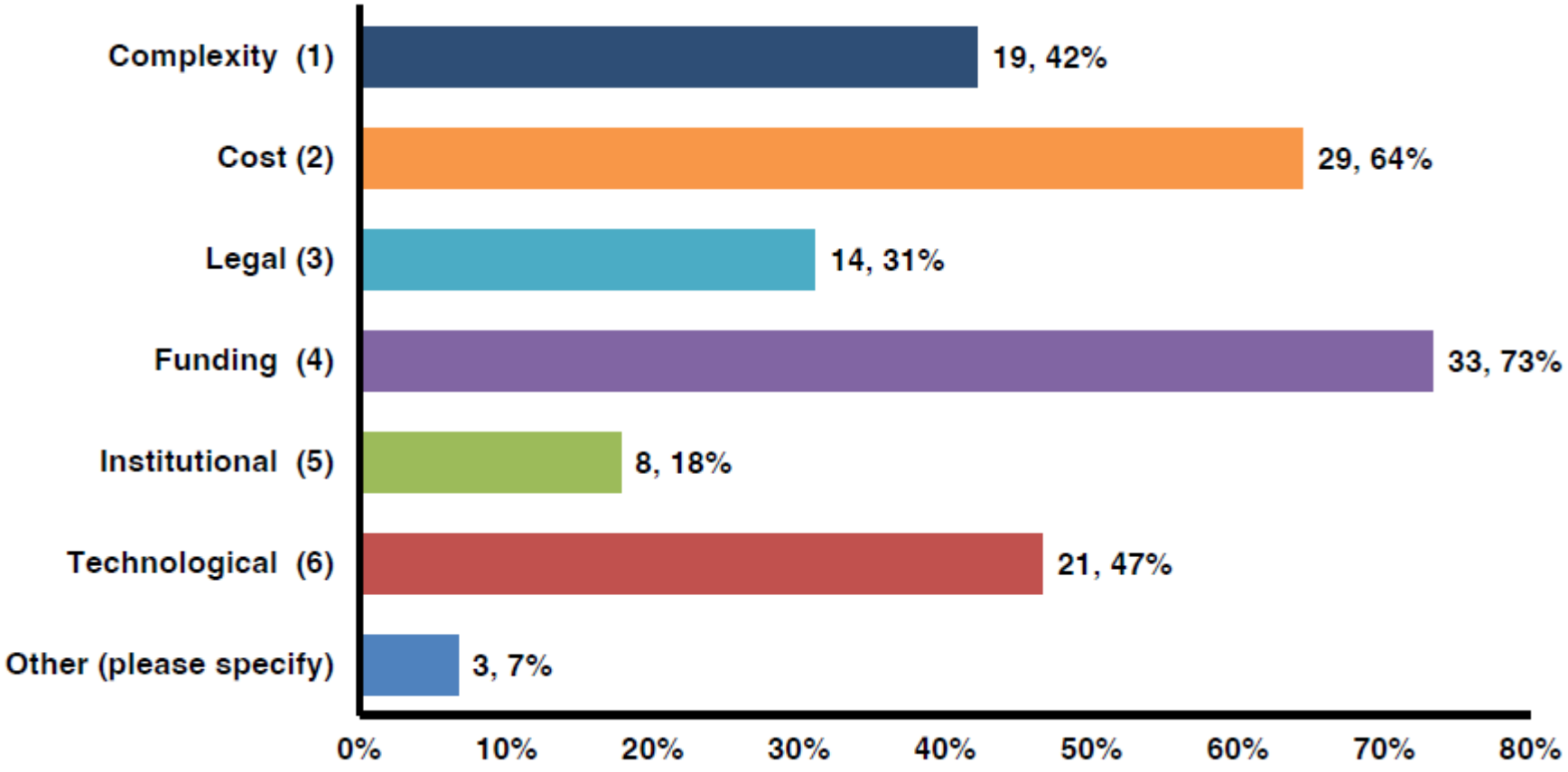
# Reasons for Using Electronic Surveillance



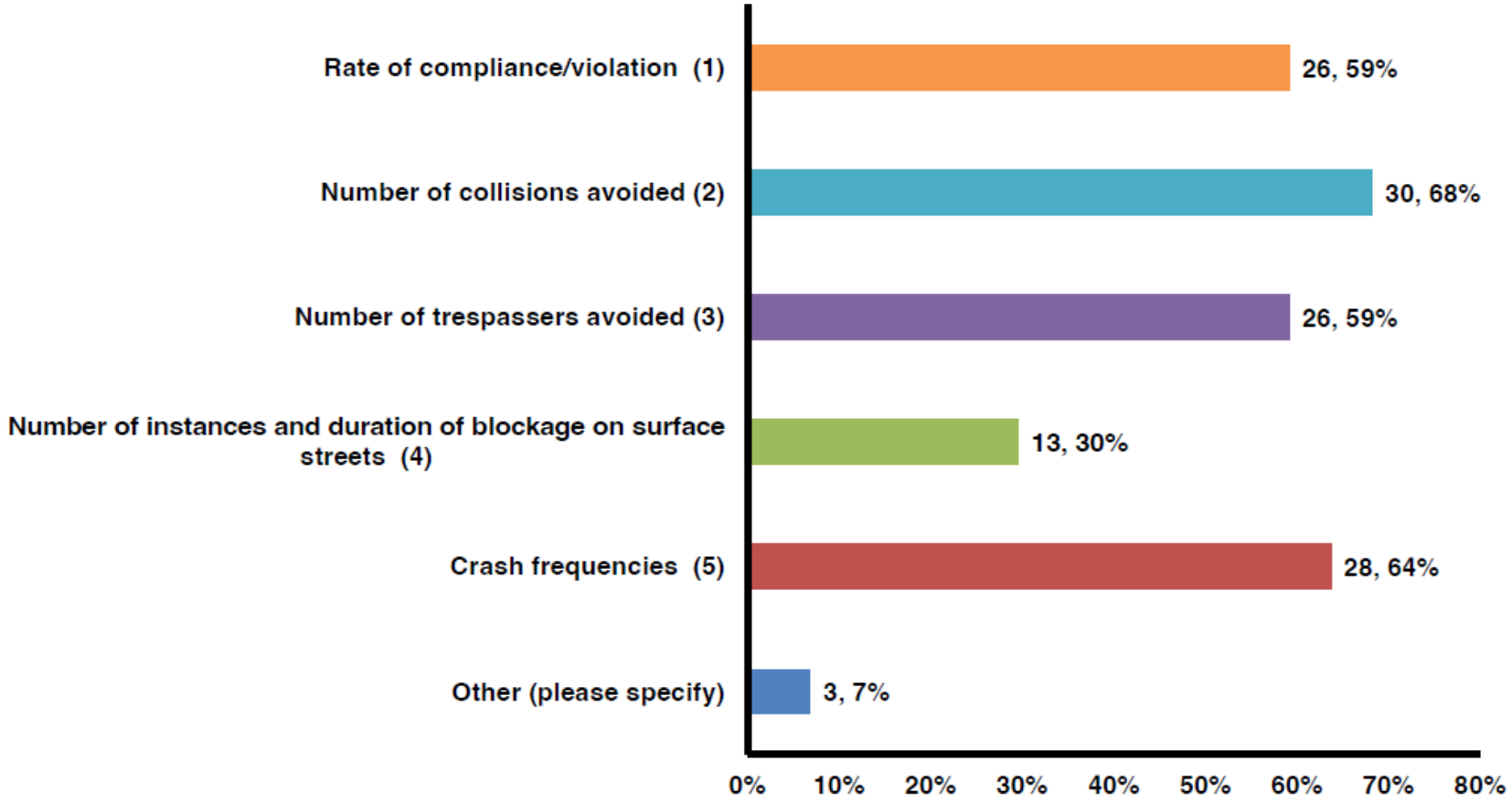
# Decision criteria



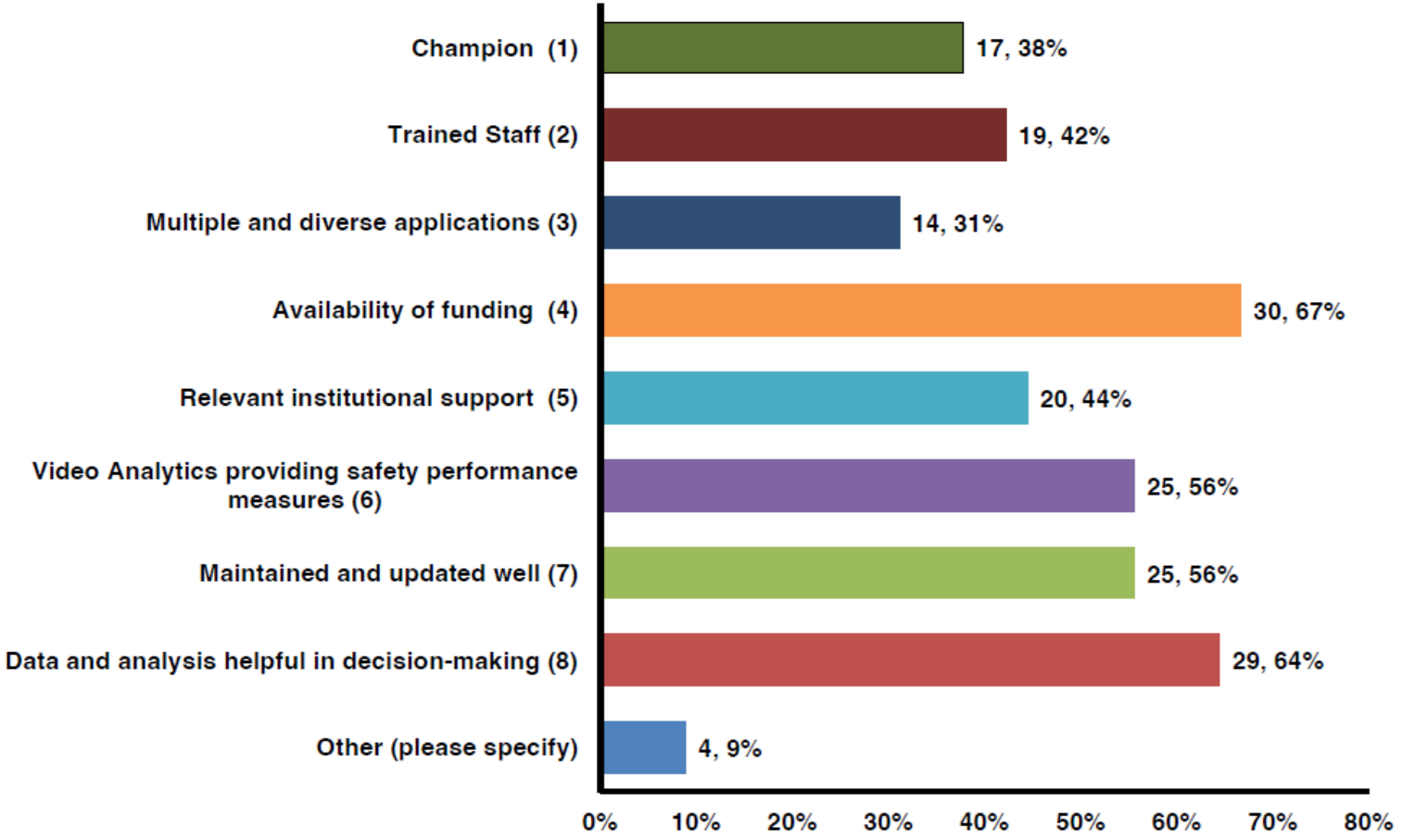
# Barriers


Complexity (1)
19, 42%
Cost (2)
29, 64%
Legal (3)
14, 31%
Funding (4)
33, 73%
Institutional (5)
8, 18%
Technological (6)
21, 47%
Other (please specify)
3, 7%
0%
10%
20%
30%
40%
50%
60%
70%
80%

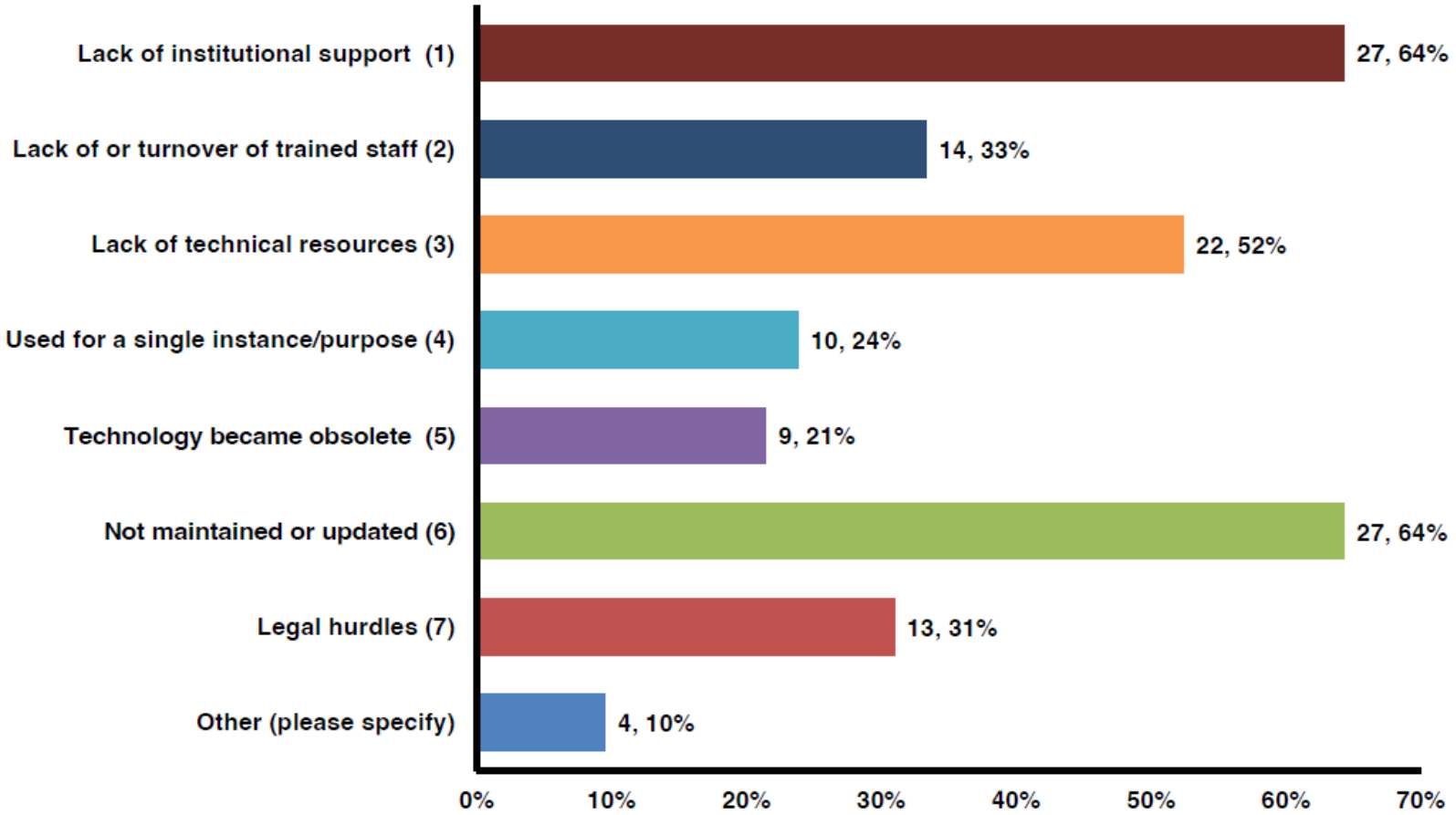
# Measure of Effectiveness



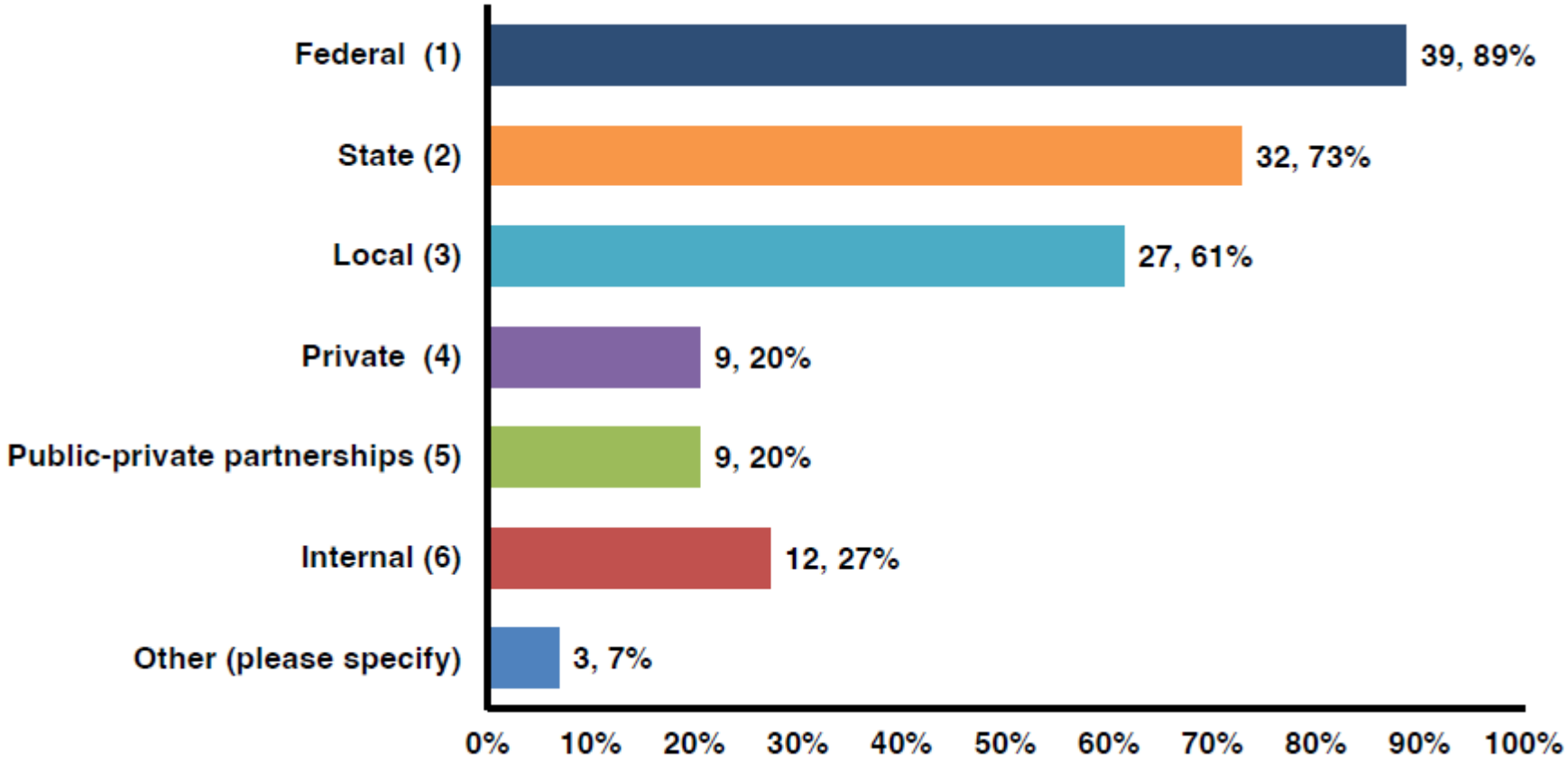
# Success Factors



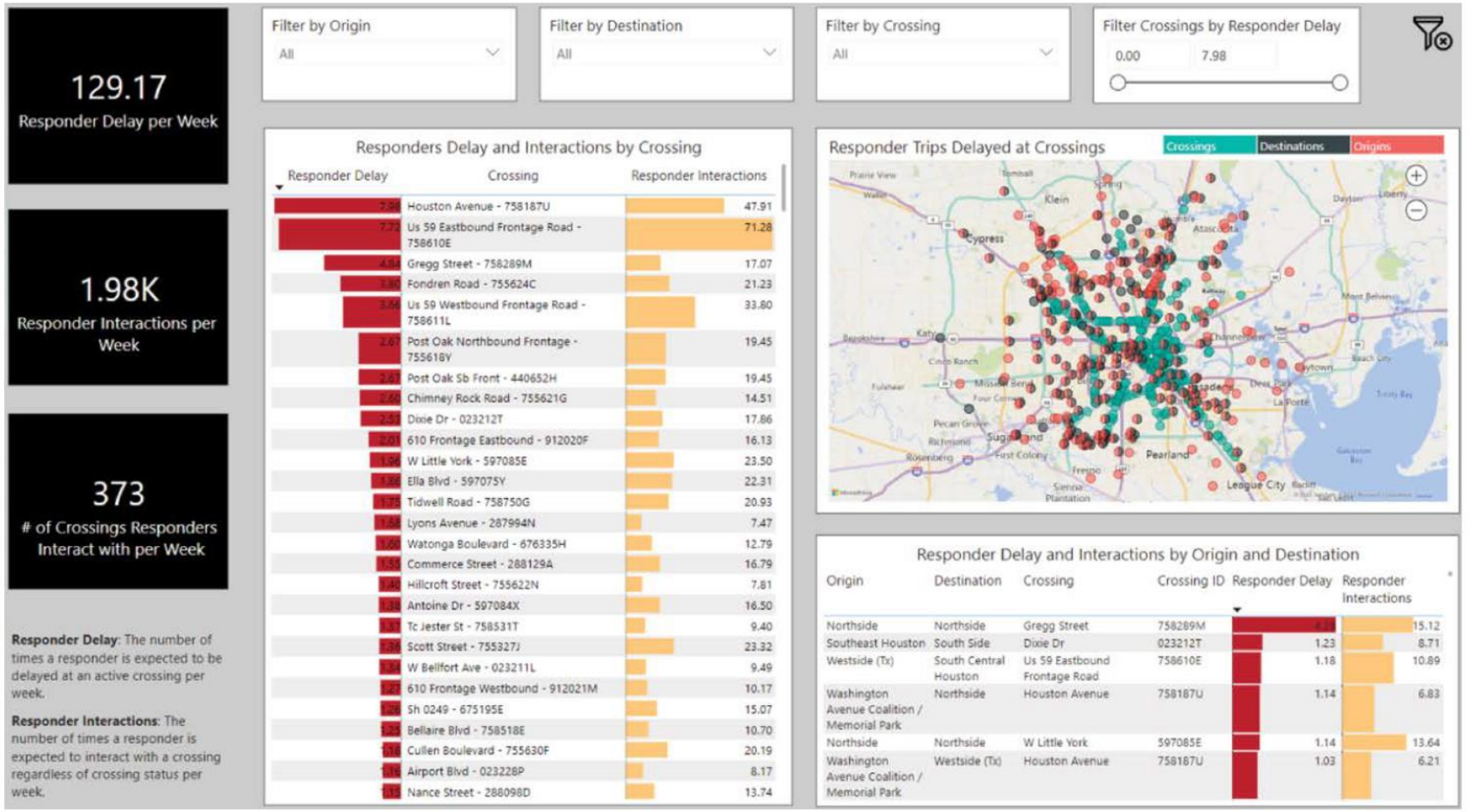
# Reasons for Failure



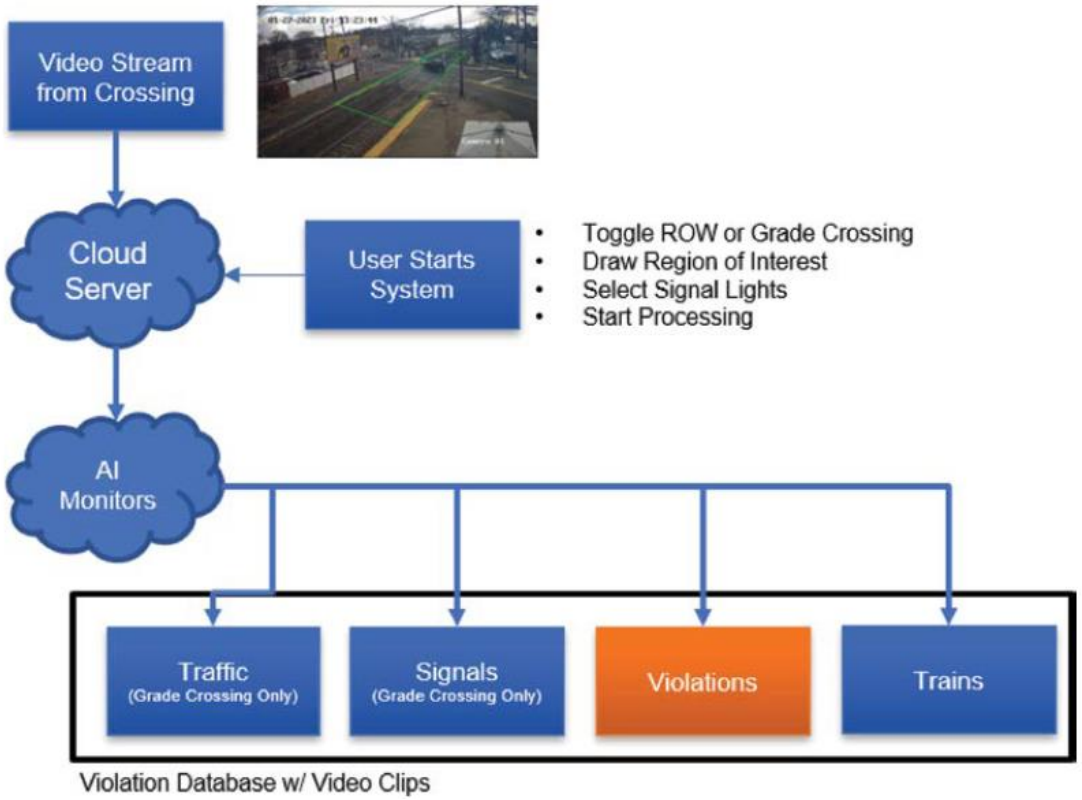
# Funding


Federal (1)
39, 89%
State (2)
32, 73%
Local (3)
27, 61%
Private (4)
9, 20%
Public-private partnerships (5)
9, 20%
Internal (6)
12, 27%
Other (please specify)
3, 7%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

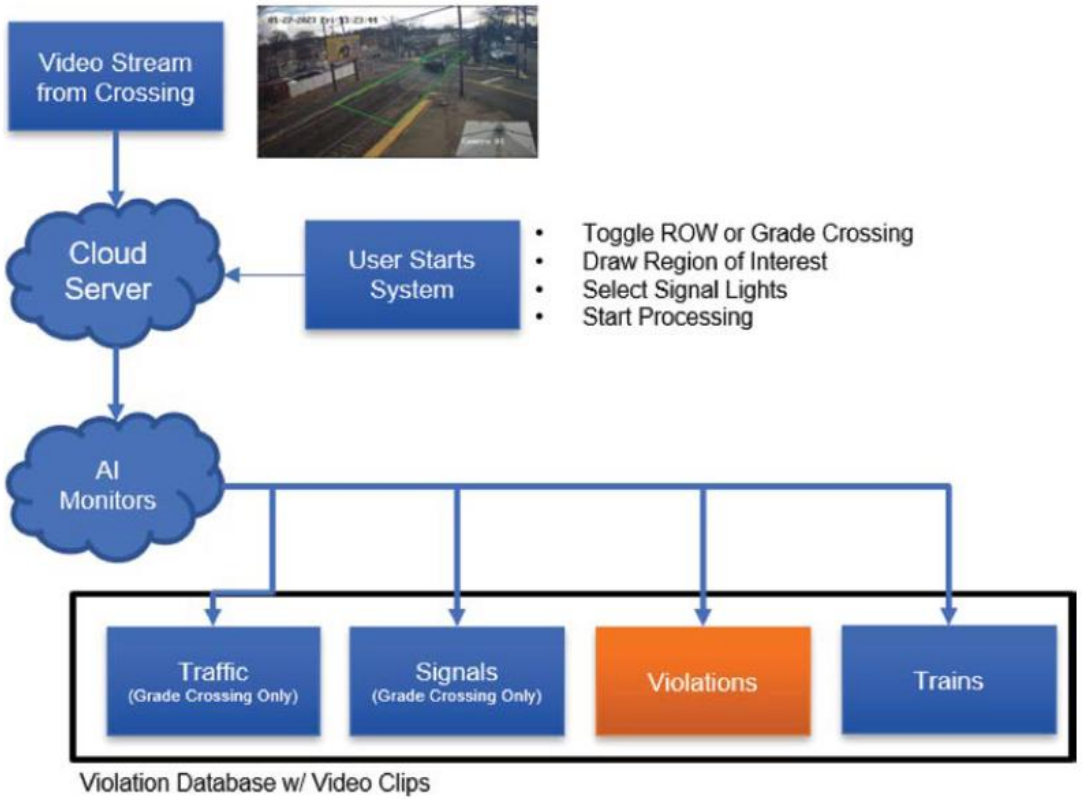
# TRAINFO


129.17
Responder Delay per Week
1.98K
Responder Interactions per Week
373
# of Crossings Responders Interact with per Week
Responder Delay: The number of times a responder is expected to be delayed at an active crossing per week.
Responder Interactions: The number of times a responder is expected to interact with a crossing regardless of crossing status per week.
Filter by Origin
All
Filter by Destination
All
Filter by Crossing
All
Filter Crossings by Responder Delay
0.00
7.98
Responders Delay and Interactions by Crossing
Responder Delay
Crossing
Responder Interactions
7.73 Us 59 Eastbound Frontage Road - 758610E 71.28
4.84 Gregg Street - 758289M 17.07
3.80 Fondren Road - 755624C 21.23
3.66 Us 59 Westbound Frontage Road - 758611L 33.80
2.67 Post Oak Northbound Frontage - 755618Y 19.45
2.63 Post Oak Sb Front - 440652H 19.45
2.60 Chimney Rock Road - 755621G 14.51
2.53 Dixie Dr - 023212T 17.86
2.01 610 Frontage Eastbound - 912020F 16.13
1.96 W Little York - 597085E 23.50
1.96 Ella Blvd - 597075Y 22.31
1.75 Tidwell Road - 758750G 20.93
1.68 Lyons Avenue - 287994N 7.47
1.60 Watonga Boulevard - 676335H 12.79
1.55 Commerce Street - 288129A 16.79
1.48 Hillcroft Street - 755622N 7.81
1.38 Antoine Dr - 597084X 16.50
1.37 Tc Jester St - 758531T 9.40
1.36 Scott Street - 755327J 23.32
1.34 W Bellfort Ave - 023211L 9.49
1.27 610 Frontage Westbound - 912021M 10.17
1.26 Sh 0249 - 675195E 15.07
1.25 Bellaire Blvd - 758518E 10.70
1.16 Cullen Boulevard - 755630F 20.19
1.16 Airport Blvd - 023228P 8.17
1.15 Nance Street - 288098D 13.74
Responder Trips Delayed at Crossings
Crossings
Destinations
Origins
Responder Delay and Interactions by Origin and Destination
Origin
Destination
Crossing
Crossing ID
Responder Delay
Responder Interactions
Northside Northside Gregg Street 758289M 4.84 15.12
Southeast Houston South Side Dixie Dr 023212T 1.23 8.71
Westside (Tx) South Central Houston Us 59 Eastbound Frontage Road 758610E 1.18 10.89
Washington Avenue Coalition / Memorial Park Northside Houston Avenue 758187U 1.14 6.83
Northside Northside W Little York 597085E 1.14 13.64
Washington Avenue Coalition / Memorial Park Westside (Tx) Houston Avenue 758187U 1.03 6.21

# RUTGERS


Video Stream from Crossing
Cloud Server
User Starts System
Toggle ROW or Grade Crossing
Draw Region of Interest
Select Signal Lights
Start Processing
AI Monitors
Traffic
(Grade Crossing Only)
Signals
(Grade Crossing Only)
Violations
Trains
Violation Database w/ Video Clips

# RUTGERS

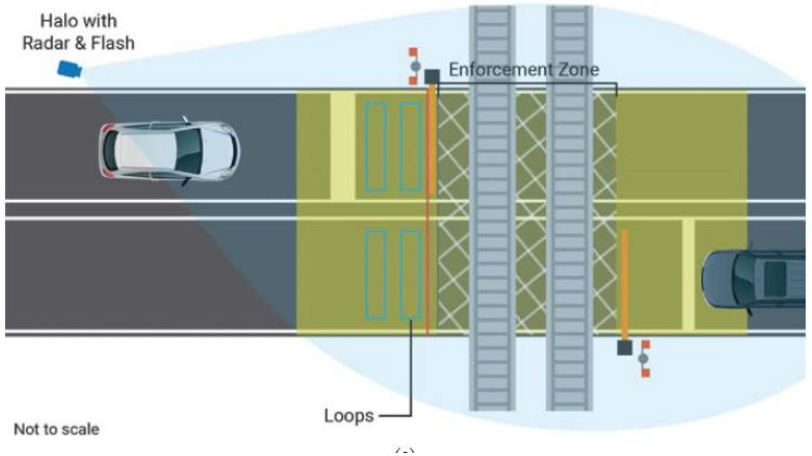

Video Stream from Crossing
Cloud Server
User Starts System
Toggle ROW or Grade Crossing
Draw Region of Interest
Select Signal Lights
Start Processing
AI Monitors
Traffic
(Grade Crossing Only)
Signals
(Grade Crossing Only)
Violations
Trains
Violation Database w/ Video Clips

# LACMTA

(a)


2
TRACKS

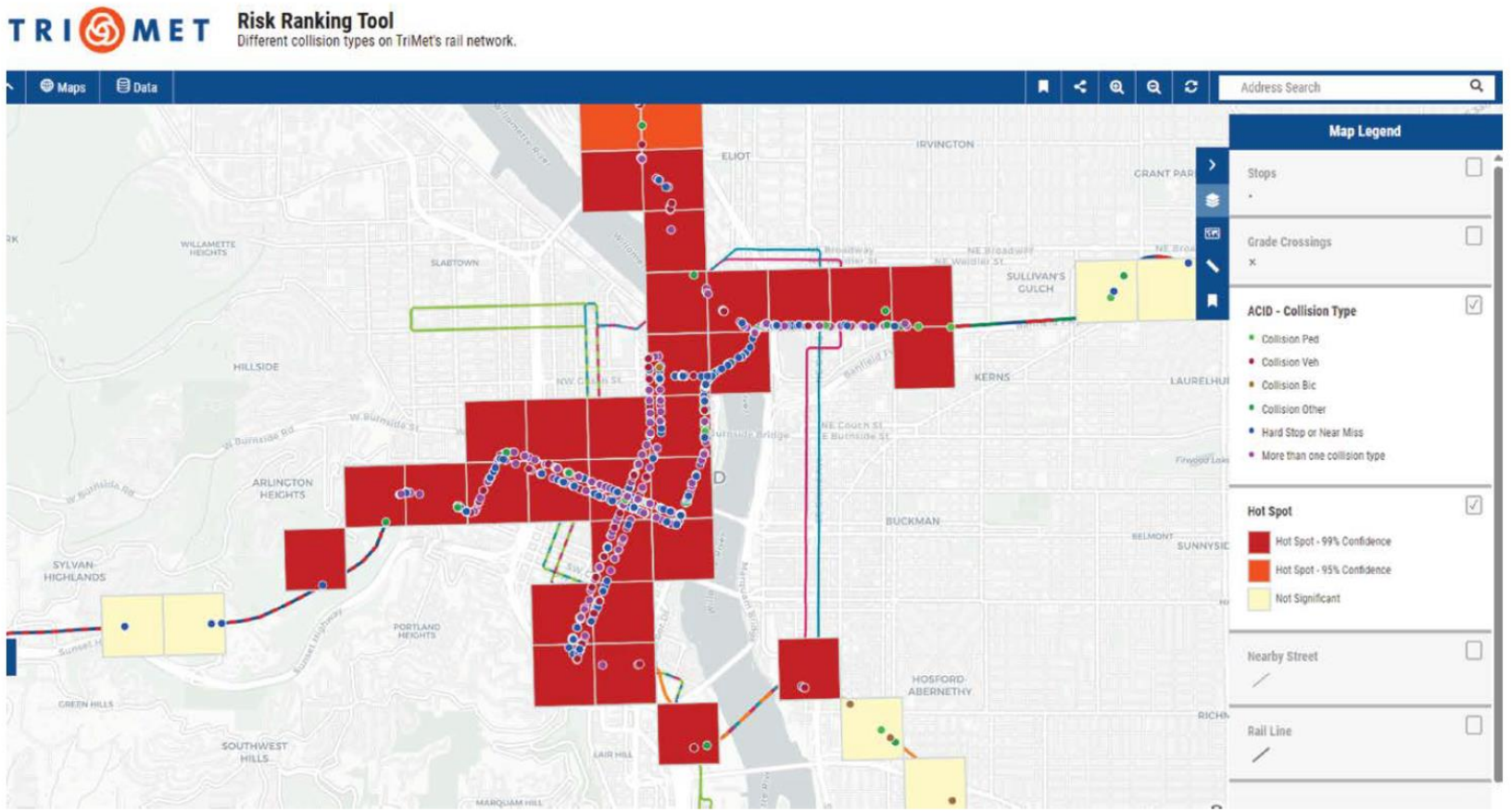
(b)


Halo with
Radar & Flash
Enforcement Zone
Loops
Not to scale

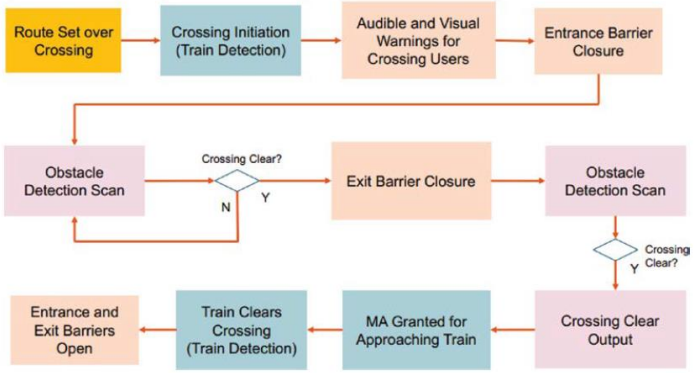
# UTA - TRAX

- 5-to-10-year project to expand the use of cameras to every crossing where most accidents happen or where trespassers gain access to the right-of-way.
- Develops a heatmap based on trespassing situations, gate breaking, and close calls for all rail crossings on LRT and commuter rail systems
- An open platform VMS solution and flexible storage from Milestone
- Great institutional support

# TRIMET


TRIMET
Risk Ranking Tool
Different collision types on TriMet's rail network.
Maps
Data
Address Search
Map Legend
Stops
Grade Crossings
ACID - Collision Type
Collision Ped
Collision Veh
Collision Bic
Collision Other
Hard Stop or Near Miss
More than one collision type
Hot Spot
Hot Spot - 99% Confidence
Hot Spot - 95% Confidence
Not Significant
Nearby Street
Rail Line
ELIOT
IRVINGTON
WILLAMETTE HEIGHTS
SLABTOWN
SULLIVAN'S GULCH
HILLSIDE
KERNS
ARLINGTON HEIGHTS
BUCKMAN
SYLVAN-HIGHLANDS
PORTLAND HEIGHTS
HOSFORD-ABERNETHY
GREEN HILLS
SOUTHWEST HILLS

# NETWORK RAIL




# CASE EXAMPLES TAKEAWAYS

- Metra and LACMTA pro - Photo Enforcement
- UTA - Wider integration & Institutional Support
- The Rutgers team and TriMet pilot programs - Video Analytics
- TRAINFO system – Blockage & Delays
- Network Rail - Integrated electronic surveillance system

# LESSONS LEARNED

- Diverse Applications – improves success
- Technologies: AI and monitoring technologies
- Systems: integrated and updated.
- Institutional Support - critical
- Performance Measurement - needed
- Safety and Security - enhanced

# QUESTIONS?

*Amiy Varma, Ph.D., PE, AICP, PTOE*
*AAAJ LLC*
*Fargo, ND*
*Email: amiyvarma@aaajvco.com*

RAIL

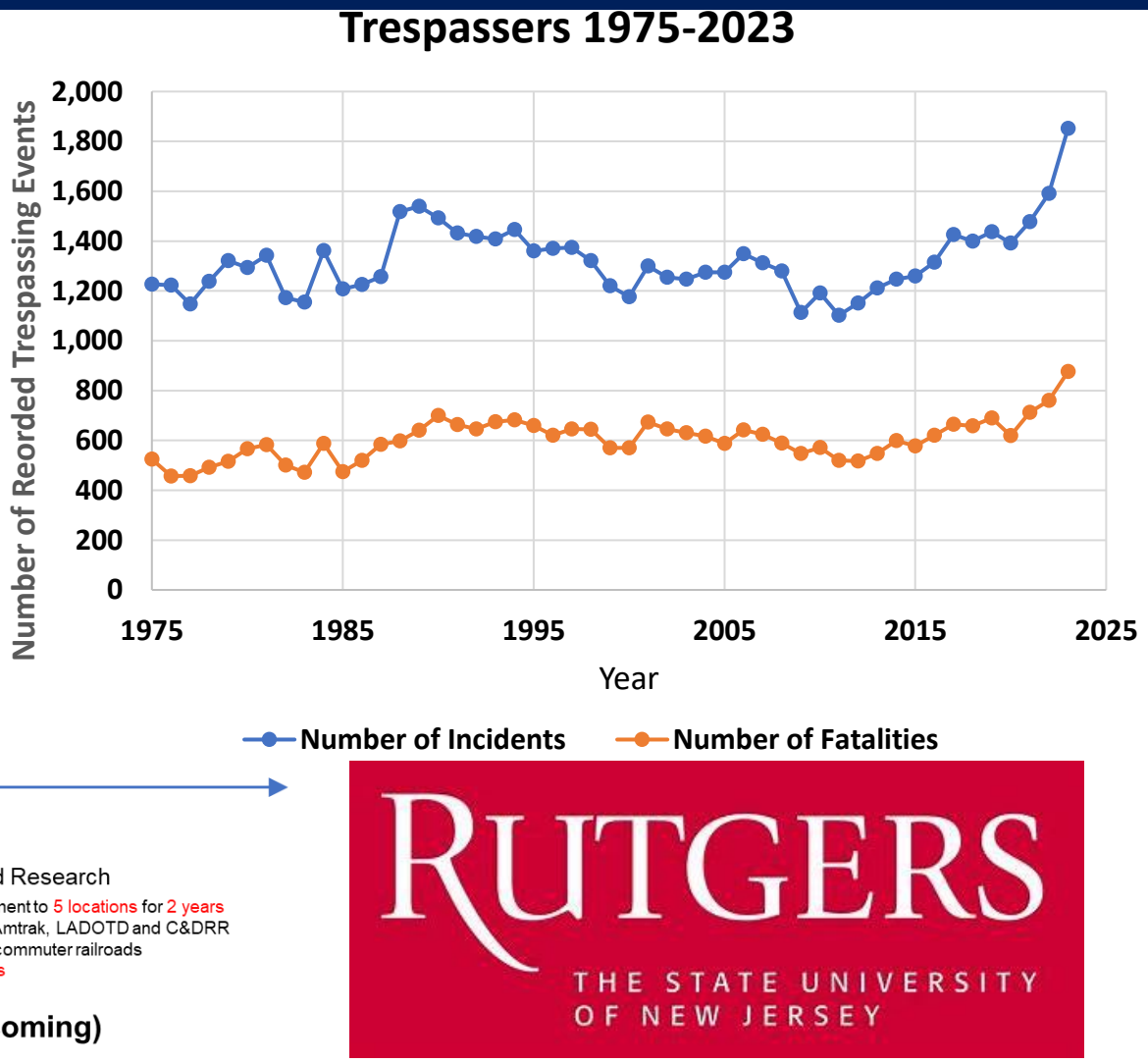
*MOVING AMERICA FORWARD*

# Trespass Database Using Artificial Intelligence

Francesco Bedini Jacobini, General Engineer
Office of Research, Data, and Innovation

# Introduction

As of 2024, 96.6% of incidents in a railroad environment occur at either grade crossing or are due to trespassing.




## Rutgers University Work

**2016–2019**

University Funded Research
- Trespassing Hypothesis Validation
- Artificial Intelligence Proof of Concept Algorithm

**2020 to 2023**

FRA Funded Research
- Realtime Processing for 4 Locations for 1 Year
- Build a Trespassing Database
- Understand Trespassing trends
- Direct Partnership with 1 Railroad
- 2 Grade Crossings and 2 Right-of-Ways

**2021 to Present**

FTA Funded Research
- Hardware Development for Remote Data Collection
- Light Rail and Heavy Rail (Transit Environment)
- Direct Partnership with 4 Transit Agencies/Railroads
- 4 Grade Crossings

**2022 (Upcoming)**

CRISI Funded Research
- Realtime deployment to 5 locations for 2 years
- Collab with with Amtrak, LADOTD and C&DRR
- Both freight and commuter railroads
- 5 grade crossings

RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

# Scope of the Project

January 1st, 2021, to May 2023

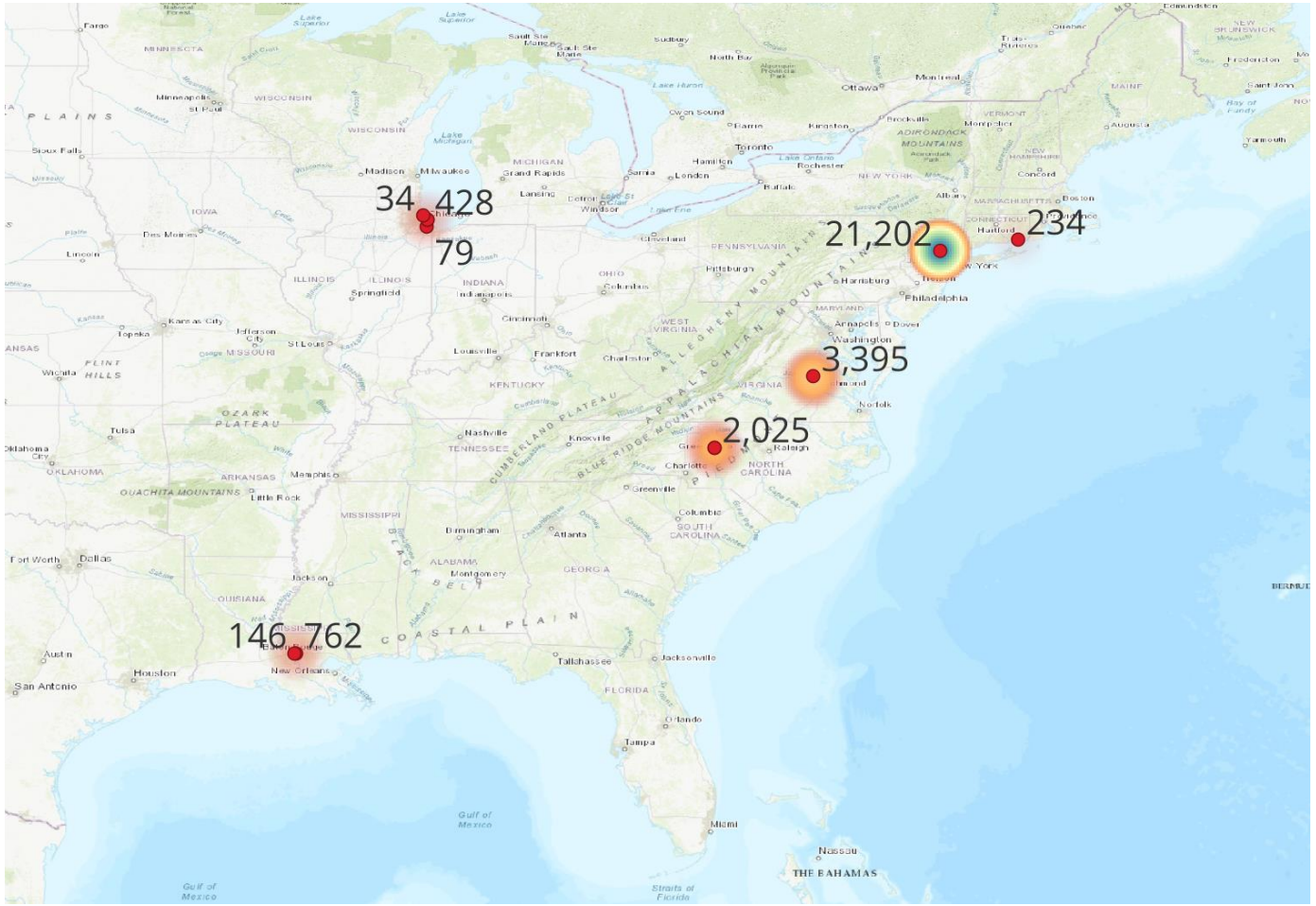
12 Locations across 6 States

50,000+ Hours of Live AI Analysis

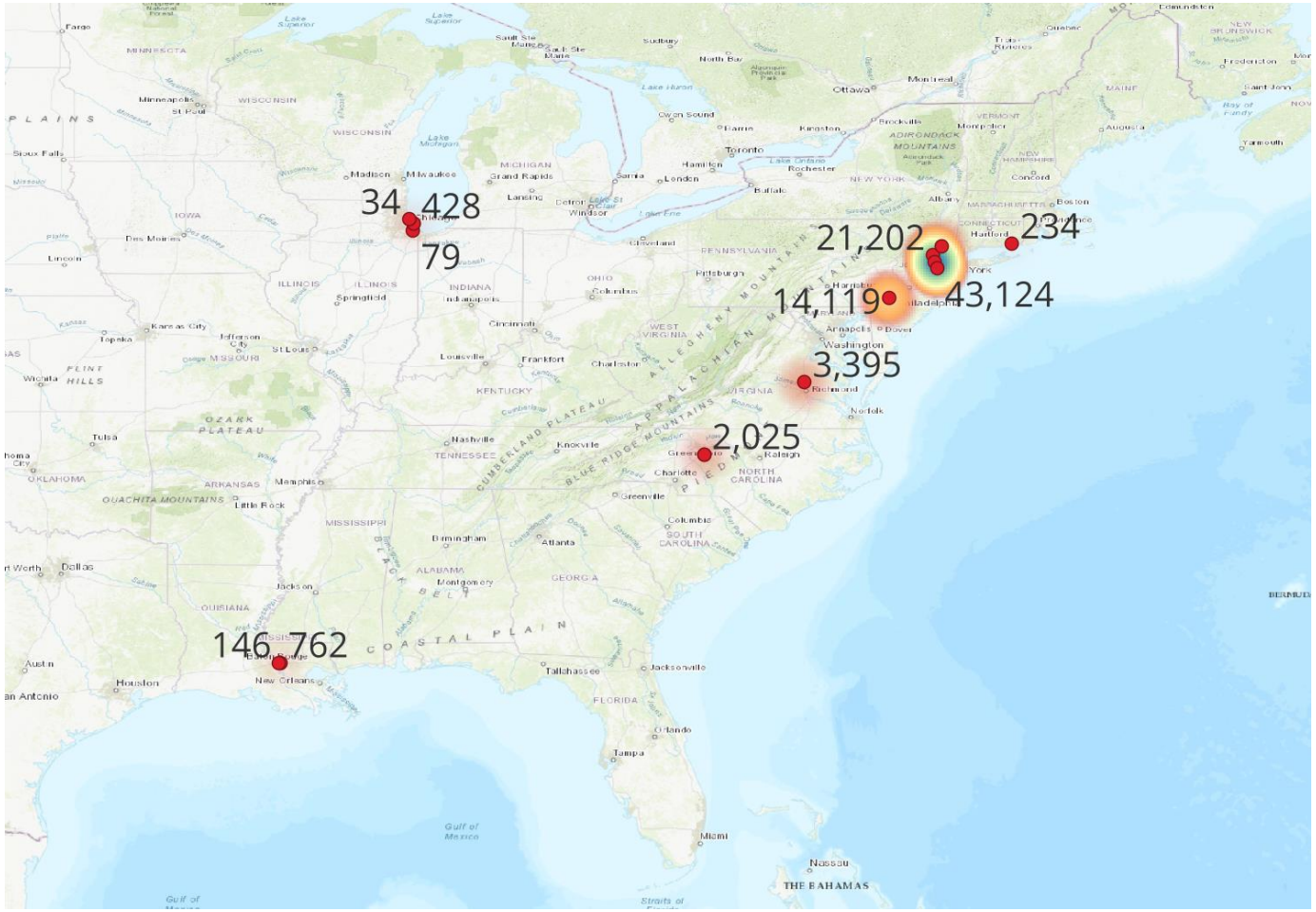
5+ TB of Violation Video Data

100,000+ Violation Events

# Project Locations



# Project Locations with FTA



# Artificial Intelligence Algorithm Development

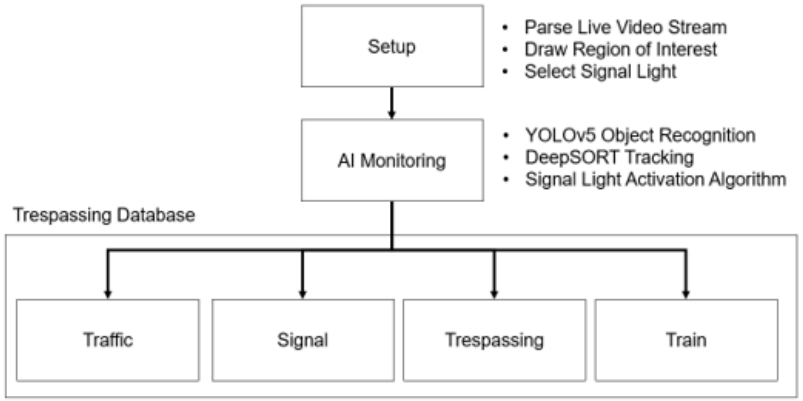



**Figure 3.1 Trespass Event Detection System Framework**


**Figure 3.2 Region of interest and signal light selection example.**

# Data Collection

**Table 4.2 Data Collection Range**

| State | Start Date | End Date | Days | Trespass Events |
|---|---|---|---|---|
| New Jersey, Crossing | 1/1/2021 | 1/31/2022 | 272 | 21,202 |
| Virginia, Crossing | 1/1/2021 | 1/31/2022 | 252 | 3,395 |
| North Carolina, North Camera View | 1/1/2021 | 12/31/2021 | 302 | 476 |
| North Carolina, South Camera View | 1/1/2021 | 12/31/2021 | 328 | 2,025 |
| Connecticut, Local Road Crossing | 1/19/2022 | 1/25/2022 | 5 | 234 |
| Louisiana, Highway Crossing | 6/9/2021 | 6/27/2021 | 15 | 762 |
| Louisiana, Local Road Crossing | 6/9/2021 | 6/28/2021 | 16 | 146 |
| Illinois, Crossing 1 | 10/17/2022 | 10/19/2022 | 3 | 79 |
| Illinois, Crossing 2 | 10/17/2022 | 10/19/2022 | 3 | 428 |
| Illinois, Crossing 3 | 10/17/2022 | 10/21/2022 | 5 | 250 |
| Illinois, Crossing 4 | 10/17/2022 | 10/18/2022 | 2 | 34 |

# Grade Crossing and Right of Way Locations Monitored

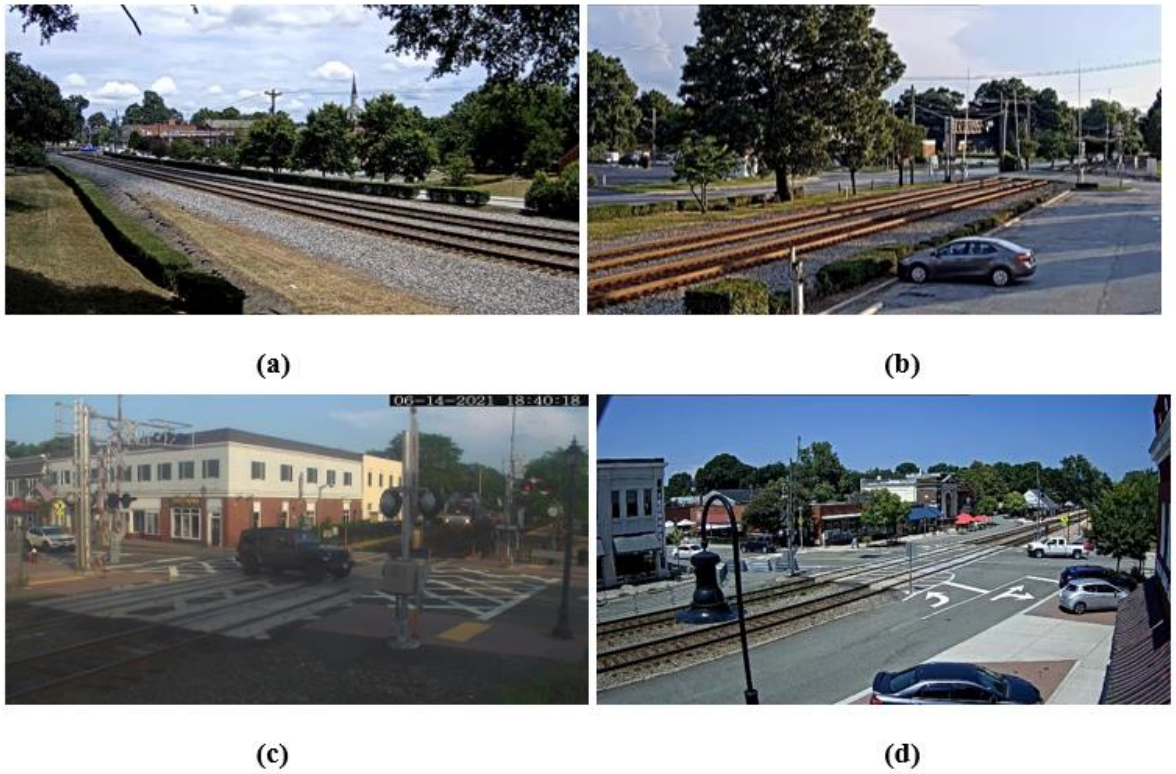



**Figure 4.1 Typical Views of Livestreams from the (a) North Carolina Right-of-Way North View, (b) North Carolina Right-of-Way South View, (c) New Jersey Grade Crossing, and (d) Virginia Grade Crossing**

# Grade Crossing and Right of Way Locations Monitored

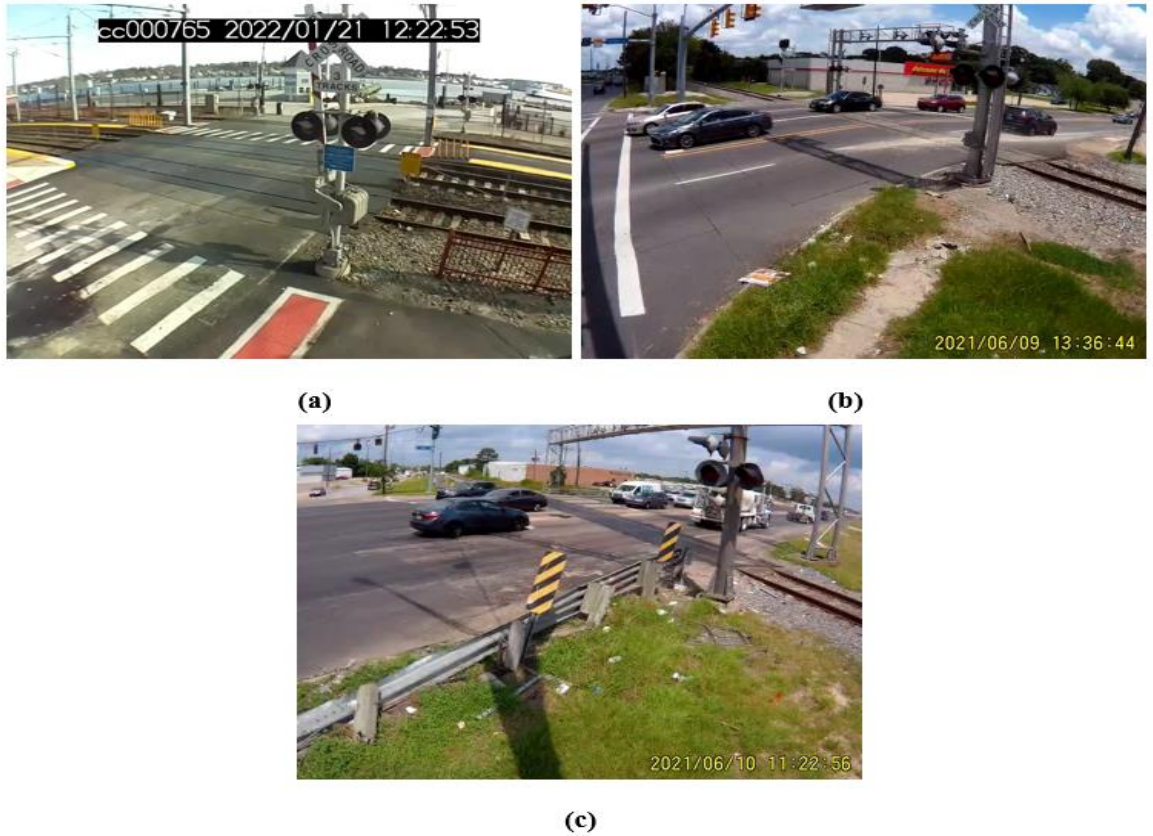



Figure 4.2 Typical Views of Recorded Data from the (a) Connecticut Grade Crossing, (b) Louisiana Local Road Grade Crossing, (c) Louisiana Highway Grade Crossing,

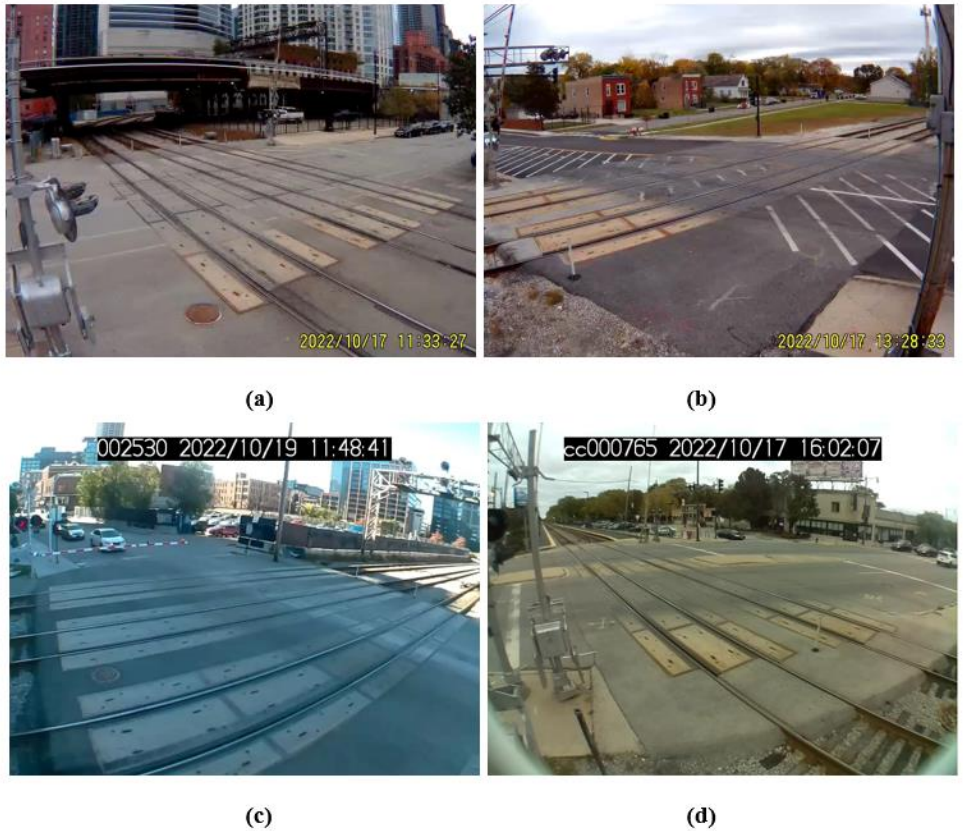



Figure 4.3 Typical Views of Recorded Data from the (a) Illinois Grade Crossing 1, (b) Illinois Grade Crossing 2, (c) Illinois Grade Crossing 3, and (d) Illinois Grade Crossing 4

# Case Studies

**Figure 5.1 Satellite View of the New Jersey Crossing**

# Ramsey Temporal Heatmaps by Class

Suggested Vehicle Enforcement Hours

(a)

| | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Grand Total |
| Monday | 28 | 9 | 4 | 0 | 7 | 47 | 109 | 132 | 99 | 58 | 30 | 45 | 51 | 59 | 46 | 96 | 113 | 168 | 160 | 221 | 236 | 57 | 56 | 34 | 1,865 |
| Tuesday | 27 | 15 | 4 | 0 | 10 | 89 | 131 | 131 | 139 | 65 | 24 | 53 | 42 | 69 | 67 | 123 | 131 | 219 | 184 | 266 | 285 | 75 | 60 | 29 | 2,238 |
| Wednesday | 28 | 22 | 8 | 0 | 10 | 63 | 144 | 146 | 183 | 94 | 31 | 44 | 66 | 65 | 39 | 115 | 137 | 229 | 194 | 291 | 263 | 72 | 76 | 25 | 2,345 |
| Thursday | 29 | 21 | 8 | 1 | 7 | 77 | 135 | 121 | 185 | 107 | 50 | 62 | 69 | 70 | 73 | 127 | 148 | 256 | 220 | 268 | 265 | 91 | 52 | 40 | 2,482 |
| Friday | 27 | 21 | 9 | 0 | 4 | 77 | 112 | 103 | 138 | 76 | 38 | 43 | 48 | 52 | 60 | 117 | 135 | 237 | 218 | 290 | 265 | 84 | 53 | 34 | 2,241 |
| Saturday | 37 | 39 | 10 | 0 | 2 | 16 | 41 | 76 | 77 | 26 | 48 | 19 | 35 | 61 | 49 | 19 | 92 | 84 | 106 | 109 | 80 | 32 | 93 | 40 | 1,191 |
| Sunday | 39 | 34 | 9 | 3 | 0 | 7 | 33 | 63 | 69 | 26 | 35 | 22 | 35 | 31 | 52 | 17 | 79 | 65 | 110 | 124 | 93 | 23 | 76 | 23 | 1,068 |
| Grand Total | 215 | 161 | 52 | 4 | 40 | 376 | 705 | 772 | 890 | 452 | 256 | 288 | 346 | 407 | 386 | 614 | 835 | 1,258 | 1,192 | 1,569 | 1,487 | 434 | 466 | 225 | 13,430 |

(b)

| | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Grand Total |
| Monday | 3 | 2 | 2 | 0 | 0 | 12 | 36 | 27 | 37 | 15 | 14 | 17 | 28 | 20 | 31 | 47 | 40 | 99 | 70 | 76 | 63 | 17 | 10 | 5 | 671 |
| Tuesday | 5 | 2 | 0 | 1 | 1 | 6 | 34 | 39 | 31 | 16 | 11 | 12 | 15 | 28 | 22 | 54 | 40 | 94 | 90 | 102 | 50 | 29 | 16 | 12 | 710 |
| Wednesday | 2 | 4 | 1 | 0 | 0 | 15 | 32 | 42 | 54 | 21 | 14 | 10 | 18 | 34 | 37 | 58 | 66 | 91 | 112 | 90 | 70 | 19 | 12 | 11 | 813 |
| Thursday | 3 | 5 | 2 | 3 | 4 | 13 | 34 | 32 | 44 | 19 | 13 | 28 | 21 | 31 | 27 | 56 | 71 | 127 | 85 | 84 | 67 | 28 | 17 | 13 | 827 |
| Friday | 2 | 2 | 4 | 1 | 1 | 9 | 24 | 31 | 37 | 22 | 10 | 23 | 17 | 35 | 30 | 53 | 48 | 99 | 88 | 95 | 61 | 27 | 18 | 14 | 751 |
| Saturday | 6 | 10 | 2 | 0 | 0 | 0 | 2 | 16 | 22 | 8 | 20 | 3 | 19 | 21 | 34 | 9 | 43 | 32 | 36 | 39 | 25 | 6 | 35 | 19 | 407 |
| Sunday | 19 | 6 | 7 | 0 | 0 | 2 | 6 | 17 | 27 | 23 | 23 | 15 | 28 | 24 | 36 | 10 | 38 | 29 | 30 | 31 | 34 | 7 | 17 | 3 | 432 |
| Grand Total | 40 | 31 | 18 | 5 | 6 | 57 | 168 | 204 | 252 | 124 | 105 | 108 | 146 | 193 | 217 | 287 | 346 | 571 | 511 | 517 | 370 | 133 | 125 | 77 | 4,611 |

a) Cars
b) Pedestrians

Suggested Pedestrian Enforcement Hours

# Ramsey Trespassing Rates by Class

Lower Volume in the AM, but
Worse Compliance

(a)

| Day of Week | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Monday | 2.67 | 3.37 | 1.51 | 0.91 | 0.00 | 9.68 | 82.09 | 184.75 | 102.22 | 12.30 | 5.99 | 1.55 | 1.72 | 1.71 | 2.85 | 0.77 | 2.86 | 2.16 | 3.26 | 3.72 | 2.75 | 0.67 | 2.35 | 0.87 |
| Tuesday | 1.48 | 0.67 | 0.54 | 0.00 | 4.13 | 63.86 | 243.85 | 292.04 | 110.86 | 22.95 | 4.44 | 2.65 | 2.06 | 2.82 | 2.25 | 3.54 | 3.04 | 4.35 | 4.10 | 5.40 | 5.61 | 1.34 | 1.38 | 1.09 |
| Wednesday | 1.12 | 0.95 | 0.46 | 0.00 | 5.39 | 106.08 | 239.05 | 290.47 | 155.66 | 21.88 | 3.12 | 2.71 | 1.53 | 2.88 | 2.87 | 4.19 | 3.59 | 5.54 | 4.76 | 6.75 | 6.97 | 1.79 | 1.51 | 0.91 |
| Thursday | 1.25 | 1.36 | 0.89 | 0.00 | 4.98 | 69.31 | 260.87 | 272.39 | 212.79 | 38.09 | 5.13 | 3.00 | 2.68 | 2.94 | 1.75 | 4.10 | 4.02 | 6.36 | 5.20 | 7.16 | 6.35 | 1.72 | 1.89 | 0.79 |
| Friday | 1.22 | 1.23 | 0.77 | 0.17 | 2.38 | 37.54 | 100.15 | 178.99 | 208.10 | 47.28 | 8.86 | 4.26 | 3.18 | 3.56 | 3.53 | 5.27 | 4.94 | 7.63 | 6.41 | 7.25 | 6.57 | 2.23 | 1.30 | 1.18 |
| Saturday | 1.05 | 1.08 | 0.62 | 0.00 | 0.74 | 22.61 | 56.74 | 112.45 | 167.27 | 42.58 | 9.07 | 4.59 | 2.73 | 2.42 | 2.19 | 3.38 | 3.51 | 6.23 | 5.92 | 7.90 | 7.64 | 2.58 | 1.67 | 1.23 |
| Sunday | 1.61 | 2.32 | 0.80 | 0.00 | 0.37 | 5.25 | 23.95 | 89.83 | 130.07 | 23.99 | 17.70 | 3.06 | 3.26 | 3.41 | 2.14 | 0.67 | 3.00 | 2.75 | 3.70 | 4.00 | 3.22 | 1.34 | 4.12 | 2.04 |

(b)

| Day of Week | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Monday | 1.73 | 1.51 | 1.69 | 0.00 | 0.00 | 169.01 | 378.95 | 300.00 | 303.28 | 33.26 | 10.73 | 9.24 | 13.03 | 8.39 | 8.36 | 9.96 | 8.72 | 17.11 | 10.59 | 11.18 | 10.53 | 3.12 | 1.99 | 1.27 |
| Tuesday | 1.97 | 1.04 | 0.00 | 2.16 | 6.45 | 73.17 | 425.00 | 300.00 | 212.33 | 31.62 | 6.74 | 4.85 | 6.57 | 13.13 | 6.90 | 13.26 | 6.83 | 12.31 | 12.69 | 14.24 | 6.84 | 4.24 | 2.41 | 2.40 |
| Wednesday | 0.63 | 1.60 | 0.79 | 0.00 | 0.00 | 161.29 | 711.11 | 328.13 | 339.62 | 47.62 | 7.61 | 3.64 | 6.50 | 13.92 | 11.93 | 12.82 | 11.28 | 11.87 | 16.14 | 12.54 | 10.73 | 2.95 | 1.95 | 2.47 |
| Thursday | 1.11 | 2.52 | 1.63 | 4.57 | 16.81 | 173.33 | 382.02 | 344.09 | 369.75 | 45.56 | 10.86 | 13.37 | 8.28 | 12.02 | 9.02 | 13.95 | 12.22 | 19.84 | 13.26 | 13.37 | 10.51 | 4.86 | 3.17 | 3.53 |
| Friday | 0.81 | 1.03 | 2.89 | 1.47 | 2.39 | 19.69 | 66.85 | 303.92 | 342.59 | 55.84 | 7.38 | 11.27 | 8.31 | 16.39 | 9.95 | 16.20 | 9.76 | 12.62 | 12.40 | 14.28 | 9.20 | 4.53 | 3.19 | 2.77 |
| Saturday | 1.64 | 4.25 | 1.00 | 0.00 | 0.00 | 0.00 | 3.77 | 128.00 | 194.69 | 31.62 | 13.90 | 1.20 | 5.67 | 5.67 | 6.30 | 1.48 | 5.78 | 3.80 | 4.43 | 5.21 | 3.70 | 1.05 | 7.26 | 4.36 |
| Sunday | 5.92 | 2.81 | 4.09 | 0.00 | 0.00 | 3.21 | 12.42 | 171.72 | 221.31 | 79.04 | 23.19 | 8.19 | 9.24 | 4.16 | 3.55 | 0.74 | 2.50 | 2.53 | 4.20 | 5.43 | 6.34 | 1.58 | 4.52 | 1.01 |

a) Cars
b) Pedestrians

# Ramsey Signal Activation Heatmap & Trespasser Per Signal

| | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Grand Total |
| Monday | 106 | 71 | 47 | 30 | 31 | 105 | 120 | 109 | 133 | 94 | 64 | 86 | 102 | 100 | 107 | 161 | 155 | 225 | 199 | 224 | 266 | 140 | 129 | 74 | 2,878 |
| Tuesday | 93 | 104 | 76 | 26 | 61 | 126 | 147 | 137 | 174 | 120 | 80 | 105 | 123 | 141 | 116 | 184 | 178 | 282 | 236 | 259 | 287 | 162 | 106 | 85 | 3,408 |
| Wednesday | 87 | 137 | 71 | 42 | 42 | 140 | 157 | 161 | 189 | 124 | 103 | 91 | 117 | 129 | 119 | 207 | 197 | 247 | 204 | 256 | 278 | 139 | 123 | 68 | 3,428 |
| Thursday | 89 | 101 | 62 | 21 | 48 | 121 | 155 | 127 | 187 | 151 | 104 | 104 | 115 | 116 | 111 | 170 | 185 | 286 | 213 | 239 | 275 | 146 | 115 | 86 | 3,327 |
| Friday | 89 | 124 | 81 | 10 | 38 | 134 | 143 | 121 | 142 | 120 | 73 | 105 | 112 | 114 | 104 | 183 | 176 | 245 | 213 | 247 | 276 | 169 | 104 | 69 | 3,192 |
| Saturday | 98 | 136 | 64 | 8 | 6 | 46 | 72 | 88 | 84 | 54 | 78 | 38 | 84 | 72 | 127 | 34 | 121 | 90 | 112 | 124 | 99 | 74 | 190 | 71 | 1,970 |
| Sunday | 129 | 80 | 63 | 9 | 3 | 27 | 53 | 74 | 92 | 57 | 63 | 27 | 75 | 60 | 95 | 35 | 142 | 84 | 106 | 114 | 108 | 86 | 164 | 71 | 1,817 |
| Grand Total | 691 | 753 | 464 | 146 | 229 | 699 | 847 | 817 | 1,001 | 720 | 565 | 556 | 728 | 732 | 779 | 974 | 1,154 | 1,459 | 1,283 | 1,463 | 1,589 | 916 | 931 | 524 | 20,020 |

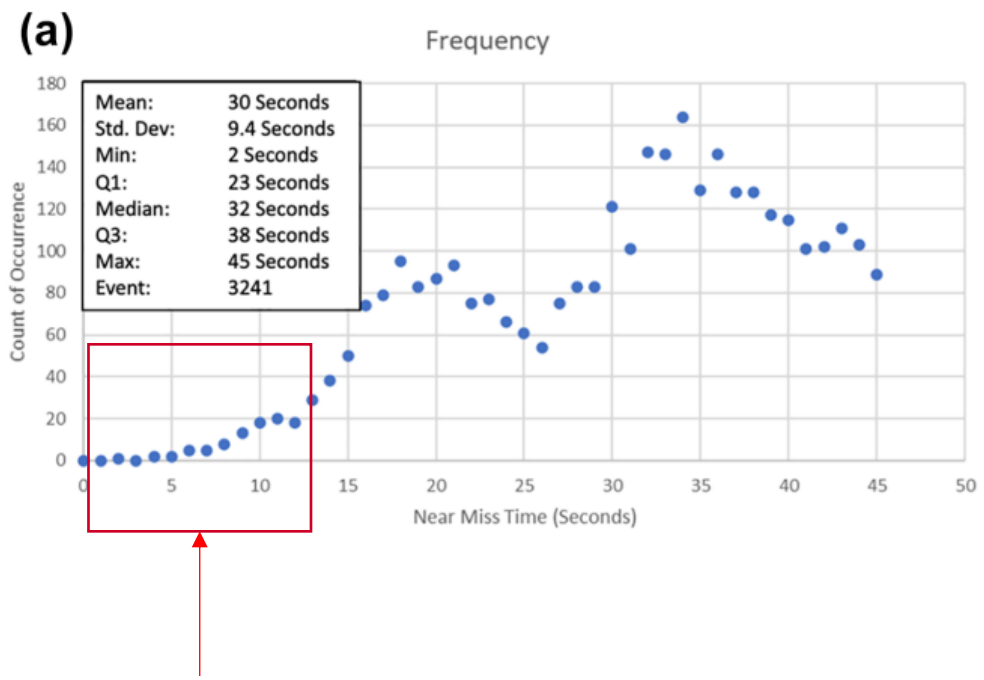
Signals

| | Hour of Day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Monday | 0.29 | 0.15 | 0.13 | 0.00 | 0.23 | 0.61 | 1.45 | 1.71 | 1.24 | 0.96 | 0.77 | 0.88 | 0.85 | 0.93 | 0.76 | 1.01 | 1.08 | 1.28 | 1.27 | 1.43 | 1.20 | 0.56 | 0.53 | 0.57 |
| Tuesday | 0.37 | 0.16 | 0.05 | 0.08 | 0.18 | 0.81 | 1.41 | 1.56 | 1.07 | 0.84 | 0.54 | 0.71 | 0.59 | 0.83 | 0.85 | 1.09 | 1.05 | 1.21 | 1.24 | 1.57 | 1.24 | 0.68 | 0.74 | 0.52 |
| Wednesday | 0.34 | 0.19 | 0.14 | 0.00 | 0.26 | 0.63 | 1.34 | 1.39 | 1.40 | 1.04 | 0.57 | 0.74 | 0.82 | 0.91 | 0.81 | 0.94 | 1.16 | 1.40 | 1.61 | 1.59 | 1.27 | 0.67 | 0.76 | 0.57 |
| Thursday | 0.37 | 0.26 | 0.18 | 0.24 | 0.23 | 0.82 | 1.25 | 1.45 | 1.40 | 0.95 | 0.71 | 0.99 | 0.90 | 0.97 | 1.11 | 1.20 | 1.30 | 1.47 | 1.63 | 1.58 | 1.28 | 0.85 | 0.63 | 0.64 |
| Friday | 0.34 | 0.22 | 0.19 | 0.10 | 0.13 | 0.69 | 1.26 | 1.41 | 1.38 | 0.98 | 0.79 | 0.73 | 0.66 | 0.87 | 0.93 | 1.05 | 1.19 | 1.49 | 1.60 | 1.68 | 1.22 | 0.69 | 0.70 | 0.70 |
| Saturday | 0.45 | 0.37 | 0.19 | 0.00 | 0.33 | 0.46 | 0.78 | 1.39 | 1.33 | 0.87 | 1.09 | 0.66 | 0.81 | 1.28 | 0.80 | 0.88 | 1.28 | 1.42 | 1.32 | 1.27 | 1.08 | 0.53 | 0.69 | 0.83 |
| Sunday | 0.45 | 0.50 | 0.27 | 0.33 | 0.00 | 0.44 | 0.81 | 1.23 | 1.17 | 0.98 | 0.97 | 1.48 | 0.92 | 0.95 | 1.01 | 0.83 | 0.94 | 1.19 | 1.41 | 1.47 | 1.20 | 0.37 | 0.59 | 0.39 |

Average Violations Per Signal

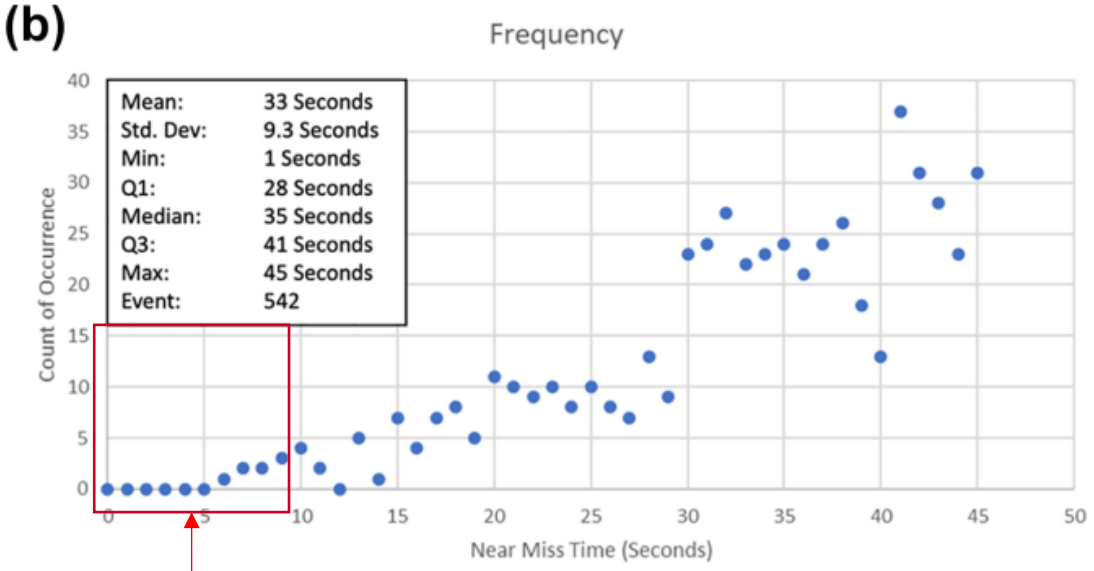
# Ramsey Near Misses

## Cars




Benchmark for Before/After Applied Near Miss Solution

## Pedestrians




Benchmark for Before/After Applied Near Miss Solution

# Ramsey Spatial Grade Crossing Violation Heatmap

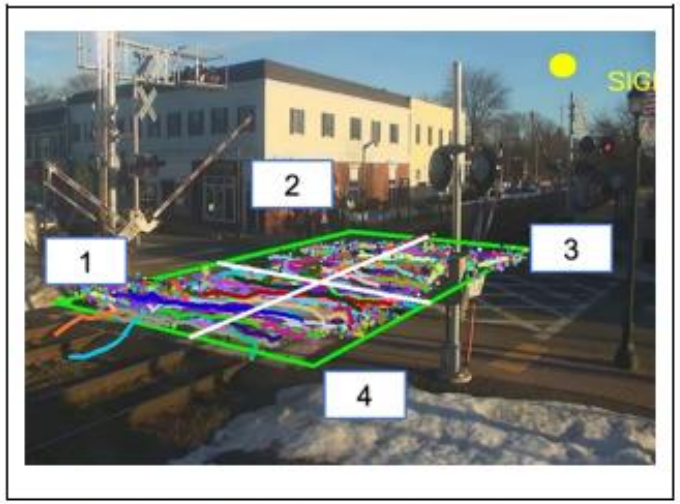



**Figure 12.** Trajectory of grade crossing violation.

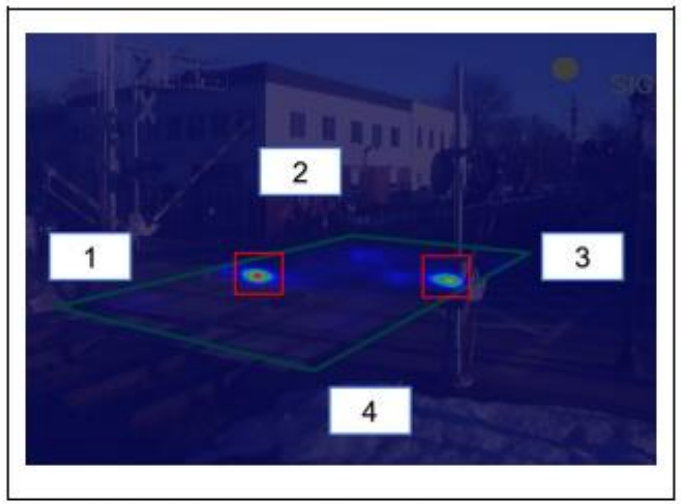



**Figure 13.** Heatmap of normal-view grade crossing violation.

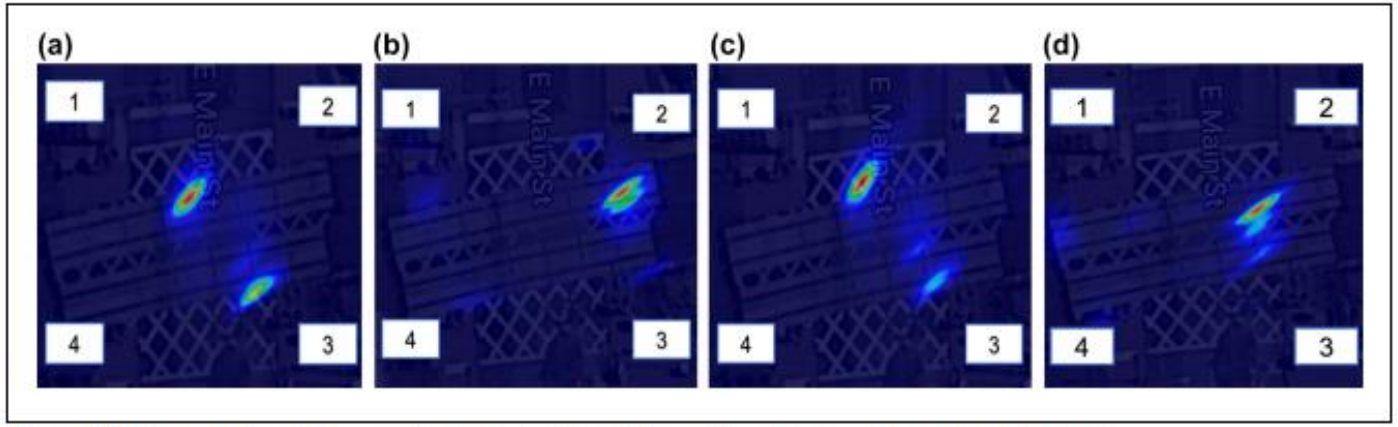
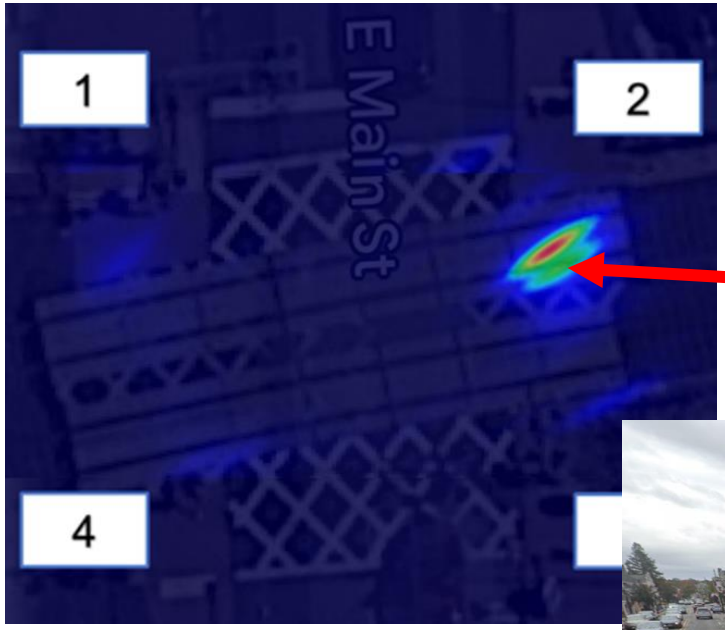



**Figure 14.** Heatmap of aerial-view grade crossing violation: (*a*) cars, (*b*) pedestrians, (*c*) trucks, and (*d*) bicycles.

# Spatial Heatmap Informed Engineering Solution




Suggested Location for Additional Pedestrian Channelization

# Case Study: Thomasville, NC Christmas Parade

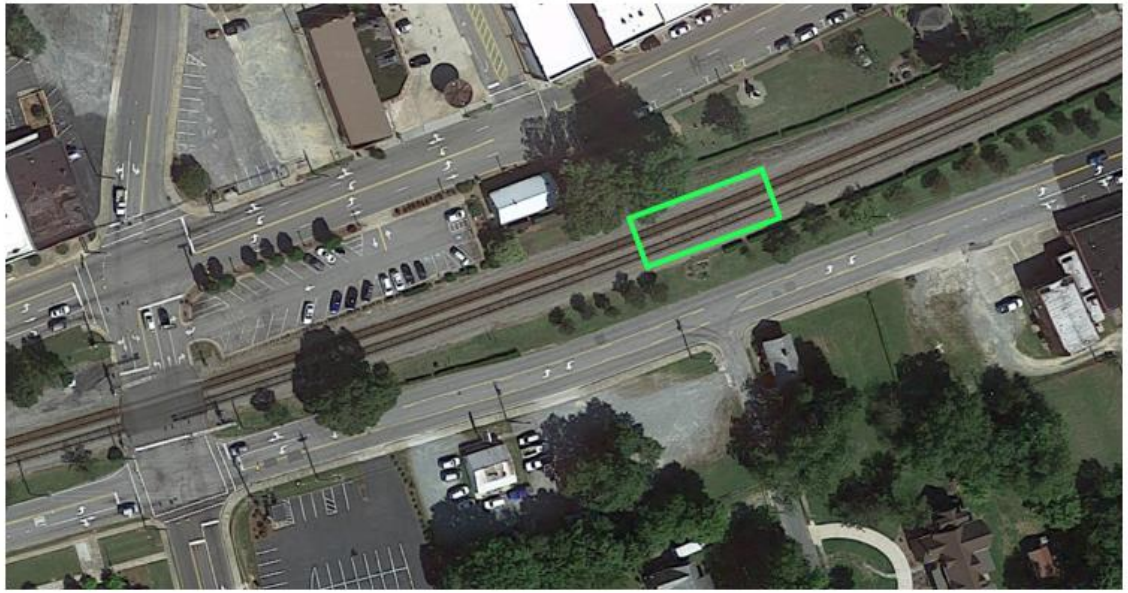
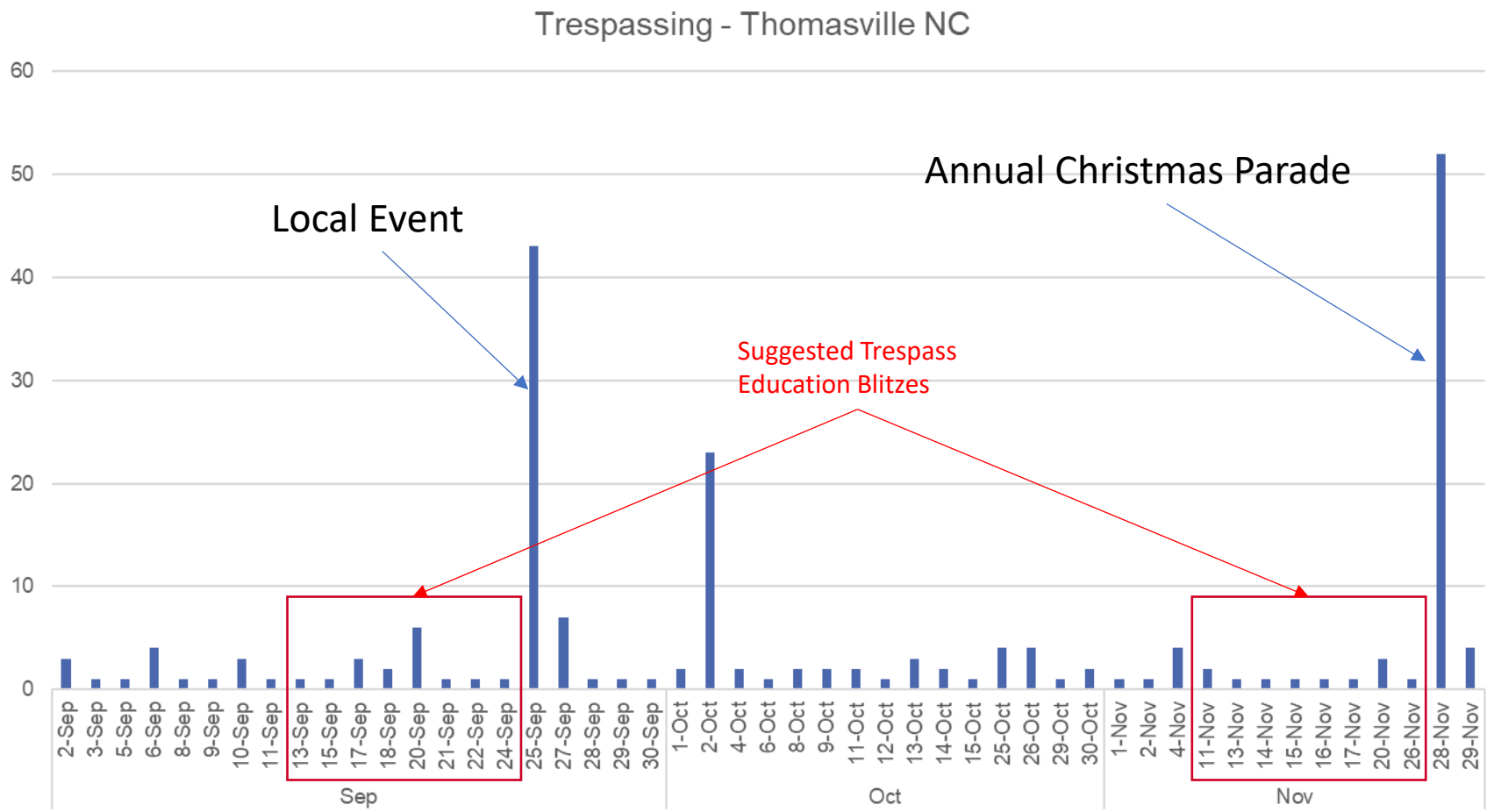
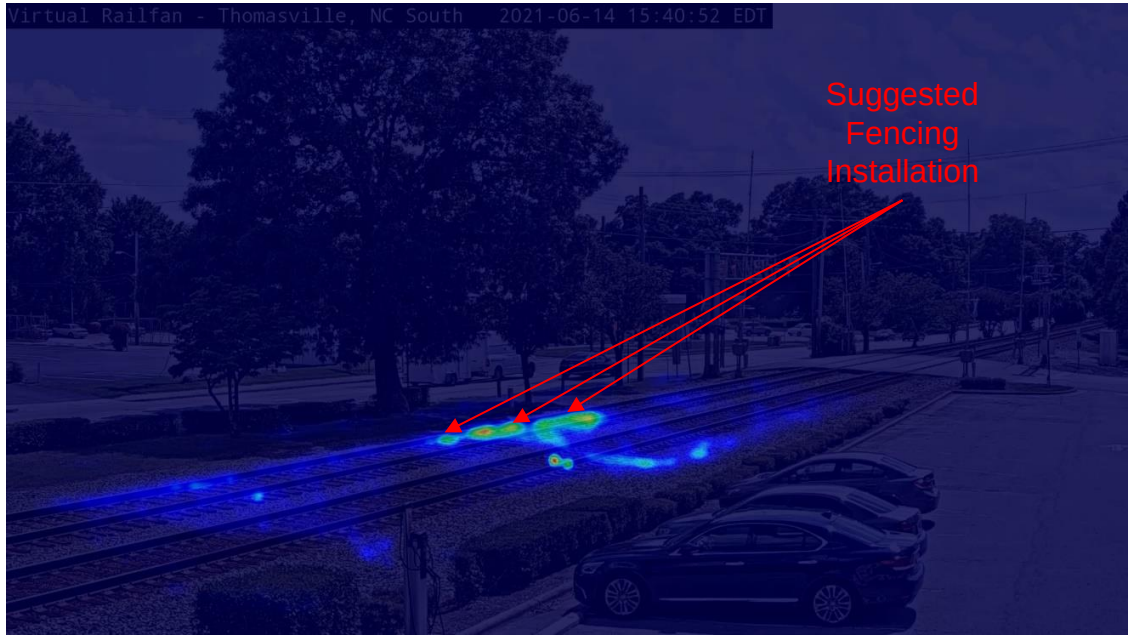


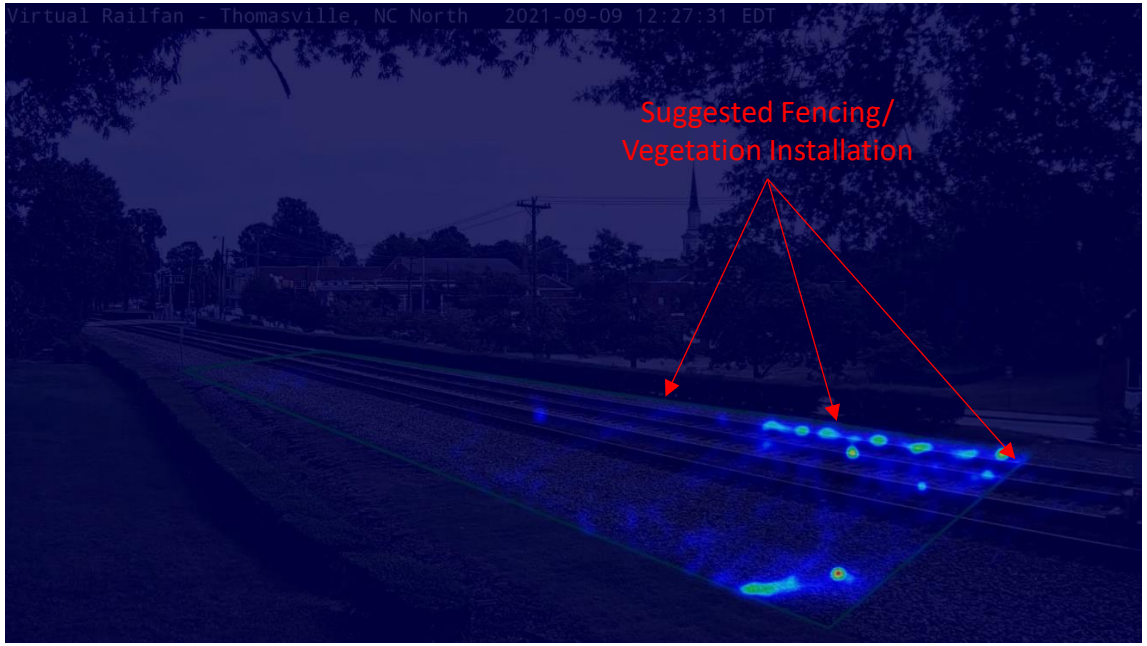
Figure 5.15 North Carolina Right-of-Way, North Camera Satellite View

# Thomasville AI Informed Education/Outreach



# Spatial Heatmap Informed Engineering Solution



# Power BI Analytic Tool

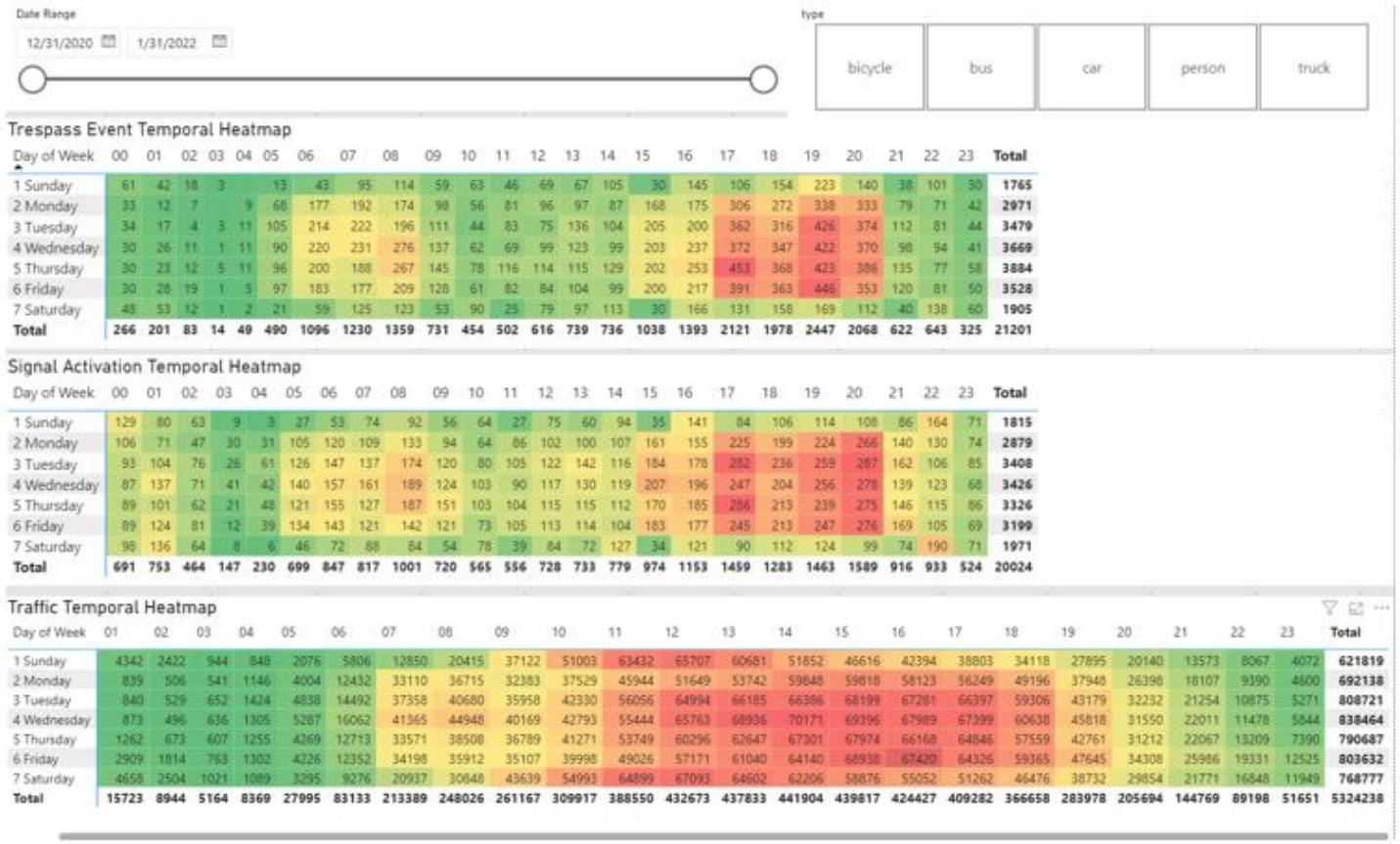



**Figure 6.5 Example Power BI Dashboard for New Jersey Grade Crossing**

# Summary and Next Steps

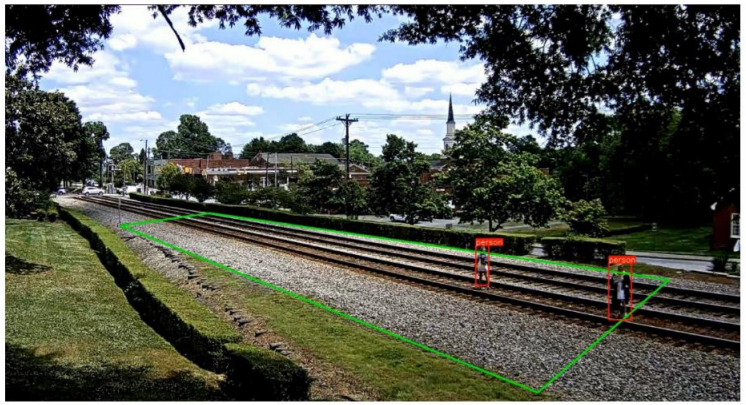
- Trespassing is a ongoing issue
- What is reported is just the tip of the iceberg
- The work done by Rutgers can assist in identifying where the locations of concern are actually
- **New projects** coming up:
  - Rutgers AI Monitoring System
  - Brightline with Witronix
  - Both are CRISI funded projects
    More to come….

# Technical Report Link

U.S. Department of Transportation
Federal Railroad Administration

Office of Research,
Development and Technology
Washington, DC 20590

**Development of Railroad Trespassing Database Using Artificial Intelligence**



# QUESTIONS?

# Today's presenters

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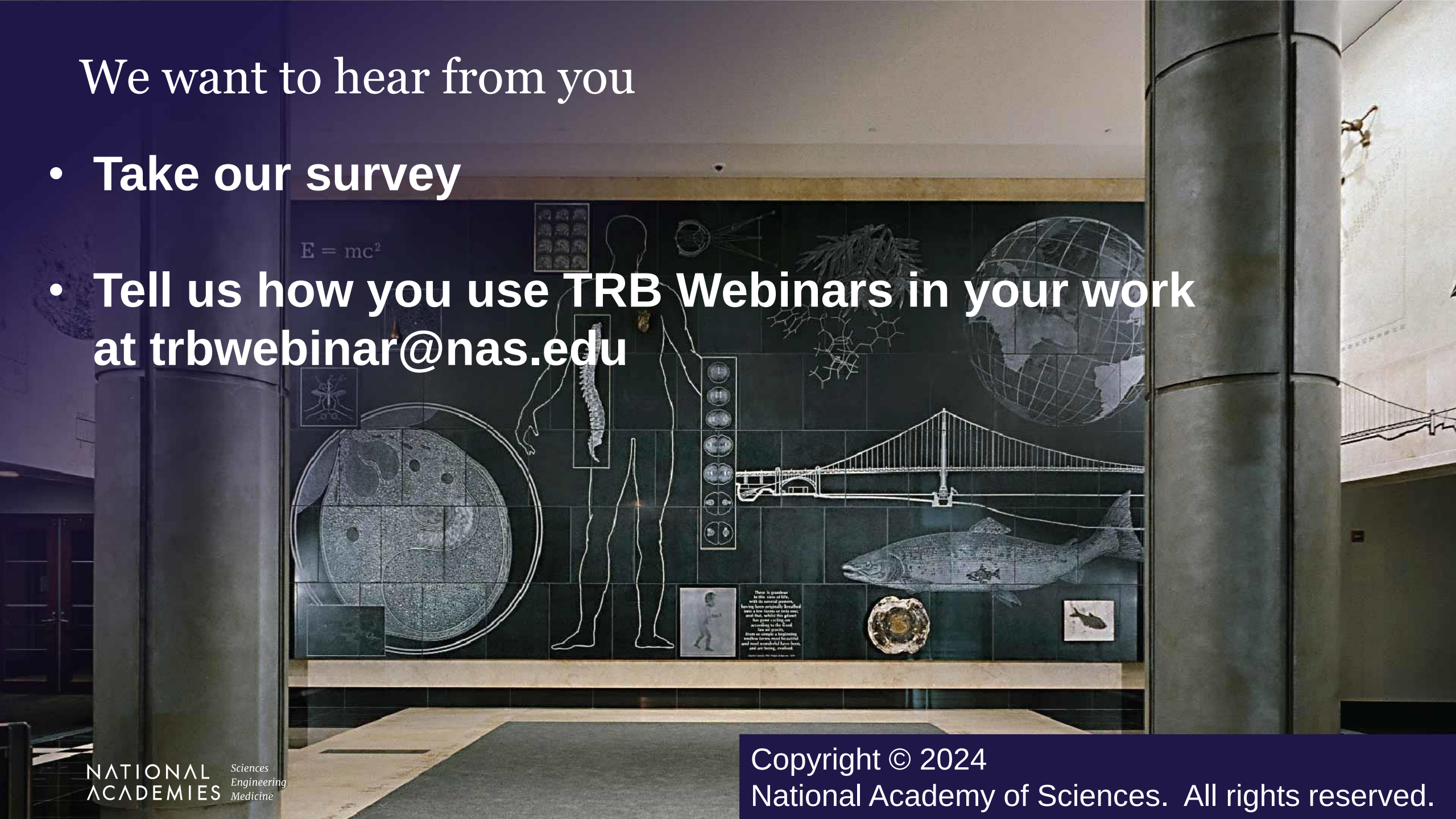


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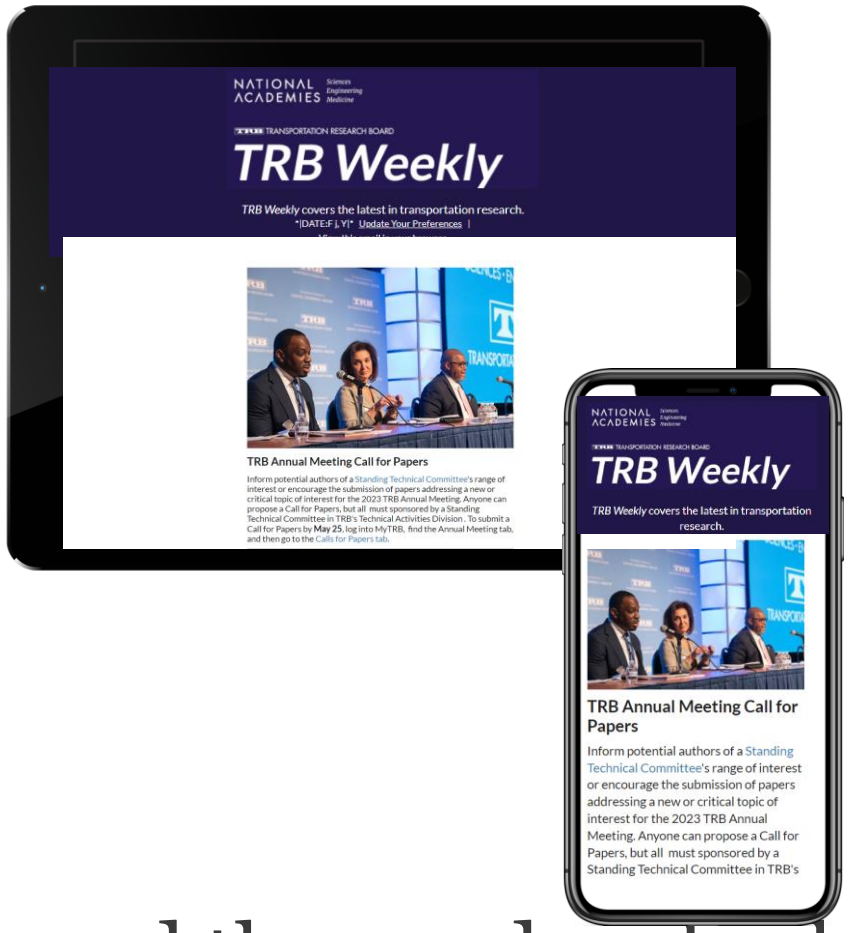


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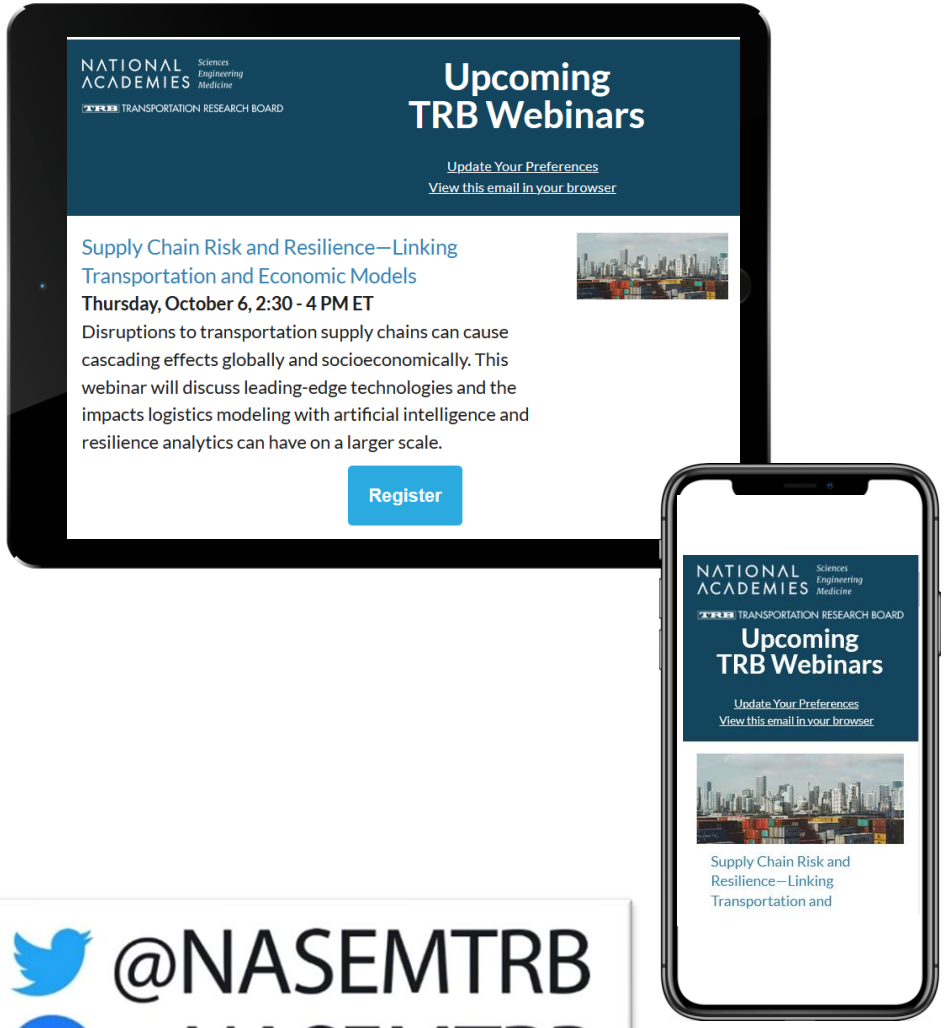


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