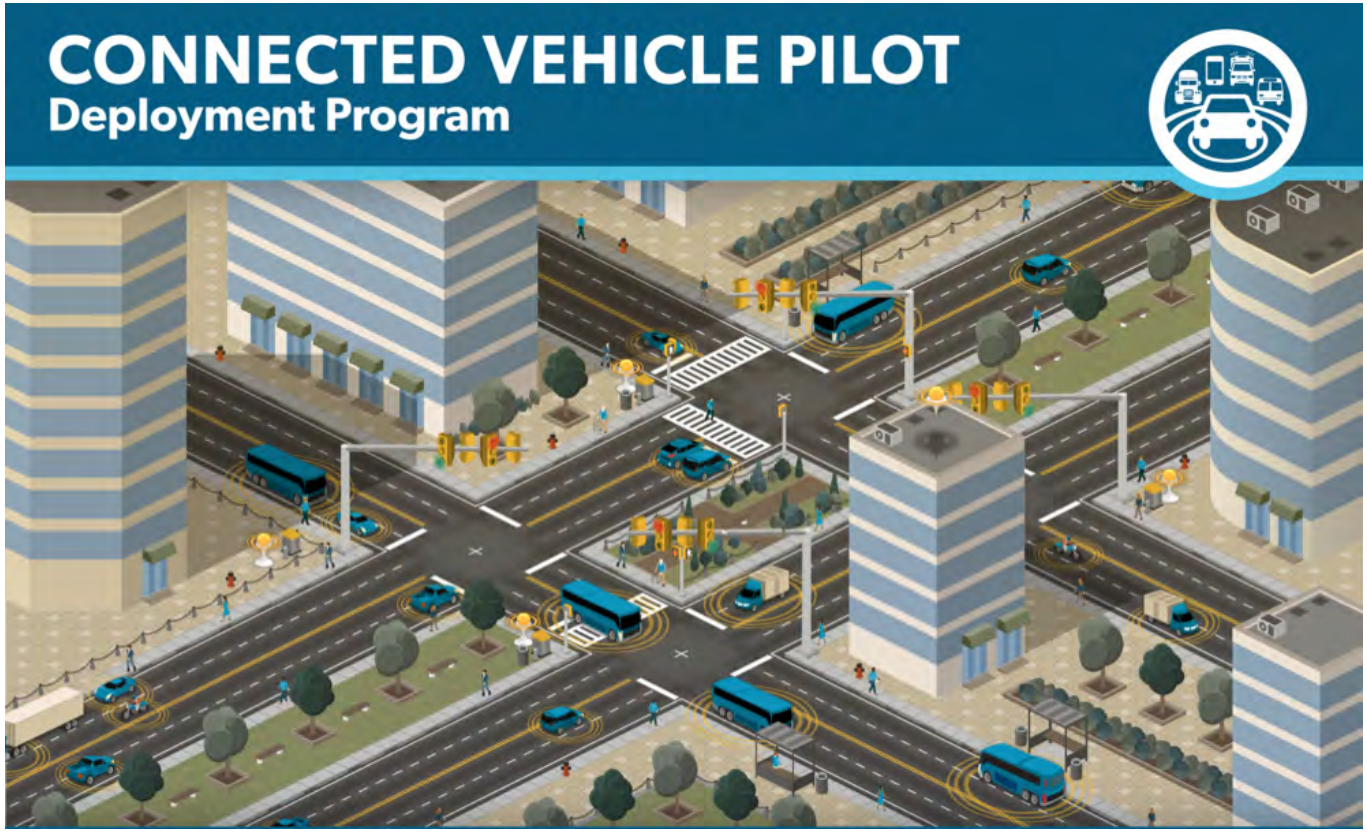
U.S. Department of Transportation
Federal Highway Administration

Tampa-Hillsborough Expressway Authority (THEA)

CONNECTED VEHICLE PILOT TAMPA



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HNTB

WI Steering Committee on Autonomous and Connected Vehicle Testing and Deployment

November 15, 2017

Presentation

- Connected Vehicle (CV) Basics
- USDOT CV Pilot Background
- Tampa-Hillsborough Expressway Authority (THEA) CV Pilot
  - Project Goals
  - Contract Specifics
  - Traffic and Safety Challenges/Use Cases and CV Apps
  - Key enabling activities
  - Lessons Learned (so far)

What is a Connected Vehicle?

Vehicles that wirelessly exchange safety and traffic information with other vehicles, roadway infrastructure and personal devices (e.g. smartphones). Three key terms:

1. Vehicles connected to other vehicles (V2V)
2. Vehicles connected to roadway infrastructure (V2I/I2V)
3. Vehicles connected to other personal devices (V2X)

Is a CV the same as an Autonomous Vehicle?

No. The driver of a connected vehicle receives safety messages but remains in full control of the vehicle at all times.

However, Autonomous Vehicles will also have some element of connectivity for safe operations.

How do CVs connect?

Currently, CVs utilize dedicated short range communications (DSRC), which is similar to Wi-Fi (specifically 75MHz of spectrum in the 5.9GHz DSRC band, IEEE 802.11p).

Future, 5G cellular?

USDOT CV Pilot Program Background

- **2010-2014**: Prototyping and assessment of 36+ CV Applications
- **2012:** USDOT tested and proved CVs' safety potential with over 2,700 equipped vehicles operating on the streets of Ann Arbor, Michigan.
- **2015:** USDOT competitively awarded funding for further demonstration of CV technologies and benefits in "real-world" settings. Three locations (out of 40+ applications) selected/funded for pilots.

USDOT CV Applications

V2I Safety

- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Environment

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

USDOT CV Applications (cont.)

Mobility

- Advanced Traveler Information System
- Intelligent Traffic Signal System
- (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

Road Weather

- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

Smart Roadside

- Wireless Inspection
- Smart Truck Parking

Agency Data

- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

1. New York City

- Safety application focus, “Vision Zero”
- Dense, large city application (Manhattan and Brooklyn)
- V2V, V2I, I2P (pedestrian)
- 8000 fleet vehicles (bus, delivery, DOT, taxi)
- 300 roadside units (RSUs)

2. Wyoming DOT

- Freight, weather, safety and travel reliability, road conditions focus
- I-80 corridor, critical interstate connector
- V2V, V2I
- 400 fleet vehicles
- 75 roadside units (RSUs)

3. THEA/Tampa

Project Goals

1. Develop and deploy CV infrastructure to support proposed applications.
2. Improve mobility in the Central Business District.
3. Reduce the number of safety incidents within the Pilot Area.
4. Reduce environmental impact within the Pilot Area.
5. Improve agency efficiency.
6. Develop a business environment for sustainability.

USDOT THEA CV Pilot Contract

- Agreement between USDOT and THEA
- Budget - **$21,519,832**:
  - Phase 1: Concept Development $2,443,071 (100% Fed.)
  - Phase 2: Design/Deploy/Test $13,905,548
  - Phase 3: Maintain/Op Pilot $5,171,213
- $3,815,352 (20%) hard cash THEA match for Phase 2/3 (THEA funded entirely by toll revenues)

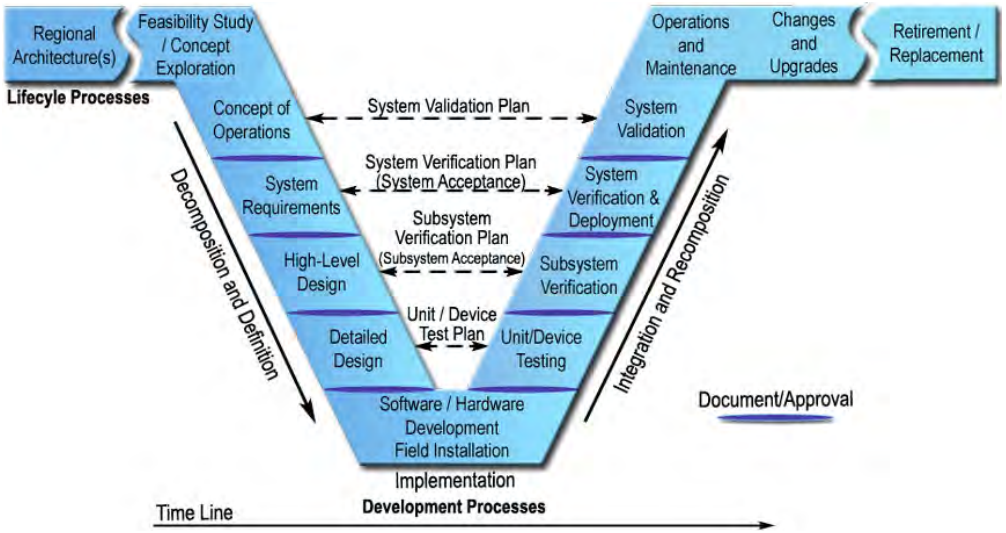
Source: THEA

USDOT THEA CV Pilot Contract (cont.)

- Schedule (~ 50 months):
  - Phase 1 Concept Development: **9/2015 - 9/2016**
  - Phase 2 Design/Deploy/Test: **9/2016 - 4/2018**
  - Phase 3 Maintain/Op Pilot: **4/2018 – 1/2020**
- All elements deployed in the pilot will be permanent
- THEA funding programmed FY2017 through FY2047 ($0.5M-$1.5M/year) to support automated and connected vehicles (including continuation and expansion of pilot)
- Exploring other funding opportunities including Mobility as a Service (MaaS) Concessionaire

USDOT THEA CV Pilot Contract (cont.)

Rigorous systems engineering and reporting process



Reports/Documentation

- Concept of Operations
- Outreach Plan
- Human Use Approval Summary
- Participant Training and Stakeholder Education Plan
- Partnership Status Summary
- Comprehensive Pilot Deployment Plan
- Application Deployment Plan
- Deployment Readiness Summary
- Data Privacy Plan
- Data Management Plan

Other THEA CV Pilot Contractual Arrangements

- THEA Contracts and Partnerships: HNTB, Siemens, BrandMotion, Global-5 Communications, USF CUTR
- THEA and City of Tampa (Operations Interlocal Agreement)
- City of Tampa and FDOT
- THEA and Hillsborough Area Transit Authority

Tampa Use Cases

Use Case	Condition	Location
UC1	Morning Backups	Selmon Expressway REL at E. Twiggs Street
UC2	Wrong Way Entry	REL at E. Twiggs Street and Meridian Street
UC3	Pedestrian/ Vehicle Conflicts	E. Twiggs Street at George E. Edgecomb Courthouse
UC4	Traffic Progression	Meridian Street to MAFB
UC5	Transit Trip Time, Transit Safety	REL to Marion Street Transit Mall
UC6	Trolley/Auto/Pedestrian/Bike Conflicts	Channelside Drive

Downtown Tampa Deployment Area

THEA Pilot CV Applications

APPLICATION	DESCRIPTION
End of Ramp Deceleration Warning (ERDW)	Alerts driver approaching ramp curve with speed safety warning
Emergency Electronic Brake Light (EEBL)	Enables broadcast to surrounding vehicles of severe braking
Forward Collision Warning (FCW)	Warns driver of impending collision ahead in same lane
Intersection Movement Assist (IMA)	Indicates unsafe (i.e., wrong way) entry into an intersection
Intelligent Traffic Signal System (I-SIG)	Adjusts signal timing for optimal flow along with PED-SIG and TSP
Probe Date Enabled Traffic Monitoring (PDETM)	Uses vehicles as probes to calculate travel times
Transit Signal Priority (TSP)	Allows transit vehicle to request and receive priority at a traffic signal
Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV)	Alerts transit vehicle driver that a car is attempting to turn right in front of the transit vehicle as well as the driver of the car.
Wrong Way Entry (WWE)	Warns driver of potential and actual Wrong Way travel direction

THEA Pilot CV Applications (cont.)

APPLICATION	DESCRIPTION
Pedestrian Collision Warning (PCW)	OBU application warning drivers of potential conflicts with pedestrians
Pedestrian Safety	Single pedestrian information device application
Pedestrian in a Signalized Crosswalk (PED-X)	Alerts vehicle to the presence of pedestrian in a crosswalk
Pedestrian Mobility (PED-SIG)	Gives pedestrians priority with signal phase and timing
Pedestrian Transit Movement Warning (PTMW)	Provides informational warnings to pedestrians that a bus or streetcar is starting up / stopping at an intersection

Use Case: Morning Queue Crashes

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

- Forward Collision Warning (FCW)
- Emergency Electronic Brake Light (EEBL)
- End of Ramp Deceleration Warning (ERDW)

Morning Queue Crashes

(live demo Nov. 13, 2017)

End of Ramp Deceleration Warning

Forward Collision Warning

Use Case: Wrong-Way Drivers

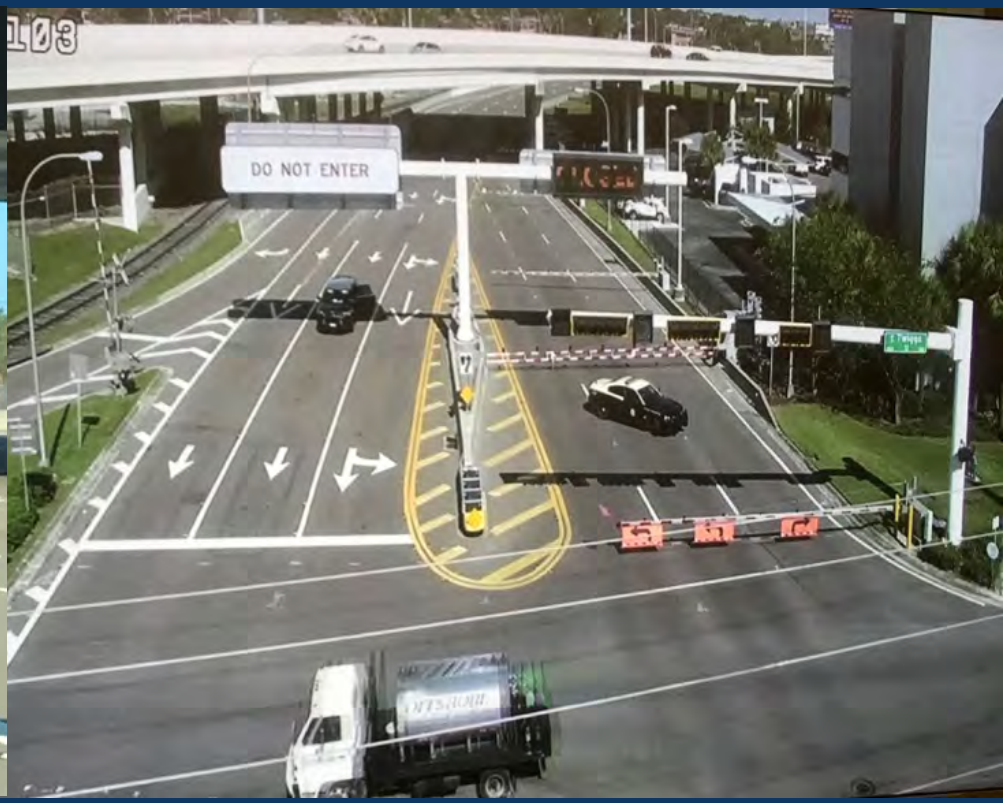
PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

- **Wrong-way Entry**
- **Intersection Movement Assist (IMA)**
- **Signal Phasing and Timing (SPaT)**

Use Case: Wrong-Way Drivers

(live demo Nov. 13, 2017)

Photo of In-Vehicle “Wrong Way” Warning



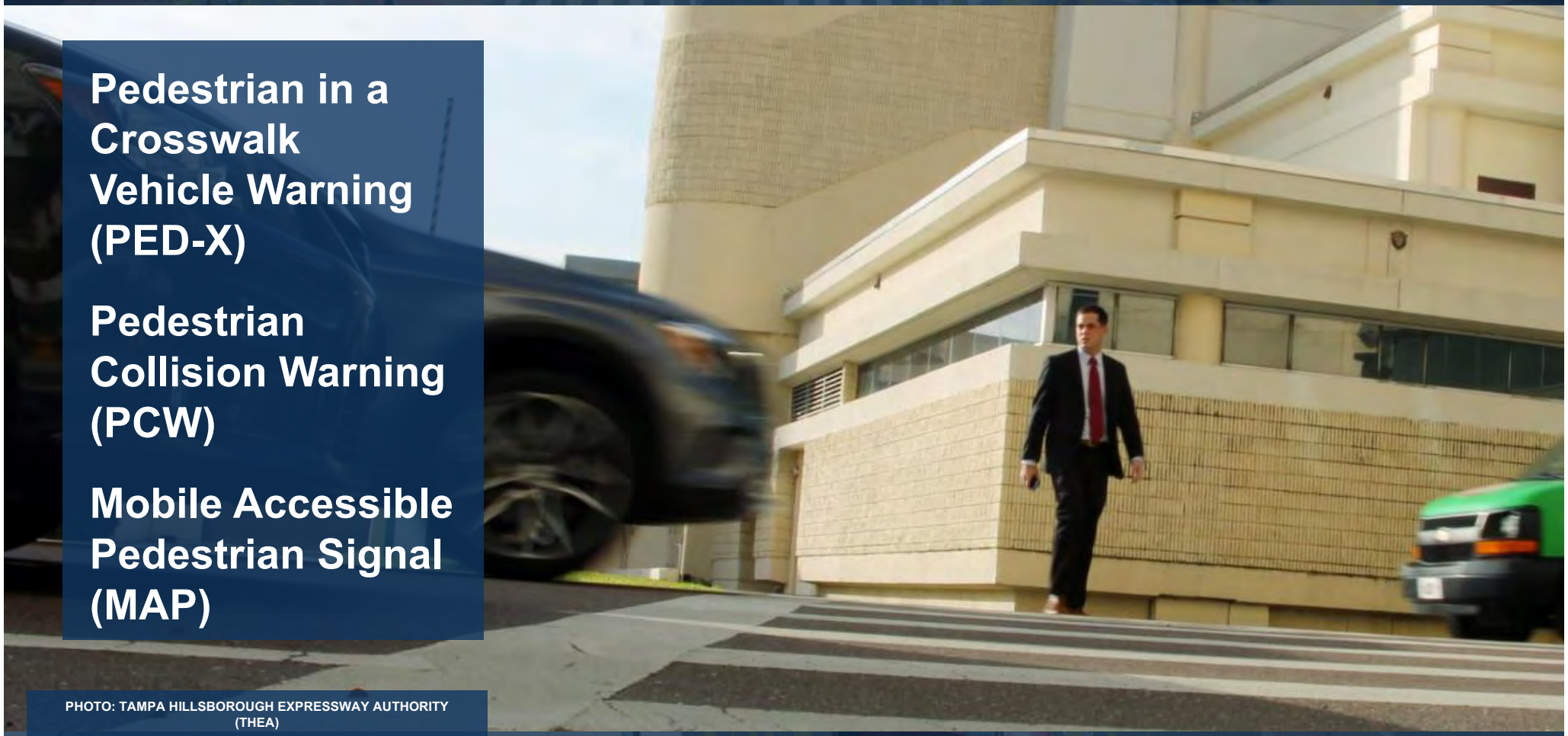
Traffic Management Center Video Image of Problem Intersection

Use Case: Wrong-Way Drivers

(live demo Nov. 13, 2017)

Photo of Approaching Vehicle “Wrong Way” Warning

Use Case: Pedestrian Safety



- Pedestrian in a Crosswalk Vehicle Warning (PED-X)
- Pedestrian Collision Warning (PCW)
- Mobile Accessible Pedestrian Signal (MAP)

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Use Case: Transit Efficiency

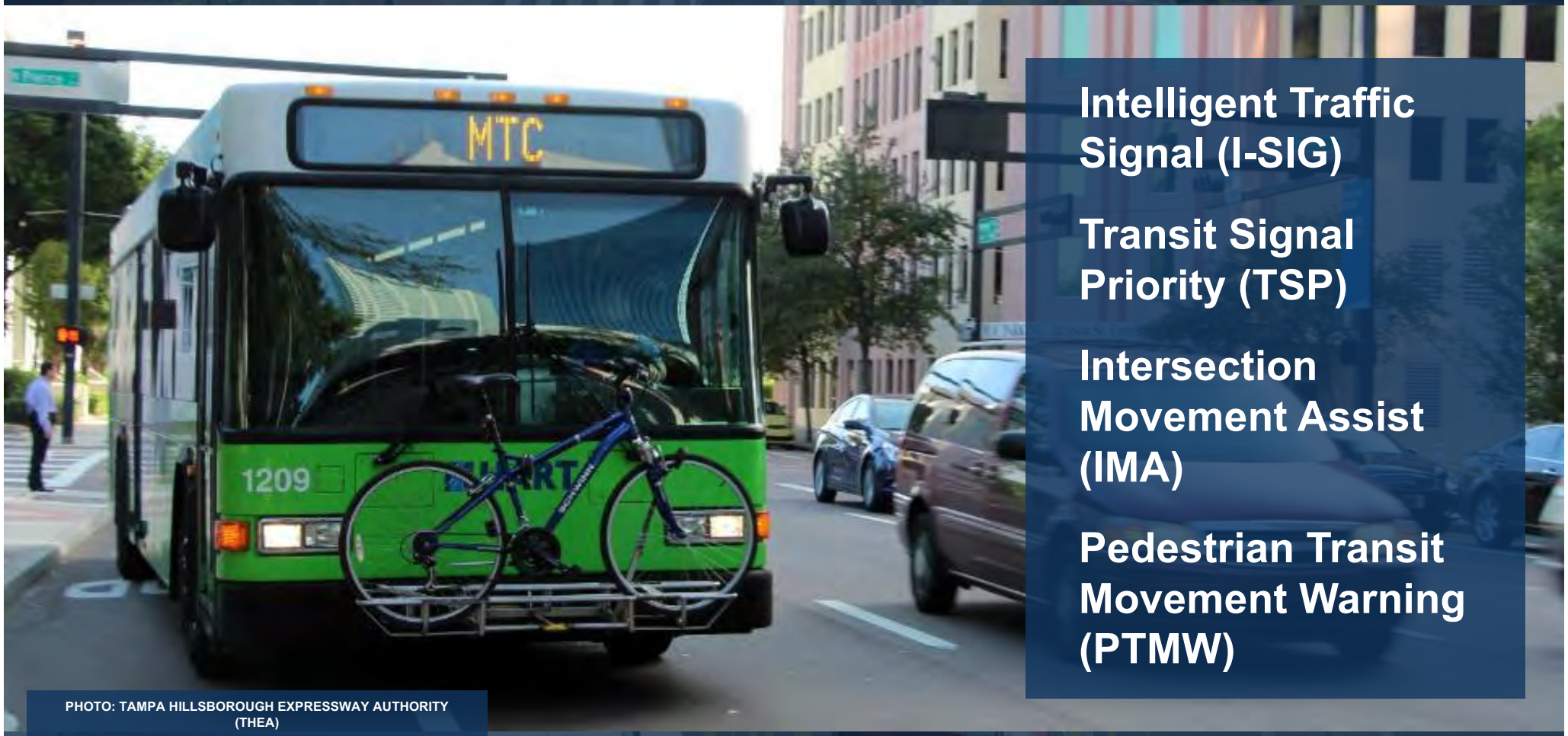


PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

- Intelligent Traffic Signal (I-SIG)
- Transit Signal Priority (TSP)
- Intersection Movement Assist (IMA)
- Pedestrian Transit Movement Warning (PTMW)

Use Case: Streetcar Conflicts/Safety

Vehicle Turning Right in Front of Transit Vehicle (VTRFTV)

Pedestrian Transit Movement Warning (PTMW)

PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

Use Case: Traffic Management

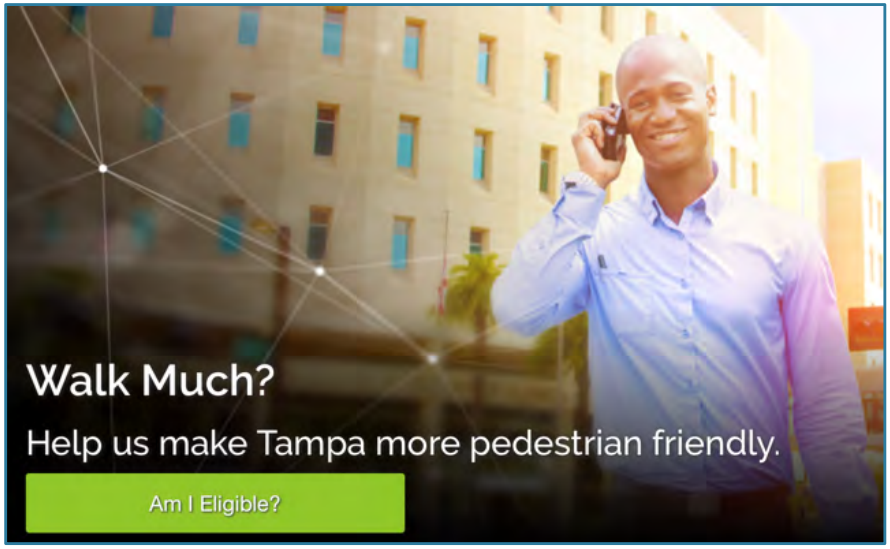
PHOTO: TAMPA HILLSBOROUGH EXPRESSWAY AUTHORITY (THEA)

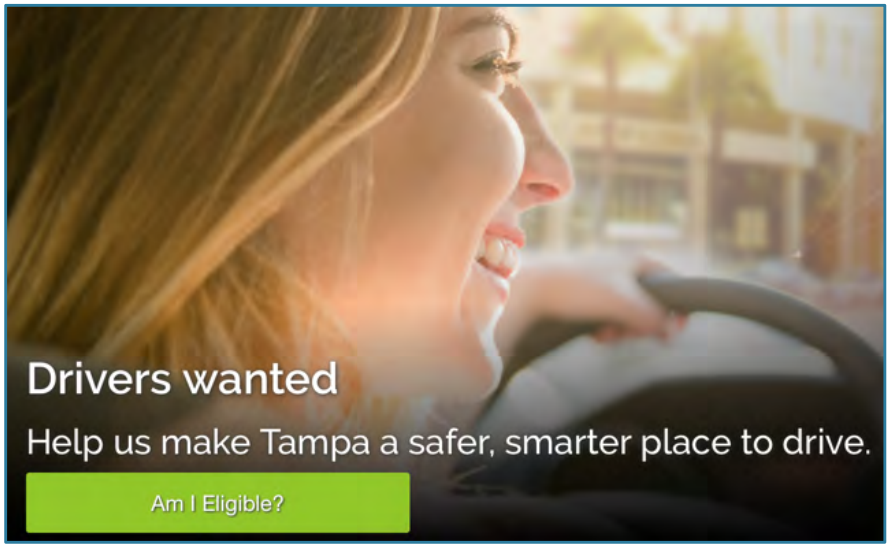
- Probe Data Enabled Traffic Monitoring (PDETM)
- Intelligent Traffic Signal (I-SIG)
- Intersection Movement Assist (IMA)

Comprehensive Outreach Plan

- Audiences and Messages
- Outreach Products: Digital, Print, Exhibits and Signs
- Distribution Strategies: Local and National
- Identity and Brand Management
- Media Relations
- Evaluation
- Crisis Communication Plan

Extensive Participant Recruiting

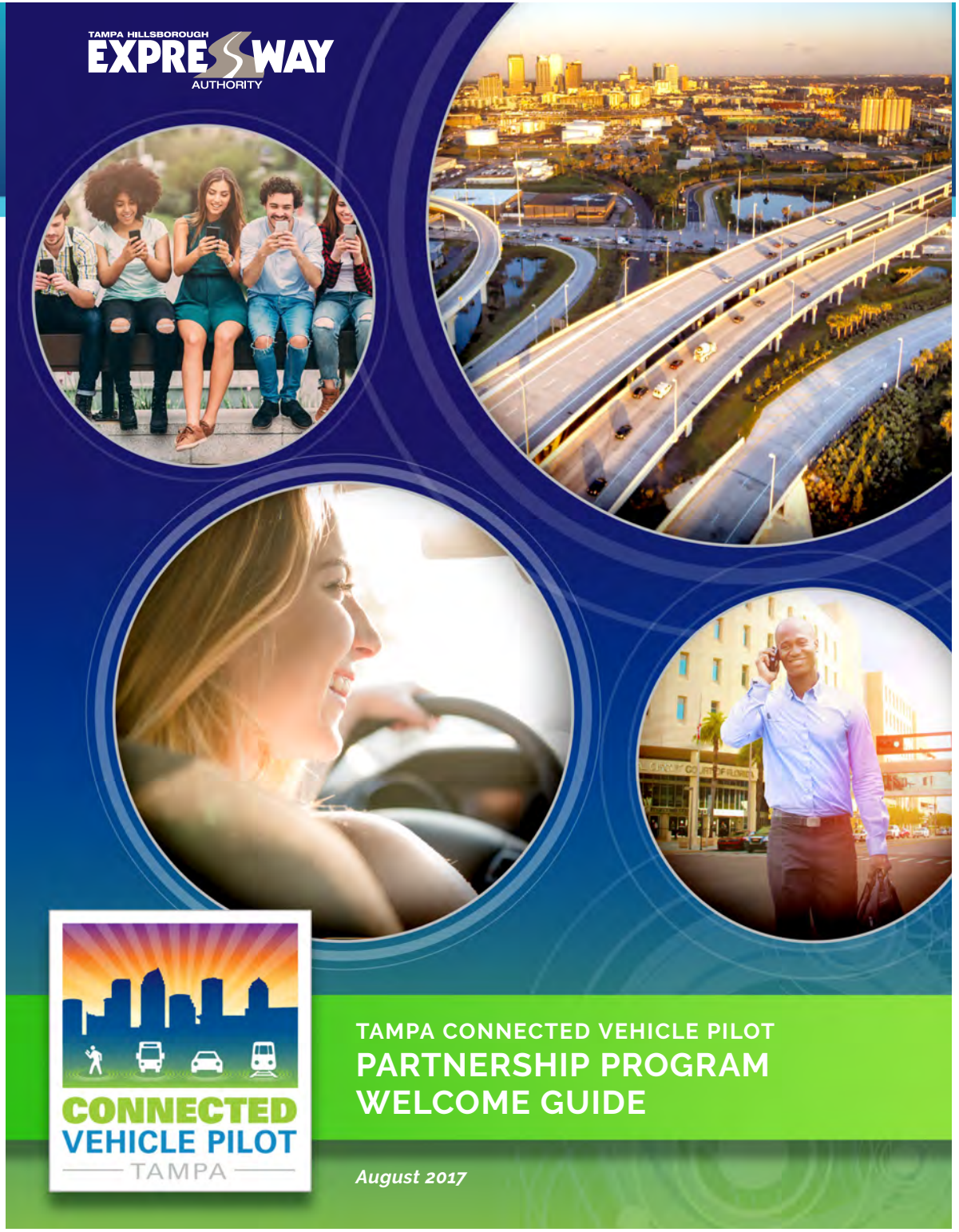




- No changes to state/local laws needed
- Human “experiment”, 3rd Party Institutional Review Board (IRB) approval requirements
- Specific eligibility criteria and screening process
- Informed Consent Document (ICD)
- Personally Identified Information (PII) and privacy considerations

Incentives

- 30% rebate on tolls (up to $550)
- Keep equipment
- Community
- Events, parties, prizes
- Exclusive updates
- Recognition



Participants and Devices

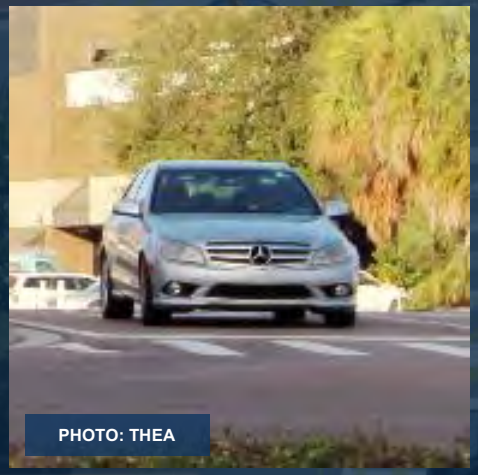


PHOTO: THEA


PHOTO: NPR

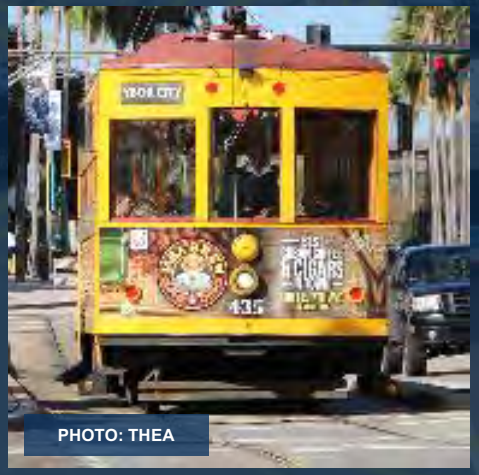

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PHOTO: THEA

1,600
Privately Owned Vehicles

500+
Pedestrian Smartphones (Android devices only)

10
TECO Line Streetcar Trolleys

10
Hillsborough Area Regional Transit (HART) buses

Participants and Devices

Smart Antenna

- SiriusXM
- DSRC V2I / I2V
- DSRC V2V

Equipment

PHOTO: THEA

PHOTO: SIEMENS

20

On-Board Transit Units (OBUs)

Tablet display for transit vehicles

40

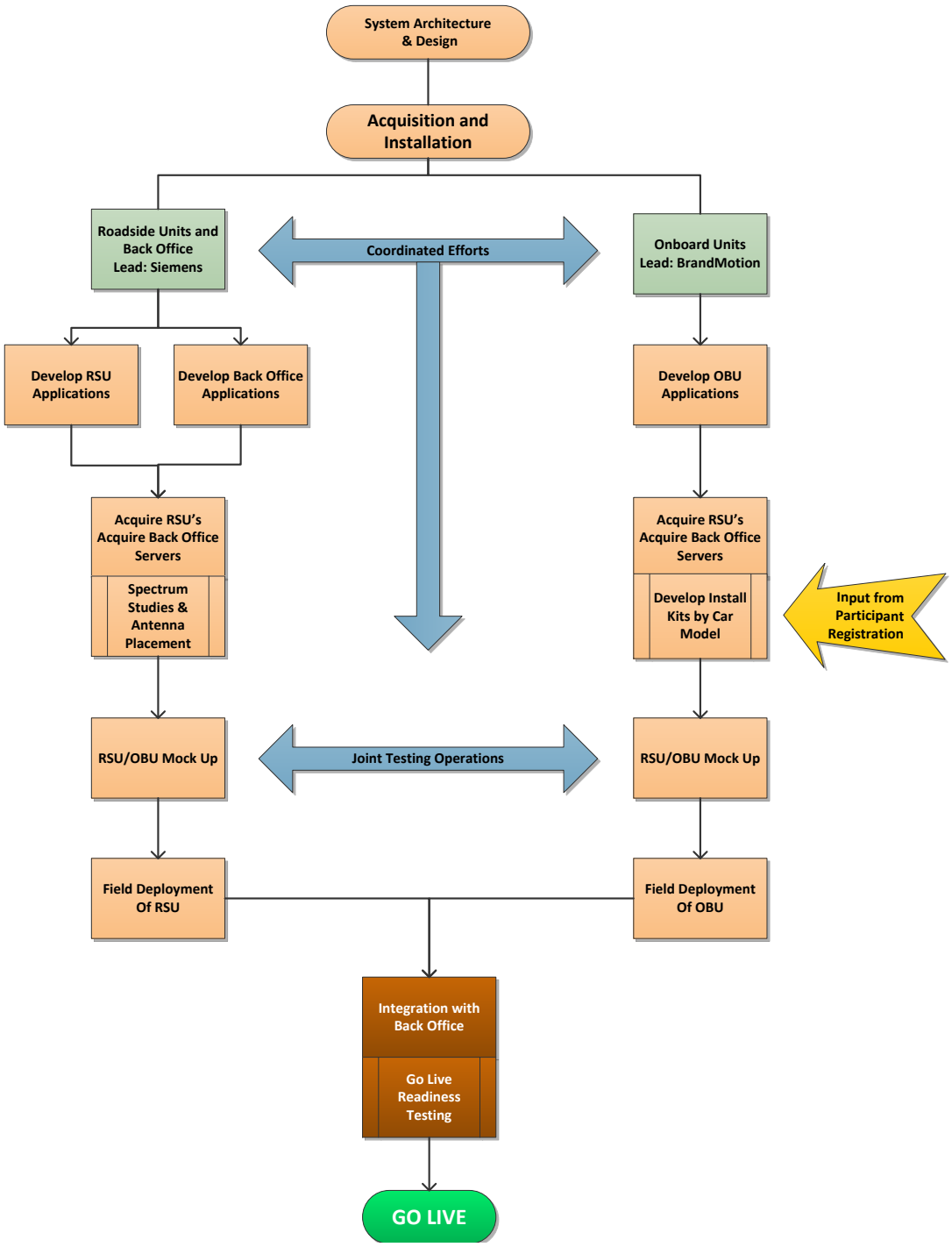
Road Side Units (RSUs)

Mounted on existing structures throughout the deployment area

Deployment

- Road Side Units (RSUs) installation by Siemens
- Participant On-Board Units (OBUs) installation by auto mechanic students at Hillsborough Community College
- Bus OBUs by HART mechanics
- Maintenance by THEA contractors, City of Tampa and FDOT
- Various software installation support and system integrators
- TMC operations

THEA CV-Pilot Deployment Plan Flow Chart



Structured Performance Measurement and Evaluation

- Performed by Center for Urban Transportation Research (CUTR) at the University of South Florida (USF)
- Data Collection/Management:
  - Administrative participant data
  - CV application data
  - Performance measurement data
- Closely tied to project goals and specific use cases

Lessons Learned (so far) - Program

- Do not lose sight of the real-world problems
- CV application maturity (and lack thereof)
- Roadway CV applications require high penetration (of equipped vehicles) to function properly. Gaps filled with traditional vehicle detector mechanisms.
- Adequate consumer/participant incentives
- Challenges with 1600 participant and 20 transit OBU installations

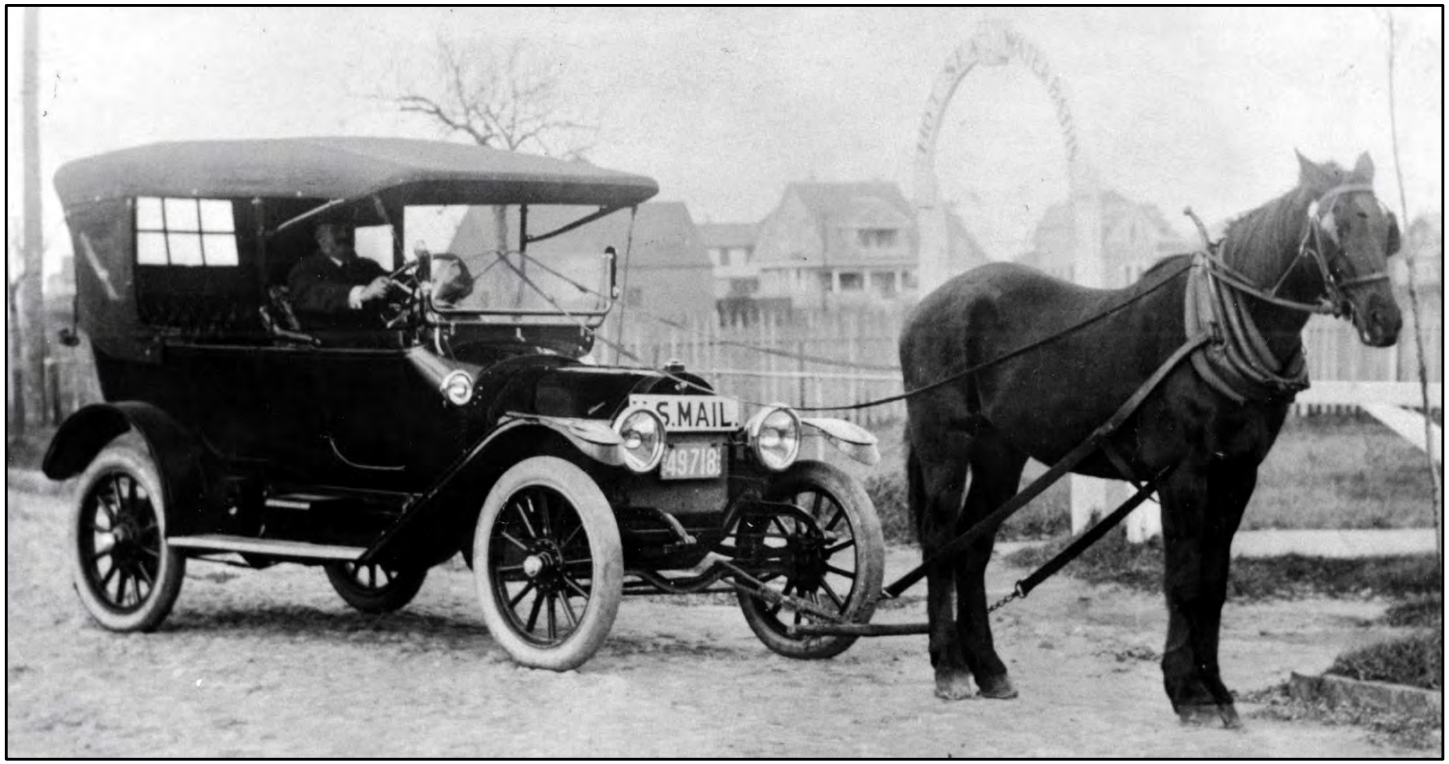
Lessons Learned – Infrastructure and In-Vehicle

- Multiple tech scans using RFPs (with on the road testing) to identify promising suppliers who can meet system, cost and project timing, critical to scrutinize and select the best suppliers
- Early sourcing of suppliers is key to creating a collaborative environment
- Collaboration around common specifications and standards
- Need for complete and experienced project team- systems, infrastructure, vehicle systems, evaluation, etc.

In Closing…

"The success of the long-term operations requires a close working relationship amongst all partners for both policy and technical issues."

THEA CV Pilot Partnership Status Summary, FHWA-JPO-16-319



Thank You!

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