SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

Improving Grade Crossing Safety using Predictive Analytics and New Technology

November 7, 2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Call-in Information

Please use this call-in number:
(800) 683-4564

Purpose of Today's Webinar

- Provide an overview of predictive analytics recently adopted by Union Pacific Railroad and new technology tested by NCDOT to improve grade crossing safety.
- Discuss and share information with State DOTs and Railroads.

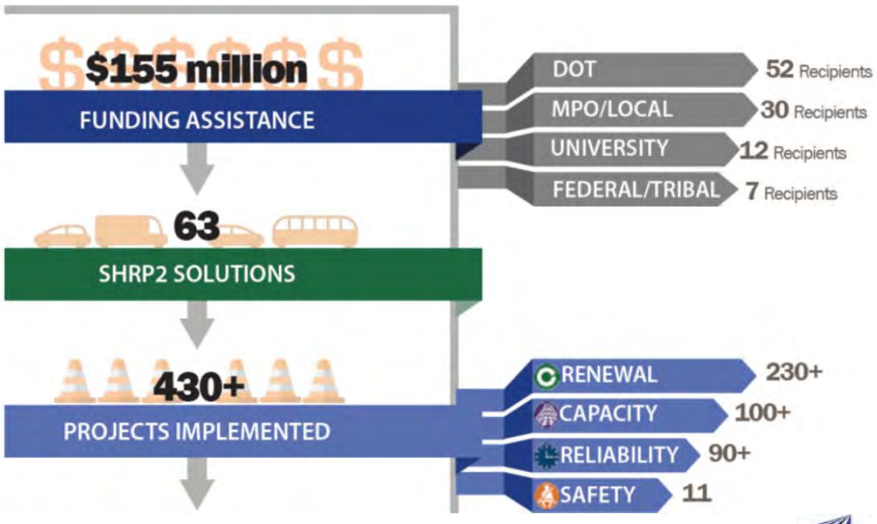
Agenda

- Welcome
- Safety Moment
- SHRP2 Program and R16 Information
- Improving Grade Crossing Safety using Predictive Analytics (UPRR) and New Technology (NCDOT)

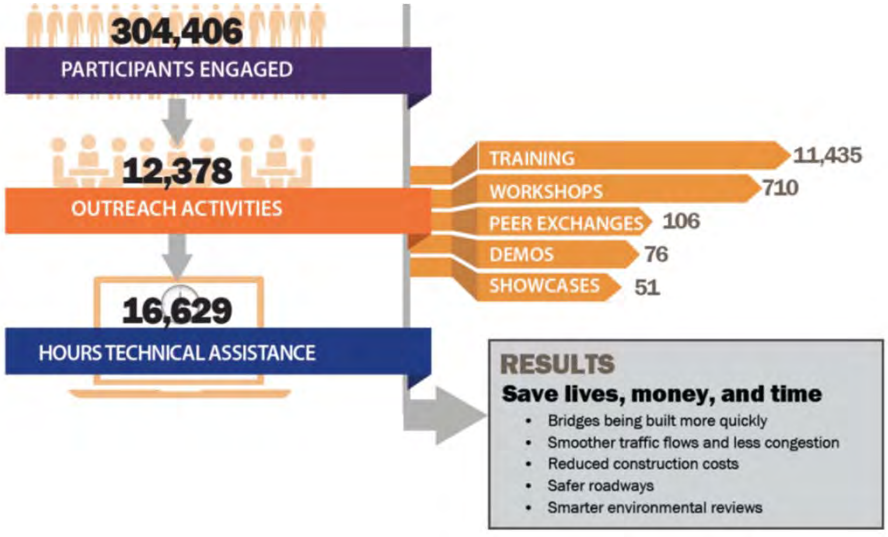
Safety Moment

- What to do if your vehicle stalls or hangs up on the tracks:
  1. Get out immediately
  2. Move away
  3. Locate the emergency phone number
  4. Call for help

SHRP2 Implementation: INNOVATE. IMPLEMENT. IMPROVE.



SHRP2 Implementation: INNOVATE. IMPLEMENT. IMPROVE.



Railroad-DOT Mitigation Strategies (R16)

Challenge

- Railroad-DOT interaction requires a thorough review of the safety, engineering, and the operational impacts of a roadway project during construction – since it will have lasting effects on the railroad for decades thereafter. Rapid construction goals require a new approach that eases the project agreement process for both industries.

Solution

- Recommended practices, model agreements, and training materials to help resolve potential conflicts.

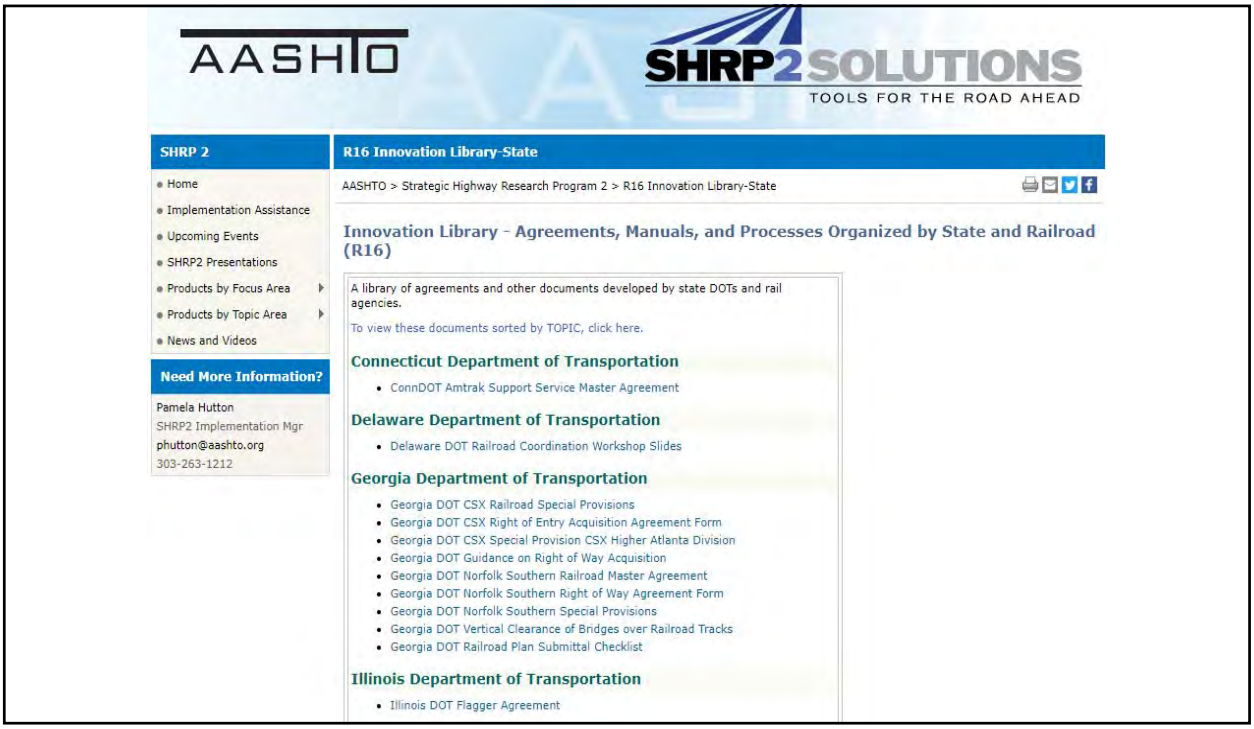
R16 Range of Activities

- Host Community of Interest providing forum for sharing of best practices and challenges
  - annual face to face meeting in Q1
  - quarterly meetings by webinar
- Host SHRP2, R16 Web Page
- Provide SME Technical Assistance
- Host Webinars, topics selected by COI
- Host annual Peer Exchange in Q3
- Produce Case Studies of most value to the COI
- Host state workshops to meet specific state DOT needs

Innovation Library – R16 Webpage

- A library of agreements and other documents developed by state DOTs and rail agencies.
- State and Railroad Agreements, Manuals, and Processes (R16)
- Organized by State/Railroad
- Organized by Topic

http://shrp2.transportation.org/Pages/R16_InnovationLibrary.aspx



A Few Housekeeping Details

- Tell us what you think. We want to hear from all of you on the call during the Question and Answer portion of the webinar.
- Do not use your computer's audio; use the call-in number instead.
- State your name and organization before speaking.
- Download the agenda and PDF of this presentation from the Files section.

NORTH CAROLINA
Department of Transportation

Radar-Based Highway Vehicle Detection System for Four-Quadrant Gated Crossings

Richard E. Mullinax, PE, PTOE, CPM

November 2018

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49 CFR 236(H) – Standards for Processor-Based Signals and Train Control Systems
- ✓Promote safety of processor-based signal and train control systems, subsystems, and components that are safety critical
- ✓49 CFR 236.907 – product safety plan
- ✓49 CFR 236.913(j) – informational filing
- ✓Informational filing / product safety plan must be submitted by the railroad

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Four-Quadrant Gates in North Carolina

- Exit gate descent is a pre-timed offset interval
- Train detected, entry gates descend first
- Exit gates descend varies from site-to-site (typically 7 to 12 seconds delay between entry gate and exit gate descent)

Proven to reduce crossing violations by 84%

SO WHAT IS THE ISSUE?

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Violations Continue

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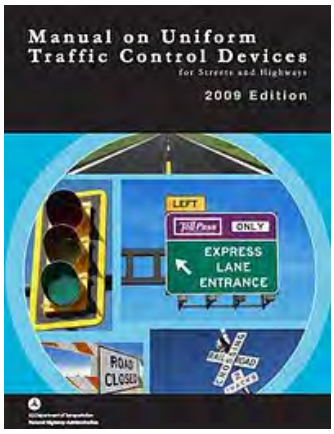
Dynamic Gate Operations

What Does This Mean?



- Entry gate and exit gate could descend simultaneously.
- But would require a vehicle detection system.
- If a vehicle is detected within the crossing, exit gate descent can be delayed to allow the highway vehicle a clear path off the crossing

MUTCD

- A mode of operation where the exit gate operation is based on the presence of vehicles within the minimum track clearance distance
- If used, highway vehicle intrusion detection devices that are part of a system that incorporates processing logic to detect the presence of vehicles within the minimum track clearance distance should be installed to control exit gate operations

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Radar-Based Highway Vehicle Detection

- Out-of-street detection
  - ✓ Impact to / from track and surface work will be minimal
  - ✓ Pavement surface quality will not impact reliability
  - ✓ Roadway pavement shifting will not cause a failure
- Provides redundancy
  - ✓ Two radar units continuously check inputs for correspondence between the units
- Minimal impact to the railroad
  - ✓ Should not negatively impact railroad operations
  - ✓ Minimum “in crossing” installation labor
- Continuous and event triggered recording capabilities

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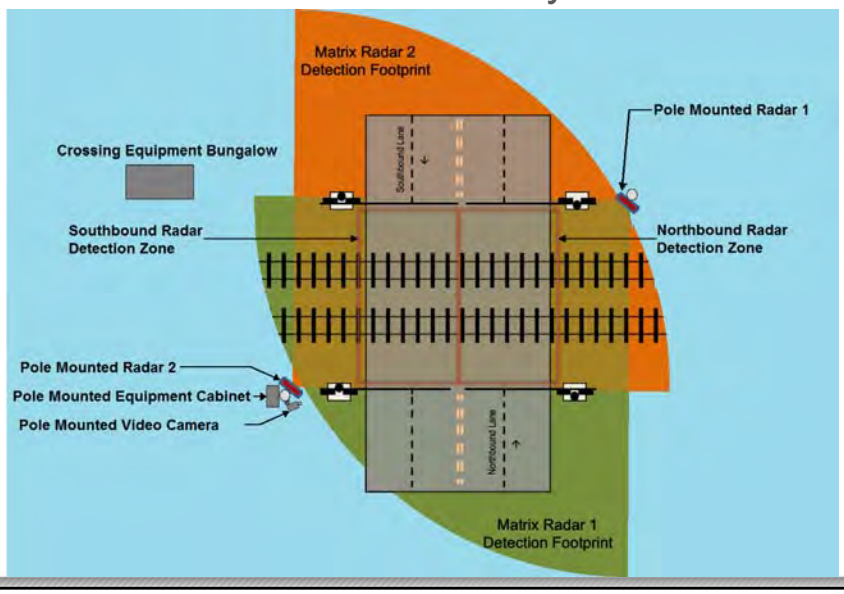
Vehicle Detection System



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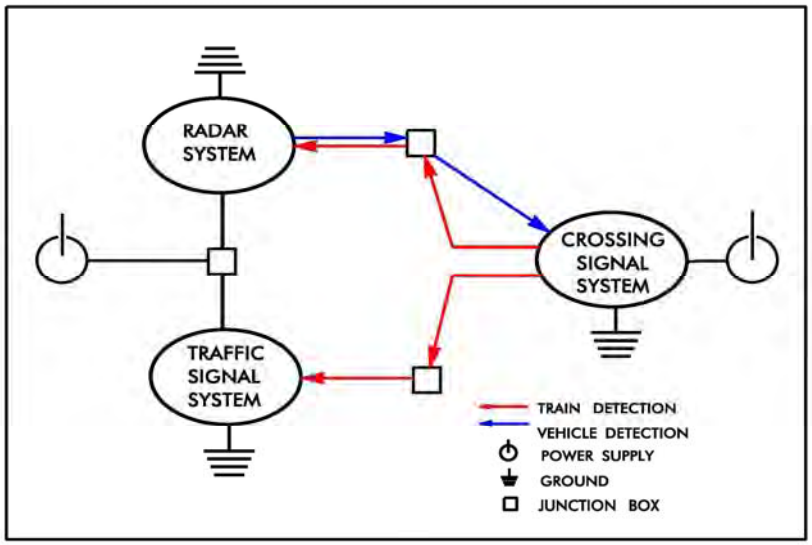
System Communications



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Video Cameras

- Continuous real-time feed
- Alerts emailed with images and clips for atypical vehicle movements
- Train activated clip
  - ➢ Begins 30 seconds prior to train entering crossing
  - ➢ Ends 30 seconds after train exits crossing

Example: Vehicle detected in Zone 2, and a train on the approach circuit

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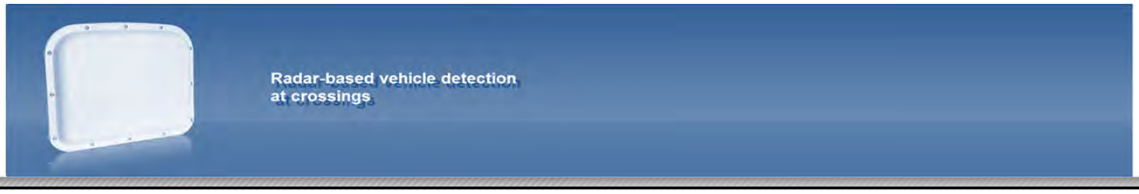
Radar-Based Highway Vehicle Detection System

- FHWA grants ($757,800)
- Island Radar- A Wavetronix Company – SmartSensor-Rail® Radar
- NCDOT owned and maintained per agreement with Norfolk Southern
- Installed at 7 locations along the H-line between Salisbury and Durham, NC
  - ✓ 3 locations activated March 2014
  - ✓ 4 locations activated February – April 2016
- AREMA compliant
- Except for a brief period, gates continue to operate pretimed during the evaluation and continue to operate pretimed today



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Radar-Based Highway Vehicle Detection System

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Image Captures

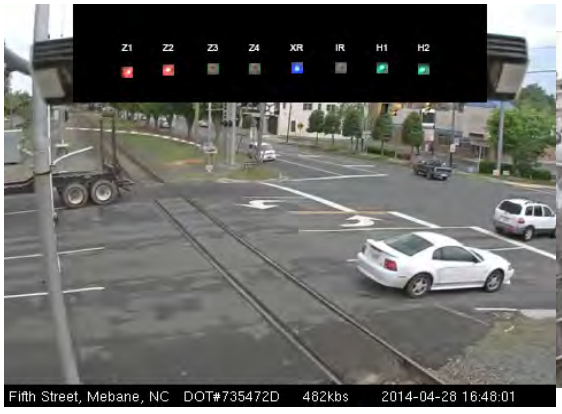

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Image Captures

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Dual Matrix Radar

- Evaluation by NCSU – ITRE (Institute for Transportation Research and Education)
- Evaluation period - 22 Mar 2014 through 31 Oct 2016
- 7,900+ gate activations with 99.81% reliability
- 15 false negative (vehicle missed)
  - 4 due to size of detection zone – zone modified and no further misses
  - 11 due to high vehicle speeds through the crossing – not high priority for detection
- 55 false positives (vehicle not present)
  - Due to train being present momentarily in detection zone after it cleared the crossing – not high priority
  - Due to radar system reacting faster than the crossing system
- System continues in operation today
  - ITRE continuous monitoring
  - Still reliable
  - Weather extremes (snow, ice, humidity, heat, and hurricanes)

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Conclusions

- 1 in 5 activations had a violating highway vehicle (pretimed)
  - Defined as entering a crossing after the start of entry gate descend.
- System performed at least at the same level of effectiveness as inductive detection loops
- System appears robust and able to withstand environmental extremes
- Island Radar VDR24 Vehicle Detection Radar (powered by Wavetronix) accepted by FRA (PSP approved for BNSF, Union Pacific, and Canadian Pacific)
- Future action – Implementation of dynamic gate operations pending submittal and approval of a Norfolk Southern modified PSP.

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A special thanks to:

Mr. Tom Hilleary, Island Radar – A Wavetronix Company
Mr. Daniel Findley, PhD, PE – NCSU – ITRE
Mr. Daniel Coble, EI – NCSU - ITRE

Contact: remullinax@ncdot.gov

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Crossing Model & Diagnostic

Paul D. Rathgeber
Director of Industry & Public Projects

Crossings Are Safe for Prudent Motorists

- Drivers, road authorities, and railroads all have a part to play in crossing safety
- When a crossing is maintained to maintenance standards, the stage has been set for a reasonably prudent driver to traverse the crossing safely.
- Vast majority of incidents are driver behavior

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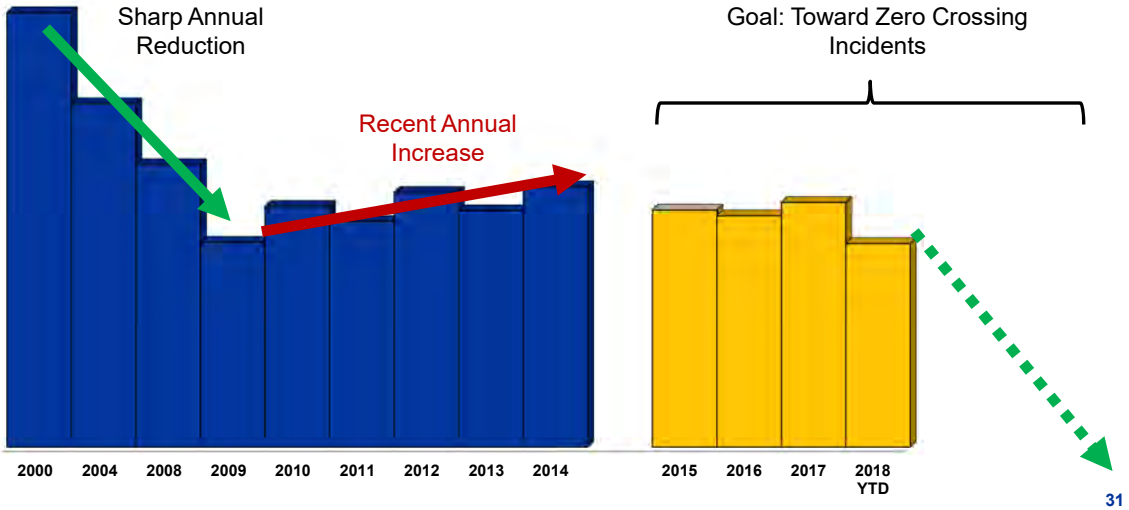
Grade Crossing Incidents



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UPRR Crossing Assessment Program Regression Model Overview

The Zero-Inflated Regressive model does not predict which crossings SHALL have Frequent or Severe Incidents

The model does not rank crossings

The model DOES objectively…

- Establish statistically relevant factors
- Establish predicted frequency and severity
- Groups related crossings
- Self adjusts
- Can incorporate new types of data

The Model correlates past incidents with crossing characteristics

Incidents are the Dependant Variable

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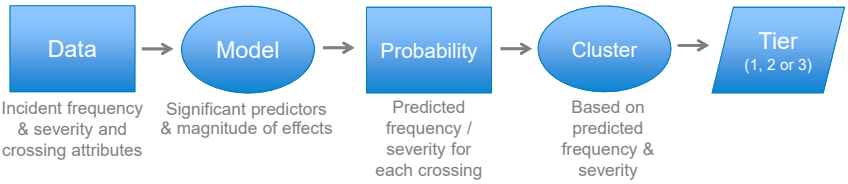
Process Overview



- Clusters are based on probability of incident (frequency & severity), not actual occurrence
  - Tier 1 & 2 crossings may have no incidents in history
  - Risk is determined based on incidents at other crossings with similar attributes
- Probability is determined by factors in the model
  - Some factors may not be in model due to correlation with others
  - Or may not be significant *after accounting for* other factors

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Data Tested in Analysis (candidate variables)

Variable Description
Actual number of incidents occurred at a crossing
Severity Category of the incident with the most impact occurred at a crossings
Crossing angle
Constant warning device indicator
Active signalized crossing
Near interstate highway indicator
Most restrictive warning device
FRA road class code
Preemptive crossing
Quiet zone indicator
Daily traffic count
Daylight through train count
Daylight switching train count
Night through train count
Night switching train count
Total train count
Daylight train count
Night train count
Through train count
Switching train count
Traffic lane count
Estimated truck percentage
Main track count
Other track count
Total track count
Minimum typical speed
Maximum typical speed
Vehicle on track event count
Unsafe motorist event count
Blocked crossing event count
Rough crossing event count
High-wide event count
Remedy ticket count
Average number of school buses

Frequency Model Significant Factors

#	Frequency variable name	Count Model *Public/Private*		Zero Inflated Model *Public/Private*	
1	Most restrictive warning device	✓	✓		
2	Preemptive crossing	✓			
3	Daily traffic count	✓	✓		
4	Total train count	✓		✓	
5	Minimum typical speed			✓	✓
6	Vehicle on track event count	✓	✓	✓	
7	Unsafe motorist event count	✓		✓	✓
8	Rough crossing event count			✓	

Severity Model Significant Factors

#	Severity variable name	Significant in public model	Significant in private model
1	Daily traffic count	✓	✓
2	Total train count	✓	✓
3	Vehicle on track event count	✓	✓
4	Unsafe motorist event count	✓	✓
5	Rough crossing event count	✓	✓

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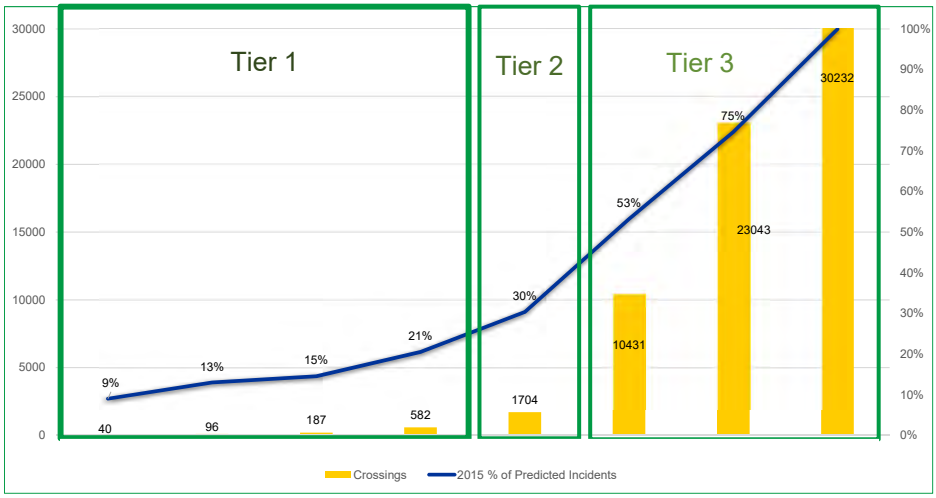
Leveraging Safety at Crossings



50% of all average daily train counts changed more than 10% after improved data source utilized

Predict 30% of incidents at 5.6% of total crossings

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Diagnostics are the Next Step

- Acquire PE agreement
- The diagnostic team evaluates the crossing as to its opportunities and judgmental consensus as to the recommended improvements.
- Three areas:
  - Traffic Operations (vehicular and train)
  - Traffic Control Devices (vehicular and train)
  - Administration (financial responsibility)
- The diagnostic team should study **all available data** and **inspect the crossing and its surroundings** with the objective of determining the conditions that affect safety and traffic operations.

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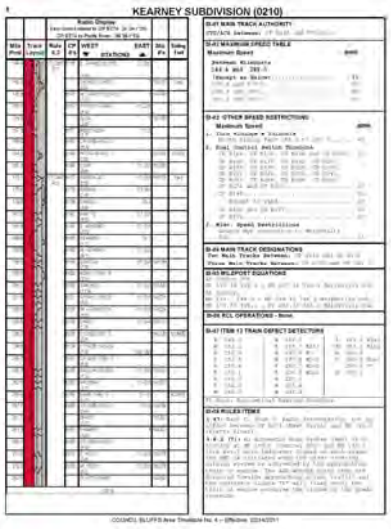
What data do we use?

- Documents
  - Call Center Data with Narratives
  - Timetable
  - Signal front sheet
  - FRA and UPRR Inventory & Accident History
  - Train counts
  - Aerial
  - Right of Way Dimension Map
  - Model Output with Statistical Factors
  - Signal Remedy Tickets
  - Interconnected Crossing Inspection or Testing Reports
  - Starter Sketch and Checklist
- Field review and observations
  - 53.1.1 –Railroad inspection
  - Site distances
  - Traffic patterns
  - Pedestrian patterns
  - Surface condition
  - Intersection configuration
  - Approaches
  - Storage distance
  - Traffic signals / preemption
  - New Developments



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Using Model Data

What does the data tell you?

- Identify Key Driver Statistics – summary table

Incident Type	Count of Incident Type
Crossing Accident - Injured Party	1
Environmental Incident	1
Fatality - Trespasser	2
Fire Related Incident	1
Rough Crossing	1
Train/Vehicle Accident Non-crossing - Property Damage	1
Vehicle on Track	8
Grand Total	**15**

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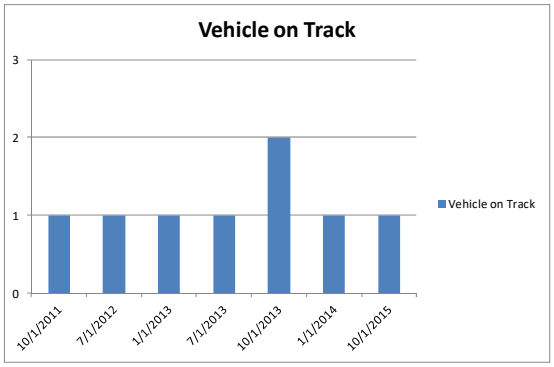
Using Model Data
What does the data tell you?

- Create quarterly or monthly date chart
- Look for trends
  - 4 events in 2013



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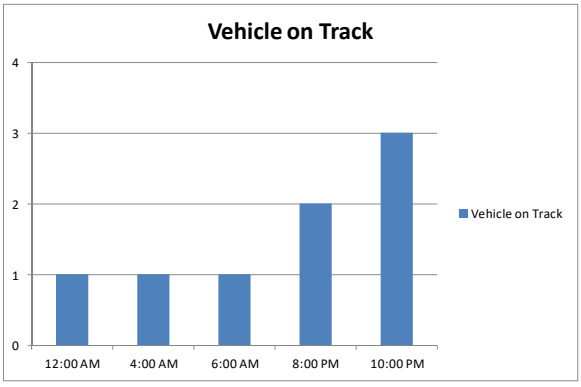
Using Model Data
What does the data tell you?

- Create Time (rounded) chart
- Look for trends
  - 5 events occurred between 8:00 - 11:00 PM



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Using Model Data
What does the data tell you?

- Read all narratives

DOT	Road	MP	Subdivision
751199P	GILMAN STREET	7.06	MARTINEZ SUB

Date Occurre	Time Occurre	Incident Type	Incident Narrative 1
9/7/2015	7:45 PM	Vehicle on Track	Cervantes, Berkeley Police, advised a vehicle on the tracks at the 4th Street and Gillman Avenue crossing which is Mile Post 7.06 of the Martinez Subdivision in Berkeley, CA. The Legal Red Flare Advisement was issued. Kevin Crim, Train Dispatcher, was notified and advised train traffic was stopped. Eric Kelly, Special Agent, was notified. UPDATE: At 07:56 PM, Anderson, Berkeley Police, advised the vehicle was a blue four door Kia Rio with California license plate 9851EDP, officers were on scene, and a tow service was en route . Kevin Crim, Train Dispatcher, was updated. UPDATE: At 08:02 PM, Josh Whiting, Corridor Manager, requested and received updated incident information. Anderson, Berkeley Police, was contacted and advised the the vehicle was on a siding track, not obstructing the main line, and requested reduced train speeds. Mr. Whiting was updated. UPDATE: At 08:21 PM, Anderson, Berkeley Police, advised the vehicle was removed from the tracks and personnel were clear of the scene. Anderson stated the **vehicle came to rest on the tracks due to driver error**. Josh Whiting, Corridor Manager, was updated. Kevin Crim, Train Dispatcher, was updated. Eric Kelly, Special Agent, was updated.
11/21/2013	5:55 AM	Vehicle on Track	John Cooper, Train Dispatcher, reported the crew of Train YOA43 20, Lead Locomotive UP6452, **observed a vehicle high centered on Mainline** Two at Mile Post 7.25 of the Martinez Subdivision. Mr. Cooper stated a vehicle description was not available. Operator 523, Berkeley Police Department, was notified and advised officers and a tow service would be dispatched. Jeffery Fikes, Senior Special Agent, was notified. UPDATE: At 06:40 AM, Calvan, Berkeley Police Department, advised the vehicle was clear of the crossing. John Thiessen, Train Dispatcher, was updated.

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Crossing Analysis
Problem-Solving Drilldown

1. Use Data to Develop a Problem Statement
2. Research and Field Observations
   i. Interview local forces, Law Enforcement, etc.
   ii. Drive all approaches
   iii. Observe crossing behavior from an inconspicuous location
   iv. Walk the approaches
3. "5 - Whys"
4. Observation Statement(s)
5. Recommendations address observation statements

Problem-solving for targeted recommendations

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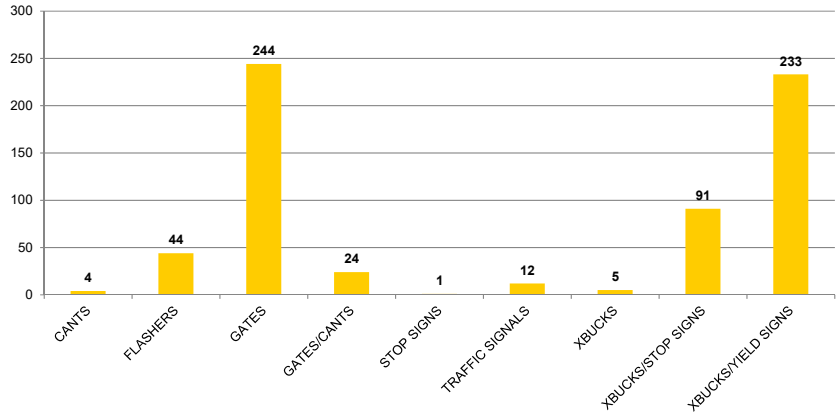
One Example of Advanced Reviews: Overview of UPRR in Colorado

- 1,503 Miles of Track
- 658 Public At Grade Road Crossings
- UP, BNSF, ATK, RTDC, GRNW

- Up to 55 Trains Per Day
- 1-8 Tracks
- 1-6 Lanes of traffic
- Max Timetable Speeds of up to 70 MPH



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Colorado Crossing Examples

1 Public Tier 1

Havana Street, Denver

20 Public Tier 2's

Washington St, 51st Ave, & York St, Denver

Chambers & Airport Rd, Aurora

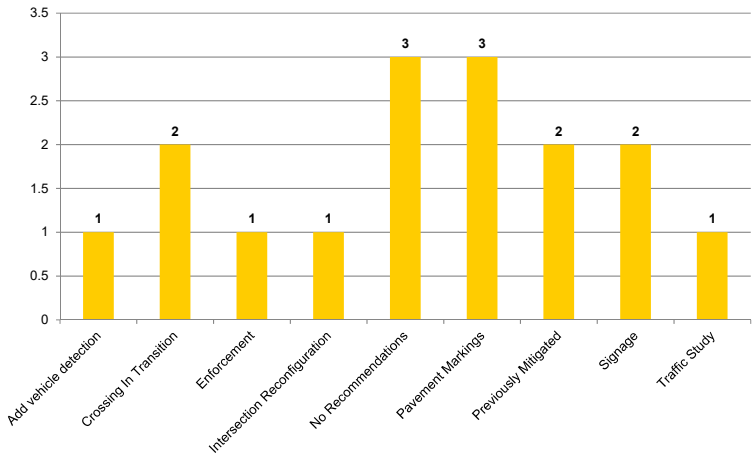
Main St, Lucerne

Robinson Ave, Florence

Royer St & Las Animas St, Colorado Springs

5th St, Castle Rock

Recommendation Categories



In Transition:
Current conditions impact normal traffic flow

Enforcement:
Joint event with local Law Enforcement

No Recommendations:
Crossing Observed Functioning as Intended

Previously Mitigated:
Completed Project work with Partners

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Colorado Specific Recommendations

- **Add Do Not Stop On Tracks R8-8**
- **Refresh Edge Line Markings**
- **Refresh Median Line Markings**
- **Add Stop Line – RR Markings**
- **Add Vehicle Detection**
- **Relocate signage for improved driver visibility/earlier warning**
- **Crossing in Transition**
- **Target Enforcement**
- **Propose Intersection Reconfiguration**
- **No Recommendations-Previously Mitigated**
- **No Recommendations-Functioning as Intended**

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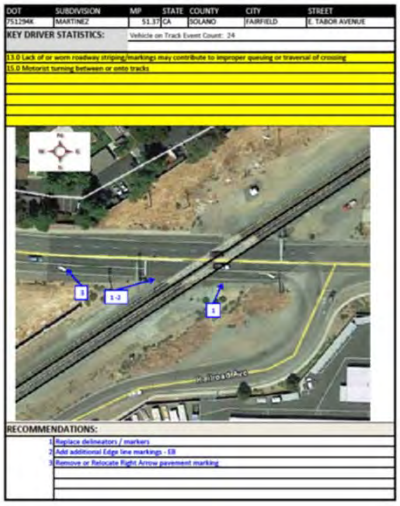
What does success look like?

East Tabor, Fairfield, California, Tier 1 Public

- Martinez Sub
- 11,000 cars per day
- BEFORE ENHANCEMENTS: 25 Vehicles on Track
- Observed improper queuing & traversal of the crossing
- Data told us motorists were turning between or onto tracks
- Recommended adding edge lines, changing location of right turn arrow pavement markings, and replacing delineators
- AFTER ENHANCEMENTS
  - Completed in Dec 2015:
  - 1-18-16, 1 Vehicle stalled and high centered
  - 1-4-18, 1 Vehicle drove off crossing and became stuck
- **NO FURTHER INCIDENTS AND NO COLLISIONS**



Summary

- Predict rather than React
  - Future Options: Proximity Model vs Priority Index vs Zero Inflated Regression
  - State by State vs System
- Use available data from both the Road Authority and the Railroads
- Go where the data takes us
- Analyze before holding a diagnostic
- Hold a Comprehensive Diagnostic
- Focus recommendations based on data, observations, & local color
- Federal Agencies, Road Authorities & Railroads must be partners

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Questions & Discussion

For More Information

Product Leads:

Katie Hulbert
FHWA Sponsor
kathleen.hulbert@dot.gov

Kate Kurgan
AASHTO Co-Product Lead
kkurgan@aashto.org

Pam Hutton
AASHTO Co-Product Lead
phutton@aashto.org

Hal Lindsey
R16 Project Manager
hal.lindsey@jacobs.com

Additional Resources:

GoSHRP2 Website:	fhwa.dot.gov/GoSHRP2
AASHTO SHRP2 Website:	http://shrp2.transportation.org
R16 Product Page	http://shrp2.transportation.org/Pages/R16_RailroadDOTMitigationStrategies.aspx