



CONNECTED VEHICLE PILOT Deployment Program



Performance Measurement and
Evaluation Support Plan
Tampa
Tampa Hillsborough Expressway Authority



Govind Vadakpat, Tampa (THEA) Site COR
Bob Frey - Tampa Hillsborough Expressway Authority

ITS Joint Program Office



TODAY'S AGENDA



- Purpose of this Webinar
 - To share the Performance Measurement and Evaluation Support plan from the Tampa (THEA) with the stakeholders of connected vehicle technologies.
- Webinar Content
 - Connected Vehicle Pilot Deployment Program Overview
 - Tampa (THEA) Performance Measurement and Evaluation Support 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

PROGRAM GOALS



PILOT SITES



ICF/Wyoming DOT



NYCDOT



Tampa (THEA)

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





Tampa (THEA) CV Pilot System Overview

Bob Frey - THEA

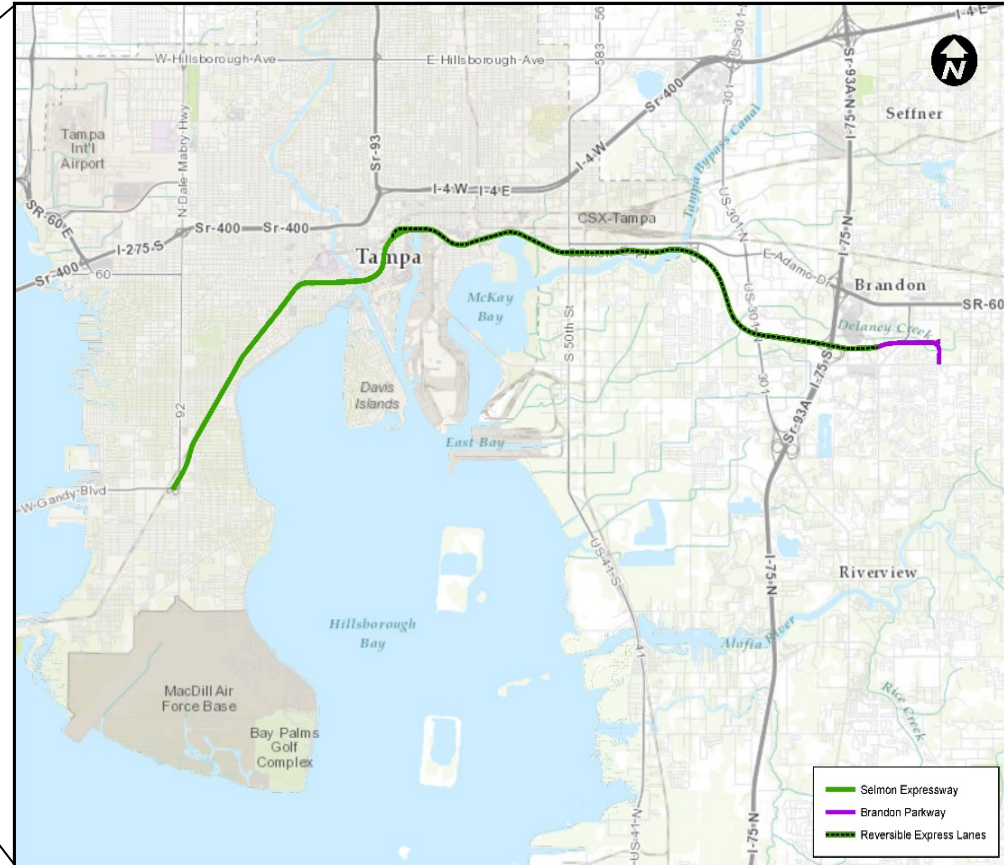
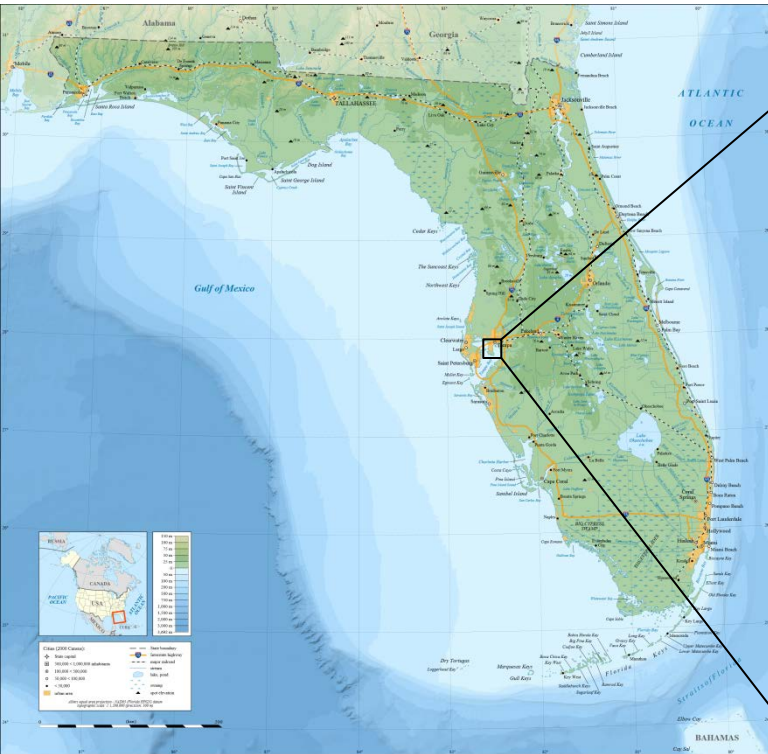
Stephen Reich

Center for Urban Transportation Research

University of South Florida



THEA Site Geography



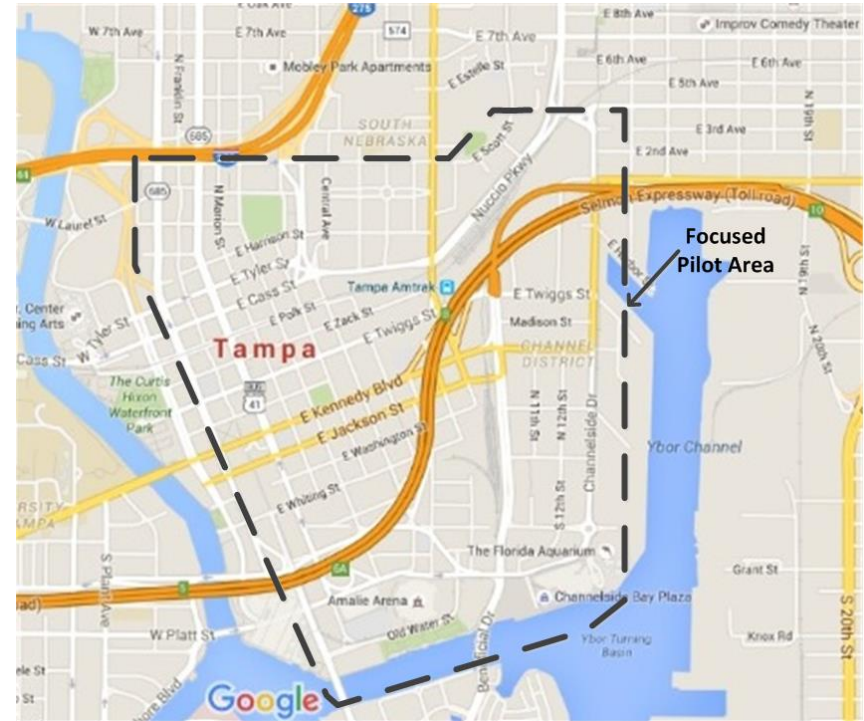
Site Description



Operational Issues



- REL terminates in Downtown Tampa – Feeding urban arterials
- Morning peaks result in queuing on the REL on a curve
- Rear end collisions
- Wrong way entrances to the REL
- Heavy pedestrian traffic – particularly at the federal courthouse
- Traffic delays effect transit schedule – downtown transit mall
- Historic trolley operates in the area – auto/pedestrian/trolley conflicts
- REL commuters destined to and from MacDill must negotiate surface street system



Operational Improvements



- Ideally, in the CV Deployment area operations would be enhanced by:
 - More efficient flow of traffic exiting the REL into the surface street system
 - Alerting REL drivers to upstream traffic stoppages
 - Safer conditions near the terminus of the REL during A.M. peaks
 - Reducing pedestrian/ vehicles at the mid-block courthouse crossing
 - More efficient management of intersections to improve transit travel reliability and general traffic
 - Reducing conflicts with the trolley and pedestrians and vehicles
 - Effectively alerting drivers to a potential wrong way entry to the REL and alerting motorists on the REL of a wrong way vehicle approaching
 - Improving throughput on the system, particularly for commuters traversing downtown





Tampa CV Pilot Goals and Objectives

Stephen Reich

Center for Urban Transportation Research
University of South Florida



Tampa CV Pilot Goals



- Develop and Deploy CV Infrastructure Identified in Phase I
- Improve Mobility in the CBD
- Reduce the Number of Safety Incidents within the Pilot Area
- Reduce Environmental Impacts within the Pilot Area
- Improve Agency Efficiency
- Develop Business Environment for Sustainability



Goals, Objectives and Use Cases



Goal	Objectives	Use Case
Goal 1: Develop and Deploy CV Infrastructure to Support Applications Identified in Phase 1	1: Deploy Dedicated Short-Range Communication (DSCR) technologies to support V2V, V2I, and V2X applications 2: Upgrade TMC software to ensure compatibility with CV applications 3: Recruit a fleet of transit and private vehicle owners to participate in the CV Pilot by installing and using CV technology offered in the pilot	All Use Cases
Goal 2: Improve Mobility in CBD	1: Replace existing traffic controllers and control systems at key intersections with I-SIG CV technology to improve traffic progression 2: Help HART buses stay on predictable schedule through TSP applications 3: Improve BRT operation and encourage ridership	Use Case 1 Use Case 2 Use Case 3 Use Case 4 Use Case 6
Goal 3: Reduce Number of Safety Incidents within the Pilot Area	1: Detect pedestrians and provide warnings to drivers of potential pedestrian conflicts 2: Detect potential vehicle conflicts and provide warnings to pedestrians 3: Provide early detection of wrong way drivers and issue warnings to wrong-way drivers and upstream motorists 4: Warn drivers of REL exit curve speed and stopped vehicles ahead 5: Detect and warn of potential conflicts between trolleys, vehicles, and pedestrians	Use Case 1 Use Case 2 Use Case 3 Use Case 5 Use Case 6



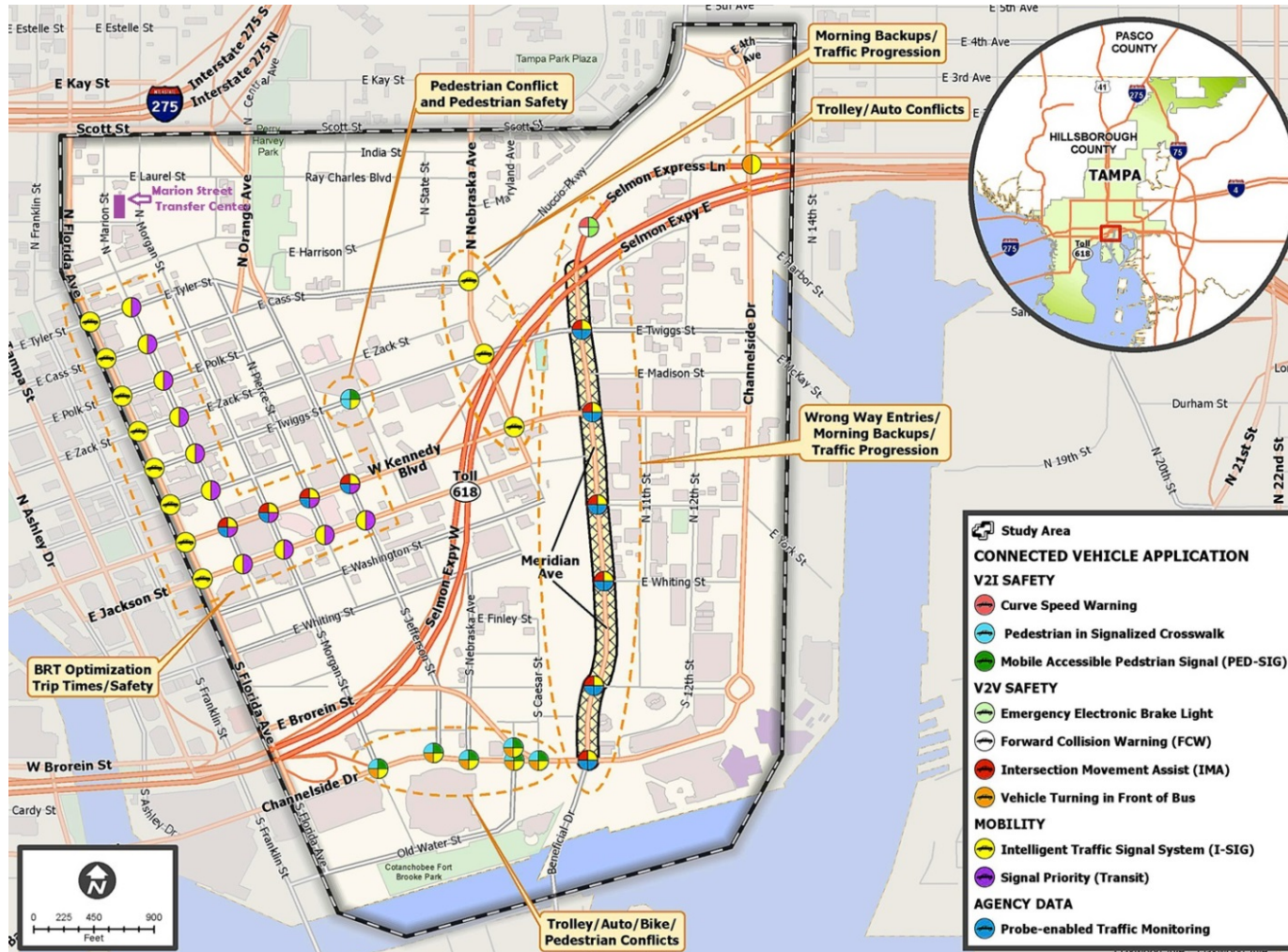
Goals, Objectives and Use Cases



Goal	Objectives	Use Case
Goal 4: Reduce Environmental Impacts within the Pilot Area	1: Deploy applications to improve overall mobility and reduce stops and idle time within the CBD, thus reducing emissions 2: Provide TSP applications to reduce HART buses idle time 3: Provide BRT applications to improve overall operation and encourage increased ridership	Use Case 1 Use Case 2 Use Case 3 Use Case 4 Use Case 6
Goal 5: Improve Agency Efficiency	1: Improve data collection capability, reducing the costs of collecting data 2: Reduce the number of incidents and police and rescue responses to incidents 3: Reduce crashes and time agencies take to gather data 4: Improve technology for crash statistics gathering 5: Improve scheduling and dispatching of HART vehicles with improved trip times and vehicle information 6: Reduce THEA's overhead in responding to wrong-way entries and crashes on REL exit ramp	To be determined
Goal 6: Develop Business Environment for Sustainability	1: Work with CAMP, OEMs, and developers to communicate benefits 2: Work with industry sectors to educate and to seek support 3: Work with business organizations to educate members on the return on investment from increased mobility 4: Work with state and local government to encourage positive legislation and funding in support of CV technology	To be addressed in Task 10



Tampa Pilot Deployment Locations



1 Morning Backups And Congestion



Target Area

Intersection of Twiggs Street and Meridian Avenue at Reversible Express Lanes Entrance/Exit



Avoid Crashes due to Back-to-back Right Turns



V2V Safety: FCW and EEBL

Reduce Queue Backup on Curve



Curve Speed Warning (CSW)

Improve Signal Timing Progression



Intelligent Traffic Signal System (I-SIG)

Performance Measures/ Data

- **Mobility**
 - Travel time
 - Travel time reliability
 - Queue length
 - Vehicle delay
 - Throughput
 - % Arrival on green
- **Safety**
 - Crash reduction
 - Crash rate
 - Types of conflicts/near misses
 - Severity of conflicts/near misses
 - % Red light violation/running
 - Approaching vehicle speed
- **Environmental**
 - Emissions reductions in idle
 - Emission reductions in running

2 Wrong-Way Incidents



Target Area

Entry/Exit Points Along Selmon and Reversible Express Lanes (REL)



Improve Safety at the Entry/Exit Point

Effectively Control Reversible Express Lane

Signal Control at Express Lane Entries



Intersection Movement Assist (IMA)

Red Light Violation



Probe Enabled Traffic Monitoring



Intelligent Traffic Signal System (I-SIG)

Performance Measures/ Data

- **Mobility**
 - Travel time
 - Vehicle delay
- **Safety:**
 - Crash reduction
 - Cash rate
 - Types of conflicts/near misses
 - Number of wrong way entries and frequency
- **Environment:**
 - Emissions reductions in idle
 - Emissions reductions in running
 - Excess time spent in idle



3 Pedestrian Safety



Target Area

Midblock of Twiggs Street at
Hillsborough County
Courthouse



Improve *Pedestrian Safety at Unmarked Crossing Locations*



Pedestrian in
Signalized
Crosswalk Warning

Provide *Pedestrian Crossing Signal Timing*



Mobile Accessible
Pedestrian Signal
(PED I-SIG) and I-SIG

Performance Measures/ Data

- **Mobility**
 - Travel time
 - Travel time reliability
 - Queue length
 - Vehicle delay
 - Throughput
- **Safety**
 - Crash reduction
 - Crash rate
 - Types of conflicts/near misses
 - Severity of conflicts/near misses
 - Approaching vehicle speed
- **Environmental**
 - Emissions reductions in idle
 - Emissions reductions in running



4 Transit Signal Priority, Optimization And Safety



Target Area

Express Route through
Downtown City Streets to
Marion Street Transit Station

Improve Signal Timing
Progression



Intelligent
Traffic Signal
System (I-SIG)

Improve Bus On-
schedule Performance



Transit Signal
Priority (TSP)

Performance Measures/ Data

- **Mobility**
 - % Arrival on green
 - Bus travel time
 - Bus route travel time reliability
 - % Arrival on schedule
 - Signal priority – # times requested and granted; requested and denied; requested, granted and denied
- **Safety**
 - % Red light violation/running
- **Environmental**
 - Emissions reductions in idle
 - Emissions reductions in running



5 TECO Line Streetcar Conflicts



Target Area

- Adamo Drive (SR 60)/ Channelside Drive
- Amalie Arena/Channelside Drive Area

Avoid Potential Vehicle Conflicts



Vehicle Turning Right in Front of Bus Warning

Improve Signal Timing for Special Events



Intelligent Traffic Signal System (I-SIG)

Performance Measures/ Data

- **Safety**
 - Crash reductions
 - Crash rate
 - Types of conflicts/near misses
 - Severity of conflicts/near misses



6 Enhanced Signal Coordination and Traffic Progression



Target Area

- Along Twiggs Street from Selmon to Marion Street
- Along Meridian Avenue from REL to Channelside Drive

Effectively Monitor Peak Queuing and Congestion



Probe Enabled Traffic Monitoring

Improve Traffic Progression



Intelligent Traffic Signal System (I-SIG)

Performance Measures/ Data

- **Mobility**
 - Travel time
 - Travel time reliability
 - Queue length
 - Vehicle delay
 - Throughput
 - % Arrival on green
- **Safety**
 - Crash reduction
 - Crash rate
 - Types of conflicts/near misses
 - Severity of conflicts/near misses
 - % Red light violation/running
 - Approaching vehicle speed
- **Environmental:**
 - Emissions reductions in idle
 - Emissions reductions in running





Tampa CV Pilot Performance Measures

Achilleas Kourtellis and Seckin Ozkul

Center for Urban Transportation Research

University of South Florida

Performance Measures by Use Case



<i>Performance Pillars</i>	<i>Performance Measures</i>	<i>UC1 Morning Peak Hour Queues</i>	<i>UC2 Wrong Way Entries</i>	<i>UC3 Pedestrian Safety</i>	<i>UC4 Bus Rapid Transit Signal Priority Optimization, Trip Times and Safety</i>	<i>UC5 TECO Line Streetcar Trolley Conflicts</i>	<i>UC6 Enhanced Signal Coordination and Traffic Progression</i>
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	✓	✓	✓	✓		✓
	Excess time spent in idle		✓				

Performance Measures by Use Case



<i>Performance Pillars</i>	<i>Performance Measures</i>	<i>UC1 Morning Peak Hour Queues</i>	<i>UC2 Wrong Way Entries</i>	<i>UC3 Pedestrian Safety</i>	<i>UC4 Bus Rapid Transit Signal Priority Optimization, Trip Times and Safety</i>	<i>UC5 TECO Line Streetcar Trolley Conflicts</i>	<i>UC6 Enhanced Signal Coordination and Traffic Progression</i>
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	✓	✓	✓	✓	✓	✓



Tampa CV Pilot Confounding Factors

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Confounding Factors



- Study Area-Specific Factors
 - Weather
 - Special Events
 - New Massive Downtown Waterfront Deployment Construction

- Deployment –Specific Factors
 - Failure, Anomaly and Exception Conditions
 - Maintenance
 - Concurrent Use of Applications

- Experimental Design-Induced Factors
 - Participant Self-Selection
 - Participant Attrition
 - Participant Moral Hazard



Tampa CV Pilot Impact Evaluation Design

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Experimental Strategies



- Random Design
- Quasi-Experimental Design
- Before and After Comparison





Random Design

- Study participants randomly selected and randomly assigned to treatment and control group
 - Treatment consists of participants assigned to the intervention (CV applications installed and equipment activated to send out warnings)
 - Control consists of participants excluded from intervention (CV applications installed and equipment not sending out warnings)
- Random assignment ensures similarity between groups and equal probability of treatment
- Objective: Measure the change in average outcomes (i.e., performance measures) between treatment and control

$$ATE = (T_1^A - T_0^N) - (C^A - C^N)$$

where T_1^A is treatment at CV technology activation (A); T_0 is treatment at normal conditions; C^A is control at CV activation; C^N is control at normal conditions. In the ConOps, normal conditions (N) are those conditions characterized by a “no problem” or “no issue” perspective without any initiation of the proposed CV technologies, which is as the system operates today. Activation conditions (A), are those “conditions that activate or trigger the CV application.”

Quasi-Experimental Design



- Adopted whenever fully random assignment cannot be achieved
- Intended to reduced bias from non-randomness of treatment and control
- Bias can be reduced by using matching methods to select matching controls
- Solution: use of propensity-score matching with multiple matching algorithms
 1. Estimate propensity score for treatment and control (logistic regression using explanatory variables to control for participant heterogeneity)
 2. Use of estimated score and matching algorithms to match treatment to controls
 3. Identify matched control by ranking frequency of matching





Before and After Comparison

- To be used in the absence of participant recruitment or when random and quasi-experimental approaches are not feasible
- Can be used given the longitudinal nature of the study (Phase III lasting 18 months)
- Based on statistical methods comparing changes in performance measures before CV implementation to after CV implementation
- Empirical methods will include:
 - Interrupted time series analysis
 - Multi-level modeling



Summary of Recommended Approach



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
Interrupted time series	✓	✓	✓	✓	✓	✓
Quasi-Experiment	✓	✓	✓		✓	✓
Random Design	✓					✓
Participant Recruitment	YES	Partially from UC1/UC4	YES, courthouse employees; jurors could adopt apps	NO	Only App adopters	YES, from UC1





Tampa CV Pilot Data Collection Plan

Sudeeksha Murari

Booz, Allen, Hamilton



Data Quality Checking, Cleaning, Aggregation and Archiving



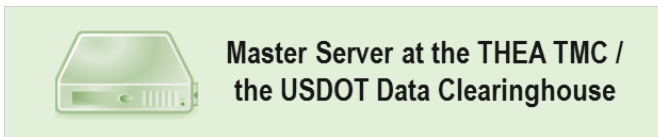
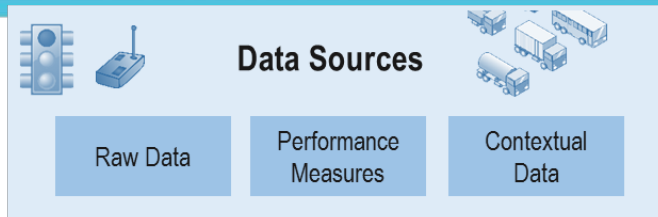
Safety Applications process and exchange the data outside of the ODE, but share the log files for archiving

V2V Safety Applications

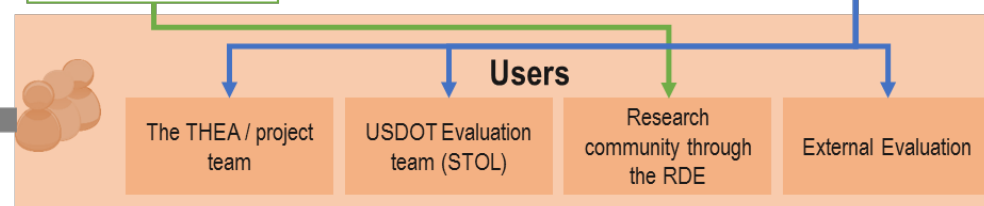
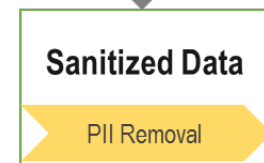
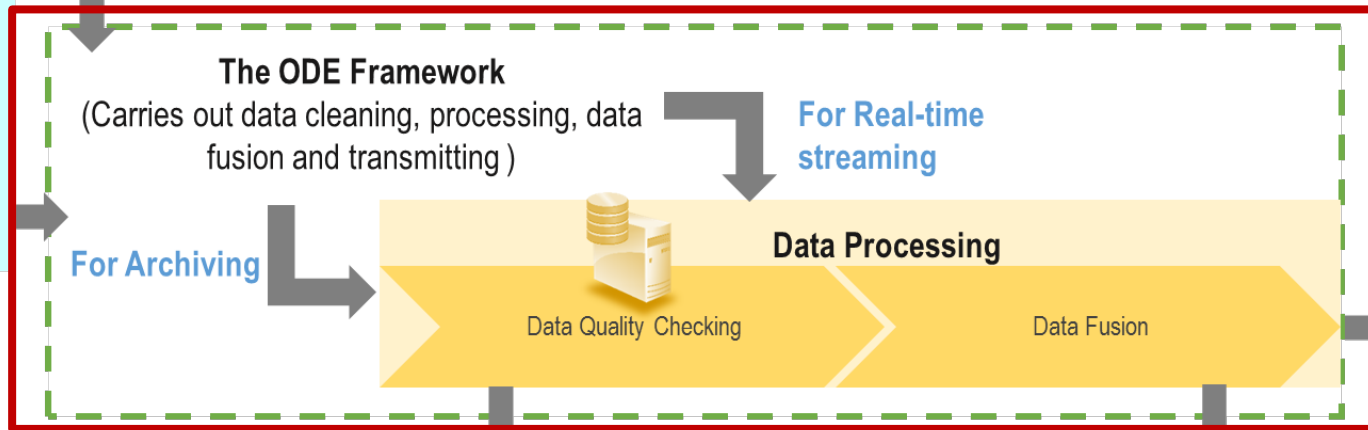
EEBL
FCW
IMA
VTRFTV

V2I Safety Applications

CSW
PED-X
MAPS



Data Source (s)	Formats
BSM data collected from the OBUs	CSV or other database format
Video Cameras	Video format
Loop detectors	CSV or other database format
Apps in OBU reporting vehicle arriving on green through V2I RSUs	Log files (Excel or Access)
DHSMV database	BSMs, Signal timings, Warnings
Weather data	CSV or other database format
Video Cameras/Loop detectors	CSV or other database format
PED-SIG	Log files from RSUs
HART proprietary communication	Log files/CSV
Video Cameras/Ped-bike counters	CSV or other database format



Data Prepared for CV Applications containing the required data elements at the required frequencies

Mobility Applications
I-SIG
TSP

Agency Data Applications
PeDM

Source: Booz Allen Hamilton, June 2016

Data Quality Checking and Cleaning



- **Data quality checking and cleaning**

- A generalized set of **basic quality checks** (completeness, validity, timestamps etc.)
- Common **error checks** (missing values, unrealistic values, issues with file formats etc.)
- The rigor of the data checking for **format and structure** is dependent on the requirements of the end users, which are the RDE, STOL, Independent Evaluator, THEA, and the CV applications that are deployed in Tampa

- **PII Removal by categories of datasets collected**

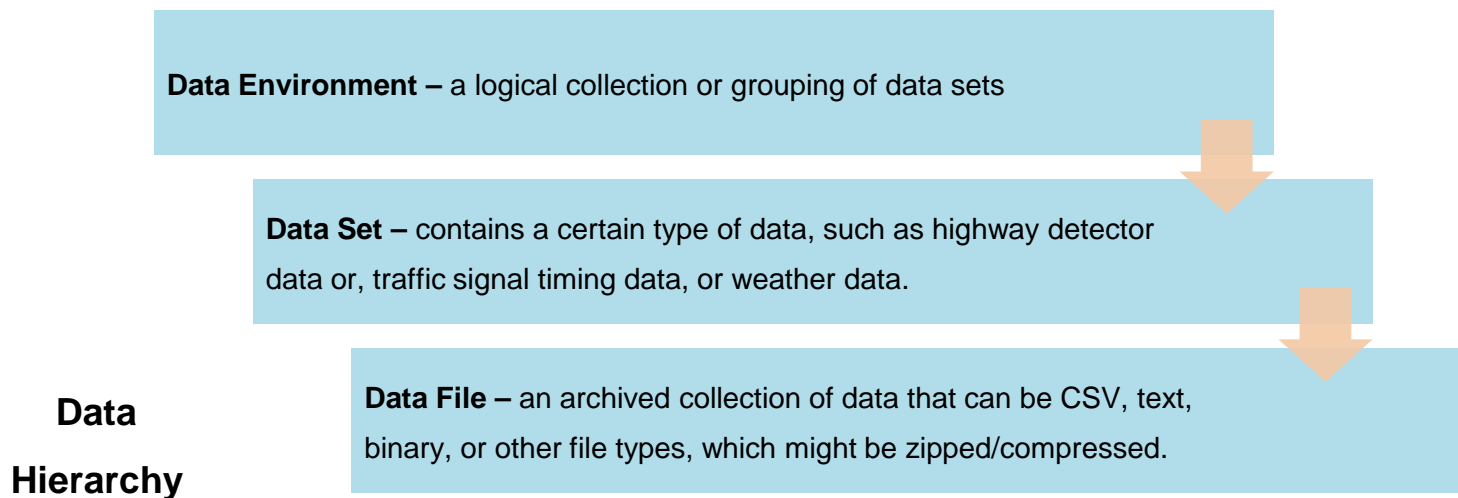
File to be Cleansed	Step	Short description
Trajectory Based - Host Vehicle files (BSM data)	Test Bed Cordon Truncation	Limit data analysis to geographic confines surrounding the test bed area
	Distance based Trip Truncation	Protect (S) PII by establishing a distance based buffer zone around each trip's origin and destination
	Temporal Trip Truncation	Protect against the discovery of (S)PII for vehicles when the distance truncation step did not sufficiently obscure a trip's O/D
	Adjustments of Sequential Data Element	Prevent the extrapolation of location data, with the aid of additional data elements such as speed
Event Based - Host Vehicle files	Truncation of event based – host vehicle files	Control the possibility of having data elements contain relevant information that may be used to deduce (S)PII
Trajectory Based - Remote Vehicle files	Truncation of trajectory based – Remote vehicle files	Guard against the deduction of the start and end of a host vehicle's trip, from a remote vehicle's location data (upon knowing range of DSRC)
Trip Summary Files	Adjustment of Trip Summaries	Allow the summary of each trip to reflect the "new" reality of each truncated host vehicle trip



Data Integration, Aggregation and Archiving



- **Data Integration** can be carried out using data from multiple sources in real-time in the ODE. This is mostly used while providing data from the ODE to the subscribing CV applications.
- **Data Aggregation:** The aggregation step creates composite/summary information using granular data sources.
- **Data archiving:** The data needs to be structured for the RDE, STOL and THEA (and for the IE).
 1. Generate a comprehensive metadata document describing all data elements being collected, their connections to their larger data sets, and a description of how they are stored and captured.
 2. Organize the data using the data hierarchy structure that is currently used within the RDE.





CV Pilot Performance Reporting and Data Sharing

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Performance Reporting



Performance Measurement Reporting

- **Performance tracking** will not be static in terms of just providing a snapshot of conditions, but will allow mechanisms to measure and contextualize progress towards established targets
- **A dashboard** will be created for sharing the performance data
- Information to the dashboard will be provided on a daily basis. Users will be able to access information displayed by frequency (daily, weekday, monthly basis).
- **Reporting frequency** to the Independent Evaluator and STOL will be daily, weekly, monthly, or by custom-set date range.





Tampa CV Pilot Next Steps

Stephen Reich

Center for Urban Transportation Research

University of South Florida



Next Steps



- Coordinate with Task 6 Lead – System Requirements
- Support Task 8 – Human Use Approval
- Assist in the Finalization of the Comprehensive Deployment Plan – Task 12
- Phase II
 - Collection of Data on Current Conditions
 - Refresh Inventory of Evaluation Best Practices



STAKEHOLDER Q&A



- Please keep your phone muted
- Please use chatbox to ask questions
- Questions will be answered in the order in which they were received

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](https://twitter.com/ITSJPODirector)

Facebook:

<https://www.facebook.com/USDOTResearch>

CV Pilot Sites' Performance Measurement Webinars

- 6/6/2016, 2:00 pm – 3:00 pm ET
ICF/WYDOT Performance Measurement Webinar
- 6/6/2016, 3:30 - 4:30 pm ET
NYCDOT Performance Measurement Webinar
- 6/7/2016, 12:00 pm – 1:00 pm ET
Tampa (THEA) Performance Measurement Webinar

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

