



OFFICE OF RESEARCH & DEVELOPMENT

2012 **R&D**
REVIEW

Non-Embedded Vehicle Detection for Four Quadrant Gate Warning Systems and Blocked Crossing Detection



U.S. Department
of Transportation

Federal Railroad
Administration

TAREK OMAR

Program Manager

Office of Research and Development

Office of Railroad Policy and Development

Program Area & Risk Matrix

Non-Embedded Vehicle Detection for Four Quadrant Gate Warning Systems and Blocked Crossing Detection

Program Areas	Risk Factors	Trespass	Grade Crossing	Derailment	Train Collision	All Other Safety Hazards
Railroad Systems Issues						
Human Factors						
Track & Structures						
Track & Train Interaction						
Facilities & Equipment						
Rolling Stock & Components						
Hazardous Materials						
Train Occupant Protection						
Train Control & Communications			X			
Grade Crossings & Trespass			X			

Acknowledgements & Stakeholders

Acknowledgements

- FRA funded this research through a BAA conducted by ByStep, LLC

Stakeholders & Project Partners

- BNSF
- State of Illinois Department of Transportation
- ByStep, LLC
- Suppliers
- Passengers and Rail Neighbors

Four Quadrant Gate Warning Systems – Exit Gate Operating Modes (EGOM)



Timed EGOM

Exit gates are delayed a predetermined time period

Dynamic EGOM

Exit gates are raised if a vehicle is detected in the crossing island

Embedded Inductive Loop Detection Systems - Drawbacks

- **Relatively Short Lifetime** due to pavement movement and environmental stresses
- **Installation and Replacement (Cost & Time)** in the crossing roadway creates a safety risk and slows trains
- **Check Loops and Lack of Redundancy** are inherent functional limitations
- **Limited Coverage in the Crossing Island** due to track proximity and concrete crossing panels

Project: Develop and Test a Non-embedded, Radar-based Vehicle Detection System



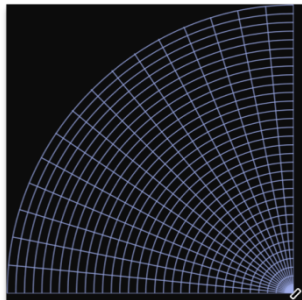
Projected Benefits

- Higher Speed Rail and On-Time Arrival
 - Lowers chance of train delays due to equipment failure
- Increased Safety
 - Detection footprint covers entire crossing
 - Two radars, full active redundancy
 - Blocked crossing detection
- Reduced Life Cycle Cost
 - Longer life than loop systems
 - Lower capital cost
 - Less complex, lower installation cost
 - No required scheduled maintenance
- Integration with Existing Equipment
 - Interfaces to existing crossing controllers
 - Interfaces to any wired or wireless network

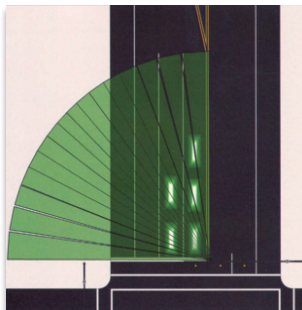
Radar used – Wavetronix SmartSensor Matrix Traffic Intersection Radar



Wavetronix® SmartSensor Matrix



16 radars in one unit, no scanning
90° x 100-foot detection pattern - 7,853ft²
MTBF > 10 years



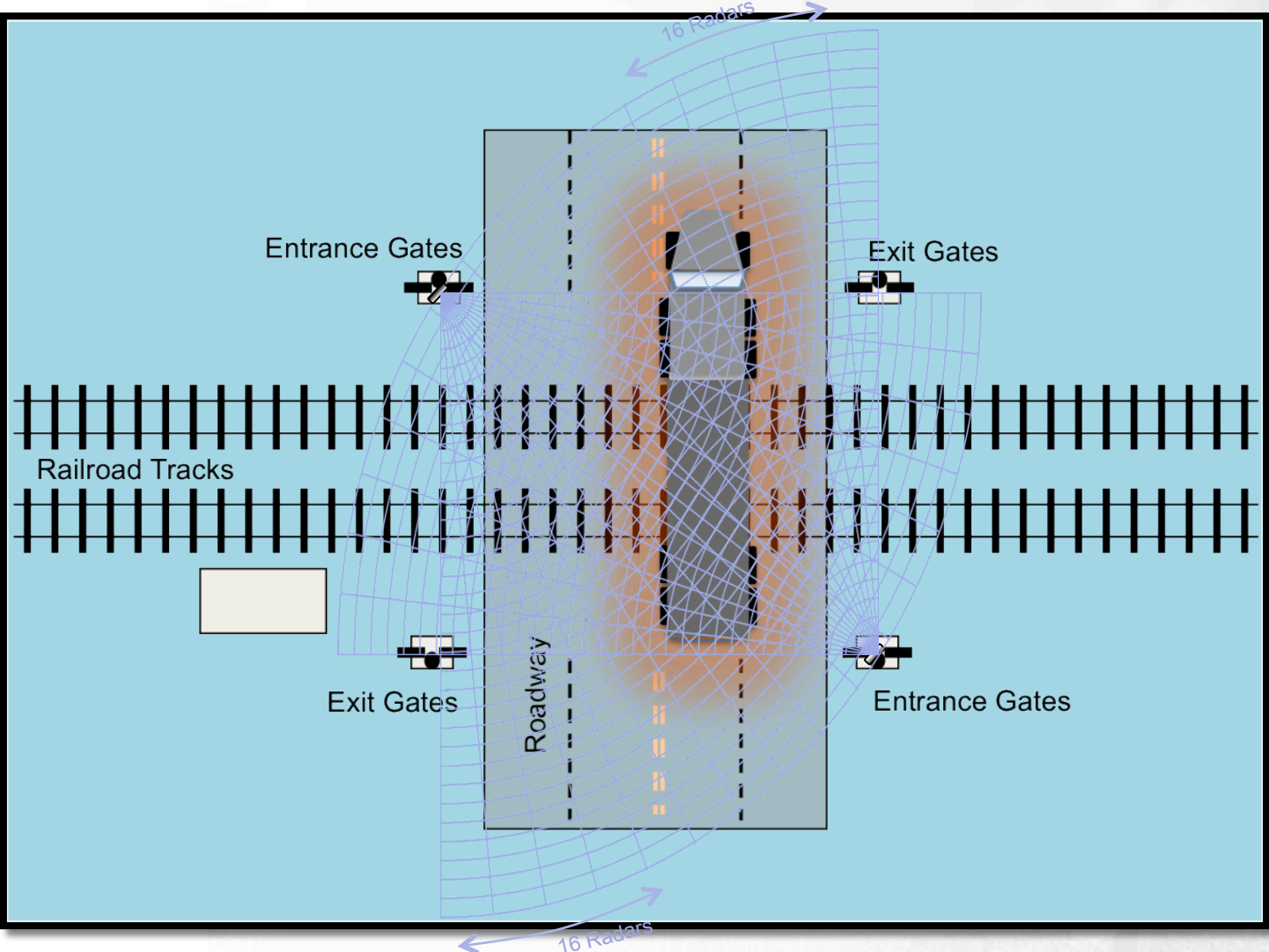
Traffic intersection control
Moving + stationary vehicle detection
Multiple radars (up to 8) can be used

Initial testing and railroad application optimization



- Tripod Radar Field Tests
- Railroad Adaptation Summary:
 - Bi-Directional Detection Modality
 - AREMA Compliant Isolation
 - Collaborative Radar Operation

DUAL RADAR CROSSING ISLAND MONITORING CONCEPT



Detection outside the Crossing Island

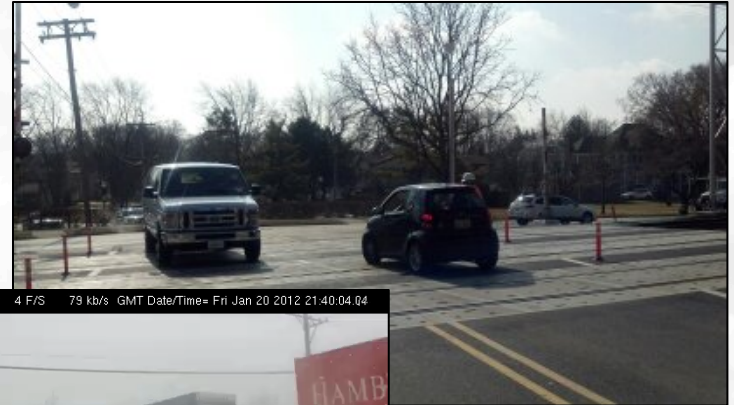


Detection outside the Crossing Island



Testing status

- Radar height sensitivity
- Snow and rain immunity
- Vehicle size and location sensitivity
- Vehicle occlusion tests
- Stuck vehicle classification
- High volume Radar vs. Loop performance tests



Monroe Street 4 F/S 79 kb/s GMT Date/Time= Fri Jan 20 2012 21:40:04.04



00:06:17:47	LIDET	
00:06:22:94		L2 Loop = 1
00:06:22:96		L2 Radar = 1
00:06:24:14		L2 Loop = 0
00:06:24:15		L2 Radar = 0
00:06:24:17		LIDET
00:06:26:35	L1 Radar = 1	
00:06:26:38	L1 Loop = 1	
00:06:28:59	L1 Radar = 0	
00:06:29:64	L1 Loop = 0	
00:06:29:66	LIDET	
00:06:29:67		L2 Loop = 1
00:06:29:69		L2 Radar = 1
00:06:32:93		L2 Loop = 0
00:06:32:95		L2 Radar = 0
00:06:32:96		LIDET
00:06:51:86	L1 Loop = 1	
00:06:51:88	L1 Radar = 1	
00:06:53:09	L1 Radar = 0	
00:06:54:10	L1 Loop = 0	
00:06:54:12	LIDET	
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00:07:04:17		L2 Radar = 0
00:07:04:18		L2 Loop = 0

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Lessons Learned

Radar-based system offers many advantages over the regular inductive loop; this includes:

- Easy Installation & Replacement
- Detection footprint covers entire crossing
- Two radars offer full active redundancy
- Blocked crossing detection
- Reduced life cycle cost
- Longer life
- Lower capital cost
- No required scheduled maintenance
- Efficient detection outside the crossing island



OFFICE OF RESEARCH & DEVELOPMENT

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REVIEW

Highway-Rail Grade Crossing Safety and Trespass Prevention Research Program (RR97)



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Program Manager

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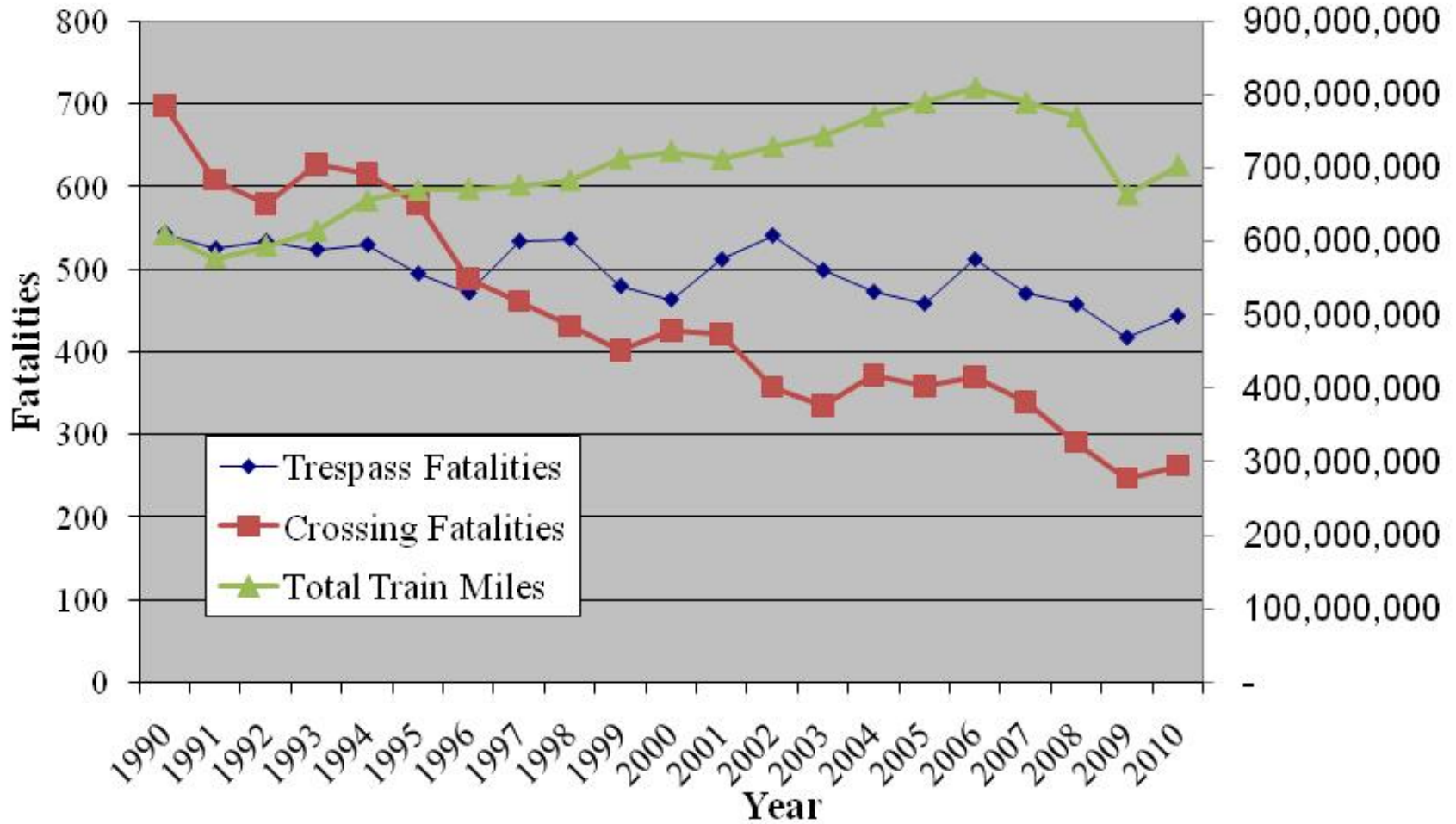
Office of Railroad Policy and Development

Program Area & Risk Matrix

Highway-Rail Grade Crossing Safety and Trespass Prevention Research Program (RR97)

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Train Occupant Protection						
Train Control & Communications		X				
Grade Crossings & Trespass		X				

U.S. Trespass and Crossing Fatalities by Year



Program Objective

Partner with FRA to analyze crash causation and develop safety countermeasures, programs, and guidance to:

- Reduce the number of fatalities at grade crossings
- Reduce the number of fatalities due to trespassing

Research Method

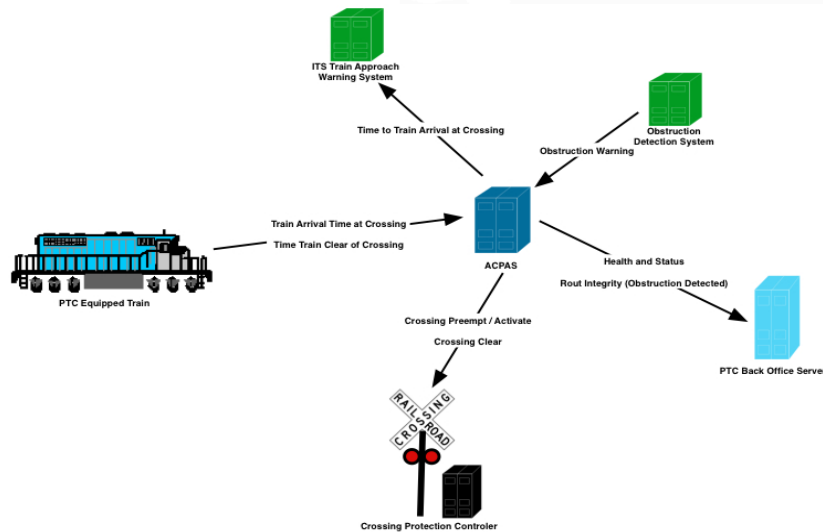
- Research the root cause of incidents and fatalities
- Engineer low cost technical solutions
- Involve the communities
- Identify corrective action
- Deploy most effective solutions
- Evaluate effectiveness



Sponsored by the FRA Office of Research and Development - Signal, Train Control and Communications Division (RPD-33)

Current Project Highlights

PTC-Based Grade Crossing Train Detection and Warning System



Project Description:

- Phase I – Technology Assessment
 - Literature Review and Industry Outreach
 - Implementation Plan
- Phase II – Conceptual Development
 - ConOps & System Requirements Spec
 - Vetting by industry stakeholder group
- Phase III-Prototype Development
 - Advertise RFP
 - Prototype development
 - Field Test and Evaluation
 - FRA Report and Research Result

Railroad Impact:

- Less wayside infrastructure → lower costs
- Technology Transfer from PTC → lower risk
- Opportunity to leverage with other activities at TTC:
 - Positive Train Location Proof of Concept
 - FRA R&D radio navigation research
- Research Needs Workshop relevance: NTO-1 (ranked 10th)

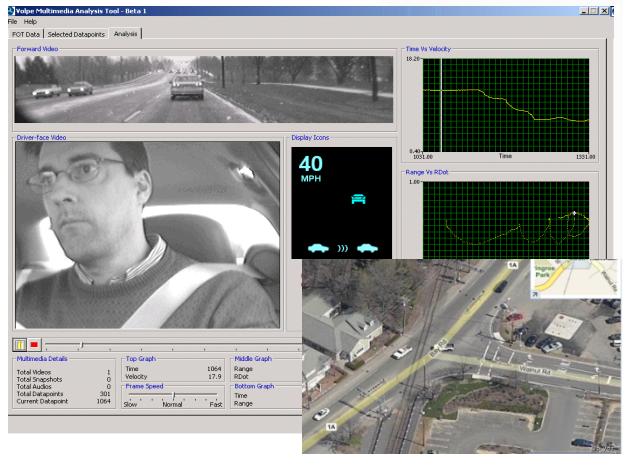
FRA Task Monitor: Tarek Omar

Schedule (3 years):

- Phase I – **Completed 8/10**
 - Phase II – 10/1/11 – 5/15/12¹
 - Phase III- 5/15/12 – 5/1/14
- ¹Phase II was delayed due to reprogramming of TTCL Task Order 219 to support this research

Project Partners: FRA/Volpe Center, TTCL, railroad suppliers, or other

Driver Behavior Analysis Using Field Operational Test Data



Railroad Impact:

- Study of real-world driver behavior using data already collected by the Volpe Center.
- 2004 Audit by Office of the IG attributed 94% of the incidents and 87% of the fatalities at grade crossing from '94-'03 to risky driver behavior or poor judgment.
- Identify potential education/awareness strategies that would best mitigate risky driver behavior at crossings.
- Research Needs Workshop relevance:
 - Evaluate effectiveness and potential motorist and pedestrian signage and treatments (4th)
 - Driver Decision Making at Complex Crossings (14th)

Project Description:

- Study driver behavior at grade crossings by analyzing Field Operational Test (FOT) data obtained from NHTSA evaluations of Integrated Vehicle-Based Safety Systems (IVBSS) heavy trucks
- Volpe was the independent FOT evaluator and retains the FOT data, which consists of a multitude of vehicle numerical data (including GPS) as well as driver and scene video data.

Schedule (2+ years):

- FY09-10:** Develop software tools and database
- FY10-11:** Perform data analysis on light vehicle data, obtain and analyze heavy vehicle FOT data
- FY12:** Conduct additional targeted data analysis

Project Partners: FRA/Volpe Center, NHTSA.

Trespass Prevention Research Study (TPRS)



Trespass Event at South End of West Palm Beach Station

Railroad Impact:

- Reduce trespass fatalities within the rail networks in West Palm Beach, Florida, provide support to zero tolerance for trespass events onto the right-of-way.
- Demonstrate potential benefits, including documenting best practices and lessons learned, of implementation and evaluations conducted within the study area.
- Develop a risk-based safety management approach to trespass mitigation (428 trespass deaths in 2010)
- Research Needs Workshop relevance:
 - RE-2 (ranked 20th)

Project Description:

- Project started in August 2009. Milestones completed: Created and facilitated Trespass Prevention Stakeholders User Group including all stakeholders within the **West Palm Beach Florida** geographical area. Conducted site visits. Develop plan for acquiring locomotive video information in line with SFRTA.
- Work with the TPRS stakeholder partnership to review the implementation of signs, barriers and education efforts. Evaluate potential benefits of the lessons learned from local activities. Develop strategies for further reduction of trespass events within the study area.
- Evaluate additional strategies through before and after data collection efforts.
- Document results via research results and reports and support the development of a US Guidance document on Trespass Reduction Strategies.

Schedule (3 years):

FY09-10: Develop stakeholder partnership

FY10-11: Evaluate current activities; develop new strategies; test new strategies; data analysis (observations, interviews)

FY11-12: Report and Research Result

Project Partners: FRA R&D and RR Safety/Volpe Center, SFRTA, CSX, FEC, AMTRAK, West Palm Beach Florida and Palm Beach County stakeholders

Trespass Prevention Research Study (TPRS)

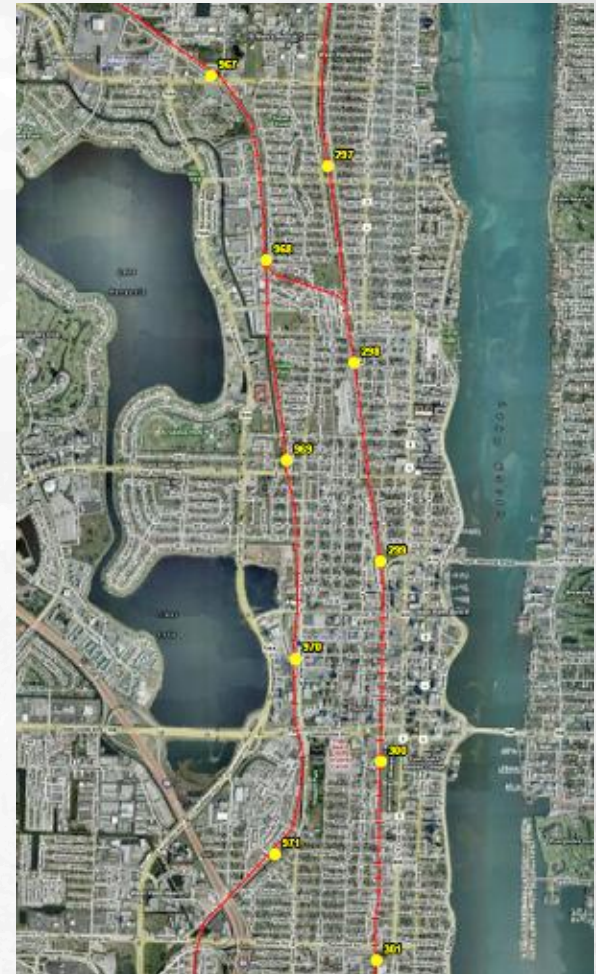
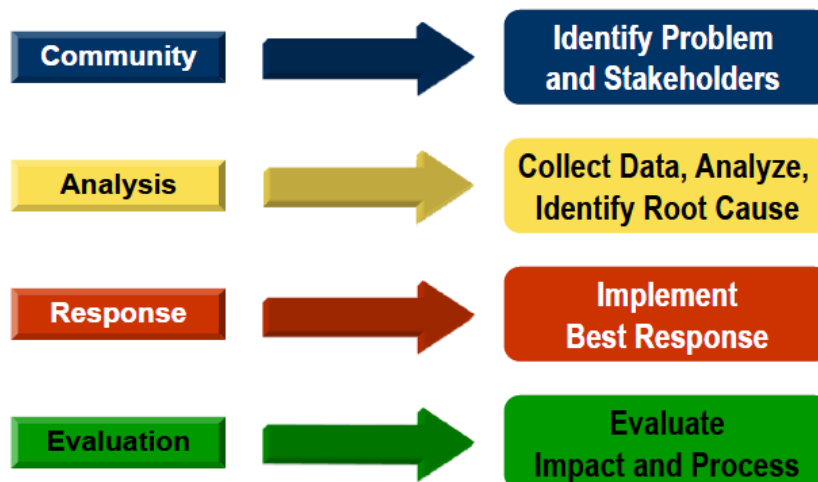
Research Objective

- Eliminate trespasser incidents and fatalities
- Provide national guidance on trespass mitigation

Study Area

- City of West Palm Beach, FL (2 corridors)
 - SFRTA, CSX, Amtrak (milepost 966-973)
 - FEC (milepost 296-301)

Approach:



TPRS Stakeholders



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



**West Palm Beach
Neighborhood Associations**

**PALM BEACH COUNTY
SHERIFF'S OFFICE**

Key Success Factors

- Reduced the GC & Trespassing Fatalities as mentioned before
- Advanced GC research are anticipated to support/assist the upcoming PTC system in 2015
- Public awareness trend is improving
- Evaluating & advancing emerging technologies
- Orchestrating a successful collaborative effort between FRA, VOLPE, AAR, state DOTs, academia, suppliers and community groups
- Assisting the regulatory effort for the FRA safety division