CONNECTED VEHICLE PILOT
Deployment Program

Insights, Challenges, and Lessons Learned from the Concept Development Phase – Tampa (THEA) Pilot Site

Govind Vadakpat, FHWA; Bob Frey, THEA; Stephen Novosad, HNTB; Steve Johnson, HNTB; Stephen Reich, CUTR

ITS Joint Program Office

TODAY'S AGENDA

- Purpose of this Webinar
  - To share the Comprehensive Deployment Plan from the **Tampa (THEA)** with the stakeholders of connected vehicle technologies.

- Webinar Content
  - Connected Vehicle Pilot Deployment Program Overview
  - **Tampa (THEA)** Comprehensive Deployment Plan
  - Stakeholder Q&A
  - How to Stay Connected

- Webinar Protocol
  - Please mute your phone during the entire webinar
  - You are welcome to ask questions via chatbox at the Q&A Section
  - The webinar recording and the presentation material will be posted on the CV Pilots website

Connected Vehicle Pilot Deployment Program Overview

Govind Vadakpat

Tampa (THEA) Pilot Site COR

Office of Operations R&D, FHWA

CONNECTED VEHICLE PILOT DEPLOYMENT PROGRAM

PROGRAM GOALS

STAY CONNECTED

- Participate in Concept Development Phase Webinars for the three Pilot Sites (see website for exact dates and times)

Feb 2016	Mar 2016	Apr 2016	May 2016	Jun 2016	Jul 2016	Aug 2016
◆◆	◆		◆◆◆			◆ ◆ ◆

Concept of Operations Webinars | **Performance Measurement Webinars** | **Comprehensive Deployment Plan Webinars**

- Visit Program Website for Updates: http://www.its.dot.gov/pilots
- Contact: Kate Hartman, Program Manager, Kate.hartman@dot.gov

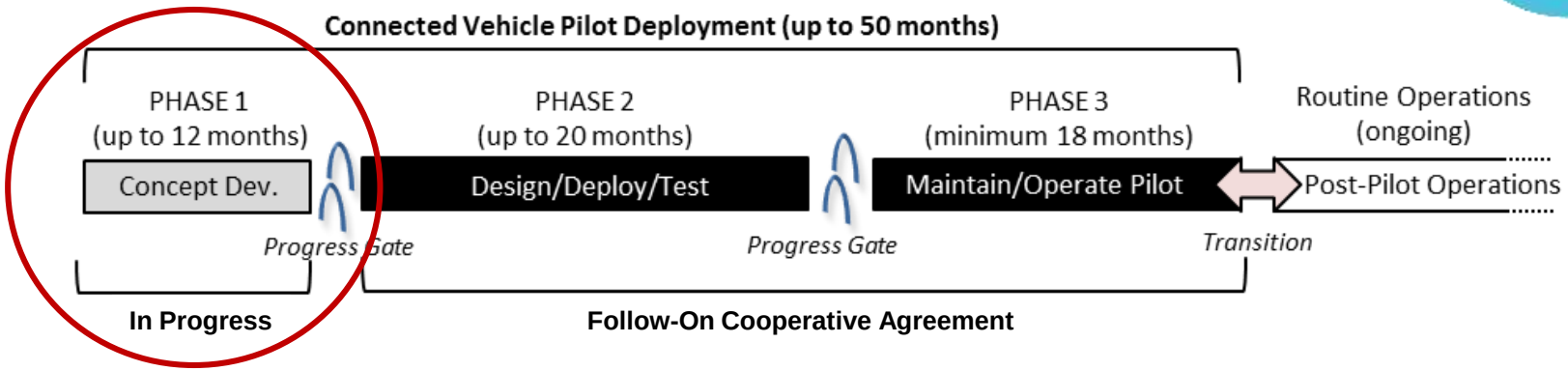
PILOT SITES

ICF/Wyoming DOT

NYCDOT

Tampa (THEA)

Moving from Concept Development Phase to Design/Deploy/Test Phase

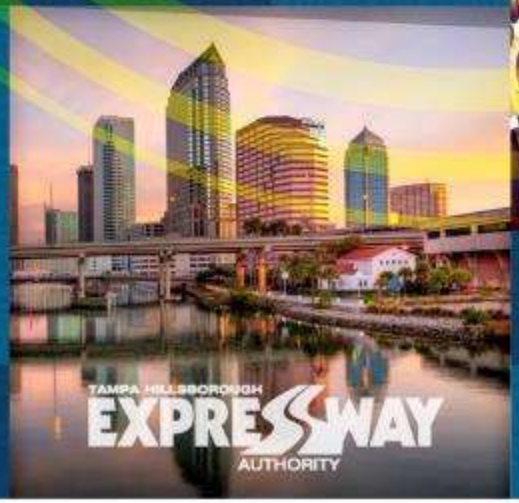


Sites are wrapping up Phase 1; projected Phase 2 Start in September 2016

- Phase 1: Concept Development (*Current Phase*)
  - Creates the foundational plan to enable further design and deployment
  - **Progress Gate: Is the concept ready for deployment?**
- Phase 2: Design/Deploy/Test
  - Detailed design and deployment followed by testing to ensure deployment functions as intended (both technically and institutionally)
  - Progress Gate: Does the system function as planned?
- Phase 3: Maintain/Operate
  - Focus is on assessing the performance of the deployed system
- Post Pilot Operations (CV tech integrated into operational practice)

Tampa (THEA)

Tampa Hillsborough Expressway Authority



Site Development Lead

Bob Frey, AICP

THEA Program Director and Site Development Lead

Tampa Hillsborough Expressway Authority (THEA)

PILOT AREA OVERVIEW

Extended Stakeholder Impact Area

Source HNTB

STAKEHOLDERS

- **Research Stakeholders**
  - USDOT JPO, FHWA, NTSA, RDE, OEM's, Independent Evaluator, Affiliate Test Bed Members, Future CV Deployers, Standards Bodies, Certification Entities
- **Key Partner Stakeholders**
  - City of Tampa, FDOT District Seven, Hillsborough Area Regional Transit Authority (HART), HNTB, Center for Urban Transportation Research (CUTR) at USF, Siemens, Brand Motion, Global 5 Communications (G5), Hillsborough Community College (HCC), CAMP, SiriusXM®, MetroTech®
- **Community Stakeholders**
  - MacDill AFB, Downtown Partnership, Chamber of Commerce, Hillsborough County MPO, Tampa PD, Hillsborough County Sheriff, FHP, Tampa FD/EMS, Amalie Arena, Tampa Shipping & Cruise Port, Tampa Civic Center, Straz Center for Performing Arts, Glazer Children's Museum, Channelside District, Tampa International Airport (TIA)
- **User Stakeholders**
  - Participant Motorists including MacDill AFB Commuters, Non-participant Motorists, HART Bus Drivers, TECO Line Trolley Car Drivers, Participant Pedestrians, Non-participant Pedestrians and Cyclists.

Deployment Goals

- **The stated goals of the USDOT CV Pilot Deployments research experiment are improving Mobility, Safety, Environment and Agency Efficiency through CV technology.**
  - **Goal 1: Develop and Deploy CV Infrastructure and Applications to Evaluate Effectiveness in Addressing the Identified Issues/Needs**
  - **Goal 2: Improve Mobility in the Central Business District (CBD)**
  - **Goal 3: Reduce the Number of Safety Incidents within the Pilot Area**
  - **Goal 4: Reduce Environmental Impacts within the Pilot Area**
  - **Goal 5: Improve Agency Efficiency**
  - **Goal 6: Develop Business Environment for Sustainability**

By the Numbers

- Number of Roadside Units: 40
- Number of Onboard Units - Vehicles:
  - 10 HART Buses
  - 10 HART (TECO Line) Trolley Cars
  - 1500 privately owned cars and light trucks
  - TBD number of nomadic devices, (smart phones, tablets, wearable bluetooth devices etc.)
    - Primary cost here is for application. Number of participants thereafter is only limited by enrollment.
    - Targets for recruiting in this segment are downtown condo associations and major office building tenant groups.

SYSTEMS ENGINEERING LEAD

Stephen Novosad, HNTB

CV Pilot Systems Engineering Lead

HNTB Corporation

Focused Pilot Deployment Area

Source HNTB

USE CASE 1 – MORNING PEAK HOUR QUEUES

Source HNTB

-
-

NEEDS

APPS

USE CASE 2 – WRONG WAY ENTRIES

NEEDS

APPS

Source HNTB

USE CASE 3 – PEDESTRIAN SAFETY

Source HNTB

-
-

NEEDS

APPS

Use Case 4 – Bus Rapid Transit Signal Priority Optimization, Trip Times and Safety

Source HNTB

- NEEDS

APPS

USE CASE 5 – TECO LINE STREETCAR CONFLICTS

-
-

NEEDS

APPS

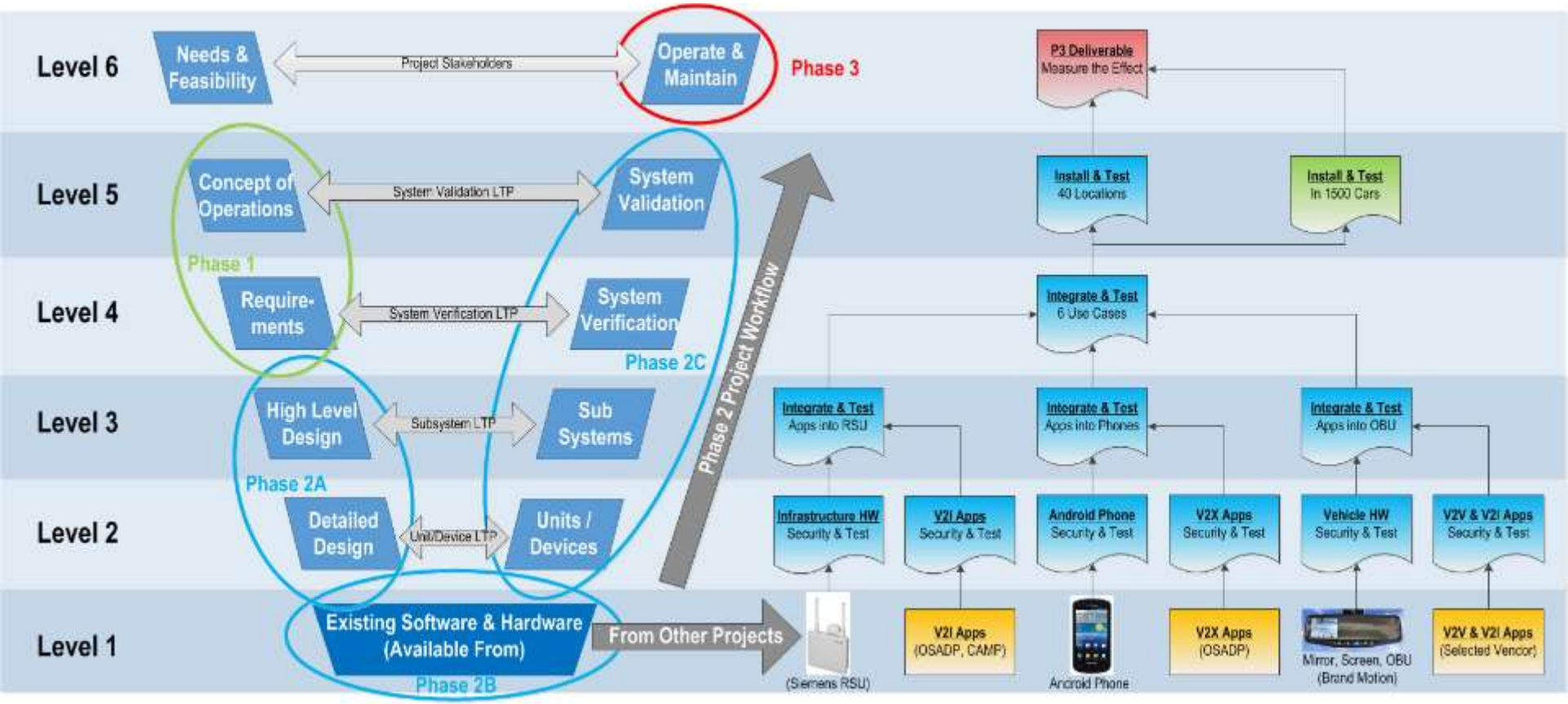
USE CASE 6 – ENHANCED SIGNAL COORDINATION AND TRAFFIC PROGRESSION

NEEDS

APPS

Source HNTB

System Engineering Process – How We Selected Sites/Apps



Source HNTB

CV Applications to be Deployed

Application	Description	Use Case
Curve Speed Warning	Alerts driver approaching curve with speed safety warning	1
Emergency Electronic Brake Light (EEBL)	Enables broadcast to surrounding vehicles of severe braking	1
Forward Collision Warning (FCW)	Warns driver of impending collision ahead in same lane	1,3
Intersection Movement Assist (IMA)	Indicates unsafe (i.e., wrong way) entry into an intersection	2
Pedestrian in a Signalized Crosswalk (PED-X)	Alerts vehicle to the presence of pedestrian in a crosswalk	2,4,6
Pedestrian Mobility (PED-SIG)	Gives pedestrians priority with signal phase and timing (PED-SIG)	2,4,6
Intelligent Traffic Signal System (I-SIG)	Adjusts signal timing for optimal flow along with PED-SIG and TSP	1,2,6
Vehicle Data for Traffic Operations (VDTO)	Uses vehicles as probes to detect potential incidents, (also called Probe-enabled Data Monitoring or PeDM)	6
Transit Signal Priority (TSP)	Allows transit vehicle to request and receive priority at a traffic signal	4
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	5
Red Light Violation Warning (RLVW)	Warns driver of potential of red light violation	2

Source HNTB

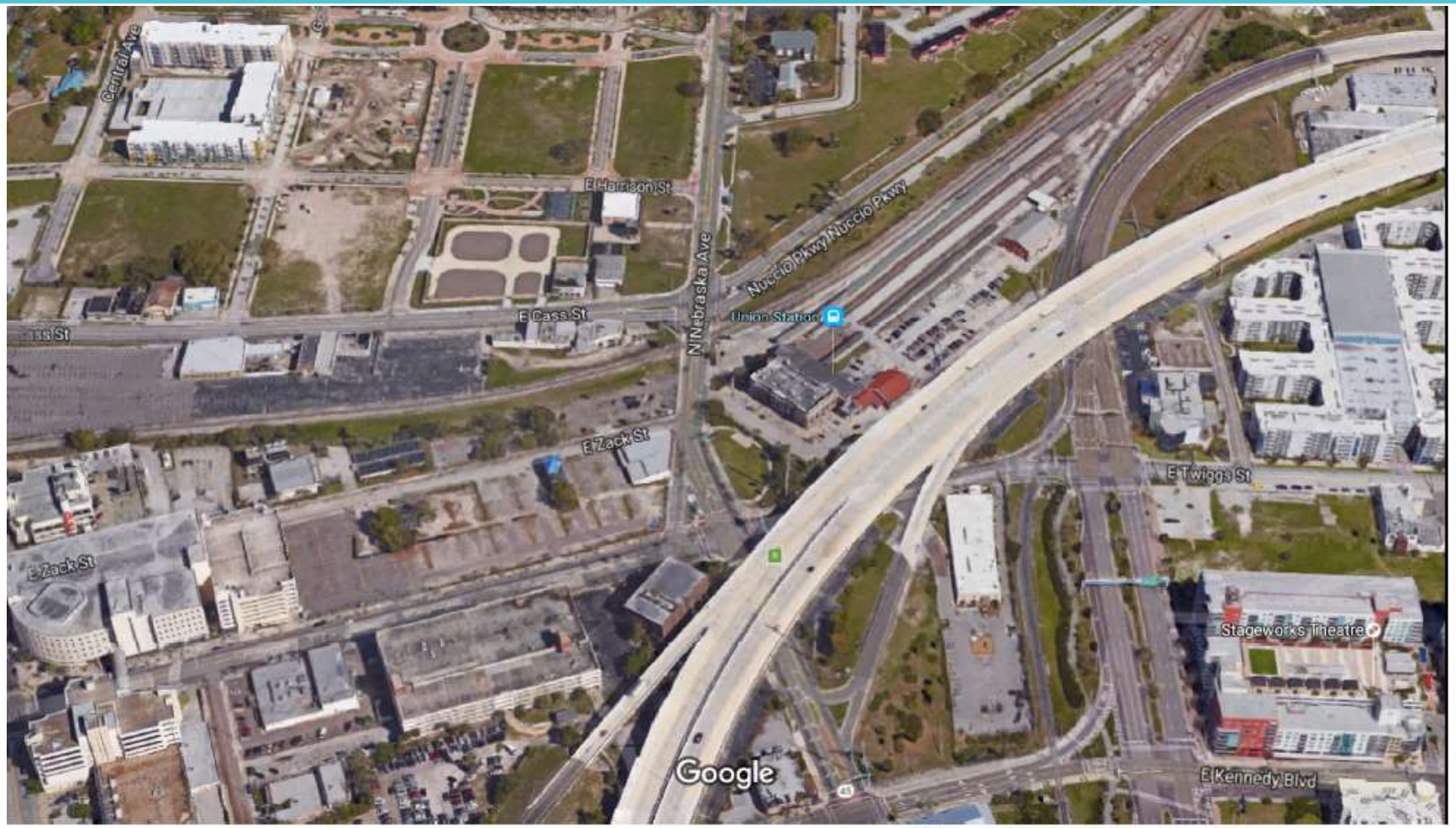
Pedestrian Conflicts – County Courthouse

Source HNTB

It's a Complex Problem

Source HNTB

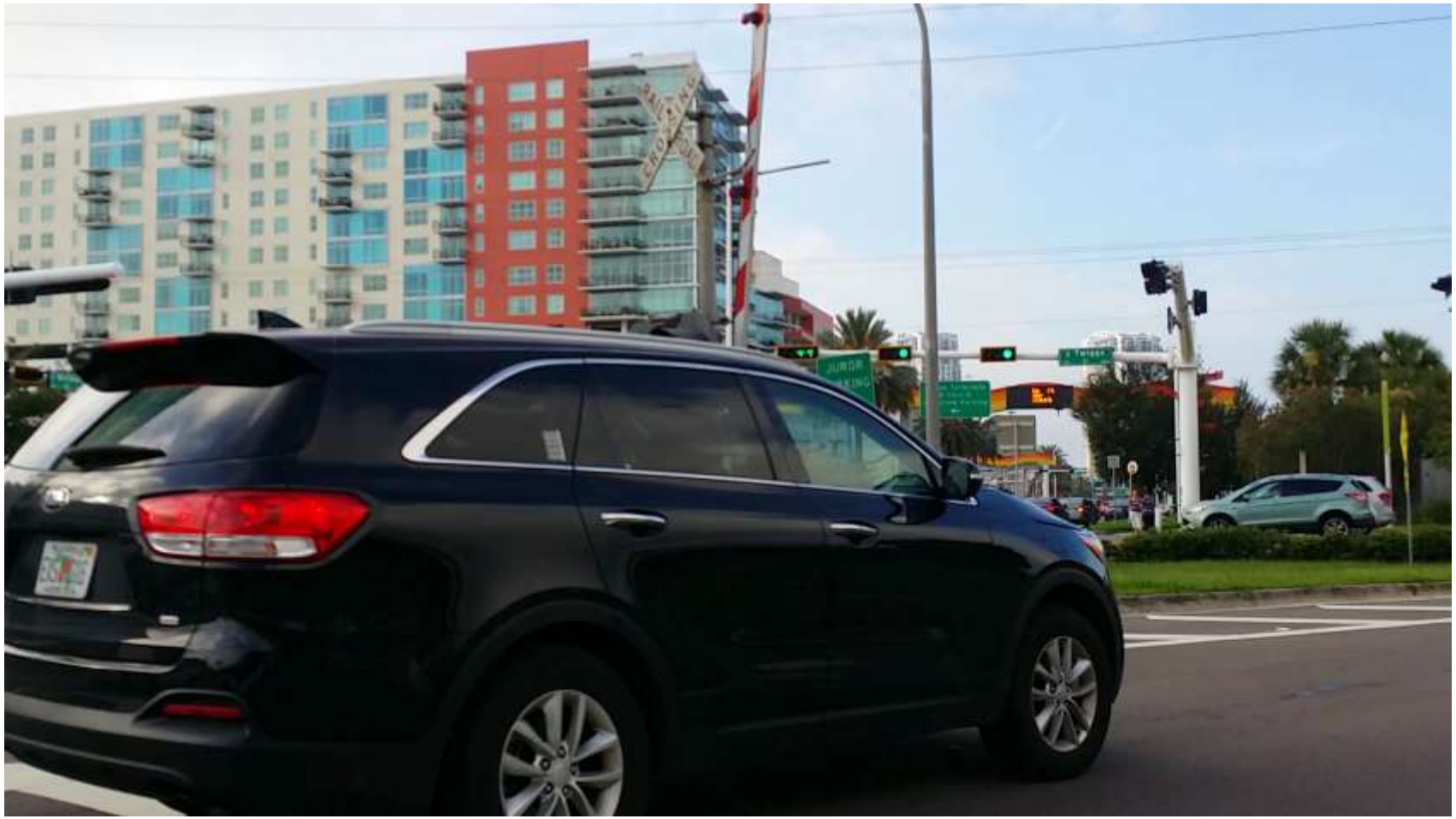
REL Exit Sweeping Curve



REL Exit Curve Congestion

Source HNTB

REL Exit Right Turn



Source HNTB

Vehicle Turning Right In Front of Trolley

Source: HART

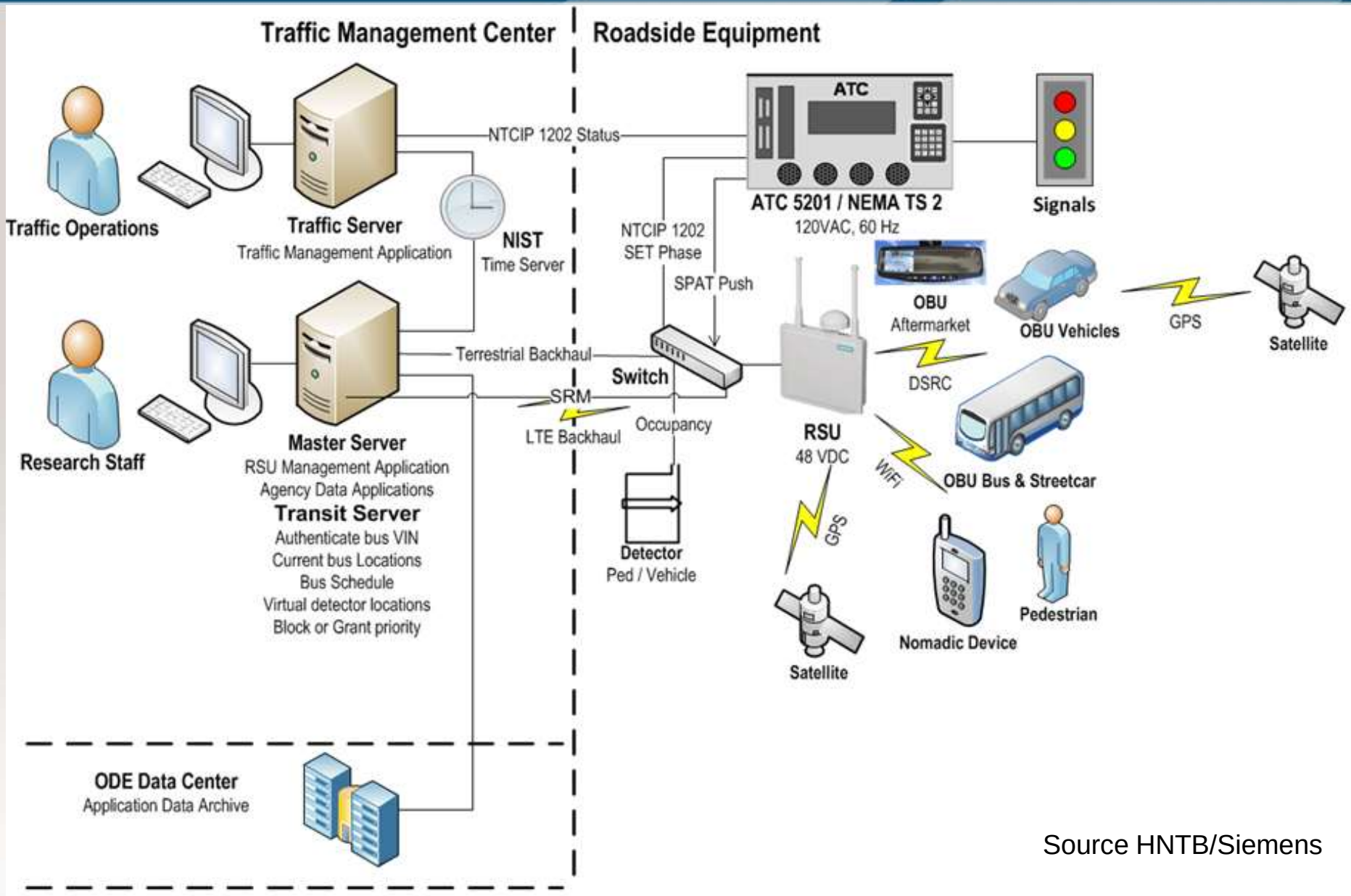
CV Apps Adaptation

- Forward Collision Warning (FCW)
  - Used as designed
- Emergency Electronic Brake Light (EEBL) Warning
  - Used as designed
- Curve Speed Warning (CSW)
  - Used as designed,
    - with input scaled to safe stopping distance
- Intersection Movement Assist (IMA)
  - Used as Designed
- Red Light Violation Warning (RLVW)
  - Used as designed to predict violation, plus added TIM warnings:
    - Before vehicle enters a closed ramp
    - To oncoming traffic when vehicle enters closed ramp
    - To Master Server when vehicle enters closed ramp for Law Enforcement
    - Warnings canceled when wrong-way vehicle exits or reverses direction

CV Apps Adaptation

- Intelligent Traffic Signal System (I-SIG)
  - Used as mathematically designed, plus:
    - Hard-coded site-specific test constants become configurable fields
    - Manufacture-specific constants become configurable fields
    - Generalize the hard-coded, fixed-phase sequences to configurable fields
- Probe Enabled Data Monitoring (PeDM) or Vehicle Data for Traffic Operations (VDTO)
  - Aggregate incremental BSM movements to travel time, incidents
- Pedestrian in signalized crosswalk warning
  - Translate WiFi PSM to DSRC BSM for FCW and IMA
- Mobile Accessible Pedestrian Signal System (PED-SIG)
  - Used as designed
- Transit Signal Priority (TSP)
  - Used as designed, plus:
    - Vehicle Identification Number (VIN) authenticated by HART central
    - Priority Request selectively granted or blocked by HART central
- Vehicle Turning Right in Front of Bus (VTRFB)
  - Used as designed except Transit vehicle is a trolley

Deployment Concept



Source HNTB/Siemens

TMC Operations Photos

Source: THEA / CoT

RSU Photos

Source: Siemens

HMI Photo

Mirror display uses sticker to depict location and concept of warning.
Actual image is still in development

Source: Brand Motion

Systems Engineering – Challenges / Lessons Learned

- Application maturity not as evolved as expected
- Evolving standards
- Concurrent planning documents development
- More direct interaction with other teams
- Use of non-CV technology as part of solution
- Security

PROGRAM MANAGEMENT LEAD

Steve Johnson, CVP

CV Pilot Program Management Lead

HNTB Corporation

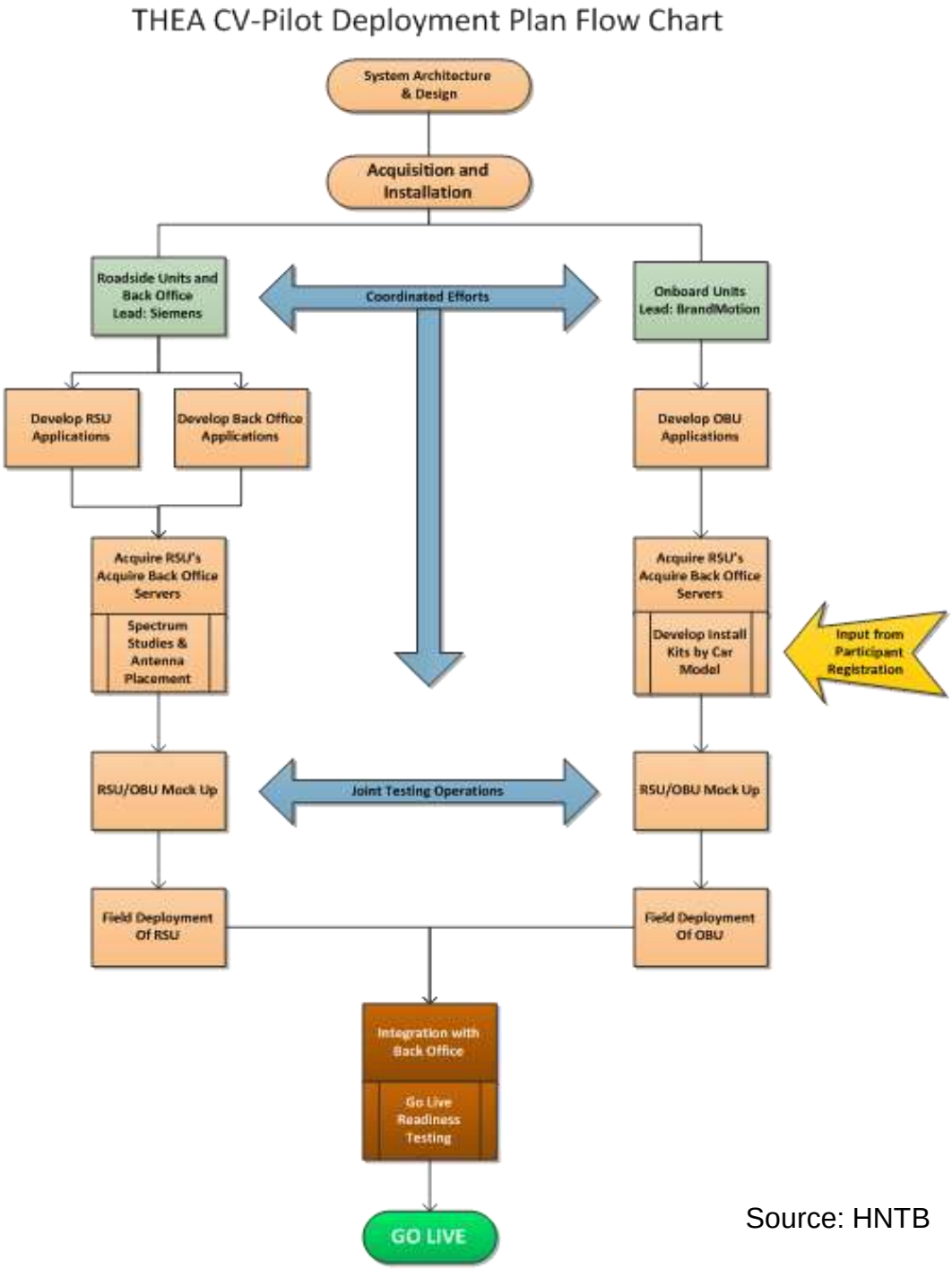
Management Approach – Processes and Team Makeup

- **Deployment Approach**
  - Relies on the System Engineering Documents from Phase 1
  - Distributes tasks functionally across dual paths
  - Leverage the key strengths of our core partners.
  - Separate acquisition/installation efforts for roadside equipment versus onboard equipment.
  - Systems engineering and final integration and testing efforts conducted jointly
  - Distributes accountability and risk
  - Cross-functional reviews and progress meetings ensure
    - interoperability,
    - requirements traceability and
    - Shared body of knowledge and lessons learned.

Deployment Approach Work Flow Diagram

- Siemens provides systems engineering and design for roadside units and TMC Operations
- Siemens provides hardware and applications acquisition, installation and testing for RSU and TMC
- Brand Motion provides systems engineering and design for onboard units
- Brand Motion provides hardware and applications acquisition, installation and testing for OBU

Overarching Systems Engineering, Design, integration and Testing is overseen by Systems Engineering Lead



Source: HNTB

Program Management – Challenges / Lessons Learned

- Challenges
  - A. Distributed Team Locations – Logistics
  - B. Aggressive Delivery Schedules
  - C. Balancing High Energy, Super Talented Teams with Need to have Centralized PM
  - D. HIGH Number of Stakeholders with Initially Low Level of Comprehension

- Lessons Learned
  - A. Importance of face to face progress meetings followed by breakout sessions
  - B. Critical documents have overlapping/redundant content.
    - a) Each progressive document must be reconciled with prior documents
    - b) QC/QA should include dedicated staff having no other project involvement
    - c) Reconciliation document for tracking these connected changes
  - C. Balance needed between empowering team leads to operate autonomously and maintaining centralized program management to keep all teams informed and connected
  - D. Need to not only engage early but to educate early as to the “Benefits” of the program and why their participation is key to success.

Performance Measurement and Evaluation

Stephen Reich, CUTR

CV Pilot Performance Measurement and Evaluation Lead

Center for Urban Transportation Research, University of South Florida

CUTR STAFFING

- Stephen L. Reich – Program Director – CUTR – program evaluation, transportation agency management, financing, operations, transportation performance metrics
  - Project Management, Staffing, Coordination, Executive Direction
  - Commitment – 50% Phase II, 70% Phase III
- Sisinnio Concas, Ph.D. Economics - urban and regional economics, economic impact analysis, travel demand modeling, econometric modeling.
  - Environmental Metrics, Experimental Design, Confounding Factors, Data Structure, Analysis
  - Commitment – 50% Phase II, 70% Phase III
- Achilleas Kourtellis, Ph.D. Civil Engineering - statistical analysis, ITS implementations and in-vehicle safety devices, driver experiments for technology testing
  - Safety Metrics, Analysis, Data Set Configuration, Human Use Support
  - Commitment – 55% Phase II, 75% Phase III
- Seckin Ozkul, Ph.D., Civil Engineering P.E. – connected/automated vehicle research, traffic engineering & Ops, traffic signal systems, ITS
  - Mobility Metrics,
  - Commitment – 15% Phases II and III
- ADDITIONAL STAFFING OF TWO FULL-TIME POST DOCS AND TWO HALF-TIME GRADUATE STUDENTS

METRICS IDENTIFIED PMESP

Performance Pillars	*Performance Measures*	*UC1 Morning Peak Hour Queues*	*UC2 Wrong Way Entries*	*UC3 Pedestrian Safety*	*UC4 BRT Signal Priority*	*UC5 Trolley Conflicts*	*UC6 Enhanced Signal Coordination Progression*
Mobility	Travel time	✓	✓	✓			✓
	Travel time reliability	✓		✓			✓
	Queue length	✓		✓			✓
	Vehicle delay	✓	✓	✓			✓
	Throughput	✓		✓			✓
	Percent (%) arrival on green	✓			✓		✓
	Bus travel time				✓		
	Bus route travel time reliability				✓		
	Percent (%) arrival on schedule				✓		
	Signal priority: - Number of times priority is requested and granted - Number of times priority is requested and denied - Number of times priority is requested, granted and then denied due to a higher priority (i.e. EMS vehicle)				✓		
Environmental	Emissions reductions in idle	✓	✓	✓	✓		✓
	Emissions reductions in running	✓	✓	✓	✓		✓

- 6 Use Cases
- 11 CV Apps
- 40 RSUs
- 4 Evaluation “Pillars”
  - Mobility
  - Environmental
  - Safety
  - Agency Efficiency
- 3 Experimental Designs
- 22 Potential Measures

METRICS IDENTIFIED PMESP (CONTINUED)

Performance Pillars	*Performance Measures*	*UC1 Morning Peak Hour Queues*	*UC2 Wrong Way Entries*	*UC3 Pedestrian Safety*	*UC4 BRT Signal Priority*	*UC5 Trolley Conflicts*	*UC6 Enhanced Signal Coordination Progression*
Safety	Crash reduction	✓	✓	✓		✓	✓
	Crash rate	✓	✓	✓		✓	✓
	Type of conflicts / near misses	✓	✓	✓		✓	✓
	Severity of conflicts / near misses	✓		✓		✓	✓
	Percent (%) red light violation/running		✓				
	Approaching vehicle speed	✓	✓	✓			✓
	Number of wrong way entries and frequency		✓				
Agency Efficiency	Mobility improvements through the mobility pillar analysis	✓	✓	✓	✓		✓
	Safety improvements through the safety pillar analysis	✓	✓	✓		✓	✓
	Customer satisfaction through opinion survey and/or CV app feedback	✓	✓	✓	✓	✓	✓

- 6 Use Cases
- 11 CV Apps
- 40 RSUs
- 4 Evaluation “Pillars”
  - Mobility
  - Environmental
  - Safety
  - Agency Efficiency
- 3 Experimental Designs
- 22 Potential Measures

Evaluation Approaches

Experimental Design	UC1 Morning Peak Hour Queues	UC2 Wrong Way Entries	UC3 Pedestrian Conflicts at Courthouse	UC4 Bus Rapid Transit Signal Priority Optimization Trip Times and Safety	UC5 TECO Line Streetcar Trolley Conflicts	UC6 Enhanced Signal Coordination and Traffic Progression
Before/ After	✓	✓	✓	✓	✓	✓

Random Design – Treatment and Control groups, random assignment, compare average treatment effect, desirable but always achievable

Quasi-Experimental – Used when random assignment not possible, selection bias reduced by using methods like propensity score matching, matching algorithm, difference in difference

Before/After – Time series analysis, no control and treatment groups, confounding factor identification, baseline data required

Performance Measurement and Independent Evaluation Support (Phase III)

Performance Measurement and Independent Evaluation Support – Task 3D

- Updated PMESS
- Data Collection, processing analysis and reporting
  - Reporting to COR designated US DOT entities
  - Internal Team and stakeholders
  - Research Data Exchange
- IE Support
  - Access to data downloads and reports using a restricted area within the website as detailed in the ODE
  - Downloadable summary tables on each performance measure for each UC
  - Custom queries via table query mechanism
  - Daily, weekly, monthly or custom time frames
- Reporting to the Community and Stakeholders
  - Dashboard Approach
  - Provide mechanisms to measure progress towards targets
  - Daily updates

Performance Measurement & Evaluation – Challenges/ Lessons Learned

- Challenges
  A. Deployment in an area undergoing significant redevelopment will likely complicate dealing with confounding factors
  B. Identification of performance targets more difficult than developing measures and methods.

- Lessons Learned
  A. Cross functional coordination is absolutely critical
  B. Early involvement in activities such as System Requirements helps facilitate meaningful measurement
  C. Early definition of needs and role of Independent Evaluator would be helpful

STAY CONNECTED

Contact for CV Pilots Program:

Kate Hartman, Program Manager

Kate.Hartman@dot.gov

Join us for the *Getting Ready for Deployment* Series

- Discover more about the CV Pilot Sites
- Learn the Essential Steps to CV Deployment
- Engage in Technical Discussion

Website: http://www.its.dot.gov/pilots

Twitter: @ITSJPODirector

Facebook:
https://www.facebook.com/USDOTResearch

CV Pilot Sites' Comprehensive Deployment Plan Webinars

- **August 19, 2016 1:00 – 2:00 pm EDT**
  Tampa (THEA) Comprehensive Deployment Plan Webinar
- **August 22, 2016 1:00 – 2:00 pm EDT**
  ICF/WYDOT Comprehensive Deployment Plan Webinar
- **August 22, 2016 3:00 – 4:00 pm EDT**
  NYCDOT Comprehensive Deployment Plan Webinar

Please visit the CV pilots website for the recording and the briefing material of the previous webinars.