

Connected Vehicle Pilot Deployment Program Phase I

Comprehensive Pilot Deployment Plan – Tampa (THEA)

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16. Abstract <p>The Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle (CV) Pilot Deployment Program is part of a national effort to advance CV technologies by deploying, demonstrating, testing and offering lessons learned for future deployers. The THEA CV Pilot is developing a suite of CV applications, or apps, that utilize vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V) and Vehicle to everything (V2X) communication technology to reduce traffic congestion, improve safety, and decrease emissions. These CV apps support a flexible range of services from advisories, roadside alerts, transit mobility enhancements, and pedestrian safety. The pilot is conducted in three Phases. Phase 1 includes the conceptual planning for the CV pilot, beginning with the Concept of Operations development. Phase 2 is the design, development, and testing phase. Phase 3 includes a real-world demonstration and of the apps developed as part of this pilot.</p> <p>This document presents the Comprehensive Deployment Plan (CDP). The CDP provides an overview of Phase 1 findings and of Phase 2 and 3 deployment management strategies for infrastructure and CV apps in Tampa. Phase 2 activities include participant recruitment and training; plans and procurement of equipment for installations; stakeholder outreach; performance measurement and independent evaluator support and privacy and data security, among others. Phase 3 activities include stakeholder outreach, performance measurement and independent evaluator support, post-pilot deployment and transition planning. The deployment schedule, project team personnel organization and a cost summary complete the CDP discussion.</p>					
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Executive Summary

As part of the national effort to deploy and test Connected Vehicle (CV) technology nationwide, the Tampa Hillsborough Expressway Authority (THEA) is deploying CV technologies that address specific local needs while laying a foundation for additional local/regional deployment, and providing transferable lessons for other prospective deployers across the nation.

This Comprehensive Deployment Plan (CDP) is the twelfth of thirteen tasks in the first phase of a multi-phase and multi-year effort. It presents the path forward from Conceptual Planning in Phase 1 to Design, Development, and Testing in Phase 2 and, finally, to real-world operations and proof of its CV applications and Use Cases in Phase 3. This report presents major findings of the Phase 1 Development Concept and the Phase 2 and 3 Development Approach, Schedule, Team Organization and Staffing Plan, and high-level Cost Summary.

This CDP document shows how the present team and stakeholder support base can and will continue to deliver the THEA CV Pilot Deployment with the inherent cohesiveness and synergy that fires our passion for the success of this cutting-edge deployment.

1 Introduction

The THEA CV Pilot Deployment is funded by a federal grant that was awarded in September 2015 by the USDOT's Intelligent Transportation Systems Joint Program Office (ITS JPO). The pilot is one of three sites selected from more than 40 applicants nationwide. These pilot sites continue the USDOT's efforts to generate a body of research data from tested utilization of CV applications, or apps, to address real world issues impacting safety, mobility, environment, and agency efficiency. Phase 1 of the pilot began in mid-September 2015 and is scheduled for completion in August 2016. It aims to meet the purposes set forth in the USDOT's Broad Agency Announcement to advance and enable safe, interoperable, networked wireless communications among vehicles, the infrastructure, and travelers' personal communications devices and to make surface transportation safer, smarter, and greener. The THEA CV Pilot is a test site that aims to demonstrate the ways that CV technology can improve an urban environment. THEA is deploying site-tailored collections of apps that address specific local needs while laying a foundation for additional local/regional deployment, and providing transferable lessons for other prospective deployers across the nation.

These CV apps support a range of services from advisories, roadside alerts, transit mobility enhancements, and pedestrian safety. The pilot is unfolding in three phases. Phase 1 is for conceptual planning whose foundation is the Concept of Operations (ConOps). Phase 2 is the design, build and test phase. Phase 3 moves into operations and a real-world demonstration and test of the CV apps.

The current phase, Phase 1 is on schedule, encompassing one year that began September 14, 2015 and is comprised of 13 tasks that include:

- Task 1 Program Management Plan (PMP)
- Task 2 Pilot Deployment ConOps
- Task 3 Privacy and Security Management Operating Concept (SMOC)
- Task 4 Safety Management Plan
- Task 5 Performance Measurement and Evaluation Support Plan (PMESP)
- Task 6 Pilot Deployment System Requirements
- Task 7 Application Deployment Plan (ADP)
- Task 8 Human Use Approval (HUA)
- Task 9 Participant Training and Stakeholder Education Plan (PTSEP)
- Task 10 Partnership Coordination and Finalization
- Task 11 Outreach Plan

- Task 12 Comprehensive Deployment Plan (CDP)
- Task 13 Deployment Readiness Summary.

Task 12, CDP is the task undertaken in this document.

1.1 Purpose

This document constitutes the CDP, which provides an overview of the management and control processes that will be employed as the THEA CV Pilot transitions from Phase 1, Concept Planning into Phase 2, Design, Build and Test and then progresses into Phase 3 Operations and Maintenance (O&M).

Phase 1 consists of thirteen tasks as part of a systems engineering process. As Phase 1 of the THEA CV Pilot draws to its conclusion, this CDP prepares the groundwork for the remaining two phases from the previous eleven tasks and projected processes to follow. Thus, this CDP (Task 12) extensively references ongoing Draft and Final THEA CV Pilot reports delivered under the eleven preceding tasks.

1.2 Assumptions and Risks

This section discusses assumptions and risks associated with the innovative THEA CV technology deployments that will be used by human subject participants on busy city streetscapes. The THEA team understands the technology and its application and is working to deliver successful, meaningful and measurable outcomes. This knowledge also helps discover the assumptions and risks of this Pilot and the ability to appropriately resolve or mitigate them.

The stated objectives of this CV Pilot Task include developing an innovative and synergistic CV pilot deployment concept that minimizes public, participant, technical, institutional and financial risk. As project managers, THEA is always managing assumptions and risks. In the context of strategic planning, assumptions may be viewed as low-level risks. For example, THEA assumes sufficient numbers of people will sign up to be participants. The degree of risk associated with this assumption is unknown, but is assumed to be low. However, without the right incentives for people to join, recruiting participants could be considered a risk. By identifying assumptions, it is expected that unseen or unlabeled risks will emerge out of closer evaluation and new objectives can be developed to mitigate the risks. In this example case, the objective of developing sufficient incentives arises. Risks can be ranked according to the seriousness of their consequences.

There are three major assumption-risk areas in the THEA CV Pilot:

- Technical
 - Hardware and Software
 - System-level
 - Performance Measures
- Organizational
 - Professional Staff Turnover
 - Schedule
 - Cost
- Participation Related
 - Recruitment
 - Staff to Train Participants
 - Safety
 - Privacy of data
 - Physical
 - Maintenance.

Every effort will be made to identify assumptions and evaluate and minimize risk. The THEA team maintains a risk register, derived from the risk register commonly recommended by USDOT (Figure 1). This offers early opportunities to discuss collaborative ways to identify assumptions and mitigate

risks. For each potential risk, the probability of occurrence (P) and the impact of the risk (I) will be assessed. A plan will then be defined to develop mitigation actions based on the potential impact. The risk register will also be updated and a risk report will detail mitigation activities and risk status.

Figure 1: USDOT Risk Register.

Id #	Contract No./Task Order No.	Project Work Stream	Status	Risk Category	Description	Impacts	Risk Response Plan	Date Assessed	(P)	(I)	P*I	Related Issue #
01												

1.2.1 Technical Assumptions and Risks

1.2.1.1 Hardware and Software

Assumption: Hardware and software will operate perfectly within design specifications.

Risk: It is possible that there will be bugs with the implementation and operation of the equipment and applications.

Consequences: All of the applications are designed as warning applications and the driver is always expected to maintain situational awareness of his/her surroundings. As a result, the impacts or consequences of failure should be minimized. If the applications that relate to safety fail, this could result in loss of participant confidence in the applications and become a confounding factor in performance measurement. Traffic flow may be impeded if the applications that enhance signal coordination and traffic progression fail. If drivers fail to maintain situational awareness and control of his/her vehicle and a warning is ignored, there is the potential for a crash with injuries.

Response: We will address these and other risks by elimination, mitigation, avoidance, transference or acceptance as determined in the Risk Management Plan created under Task 1 of Phase 1. The associated risk register will be updated and maintained throughout Phases 2 and 3.

1.2.1.2 System Level

Assumption: The system will operate perfectly within design specifications.

Risk: It is possible that the system will have operational flaws that pass through testing. Unforeseen scenarios may generate unforeseen results from the system.

Consequences: Data collected could be compromised if data formats are changed or corrupted. System malfunctions could provide incorrect information to participants, resulting in participants being disappointed with the technology or bad word of mouth. Fixing the issues could result in cost overruns.

Response: Thorough testing at system level, including additional test plans and scenarios. Develop and be prepared to implement a plan for notifying participants of problems.

1.2.1.3 Performance Measures

Assumption: All Performance Measures will be useful and meaningful.

Risk: Some performance measures will fail to realize their potential. Data collected will not be statistically significant to prove impacts of the Pilot deployment. Algorithms and systems will not be sufficient to process data or properly analyze data.

Consequences: Project will not document impacts of the CV deployment as necessary to promote future expansion.

Response: Build into performance measures valid and appropriate experiments and statistical levels of significance. Maximize use of flexible computing resources that can support data as it becomes available.

1.2.2 Organizational Assumptions and Risks

1.2.2.1 Professional Staff Turnover

Assumption: There will be little or no turnover of staff and key personnel.

Risk: Some staff will leave or take extended leave and legacy decisions and program background will be lost.

Consequences: Remaining staff will shoulder the burden of timed deliverables. The project could fall behind schedule while new staff is brought on and up to speed.

Response: The core team is continuing to develop a depth of knowledge in the CV Pilot design. The overall team has a large depth of staff and resources available, built upon long-term relationships that have been established over years of working together. Our team has redundancy in capable staff as well as contingency possibilities to replace key personnel over the life of the project. New staff is being brought on board and up to speed to continue to develop depth.

1.2.2.2 Schedule

Assumption: The schedule for all Tasks in Phase 2 is manageable.

Risk: Any one task may become compromised or there may be too many deliverables besides hardware/software/system/recruitment to do in the time allotted.

Consequences: Cost overruns, delays.

Response: The Project Management Plan includes a Schedule Management Plan to address this component of risk. In addition to key deliverables, the schedule and PMP includes scheduled meetings with task leaders to identify and address schedule adherence, with meetings scheduled on a bi-weekly basis or more frequently as needed. Schedule risks will be identified quickly and addressed through the Risk Management Plan. If tasks are not keeping pace with the baseline schedule, mitigation efforts will be undertaken to bring the task back in line. When tasks are not keeping pace with the baseline schedule, mitigation efforts will be undertaken to bring the task in line in accordance with accepted PMP standards. The most current Guide to the Project Management Body of Knowledge, 5th Ed.: PMBOK® Guide, Fifth Edition, (Project Management Institute, 2013), is the reference for the creation and continuance of the Project Management Plan and associated documents for all three Phases of this Pilot Deployment.

1.2.2.3 Cost

Assumption: The project will stay within contract limits and within scope.

Risk: As this is a fixed price contract, the risk to the owning agency is minimal. Unforeseeable or unlikely events, such as in this section (Section 1.2) could cause the project cost to go out of budget. Changes to the project scope by outside direction, including but not limited to the outside evaluation effort may exceed costs dedicated to those support tasks.

Consequences: Project may need to be scaled back to address budget concerns, including the elimination of applications or a reduction in the scale of the project, including the number of physical sites or equipped vehicles.

Response: Through the PMP, the team will evaluate the budget with the schedule at the bi-weekly meetings with the task leads to identify any scope changes or cost overruns. In the event an overrun is identified, the team will establish the cause of cost overrun, document the cause and determine the appropriate response. If the impact is due to outside forces, the team will address the concern with the USDOT to determine outside mitigation factors that may be required.

1.2.3 Participation-Related Assumptions and Risks

1.2.3.1 Recruitment

Assumption: THEA will be able to recruit sufficient numbers of auto drivers and pedestrians.

Risk: Insufficient numbers of people sign up.

Consequences: If the auto drivers and pedestrians are not adequately recruited, the number of interactions between vehicles and other vehicles or roadside devices may fall below the expected number, resulting in in-valid statistical samples of participant data being collected.

Response: Increase the publicity and outreach efforts. Add new and more enticing incentives to get drivers and pedestrians to participate.

1.2.3.2 Hiring of Staff to Train Participants

Assumption: Adequate numbers of bilingual trainers can be found, trained and retained.

Risk: There is an insufficient pool of qualified persons to fill the positions.

Consequences: The schedule assumes both a certain number of devices installed per day requiring training and a percentage of drivers that require bilingual trainers. If there is a higher percentage of drivers requiring bilingual training than anticipated or there are insufficient trainers, there may be a delay in the ability to install OBUs and train the drivers. The result is an extension of time necessary to install devices in vehicles, reducing the amount of data that is collected and increasing the cost associated to install devices.

Response: Develop a more aggressive recruiting campaign for the training staff, including more enticing salaries. When selecting participants, ensure that the language required for training is included as part of the installation scheduling process so the team can schedule bilingual trainers accordingly.

1.2.3.3 Safety

1.2.3.3.1 Data Safety and Privacy

Assumption: Participant data integrity will be created and maintained.

Risk: Administrators or their staff inadvertently expose data, system software is not secure, or hackers breach the database. Evaluation team requires access to PII sensitive data for evaluation.

Consequences: THEA will have to notify the participants (per the Informed Consent Document (ICD)) that may result in participants not being willing to engage in the program or quitting mid-way through the program resulting in additional recruiting and installation expenses.

Response: Ensure that access to PII data is limited as defined in the SMOC. Design participant security right the first time, thoroughly test, adequately train registration staff. Ensure that all who have access to PII data undergo adequate training, including regular refreshing of the training information to reinforce data privacy requirements.

1.2.3.3.2 Physical

Assumption: Drivers and pedestrians with apps will safely use the apps.

Risk: Some people will have crashes and injuries.

Consequences: Injury, bad press, bad word of mouth, loss of participants. Notification of THEA Safety Manager. Possible IRB review.

Response: Report as Safety Management Plan requires, evaluate if an app is responsible. Check that apps are working properly. Ensure participant training covers the applications and reinforces that the applications do not replace the need for drivers and pedestrians to act in a normal manner and that they must continue to be fully aware of their situation.

1.2.3.4 Maintenance

Assumption: Maintenance of OBUs and pedestrian apps will be minimal and manageable.

Risk: Fairly large numbers of OBUs fail or pedestrian apps fail.

Consequences: Multiple software or firmware updates are necessary. Users will be required to visit the installation center multiple times for upgrades to hardware or software. Multiple versions of devices are deployed that are not compatible with one another resulting in a lack of acceptable data for evaluation and performance metrics. Additional costs to install, upgrade and maintain devices in the vehicles. Large queues for repairs or replacement of OBUs at installation facility. The potential exists for failure of pedestrian app project.

Response: Add additional tests to devices prior to installation. Potentially deploy a pre-pilot project with a limited number of devices and participants to catch any early or critical issues prior to full

deployment. Manage queues at installation facility, create more installation bays, recall and repair/replace the OBU or pedestrian app, publicity damage control.

1.3 Organization of the Report

This section provides information on how the sections are organized and a brief description of each section.

Section 1 – Introduction

This present section introduced the CDP and presents:

- Purpose of the report
- Assumptions and Risks
- Organization of the Report.

Section 2 – Deployment Concept

This section summarizes the deployment concept drawing on the ConOps (and other Phase 1 documents).

Section 3–Deployment Approach

These sections go into the details for each key area of deployment. Specific deployment elements are considered for each key area. These include:

Phase 2 Tasks

1. Program Management
2. System Architecture and Design
3. Data Management Planning
4. Acquisition and Installation Planning
5. Application Development
6. Participant and Staff Training
7. Operational Readiness Test and Demonstration Planning
8. Installation and Operational Readiness Testing
9. Maintenance and Operations Planning
10. Stakeholder Outreach
11. Performance Measurement and Independent Evaluation Support
12. Participation in Standards Development

Phase 3 Tasks

13. Program Management
14. System Operations and Maintenance
15. Stakeholder Outreach
16. Performance Measurement and Independent Evaluation Support
17. Post-Pilot Deployment Transition Planning
18. Participation in Standards Development

Section 4 – Deployment Schedule

This section provides a high-level deployment schedule and some supporting information regarding the capability to acquire, configure, install, and test key elements of the proposed system.

Section 5 – Team Organizational Summary

This section summarizes team organization, key personnel, and organizational/governance processes.

Section 6 – Cost Summary

This section summarizes the projected cost estimates at a high-level, and is intended to provide information and guidance for other deployers regarding the costs allocated for the project by

- Phase
- Task
- Major areas of expenditure (e.g., labor, in-vehicle equipment, roadside equipment, software development, systems integration, etc.).

2 Deployment Concept

This section summarizes the deployment concept drawn from the ConOps (and other Phase 1 documents) to clearly describe, along with other aspects of the deployment concept:

1. Stakeholders and Needs
2. Deployment Objectives
3. CV apps and Use Cases, Project Boundaries, Equipment and Participants Required
4. Privacy and Data Security
5. Safety Management
6. Performance Measures
7. Human Use, Recruitment and Training.

The THEA CV Pilot Deployment is staged in three Phases following a Systems Engineering model. Systems engineering is a disciplined approach to project development, building, execution and maintenance. The three Phases are:

- Phase 1 - Concept Development (up to 12 months) consists of 13 tasks. The tasks are outlined in detail in the Federal Broad Agency Announcement (BAA) (USDOT, 2015).
- Phase 2 – Design/Build/Test the system prior to operation (up to 20 months).
- Phase 3 – Operate and Maintain the CV system, assess the impacts and measure performance (minimum of 18 months).

The entire project will span approximately four years (50 months).

2.1 Stakeholders and Needs

The ConOps was written to enhance stakeholder involvement and understanding. The THEA CV Pilot has multiple stakeholders identified with the Pilot (THEA, Task 3, SMOC, March 2016). A listing of Stakeholders on the review panel and their roles in the project is shown in Table 1. Core team stakeholders are the members of the project team. Salus IRB is listed as the IRB of Record. Key Agency Partners are those agencies that are directly affected by the Pilot Deployment. Key Stakeholder Agencies and Key Stakeholder Organizations are those agencies/organizations that may interact with the pilot. Key Technology and Vendor Stakeholders are those private companies that may supply hardware or software to be used during the operation of the Pilot. Project Originators are the USDOT offices that are overseeing the Pilot project. Independent Evaluators (IEs) are those entities that are supporting the USDOT in conducting the review of the Pilot project.

Table 1: THEA CV Pilot Project Stakeholders

Partner/Stakeholder Organization	Stakeholder Category
Tampa Hillsborough Expressway Authority	THEA CV Team (Lead Agency)
HNTB Corporation	Core Team Member
City of Tampa (COT) Traffic Engineering/Traffic Management Center (TMC)	Core Team Member
Siemens Industry, Inc. Mobility Division - Intelligent Transportation Systems	Core Team Member
BrandMotion	Core Team Member

Partner/Stakeholder Organization	Stakeholder Category
University of South Florida Center for Urban Transportation Research (CUTR)	Core Team Member
Global 5 Communication	Core Team Member
Booz Allen Hamilton (BAH)	Core Team Member
Salus IRB	IRB
USF IRB	IRB
Hillsborough Area Regional Transit (HART) TECO Streetcar Line (a Division of HART)	Key Agency Partner
Florida Department of Transportation (FDOT) District 7 (D7)	Key Agency Partner
Hillsborough County	Key Stakeholder Agency
Amalie Arena	Key Stakeholder Agency
City of Tampa Police (TPD)	Key Stakeholder Agency
Florida Highway Patrol – Tampa	Key Stakeholder Agency
Hillsborough County Sheriff's Office	Key Stakeholder Agency
MacDill Air Force Base (MAFB) Public Affairs Office	Key Stakeholder Agency
Tampa Bay Port Authority (Cargo and Cruise)	Key Stakeholder Agency
Tampa Convention Center	Key Stakeholder Agency
Tampa Downtown Partnership	Key Stakeholder Agency
Tampa Bay Lightning Hockey Team	Key Stakeholder Organization
Tampa Bay Lightning Hockey Club	Key Stakeholder Organization
Crash Avoidance Metrics Partnership (CAMP)	Key Technology Stakeholder
Metrotech Net, Inc.	Key Vendor Stakeholder
USDOT ITS JPO	Project Originator
USDOT FHWA	Project Originator
Noblis	USDOT Support Contractor
To be determined	Independent Evaluator (IE)

Source: (THEA, Task 2, ConOps, February 2016)

2.1.1 Stakeholder and Partner Needs

Each Use Case described (see Section 2.3) is designed to address Stakeholder and Partner Needs:

1. The Selmon Expressway's Reversible Express Lane (REL) morning commute endpoint is at the intersection of Twiggs Street and Meridian Avenue. Twiggs Street and Meridian Avenue are also major routes for HART buses into and out of the downtown Tampa CBD. Drivers experience significant delay during the morning peak hour resulting in, and often caused by, a correspondingly large number of rear-end crashes.
2. At the entry to the Selmon Expressway REL during inbound operations (6:00 AM – 1:30 PM weekdays) there are wrong-way entries.
3. Bus Rapid Transit (BRT) routes offer efficiency gains in moving more people; however, during peak periods, the BRT service suffers from poor signal progression, heavy volumes and passenger vehicles blocking access to bus stops.
4. Meridian Avenue and West Kennedy Blvd experience transit signal delay, pedestrian conflicts and signal coordination issues.

5. At the Hillsborough County Courthouse on Twiggs Street, there is significant competing vehicular and pedestrian traffic during the morning peak hour (7:00 AM – 10:00 AM). There are a significant number of pedestrian-vehicle mishaps.
6. Vehicles and pedestrians conflict with the TECO Line Streetcar Trolley at crossing locations throughout the project area, particularly along Channelside Drive.
7. On the east portion of the project area along the Channelside Drive corridor, visitors experience delays associated with arrivals and departures at the International Cruise Ship terminals and the Amalie Arena.
8. MAFB experiences long queue times at controlled access points during the peak morning arrival time. THEA is working with MAFB on dynamic routing and it is likely that the project will benefit from this Pilot by adding a CV component. MAFB presents an opportunity to create a fleet of vehicle probes for data collection.

2.2 Deployment Objectives

The stated goals of the USDOT CV Pilot Deployments research experiment are improving Mobility, Safety, Environment and Agency Efficiency through CV technology. The performance measures desired for the six Use Cases are treated in the next section where measures of effectiveness are identified. The ConOps (THEA, Task 3, SMOC, March 2016, pp. 14-15) identifies goals and objectives for the project:

Goal 1: Develop and Deploy CV Infrastructure to Support the Applications Identified During Phase 1

- Objective 1: Deploy DSRC technologies to support V2V, V2I and V2X applications
- Objective 2: Upgrade TMC software to ensure compatibility with CV Applications
- Objective 3: Recruit a fleet of transit and private vehicle owners and individuals carrying V2X-enabled mobile devices to participate in the CV Pilot by installing and using CV technology offered in the pilot.

Goal 2: Improve Mobility in the Central Business District (CBD)

- Objective 1: Replace existing traffic controllers and control systems at key intersections with intelligent-signal (I-SIG) CV technology to improve traffic progression at identified problem areas.
- Objective 2: Provide Transit Signal Priority (TSP) applications to help HART buses stay on a predictable schedule.
- Objective 3: Provide BRT-related applications to improve overall operation and encourage increased ridership

Goal 3: Reduce the Number of Safety Incidents within the Pilot Area

- Objective 1: Provide detection of pedestrians and warnings to drivers of potential pedestrian conflicts.
- Objective 2: Provide detection of potential vehicle conflicts and warnings to pedestrians.
- Objective 3: Provide early detection of wrong-way drivers and issue warnings to wrong-way drivers and upstream motorists
- Objective 4: Give drivers warnings of the REL exit curve and stopped vehicles ahead
- Objective 5: Provide detection and warning of potential conflicts between trolley vehicles and autos, pedestrians/bicycles

Goal 4: Reduce Environmental Impacts within the Pilot Area

- Objective 1: Provide CV Mobility and Safety applications to improve overall mobility and reduce stops and idle time within the CBD, thus reducing emissions
- Objective 2: Provide TSP applications to reduce idle time of HART buses
- Objective 3: Provide BRT-related applications to improve overall operation and encourage increased ridership

Goal 5: Improve Agency Efficiency

- Objective 1: Improve traffic data collection capability, reducing the costs of collecting data

- Objective 2: Reduce the number of incidents and police and rescue responses to incidents
- Objective 3: Reduce crashes and time agencies take to gather data
- Objective 4: Improve technology for crash statistics gathering
- Objective 5: Improve scheduling and dispatching of HART vehicles with improved trip times and vehicle information
- Objective 6: Reduce overhead of THEA responding to wrong-way entries and crashes on REL exit ramp

Goal 6: Develop Business Environment for Sustainability

- Objective 1: Work with CAMP, OEM's, and third party developers to develop business cases for advancing CV-ready vehicles
- Objective 2: Work with industry sectors that will benefit from CV implementation, e.g.: insurance carriers, fleet managers, safety organizations, etc., to provide education on the benefits and seek support for advancement of the system
- Objective 3: Work with Chambers of Commerce and other business organizations to educate members on the return on investment from increased mobility.
- Objective 4: Work with state and local Government to encourage positive legislation and funding in support of CV technology.

2.3 CV Apps and Use Cases

THEA intends to deploy eleven different CV apps in the Tampa Pilot region that fall under the four categories of V2I and V2V enabled safety applications, mobility applications, and agency data applications (THEA, Task 7, ADP, June 2016). The Use Cases are amply treated in the ConOps (THEA, Task 2, ConOps, February 2016) and succeeding Tasks.

Approximately 40 RSUs will be installed on city streets. Up to 1500 vehicles will be equipped with OBUs and 500 pedestrians with a CV app on their smartphones. It is expected that all the transit vehicles at HART will be equipped – 189 buses and 9 streetcars.

2.3.1 Apps, Use Cases and Locations

The THEA CV Pilot Deployment is an experiment that uses a subset of the applications, or apps, that are delineated in the Connected Vehicle Reference Implementation Architecture (CVRIA) (Iteris, Accessed June 2015). The project uses eleven apps from CVRIA that are listed in Table 2 with a brief description. (More complete descriptions are available on the CVRIA website.) Several of the applications to be examined in this traffic-effects study were tested in the University of Michigan Transportation Research Institute (UMTRI) CV Safety Pilot Model Deployment (EEBL, FCW and IMA) (Harding, et al., August 2014).

Table 2: CV Apps in the THEA CV Pilot.

Application	Description
Curve Speed Warning (CSW)	Alerts driver approaching 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
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
Intelligent Traffic Signal System (I-SIG)	Adjusts signal timing for optimal flow along with PED-SIG and TSP

Probe Data Enabled Traffic Monitoring (PDETM)	Uses vehicles as probes to detect potential incidents ¹
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
Red Light Violation Warning (RLVW)	Warns driver of potential of red light violation and adapted to warning the driver of wrong-way entry to the Selmon REL

Source: (THEA, Task 2, ConOps, February 2016).

The THEA CV Pilot has developed six Use Cases that combine the eleven CV apps. They are summarized in Table 3 and mapped in Figure 2. The sites and functionalities depicted on the map in Figure 2 correspond to planned locations, hardware (HW) Objects and software (SW) applications (see Table 6 in Section 3.4.1.2.2.2.).

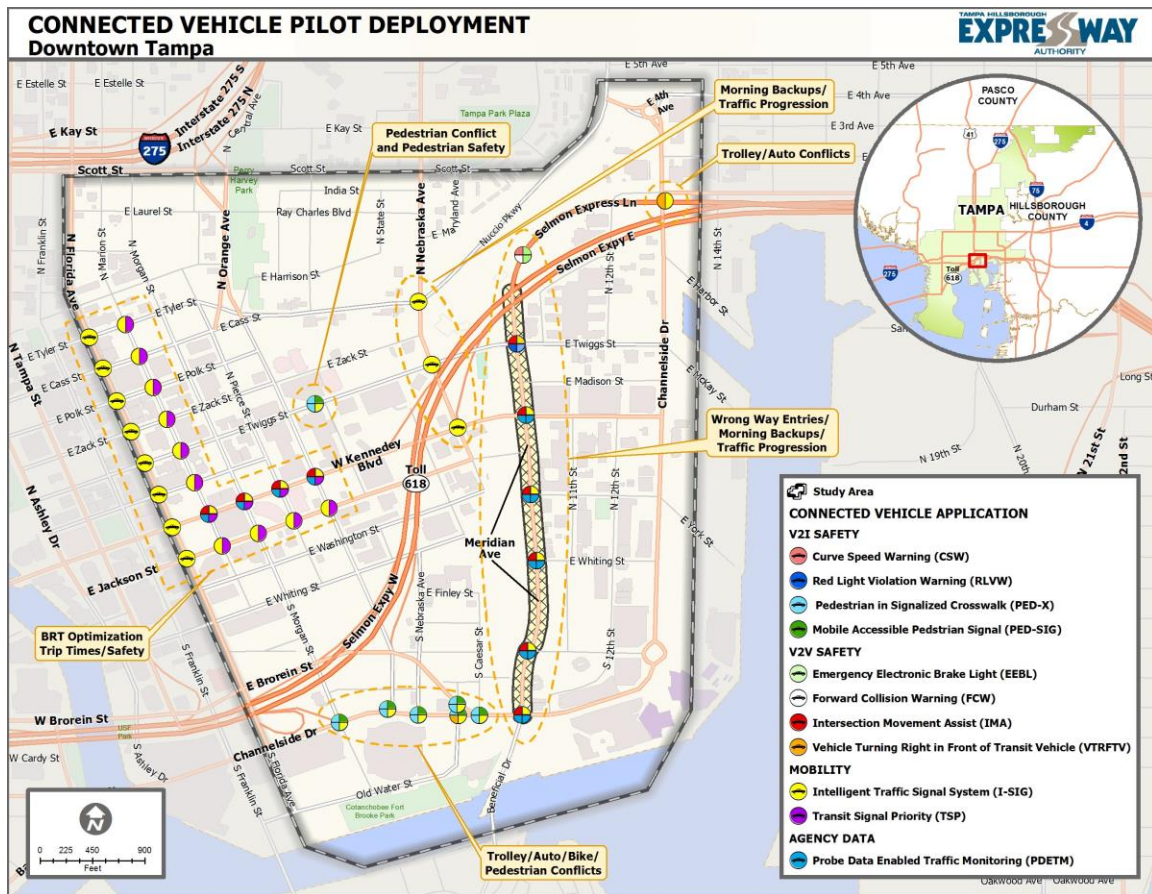
Table 3: THEA CV Pilot Deployment Use Case Summary.

Use Case	Condition	Location
UC1	Morning Backups	Selmon Expressway REL approaching E. Twiggs Street
UC2	Wrong Way Entry	REL at E. Twiggs Street and Meridian Ave
UC3	Pedestrian Safety	E. Twiggs Street at George E. Edgecomb Courthouse
UC4	BRT Signal Priority Optimization, Trip Times and Safety	Marion Street Transit Mall, Marion Street, Kennedy Blvd, Jackson St.
UC5	TECO Trolley Conflicts	Channelside Drive: Old Water St and N. 12 th St. (Adamo Dr.)
UC6	Enhanced Signal Coordination and Traffic Progression	Meridian Avenue, Channelside Dr, Nebraska Ave, Kennedy Blvd., Jackson St, Marion Street, Florida Avenue

Source: (THEA, Task 2, ConOps, February 2016).

¹ PDETM is variation of Vehicle Data for Traffic Operations (VDTO) used in CVRIA.

Figure 2: THEA CV Pilot Deployment Locations



Source: (THEA, Task 2, ConOps, February 2016)

2.3.1.1 Use Case 1: Morning Peak Hour Queues

As vehicles exit the inbound Selmon Expressway REL onto Meridian Street and make right turns onto East Twigg Street, the right-turn lane backs up due to local congestion, causing the queue to backup up onto the REL. As vehicles approach the REL exit, they may not be able to anticipate where the end of the queue is for the right turn lane, potentially causing them to hard brake or attempt a rapid lane change. Applications to be deployed at this location are:

- V2I – CSW
- V2V – EEBL
- V2V – FCW
- V2I – I-SIG.

2.3.1.2 Use Case 2: Wrong Way Entries

At the intersection of the REL with East Twigg Street and Meridian Avenue, there is opportunity for a driver to become confused and attempt to enter the REL going the wrong way, especially when traffic flow from the REL is low near the end of the AM peak operation. Drivers on East Twigg Street can mistakenly enter the REL by inadvertently making a left turn or right turn onto the REL exit. Drivers approaching the intersection on Meridian can misunderstand the purpose of barriers straight ahead and veer slightly to the left into the REL exit. The RLWV app is adapted to warning the driver of

wrong-way entry to the Selmon REL. Each of these possibilities is a safety concern. The CV applications to be used in this Use Case are:

- V2I – IMA
- V2I – RLWW
- V2I – PDETM
- V2I – I-SIG.

2.3.1.3 Use Case 3: Pedestrian Conflicts

At the George E. Edgecomb Hillsborough County Courthouse, there is one primary mid-block crosswalk for pedestrian access to/from the main parking garage. Lack of attention by drivers causes a safety concern for pedestrians trying to reach the courthouse. Some pedestrians elect to take a shortcut by crossing East Twiggs Street mid-block and outside the crosswalk.

Pedestrian-vehicle conflicts also occur at other intersections in the study area including the Port Cruise Line area and Amalie Arena and are treated in Use Case 5. Planned CV deployments in this Use Case include:

- V2I – PED-X
- V2I – PED-SIG
- V2I – I-SIG.

2.3.1.4 Use Case 4: BRT Signal Priority Optimization, Trip Times and Safety

Marion Street is a two-lane urban arterial in the heart of the Tampa CBD that serves as the primary bus route and Transitway and terminates on the north end at the Marion Transit Center. HART operates several routes that converge onto Marion Street at the Marion Street Transit Station. Along these routes, many of the bus stops are on the near-side approach to an intersection. When there is congestion, buses are unable to reach their stops causing them to potentially fall behind schedule, thus, causing a mobility concern. CV applications planned for deployment of this Use Case include:

- V2I – TSP
- V2I – I-SIG.

2.3.1.5 Use Case 5: TECO Trolley Conflicts

The TECO Streetcar Line, operated by HART, runs along Channelside Drive from the Amalie Arena area up Channelside Drive and past the Selmon Expressway. As the pedestrians disembark from the streetcar and the streetcar prepares to depart, it is possible for a vehicle to attempt a right turn in front of the streetcar. The potential of a streetcar-vehicle crash and a pedestrian incident are safety concerns. CV Technology will be used to provide information to streetcar operators, bus drivers, auto drivers, and pedestrians to improve safety at these locations. The CV applications to be used in this Use Case are:

- V2I – VTRFTV
- V2I – PED-X
- V2I – PED-SIG
- V2I – I-SIG.

2.3.1.6 Use Case 6: Traffic Progression Enhancement

There is significant congestion and delay along Meridian Avenue during morning peak travel periods. The interaction of traffic modes increases the potential for pedestrian incidents, creating a safety concern. The CV technologies that will be used to improve mobility and safety through the downtown area for this Use Case are:

- V2I – PDETM
- V2I – I-SIG.

2.4 Privacy and Data Security

2.4.1 Preliminary Information about CV Technology for Security Issues

CV technology relies on communications between vehicles (V2V) and between vehicles and traffic infrastructure (V2I). The entire set of combinations which includes Personal Information Devices (PIDs, e.g., smartphones) is known as vehicle to everything or V2X. The infrastructure in V2I is usually referred to as Roadside Units (RSUs) or Roadside Equipment (RSE).

Vehicle OBUs send out a “Here I am” message, or Basic Safety Message (BSM), every tenth of a second over Dedicated Short-Range Communications (DSRC) which are one-way or two-way short-range to medium-range (about 1 kilometer) wireless communication channels specifically designed for automotive use and with its own protocols and standards. Briefly, the BSM safety V2V core data elements consist of: time, position, speed, heading, acceleration, braking system status and vehicle size. The data within the BSM does not include information on the vehicle owner/operator, make/model, license plate, or VIN. Additional data elements can be added and sent less frequently, depending on vehicle model and purpose, such as heavy braking events and windshield wiper status. (See: http://www.its.dot.gov/itspac/october2012/PDF/data_availability.pdf for an overview) (Cronin, Accessed 2016).

Within Task 3, Privacy and SMOC, the team developed requirements to maintain privacy and security of users and equipment (THEA, Task 3, SMOC, March 2016). These requirements address communications security (to maintain privacy and security V2X device communication), access security (in regard to accessing data and devices), hardware security, and software and operating system security.

2.4.2 Personal Information and Privacy

In general, there will be three types of data collected for the pilot: administrative participant data, CV application data and performance measurement data. Participant data is necessary to track involvement, conduct training, and maintain communications. CV data is the data generated by CVs and/or the communications systems. Performance measurement data is generated from CV data as well as from additional sources, such as video cameras installed on REL infrastructure. Performance measurement data is also discussed in Section 4.0, Performance Measurement and Evaluation Support Plan.

To ensure that data is appropriately protected, these data types should only be accessed and used for their intended purpose. Pilot applications and communications are formulated to protect the privacy of the users to the highest degree possible. Some applications will reveal more data than others. Therefore, it is important that applications only reveal necessary information for applications to function correctly, as revealing the information within application A may allow it to be correlated with information from application B.

To address these concerns for broadcast and transactional unicast (from one point to one other point) communications, the THEA CV Pilot team will implement the following recommendations to maintain privacy:

- Authorization
 - The definition of “authorized to use the service” will be application specific.
- Privacy
 - Not require either party to reveal sensitive information unencrypted.
 - Not contain the User’s location information unless this is necessary as part of service.
 - Not use identifiers that can be straightforwardly linked to the User’s real-world identity (VIN, license number, etc.).

- Use temporary and one-time identifiers. Separate instances of the exchange shall not use identifiers (USER MAC address, UE-ID (IMEI), IP address, certificate, temporary ID, session ID, etc.) that have been used in a previous instance of the exchange.

For all data that is collected and shared for further research, permissions must be obtained from the personnel that generated the data. Of course, these privacy concerns differ between state/local-owned vehicles and privately owned vehicles. The privacy process for determining how to manage data for processing and sharing is listed below. These processes and rules reside within the Performance Management Plan in development which provides more detail on the process.

- 1) **Establish data ownership.** As a general rule, whoever owns the vehicle generally, but not always, owns the data generated by that vehicle.
- 2) **Secure consent from the data owner.** The owner of data must consent to providing the data in an agreement (drafted by the CV Pilot THEA team) that spells out how the data is used and by whom. This should include the redistribution of data to third parties.
- 3) **Protect the privacy of the data owner.** Any information that reveals the identity of the data owner must be eliminated.
- 4) **Identify data aggregation issues.** In some cases, aggregating CV data over time can reveal patterns that are sensitive from the point of view of commercial, military or other propriety information about the internal operations of firms or agencies.
- 5) **Obtain data sharing agreements prior to uploading data to any repository.** These data sharing agreements must be approved by all entities, and/or their representatives, whose data will be included in the data sets that the CV Pilot team will be providing to the USDOT Research Data Exchange (RDE) or the Saxton Transportation Operations Laboratory (STOL) repositories. The RDE will provide publicly available data services that support CV research activities (USDOT FHWA, Accessed 2016).

If a stakeholder would like to receive vehicle data for their vehicle or vehicle fleet (e.g., HART), such data could be available to them at intervals if specified within the consent agreement. In the event that any data is actually collected by the device and periodically downloaded by the THEA CV Pilot team (e.g., buses and streetcars), the owner will have the opportunity to receive a copy of that data. The vehicle situation/probe data collected by RSEs will not be available to users, because the privacy of vehicle situation/probe data is protected by the “privacy by design” features of the Security Credentials Management System (SCMS) Proof of Concept (POC) and IEEE 1609.2 IEEE Standard for Wireless Access in Vehicular Environments — Security Services for Applications and Management Messages, which will be discussed further in the following sections, and the owner will not be known.

2.4.2.1 Participant Data

Currently, the team anticipates that Participant Training and Stakeholder Education will require collection of the following Personally Identifiable Information (PII) in order to administer training and education leading up to and continuing throughout the pilot deployment.

- Name
- Date of Birth
- Contact information
 - Home and work mailing addresses
 - Email
 - Phone number
- Copies of
 - Driver license identification number

- Insurance card
- Vehicle registration
 - Vehicle type data, VIN data
- Demographic data (as defined by Task 5: Performance Measurement)
 - Age
 - Sex
 - Race
 - Language preference (English/Spanish)
 - Recruitment method that attracted participation

Data on age, gender and race/ethnicity for will be used to show how all groups are represented in the conduct of the study.

The THEA team is currently planning for Participant Outreach to include the following methods and avenues of communication.

- Public-facing website
- Secure participant portal on the website for communications with participants
- Electronic newsletter to participants
- Email and/or SMS alert system for critical communication with participants.

These communications methods will require collection of information on participant contact information such as email address and phone number to send newsletters, emails, and/or SMS alerts. Participants will also have to register for access to the secure participant portal on the website with a username and password. If there is a security breach related to personal information of participants, the THEA pilot team will notify the participants of the breach, the nature of the breach, and how the team will resolve it.

The participant data collected for registration, ICD signing, incident reporting, questionnaires, leaving the project and so forth must be in an encrypted, standalone, password-protected database and kept separate from CV data used by the TMC and Performance Measurement team. There should be an established list of team personnel that have access to the data and should be physically separated from CV data. The THEA CV Pilot team will limit access to those personnel who require access to the data in order to perform their duties within the pilot deployment.

2.4.2.2 CV App Data

Personal information collected in the THEA CV pilot will be kept to the minimum necessary for the V2X system to function effectively. CV app data collected by the V2X communication system as described in the THEA CV Pilot ConOps will not contain specific PII or PII-related data. The application assessment does not directly reveal any PII or PII-related information being collected. However, concerns have been raised on the overall privacy implications of a system in which vehicles broadcast location and motion information 10 times every second. Much of these privacy concerns are addressed in the SCMS POC and associated security standards that will be implemented during the CV Pilot.

The SCMS POC being built by the USDOT and Crash Avoidance Metrics Partnership (CAMP) has “privacy by design” as a major tenet of the system development. The CAMP partnership is a consortium of auto makers working in cooperation with the National Highway Traffic Safety Administration (NHTSA) to advance the safety research objectives of USDOT’s Intelligent Vehicle Initiative. All V2X system communications will utilize the SCMS POC design along with the IEEE 1609.2 standard to provide communications security and protect user privacy. In order for vehicle OBEs, PIDs, and RSUs to communicate, they must be enrolled with the SCMS which will provide certificates to prove authenticity of their BSMs and other messages. Note that the BSM does not contain personal information. It only contains the location and motion characteristics of the vehicle

(e.g., speed, heading, acceleration) and certificate information. To protect privacy and prove authenticity, OBEs and PIDs will use pseudonym certificates to sign all messages. Based on information provided by USDOT on the current SCMS POC design, the device will have a pool of 20 certificates that are valid simultaneously for only one week. Certificates for consecutive time periods (i.e., each week) are valid simultaneously for one hour. The device will rotate through certificates every five minutes to limit trackability, which is a commonly voiced concern, and preserve privacy. Also, any communication to the SCMS through the RSE, for example to replenish certificates, is encrypted and also passes through the Location Obscurer Proxy which strips the request of any device identifying information. All devices will be compliant with the SCMS POC Implementation End Entity Requirements and Specifications Supporting SCMS Software Release documentation to support execution of SCMS POC interaction.

2.4.3 V2X System and Device Security

As stated in the previous section on PII, communications security for the THEA CV Pilot is largely ensured through compliance with the SCMS POC design and existing standards and protocols, such as IEEE 1609.2. However, these designs and standards do not cover the security for every aspect of the full V2X communications system. The team developed further requirements and guidance on access security, hardware security, and software and operating system security to limit vulnerabilities and protect users and equipment. Even if the devices malfunction or are compromised, the SCMS POC will specify misbehavior detection strategies to determine if devices are misbehaving (e.g., sending BSMS with blatantly incorrect data, such as a speed of 200 mph) and identify to remaining devices within the V2X system that the specific device is misbehaving. Devices that receive messages from a known misbehaving device will simply ignore the messages. The team will also implement external reporting mechanisms where the participant, technician, TMC operator, etc. can report suspected device misbehavior. In these cases, the misbehaving device will be replaced and evaluated to determine the cause of misbehavior.

2.4.3.1 Access Security

The Privacy and SMOC addresses access security, such as the various role-based users that can access V2X devices, user name and password policies, and whether remote access to devices is permitted in the THEA CV Pilot. The team will leverage existing THEA access security related policies, such as the THEA Network Security Policy, THEA/City of Tampa Joint TMC Memorandum of Understanding (MOU), and Standard Operating Procedures (SOP) to reuse as appropriate and modify as necessary for use in the Pilot. New organizational roles will be created to oversee the execution of the security concept and continued operation of the V2X security and privacy system. These new roles include an Information Security Director, Information Security Manager, Provisioning and Maintenance Engineers, and Network Administration. These new roles may be filled by existing personnel as additional duties. The THEA CV Pilot team will provide training to personnel filling new roles, as well as the TMC and the rest of the THEA CV Pilot team in general, on new privacy and security processes and procedures. Physical device access will require role-based authentication and remote access (which will only be supported by RSUs and other fixed infrastructure) will require identity-based authentication.

At least one server with adequate disk space will be dedicated to archive pilot data. Data collected by the pilot will eventually become part of the USDOT RDE, and be available to Test Bed Affiliates and other independent evaluators. CV data collected from vehicles and RSUs will not contain any PII or PII-related information. There will also be controls in place to limit the ability to string vehicle trips together, such as the strategy of having mandatory gaps in the vehicle situation/probe data. Even with these controls, the THEA CV Pilot team will scrub vehicle situation data to determine the effectiveness of strategies in providing privacy, not necessarily just anonymity, to participants. If not effective, these strategies will be supplemented by existing sanitization algorithms used by SE Michigan Testbed to remove pieces of trip data before submission to the RDE.

CV app data used to produce traffic data (e.g., volume, occupancy, travel times, location, heading, speed) collected from vehicles, RSUs, and other devices will not be housed with PII and PII-related data on the participants, which is maintained for administrative and performance management reasons. These databases will be maintained separately and one person or role will not have access to both databases. Only TMC personnel and/or roles will have access to the CV data stored and analyzed by the TMC. Only select human use, registration and participant training personnel, or other group as specified in later concepts and plans, and/or roles will have access to participant data. Participant data will only be used for administrative purposes in tracking devices (and reconfiguring malfunctioning devices) and for performance management purposes. The THEA CV Pilot team will look into the potential to have these databases on separate networks and/or physical locations to increase privacy and security.

2.4.3.2 Physical Security

Security requirements for each device classification that will be used in the pilot specify hardware security control requirements to prevent physical key extraction and similar attacks. The team used a widely accepted standard used to specify hardware security requirements, Federal Information Processing Standard (FIPS) 140-2: Security Requirements for Cryptographic Modules. FIPS 140-2 covers security requirements for cryptographic modules, including protections to prevent device tampering such as tamper evident protections and tamper resistant protections.

2.4.3.3 Software and Operating System Security

While FIPS 140-2 addresses the majority of hardware security requirements, it does not cover all software and operating system requirements, which also need to be addressed. These requirements ensure BSMs cannot be modified and that additional software cannot be installed that would allow an attacker to generate false BSMs using valid BSM keying material, among other threats. Software and operating system security requirements were developed to cover various types of device architecture, manufacturing and operational states, secure device boot, and operating system.

2.5 Physical Safety

The Safety Management Plan (THEA, Task 4, Safety, March 2016) addresses participant safety, equipment and software.

2.5.1 ICDs and Safety

The Safety Management Plan is first applied to participants in the ICDs during registration, as explained in Section 2.7 of that report (THEA, Task 4, Safety, March 2016). As the Safety Management Plan Final Report states and the ICDs confirm, the driver must be in control of the vehicle, and pedestrians, as well, must assess the situation and react appropriately, and obey traffic signs and Florida law. The ICDs for drivers clearly state this Pilot experiment is not an autonomous vehicle test. The ICDs for all participant groups - car drivers, pedestrians and transit drivers - include instruction details for contacting the THEA representative so the participant can get instructions for reporting any issues and getting the device repaired or replaced. The following twelve situations were identified in the Safety Management Plan and addressed in the ICDs as possible failures that would require such help:

- Any device failure where the device is not operating as user was instructed that it should.
 - The device installed inside the cabin of the vehicle may detach and cause damage or harm in the case of a crash.
 - Problematic location of device installation.
 - The device installed inside the cabin of the vehicle detaches while the vehicle is in normal operation.

- There is a short circuit in the equipment installed that causes overheating.
- Improper installation causes device to drain the battery of the test vehicle.
- The detection at the pedestrian crossings malfunctions failing to issue a warning to either a participating pedestrian or a participating driver.
- Communication failure causes device to issue incorrect warnings or not to issue a warning when a hazard is present.
- A misconception by the participant results in the participant believing the system takes control of the vehicle in case of a hazard.
- The driver is distracted by the device information and warnings.
- The participant becomes dependent upon the application to warn them of safety risks.
- The driver reacts to the warning messages in an undesirable way, such as hard breaking, swerving, becoming distracted or startled and causing a crash.

2.5.2 Safety Functions

There are several safety functions that will be addressed in the Safety Operational Concept. Further details are to be found in Section 6 of the Safety Management Plan Final Report:

- Equipment Procurement
- Device Installation
- Fail-Safe System Mode
- Quality Training.

Equipment Procurement will utilize quality equipment by requiring all of the suppliers to provide and follow an approved quality management process in designing, constructing and producing their devices.

Device Installation will be comprised of manufacturer approved vendors or THEA CV Pilot partner personnel who have been sufficiently trained by manufacturer approved vendors and will include lessons learned and best practices in the installation procedures.

Fail-Safe System Mode guarantees that in the event of a system failure, the system and devices will respond in a way that will cause no harm to the system, devices, participants, or other road users

Quality Training means that all participants, system operators, system maintainers, installer/maintainers and owners of a response plan referenced herein will receive adequate, approved training based on their point of interface with the system. This training will be documented as it occurs as part of the THEA CV Pilot Deployment. This training will include a training course in protecting human research participants as prescribed and delineated in Section 2.7.

2.5.3 Safety Management

Safety Management requires oversight by a Safety Manager, with responsibility for all the key safety areas:

- Leadership and direction in safety procedures
- Ensuring compliance with applicable regulations and the Safety Management Plan
- Incorporating safety into design, deployment, and operational phases
- Guidance for equipment procurement and acceptance
- Oversight for device certification, testing and installation
- Safety leadership for maintenance and updates
- Operational safety and monitoring
- Safety documentation and training
- Incident reporting, documentation, and investigation
- Maintaining and updating safety processes and the Safety Management Plan
- Safety coordination with other entities and task leads.

The Safety Incident Process is designed to standardize the management of any roadway incidents involving the CV Pilot's participants. There are six steps:

1. When an incident occurs involving a participant, the appropriate law enforcement and emergency services are notified immediately
2. Agencies respond. Steps 1 and 2 are standard for anyone involved in a traffic incident.
3. Safety Manager fills out an Incident report (see (THEA, Task 4, Safety, March 2016) Appendix A).
4. Safety Manager includes the incident as part of the Safety Review (see (THEA, Task 4, Safety, March 2016)Appendix B).
5. Safety Review indicates the action to be taken
6. Communication to the THEA team and incorporated into the Safety Management Plan.

2.5.4 Safety Incident Reporting

Incidents will be reviewed following the procedures in Section 6.2.3 of the Safety Management Plan and documented utilizing the Incident Report Form (see (THEA, Task 4, Safety, March 2016) Appendix A). The intent of a safety incident reporting process is to identify improvements that can be made to prevent a recurrence of that incident. The following safety incident reporting policy will be followed.

- Safety incidents will be reported and recorded by the participants and team members using the draft Incident Report Form in the Appendix.
- Participants will receive guidance on safety reporting during their training.
- Safety incidents will be investigated and the underlying causes identified.
- Serious harm incidents will prompt a review of the Safety Management Plan.
- A regular review of all safety incidents occurs to identify any trends.

2.5.5 Safety Reviews

Regular assessments help to identify any new safety risks and develop the appropriate control measures. When THEA conducts safety reviews (Safety Review Template, Appendix B) THEA will ensure that:

- Reviews are conducted by the appropriate technical experts and team members
- Opportunities for improvement are identified
- Outcomes are communicated to the team members
- Actions arising from reviews are implemented
- Ongoing monitoring is maintained to ensure that our operations comply with the Safety Management Plan.

Reviews will be conducted at the following key points:

- Safety review for each project deliverable in Phase 1 to determine if there are any impacts to safety risk assessment and to ensure mitigation of risks
- Safety review of the design
- Design review before installation
- Safety review before deployment
- System security review before deployment
- Equipment, software and process check before deployment
- Periodic equipment, software, and process checks during operation
- Regular safety communications and updates
- Safety investigation after an incident
- Following a critical event or significant change that may impact safety
- After a complaint of a safety nature is received from participants, team members, or others
- Following a change in the applicable standards and codes of practices.

2.6 Performance Measures

The PMESP (THEA, Task 5, PMESP, June 2016) outlines the goals and objectives for the Pilot as well as the proposed performance metrics. The document addresses:

- Problems and operational needs by Use Case of the Pilot goals - improving Mobility, Safety, Environment and Agency Efficiency
- The improvements desired for the six Use Cases
- The goal-related performance measures for each of the Use Cases
- Confounding factors
- System deployment impact evaluation
- Methods and procedures for data collection
- Methods for estimating and reporting each identified performance measure
- The interface between THEA and the Independent Evaluation effort.

Since this deployment will utilize several CV technologies in different locations to deal with a collection of safety and mobility field conditions, an experimental design, participant selection and set of performance measures are described for each of the six Use Cases. The experiment design identifies three approaches to control and minimize the impact of study-area specific and deployment-specific confounding factors: random design, quasi-experimental design, and before and after comparison (time series analysis). These experiment designs are applied, as appropriate, to each Use Case. While each Use Case may not be appropriate for evaluation in each of the four evaluation pillars - Safety, Mobility, Environment, and Agency Efficiency, the assessment of the full set of CV application deployments will address all of them.

In general, there will be three types of data collected for the Pilot:

- Administrative participant data
- CV application data
- Performance measurement data.

Participant data is necessary to track involvement, conduct training, and maintain communications. CV data is the data generated by OBUs, RSEs and mobile devices. Performance measurement data is generated from CV data as well as from additional sources, such as video cameras installed on Pilot infrastructure and anonymous opinion surveys.

CV data will be analyzed in aggregate for standard traffic engineering measures such as average travel time, percent arrivals on green, etc. as shown in Table 4 without identifying individuals.

Table 4: Summary of Performance Measures.

<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	✓	✓	✓	✓		✓
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	✓	✓	✓	✓	✓	✓

Source: (THEA, Task 5, PMESP, June 2016)

2.6.1 Experimental Strategies

In an ideal context, confounding factors can be controlled for by conducting counterfactual analysis via random experiment design. Counterfactual modeling measures the potential outcome in the absence of an intervention, such as the implementation of the CV connected technology. Empirically, there are different options for assessing the counterfactual, ranging from a simple before vs. after comparison of outcomes to measuring responses in the context of a random experiment design. The applicability of each approach is contingent upon the baseline characteristics of each use case defined in the ConOps.

This plan identifies three approaches to control and minimize the impact of study-area specific and deployment-specific confounding factors:

1. Random Design
2. Quasi-Experimental Design
3. Before and After Comparison (Time Series Analysis)

These experimental design approaches are discussed for each Use Case in the Final Report for Task 5, PMESP (THEA, Task 5, PMESP, June 2016).

2.6.2 IE

Performance and other data supporting a comprehensive assessment of deployment impacts will be shared with a USDOT-identified IE and the data needs associated with an independent evaluation effort will be supported. Data produced by the CV equipment for each Use Case will be stored in a database that is available to FHWA, the THEA team and the IE. Data will be scrubbed of all PII. The Use Case information flows are the source of data for the IE's performance measures, in whatever way the IE wishes to structure them.

2.7 Participant Human Use, Recruitment and Training

The safety, risks drivers will face and the use of human beings in the THEA CV Pilot is critical to its success. There are several layers of participant safety concerns:

- Privacy and data security of participants
- Physical safety when driving with the apps
- Human Use issues.

This first two have been dealt with in Sections 2.4, 2.5 and 2.6. THEA's approach to Human Use issues - fair treatment in the recruitment, registration, information taken, training and installation of OBUs and maintenance – is an important part of the CDP.

Since the project is a federally funded research experiment involving human participants, the project also has as a goal the protection of the participants. The project, thus, follows the Common Rule, a rule of ethics regarding research with human subjects adopted by the USDOT that is codified in U.S. Code of Federal Regulations, 49 CFR Part 11. Among other provisions, the Common Rule warrants an Institutional Review Board (IRB) to have oversight of the treatment of human subjects. The US Department of Health and Human Services (HHS) oversees IRB activities and issued a Federal Wide Assurance (FWA) number (FWA00024177, expiring 5/13/2021) that acknowledges that Salus IRB is the IRB for the THEA CV Pilot Deployment. Salus IRB gave its approval to the Draft Research Protocol and ICDs on June 1, 2016 and for the Final Research Protocol on June 16, 2016.

This section includes findings and plans for protecting participants – auto drivers, pedestrians and transit drivers – especially with respect to their recruitment, registration, informed consent, training,

installation and maintenance of equipment installed in their vehicles, and ongoing treatment. Salus IRB will need to approve final recruitment advertisements, training videos and other activities before they are applied in the field. As these plans transition to designs in Phase 2, THEA will make amendment requests to Salus IRB of revisions to the Research Protocol and ICDs, as necessary.

2.7.1 Safeguards for Protecting Vulnerable Populations

Among the vulnerable populations who may participate in this research are: pregnant women, non-English speaking persons (eight percent Spanish and one percent Haitian-Creole), educationally disadvantaged and economically disadvantaged persons. Vulnerable persons are not targeted for this study, nor are they to be systemically left out. Participation by anyone meeting minimal requirements is welcome. Because of the expense involved, efforts may not be made to attract non-English speakers by offering Spanish versions of the recruitment advertisements, though it is anticipated that ICDs and training materials will be made available in Spanish.

2.7.2 Participant Lifecycle

When the project viewpoint moves from systems engineering and device functionality to human use, the project takes on a substantially different look and feel. Participants have an entirely different set of concerns from systems engineers and their needs and treatment is a subject unto itself. Through the lifecycle of participant involvement, the tasks include: recruitment, selection, registration/ICD signoff, training, installation, device use, reporting, retiring and retrieval. The THEA staff persons who work in the selection, registration training and installation process will complete a course in *Protecting Human Research Participants* from the NIH web-based training course or obtain equivalent certification.

2.7.3 Human Use Treatment of Drivers

2.7.3.1 Recruitment

Participating car drivers are expected to come from the Tampa commuter shed in the outlying Brandon suburbs, where the Selmon Expressway REL originates, and from the commuter population in the greater Tampa area whose morning commutes terminate in or travel through downtown Tampa. Recruitment will target commuters headed to downtown Tampa, other destinations near downtown and MAFB, who use the REL, Meridian Avenue, Twiggs Street, Channelside Drive, and other roads in the study area.

The study design is intended to provide a balanced sample of drivers by age and gender. However, obtaining the desired number of participants in the specified age groups in a timely way may prove to be difficult. Of most concern is attracting both younger (ages 18 to 20) and older (ages 70 and above) drivers and pedestrians. Special efforts may be necessary to meet sample requirements. The study also expects to attract a number of non-English-speaking participants, especially native Spanish speakers, who make up approximately eight percent of the Hillsborough County population, according to the U.S. Census Bureau. However, there will not be a specific effort to recruit non-English speakers.

THEA will take a staged approach to recruiting. Most recruiting efforts will point potential participants to the THEA CV Pilot website which will feature a recruiting page that includes:

- A video introducing potential participants to CVs, THEA and the basics of participation
- A Frequently Asked Questions (FAQ) section, with the ability to ask additional questions (via online form and email)
- A questionnaire that will screen potential participants based on pre-established criteria
 - Adult (18+)
 - Valid driver license

- Valid automobile insurance
- Vehicle ownership (not lease vehicle) and Vehicle Identification Number
- 1997 model year or newer vehicle (OBD II port availability)
- Commute point of origin and destination
- Basic demographic information
 - Age
 - Gender
 - Race
 - Language preference (English/Spanish)
 - recruitment method that attracted participation
- An online scheduling function to allow pre-screened participants to set up an appointment for Registration/ICD signoff, Training and OBU installation.

The staged approach will allow THEA to grow its recruiting efforts based on success, making use of more cost-effective methods first. Task 5, Performance Measurement will establish the recruiting goals and timelines for each stage. The preliminary recruitment plan activities (THEA, Task 9, July 2016) include:

- Stage 1
 - News media
 - Recruitment kickoff media event
 - At THEA TMC and/or
 - At installation location to demo technology and OBUs
 - News coverage provides legitimacy for other recruitment efforts
 - THEA DMS (overhead digital signs) messaging
 - Selmon Expressway
 - Meridian Avenue
 - Partner fleets (invite their commuters to participate in their personal vehicles)
 - HART
 - TECO Streetcar Line
 - City of Tampa
 - Craigslist ads
 - Printed material distributed to stakeholders (downtown businesses and organizations)
 - Flyers
 - Posters
 - Email
 - Existing THEA customers
 - Stakeholders (from the Stakeholder Registry)
 - MacDill probe study participants
 - THEA newsletter articles
 - Social media
 - THEA (Twitter and Facebook)
 - Partners
 - Stakeholders
 - Out-of-home messaging
 - Traveling display, sandwich boards
 - Downtown buildings
 - Downtown events
 - WaWa, CVS, Publix locations (partnership possibilities)
 - Building banners on THEA building, other buildings in/around downtown

- Stage 2 (continue above efforts and add ...)
 - News media
 - Additional stories, events
 - Presentations at stakeholders
 - Employer outreach
 - Rotary and civic groups
 - Paid messaging
 - Online (targeted to age, gender as necessary)
 - Google
 - Social media (e.g., Facebook)
 - Targeting
 - Physical home/work locations
 - Age and/or gender
 - Interests
 - Pandora (reaches in-car)
 - Out-of-home messaging
 - Traveling display, sandwich boards
 - Downtown buildings
 - Downtown events
 - Brandon Town Center Mall
 - Regency Park (in Brandon)
 - Movie theater (AMC at Regency Park)
 - Retail stores (focus on tech?)
 - Apartment complexes
 - WaWa, CVS, Publix locations (partnership possibilities)
 - Building banners on THEA building, other buildings in/around downtown
- Stage 3 (continue above efforts and add ...)
 - Out-of-home messaging
 - Billboards along the Selmon Expressway/REL
 - HART bus exterior advertisements
 - Portable Dynamic Message Signs along Use Case roads
 - Paid messaging
 - Radio
 - TV
 - In Brandon (and other) movie theaters

It has not been determined as to which of these media methods will be employed in the study. Amendments to the Protocol will clarify what methods will be employed. Presentation details will be forwarded with the amendments, as needed, for IRB review.

2.7.3.2 Driver Registration, Training and Installation Location Requirements

Several of these tasks — selection, registration/ICD signoff, training and installation, and retiring and retrieval — must have a location and, ideally, one where all these tasks may be done in one relatively brief visit. While a site has not been chosen at this time and is scheduled for Phase 2, there appear to be several attractive options in the vicinity of the test area (i.e., the Selmon Expressway and Meridian Avenue) that would be accessible to potential participants.

2.7.3.3 Driver Registration Facility Requirements

The registration facility requirements are for a safe and secure room where the registrar(s) and recruit(s) can talk without distraction or interruption. The potential participant will not be trained or the vehicle modified until selection and registration/ICD signoff are complete. Training and installation will occur concurrently. During the UMTRI CV Safety Model Pilot Deployment, OBU installation took from one-half hour to one hour with few exceptions. This is anticipated to be sufficient time for the training of the driver and installation of the device.

2.7.3.4 Driver Participant Selection

Selmon Expressway REL and City of Tampa drivers will account for 1500 vehicles equipped with devices.

Subjects willing to have a device installed in their personal vehicle will be screened based on their ability to meet the following criteria:

1. Current, valid driver's license
2. Adult (18+)
3. Valid automobile insurance
4. Owns (or is financing for ownership) a vehicle (not lease vehicle)
5. The vehicle is 1997 model year or newer vehicle (OBD II port availability)
6. Their daily commute intersects downtown Tampa, or they routinely drive on Meridian Avenue, Twiggs Street or use the Selmon REL
7. Willing, at least initially, to participate for the 18-month duration of the model deployment,
8. Allow THEA periodic access to retrieve data or check device health,
9. No existing crash warning systems on the vehicle.

Scheduling of device installations, data downloads, and any other necessary interactions will be conducted via an on-line scheduling system where participants can select times and dates that accommodate their schedules. For persons without online access alternative measures (e.g., phone, email) will be used.

Persons agreeing to have a device installed in their personal vehicle may receive small gifts of appreciation, such as free SiriusXM service for the life of the CV Pilot or a FitBit, for example, but no direct monetary compensation from the project budget. A Selmon Expressway toll reduction is also under consideration. THEA is currently exploring these and other options.

2.7.3.5 Driver Registration Process

If, after watching an introductory video and reading the FAQs, a person wishes to participate, he or she must complete and pass an online selection questionnaire and set an appointment for registration, ICD signing, training and OBU installation. THEA will communicate electronically with the candidate to remind him/her of the appointment.

At the registration location, the potential participant will watch a brief video explaining the Informed Consent process. A THEA staff person will present the person with an electronic ICD document (on a tablet or PC) and ask him/her to read it. (The ICD will be available in English and Spanish.) The staff person will offer to answer questions. Some staff will be bilingual (English/Spanish) to accommodate Spanish-preference participants. The participant will then sign or not sign the ICD. If the participant signs, they go on to the training and their vehicle is taken for installation of the device.

THEA will use secure software for taking of PII data when participants register (see Section 2.2.1). THEA will supply software for the taking of data by the registrar(s), which the participant will verify with ID – driver's license, vehicle registration and proof of insurance for drivers. The data will be uploaded to a secure database (per Section 2). With respect to the ICD signature there are two possibilities:

- Store paper copies of the signed ICD in a secure, locked file cabinet at the THEA registration facility.

- Store digital copies of the electronically signed ICD in the secure facility with the other registration information.

Participants will be given a paper copy or emailed a copy of their signed ICD which will also act as a registration certificate with instructions for contacting the CV Pilot administrators if the participant has questions, sells the car, is involved in a crash, relocates, wishes to quit the study, and so forth.

2.7.3.6 Driver Informed Consent Document

The completed Salus ICD template for auto drivers is attached to the Human Use Approval Final Report as the Driver ICD Appendix (THEA, Task 8, HUAS, June 2016). The ICD follows the Salus ICD template that treats:

- Purpose of the study
- What will happen during the study
- What the participant needs to know
- Potential risks to participants
- Benefits of the study
- Payment and incentives for participation
- Injury and Legal Rights
- Voluntary nature of participation
- Whom to contact with questions, concerns, complaints or traffic incidents.

At this stage the ICD cannot define all requirements precisely, such as the location or time period for returning the vehicle for data collection. Revisions and additional details will be clarified by ICD amendment as needed.

2.7.3.7 Driver Trainers and Participant Training

THEA will provide training to a corps of trainer/registrars who will provide training in use of the OBU at the installation site. The trainer/registrars will receive training and certification in protecting human research participants. Some trainer/registrars will be bilingual (English and Spanish) so they can provide services in Spanish to participants who are more comfortable speaking and signing legal documents in Spanish.

Upon signing the Informed Consent Document (ICD), a trainer will instruct the participant in the use of the OBU while the OBU is installed in the vehicle. During the UMTRI CV Safety Pilot, OBU installation took from one-half hour to one hour with few exceptions. This is presently anticipated to be sufficient time for the training of the driver and installation of the device.

The participant training will be done primarily by video for consistency followed by trainer Q&A during the installation process. The conceptual plan for the training aims to cover the following points:

- CV 101 – CV User-Oriented Fundamentals
- USDOT CV program background
- THEA Pilot Deployment background
 - FHWA contract
 - Traffic problems
 - CV treatments
 - Working to get experiment results – measuring CV app outcomes for safety, mobility and the environment
- Functions of the OBU and apps
 - OBU normal use and care
 - User-accessible functionality
 - Post-vehicle-service check (e.g., did the Jiffy Lube guy disconnect the OBU?)
 - Reporting issues to the CV Pilot participant software system

- Requesting service, replacement
- In case you move or wish to leave the CV Pilot
 - If your OBU doesn't appear in the system THEA will contact you
- Driver-Vehicle Interfaces (DVI) and Basic Safety Messages (BSMs)
 - Alerts that will elicit response, and expected response
 - Driver responsibility to control the vehicle (CV is not AV)
 - USDOT/THEA not responsible for traveler behavior or damages and do not offer compensation
- Participant communication
 - Electronic newsletters from THEA
 - Reporting alerts, incidents and crashes
 - Feedback
- Safety – Once again - Driver responsibility to control the vehicle at all times
- Questions.

Training documents at this Phase 1 stage of the project are in preliminary development. A draft high-level Training plan will be submitted for sponsor review (USDOT) by May 27, 2016 and for final acceptance by August 8, 2016. Also, since the apps are in development, detailed training for use of the app is not available at this stage. The intention is to have the training elements follow best practices for training of participants. Training details will be made available in IRB amendment documents as they become available.

2.7.3.8 Vehicle Installation

Training and installation will occur concurrently. During the UMTRI CV Safety Pilot, OBU installation took from one-half hour to one hour with few exceptions. This is anticipated to be sufficient time for the training of the driver and installation of the device.

Installations will require a clean, well-lit, light-duty garage with equipment for installing the OBU. During the UMTRI CV Safety Pilot OBUs were installed without the use of a lift to elevate the vehicle. Skilled installers can work through the non-invasive installation with light tools. Drilling holes in the vehicle body should not be necessary. The most invasive part of the installation will usually be running a small magnetically attached antenna out the window onto the roof. If any holes, etc. need to be made, the driver will be informed beforehand for consent. The driver's wishes will be respected (per ICD).

Supervisors of installers will obtain certification in protecting human research participants. This will hold for any OBU automotive supplier that wishes to install its OBUs. The supervisors will get certification in protecting human research participants.

2.7.3.9 OBU Device Use

If the driver has a problem with the device, the driver is still responsible for the operation of the vehicle and should take every measure to report the problem to a THEA representative. This will also be covered in the training session. This is discussed at length in the Safety Management Plan.

2.7.3.10 Driver Reporting Procedures

Drivers will stop by the installation site for data retrieval occasionally (e.g., once every six months) as defined in the ICD. Participants will be informed by email of the time period over which they can have the data collected and how to make an appointment.

Incident reporting, documentation, and investigation will be carried out according to the SMOC (Section 2) and the Safety Management Plan (Section 3). The Safety Manager will fill out the Incident Report Form (Appendix A) and enter the data into the secure participant database software. In the

same manner the Safety Manager will also conduct a Safety Review by filling out a Safety Review Template (Appendix B) when there is an injury.

Legal issues may arise with crashes. The ICD for passenger car drivers states: *There may be times when the study investigator will not be able to guarantee privacy, such as when the study records are requested by a court of law.* If required by legal procedure, THEA will make selected raw BSM data available over the time period and location in question without analysis or interpretation.

2.7.3.11 OBU Retiring and Retrieval

A driver may leave the CV Pilot for a number of reasons, including dissatisfaction with the device or the program, selling the car, crashing the car (inoperable), relocation, changing jobs or travel route, illness, injury, death, termination of the project and so forth. If the driver leaves the study prior to the 18 month agreement, the manufacturer/supplier would require that the device be properly removed by the THEA installers for reuse in the study, so the driver will be responsible to notify a THEA representative in a timely way as delineated in the ICD. In some situations, with the driver's permission, THEA staff may be authorized to travel to the site of the vehicle to remove it.

If the vehicle is in a crash and inoperable, the driver should notify a THEA representative to have the OBU removed. The driver will not be responsible for any damage to the OBU in the event of a crash (per ICD).

If the vehicle does not appear on any RSU for some time (e.g., six weeks), a THEA representative may contact the driver to find out the status of the OBU and the driver's relationship to the project (e.g., still in the area?) as stated in the ICD.

When a participant leaves the study or at the study's completion, THEA staff will offer participants a questionnaire to voluntarily complete, as stated in the ICD. The study may allow participants to keep and use the OBUs after the completion of the study if they wish. Details of this survey are not yet available, but it will inquire only into how participant use of the equipment enhanced or detracted from driving, program evaluation, human factors or quality assurance.

2.7.4 Human Use Treatment of Pedestrians

Pedestrians called for jury duty at the Hillsborough County Courthouse often elect to cross East Twiggs Street at a mid-block crosswalk and sometimes cross outside the crosswalk. Planned CV deployment at this location includes:

- V2I – Pedestrian in Crosswalk Warning, an in-vehicle app
- V2I – PED-SIG, a smartphone app to aid pedestrians of vehicles approaching the crosswalk.

In addition, pedestrians use the intersections on Channelside Drive and have conflicts with vehicles turning right in front of streetcars and with traffic at Amalie Arena. The same apps may be applied with these pedestrians.

2.7.4.1 Pedestrian Recruitment

Recruitment is the first step in the process. One plan is to recruit through jury duty notification, by offering online information, FAQs, and appointments. Selection and preliminary registration may be done online, as with auto drivers or, perhaps, only in person at a booth at the courthouse, which would reduce false registrations. Registrations will need to be verified in person.

Another plan is to do only in-person recruitment with a booth at the courthouse Tuesday through Friday for those selected for jury duty and who will use the mid-block crossing for several days.

Recruitment would include employees of the courthouse and nearby businesses who use the Twiggs Street mid-block crossing.

For locations outside the courthouse (e.g. Amalie Arena, Channelside Drive), recruitment of pedestrians could come, in part, from HART's TECO Streetcar Line and study area bus route customers. Postcards handed out onboard would be one way of targeting potential participants.

Amendment to the IRB Approval will be requested when the app and pedestrian recruitment are further developed.

2.7.4.2 Pedestrian Registration, Training and Installation Location Requirements

Use Case 3 will be tested at the mid-block Twiggs Street crossing at the Hillsborough County Courthouse and in the Channelside District at streetcar stops. The courthouse would be a natural site for the registration process for that site.

Arrangements will be made with the cruise lines, Amalie Arena or another entity in the Channelside District or downtown to induct new participants. A covered booth at a TECO Streetcar Line stop might be used for this purpose if a more substantial, well located farecard sales outlet cannot be identified.

2.7.4.3 Pedestrian Processing

Similar to the process for auto drivers, pedestrians would go through a process of Selection, Registration/ICD signoff, Training and app Installation when they go to a facility located at the courthouse or Channelside Drive. A registrar certified in protecting human research participants would examine the participant's ID, verify that they meet the smartphone requirements (e.g., iOS 3.0 or later), enter the applicant's information into the secure participant software and offer the Pedestrian ICD to the potential participant to read and sign. The registrar would be available for questions.

The registrant's data will be uploaded to a secure database (per Section 2). With respect to the ICD signature, since the pedestrians are using smartphones, paper copies would not seem to be necessary. The participant software will store digital copies of the electronically signed ICD in the secure facility with the other registration information and email the participants a copy of their electronically signed ICD that will also act as a registration certificate with instructions for contacting the CV Pilot administrators if the participant has questions, difficulties with the app, is involved in a crash, completes their jury duty, wishes to quit the study, and so forth.

2.7.4.4 Pedestrian Informed Consent Document

The completed Salus ICD template for pedestrians is attached to the Human Use Approval Final Report as the Pedestrian ICD Appendix (THEA, Task 8, HUAS, June 2016). The ICD follows the Salus ICD template that treats:

- Purpose of the study
- What will happen during the study
- What the participant needs to know
- Potential risks to participants
- Benefits of the study
- Payment and incentives for participation
- Injury and Legal Rights
- Voluntary nature of participation
- Whom to contact with questions, concerns, complaints or injuries.

At this stage the ICD cannot define all requirements precisely. Revisions and additional details will be clarified by ICD amendment as needed.

2.7.4.5 Pedestrian App Training and Installation

Upon signing the ICD, the participant will receive a brief training and will install the app over a secure WiFi connection. The registrar will have equipment to test that the app is working.

Training of trainer/installers will also be part of the pedestrian training plan and will include certification in protecting human research participants.

Training documents at this Phase 1 stage of the project are in preliminary development. A draft high-level plan will be submitted for sponsor review (USDOT) by May 27, 2016 and for final acceptance by August 8, 2016. Also, since the apps are in development, detailed training for use of the app is not available at this stage. The intention is to have the training elements follow best practices for training of participants. Training details will be made available in IRB Approval amendment documents as they become available.

2.7.4.6 Pedestrian Reporting Procedure

Incident reporting, documentation, and investigation will be carried out according to the Privacy and SMOC Plan (Section 2) and the Safety Management Plan (Section 3). The Safety Manager will fill out the Incident Report Form (Appendix A) and enter the data into the secure participant database software. In the same manner the Safety Manager will also conduct a Safety Review by filling in the Safety Review Template (Appendix B) when there is an injury.

Legal issues may arise with crashes. The ICD for pedestrians states: *There may be times when the study investigator will not be able to guarantee privacy, such as when the study records are requested by a court of law.* If required by legal procedure, THEA will make selected raw Pedestrian App and BSM data available over the time period and location in question without analysis or interpretation.

2.7.4.7 Pedestrian App Retirement and Removal

To leave the project, presumably when the participant is finished with jury duty, visiting the Tampa area, or at the end of the study, retiring and retrieval of the app would be at the discretion of the participant. The app will not function outside the study area. There will be an option in the app to notify THEA that the participant is done with participation. Participants will be sent a query to fill out a questionnaire about their experience with the apps upon their termination with the study. Details of this survey are not yet available, but it will inquire only into how participant use of the equipment enhanced or detracted from safely crossing the street, program evaluation, human factors or quality assurance.

2.7.5 Human Use Treatment of HART Drivers

2.7.5.1 HART Recruitment, Registration and Training

Recruitment, registration and training of HART drivers will be done at the HART worksite. Training of trainers will also be part of the HART driver training plan and will include certification in protecting human research participants. Drivers will be informed during their training that they are part of a study to evaluate the effectiveness of the devices that will be installed in the vehicles.

At this stage it is not known what proportion of HART buses or bus drivers will take part in the study. Buses must be rotated approximately every three months as to the routes they cover according to Title VI of the Civil Rights Act (Hillsborough Area Regional Transit, November 5, 2015) so the same buses will not be used throughout the study. One plan is to equip all the buses for signal priority, even those that would not pass through equipped intersections. The logistics of driver assignment means that at present it can only be determined that the minimum number of bus drivers who would need training would be about 80, but it might turn out to be more efficient to train all the drivers (about 400),

whether they end up using the equipment or not, so that scheduling can be done on an ad hoc basis when needed. There are only nine streetcars and so all the 25-30 streetcar motormen will receive training.

Training documents at this Phase 1 stage of the project are in preliminary development. A draft high-level plan will be submitted for sponsor review (USDOT) by May 27, 2016 and for final acceptance by August 8, 2016. Also, since the apps are in development, detailed training for use of the apps are not available at this stage. The intention is to have the training elements follow best practices for training of participants. Training details will be made available in amendment documents for IRB approval as they become available.

2.7.5.2 HART Informed Consent Document

It is proposed to treat HART as the participant and the ICD (see (THEA, Task 8, HUAS, June 2016) HART ICD Appendix) is written for a HART representative's signature. HART employees will be covered by their contract with the agency. No driver PII will be collected for the CV Pilot. Only vehicle data will be collected. Project managers will go through HART to repair OBU installations, when needed.

The completed Salus ICD template for HART and its drivers is attached. The ICD follows the Salus ICD template that treats:

- Purpose of the study
- What will happen during the study
- What the participant needs to know
- Potential risks to participants
- Benefits of the study
- Payment and incentives for participation
- Injury and Legal Rights
- Voluntary nature of participation
- Whom to contact with questions, concerns, complaints or injuries.

Revisions and additional details will be clarified by ICD amendment as needed.

2.7.5.3 HART Reporting Procedure

Drivers will report incidents as they normally would, according to HART policies and procedures, and HART will contact the CV Pilot Safety Manager. CV incident reporting, documentation, and investigation will be carried out according to the Safety Management Plan (Section 2.x). The Safety Manager will fill out the Incident Report Form (see (THEA, Task 4, Safety, March 2016) Appendix A) and enter the data into the secure database software. In the same manner the Safety Manager will also conduct a Safety Review by filling out the Safety Review Template (see (THEA, Task 4, Safety, March 2016) Appendix B) when there is an injury.

Legal issues may arise with crashes. The ICD for HART states: *There may be times when the study investigator will not be able to guarantee privacy, such as when the study records are requested by a court of law.* If required by the legal system, THEA will make raw BSM data available over the time period in question without analysis or interpretation.

2.7.5.4 HART OBU Installation, Repair and Removal

The supplier/manufacture will install the OBUs with the help of the HART maintenance staff. Installation of equipment is part of the HART staff's regular duties and they are not human research participants.

2.7.5.5 HART User Survey

THEA will offer drivers a questionnaire about their experience with the apps upon completion of the study period. Details of this survey are not yet available, but it will inquire only into how participant use of the equipment enhanced or detracted from driving, program evaluation, human factors or quality assurance.

3 Deployment Approach

Section 2 outlined some of the important outcomes of Phase 1. These outcomes are applicable to the Tasks in Phases 2 and 3. This section covers the technical deployment approach to be taken in Phases 2 and 3, organized in order of Phase and Task.

THEA will comply with all requirements of the Notice of Funding Opportunity (USDOT FHWA, NOFO, May 17, 2016) that supports the “Connected Vehicle (CV) Pilot Deployment Program” for the ITS JPO within the USDOT. As part of this CDP Task Report, Phase 1 final deliverables will be incorporated by reference. Incorporation by reference implies that agreements, processes, quantities, specifications, and other content identified in this document are considered binding elements of Phases 2 and 3.

3.1 Program Management – Task 2A

Program management in Phases 2 and 3 will continue to follow the PMP created in Phase 1 and to be updated in Phase 2. This PMP also closely aligns with the Systems Engineering approach used in Phase 1 and continued throughout the pilot. A Scope Management Plan, Schedule Management Plan, Cost Management Plan, Communication Plan, Safety Management Plan, Configuration Management Plan and Baseline Schedule were included as appendices to the Phase 1, Task 1 PMP. The PMP and all appendices will be maintained and updated as applicable throughout the entire pilot.

The overarching technology development and deployment plan for Phase 2 is based on a top-down approach to distribute technology tasks functionally across dual paths leveraging the key strengths of our core technology partners. This technology deployment plan calls for separate acquisition and installation efforts for roadside equipment versus onboard equipment with coordinated interfaces at the functional level. Systems engineering and final integration and testing efforts will be conducted jointly and the entire process will be monitored and tracked within the program management structure. THEA takes the position that this approach distributes accountability and risk, while taking full advantage of each core partner’s critical expertise. Cross-functional reviews and progress meetings will ensure interoperability, requirements traceability and advancement of the common goals for successful deployment. Figure 3 depicts the major technology workflows with divergence and convergence of the distributed tasks.

Figure 3 does not include other less technical, though equally important areas of Phase 2, such as participant lifecycle, performance measurement and stakeholder outreach, which are treated further in sections that follow and in their respective Task Reports.

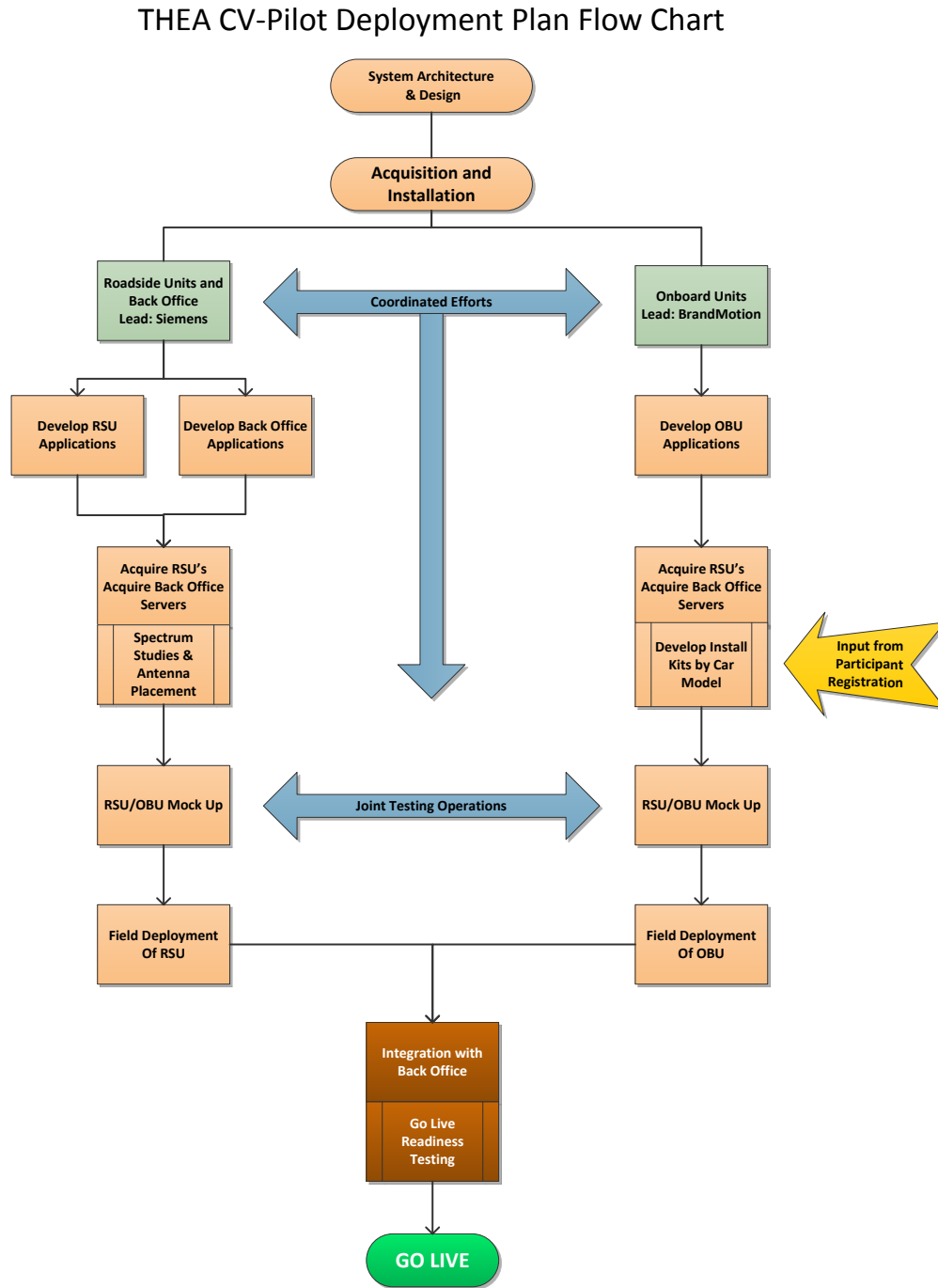
Regarding Stakeholders, Agreements and Funding as parts of Program Management, Section 2.1 delineates the roles THEA’s Stakeholders play in the Pilot deployment and the Task 10, Partnership Coordination Final Report explains Pilot funding, policy governance and ongoing operating agreements. To briefly summarize those findings, Phases 2 and 3 are funded through a cooperative agreement between the USDOT and THEA. The USDOT funding covers 80% of the costs identified through the original response to the USDOT BAA and THEA (USDOT, 2015). THEA has budgeted the match as a 100% hard cash match. At the completion of Phase 3, USDOT will discontinue funding which will then depend on THEA. THEA has programmed funds beginning in Fiscal Year 2017 through Fiscal Year 2047 to support automated and CV activities including operating and maintaining the roadside equipment and networks associated with this Pilot Deployment. A total of \$6.9 million to fund these activities is being accounted for and funded by THEA revenue. These needs are used in

the agency's financial forecasts and are treated as a priority as are any operational, maintenance and system preservation needs are. In other words, this operations and maintenance funding is considered core and only after the payment of debt service in hierarchy of funding priorities (THEA, Task 10, Partnerships, July 2016).

The deployment, operations and maintenance of the Pilot will be the responsibility of THEA and THEA's contractors/vendors. The deployment and operations, however, will require coordination with the City of Tampa, HART and [Florida Department of Transportation \(FDOT\)](#). There are already contractual relationships between all of these agencies that, based on an initial review, cover all aspects of the Pilot program and no new agreements or addenda are anticipated. In the event that a new agreement or addendum is needed, it will be included in the annual update and in Task 2-G and 3-E.

The Pilot program development and deployment is also reliant on vendors and partners, including, but not limited to, HNTB, Siemens, BrandMotion, Sirius and CUTR. These vendors are all under contract with THEA to provide this support. At this point, the need, scope and appropriate contractual relationship for these vendors beyond Phase 3 have not been identified. Any ongoing need, roles and responsibilities and necessary agreements with these vendors will be documented in the annual updates and in Tasks 2-G and 3-E.

Figure 3: Phase 2 Technology Deployment Work Flow Diagram.



Source: HNTB

3.1.1 Scope, Schedule and Cost Management

Deployment of a successful CV Pilot Deployment concept will require a disciplined approach to manage the execution of the work and make sure the team responsible for deployment delivers the highest quality products and support activities (e.g., participant recruitment, performance

measurement) on time and within budget. Consistent processes and procedures will be used to ensure quality, timeliness, and cost control.

3.1.1.1 Scope

Scope management ensures that all required activities are performed and that only required activities are performed. THEA will have plans and practices in place for verifying and controlling the overall scope of the CV Pilot Deployment. The Scope Management Plan (SMP) is a component of the PMP delivered under Task 2-A.

3.1.1.2 Schedule

Schedule management provides for the timely execution of work activities. The Project Schedule will list all activities required to bring all required work to a successful completion. It will identify how the team will monitor the project schedule and manage changes after a baseline schedule has been approved. The schedule management plan will include identifying, analyzing, documenting, prioritizing, approving or rejecting, and publishing all schedule-related changes. The Schedule Management Plan is a component of the PMP delivered under Phase 2, Task 2-A and includes the baseline schedule and monthly updates.

3.1.1.3 Cost

Cost management is to include the process of planning and controlling the budget for the CV Pilot Deployment. THEA will ensure that any issues with funding surface quickly, before cost overruns can occur. The Cost Management Plan is a component of the PMP delivered under Task 2-A.

3.1.2 Communications

Communications management will include the systematic planning, implementing, monitoring, and revision of all the channels of communication within the project partners and with other stakeholders.

A partner will refer to an organization or individual on the deployment team. A stakeholder will refer to an organization or individual potentially impacted by the deployment itself, regardless of whether they are team members (partners) or not.

Communications management will ensure effective internal team communications and governance methods, as well as communications with the USDOT's Agreement Officer Representative (AOR).

3.1.3 Configuration Management

Configuration management will include managing how items to be placed under configuration control are identified, when they are identified, and when they are placed into a configuration control process or system. Configuration management will include establishing a Configuration Control Board (CCB) and include procedures for handling proposed changes to items under configuration control, and the role of the USDOT in configuration control. The CCB will consist of the System Engineering Lead, Infrastructure Integration Lead, In-vehicle Integration Lead, the Personal Information Device Integrate Lead, and a to be determined number of key technical staff. The CCB's responsibility is to manage procedures for handling proposed changes to items under configuration control, determine the disposition of proposed changes, and the role of the USDOT in configuration control. During Phase 2 as the project moves through the system engineering process, the CCB will review the results of testing, work with the project team to address changes needed for the CCB to recommend the project progress through the quality gate. Additionally, the CCB will meet with the stakeholders and make a recommendation as to whether to advance the project through the quality gates. The stakeholders are the ultimate approvers for advancing the project through a quality gate. There are quality gates following the Unit/Device testing, Subsystem Testing, Validation testing, and Verification testing. Following each of these tests, the CCB meets, determines whether to recommend advancing the project, and shares its recommendation with the stakeholders. The CCB will also be called to meet virtually or in-person as necessary during Phases 2 and 3 to support other proposed changes as they may arise. The CCB will be chaired by System Engineering Lead and will meet at THEA offices.

The Configuration Management Plan is a component of the PMP delivered under Task 2-A.

3.1.4 Risk Management

Risk Management will include identifying, prioritizing, and managing program risks in a timely and efficient manner. Risks that may impact the schedule, scope, or costs of activities performed under the program should be identified, documented, and tracked. Plans for mitigating and reducing risks will be identified and implemented. The Risk Management Plan is a component of the PMP delivered under Task 2-A and includes a Risk Matrix.

3.1.5 Program Management Plan (PMP)

THEA will prepare a PMP that describes the activities required to perform the work, per the current PMBOK Guide. The PMP shall explain the roles and responsibilities of all key individuals within the program/project team. At a minimum, the PMP shall contain a Scope Management Plan, a Schedule Management Plan, a Communications Management Plan, a Cost Management Plan, a Quality Management Plan, Configuration Management Plan, and a Risk Management Plan.

The PMP will be accompanied by a detailed CV Pilot Deployment Project Schedule, considered to be a logical component of the PMP, which may be a physically separate electronic file. The Project Schedule will list all activities required to bring all required work to a successful completion and will contain – at a minimum – three levels of the Work Breakdown Structure (WBS).

The Project Schedule will be updated monthly. The Project Schedule will describe:

- Name of the work activity
- Expected start and end dates
- Name of the individual with the primary responsibility for accomplishing the work
- Dependencies with other work activities in the Project Schedule
- All deliverables, procurements, or milestones resulting from the work activity.

THEA will deliver a draft PMP to the USDOT. After receiving USDOT comments and resolving them, THEA will provide a revised version of the PMP and its related documents. During the course of the deployment, THEA will propose modifications to the PMP, as needed. Any such modifications shall go through the cycle of draft submission, USDOT review and comment, comment resolution, and submission of a revised version.

3.1.6 Kickoff

Within four weeks after the effective date of the award, representatives from THEA's deployment team shall attend a kick-off meeting to be held in Washington, DC with the USDOT and its representatives to ensure that all parties have a common understanding of the award requirements and expectations. THEA will bring its key personnel to this meeting and the AOR will arrange the location, the agenda, and the list of other attendees.

3.1.7 Progress Reports and Teleconferences

THEA will provide monthly progress reports that identify all deliverables and deliverable status (not initiated, in progress X% complete, draft delivered, in revision X% complete, final delivered, accepted). Monthly reports will contain a narrative of accomplishments by task and projected activities in the next quarterly period. Monthly reports will also contain an updated project schedule with a schedule risk narrative, a technical risk narrative, a partnership risk narrative, a retrospective cost narrative, and a projected cost-to-complete narrative.

3.1.7.1 Coordination Teleconference Participation

THEA will organize and participate in a site-specific *bi-weekly deployment coordination teleconference* with the AOR and federal team members to cover work in progress, identify issues and risks, and coordinate technical assistance.

To assist in coordination across sites and encourage collaboration among deployment sites, THEA will have a minimum of one representative to participate in a monthly all-site coordination teleconference to be conducted with all Phase 2 and Phase 3 Recipients.

3.1.8 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into Task 2-A:

- Phase 1 Project Management Plan (Final).

Deliverables:

- Kick-off Meeting
- PMP
- Revised PMP (as required)
- Project Schedules (updated monthly)
- Monthly Progress Reports
- Participation in site-specific bi-weekly coordination teleconferences
- Participation monthly all-site coordination teleconferences.

3.2 System Architecture and Design – Task 2-B

This System Architecture and Design task area builds on systems engineering work conducted in Phase 1 and documented in key Phase 1 deliverables, including the ConOps, System Requirements, and CDP. The objective of this task is to first develop a well-structured architecture for the site deployment concept; and second to prepare a detailed design based on that architecture that embodies the deployment concept.

3.2.1 System Architecture

At the onset of the System Architecture task, THEA will review the existing regional ITS Architecture that includes the Pilot deployment. THEA will build off of the regional architecture and include the Connected Vehicle Reference Implementation Architecture (CVRIA); which is generated from the SET-IT tool. THEA will document variances that are needed in the regional architecture to incorporate the CVRIA. As part of defining the architecture, THEA will describe each CV application and how the applications will be adapted for used in the Pilot. THEA will not be developing new applications nor making extensive modifications to the existing applications. One of THEA's objectives is to demonstrate how existing applications can be used to solve the real world problems THEA identified as part of its proposal.

In order to develop the system architecture, THEA will utilize the work it performed using the SET-IT tool in Phase 1 during the development of the Concept of Operations. THEA created its six Use Cases and assigned the appropriate CV applications to them. THEA customized the CV applications to meet its needs. The stakeholders were defined in SET-IT as well as their relationships.

THEA will update each use case and its associated applications to reflect the work that was performed throughout Phase 1. SET-IT will generate a set of architecture diagrams for the project. THEA plans to have an Enterprise Architecture, a Functional Architecture by use case, a Physical Architecture, and a Communications Architecture. These architectures can be derived from the work performed using the SET-IT tool.

The Enterprise Architecture will be extracted from SET-IT. The Enterprise Architecture depicts the overall system and participating stakeholders. This architecture shows how the stakeholders interact with one another and with the system. It sets the expectation for what each stakeholder has to do and how they interact with one another.

The Functional Architecture will consist of the architecture for each use case incorporating the use case's designated applications. To be clear, several of the applications appear in more than one use case, but will function the same in each case. Each use case's architecture will show each

application's logical architecture as well as how and where the applications interact with one another, if they do.

Each use case and its applications will have a Physical Architecture where the actual components of each application are identified specifically to THEA Pilot. For example, an RSU could be identified as a City of Tampa RSU deployed at intersections or a THEA RSU deployed along and prior to the REL exit ramp curve. The Physical Architecture will define how these hardware components connect with one another.

Finally, a Communications Architecture is generated from the SET-IT. The Communication Architecture is based on the Physical Architecture and identifies the communications medium (e.g., DSRC, Wi-Fi), the communications protocol between the hardware components, and the security protocol (e.g., whether the messages between the devices are encrypted or not).

The architectures discussed above will be documented in the System Architecture Document (SAD) along with a narrative that explains the architecture and how it applies to the Pilot. THEA will follow IEEE Standard 42010-2011 (IEEE Recommended Practice for Software Architecture Descriptions) includes guidelines for format and content to develop a SAD.

Standards are critical to the successful implementation of CV not only on a limited scale, but also on a regional, statewide and national scale. There are several CV standards that exist or are in the development stage. THEA has identified the initial standards that it will use to implement the Pilot. During the development of the System Architecture, THEA will refine and lock in the list of standards for the Pilot. It is important for THEA to determine which standards and which version of the standards it will use as CV device vendors and other interested parties will need that information to be able to provide compliant devices to THEA. Where new standards are needed, these needs will be fully documented in the Standards Plan. To support nationwide deployment of ITS infrastructure and CV technologies, THEA will use existing ITS standards, architectures, and certification processes for ITS and CV- based technologies whenever viable, and document those cases where such use is not viable.

As part of this task as well as other tasks throughout Phase 2, THEA will participate in standards meetings to provide input to the standards committees on what THEA has identified as a necessary standard as a result of implementing the Pilot (Task 2-L).

3.2.1.1 System Architecture Walkthrough

After the delivery of the draft Systems Architecture, THEA will conduct a System Architecture Walkthrough (see IEEE Standard 1028-2008) with the AOR and federal team members in the Washington DC metropolitan area (including a Walkthrough Workbook to structure and expedite the Walkthrough process) to demonstrate the completeness and technical soundness of the architectural approach. THEA will plan and allocate two full working days for the Walkthrough. THEA will respond to USDOT comments (both written comments provided prior to the Walkthrough and verbal comments provided during the Walkthrough), and submit a revised System Architecture document and an accompanying comment resolution report. Based on USDOT review of the revised document, THEA will deliver a final System Architecture document.

A webinar will be made available for remote participation by additional THEA team members. THEA will work with USDOT staff to determine the webinar content and the webinar scheduling.

3.2.2 System Design

With the System Architecture in place, THEA will initiate the system design. Based on the System Requirements Specification (SyRS) (THEA, Task 6, SyRS, May 2016) and the system architecture,

the system design will be created. The system design will take the Functional Architecture components and create subsystems that are defined and decomposed into more details modules. These modules will be based on the existing source code and documentation that is obtained by THEA. THEA will examine each applications source code and documentation, determine what adaptations need to be performed for each application, and document those adaptations in modules defined for the application. Requirements will be allocated to the system components, and interfaces will be specified in detail.

THEA has performed an initial review of the existing applications and identified which applications will need to be adapted and what the adaptation(s) maybe. The following table identifies the application, its original definition, whether it needs adaptation, and what the adaptation is.

Table 5: CV Apps and Adaptations.

CV App	Original Definition	Adaptation(s)
Forward Collision Warning	Warns the driver of the vehicle in case of an impending rear-end collision with another vehicle ahead in traffic in the same lane and direction of travel.	Used as designed
Emergency Electronic Brake Light	Enables a vehicle to broadcast a self-generated emergency brake event to surrounding vehicles. Upon receiving the event information, the receiving vehicle determines the relevance of the event and if appropriate provides a warning to the driver in order to avoid a crash.	Used as designed
Curve Speed Warning	Allows connected vehicles to receive information that it is approaching a curve along with the recommended speed for the curve. This capability allows the vehicle to provide a warning to the driver regarding the curve and its recommended speed	Used as designed, with input scaled to safe stopping distance
Intersection Movement Assist	Warns the driver of a vehicle when it is not safe to enter an intersection due to high collision probability with other vehicles at stop sign controlled and uncontrolled intersections	Used as Designed
Red Light Violation Warning	Enables a connected vehicle approaching an instrumented signalized intersection to receive information from the infrastructure regarding the signal timing and the geometry of the intersection	Used as designed to predict violation, plus added TIM warnings: <ul style="list-style-type: none"> □ 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
Intelligent Traffic Signal System	Uses both vehicle location and movement information from connected vehicles as well as infrastructure measurement of non-equipped vehicles to improve the operations of traffic signal	Used as mathematically designed, plus: <ul style="list-style-type: none"> ▪ Hard-coded site-specific test constants become

	control systems. The application utilizes the vehicle information to adjust signal timing for an intersection or group of intersections in order to improve traffic flow, including allowing platoon flow through the intersection.	<ul style="list-style-type: none"> configurable fields Manufacture-specific constants become configurable fields Generalize the hard-coded, fixed-phase sequences to configurable fields
Probe Enabled Data Monitoring or Vehicle Data for Traffic Operations	Uses probe data information obtained from vehicles in the network to support traffic operations, including incident detection and the implementation of localized operational strategies.	Aggregate incremental BSM movements to travel time, incidents
Pedestrian in signalized crosswalk warning	Provides to the connected vehicle information from the infrastructure that indicates the possible presence of pedestrians in a crosswalk at a signalized intersection.	Translate WiFi PSM to DSRC BSM for FCW and IMA
Mobile Accessible Pedestrian Signal System	Integrates traffic and pedestrian information from roadside or intersection detectors and new forms of data from wirelessly connected, pedestrian (or bicyclist) carried mobile devices (nomadic devices) to request dynamic pedestrian signals or to inform pedestrians when to cross and how to remain aligned with the crosswalk based on real-time Signal Phase and Timing (SPaT) and MAP information.	Used as designed
Transit Signal Priority	Uses transit vehicle to infrastructure communications to allow a transit vehicle to request an priority at one or a series of intersection. The application includes feedback to the transit driver indicating whether the signal priority has been granted or not.	Used as designed, plus: <ul style="list-style-type: none"> Vehicle Identification Number (VIN) authenticated by HART central Priority Request selectively granted or blocked by HART central
Vehicle Turning Right in Front of Bus	Determines the movement of vehicles near to a transit vehicle stopped at a transit stop and provides an indication to the transit vehicle operator that a nearby vehicle is pulling in front of the transit vehicle to make a right turn.	Transit vehicle is a street car

THEA will document the system design in the Systems Design Document (SDD) following the IEEE Standard 1016-1998 which includes guidelines for format and content to develop the SDD.

3.2.2.1 System Design Walkthrough

After the delivery of the draft SDD, THEA will host and conduct a System Design Walkthrough based on IEEE Standard 1028-2008 with the AOR and federal team members within or near the deployment site to demonstrate the completeness and technical soundness of the system design. THEA will conduct the walkthrough as a webinar such that those who could not attend in person can participate via the webinar. THEA will create a Walkthrough Workbook to structure and expedite the Walkthrough process). THEA will plan for a minimum of two full working days to conduct the Walkthrough THEA will

respond to USDOT comments (both written comments provided prior to the Walkthrough and verbal comments provided during the Walkthrough), THEA will submit a revised SDD and an accompanying comment resolution report. Based on USDOT review of the revised SDD, THEA will deliver a final SDD.

3.2.3 Products

When the SDD is complete, as needed, THEA will deliver updated versions of Phase 1 deliverables. At a minimum, these updates will include: ConOps, System Requirements Specification, and CDP. Significant changes that impact other prior documents will be added as amendments as needed.

The following Phase 1 contract deliverables are hereby incorporated by reference Task 2-B:

- Phase 1 ConOps (Final)
- Phase 1 System Requirements Specification (Final)
- Phase 1 Comprehensive Deployment Plan (Final).

Deliverables:

- Draft SAD
- Systems Architecture Walkthrough and Workbook (DC metro area)
- Revised SAD with Comment Resolution Report
- Final Systems Architecture Document
- Draft SDD
- Systems Design Walkthrough and Workbook (deployment site)
- Revised SDD with Comment Resolution Report
- Final SDD
- Updated Phase 1 Deliverables:
 - Revised ConOps
 - Revised Systems Requirements
 - Revised Comprehensive Deployment Plan.

3.3 Data Management Planning – Task 2-C

THEA will develop a Data Privacy Plan (DPP) and a Data Management Plan (DMP) that relate to how data will be collected, integrated, managed, and disseminated during Phase 2 and Phase 3. This includes real-time and archived data (specifically identifying data to be shared on the Research Data Exchange (RDE)) that are used to control or are generated by systems managed by THEA and its partners.

3.3.1 Data Privacy Plan

Improper handling of PII or Sensitive Personally Identifiable Information (SPII) by THEA could have significant adverse impacts on the privacy of individuals.

For this reason, USDOT and THEA are committed to ensuring that THEA institute sufficient data privacy controls to mitigate the risk of harm to individuals that would result in the improper handling or disclosure of the PII and SPII collected from individuals in connection with a DOT-funded CV Pilot Deployment project. THEA will:

- Devote sufficient resources, and develop and adhere to policies and procedures to ensure that privacy-risks stemming from deployment are mitigated appropriately and in accordance with the privacy controls identified in Section H.1 of the NOFO that supports the “Connected Vehicle (CV) Pilot Deployment Program” for the ITS JPO within the USDOT.
- Develop and submit for USDOT approval a DPP that documents the technical, policy, standards, and physical controls that it will put in place (and require THEA’s contractors to put in place) to mitigate potential privacy harms; the plan shall include documentation sufficient to verify that THEA will interact with PII only on infrastructure that is subject to appropriate security controls.

- Ensure that THEA stakeholders, contractors, and others (including evaluators) who handle or may access PII or SPII developed by THEA in connection with a CV Pilot Deployment project adhere to THEA's DPP and have policies and procedures in place to safeguard the security and privacy of participant data. To this end THEA will include in all sub-grant agreements and contracts appropriate data security and privacy requirements
- Upon request by USDOT, provide sufficient documentation to demonstrate that its infrastructure, policies and procedures (and those of any THEA stakeholders or contractors having access to PII or SPII) comply with the privacy control requirements set forth in Section H.1 of the NOFO that supports the "Connected Vehicle (CV) Pilot Deployment Program" for the ITS JPO within the USDOT, including but not limited to confirming that PII and SPII will be stored only on infrastructure employing security controls commensurate with the risk to the individual that would result from unauthorized access, disclosure, or use of the information.

Section H.1 of the NOFO document contains a summary of more detailed information related to USDOT Privacy Policy pursuant to the scope and content of a DPP. The DPP should be consistent with an overall Privacy Management Plan, prepared by THEA to address and to be in accordance with state and local laws. The Privacy Management Plan is not a deliverable under this agreement. THEA is responsible only for submitting a Notice of Privacy Management Consistency (a one-page letter) to USDOT that a Privacy Management Plan has been completed prior to the finalization of the DPP.

Though the purpose of the overall Privacy Management Plan is to address and to be in accordance with state and local laws beyond the scope of the DPP, there do not appear to be state or local laws that would require additional security. It would appear that THEA's one page letter: Notice of Privacy Management Consistency to USDOT would simply state that the DPP satisfies the requirements of the Privacy Management Plan. THEA will check with FDOT and City of Tampa for additional requirements that may be in effect.

The DPP will be consistent with the SMOC (Phase 1, Task3), which includes a Privacy Operational Concept – any variances shall be identified and highlighted for USDOT review and approval.

THEA will deliver a draft DPP to the USDOT for review. THEA will prepare a revised DPP in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised DPP, and with the insertion of a confirmation clause inserted into the DPP that a Privacy Management Plan has been prepared, THEA will deliver a final DPP.

3.3.2 Data Management Plan

This plan will serve as an operational guide for managing data collectively as a strategic asset, and, subject to applicable privacy, security and other safeguards, making data available to enable transparent system performance measurement, support independent evaluation, and fuel entrepreneurship, innovation, and economic development. The DMP will document the flow of data from generation through its use to applications in the deployment, including.

- Data sources and destinations
- Volume of data flow
- Contents of data flow
- Communications medium involved.

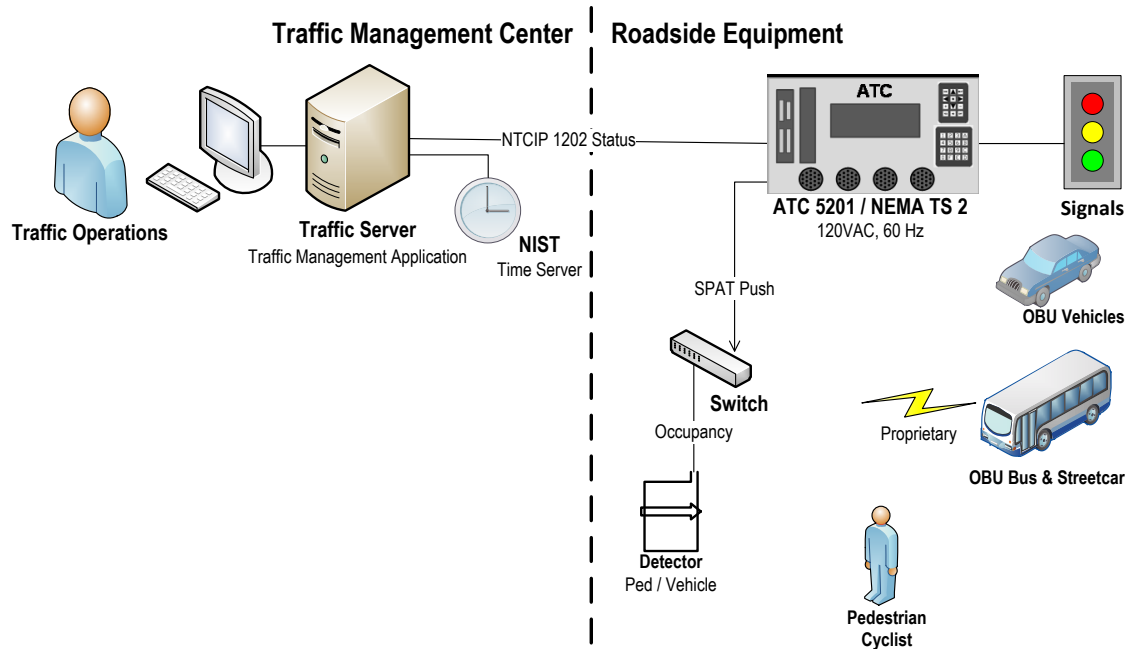
Readers are referred to Chapter 7 of the PMESP for details on data sources for evaluation (THEA, Task 5, PMESP, June 2016).

3.3.2.1 Current Situation

As shown in Figure 4, the Traffic Management Center (TMC) currently controls a wide area network of Advanced Traffic Controller, ATC 5201 and NEMA TS 2 traffic signal controllers using a modern traffic management software application. National Institute of Standards and Technology (NIST) time server is used to send accurate time of day to all controllers connected to the traffic server. In the event of TMC failure, each controller continues to track time of day via counting 60 Hz power line cycles.

Although power frequency can vary, each controller will retain identical times for proper traffic progression, based on a common 60 Hz time base. Transit priority is achieved via a local proprietary request from the bus to each signal controller with no central software application at HART.

Figure 4: Data Management Functional Diagram, Current Situation



Source: HNTB

3.3.2.2 Planned Operation

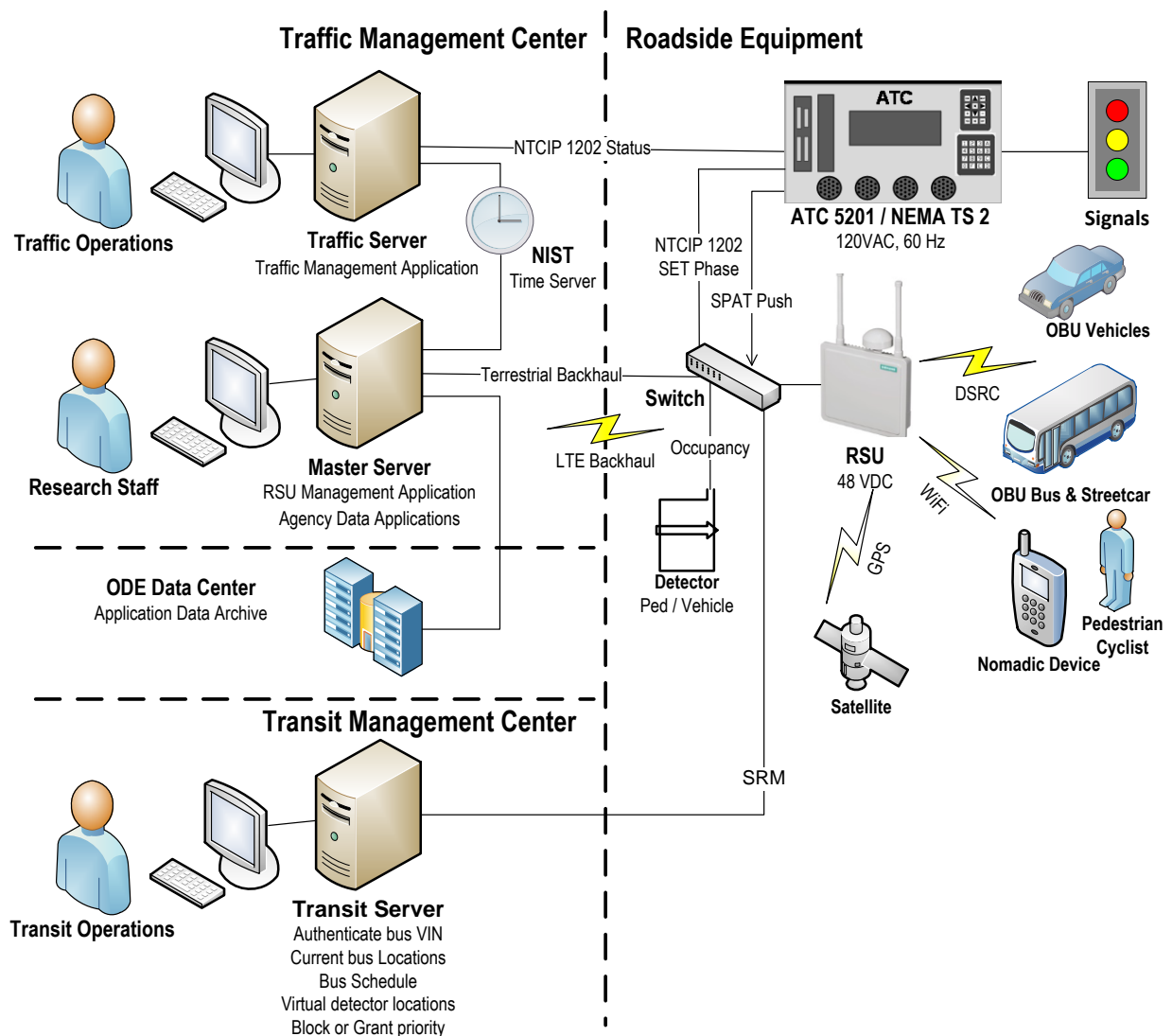
Figure 5, Planned Operation depicts the data generation and management of the project. The current traffic management operations are unaffected. No updates to the traffic management applications are anticipated. The Master Server is added as a separate system that has no data flow to or from the Traffic Server. The Master Server implements the following functions:

- Manages the wide area network of RSUs via an LTE or terrestrial backhaul, depending upon the availability of existing communications infrastructure at each site. The RSU management software application includes area maps showing the location and status of each RSU and uses the maps to geo fence each RSU to filter only the messages originating within the fence drawn on the map, and to discard those outside the fence.
- Collects and stores messages, alerts and warnings from the applications running in the RSU.
- Implements the agency data applications, such as travel time and incident detection.
- Receives NIST time identical to the Traffic Server in order to synchronize all RSUs identically to the controllers. In the event of Master Server failure, each RSU receives GPS time.

Each RSU is used to implement one to four V2I applications running simultaneously. As stated in Chapter 7 of the PMESP, The V2V Safety and V2I Safety applications will not be subscribers to data from the ODE. However, the data from the apps are sent to the ODE for archiving purposes. The reason that the Safety applications are not served by the ODE is that the latency required by the Safety applications is very low for them to be useful, which cannot be achieved when the data is sent for processing to the TMC or the ODE and then returned to the Safety applications as alerts or warnings. For example, BSM and PSM communications occurs locally among RSUs, vehicles and pedestrians to issue safety warnings quickly. The subsequent alerts and warnings can be archived in the ODE, but at no time is the Master Server or ODE included in the control loop that generates the

safety warning. For unequipped vehicles, pedestrians and bicycles without nomadic devices, traditional detection equipment is used to proxy messages as if all are equipped so that the new vehicles are aware of the crash threats. Existing signal controllers are retained with a version of software used in Safety Pilot developed under Contract No. DTFH61-06-D-00007 that issues a continuous real time push of “NTCIP-like” SPAT objects that provides a digital representation of what is displayed on the signals now, next, and the countdown to the next display. The RSU adds the timestamp to complete the J2735 message format. The traffic progression application can then SET the correct signal phase using NTCIP 1202 objects to the controller. In the event of complete failure of both the Traffic Server and the Master Server, the signal controller time of day derived from power service will drift with respect to the RSU time of day derived from GPS. Since the RSU always adds the timestamp to the J2735 SPAT message, time of day offsets between signal controller and RSU is never a factor in the connected vehicle operations. Transit Priority requests are sent to the HART central for authentication, which can selectively forward or block the requests depending upon whether the bus is ahead or behind schedule.

Figure 5: Data Management Functional Diagram, Planned Operation



Source: HNTB

The plan will describe all data collection activities. Further, the plan should assess the variety, volume, and velocity (frequency of collection) of deployment-related data that can be accommodated in order to ensure the end-to-end delivery of data to all identified users. The plan shall establish quality control procedures, and any automated data checking routines developed should be identified for sharing as an open source capability (see Task 2-E). In cases where data includes PII or other restrictions, the document shall address how THEA will make those data available, as possible, in a secure environment for the use of designated parties, vetted with the concurrence of both the site and USDOT. The DMP is intended to provide clear operational procedures consistent with data-related elements of multiple deliverables, including (but not limited to):

- Data Privacy Plan
- Phase 1 Security Management Operating Concept, which includes a Privacy Operational Concept
- Phase 1 Performance Measurement Plan, which describes Field Data Collection, data sharing associated with support to an IE, and includes a Data Sharing Framework (see below)
- Phase 1 System Requirements, which includes Data Sharing Requirements
- Phase 1 Human Use Approval Summary, which includes feedback from an IRB related to participant data collection and use.

3.3.3 Data Sharing Framework

CV, mobile device, and infrastructure sensor data captured during deployment are expected to be broadly shared with the community. However, data sharing is subject to the protection of intellectual property rights and personal privacy and must be handled securely. Appropriately prepared system control, performance and evaluation data, stripped of PII, are expected to be shared with the USDOT and posted in timely fashion on resources such as the Research Data Exchange (RDE) (www.its-rde.net). The USDOT envisions that this data sharing capability will better support the needs of ITS researchers and developers while reducing costs and encouraging innovation. Data accessible through the RDE will be well-documented and freely available to the public. Hence, in the DMP, THEA will identify all appropriate data and processes (including privacy-related processes) to be utilized in data sharing/uploading through the RDE. All submittals to the RDE will be made in accordance with guidelines on preparation for submission and accompanying meta-data as posted on the RDE site.

While the RDE currently only supports dissemination of data that has been stripped of PII, the USDOT may develop additional future capabilities to facilitate sharing sensitive data with qualified researchers, and automate cleansing of data sets to remove PII to enable public dissemination. The RDE currently can accept real-time data feeds and this capability is also planned for enhancement. The USDOT expects to work closely with THEA to ensure that data produced during the demonstration is shared efficiently and cost effectively, leveraging these and other shared resources as appropriate to increase the completeness and timeliness of data exchange.

Sensitive data may be kept at the Saxton Transportation Operations Laboratory for subsequent use by qualified researchers, subject to the consent agreement by each participant with THEA and USDOT.

This task is related to Data Management Planning; the execution of activities related to data collection and data sharing in accordance with the approved DPP and DMP is included as part of tasks 2-H, 2-K, 3-B and 3-D.

3.3.4 Products

THEA will deliver a draft DMP to the USDOT for review. THEA will prepare a revised DMP in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised DMP, THEA will deliver a final DMP.

The following Phase 1 contract deliverables are hereby incorporated by reference into Task 2-C:

- Phase 1 Security Management Operating Concept (Final)
- Phase 1 Performance Measurement Plan (Final)
- Phase 1 System Requirement Specification (Final)
- Phase 1 Human Use Approval Summary (Final).

Deliverables:

- Draft DPP
- Revised DPP with Comment Resolution Report
- Final DPP
- Notice of Privacy Management Consistency
- Draft DMP
- Revised DMP with Comment Resolution Report
- Final DMP.

3.4 Acquisition and Installation Planning – Task 2-D

3.4.1 Comprehensive Acquisition Plan (CAP)

3.4.1.1 Vehicles and In-Vehicle

3.4.1.1.1 Descriptions

The THEA CV Pilot Deployment involves different types of vehicles: cars, buses and trolleys (streetcars). The diversity of these vehicles along with the different technologies available in-vehicle is one of the most critical aspects to consider for a high quality CV Pilot implementation. Cars, trolley and buses have different characteristics in terms of system architecture, environmental constraints, driver interactions and installation procedures.

Regardless of the type of vehicle (cars, buses, streetcars) contained in the Pilot, there are common features that each CV system must provide and include:

- Communication with the outboard devices (other vehicles, RSUs, pedestrians' smartphones).
- In-Vehicle data acquisition and processing (implementation of specific applications)
- Interaction with the Driver (information provided as indications, warnings, alerts).

The most common in-vehicle architecture implementation to provide these features includes the use and integration of three independent devices: antennas, OBUs and Human Machine Interfaces (HMIs). These devices are connected in the vehicle and with the vehicle system to implement the features above described.

3.4.1.1.2 In-Vehicle On-Board Unit (OBU) Kits

The vehicle antennas are typically dedicated to the communication of the vehicle with infrastructure (Road Side Units), other vehicles (DSRC antenna) and the reception of the vehicle coordinates (GNSS antenna).

The OBU (typically one for each vehicle) acquires and processes data received or transmitted by the antennas. The HMI communicates information to the driver about specific hazards and actions to take to improve safety and/or mobility.

Beyond the common in-vehicle architecture of three independent devices installed separately, there exist design variants in which a single device can implement one or more of the features above described. For example, the antenna and DSRC radio can be combined into a "smart antenna" combining the standard antenna function, and data acquisition processing, while other devices contain an OBU with integrated HMI.

All optional devices and technologies have been analyzed to determine the best solutions for the Tampa Pilot in terms of performance, installability, reliability and user interaction for each different vehicle type.

Through a Request for Information (RFI) process, technology providers have disclosed their current products and roadmaps, allowing the in-vehicle integrator to evaluate different architectures and technical solutions. Part of this process also involves the evaluation of performances, readiness, quality, services offered to support the pilot, and costs. This analysis is currently ongoing and will be preparatory for the sourcing activity in the pilot development and deployment phase.

The ultimate aim of this process is to identify the most suitable products for specific vehicle types and eventually create a compatibility matrix where each vehicle involved in the pilot is coupled with a specific in-vehicle installation kit.

An in-vehicle kit contains:

- Hardware (antennas, OBU, HMI)
- Software (pre-loaded on the hardware)
- Brackets/Mounting
- Harnesses
- Wiring Diagram
- Installation Instructions
- User manual.

Besides the above mentioned process, the in-vehicle integrator has conducted a wide analysis of current solutions adopted by other Pilots, taking advantage of the lessons learned during other CV deployments, including work in the UMTRI Safety Pilot Model Deployment (SPMD).

3.4.1.1.2.1 Antennas

There are different antenna configurations available that differ chiefly by application purpose (e.g., DSRC, GNSS, SAT) and also by the number of functions integrated into a single device. There are single devices that include multiple DSRC antennas and a single GNSS antenna, while others are dedicated to a specific function (DSRC or GNSS).

Mounting features are very important characteristics to consider for antennas. The vehicles involved in the Pilot most likely already contain some kind of antenna installed and this is an important factor to be considered while selecting the most appropriate antenna for each participating vehicle.

Solutions that permit loss or degradation of pre-existing vehicle functions will not be considered acceptable.

The antenna mounting location significantly affects the performances of the antennas, so, each in-vehicle kit will have detailed instructions to install the antenna in a specific mounting location. It will not be possible to change antenna location after installation.

3.4.1.1.2.2 OBU

The OBU performs data acquisition and processing of information received from/transmitted to the antennas. The OBU is also responsible for the communication with an HMI Device that conveys information to the driver.

The distance between OBU and Antenna is critical and must be minimized to ensure communication performances. This leads us to consider “smart antennas” as attractive solutions where the OBU-ANTENNA distance might become a critical performance parameter.

The OBU's size and weight, along with the mounting features, are critical. OBUs should not be accessible and visible by the user (unless they are part of a system integrated into an HMI).

Another key feature of an OBU is the interface with the HMI device. Most of the OBU Devices offer different means to provide information to the HMI. The typical interfaces are: Video (RCA/HDMI), Audio, Ethernet, BT, CAN Bus.

Using Audio/Video interfaces imply that the HMI logic is implemented in the OBU. In this case the HMI device is a passive device, while interfaces like Ethernet, BT and CAN bus are used when the HMI logic implementation reside within the HMI device. In this case, thus the OBU only informs the HMI device of the alerts/warnings status.

The OBU software will preloaded in the OBU devices before installation.

3.4.1.1.2.3 HMI

HMI devices are responsible for communicating vehicle safety information to the driver. This user interaction is very important because it allows the system to inform the driver about potential hazards, and/or suggest actions to improve safety.

There are a number of possible HMI devices that can be installed and used, ranging from highly integrated and seamless, or lightly integrated aftermarket add-on in nature, and ranging from audio, visual, haptic, or combination, as the means of communication of V2X app information to the driver.

THEA is strongly considering the use of OEM-oriented aftermarket internal rearview mirrors with embedded display driven by the OBU (audio/video output). This HMI is a device that is installed in the car to replace the factory internal rearview mirror without losing its original function. Interior rearview mirrors with integrated display and RCA or HDMI inputs may represent the most suitable solution for light vehicles.

Smart LED bars with audio integration are possible standalone aftermarket add-on solutions if properly integrated into the vehicle. In this case the interface with the OBU is through a dedicated CAN, USB or Ethernet protocol. The main benefits of this solution consist in a more efficient management of concurrent alerts and a possible reduction of driver cognitive load by using a specific position for each warning recognizable with a dedicate symbol. This solution can be used on all type of vehicles.

Specific HMI requirements in terms of description of what and how the HMI device will interact with the driver will be finalized at the beginning of the CV Pilot Phase2 (fall/winter 2016).

HMI devices that can be modified by the user in any way (software, mounting location) are not considered reliable solutions.

The HMI software will be preloaded in the HMI devices before installation.

Buses and trolleys have specific environmental constraints and the HMI final solution requires a deeper analysis that is ongoing. The main environmental constraints consist of high ambient noise (street and vehicle noise) that influences audio communication to the driver. The location of the HMI device also needs to be optimized to the distance of any physical information display from the driver. Buses and trolleys may have computers with displays already installed that can be used as HMI for the CV apps, but in any case a bus/trolley-specific consideration of appropriate HMI is required.

The in-vehicle integrator will complete the evaluation of these constraints at the beginning of Phase 2.

3.4.1.2 Roadside

3.4.1.2.1 Descriptions

Inventory of roadside equipment and software applications procured for project Phase 2 consist of:

Roadside Equipment:

- Qty (65) Roadside Units (RSU), (40) installed in field + (25) for test and replacement:
 - US DOT FHWA DSRC Roadside Unit (RSU) Specification Document, Version 4.0
 - Added local WiFi hot spot
 - Added LTE cellular backhaul
- Qty (65) Antenna sets, including:
 - DSRC
 - WiFi
 - GPS
 - LTE
- Qty (65) Power over Ethernet Injector
- Qty (65) Outdoor CAT6 Ethernet Cable, cut to installed length from control cabinet to RSU
- Qty (65) RSU Mounting hardware
- Qty (3) Vehicle detectors:
 - Detector 1, configured as a two-zone speed trap on each REL curve lane
 - Detector 2, configured as a two-zone speed trap on the right-turn from REL to Twiggs
 - Detector 3, configured as a two-zone speed trap on each RLE entrance lane
- Quantity (3) Vehicle detector mounting hardware
- Quantity (3) Outdoor CAT6 Ethernet cable, cut to installed length from detector to RSU
- Qty (5) Pedestrian detectors:
 - Detector 1, configured for crosswalk pedestrian occupancy, defined as one or more persons located within the marked crosswalk
 - Detectors 2 and 3, configured for crosswalk pedestrian presence, defined as one or more persons located within six feet from the face of each curb or from each edge of the pavement at the beginning of the WALK signal indication
 - Detectors 4 and 5 configured for j-walk, defined as one or more persons located in the roadway within RSU WiFi range, but outside each edge of the marked crosswalk
- Quantity (5) Pedestrian detector mounting hardware
- Quantity (5) Outdoor CAT6 Ethernet cable, cut to installed length from detector to RSU

Roadside Software Applications:

- Curve Speed Warning (CSW)
- Red Light Violation Warning (RLVW)
- Proxy: Convert vehicle detector speed trap occupancy states to Basic Safety Message (BSM)
- Pedestrian Safety: Translate WiFi Personal Safety Message (PSM) to DSRC BSM (PED-X)
- Transit Signal Priority (TSP)
- Intelligent Traffic Signal (I-SIG)
- Pedestrian Safety (PED-SIG).

Speed Trap Operation:

Speed Trap is a common NEMA TS 2 software application in which two vehicle detectors are placed at a known distance apart in the direction of traffic flow. Each detector issues one bit indicating that a vehicle occupies that location. As a vehicle travels first over one detector then the second detector, the time between each occupation is used to determine the speed of the vehicle, based on the known distance between detectors. The direction of vehicle travel is determined by which detector was occupied first. That way the direction and speed can be added to the location of the detectors to populate and broadcast a Basic Safety Message from the RSU as if an older vehicle is equipped with an OBU.

3.4.1.2.2 Roadside Unit (RSU) Kits

3.4.1.2.2.1 Hardware

RSU inventory and installed locations are shown as “HW Object” column of Table 6.

3.4.1.2.2.2 Software

V2I software applications installed in each RSU are shown as “SW Application” column of Table 6. The locations, HW Objects and SW applications in Table 6 correspond to the sites and functionalities depicted on the map in Figure 2. In Table 6 traditional detectors are signified as “I” for infrastructure.

Table 6: RSU Locations and Software Applications.

Use Case	Location	HW Object	SW Application	
Morning Backup (includes queue data from RSU9)	REL 27.954404, -82.448805	RSU 1	V2I	CSW
				RLVW
				Proxy
		Detector, Curve	I	Vehicle Detection
		OBU	V2I	CSW
				RLVW
EEBL				
	V2V	FCW		
Wrong-Way Entry	Twiggs & Meridian 27.952315, -82.449056	RSU 2	V2I	I-SIG
		Detector, Right Turn		RLVW
		Detector, Entrance	Agency	PDETM
		OBU	V2V	IMA
			V2I	RLVW
Pedestrian Safety	Twiggs & Courthouse 27.950822, -82.453815	RSU 40	V2I	Proxy
		Crosswalk Detector	I	I
		Curbside Detector 1		
		Curbside Detector 2		
		J Walk Detector 1		
		J Walk Detector 2		
OBU / PSD	V2V	PED-SIG		
		PED-X		
Transit Signal Priority	Marion & Tyler 27.952711, -82.458214	RSU 19	V2I	I-SIG
		OBU		TSP
	Marion & Cass 27.952015, -82.457876	RSU 20	V2I	I-SIG
		OBU		TSP
	Marion & Polk 27.951267, -82.457521	RSU 21	V2I	I-SIG
		OBU		TSP
	Marion & Zack 27.950531, -82.457215	RSU 22	V2I	I-SIG
		OBU		TSP
	Marion & Twiggs 27.949770, -82.456896	RSU 23	V2I	I-SIG
		OBU		TSP
	Marion & Madison 27.949011, -82.456561	RSU 24	V2I	I-SIG
		OBU		TSP
	Marion & Kennedy 27.948281, -82.456253	RSU 25	V2I	I-SIG
				TSP
			Agency	PDETM
	OBU	V2V	IMA	

Use Case	Location	HW Object	SW Application		
	Marion & Jackson 27.947523, -82.455931	RSU 26	V2I	TSP	
		OBU	V2I	I-SIG	
	Morgan & Jackson 27.947806, -82.455082	RSU 27	V2I	TSP	
		OBU	V2I	I-SIG	
	Pierce & Jackson 27.948095, -82.454242	RSU 28	V2I	TSP	
		OBU	V2I	I-SIG	
	Jefferson & Jackson 27.948403, -82.453403	RSU 29	V2I	TSP	
		OBU	V2I	I-SIG	
	Morgan & Kennedy 27.948575, -82.455406	RSU 30	V2I	TSP	
			Agency	PDETM	
		OBU	V2V	IMA	
			V2I	TSP	
	Pierce & Kennedy 27.948857, -82.454581	RSU 31	V2I	I-SIG	
			Agency	TSP	
		OBU	V2V	PDETM	
			V2I	IMA	
	Jefferson & Kennedy 27.949159, -82.453716	RSU 32	V2I	TSP	
			Agency	I-SIG	
		OBU	V2V	PDETM	
			V2I	IMA	
	Trolley Conflicts	Channelside & Morgan 27.943424, -82.453165	RSU 33	V2I	I-SIG
					PED Safety
					PED-X
		Channelside & Jefferson 27.943604, -82.452140	RSU 34	V2I	I-SIG
PED-SIG					
PED Safety					
Channelside & Nebraska 27.943549, -82.451285		RSU 35	V2I	I-SIG	
				PED-SIG	
				PED Safety	
Channelside & Old Water 27.943525, -82.450382		RSU 36	V2I	I-SIG	
				PED-SIG	
Channelside & Brorein 27.943755, -82.450395		RSU 37	V2I	PED Safety	
	VTRFTV				
Channelside & Caesar 27.943585, -82.449882	RSU 38	V2I	I-SIG		
			PED-SIG		
			PED Safety		
Channelside & North 12th 27.955866, -82.445567	RSU 39	V2I	I-SIG		
			PED-SIG		
			PED Safety		
Traffic Progression	Kennedy & Meridian	RSU 3	V2V	VTRFTV	
			V2I	I-SIG	

Use Case	Location	HW Object	SW Application		
	27.950576, -82.449003		Agency	PDETM	
		OBU	V2V	IMA	
	Washington & Meridian 27.948732, -82.448792	RSU 4		V2I	I-SIG
			OBU	Agency	PDETM
	Whiting & Meridian 27.947184, -82.448675	RSU 5		V2I	I-SIG
			OBU	Agency	PDETM
	Cumberland & Meridian 27.945015, -82.448765	RSU 6		V2I	I-SIG
			OBU	Agency	PDETM
	Channelside & Meridian 27.943557, -82.448889	RSU 7		V2I	I-SIG
			OBU	Agency	PDETM
	Nebraska & Cass 27.953322, -82.451271	RSU 8		V2I	I-SIG
	Nebraska & Twiggs 27.947184, -82.448675	RSU 9		V2I	I-SIG
	Nebraska & Kennedy 27.950303, -82.450353	RSU 10		V2I	I-SIG
	Florida & Tyler 27.952442, -82.459046	RSU 11		V2I	I-SIG
	Florida & Cass 27.951720, -82.458746	RSU 12		V2I	I-SIG
	Florida & Polk 27.950953, -82.458412	RSU 13		V2I	I-SIG
	Florida & Zack 27.950233, -82.458089	RSU 14		V2I	I-SIG
	Florida & Twiggs 27.949471, -82.457758	RSU 15		V2I	I-SIG
Florida & Madison 27.948723, -82.457418	RSU 16		V2I	I-SIG	
Florida & Kennedy 27.947969, -82.457035	RSU 17		V2I	I-SIG	
Florida & Jackson 27.947229, -82.456796	RSU 18		V2I	I-SIG	

3.4.1.3 Mobile Devices

3.4.1.3.1 Descriptions

Personal Safety Devices (PSD) are defined as smart phones running the Android™ mobile operating system

3.4.1.3.2 Mobile Device Kits

3.4.1.3.2.1 Hardware

Hardware of the Mobile Device Kits consists of smart phones privately purchased and maintained by each participant, including the latest Android operating system version available at the time of deployment.

3.4.1.3.2.2 Software

Software applications installed in the Mobile Device Kits include:

- PED-SIG: Smart phone app available on the USDOT Open Source Portal that is used to request pedestrian service.
- PED Safety: Smart phone app available on the USDOT Open Source Portal that broadcasts PSM when within RSU WiFi range

3.4.2 Comprehensive Installation Plan (CIP)

3.4.2.1 Roadside typical installation details and procedures (use case specific)

3.4.2.1.1 Mounting details & procedures

Roadside typical installation details and procedures shown in Table 7 assume the use of 120 VAC service power. Optionally, 48 VDC service power from solar, wind or battery could be substituted if required to operate during failure of the power grid, such as hurricanes. In that case, installation of conduit to 120 VAC service source would be replaced with the installation of a 48 VDC Uninterruptable Power Supply (UPS), serviced by solar, wind etc. Use of UPS allows the TMC to send alerts and Traveler Information Messages (TIM) to smart phones via the RSU local WiFi hot spot.

Table 7: Roadside Equipment Mounting Procedure.

Use Case	HW Devices	Mounting Procedure
Morning Backup	RSU1 Detector 1	<ol style="list-style-type: none"> 1. Mount electrical cabinet on outside of REL guard barrier 2. Install conduit from 120 VAC service to electrical cabinet 3. Install Power over Ethernet (POE) injector inside of the electrical cabinet 4. Install detector processor inside of electrical cabinet 5. Install support pole to outside of REL guard barrier 6. Install RSU on support pole, including antennas 7. Ensure that RSU is line-of-sight to REL curve lanes 8. Install detector camera on support pole 9. Align camera field of view to cover the three lanes
Wrong Way	RSU 2 Detector 2 Detector 3	<ol style="list-style-type: none"> 1. Install POE injector inside of traffic control cabinet 2. Install detector processor inside of traffic cabinet 3. Install RSU on sign gantry, including antennas 4. Ensure that RSU is line-of-sight to REL lanes 5. Install Detector 2 camera on pole near right turn lane 6. Install Detector 3 camera on sign gantry at REL entrance 7. Align camera 2 field of view to cover right turn lane 8. Align camera 3 field of view to cover REL entrance lanes
Pedestrian Safety	RSU 40 Crosswalk Detector Curbside Detector 1 Curbside Detector 2 J Walk Detector 1 J Walk Detector 2	<ol style="list-style-type: none"> 1. Install POE injector inside of flasher cabinet 2. Install detector processor inside of flasher cabinet 3. Install RSU on flasher pole, including antennas 4. Ensure that RSU is line-of-sight to lanes and curbsides 5. Install Detector cameras on pole near crosswalk 6. Align crosswalk camera field of view to cover crosswalk 7. Align curbside 1 camera field of view to first curbside 8. Align curbside 2 camera field of view to second curbside 9. Align jwalk 1 camera field of view to lanes west 10. Align jwalk 1 camera field of view to lanes east

Transit Signal Priority	RSU 19-32	<ol style="list-style-type: none"> 1. Install POE injector inside of traffic control cabinet 2. Install RSU on pole, including antennas 3. Ensure that RSU is line-of-sight to travel lanes
Trolley Conflicts	RSU 33-39	<ol style="list-style-type: none"> 1. Install POE injector inside of traffic control cabinet 2. Install RSU on pole, including antennas 3. Ensure that RSU is line-of-sight to travel lanes
Traffic Progression	RSU 3-18	<ol style="list-style-type: none"> 1. Install POE injector inside of traffic control cabinet 2. Install RSU on pole, including antennas 3. Ensure that RSU is line-of-sight to travel lanes

3.4.2.1.2 Electrical Wiring Details and Procedures

Table 8: Electrical Wiring Details & Procedures.

Use Case	HW Devices	Mounting Procedure
Morning Backup	RSU1	<ol style="list-style-type: none"> 1. Connect power from source to cabinet service entry 2. Connect cabinet service power to POE injector 3. Connect cabinet service power to detector processor
	Detector 1	
Wrong Way	RSU 2	<ol style="list-style-type: none"> 1. Connect cabinet service power to POE injector 2. Connect cabinet service power to detector processors
	Detector 2	
	Detector 3	
Pedestrian Safety	RSU 40	<ol style="list-style-type: none"> 1. Connect cabinet service power to POE injector 2. Connect cabinet service power to detector processors
	Crosswalk Detector	
	Curbside Detector 1	
	Curbside Detector 2	
	J Walk Detector 1	
J Walk Detector 2		
Transit Signal Priority	RSU 19-32	<ol style="list-style-type: none"> 1. Connect cabinet service power to POE injector
Trolley Conflicts	RSU 33-39	<ol style="list-style-type: none"> 1. Connect cabinet service power to POE injector
Traffic Progression	RSU 3-18	<ol style="list-style-type: none"> 1. Connect cabinet service power to POE injector

3.4.2.1.3 Communications Wiring Details and Procedures

Table 9: Communications Wiring Details and Procedures.

Use Case	HW Devices	Mounting Procedure
Morning Backup	RSU1	<ol style="list-style-type: none"> 1. Connect camera cable to detector processor

	Detector 1	<ol style="list-style-type: none"> 2. Thread camera cable to detector processor through pole 3. Connect camera cable to camera with weatherproof boot 4. Connect processor Ethernet output to POE injector input 5. Connect one end of CAT6 (Category 6) Ethernet cable to POE injector output 6. Thread CAT6 cable through mounting pole to RSU 7. Connect CAT6 cable to RSU using weatherproof boot
Wrong Way	RSU 2	<ol style="list-style-type: none"> 1. Connect camera cable to detector processor 2. Route camera cable to detector processor through poles 3. Connect camera cable to camera with weatherproof boot 4. Connect processor Ethernet output to POE injector input 5. Connect one end of CAT6 cable to POE injector output 6. Route CAT6 cable through mounting poles to RSU 7. Connect CAT6 cable to RSU using weatherproof boot
	Detector 2	
	Detector 3	
Pedestrian Safety	RSU 40	<ol style="list-style-type: none"> 1. Connect camera cables to detector processors 2. Route camera cables to detector processor 3. Connect camera cables to camera with weatherproof boot 4. Connect processor Ethernet output to POE injector input 5. Connect one end of CAT6 cable to POE injector output 6. Route CAT6 cable through mounting poles to RSU 7. Connect CAT6 cable to RSU using weatherproof boot
	Crosswalk Detector	
	Curbside Detector 1	
	Curbside Detector 2	
	J Walk Detector 1	
J Walk Detector 2		
Transit Signal Priority	RSU 19-32	<ol style="list-style-type: none"> 1. Connect one end of CAT6 cable to POE injector output 2. Route CAT6 cable through mounting poles to RSU 3. Connect CAT6 cable to RSU using weatherproof boot
Trolley Conflicts	RSU 33-39	<ol style="list-style-type: none"> 1. Connect one end of CAT6 cable to POE injector output 2. Route CAT6 cable through mounting poles to RSU 3. Connect CAT6 cable to RSU using weatherproof boot
Traffic Progression	RSU 3-18	<ol style="list-style-type: none"> 1. Connect one end of CAT6 cable to POE injector output 2. Route CAT6 cable through mounting poles to RSU 3. Connect CAT6 cable to RSU using weatherproof boot

3.4.2.1.4 Installation checklists and inspection

Table 10: Installation Checklists & Inspection.

Use Case	HW Devices	Mounting Procedure
Morning Backup	RSU1	<ol style="list-style-type: none"> 1. Apply service power to Ethernet injector and processor 2. Configure two detector zones per lane as speed traps
	Detector 1	<ol style="list-style-type: none"> 3. Run RSU self test:

		<ol style="list-style-type: none"> a. Transmit BSM via DSRC from pilot vehicle b. Receive BSM via LTE² at Master Server c. Pass: Pilot BSM = Master Server BSM <ol style="list-style-type: none"> 4. Run Proxy self test: <ol style="list-style-type: none"> a. Drive pilot vehicle over each speed trap b. Receive proxy BSM via LTE at Master Server c. Pass: Master Server BSM = Proxy BSM <ol style="list-style-type: none"> i. Location = Trap latitude & longitude ii. Heading = Offset angle between zones iii. Speed = (Trap distance ÷ trap time) iv. Elevation = Zone elevation v. Size Classification = Proxy 5. Reopen REL per time of day plan
Wrong Way	<p>RSU 2</p> <p>Detector 2</p> <p>Detector 3</p>	<ol style="list-style-type: none"> 1. Apply service power to Ethernet injector and processor 2. Configure two detector zones per lane as speed traps 3. Run RSU self test: <ol style="list-style-type: none"> a. Transmit BSM via DSRC from pilot vehicle b. Receive BSM via LTE at Master Server c. Pass: Pilot BSM = Master Server BSM 4. Run Proxy self test: <ol style="list-style-type: none"> a. Drive pilot vehicle over each speed trap b. Receive proxy BSM via LTE at Master Server c. Pass: Master Server BSM = Proxy BSM <ol style="list-style-type: none"> i. Location = Trap latitude & longitude ii. Heading = Offset angle between zones iii. Speed = (Trap distance ÷ trap time) iv. Elevation = Zone elevation v. Size Classification = Proxy 5. Reopen REL per time of day plan
Pedestrian Safety	<p>RSU 40</p> <p>Crosswalk Detector</p> <p>Curbside Detector 1</p> <p>Curbside Detector 2</p> <p>J Walk Detector 1</p> <p>J Walk Detector 2</p>	<ol style="list-style-type: none"> 1. Apply service power to Ethernet injector and processor 2. Configure detector zones as follows: <ol style="list-style-type: none"> a. Crosswalk zone b. Curbside 1 zone, within 6 ft of crosswalk c. Curbside 2 zone, within 6 ft of crosswalk d. Jwalk 1 zone, west of crosswalk e. Jwalk 2 zone, east of crosswalk 3. Run RSU self test: <ol style="list-style-type: none"> a. Transmit BSM via DSRC from pilot vehicle b. Receive BSM via LTE at Master Server c. Pass: Pilot BSM = Master Server BSM 4. Run Proxy BSM self-test <ol style="list-style-type: none"> a. Accurately survey MAP of each zone location b. Walk through each zone c. Receive proxy BSM from detectors d. Pass: Walker location = Surveyed zone location 5. Run PSM self test: <ol style="list-style-type: none"> a. Transmit PSM via WiFi from smart phone b. Translate WiFi PSM to DSRC BSM c. Receive BSM on pilot vehicle

² Long-Term Evolution (LTE) is a standard for high-speed wireless communication for mobile phones and data terminals.

		<ul style="list-style-type: none"> d. Transmit BSM via LTE at Master Server e. Pass: Pilot BSM = Master Server BSM = PSM <p>6. Run PSM self test:</p> <ul style="list-style-type: none"> a. Walk smart device PSM through each zone b. Convert PSM to BSM c. Receive proxy BSM via LTE at Master Server d. Pass: Master Server BSM = PSM <ul style="list-style-type: none"> i. Location = Zone latitude & longitude ii. Heading = PSM walker direction iii. Speed = PSM travel speed iv. Elevation = Zone elevation v. Size Classification = PSM
Transit Signal Priority	RSU 19-32	<ul style="list-style-type: none"> 1. Apply service power to Ethernet injector 2. Run RSU Priority Request self test: <ul style="list-style-type: none"> a. Transmit SRM via DSRC from pilot vehicle b. Receive RSM via LTE at Master Server c. Transmit NTCIP priority SET object to CU d. Pass: Pilot BSM = Master Server BSM e. Pass: Controller front panel = Priority service 3. Run RSU Priority Status self test <ul style="list-style-type: none"> a. Transmit NTCIP priority status object from CU b. Receive NTCIP priority status object at RSU c. Transmit SSM object by RSU d. Send SSM object to Master Server e. Pass: NTCIP priority status = requested phase f. Pass: SSM to pilot vehicle = requested phase g. Pass: SSM at Master Server = requested phase
Trolley Conflicts	RSU 33-39	<ul style="list-style-type: none"> 1. Apply service power to Ethernet injector and processor 2. Run RSU self test: <ul style="list-style-type: none"> a. Transmit BSM via DSRC from pilot vehicle b. Receive BSM via LTE at Master Server c. Pass: Pilot BSM = Master Server BSM 3. Run PSM self test: <ul style="list-style-type: none"> a. Transmit PSM via WiFi from smart phone b. Translate WiFi PSM to DSRC BSM c. Receive BSM on pilot vehicle d. Transmit BSM via LTE at Master Server e. Pass: Pilot BSM = Master Server BSM = PSM
Traffic Progression	RSU 3-18	<ul style="list-style-type: none"> 1. Apply service power to Ethernet injector 2. Run RSU Priority Request self test: <ul style="list-style-type: none"> a. Transmit BSM via DSRC from pilot vehicle b. Receive RSM via LTE at Master Server c. Transmit NTCIP phase SET object to CU d. Pass: Pilot BSM = Master Server BSM e. Pass: Controller front panel = Phase service 3. Run RSU Priority Status self test <ul style="list-style-type: none"> a. Transmit NTCIP phase status object from CU b. Receive NTCIP phase status object at RSU c. Transmit SSM object by RSU d. Send SSM object to Master Server e. Pass: NTCIP phase status = requested phase f. Pass: SSM to pilot vehicle = requested phase g. Pass: SSM at Master Server = requested phase

3.4.2.2 In-Vehicle typical installation details and procedures (vehicle specific)

The In-Vehicle installation procedure will be based on the In-Vehicle Integrators' use of best practices in automotive aftermarket industry. The THEA CV Pilot involves different type of vehicles (cars, buses, streetcars). Regardless of the type of vehicle (cars, buses, streetcars) the installation procedure will involve the following preliminary activities:

- Definition of vehicles Kits (see 3.4.1.1.2)
- VP&R (Validation Plan and Report)
- Validation of the defined kits
- Sourcing of local (Tampa) installers
- Installation training.

As described in 3.4.1.1.2 each kit includes installation instructions for the specified vehicle. The instructions include descriptions, pictures and videos, if necessary, to guide the installers through the process.

Each kit provides also a wiring diagram for an easy understanding of the electrical connections. The instructions along with the training and tech support will ensure the successful of the installation procedure.

3.4.3 Acquisition and Installation Plan Requirements

This task area covers planning for the acquisition, configuration, and installation of all in-vehicle, roadside, mobile device, center, and other equipment, software and supporting capabilities required to design, build, integrate and test the designed system. The phrase “other equipment, software, and supporting capabilities” includes software development outside of CV/traveler application-specific development explicitly covered under Task 2-E (Application Development).

3.4.3.1 Comprehensive Acquisition Plan

THEA will develop a Comprehensive Acquisition Plan (CAP) that identifies the type and number of devices, equipment, and software-based capabilities to be acquired. The Plan shall have one section for vehicles and in-vehicle equipment, one for roadside equipment, one for mobile devices, one for management center equipment/capabilities, and one for other equipment and supporting capabilities. The CAP shall provide an overview of the proposed acquisition approach that includes an assessment of time-to-procure relative to the overall deployment schedule. The CAP should include a plan to equitably engage and educate prospective vendors over time in case of changes to requirements, quantities, and delivery timelines.

In addition, for each identified type of equipment, the CAP shall include:

- a. Description of the item
- b. Reference(s) to relevant requirements and specifications derived from the SDD
- c. Note any/all certifications requirements
- d. Describe the method of acquisition
- e. Potential vendors/suppliers.

There may be substantially different acquisition schedules depending on the nature and type of equipment/capability being acquired. The CAP is intended to document the process and provide assurance that this process is systematic, orderly and well-documented. Individual item/capability acquisition is not subject to USDOT approval prior to acquisition.

THEA will deliver a draft CAP to the USDOT for review. THEA will prepare a revised CAP in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised CAP, THEA will deliver a final CAP.

THEA will develop a Comprehensive Installation Plan (CIP) that incorporates the CAP and further identifies the types and number of equipment required to be configured, and installed. Note that the installation of infrastructure related elements must be adhere and be consistent with state and local standards and installation approval procedures. The Plan shall have one section for vehicles and in-vehicle equipment, one for roadside equipment, one for mobile devices, one for management center equipment/capabilities, and one for other equipment and supporting capabilities.

The CIP will provide an overview of the supplier base and procurement method(s), a high-level plan for inventory and configuration management, a high-level initial installation schedule, and one or more high-level installation plan(s) covering (at a minimum):

- Wiring, fiber optic splicing (if applicable) and interconnects
- Rack mount elevation of communications devices and the Control Center
- Electrical and power interface diagram (including grounding and transient voltage surge suppression)
- Infrastructure hardware mounting details
- In-vehicle hardware mounting details.

In addition, for each identified type of equipment, the CIP shall identify:

- a. Supplier(s)
- b. Inventory control method(s)
- c. Required configuration or pre-installation modifications
- d. Pre- and post-installation inspection procedures
- e. Detailed installation procedures
- f. QA/QC processes (with identified responsible parties)
- g. A preliminary, high-level installation schedule
- h. Hardware/software configuration control processes
- i. Spare parts/warranty contingency plans.

3.4.4 Products

THEA will deliver a draft CIP to the USDOT for review. THEA will prepare a revised CIP in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised CIP, THEA will deliver a final CIP.

Deliverables:

- Draft Comprehensive Acquisition Plan (CAP)
- Revised CAP with Comment Resolution Report
- Final Comprehensive Acquisition Plan
- Draft Comprehensive Installation Plan (CIP)
- Revised CIP with Comment Resolution Report
- Final Comprehensive Installation Plan.

3.5 Application Development – Task 2-E

3.5.1 Configuration and Development

3.5.1.1 Application Configuration

3.5.1.1.1 Descriptions

The eleven applications with their categories are shown in Table 11 that expands the descriptions in Table 2.

Table 11: Application Descriptions.

App	Name	Category	Description
CSW	Curve Speed Warning	V2I Safety	An application where alerts are provided to the driver who is approaching a curve at a speed that may be too high for safe travel through that curve.
PED-X	Pedestrian in Signalized Crosswalk	V2I Safety	An application that warns car and bus operators when pedestrians, within the crosswalk of a signalized intersection, are in the intended path of the car or bus.
RLVW	Red Light Violation Warning	V2I Safety	An application that broadcasts signal phase and timing (SPat) and other data to the in-vehicle device, allowing warnings for impending red light violations; adapted to warn drivers of wrong way entry to the Selmon REL
IMA	Intersection Movement Assist	V2V Safety	An application that warns the driver when it is not safe to enter an intersection—for example, when something is blocking the driver's view of opposing or crossing traffic. This application only functions when the involved vehicles are each V2V-equipped.
EEBL	Emergency Electronic Brake Light	V2V Safety	An application where the driver is alerted to hard braking in the traffic stream ahead. This provides the driver with additional time to look for, and assess situations developing ahead
FCW	Forward Collision Warning	V2V Safety	An application where alerts are presented to the driver in order to help avoid or mitigate the severity of crashes into the rear end of other vehicles on the road. Forward crash warning responds to a direct and imminent threat ahead of the host vehicle
VTRFTV	Vehicle Turning Right in Front of Transit Vehicle	V2V Safety	An application that warns transit bus operators of the presence of vehicles attempting to go around the bus to make a right turn as the bus departs from a bus stop
I-SIG	Intelligent Traffic Signal System	Mobility	An overarching system optimization application accommodating signal priority, transit and pedestrian preemption and pedestrian movements
TSP	Transit Signal Priority	Mobility	Two applications that provide signal priority to transit at intersections and along arterial corridors
PED-SIG	Mobile Accessible Pedestrian Signal	Mobility	An application that allows for an automated call from the smart phone of a pedestrian to the traffic signal, as well as audio cues to safely navigate the crosswalk
PDETM	Probe Data Enabled Traffic Monitoring	Agency	An application that utilizes communication technology to transmit real time traffic data to RSUs (V2I)

3.5.1.1.1.1 V2I Safety Applications

Treatment of each V2I app (CSW, PED-X and RLVW) can be found in the ADP Section 2.1.1.

3.5.1.1.1.2 V2V Safety Applications

Treatment of each V2V app (EEBL, FCW, IMA, VTRFTV) can be found in the ADP Section 2.1.2.

3.5.1.1.1.3 V2I Mobility Applications

Treatment of each V2I app (I-SIG, TSP, PED-SIG) can be found in the ADP Section 2.1.3.

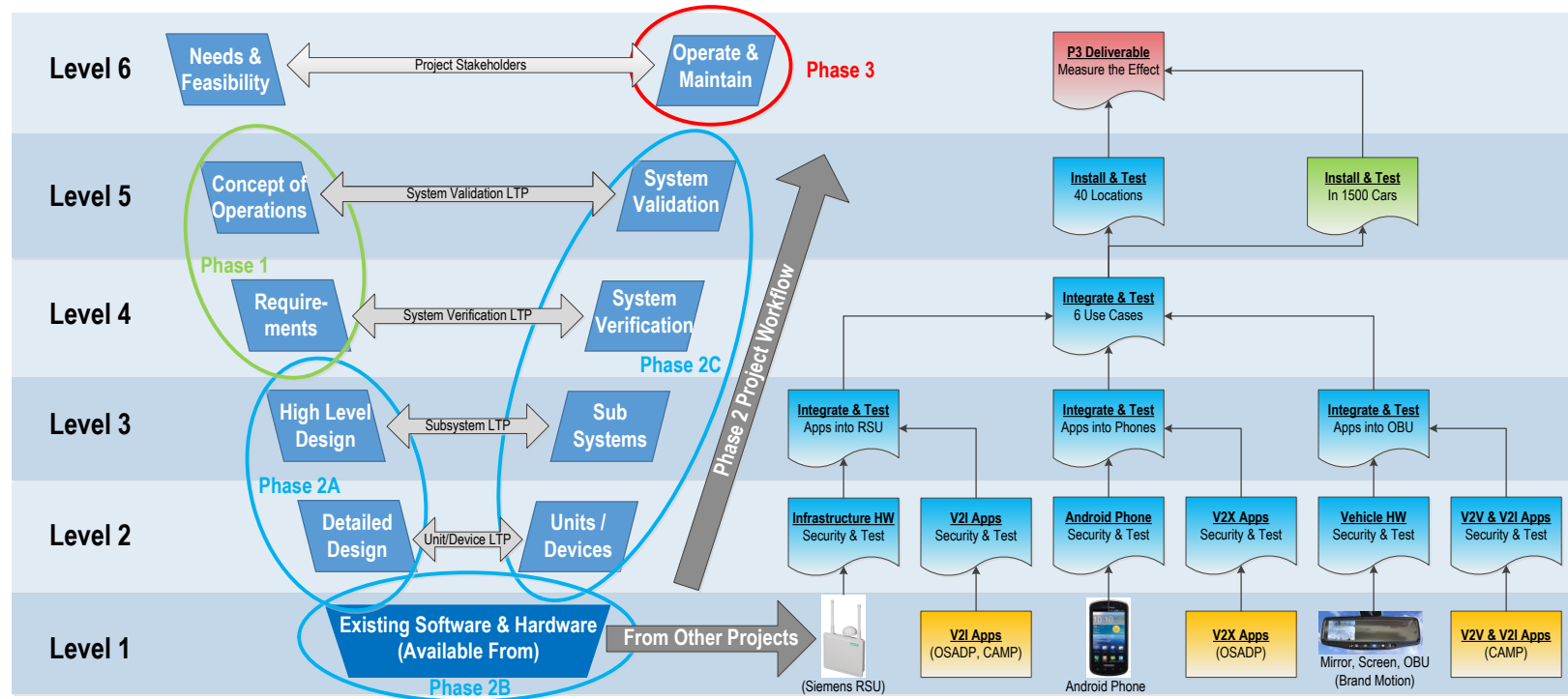
3.5.1.1.1.4 Agency Data Applications

Treatment of each Agency Data app (PDETM) can be found in the ADP Section 2.1.3

3.5.1.1.2 WBS

The WBS follows the Systems Engineering Process (SEP) VEE model at a high level as shown in Figure 6. Each horizontal swim lane represents a Level that traces from a definition level on the left side of the VEE to an integration level on the right side of the VEE. The workflow down the left side of the VEE decomposes User Needs of the owner/operators into individual hardware devices and software application units that are needed to meet the Requirements. The workflow up the right side of the VEE recomposes the individual units and devices through integrating into subsystems, systems and finally into to the completed system Use Cases. At each Level the \leftrightarrow arrows indicate the traceability from the left to the right of the VEE, to ensure that the installed system ultimately meets the expected performance set forth by the owner/operators at the inception of the project. Quality Gates separate the project workflow transition from one Level to the next. Quality Gates cannot be passed until the stakeholders agree that the traceability \leftrightarrow is intact.

Figure 6: High Level Work Breakdown Structure.



Source: HNTB

Phase 1, Level 4: Requirements

Project Phase 1 identified an inventory of available hardware devices and software applications as candidates to meet Requirements:

- ITSA World Congress, Bordeaux FR on October 5-9 2015: Honda, Cohda, NXP and Siemens demonstrated V2V, V2I and Agency Data candidate applications
- CAMP demonstrations, Fowlerville MI on April 19, 2016: CAMP demonstrated V2V and V2I candidate applications
- MCity, Ann Arbor MI on April 20, 2016 demonstrated V2V and V2I candidate applications
- “Vendor Week” held by the Project Team at THEA during the week of April 23, 2016. Interested hardware manufacturers and software suppliers demonstrated existing technologies that are candidates to meet the project Requirements.
- Open Source Application Development Portal (OSADP) candidate applications were downloaded and investigated by the Siemens software development group in Austin TX in order to estimate effort required to adapt each application to the project Requirements for the Phase 2 project plan without changes.

Security conformance of each device to the SMOC was investigated by the Siemens cyber security group in Princeton NJ in order to estimate the effort required to harden devices and the interfaces between devices and the Master Server.

Phase 2A, Level 3: High Level Design (HLD)

HLD consists of Functional Block Diagrams of major system elements and of the interfaces that connect the major system elements. Use of the Set It tool developed by FHWA will be used to trace elements of the HLD back to Requirements.

Phase 2A, Level 2: Detailed Design

No project funds are used for detailed design of new hardware devices, or new software applications. The detailed design of hardware devices and software applications were completed on prior USDOT supported projects, by CAMP or by private sector organizations.

Existing hardware devices include:

- CV RSU available from manufacturers
- CV Class 2 aftermarket OBU available from manufacturers
- Smart Phone based on the Android™ mobile operating system available from manufacturers
- Master Server equipment available from manufacturers

Software includes the eleven applications shown in Table 11, available from:

- OSADP on Apache license
- CAMP on distribution license
- Software vendors on distribution license

Phase 2B, Level 1: Hardware and Software Development

Project Phase 2B funding is used to complete the following Work Packages (WP):

- WP1: Investigate existing hardware devices and software applications from the inventory identified in project Phase 1.
- WP2: Select the existing technologies that best meet the project Requirements developed in project Phase 1
- WP3: Identify gaps in Requirements that are not met by the existing technologies, if any
- WP4: Execute distribution licenses for each candidate that is selected for deployment:
 - Obtain Open Source Declaration statements for each hardware device
 - Obtain Open Source Declaration statements for each software application, including derivative works
 - Negotiate and sign distribution licenses for software sourced by CAMP
 - Negotiate and sign distribution licenses for software sourced by private vendors
- WP5: Project Team creates the Master Test Plan (MTP) in IEEE-829 format that describes:
 - The overall test processes and testing workflow

- All of the activities
- All of the test tasks
- All of the Level Test Plans that are included in the project
- WP6-25, 66-74, 93-97, 110-115 (see the WP descriptions within each Level section): Project Team creates Level Test Plan (LTP) in IEEE-829 format for each hardware device and each software unit, including:
 - Test Scope
 - Test Environment
 - Test Resources
 - Test Cases traceable to Requirements
 - Test Procedures traceable to one or more Test Cases
 - Expected Test Results
 - Pass / Fail criteria

Project Quality Gate 1: Project Plan Acceptance

After completion of Phase 2B, a full-stop is applied to the project for Quality Gate 1 review by the project Stakeholders:

- Approval of distribution licenses for each application
- Approval of MTP
- Approval of all LTP
- Gaps in Requirements that are not met by existing technologies are addressed by the CCB

Phase 2C, Level 2: Hardware Device Level Test and Software Unit Level Test

Associated WP created in Phase 2B:

- WP6: LTP for one RSU hardware device
 - Conformance to standards
 - Project Requirements
 - Security scan
- WP7: LTP for up to three OBU hardware devices
 - Conformance to standards
 - Project requirements
 - Security scan
- WP8: LTP for CSW software object residing in RSU
- WP9: LTP for CSW software object residing in OBU
- WP10: LTP for RLWV software object residing in RSU
- WP11: LTP for RLWV software object residing in OBU
- WP12: LTP for Proxy software object residing in RSU
- WP13: LTP for EEBLW software object residing in OBU
- WP14: LTP for FCW software object residing in OBU
- WP15: LTP for BSM software object residing in OBU
- WP16: LTP for I-SIG software object residing in RSU
- WP17: LTP for PROBE software object residing at the Master Server
- WP18: LTP for IMA software object residing in OBU
- WP19: LTP for PED-SIG software object residing in OBU
- WP20: LTP for PED-SIG software object residing in PSD
- WP21: LTP for PED-SIG software object residing in RSU
- WP22: LTP for PED Safety software object residing in RSU
- WP23: LTP for TSP software object residing in RSU
- WP24: LTP for TSP software object residing in OBU
- WP25: LTP for VTRFTF software object residing in OBU

WBS for Hardware Device and Software Application Unit Testing:

- Each device manufacturer and software supplier conducts the Level Test Procedure and supplies a Level Test Report
- Next, the Project Team conducts security scans of the LTP for:
 - One RSU type
 - Up to three OBU types

Test Report Analysis:

- Test Results that match Expected Results are considered a PASS
- Test Results that do not match Expected Results are not considered a FAIL, but are documented in an Anomaly Report (AR) that is reviewed by the CCB. For example, the unexpected results might be a failure of the unit under test (UUT), but also could be due to test operator error, test equipment malfunction, interpretation of requirement, etc. Anomaly Report includes:
 - Actual and expected results
 - When it occurred
 - Supporting evidence that will help in its resolution
 - Assessment of the impact upon further testing or suspension of testing
 - Responsibility of CCB to dispose of each AR in time to maintain the overall project schedule
- Security scans result in threat-based security hardening recommendations per the Security Management Operational Concept (SMOC)
 - Prioritized in descending order of (threat + cost to harden)
 - RSU and OBU manufacturers are responsible to implement high priority hardening recommendations within the project budget
 - Low priority hardening recommendations not allowed by the project budget are documented but not implemented

WP to audit LTP Test Report received from the selected suppliers and CCB disposal of Anomalies for each software Unit and hardware Device:

- WP26: RSU hardware devices
- WP27: OBU hardware devices
- WP28: CSW software object residing in RSU
- WP29: CSW software object residing in OBU
- WP30: RLWW software object residing in RSU
- WP31: RLWW software object residing in OBU
- WP32: Proxy software object residing in RSU
- WP33: EEBLW software object residing in OBU
- WP34: FCW software object residing in OBU
- WP35: BSM software object residing in OBU
- WP36: LTP for I-SIG software object residing in RSU
- WP37: LTP for PROBE software object residing at the Master Server
- WP38: LTP for IMA software object residing in OBU
- WP39: LTP for PED-SIG software object residing in OBU
- WP40: LTP for PED-SIG software object residing in PSD
- WP41: LTP for PED-SIG software object residing in RSU
- WP42: LTP for PED Safety software object residing in RSU
- WP43: LTP for TSP software object residing in RSU
- WP44: LTP for TSP software object residing in OBU
- WP45: LTP for VTRFTF software object residing in OBU

Project Quality Gate 2:

After completion of WP26 to WP45, a full-stop is applied to the project for Quality Gate 2 review by the project Stakeholders:

- Ensure that Anomalies and Open Issues are resolved for each hardware device and software unit by the CCB

- Identify any gaps in performance needed to meet project requirements that can be traced back to the inherited Detailed Designs
 - Improvement of inherited hardware and software is out of scope for Phase 2
 - Does the performance gap present a safety issue?
 - If YES, document the safety issue and do not deploy in the field
 - If NO, document the performance issue for future improvements and deploy in the field
- Update the project cost based on changes to the planned deployments, if any
- Update the project schedule based on changes to the planned deployments, if any

Configuration Management (CM) begins for all accepted hardware and software objects, including:

- Archive for each hardware and software object must include:
 - LTP
 - Test Cases
 - Test Procedures
 - Test Report
- Source code, with revision number
- Binary code, with revision number
- Board Support Packages (BSP) containing development tools, with revision number
- Step by step instructions to compile the source code to obtain the object code, with revision number

WP to create CM for each of the following:

- WP46: RSU hardware device, including operating system and wireless stack
- WP47: OBU hardware device, including operating system and wireless stack
- WP48: CSW software object residing in RSU
- WP49: CSW software object residing in OBU
- WP50: RLWW software object residing in RSU
- WP51: RLWW software object residing in OBU
- WP52: Proxy software object residing in RSU
- WP53: EEBLW software object residing in OBU
- WP54: FCW software object residing in OBU
- WP55: BSM software object residing in OBU
- WP56: LTP for I-SIG software object residing in RSU
- WP57: PROBE software object residing at the Master Server
- WP58: IMA software object residing in OBU
- WP59: PED-SIG software object residing in OBU
- WP60: PED-SIG software object residing in PSD
- WP61: PED-SIG software object residing in RSU
- WP62: PED Safety software object residing in RSU
- WP63: TSP software object residing in RSU
- WP64: TSP software object residing in OBU
- WP65: VTRFTF software object residing in OBU

After completion of Level 2 CM, Quality Gate 2 is passed, project Phase 2 resumes at Level 3

Phase 2C, Level 3: Subsystem Level

The Project Team integrates the software applications into the hardware devices as shown in Figure 6:

- V2I software applications are integrated into the RSU and then tested as a Subsystem
- V2V software applications and the V portion of V2I applications are integrated into the OBU and then tested as a subsystem
- V2X software applications are integrated into the smart phone and then tested as a subsystem

Associated WP created in Phase 2B:

- WP66: LTP to integrate CSW, RLWW and Proxy into RSU 1, including vehicle detectors

- WP67: LTP to integrate BSM, CSW, RLWV, EEBLW, IMA and FCW into OBU
- WP68: LTP to integrate I-SIG, RLWV and PROBE into RSU 2
- WP69: LTP to integrate Proxy into RSU 40, including pedestrian detectors
 - Crosswalk
 - Curbside 1
 - Curbside 2
 - J walk 1
 - J walk 2
- WP70: LTP to integrate PED-SIG, PED-X and PSM into PSD
- WP71: LTP to integrate I-SIG and TSP into RSU 19 to RSU 32
- WP72: LTP to integrate I-SIG, PED-SIG and PED Safety into RSU 33 to RSU 39
- WP73: LTP to integrate I-SIG and PROBE into RSU 3 to RSU 7
- WP74: LTP to integrate I-SIG and PROBE into RSU 8 to RSU 18

Integration Level Test Reports:

The Project Team conducts the Level Test Procedure for that integration and supplies the Level Test Report verifying that the design under test (DUT) produces the test results that are expected in the Test Procedure:

- Test Results that match Expected Results are consider a PASS
- Test Results that do not match Expected Results are not considered a FAIL, but are documented in an AR that is reviewed by the CCB. For example, the unexpected results might be a failure of the UUT, but also could be due to test operator error, test equipment malfunction, etc. The CCB is responsible to dispose of each AR in time to maintain the overall project schedule.

WP to execute LTP with resulting Test Reports and CCB disposal of Anomalies for:

- WP75: Integration of CSW, RLWV and Proxy into RSU 1, including vehicle detectors
- WP76: Integration of BSM, CSW, RLWV, EEBLW, IMA, PED-SIG and FCW into OBU
- WP77: Integration of I-SIG, RLWV and PROBE into RSU 2
- WP78: Integration of Proxy into RSU 40, including pedestrian detectors
- WP79: Integration of PSM into PSD
- WP80: Integration of I-SIG and TSP into RSU 19 to RSU 32
- WP81: Integration of I-SIG, PED-SIG and PED Safety into RSU 33 to RSU 39
- WP82: Integration of I-SIG and PROBE into RSU 3 to RSU 7
- WP83: Integration of I-SIG and PROBE into RSU 8 to RSU 18

Project Quality Gate 3:

After completion of WP75 to WP83, a full-stop is applied to the project for Quality Gate 3 review by the project Stakeholders:

- Ensure that Anomalies and Open Issues are resolved for each integration
- Identify any gaps in performance needed to meet project requirements that can be traced back to the High Level Design
 - Traceability to HLD is part of the Phase 2 project scope
 - Can the gap be resolved by adjustments to the HLD?
 - If YES, can the Requirements still be met with the HLD adjustment?
 - Stakeholders can agree to document the adjustment
 - Stakeholders can agree to accept and document the performance gap
 - Does the performance gap present a safety issue?
 - If YES, document the safety issue and do not deploy in the field
 - If NO, document the performance issue
- Update the project cost based on changes to the planned deployments, if any
- Update the project schedule based on changes to the planned deployments, if any

Configuration Management (CM) begins for all integrations, including:

- Archive for each hardware and software object must include:
 - LTP

- Test Cases
- Test Procedures
- Test Report
- Binary code for each software object integrated, with revision number
- Board Support Packages (BSP) containing development tools, with revision number
- Step by step instructions to install and test the object code, with revision number

WP to create CM for each of the following:

- WP84: Integration of CSW, RLVW and Proxy into RSU 1, including vehicle detectors
- WP85: Integration of BSM, CSW, RLVW, EEBLW, IMA and FCW into OBU
- WP86: Integration of I-SIG, RLVW and PROBE into RSU 2
- WP87: Integration of Proxy into RSU 40, including pedestrian detectors
- WP88: Integration of PED-SIG, PED-X and PSM into PSD
- WP89: Integration of I-SIG and TSP into RSU 19 to RSU 32
- WP90: Integration of I-SIG, PED-SIG and PED Safety into RSU 33 to RSU 39
- WP91: Integration of I-SIG and PROBE into RSU 3 to RSU 7
- WP92: Integration of I-SIG and PROBE into RSU 8 to RSU 18

After completion of Level 3 CM, Quality Gate 3 is passed, project Phase 2 resumes at Level 4

Phase 2C, Level 4: System Verification

System Level: The Project Team integrates the tested subsystems into the six full system Use Cases before installation in the field. Although not practical to test each system in all possible combinations of inputs, best practice System Test involves the use of:

- Positive Test samples over a range of inputs ensure that proper inputs produce expected operational results
- Negative Test samples over a range of inputs to ensure that improper inputs produce expected results in the form of error logs and continuous safe operation
- Boundary Tests to ensure that inputs just below, exactly at and just above boundaries produce expected results

Associated WP created in Phase 2B:

- WP93: LTP for Morning Backups
- WP94: LTP for Wrong-Way Entries
- WP95: LTP for Pedestrian Safety
- WP95: LTP for Transit Signal Priority
- WP96: LTP for Trolley Conflicts
- WP97: LTP for Traffic Progression

System Level Test Reports:

The Project Team conducts the Level Test Procedure for each of the integrated systems and supplies the Level Test Report verifying that the DUT produces the test results that are expected in the Test Procedure:

- Test Results that match Expected Results are consider a PASS
- Test Results that do not match Expected Results are not considered a FAIL, but are documented in an AR that is reviewed by the CCB. For example, the unexpected results might be a failure of the UUT, but also could be due to test operator error, test equipment malfunction, etc. The CCB is responsible to dispose of each AR in time to maintain the overall project schedule.

WP to execute LTP with resulting Test Report and CCB disposal of Anomalies for:

- WP98: System for Morning Backups
- WP99: System for Wrong-Way Entries
- WP100: System for Pedestrian Safety
- WP101: System for Transit Signal Priority
- WP102: System for Trolley Conflicts
- WP103: System for Traffic Progression

Project Quality Gate 4:

After completion of WP98 to WP103, a full-stop is applied to the project for Quality Gate 4 review by the project Stakeholders:

- Ensure that Anomalies and Open Issues are resolved for each system verification
- Identify any gaps in performance needed to meet project requirements that can be traced back to the System Requirements
 - Traceability to Requirements is part of the Phase 2 project scope
 - Can the gap be resolved by adjustments to the Requirements?
 - If YES, can the Operational Concept still be fulfilled with the Requirements adjustment?
 - Stakeholders can agree to document the adjustment
 - Stakeholders can agree to accept and document the performance gap
 - Does the performance gap present a safety issue?
 - If YES, document the safety issue and do not deploy in the field
 - If NO, document the performance issue
- Update the project cost based on changes to the planned deployments, if any
- Update the project schedule based on changes to the planned deployments, if any

Configuration Management (CM) begins for all systems, including:

- Archive for each hardware and software object must include:
 - LTP
 - Test Cases
 - Test Procedures
 - Test Report
- Configuration of each major assembly hardware and integrated software
- Interfaces of each major assembly
- Step by step instructions to install and connect the major assemblies

WP to create CM for each of the following:

- WP104: System for Morning Backups
- WP105: System for Wrong-Way Entries
- WP106: System for Pedestrian Safety
- WP107: System for Transit Signal Priority
- WP108: System for Trolley Conflicts
- WP109: System for Traffic Progression

After completion of Level 4 CM, Quality Gate 4 is passed, project Phase 2 resumes at Level 5

Phase 2C, Level 5: System Validation

System Validation Level: The Project Team installs the six fully-tested Systems in the field, programmed with operational data

- Roadside equipment and applications are installed at the locations shown in Table 6.
- OBUs and applications are installed in the participant vehicles
- Applications are installed in participant smart phones
- Pilot vehicles equipped with OBUs are driven through the Use Case locations to test for expected results
- Pilot pedestrians equipped with smart phones are walked through the Use Case locations to test for expected results
- Messages, alerts and warnings collected in the Master Server are validated for expected results

Associated WP completed in Phase 2B: Installation and Validation in the vehicles and at the locations shown in Table 6.

- WP110: LTP for Morning Backups
- WP111: LTP for Wrong-Way Entries
- WP112: LTP for Pedestrian Safety

- WP113: LTP for Transit Signal Priority
- WP114: LTP for Trolley Conflicts
- WP115: LTP for Traffic Progression

System Level Test Reports:

The Project Team conducts the Level Test Procedure for each of each field installation with equipped vehicles and supplies the Level Test Report verifying that the DUT produces the test results that are expected in the Test Procedure:

- Test Results that match Expected Results are consider a PASS
- Test Results that do not match Expected Results are not considered a FAIL, but are documented in an AR that is reviewed by the Change Control Board (CCB). For example, the unexpected results might be a failure of the UUT, but also could be due to test operator error, test equipment malfunction, etc. The CCB is responsible to dispose of each AR in time to maintain the overall project schedule.

WP to execute LTP with equipped vehicles at locations shown in Table 6, including Test Report and CCB disposal of Anomalies for:

- WP116: System for Morning Backups
- WP117: System for Wrong-Way Entries
- WP118: System for Pedestrian Safety
- WP119: System for Transit Signal Priority
- WP120: System for Trolley Conflicts
- WP121: System for Traffic Progression

Project Quality Gate 5:

After completion of WP116 to WP121, a full-stop is applied to the project for Quality Gate 5 review by the project Stakeholders:

- Ensure that Anomalies and Open Issues are resolved for each system validation
- Identify any gaps in performance needed to meet project requirements that can be traced back to the ConOps
 - Traceability to Operational Concept is part of the Phase 2 project scope
 - Can the gap be resolved by adjustments to the ConOps?
 - If YES, can the User Needs still be fulfilled with the ConOps adjustment?
 - Stakeholders can agree to document the adjustment
 - Stakeholders can agree to accept and document the performance gap
 - Does the performance gap present a safety issue?
 - If YES, document the safety issue and do not deploy in the field
 - If NO, document the performance issue
- Update the project cost based on changes to the planned deployments, if any
- Update the project schedule based on changes to the planned deployments, if any

Configuration Management (CM) begins for all vehicle and field deployments, including:

- Archive for each hardware and software object must include:
 - LTP
 - Test Cases
 - Test Procedures
 - Test Report
- Configuration of each system deployed at the roadside and in vehicles
- Locations of deployments and vehicle installations
- Step by step instructions to install and commission each field device and each vehicle device

WP to create CM for each of the following:

- WP122: System for Morning Backups
- WP123: System for Wrong-Way Entries
- WP124: System for Pedestrian Safety

- WP125: System for Transit Signal Priority
- WP126: System for Trolley Conflicts
- WP127: System for Traffic Progression

After completion of Level 5 CM, Quality Gate 5 is passed and project Phase 2 moves to Level 6

Phase 2C, Transition to Level 6: End to End System Validation

Before completion of Phase 2, the Operation and Maintenance of the complete system is transitioned from the Project Team to the Stakeholders. End to End System Validation test is conducted with each Stakeholder owner/operator, along with operator training to ensure the system is fully-commissioned. The Project Team participates in training and outreach.

WP for End to End Validation, commissioning and operator training for each of the six validated systems

- WP128: System for Morning Backups
- WP129: System for Wrong-Way Entries
- WP130: System for Pedestrian Safety
- WP131: System for Transit Signal Priority
- WP132: System for Trolley Conflicts
- WP133: System for Traffic Progression

3.5.1.1.3 Priority

The Phase 2 priorities begin with one MTP and an LTP to test each WP. The LTPs trace back to the Requirements and Concepts approved in project Phase 1. The Project Team expects concurrence with the MTP and LTPs by all stakeholders, including PASS / FAIL criteria, before any software or testing funding is consumed.

- Priority 1: Creating an overall MTP
- Priority 2: Creating all LTP identified in WBS
- Priority 3: Trace LTP to Requirements developed in project Phase 1
- Priority 4: Pass Quality Gate 1
- Priority 5: Pass Quality Gate 2
- Priority 6: Pass Quality Gate 3
- Priority 7: Pass Quality Gate 4
- Priority 8: Pass Quality Gate 5

3.5.1.1.4 Application Configuration Schedule

An Application Configuration Schedule is shown in the ADP, Section 14.5.

3.5.1.2 Application Development (if needed)

3.5.1.2.1 Descriptions

The scope of Phase 2 is to adapt existing Connected Vehicle applications and equipment to six Use Cases in order to measure the effect, both positive and negative. To that end, no application development is planned. As noted in the Level Test workflow, five full-stop Quality Gates are planned to identify gaps in traceability before transition to the next Level. At each Quality Gate, any performance gaps due to the inherited applications will be analyzed for performance and public safety. Verified safety issues will prevent installation on the street and in vehicles. Degraded but safe performance can be approved for installation by the Stakeholders, and the recommendations for improvement documented for future projects.

3.5.1.3 Open Source and Supporting Documentation

Open source, supporting documents and distribution licenses are identified in Phase 2B WP.

3.5.2 Application Development Plan

As a part of the Concept Development Phase (Phase 1), THEA identified a set of CV/traveler applications to be deployed as a part of the system. In this task, these applications are augmented with any and all necessary enhancements, follow-on development, or alteration required prior to installation within the designed system. The deployment approach shall be consistent with the Phase 1, ADP. The intent of the THEA CV Pilot is to

reuse existing CV apps and not perform any modifications. THEA anticipates that porting the apps to a new platform will be required as part of this effort. Porting apps is not considered development,

3.5.3 Application Development Schedule

Based on the ADP, THEA will prepare an Application Development Schedule (ADS) that identifies the work breakdown structure (noting all dependencies among activities) required to make the applications deployment-ready. This includes the development/enhancement of individual applications to meet deployment-specific needs, the integration of applications in a synergistic collection (e.g., “bundle”), interfacing (as required) with security and credential management systems, and interfacing with existing legacy systems. The ADS shall include a testing plan and report progress against these tests as an element of updated ADS submittals.

THEA will report progress biweekly (every two weeks), which for each application/work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues should be tracked and appended to the ADS.

THEA will deliver an initial draft ADS to the AOR for review. THEA will prepare bi-weekly updates to the ADS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated ADS will be accompanied by a concise summary of development activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

Per the ADP, open source software and supporting documentation to be provided in this task will be identified within the ADS as deliverables/milestones and submitted to the Open Source Application Development Portal (OSADP), <http://www.itsforge.net/>. All submittals to the OSADP will be made in accordance with guidelines on formatting and documentation posted on the OSADP site.

3.5.4 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into Task 2-E:

- Phase 1 Application Deployment Plan (Final).

Deliverables:

- Initial Application Development Schedule (ADS)
- ADS Update with Progress/Risk Summary (bi-weekly)
- Open Source Software and Supporting Documentation (per the ADP and ADS).

3.6 Participant and Staff Training – Task 2-F

3.6.1 IRB Oversight

THEA will modify the Final RPD and ICDs described in Section 2.7.3 as the activities for participant and staff training progress in Phase 2. Amendments with respect to the Research Protocol and ICDs for protecting human research participants will be submitted to Salus IRB as details come to light and revisions and designs are made.

Protecting participants – auto drivers, pedestrians and transit drivers – is an important and complex task, as it involves their recruitment, registration, informed consent, training, installation and maintenance of equipment installed in their vehicles, and ongoing treatment. Salus IRB will need to approve final recruitment advertisements, training videos and other activities before they are applied in the field.

As these plans transition to designs in Phase 2, THEA will make amendment requests to Salus IRB of revisions to the Research Protocol and ICDs, as necessary.

3.6.1.1 Participant Lifecycle Activities

Recruitment, registration, informed consent, training, installation and maintenance of OBUs installed in their vehicles, and ongoing treatment of participants are part of the lifecycle of a participant. Phase 2 encompasses – for auto drivers and pedestrians:

- Design of recruitment materials for web-based, location-based and other media
- Registration software that protects participant PII
- Final ICDs and IRB approval of ICDs
- Procurement of a site(s) for registration, signing ICDs, participant training and OBU and mobile device installation
- Production of training videos and hiring and training of trainers, some of whom will be bilingual (Spanish-English)
- Training of OBU installation and maintenance staff, procurement of tools.

For HART and other fleet owners the lifecycle of activities are somewhat relaxed as the OBU supplier(s) will train HART staff and the staff will use the HART garage and facilities for installation and training in use of the apps.

Section 2.7.3 and the Phase 1, THEA CV Reports for Tasks 8 and 9 explain the planning for this activity.

3.6.1.2 Scheduling

Some participant lifecycle activities will be dependent on the completion of other project activities (e.g., safe PII participant software) and other planning activities; other activities will depend more on IRB approval. Some training activities will be related to applications and some to core functions (e.g., the SCMS). The time needed for each auto participant's registration, training and installation is estimated to be about one hour. With 1500 vehicles the time to install depends on the number of bays deployed, but will be, perhaps, three months, so timing OBU deployment is important to coincide with completion of OBU-RSU and system field tests and the start of Phase 3 Operations.

3.6.2 Participant and Staff Training

Updates to the Task 8, Human Protection Research Protocol (HPRP) and Task 9, Participant Training and Stakeholder Education Plan (PTSEP) (THEA, Task 9, July 2016) will document the detailed designs.

In this task, relevant participants, operators, installers, maintenance staff, and other personnel are trained to install, interact with, operate, maintain, and/or repair the deployed system. This activity is guided by the PTSEP prepared in Phase 1. This includes the development and/or acquisition of recruitment and training materials, recruiting, delivery of training to all required personnel and evaluation and training. Some training activities will be dependent on the completion of the system design and/or installation planning activities; others will not be dependent. Some training activities will be related to applications and some to core functions (e.g., the SCMS). An update to the PTSEP may be required as an initial step in this task. An updated PTSEP will produce a work breakdown structure of activities required to implement the PTSEP. These Phase 2 activities will be documented in a Training Implementation Schedule (TIS).

Recruitment cannot be initiated without human use approval obtained through an IRB per the Human Use Approval Summary (HUAS) completed in Phase 1. Per the processes identified in the HUAS, THEA will submit documentation assessing to the completion of this requirement in this task prior to the initiation of any recruitment activity.

THEA will report progress in a (minimum) monthly update to the TIS, which for each application/work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues will be tracked and appended to the TIS.

THEA will deliver an initial draft TIS to the AOR for review. THEA will prepare monthly updates to the TIS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated TIS will be accompanied by a concise summary of activities underway, progress

made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

3.6.3 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into this Statement of Work Task 2-F:

- Phase 1 Participant Training and Stakeholder Education Plan (Final)
- Phase 1 Human Use Approval Summary (Final).

Deliverables:

- Initial Training Implementation Schedule (TIS)
- Training Materials (Initial and Updates, as specified in the PTSEP and TIS)
- Updated TIS with Progress/Risk Summary (monthly)
- Human Use Approval Confirmation Materials (per the HUAS).

3.7 Operational Readiness Test and Demonstration Planning – Task 2-G

As discussed above, once THEA completes the LTPs and has passed the quality gate with the CCB and stakeholders, THEA will prepare test plans for a series of coordinated tests and demonstrations that demonstrate the system meets the requirements. This testing corresponds to the system verification portion of the System Engineering V diagram. This testing will be performed in a laboratory like environment. Test cases are developed and traced to the requirements. As these test cases are executed, they demonstrate the system meets the requirements. The test plan will describe the actions to be taken when a test fails.

3.7.1 Operational Readiness

Operational readiness is established with a comprehensive set of tests and supporting demonstrations to be designed and conducted by THEA. In general, THEA will conduct a set of relevant tests to verify that the system performs according to the documented System Requirements. Upon completion of the testing, the test team, System Engineering Lead, Infrastructure Integrator Lead, and In-vehicle Integrator Lead meet to discuss any failures that occurred during testing. Once decisions are reached, either the issues are addressed and the test re-executed or the system is passed. When the system is passed, the CCB is convened to make a final recommendation as to whether the system passes the tests. If the CCB determines that the system does not pass, the implementation team is informed to address the issues. When the CCB recommends the system is ready, a meeting is scheduled with the stakeholders. The stakeholders have the final say in whether the system moves forward. Once the stakeholders agree, the system has passed the quality gate. Test results are documented and reported to USDOT. At this point demonstrations are may be provided to the stakeholders to show the system executes the use case/scenarios in a controlled environment.

3.7.2 Operational Readiness Concept Briefing

THEA will develop an Operational Readiness Concept Briefing, which outlines the aspects of the deployment to be considered in the assessment of operational readiness. As indicated above, this includes comprehensive systems engineering considerations (i.e., unit, subsystem and system testing identified in the System Requirements) as well as assessments of whether the deployment can operate safely and securely, whether staff and participants are suitably trained, human use approval has been obtained for all deployment participants, institutional and financial arrangements have been finalized, and whether the impact of the deployment can be discerned, measured, and reported. The briefing will be held in the Washington DC metro area (also available for remote participants through a webinar). The briefing summarizes the general approach to be used in Operational Readiness Test Planning and Operational Readiness Demonstration planning. The briefing will describe the planned structure of the ORP Walkthrough (see below). The briefing shall include a preliminary list of proposed demonstrations. Demonstrations must cover, among other topics:

- Key use cases illustrating the capability of the system to perform in accordance with the Phase 1 ConOps.
- Safety-focused demonstration elements illustrating the capability of the system to address key scenarios identified in the Phase 1 Safety Management Plan.

- Security-focused demonstration elements illustrating the capability of the system to successfully interact with the SCMS and carry out key security-related capabilities identified in the Phase 1 SMOC. One or more demonstration elements will explicitly consider misbehavior detection.
- Privacy-focused demonstration elements illustrating key aspects of the Phase 1 Privacy Operational Concept and the Phase 2 Privacy Management Plan.
- Performance measurement and evaluation support demonstration elements (e.g., a dry run) illustrating key aspects of the Phase 1 Performance Measurement Plan, including data collection and processing (see Task 2-K, below).
- Institutional coordination and successful execution of governance frameworks, management processes, and financial arrangements, illustrating key aspects of the Phase 1 Partnership Status Summary.
- Maintenance-oriented demonstration elements (see Task 2-I, below).

Once THEA has developed the briefing, THEA will share the briefing with USDOT for review and comment. Once THEA has addressed USDOT's comments, a webinar will be made available for remote participation by additional THEA team members.

3.7.3 Operational Readiness Plan

THEA will incorporate discussion and/or written comments from the USDOT regarding the briefing into a draft Operational Readiness Plan (ORP), with one section regarding tests (ORTP) and a second section describing demonstrations (ORDP). The ORP will be used to perform the system validation portion of the System Engineering V-diagram. This testing will validate the system meets the user needs. For these tests, a small number of hardware devices (e.g., 1 RSU, 3 OBU, 3 PIDs) and software applications will be deployed. Requirements that will not be met by demonstration or test will be evaluated by observation, inspection or analysis and reported in the ORP as (OROIAP).

Section 2.5.3 describes the role of the Safety Manager to oversee the process by which THEA and the vendor will evaluate equipment acceptability. THEA is discussing with FDOT the role of its traffic equipment evaluator, the Traffic Engineering Research Laboratory (TERL) at Florida State University (FSU) in reviewing and certifying the OBUs, HMIs, RSUs, etc. It is not clear at this time if the research products used in the THEA Pilot will require inclusion in the FDOT Approved Products List (APL).

3.7.3.1 ORTP

The ORTP will incorporate (at a minimum) the following elements for each test:

- *Test Descriptions.* Test Descriptions shall include written descriptions of the individual verification and validation processes that will occur as part of the effort to ensure that the system was built correctly and that the correct system was built. Test descriptions shall be linked back to documented System Requirement(s) whose fulfillment and user needs they will determine. The document will include a requirements-to-test procedure matrix that shows the test coverage relationship among the tests and the requirements. Every need/requirement should have at least one test case associated with it and each test case should have at least one requirement associated with it.
- *Test Cases.* Each test case will include a set of test inputs, execution conditions, and expected results. The Test Cases will be derived from the six User Cases the Pilot is built around. There will be at least one test case for each Use Case.
- *Test Procedures.* Test procedures describe how the test is executed in a step by step fashion which when executed successfully proves the test passed. The tests can be verified by inspection, test, demonstration, and analysis.
- *Test Data.* Test Data should include scripts used to execute software operations, data that must be entered (identified in the test procedures), or a description of what system-generated data will exercise different components of the system to successfully perform the test.
- *Test Results.* The expected test results are documented either within the test procedures, if there are intermediate results that have to pass before moving to next step, or at the end of the test procedure. There will be sections where the test team documents the results of the test. It may be a simple pass/fail or could include documenting the data that was produced as part of the test.

- *Test Failure Remediation.* For tests that fail, the test team will document how the test failed, whether it was retested due to circumstances outside the control of the test environment, and what recommended actions need to occur.

Upon completion of the testing, the test team, System Engineering Lead, Infrastructure Integrator Lead, and In-vehicle Integrator Lead meet to discuss any failures that occurred during testing. Once decisions are reached, either the issues are addressed and the test re-executed or the system is passed. When the system is passed, the CCB is convened to make a final recommendation as to whether the system passes the tests. If the CCB determines that the system does not pass, the implementation team is informed to address the issues. When the CCB recommends the system is ready, a meeting is schedule with the stakeholders. The stakeholders have the final say in whether the system moves forward. Once the stakeholders agree, the system has passed the quality gate.

3.7.3.2 ORDP

Once the system has passed system validation, the small deployment may be increased to provide demonstrations of the system across the deployment area. An ORDP will be developed to incorporate (at a minimum) the following elements for each demonstration:

- *Demonstration Descriptions.* The descriptions identify the objective, general location, participants, equipment, and actions to be taken within the demonstration to illustrate the successful deployment of key use cases
- *Demonstration Procedures.* Procedures describe the steps (similar to a test procedure) to demonstrate and observe the validation criteria associated with the overall purpose of the demonstration.
- *Demonstration Data.* Demonstration data identified the data collected before, during, or after the demonstration to support the observable demonstration validation criteria related to demonstration success (e.g., pass or fail).
- *Demonstration Results.* Documents the results of each demonstration conducted. The ORDP will also describe how demonstration results will be summarized and documented across all demonstrations.

3.7.3.3 ORP Walkthrough

After the delivery of the draft ORP, THEA will conduct an Operational Readiness Plan Walkthrough in the Washington DC metropolitan area to demonstrate the completeness and technical soundness of the test plan. THEA will prepare a Walkthrough Workbook to be used at the Walkthrough process. THEA will note comments received during the walkthrough and in conjunction with the comments provided before the Walkthrough, THEA will update and submit a revised ORP and an accompanying comment resolution report. Based on USDOT review of the revised ORP, the THEA will deliver a final ORP.

A webinar will be made available for remote participation by additional THEA team members.

3.7.4 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into Task 2-G:

- Phase 1 ConOps (Final)
- Phase 1 Safety Management Plan (Final)
- Phase 1 Security Management Operational Concept (Final)
- Phase 1 Performance Measurement Plan
- Phase 1 Partnership Status Summary (Final).

Deliverables:

- Operational Readiness Concept Briefing (DC metro area)
- Draft Operational Readiness Plan (ORP)
- ORP Walkthrough and Workbook (DC metro area)
- Revised ORP with Comment Resolution Report
- Final Operational Readiness Plan (ORP).

3.8 Installation and Operational Readiness Testing – Task 2-H

THEA will deploy the remaining RSUs in the Pilot deployment area and install the OBUs in participants vehicles according to the Comprehensive Installation Plan (CIP). The complete system will be ready for operations. Before turning the system over to the stakeholders for operations and maintenance, an End to End test will be performed with the Stakeholders staff operating the system. This test will be the operational readiness test. Operational readiness is established according to the ORP.

Upon completion of the End to End testing, the stakeholder staff, System Engineering Lead, Infrastructure Integrator Lead, and In-vehicle Integrator Lead meet to discuss any failures that occurred during testing. Once decisions are reached, either the issues are addressed and the test re-executed or the system is passed. When the system is passed, the CCB is convened to make a final recommendation as to whether the system passes the tests. If the CCB determines that the system does not pass, the implementation team is informed to address the issues. When the CCB recommends the system is ready, a meeting is schedule with the stakeholders. The stakeholders have the final say in whether the system moves forward. Once the stakeholders agree, the system has passed the quality gate.

3.8.1 Installation and Operational Readiness Schedule (IORS)

In this task, THEA will create and document in an Installation and Operational Readiness Schedule (IORS), a work breakdown structure of activities (and dependencies) required to implement the CIP and ORP.

THEA will provide progress as a weekly update to the IORS, which for each work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues should be tracked and appended to the IORS. Weekly updates are expected to be delivered from the time that this task is initiated until the end of Phase 2.

As a part of the weekly IORS update, THEA will include an appendix that reports the number of DSRC-equipped devices installed and an operational status indicator (e.g., installed, installed and tested, operational, under repair/not in operation), categorized by type, with their physical locations where appropriate. Device types include: vehicle and in-vehicle equipment, roadside equipment, mobile devices, management center equipment, and any other equipment equipped with a DSRC transmitter or receiver.

3.8.2 IORS

THEA will deliver an initial draft IORS to the AOR for review. THEA will prepare weekly updates to the IORS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated IORS will be accompanied by a summary of activities underway, progress made since the last update, expected progress for the next reporting period, and any/all technical issues/risks with mitigation actions taken since the last update. If critical technical issues are found, regularly scheduled technical working groups may be necessary to help resolve these issues.

3.8.3 Products

Deliverables:

- Installation and Operational Readiness Testing Schedule (IORS)
- Updated IORS with Progress/Risk Summary (weekly)
- Test Results Summary Documentation (per the ORP)
- Operational Readiness Demonstrations (per the ORP).

3.9 Maintenance and Operations Planning – Task 2-I

This task area covers planning for the operations and maintenance of all in-vehicle, roadside, mobile device, center, and other equipment and supporting capabilities required in the deployed system.

3.9.1 Comprehensive Maintenance and Operations Plan

THEA will develop a Comprehensive Maintenance and Operations Plan (CMOP) that identifies the types and number of equipment required to be maintained. The CMOP summarizes key operational methods and procedures that ensure safe and efficient operations in Phase 3. The CMOP will identify the Maintenance Management System (MMS) to manage the hardware devices and software applications. All Pilot assets will be defined and managed by the MMS.

3.9.1.1 Maintenance and Operations

The maintenance section will consist of a discussion of in-vehicle equipment, roadside equipment, mobile devices, TMC equipment, and additional supporting equipment. These discussions will include the manufacturers recommended maintenance schedules (i.e., preventative maintenance), examination of when equipment becomes outdated and needs to be replaced, what should be done when there are physical failures, and other maintenance related activities. Additional items that will be discussed are:

- Routine maintenance requirements/schedules
- Inspection procedures
- Maintenance/replacement procedures (and responsible entities)
- QA/QC processes
- Hardware/software configuration control processes
- Recall processes
- Spare parts/warranty contingency plans.

3.9.1.2 When physical equipment fails, the actions taken will be dependent on which equipment fails. For example, if an in-vehicle device fails, it will be replaced and then diagnosed after the participant has left. This method minimizes the amount of time the participant has to be in the facility. Operations

The CMOP shall discuss the operational methods and processes, a high-level maintenance approach, as well as a high-level plan for inventory and configuration management. The departments and staff involved in the various aspects of O&M are identified and their role in O&M defined, as well as a description of the maintenance-activities to be performed including preventative, routine, and long term.

3.9.2 Products

THEA will deliver a draft CMOP to the USDOT for review. THEA will prepare a revised CMOP in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised CMOP, THEA will deliver a final CMOP.

Deliverables:

- Draft CMOP
- Revised CMOP with Comment Resolution Report
- Final CMOP.

3.10 Stakeholder Outreach – Task 2-J

3.10.1 Deployment Outreach Plan

Stakeholder Outreach activity in Phase 2 is guided by the Deployment Outreach Plan (DOP) prepared in Phase 1, Task 11. This includes the development and/or acquisition of outreach materials, web/social media content, trade show and conference materials, and other supporting materials intended to inform and engage stakeholders and the general public. In addition, this task is intended to cover all outreach events held for stakeholders in Phase 2 at the deployment site and the accommodation of requests for site visits by the media, researchers, and other visitors. Some outreach activities will be dependent on progress made in deploying the system; others will not be dependent. Table 12 shows how Audiences, Messages and Methods are related. Creating a timeline for the realization of the Outreach Plan will be part of the initial work to be done in Phase 2. Outreach efforts will target 10 specific audiences: team members, partners, stakeholders, participants, the general public, interest groups, transportation agencies, the transportation industry, policymakers, and the

news media. The pilot outreach team will tailor the messages and methods of communication to meet THEA's goals for each target audience (see (THEA, Task 11, Outreach, Draft - July 2016).

Table 12: Audiences, Messages and Methods.

Audience	Targets	Message	Methods/ Media
Stakeholder Community			
Team members	THEA, HNTB, Booz Allen Hamilton, USF CUTR, Global-5, Siemens, BrandMotion, Sirius XM	Program updates, need for consistent messaging	Website, presentations, webinars, onsite tours, talking points, media training
Partners	City of Tampa, HART, FDOT, TECO Streetcar Line	Goals, benefits, program updates	Website, presentations, webinars, e-newsletter, onsite tours, talking points
Stakeholders	Hillsborough County, Amalie Arena, Tampa Police, Florida Highway Patrol, Hillsborough County Sheriff's Office, MacDill AFB, Tampa Bay Port Authority, Tampa Convention Center, Tampa Downtown Partnership, Tampa Bay Lightning and others	Goals, benefits, program updates, potential impacts, partnership opportunities	Website, presentations, webinars, e-newsletter, video, media coverage, social media, traveling exhibit, onsite tours, speakers' bureau, good neighbor outreach
Participants	All pilot participants	Goals, benefits, program updates, FAQs, instructions, reminders	Website (including a secure section for participants only), presentations, webinars, e-newsletter, video, electronic alerts, fact sheets, brochures, tips cards, media coverage, social media, onsite tours
General public	Residents and visitors to the region, THEA customers, state and national audiences	Goals, benefits, program updates, FAQs	Website, presentations, webinars, e-newsletter, video, fact sheets, brochures, rack cards, media coverage, social media, traveling exhibit, onsite tours, TV programming
Interest groups	Business/economic development organizations, environmental industry and advocacy groups, privacy/security industry and advocacy groups, safety advocacy groups, bicycle and pedestrian groups	Goals, benefits, program updates, FAQs	Website, presentations, webinars, e-newsletter, video, fact sheets, brochures, rack cards, media coverage, social media, traveling exhibit, onsite tours, speakers' bureau, conferences, trade shows
Transportation Agencies and Industry			
Transportation agencies	State and local DOTs, city and county governments, transit agencies, tolling authorities, MPOs, TPOs	Goals, benefits, program updates, FAQs, deployment details, technical	Website, presentations, webinars, e-newsletter, video, fact sheets, brochures, rack cards, media coverage, social

Audience	Targets	Message	Methods/ Media
		results, lessons learned, research opportunities	media, onsite tours, conferences, trade shows, authored articles in industry media
Transportation industry	AV/CV/ITS/V2V/V2I community, vendors, consultants, OEMs, researchers, trade associations, related technology industries (e.g. wireless communications)	Goals, benefits, program updates, FAQs, deployment details, technical results, lessons learned, research and business opportunities	Website, presentations, webinars, e-newsletter, video, fact sheets, brochures, rack cards, media coverage, social media, onsite tours, conferences, trade shows, authored articles in industry media
Policymakers			
Policymakers	Local, state, national	Goals, benefits, program updates, FAQs	Website, presentations, webinars, e-newsletter, video, fact sheets, brochures, rack cards, media coverage, social media, onsite tours, conferences, trade shows
Media			
Media	Local, state, national, international, industry	Goals, benefits, program updates, FAQs, potential impacts	Website, presentations, webinars, e-newsletter, video, fact sheets, social media, onsite tours, authored articles, news releases, backgrounders, press conferences, media events

Source: (THEA, Task 11, Outreach, Draft - July 2016)

THEA will participate in a minimum of two USDOT-organized webinars a year regarding pilot deployment progress and performance. THEA will also participate in a minimum of three workshops, conferences, and/or trade shows each year. Refer to the DOP for webinar topics and key outreach events identified by USDOT wherein THEA will support in Phase 2.

3.10.2 Coordination with Other Deployment Activity

In order to meet overall program goals of accelerating the deployment of CV technologies, THEA will share insights and lessons learned with peers considering or actively deploying CV technologies. This includes the accommodation of site visits and other activity/products developed in this task. In addition, THEA will maintain a Lessons Learned Logbook (LLL) that incorporates a brief summary of the issue identified, the potential impacts, mitigating actions taken, and results identified (to date). This logbook is a sub-element of the Outreach Implementation Schedule (OIS) described below, and compiles risks/issues/lessons learned from other tasks and deliverables, at a minimum the IORS, TIS, and PMESS.

3.10.3 Support for International Collaboration

The USDOT is interested in sharing lessons learned from the THEA CV Pilot Deployment with its international partners. The USDOT currently has MOUs with the European Commission, Japan, Korea, Canada, and Mexico. THEA will collaborate on similar projects with international partners with which USDOT has research coordination agreements for the purpose of expanded learning. The format of the collaboration may include hosting foreign scanning tours, complementary alignment of evaluation activities, or it could involve a partial alignment of deployment or research activities and objectives to create “twinned” complementary project components. These exchanges assume that the international partners will fund projects on topics of relevance to the USDOT, and that an agreement can be reached among the international partners, USDOT, and the program managers of the research and deployment programs. The USDOT will identify areas of shared interest with its international partners from among awarded programs and initiate collaboration discussions. No

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funds will be exchanged between USDOT and foreign-funded programs; each side will have responsibility for their respective budgets.

3.10.4 Outreach Implementation Schedule

At the start of this task, THEA will revise the DOP and update (as needed) throughout Phase 2. Based on the revised/updated DOP, THEA will create and document in an OIS, a work breakdown structure of activities required to implement the DOP in Phase 2.

THEA will report progress as a (minimum) monthly update to the OIS, which for each activity/work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, risks and issues should be tracked and appended to the OIS as a part of the LLL sub-element.

THEA will deliver an initial draft OIS to the AOR for review. THEA will prepare monthly updates to the OIS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated OIS will be accompanied by a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

THEA will document planned and conducted travel in the DOP.

3.10.5 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into Task 2-J:

- Phase 1 Deployment Outreach Plan (Final).

Deliverables:

- Revised DOP
- Initial OIS
- Outreach Materials (as specified in the DOP and OIS)
- Updated OIS with Progress/Risk Summary (monthly)
- Updated Deployment Outreach Plan (minimum one update).

3.11 Performance Measurement and Independent Evaluation Support – Task 2-K

3.11.1 Baseline data collection, processing and analysis

THEA will collect, process, and distribute data and performance reports according to the Phase 1 Task 5, PMESP (THEA, Task 5, PMESP, June 2016). Plans are also discussed in Section 2.6 of this report.

THEA will measure the impact of the deployment on mobility and environmental measures, assess improvements in public agency efficiency, and support the independent evaluation effort. The collection, processing, quality control, and transfer of data from the deployment site in support of performance measurement and evaluation will be documented within the DMP (itself consistent with the PMESP).

The focus of activity in this Phase 2 task relates to establishing working end-to-end data collection and processing capabilities, coordination with the IE, and the collection and processing of baseline (“before”) data to support performance measurement activities.

The accuracy and effectiveness of performance measurement depends on the presence of concurrent confounding factors. Two types of confounding factors are likely to arise from the pilot implementation: study-area specific factors (e.g., climate, special events), and; deployment-specific factors (e.g., participant specific, technology-specific). Observed factors can be accounted for by their proper inclusion as explanatory variables and modeling method, while unobserved factors can be accounted for by utilizing appropriate statistical techniques to reduce omitted-variable bias.

In an ideal context, confounding factors can be controlled for by conducting counterfactual analysis via random experiment design. Counterfactual modeling measures the potential outcome in the absence of an intervention, such as the implementation of the CV connected technology. Empirically, there are different options for assessing the counterfactual, ranging from a simple before vs. after comparison of outcomes to measuring responses in the context of a random experiment design.

The PMESP identifies three approaches to control and minimize the impact of study-area specific and deployment-specific confounding factors: Random Design, Quasi-Experimental Design, and Before and After Comparison (Time Series Analysis). Random Design involves treatment and control groups that have been randomly assigned and a comparison made of the average treatment effect. This approach is desirable but not always achievable

When a random assignment not possible, a Quasi-Experimental approach will be used. Selection bias is then reduced by using methods through the use of propensity score matching, matching algorithm, and, difference in difference approaches.

Some use cases and the participants will not lend themselves to either of these methods. In those cases, a Before/After (time series analysis), will be employed. Application of these experiment designs to Use Cases is summarized in Table 13.

Table 13: Recommended Experimental Design

<i>Experimental Design</i>	<i>UC1 Morning Peak Hour Queues</i>	<i>UC2 Wrong Way Entries</i>	<i>UC3 Pedestrian Conflicts at Courthouse</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>
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

Source: (THEA, Task 5, PMESP, June 2016)

3.11.2 IE Support

THEA will support an independent evaluation effort as outlined in the PMESP, including:

- Performance measure calculation procedures

- A summary of relevant analytical tools available to assist in evaluation, as well as access to and use of relevant analytical models (tool inputs), observed data for model calibration, and existing calibration/validation documents for the purpose of supporting independent evaluation
- Data related to the mitigation of confounding factors, including factors tracked, sources of available information utilized to track these factors, and mitigation approaches (if any) utilized. Examples of currently identified confounding factors include weather data, special events logs, changes in land use in the study area, changes to the street system, equipment anomalies, and participant self-selection, participant attrition and moral hazard effects.
- Facilitation of IE access to site staff and stakeholders but excluding participants
- THEA will assist the IE in developing and disseminating anonymous user opinion surveys. THEA will not be granting assistance in IE use of the Pilot's participant pool for direct interaction by the IE with participants. Such IE interaction with participants would require IRB approval and be done separately from this Pilot and under the IE's "own" IRB approval. The IE's IRB approval and research protocol would have to also be reviewed and approved by THEA's IRB (i.e., Salus IRB) and any effort by or cost to the THEA team to provide assistance in this regard is out of scope for the Pilot. By THEA's exclusive dissemination of IE user surveys to the participants without releasing PII to the IE, the need for the IE to involve another IRB is unnecessary. Only THEA will disseminate anonymous user surveys in accordance with its IRB (i.e., Salus IRB) approved RPD and ICDs. No PII will be released to the IE.

3.11.3 Performance Measurement and Evaluation Support Schedule (PMESS)

THEA will prepare a Performance Measurement and Evaluation Support Schedule (PMESS) that includes a work breakdown structure of activities (and dependencies) required to implement the PMESP and Data Management Plan (DMP) for the specific purposes of the performance measurement and evaluation.

The PMESS will identify milestones, performance summary reports, and pre-deployment ("Before") data for coordination with USDOT and a USDOT-identified IE. Consistent performance reporting in Phase 2 will be critical in measuring and assessing the impacts of the deployment prior to making the system operational in Phase 3. The PMESS shall also outline key elements of a performance measurement focused dry-run demonstration for the purposes of ensuring that data collection and processing capabilities are in place and functioning properly prior to the commencement of Phase 3.

THEA will provide a weekly update to the PMESS, which for each work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues should be tracked and appended to the PMESS. THEA will deliver the products (identified in the PMESP) of these activities, for example data, logbooks, analytical models, system performance reports, and other supporting information on or before delivery dates identified in the PMESS.

THEA will deliver an initial draft PMESS to the AOR for review. THEA will prepare weekly updates to the PMESS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated PMESS will be accompanied by a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

Periodically (but no less than once) THEA will update the PMESP in Phase 2. THEA will document within the updated PMESP any/all analytical models and algorithmic methodologies utilized in performance measure calculation.

3.11.4 Products

The following Phase 1 contract deliverables are hereby incorporated by reference into this Statement of Work Task 2-K:

Phase 1 Performance Management and Evaluation Support Plan (Final)

Deliverables:

- Draft Performance Measurement and Evaluation Support Schedule (PMESS)
- Updated PMESS with Progress/Risk Summary (weekly)
- Pre-Deployment Performance Data, logbooks, analytical models and other supporting information (per the PMESS)
- System Performance Reports (per the PMESS)
- Updated PMESP (minimum one update).

3.11.5 Oversight of Performance Measures PII in Phase 2

CUTR is the task lead for Phase 1, Task 5, Performance Measurement and Evaluation Support. The University of South Florida IRB, which has oversight of CUTR's activities, will review PII elements of CUTR's Performance Measurement work in Phase 2. This will not change Salus IRB oversight of the entirety of Phase 2 activities. USF's oversight of CUTR's work is independent and supplementary to Salus IRB's oversight of the entire project. Salus IRB is aware of USF IRB oversight of CUTR and has expressed no exception or conflict with USF's additional oversight of CUTR's performance measurement work.

3.12 Participation in Standards Development – Task 2-L

3.12.1 Standards Technical Memoranda

One of the ancillary benefits of the CV Pilot program is that it will permit the USDOT and the CV industry to exercise the various standards that have been developed by the various Standards Development Organizations (SDOs). The THEA team will support the various SDOs by participating in the relevant standards development activities, including participating at select SDO working groups. This support will include providing technical information based on the deployment in Tampa that is focused on providing appropriate input to expand, correct or otherwise improve the relevant standards, including the ITS architecture.

As part of the Systems Architecture Document in Task 2-B, the relevant standards are being identified and document in the Standards Plan. As part of the support for Standards Development, the THEA team will document the relevant experiences to improve the current standards through the development of Standards Technical Memoranda, formatted specifically for the relevant SDO.

As these technical memoranda are prepared, the THEA team will present them to the USDOT for review and comment. If these comments are of significant value, the THEA team will have a representative participate in the appropriate SDO working group or technical committee meeting to discuss the issues identified.

3.12.2 Participation in SDO Working Group or Committee Meetings

The THEA Team is planning, as part of the Phase 2 and 3 efforts, to actively participate, at a minimum, in the SAE J2735 and 2945 meetings. This constant participation will provide the THEA Team and the USDOT with a first-hand and timely account of upcoming issues that are relevant to the CV Pilot and will provide a more efficient conduit for the sharing of Technical Memoranda to these committees.

3.12.3 Products

Deliverables:

- SDO-specific Technical Memoranda (2-L & 3-F)
- Participation in SDO working groups or committee meetings/activities (2-L & 3-F)

3.13 Program Management – Task 3-A

This task is a continuation of the Phase 2 Program Management activity, with the same objectives, activities and scope and continuing with the systems engineering approach depicted in Figure 6.

The kick-off meeting may occur at the USDOT in Washington DC, or at the THEA site. A webinar will be made available for remote participation by additional THEA team members.

3.13.1 Products

Deliverables:

- Kick-off Meeting
- PMP
- Revised PMP (as required)
- Project Schedules (updated monthly)
- Monthly Progress Reports
- Participation in site-specific bi-weekly coordination teleconferences
- Participation in monthly all-site coordination teleconferences.

3.14 System Operations and Maintenance – Task 3-B

During Phase 3, THEA will implement the CMOP to ensure the Pilot has continuous operations and the devices are properly maintained. A System Operations and Maintenance Schedule (SOMS) will be created from the activities defined in the CMOP. The SOMS will identify preventative maintenance activities, scheduled routine maintenance tasks, as well as other maintenance activities. For each of these tasks, the planned duration of maintenance will be defined, any closures or disruptions will be identified on the SOMS.

THEA will report progress in a monthly update to the SOMS, which for each work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues should be tracked and appended to the SOMS.

As a part of the monthly SOMS update, THEA will include an appendix that reports the number of DSRC-equipped devices installed and an operational status indicator (e.g., installed, installed and tested, operational, under repair/not in operation), categorized by type, with their physical locations where appropriate. Device types include: vehicle and in-vehicle equipment, roadside equipment, mobile devices, management center equipment, and any other equipment equipped with a DSRC transmitter or receiver.

THEA will deliver an initial draft SOMS to the AOR for review. THEA will prepare monthly updates to the SOMS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated SOMS will be accompanied by a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks/incidents with any/all mitigation actions taken since the last update.

3.14.1 Products

Deliverables:

- Initial System Operations and Maintenance Schedule (SOMS)
- Updated SOMS with Progress/Risk Summary (monthly).

3.15 Stakeholder Outreach – Task 3-C

3.15.1 Deployment Outreach Plan

THEA will conduct Stakeholder Outreach in Phase 3 as described in the updated DOP. This includes, for example, the development and/or acquisition of outreach materials, web/social media content, trade show and conference materials, and other supporting materials intended to inform and engage stakeholders and the general public. As in Phase 2, activity in this task includes collaboration with domestic and international sites planning for or deploying CV technologies.

THEA will participate in a minimum of two USDOT-organized webinars a year regarding pilot deployment progress and performance. THEA will also participate in a minimum of three workshops, conferences, and/or

trade shows each year. Refer to the DOP for webinar topics and key outreach events identified by USDOT wherein THEA will support in Phase 3.

3.15.2 Operational Capability Showcase

Outreach activities in Phase 3 will include an Operational Capability Showcase no later than the first 12 months of Phase 3. This is not a structured demonstration but is intended as a media event to show the capabilities, intent, and value of the deployment. The showcase will also include an interoperability activity, wherein one or more in-vehicle or mobile device from a different CV Pilot Deployment site is shown to be interacting successfully with the local deployment. THEA will prepare a draft Operational Capability Showcase Plan (OCSP) for USDOT comment. Based on the USDOT comments, THEA will prepare a revised OCSP with an accompanying comment resolution summary. Based on USDOT review of the revised OCSP, THEA will prepare a final OCSP. Work activities associated with the showcase will be incorporated into the OIS, as necessary.

THEA will conduct the Operational Capability Showcase in coordination with the AOR and federal outreach activity. THEA will document the showcase with a draft Operational Capability Showcase Summary (OCSS) indicating how the results/products of the showcase have been integrated into site outreach materials and interactions in workshops, conferences and trade shows. THEA will prepare a revised OCSS in response to USDOT comments with an accompanying Comment Resolution Report. Based on USDOT review of the revised OCSS, THEA will deliver a final OCSS.

3.15.3 Outreach Implementation Schedule

THEA will create a work breakdown structure of activities required to implement the DOP in Phase 3 and document them in an OIS. THEA will report progress in a (minimum) monthly update to the OIS, which for each activity/work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, risks and issues should be tracked and appended to the OIS (including an updated Lessons Learned Logbook).

THEA will deliver an initial draft OIS to the AOR for review. THEA will prepare monthly updates to the OIS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated OIS will be accompanied by a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

3.15.4 Products

Deliverables:

- Initial OIS
- Outreach Materials (as specified in the DOP and OIS)
- Updated OIS with Progress/Risk Summary (monthly)
- Draft OCSP
- Revised OCSP with Comment Resolution Summary
- Final OCSP
- Operational Capability Showcase
- Draft OCSS
- Revised OCSS with Comment Resolution Report
- Final OCSS.

3.16 Performance Measurement and Independent Evaluation Support – Task 3-D

3.16.1 Baseline data collection, processing and analysis

THEA will collect, process, and distribute data according to the updated PMESP from Phase 2 to measure the impact of the deployment on key safety, mobility and environmental measures, assess improvements in public agency efficiency, and to support broader independent evaluation effort.

The collection, processing and transfer of data from the deployment site in support of performance measurement and evaluation is documented within the Data Management Plan (itself consistent with the PMESP). The focus of activity in this Phase 3 task is measuring the impact of CV applications and the overall impact of the deployment on site-identified key performance measures and supporting an independent evaluation effort.

3.16.2 IE Support

In addition to the activities described above, in this task the site staff will support an independent evaluation effort as outlined in the PMESP, including but not limited to:

- Performance measure calculation procedures
- A summary of relevant analytical tools available to assist in evaluation, as well as access to and use of relevant analytical models (tool inputs), observed data for model calibration, and existing calibration/validation documents for the purpose of supporting independent evaluation
- Data related to the mitigation of confounding factors, including factors tracked, sources of available information utilized to track these factors, and mitigation approaches (if any) utilized by the sites
- Facilitation of IE access to site staff and stakeholders for the purposes of supporting surveys and interviews, excluding participants.

3.16.3 Performance Measurement and Evaluation Support Schedule (PMESS)

THEA will prepare a Performance Measurement and Evaluation Support Schedule (PMESS) that includes a work breakdown structure of activities (and dependencies) required to implement the PMESP (and DMP) for the specific purposes of the performance measurement and evaluation. THEA will deliver the products (identified in the PMESP) of these activities, such as data, logbooks, analytical models, system performance reports, and other supporting information on or before delivery dates identified in the PMESS.

The PMESS will identify milestones, performance summary reports, and the delivery of post-deployment (“After”) data for coordination with USDOT and a USDOT-identified IE. If there is a control area and/or group used for comparison, then the “without” data and performance reports for the same post-deployment time period also needs to be delivered.

THEA will provide progress in a weekly update to the PMESS, which for each work breakdown element shows progress against milestones denoting (at a minimum) initiation, 20% complete, 50% complete, 80% complete, and completed activities. As they arise, technical risks and issues should be tracked and appended to the PMESS.

THEA will deliver an initial draft PMESS to the AOR for review. THEA will prepare weekly updates to the PMESS in response to USDOT comments on format and content, as well as to document progress against plan and track risks/issues. The updated PMESS will be accompanied by a concise summary of activities underway, progress made since the last update, and any/all technical issues/risks with any/all mitigation actions taken since the last update.

Periodically (but no less than once) THEA will update the PMESP and DMP in Phase 3. THEA will document within the updated PMESP any/all analytical models and algorithmic methodologies utilized in performance measure calculation.

3.16.4 Products

Deliverables

- Draft Performance Measurement and Evaluation Support Schedule (PMESS)
- Updated PMESS with Progress/Risk Summary (weekly)

- Post-Deployment Performance Data, logbooks, analytical models and other supporting information (per the PMESS)
- System Performance Reports (per the PMESS)
- Updated PMESP and DMP documents (as required).

3.17 Post-Pilot Deployment Transition Planning – Task 3-E

As Phase 3 moves toward conclusion, THEA will develop the Post Pilot Deployment Comprehensive Transition Plan (CTP). In Phase 1, THEA developed multiple documents regarding the proposed system operational concepts, design, funding and governance. These documents are intended to guide the final design and implementation in Phase 2 and the operations in Phase 3. Over the course of Phases 2 and 3, it is anticipated that lessons will be learned regarding the different operational concepts based on real-world implementation and operations. The CTP will be used to guide the THEA in the transition activities, but also to support USDOT efforts associated with documenting the benefits and lessons learned associated with the CV Pilot program. The CTP will be instrumental in THEA's transition from a Pilot program to a real world long term deployment.

3.17.1 Transitions

The CTP will include four sections that cover the key transition points:

- **Operational Concepts.** This section will address the concepts and applications that were envisioned in Phase 1. Each key concept and application will be documented and evaluated to determine if they are worth continued operations after Phase 3 is completed. The evaluation criteria and rationale will be developed and included as part of this section and will be based on the results of the performance measurements generated by each component.
- **Financial Resources and Commitments.** This section will be an update to the Task 10 report from Phase 1, Partnership Coordination and Finalization. The focus of this section will include updates to agreements that are necessary as the project shifts from Phase 3 to Post-Deployment and updates to the documents that show the financial resources necessary for continued operations.
- **External Dependencies.** Any systems that the THEA Pilot used that were not designed, built, procured, licensed, operated or maintained by the THEA Pilot site that are necessary for continued operations will be identified. One example is the SCMS for the provision of security material, however other systems may be identified as the project shifts from Phase 1 to 2.
- **Contingency Plans.** As the project shifts to a post-pilot environment, the risks associated with operations will be impacted. This section will document any identified risks associated with continued operations, possible mitigations and include contingency plans for those risks or issues to ensure successful continued operations.

3.17.2 Products

Deliverables:

- Draft Comprehensive Transition Plan (CTP)
- Revised CTP with Comment Resolution Report
- Final CTP.

3.18 Participation in Standards Development – Task 3-F

3.18.1 Standards Technical Memoranda

As in Task 2-L (Section 3.12), the THEA team will support the various SDOs by participating in the relevant standards development activities, including participating at select SDO working groups.

3.18.2 Participation in SDO Working Group or Committee Meetings

The THEA Team is planning, as part of the Phase 2 and 3 efforts, to actively participate, at a minimum, in the SAE J2735 and 2945 meetings. This constant participation will provide the THEA Team and the USDOT with a first-hand and timely account of upcoming issues that are relevant to the CV Pilot and will provide a more efficient conduit for the sharing of Technical Memoranda to these committees.

3.18.3 Products

Deliverables:

- SDO-specific Technical Memoranda (2-L & 3-F)
- Participation in SDO working groups or committee meetings/activities (2-L & 3-F).

4 Deployment Schedule

A complete, baseline WBS will be provided as a component of the PMP to be submitted four weeks from award of Phase 2. This WBS will be presented to a minimum of the third level and be updated monthly throughout Phases 2 and 3. This baseline schedule will correspond to the tasks and deliverables making up Phases 2 and 3.

4.1 Schedule Description

This section presents a graphical presentation of the task dependencies by Phase, key deliverables, milestones, spanning the period of performance, along with explanatory text (see Figures 7 and 8).

Figure 7: Estimated Task Schedule – Phase 2.

Phase 2	Month From Award																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2-A Program Mgt.																				
2-B System Arch/Design																				
2-C Data Mgt. Planning																				
2-D Acquisition/Install Plan																				
2-E App Development																				
2-F Participant/Staff Train																				
2-G Test/Demo Planning																				
2-H Installation and Testing																				
2-I Maint and Ops Planning																				
2-J Stakeholder Outreach																				
2-K Perf Meas./IE Support																				
2-L Standards Development																				

Source: (USDOT FHWA, NOFO, May 17, 2016).

Figure 8: Estimated Task Schedule – Phase 3.

Phase 3	Month From NTP											
	1	2	3	4	5	6	7	8	9	10	11	12
3-A Program Mgt.												
3-B System Ops/Maint.												
3-C Stakeholder Outreach												
3-D Perf Meas./IE Support												
3-E Transition Planning												
3-F Standards Development												

Source: (USDOT FHWA, NOFO, May 17, 2016)

4.2 Supporting Information on Current Acquisition and Installation Planning

The overarching plan for Phase 2 is based on a top down approach to distribute tasks functionally across dual paths leveraging the key strengths of our core partners. This plan calls for separate acquisition and installation

efforts for roadside equipment versus onboard equipment with coordinated interfaces at the functional level. Systems engineering and final integration and testing efforts are conducted jointly and the entire process is monitored and tracked within the program management structure. THEA takes the position that this approach distributes accountability and risk, while taking full advantage of each core partner's critical expertise. Cross-functional reviews and progress meetings will ensure interoperability, requirements traceability and advancement of the common goals for successful deployment. Figure 3 (Section 3.1) depicts the major workflows with divergence and convergence of the distributed tasks.

Not all elements are fully identified. The purpose of this section is to understand the status and level of detailed thinking conducted to-date regarding the procurement, configuration and installation of these key technologies.

5 Team Organizational Summary

THEA fielded a very robust team for the Phase 1, Concept Development which is on track to finish ahead of schedule. The vast majority of this team remains to provide consistent follow-on efforts in the same or similar roles. This continuity ensures that skills honed and lessons learned during Phase 1 will be appropriately applied in the effective advancement of the Phase 1 concept into a operationally ready CV-Pilot Deployment during Phase 2 and into an effective means to collect, evaluate and distribute CV program data via the RDE. The staff represented herein includes several who also have involvement in prior projects such as the UMTRI Safety Pilot and recent and ongoing efforts such and Smart Cities, and State and local AV/CV planning and/or deployment.

As the team is largely a carryover from Phase 1, there is an inherent cohesiveness and synergy that fires our passion for the success of this cutting-edge deployment. As THEA's GEC, HNTB will remain in the Program Management Lead role and provide administrative support in addition to its technical tasks.

The following narrative and organizational chart indicates the task leaders by name and support efforts by firm or agency. For ease of review, we follow the Phase 2/3 Tasks as laid out in the NOFO. This section covers only the Key Staff in detail. Task leaders and other support personnel are detailed in Volume I, Part II of the NOFO Application, including firm/agency qualifications, resumes of key staff and task leader bios along with their level of effort as percent of time dedicated to the CV Pilot.

5.1 Key Staff

The NOFO identifies the following key staff:

- Site Deployment Lead
- Systems Engineering Lead
- Project Management Lead.

THEA's proposed Phase 2/3 key staff provides continuity in leadership established in Phase 1. Resumes for these key staff are included at the end of this section.

5.1.1 Site Deployment Lead: Robert "Bob" Frey (THEA)

As the overall agency program manager and site lead for the THEA Pilot, Bob was actively involved in all aspects of Phase 1 main point of contact. This role will continue in throughout Phases 2/3. He serves as the THEA Planning Director and has more than 24 years of planning and operations experience working throughout Florida and the United States. In the two years since starting the initiative, THEA has accomplished bringing the *first* State of Florida Automated Vehicle Summit to Tampa as a partner with FDOT, sponsored the University of South Florida's Automated Vehicle Institute, joined the OST-R affiliated test bed program, had a demonstration project with Audi that included National television coverage with Governor Scott and sits on the Florida Department of Transportation Connected Vehicle Working Group. THEA's planning focus has been to bring safer mobility choices to Tampa Bay using innovation and creativity to overcome transportation problems. Bob holds a Masters of Public Policy degree from Baylor University, is a member of the American Institute of Certified Planners and a graduate of the International Bridge, Toll, and Tunnel Association (IBTTA) Leadership Academy.

5.1.2 System Engineering Lead: Stephen Novosad (HNTB)

Stephen was the system development lead (SDL) for Phase 1 and will continue in the systems engineering lead role for Phases 2/3. Mr. Novosad has more than 30 years of experience in ITS/ATMS including considerable work with emerging technologies and software development. He has provided subject matter expertise toward efforts including: Vehicle Infrastructure Integration (VII 2003); 2001 World Congress Connected Vehicle Demonstration and SunGuide® Connected Vehicle Software; Qualification and Certification testing of IntelliDriveSM (OmniAir Consortium); Standards Compliance and Interoperability Certification Program for Connected Vehicle Hardware and Software; V2I Integrated Prototype Development and Deployment; FDOT Connected Vehicle Activities (2011-2015); OmniAir Vice-Chair (2013-2015). Stephen is also a member of the Connected Vehicle Working Group and the Sustainability in Transportation Working group.

5.1.3 Project Management Lead: Steve Johnson (HNTB)

Steve was the program management lead (PML) in Phase 1 and will continue in the project management lead role for Phases 2/3. Mr. Johnson brings more than 30 years of experience as a technical project manager in information technology, INFOSEC and telecommunications with an emphasis on Intelligent Transportation Systems (ITS)/Advanced Traffic Management Systems (ATMS). His expertise includes project management, resource management, change management, quality control, and service-level agreements. His technical skills include ITS/ATMS, network engineering, systems integration, INFOSEC, outside plant cable construction, premise wiring, traffic signal design and operation, and wireless networks, including over 300 miles of Fiber Optic network and ITS/ATMS Infrastructure. He has also provided CEI project administration for a major Managed Lanes project and over 200 signalized intersections. Steve is a national thought leader with published articles (Telematics for Emergency Dispatch and Traffic Incident Management, 2010; Who's in Charge and Where Are They?: A Primer on Command and Control for Traffic Incident Management). He presented on the CyberSecurity Challenges for CV at the 2016 TIA Conference and moderated a panel on Funding the Next generation of Tech at ITS America 2016.

5.2 Core Team Member Firms

5.2.1 HNTB Corporation

HNTB is a leading provider of CV program technical support services to clients throughout the United States. Many state departments of transportation and toll authorities are developing plans that incorporate CV technologies and applications. This experience is directly relevant to the THEA CV Pilot Project. HNTB maintains its role as Program Management Lead for Phases 2/3 and will provide support across all tasks.

5.2.2 Siemens

As a world leader in Intelligent Traffic Solutions, Siemens Industry, ITS is uniquely qualified to assist THEA in developing and implementing a connected vehicle solution. Siemens is a member of the U.S. Department of Transportation Research and Innovative Technology Administration Affiliated Test Beds with Siemens employee and innovator, Dave Miller, sitting on the ITE Connected Vehicle Task Force. Siemens is the Lead Developer/Integrator for all roadside applications/devices and overall Integration/Test Leader

5.2.3 Brandmotion LLC

Brandmotion is in its 11th year of working to make vehicles safer, faster. The company was formed in 2005 as a spin-out of Tier 1 automotive supplier Johnson Controls, with a focus on integrating and distributing emerging safety, mobility and convenience features for cars and trucks already on the road. The Brandmotion team seeks to help automotive suppliers leverage and extend their technology onto existing vehicles, and at the same time provide consumers with greater freedom of choice in choosing the features and content for their vehicles.

Brandmotion specializes in the design integration of emerging automotive safety technology: for car dealers seeking to provide their customer exactly the car they want, for fleets and fleet managers looking to make their company assets safer and more productive, for automakers looking to offer innovative new ala carte dealer-installed add-on features, and for automotive suppliers seeking additional distribution channels for emerging

technology. Brandmotion is a recognized brand among aftermarket installers of 12V mobile electronic, and was awarded “2016 SEMA PRO Manufacturer of the Year” honors at the 2015 SEMA Show in Las Vegas. Brandmotion will lead the development and integration of all on-board applications/devices and will support Siemens in the overall Integration/Readiness Test activities.

5.2.4 Center for Urban Transportation Research (CUTR) at USF

CUTR is a Tier I University Transportation Center (UTC) located in Tampa that has successfully competed in each cycle of UTC awards. Like HNTB, CUTR has a separate CV support contract with THEA and provides oversight on THEA's CV projects. The Center will be a resource for the project team and project partners with its principal activity focused on Performance Measurement.

5.2.5 Global-5 Communications

Global-5 Communications is the nation's leading transportation communications firm and will be leading Participant and Staff Training as well as Stakeholder Outreach. Global-5 has more than a decade of experience managing project outreach activities for transportation clients including the FHWA, ITS Florida, and ITS America. The firm has also delivered nationwide training webinars and videos for the FHWA Office of Innovation, working collaboratively with the National Highway Institute.

5.2.6 Booz Allen Hamilton

Booz Allen Hamilton brings a breadth and depth of CV experience, having worked closely with the USDOT and multiple stakeholders for several years on the research, development, and testing that set the foundation for the large-scale pilots. Booz Allen brings experts in the areas of SMOC, performance measurement and evaluation of CV programs and technologies, and CV applications ConOps and deployment plans. They have demonstrated experience with the U.S. DOT DMA program activities, the AASHTO Footprint Analysis, and various CV Test Bed activities. BAH's primary focus during Phases 2/3 is on support for Data Management Planning and Standards Participation.

5.2.7 Hillsborough Community College (HCC)

Hillsborough Community College is affiliated with the University of South Florida, offering two-year courses of study, many of which transfer directly into the four-year USF programs. HCC provides an Associate of Science Degree In Automotive Technologies which also results in certification of graduates as master mechanics. HCC will support Brandmotion in providing installation services of OBUs under the supervision of Brandmotion and HCC senior instructors. During Phase 3, HCC will assist in the help desk support and OBU Maintenance Program. In addition to providing an equipped facility for installations, this partnership with HCC provides workforce development to the Tampa Bay community and its auto dealerships which will soon find themselves in need of CV knowledgeable automotive technicians.

6 Cost Summary

This section summarizes the projected cost estimates at a high-level, and is intended to provide information and guidance for other deployers regarding the costs allocated for the project by

- Phase
- Task
- Major areas of expenditure (e.g., labor, in-vehicle equipment, roadside equipment, software development, systems integration, etc.).

Detailed cost elements are included in Volume II, Part I.

6.1 Total Budget Summary, Phases 2 and 3

THEA's original grant application submitted over a year ago, included a high level budget for Phases 1 and 2. The total submitted budget for both Phases at that time was \$19,076,770.00 with \$16,675,354.00 allocated to Phase 2 and \$2,401,416.00 to Phase 3.

THEA is glad to report that our proposed total budget for Phases 2 & 3 under the NoFO is substantially the same albeit with a higher percentage of the budget falling into Phase 3. THEA was able to shift Phase 2 funds to Phase 3 in order to keep overall budget within range of original estimate. The NoFO proposed budget for both Phases is \$19,076,761

The total USDOT/THEA participation is indicated in Table 14 below.

Table 14: Federal and Matched Costs by Project Phase.

Phase 2 Total	100%	\$13,905,548
Phase 2 Federal	82%	\$11,402,549
Phase 2 Match	18%	\$2,502,999
Phase 3 Total	100%	\$5,171,213
Phase 3 Federal	73%	\$3,776,213
Phase 3 Match	27%	\$1,395,000
Project Total	100%	\$19,076,761
Federal	80%	\$15,178,762
Local Match	20%	\$3,897,999

6.2 Total Budget by Project Phase, Task and Services-Materials Split

Table 15 below shows the Phase 2/3 budget by phase, task and category (Services/Materials) ²

Table 15: Total Budget by Project Phase, Task and Services-Materials Split.

Phase/Task	Description	Total Task Budget	Professional Services	Professional Services %	Materials	Materials %
2-A	Program Management	1,240,000	1,240,000	100%		0%
2-B	System Architecture and Design	2,950,000	2,950,000	100%		0%
2-C	Data Management Planning	1,000,000	1,000,000	100%		0%
2-D	Acquisition and Installation Planning	4,265,000	1,192,556	27%	3,072,444	73%
2-E	Application Development	1,400,000	1,400,000	100%		0%
2-F	Participant and Staff Training	250,000	250,000	100%		0%
2-G	Operational Readiness Test and Demonstration Planning	150,548	150,548	100%		0%
2-H	Installation and Operational Readiness Testing	500,000	500,000	100%		0%
2-I	Maintenance and Operations Planning	1,000,000	1,000,000	100%		0%
2-J	Stakeholder Outreach	400,000	400,000	100%		0%
2-K	Performance Measurement and Independent Evaluation Support	300,000	300,000	100%	0	0%
2-L	Participation in Standards Development	450,000	450,000	100%	0	0%
	Phase 2 Total	13,905,548	10,833,104	92%	3,072,444	8%
3-A	Program Management	350,000	350,000	100%	0	0%
3-A(1)	Toll Incentive Plan	1,395,000	1,395,000	100%	0	0%
3-B	System Operations and Maintenance	1,528,990	1,528,990	100%	0	0%
3-C	Stakeholder Outreach	347,000	347,000	100%	0	0%
3-D	Performance Measurement and Independent Evaluation Support	1,400,223	1,400,223	100%	0	0%
3-E	Post-Pilot Deployment Transition Planning	50,000	50,000	100%	0	0%
3-F	Participation in Standards Development	100,000	100,000	100%	0	0%
	Phase 3 Total	5,171,213	5,171,213	100%	0	0%

Totals:	Professional Services	\$16,004,317	Materials	\$ 3,072,444	Phase 2/3 Total	\$ 19,076,761
	Total %	84%	Total %	16%		

² Travel, meetings and other expenses are included in the professional services cost. Materials cost includes RSU, OBU and specialized tools and test equipment. Materials shown under training and outreach include training materials and materials for trade show displays etc.

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Appendix A. Acronyms

Table A-1: Acronyms

ACRONYM	DEFINITION
ADP	Application Deployment Plan
ADS	Application Development Schedule
AOR	Agreement Officer Representative
APL	Approved Products List
AR	Anomaly Report
ASD	Aftermarket Safety Device
ASIL	Automotive Safety Integrity Level
ATC	Advanced Traffic Controller
BRT	Bus Rapid Transit
BSM	Basic Safety Message
BT	British Telecommunications
CAMP	Crash Avoidance Metrics Partnership
CAN	Controller-Area Network
CAP	Comprehensive Acquisition Plan
CBD	Central Business District
CCB	Configuration Control Board
CDP	Concept Development Plan
CIP	Comprehensive Installation Plan
CMOP	Comprehensive Maintenance and Operations Plan
ConOps	Concept of Operations
CSW	Curve Speed Warning
CTP	Comprehensive Transition Plan
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DMP	Data Management Plan
DOP	Deployment Outreach Plan
DPP	Data Privacy Plan
DSRC	Dedicated Short Range Communications
DUT	Design Under Test
EEBL	Emergency Electronic Brake Light
FAQ	Frequently Asked Questions
FCW	Forward Collision Warning
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standard
FSU	Florida State University

FWA	Federal Wide Assurance
GNSS	Global Navigation Satellite System
HART	Hillsborough Area Regional Transit
HDMI	High-Definition Multimedia Interface
HLD	High-Level Design
HMI	Human Machine Interface
HHS	Health and Human Services
HPRP	Human Protection Research Protocol
HUA	Human Use Approval
HUAS	Human Use Approval Summary
HW	Hardware
ICD	Informed Consent Document
IE	Independent Evaluator
IEEE	Institute of Electrical and Electronics Engineers
IMA	Intersection Movement Assist
IOORS	Installation and Operational Readiness Schedule
IRB	Institutional Review Board
I-SIG	Intelligent Signal Systems
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
LED	Light-Emitting Diode
LTP	Level Test Plan
LLL	Lessons Learned Logbook
LTE	Long Term Evolution
MAFB	MacDill Air Force Base
MOU	Memorandum of Understanding
MTP	Master Test Plan
NEMA	National Electrical Manufacturer's Association
NIST	National Institute of Standards and Technology
NOFO	Notice of Funding Opportunity
O&M	Operations and Maintenance
OBD	On-Board Device
OBE	On-Board Equipment
OBU	On-Board Unit
OCSP	Operational Capability Showcase Plan
OCSS	Operational Capability Showcase Schedule
ODE	Operational Data Environment
OEM	Original Equipment Manufacturer
OIS	Outreach Implementation Schedule
ORP	Operational Readiness Plan
ORDP	Operational Readiness Deployment Plan
OROIAP	Operational Readiness Observation, Inspection and Analysis Plan

ORTP	Operational Readiness Test Plan
OSADP	Open Source Application Development Portal
PDCA	Plan-Do-Check-Act
PDETM	Probe Data Enabled Traffic Monitoring
PED-SIG	Mobile Accessible Pedestrian Signals System
PED-X	Pedestrian in a Signalized Crosswalk
PID	Personal Information Devices
PII	Personally Identifiable Information
PMBOK	Project Management Body of Knowledge
PMESP	Performance Measurement and Evaluation Support Plan
PMESS	Performance Measurement and Evaluation Support Schedule
PMP	Project Management Plan
POE	Power Over Ethernet
PSD	Personal Safety Device
PTSEP	Participant Training and Stakeholder Education Plan
RCA	Radio Corporation of America
RDE	Research Data Exchange
RFI	Request for Information
REL	Reversible Express Lanes
RLVW	Red Light Violation Warning
RSD	Roadside Device
RSE	Roadside Equipment
RSU	Road Side Unit
SAE	Society of Automotive Engineers
SCMS	Security Credential Management System
SAD	System Architecture Document
SDD	System Design Document
SDO	Standards Development Organizations
SMOC	Security Management Operating Concept
SMS	Short Message Service
SOMS	System Operations and Maintenance Schedule
SW	Software
TIS	Training Implementation Schedule
SPII	Sensitive Personally Identifiable Information
SyRS	System Requirements Specification
TERL	Traffic Engineering Research Laboratory
THEA	Tampa Hillsborough Expressway Authority
TMC	Transportation Management Center
TSP	Transit Signal Priority
UMTRI	University of Michigan Transportation Research Institute
UUT	Unit Under Test
USDOT	United States Department of Transportation

V2I	Vehicle-To-Infrastructure
V2V	Vehicle-To-Vehicle
V2X	Vehicle-To-Everything
VAD	Vehicle Awareness Device
VDTO	Vehicle Data For Traffic Operations
VIN	Vehicle Identification Number
VTRFTV	Vehicle Turning Right in Front of a Transit Vehicle
WBS	Work Breakdown Structure
WP	Work Package

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