Connected Vehicle Pilot Deployment Program Phase 2

System Architecture Document – Tampa (THEA)

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Final Report — November 2018
Publication Number: FHWA-JPO-17-459

Produced by Tampa Hillsborough Expressway Authority
Connected Vehicle Pilot Deployment Program Phase 2
U.S. Department of Transportation Intelligent Transportation Systems, Joint Program Office

Notice

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-17-459		

4. Title and Subtitle	5. Report Date
Connected Vehicle Pilot Deployment Program Phase 2, System Architecture Document– Tampa (THEA)	November 2018
	6. Performing Organization Code
7. Author(s) Tampa Hillsborough Expressway Authority	**8. Performing Organization Report No.**
9. Performing Organization Name and Address Tampa Hillsborough Expressway Authority 1104 East Twiggs Street, Suite 300 Tampa, Florida 33602	**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH6116RA0007
12. Sponsoring Agency Name and Address ITS-Joint Program Office 1200 New Jersey Avenue, S.E., Washington, DC 20590	**13. Type of Report and Period Covered** **14. Sponsoring Agency Code** **HOIT-1**

15. Supplementary Notes
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16. Abstract

The Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle (CV) Pilot Deployment Program is intended to develop a suite of applications that utilize vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication technology to reduce traffic congestion, improve safety, and decrease emissions. These CV applications 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 planning for the CV pilot including the concept of operations development. Phase 2 is the design, development, and testing phase. Phase 3 includes a real-world demonstration of the applications developed as part of this pilot.

This document represents the System Architecture Document.

The System Architecture Document is intended to provide the architecture for the pilot system. The architecture is based on the functional requirements and user needs and is used as the basis for the design.

17. Key Words	18. Distribution Statement
Applications, Connected Vehicles, Architecture, Design Deployment, Mobility, Pilot, Safety, Software	

19. Security Classification. (of this report)	20. Security Classification. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	176	

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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Acronyms

ACRONYM	DEFINITION
ATMS	Advance Traffic Management System
BER	Basic Encoding Rules
BRT	Bus Rapid Transit
BSM	Basic Safety Message
BT	Bluetooth
CAMP	Crash Avoidance Metrics Partnership
CAN	Controller Area Network
CBD	Central Business District
CDP	Comprehensive Deployment Plan
CMS	Central Management System
ConOps	Concept of Operations
COT	City of Tampa
CRL	Certificate Revocation List
CUTR	Center for Urban Transportation Research
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DER	Distinguished Encoding Rules
DMS	Dynamic Message Sign
DMZ	Demilitarized Zone
DSRC	Dedicated Short-Range Communications
EEBL	Emergency Electronic Brake Light
ERDW	End of Ramp Deceleration Warning
FCW	Forward Collision Warning
GPIO	General Purpose Input Output
GPS	Global Positioning System
HART	Hillsborough Area Regional Transit
HCC	Hillsborough Community College
HMI	Human Machine Interface
HTML	Hypertext Markup Language
HW	Hardware
I-SIG	Intelligent Signal Systems
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IMA	Intersection Movement Assist
ISM	Infrastructure Sensor Message
ISO	International Organization for Standardization

ITS	Intelligent Transportation System
ITS JPO	Intelligent Transportation Systems Joint Program Office
LIDAR	Light Imaging Detection and Ranging
LTE	Long-Term Evolution
MAFB	MacDill Air Force Base
MAP	Map Message
MMITSS	Multi-Modal Intelligent Traffic Signal System
MOU	Memorandum of Understanding
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
NMEA	National Marine Electronics Association
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
NTSC	National Television System Committee
O&M	Operations and Maintenance
OBE	On-Board Equipment
OBU	On-Board Unit
OCIT	Open Communications Interfaces for Traffic Systems
OCPI	Open Content Provider Interface
OSADP	Open Source Application Development Portal
OTA	Over-the-Air
PAN	Personal Area Network
PCW	Pedestrian Collision Warning
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
PME	Performance Measurement Evaluators
PSM	Personal Safety Message
PTMW	Pedestrian Transit Movement Warning
RDE	Research Data Exchange
REL	Reversible Express Lanes
RFQ	Request for Qualifications
RSE	Roadside Equipment
RSU	Road Side Unit
SAD	System Architecture Document
SAE	Society of Automotive Engineers
SCMS	Security Credential Management System
SD	Secure Digital

SET-IT	Systems Engineering Tool for Intelligent Transportation
SMOC	Security Management Operational Concept
SNMP	Simple Network Management Protocol
SPaT	Signal Phasing and Timing
SRM	Signal Request Message
SW	Software
TECO	Tampa Electric Company
TERL	Traffic Engineering Research Lab
THEA	Tampa Hillsborough Expressway Authority
TIM	Traveler Information Message
TMC	Transportation Management Center
TMDD	Traffic Management Data Dictionary
TSP	Transit Signal Priority
U of AZ	University of Arizona
USB	Universal Serial Bus
USDOT	United States Department of Transportation
V2I	Vehicle-To-Infrastructure
V2V	Vehicle-To-Vehicle
V2X	Vehicle-To-Everything
VAD	Vehicle Awareness Device
VTRFTV	Vehicle Turning Right in Front of a Transit Vehicle
WSM	WAVE Short Message
WWE	Wrong Way Entry

1 Introduction

1.1 Purpose of the Document

This document is the System Architecture Document (SAD) for the Tampa Hillsborough Expressway Authority (THEA) Connected Vehicle (CV) Pilot project for the United States Department of Transportation's (USDOT) connected vehicle program. The SAD describes the architecture for the CV system that will be deployed in the Tampa Central Business District (CBD).

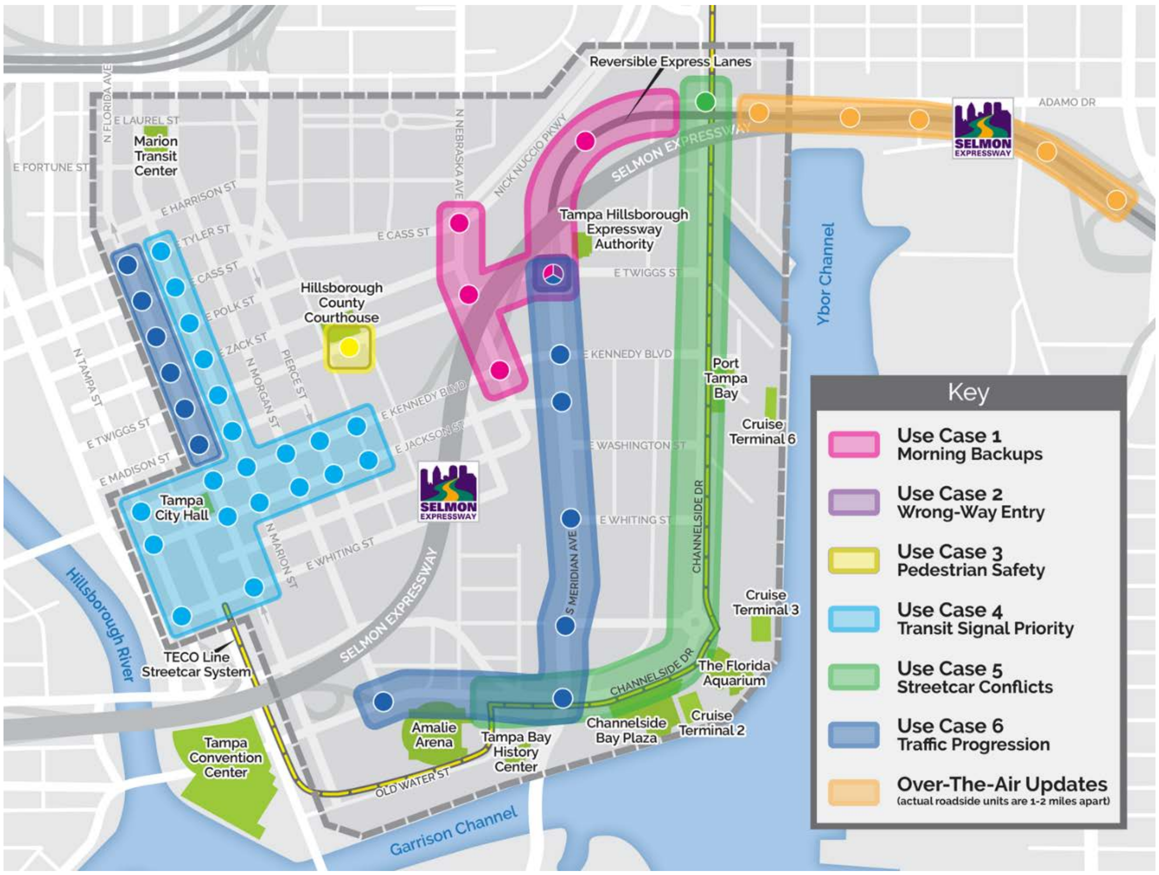
1.2 Project Scope

The THEA CV Pilot Deployment is funded by a federal grant that was awarded in September 2015 by the United States Department of Transportation's (USDOT) 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 was completed in August 2016. It aimed 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 communication 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.

The THEA CV Pilot Deployment aims to create a connected urban environment to measure the effect and impact of CVs in Tampa's vibrant downtown. The proposed pilot project offers several CV applications that can be deployed in Tampa's CBD and environs to create a more connected downtown. This environment has a rich variety of traffic, mobility, and safety situations that are amenable to vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) solutions. "Everything" includes all communications media (e.g., smartphones). The deployment area is in busy downtown Tampa and offers a tolled expressway with street-level interface, bus and trolley service, high pedestrian/bicycle densities, special event trip generators, and high dynamic traffic demand over the course of a typical day. These diverse environments are in one concentrated deployment area, which collectively encompasses many traffic situations that allow for CV application deployment and performance testing. These CV applications support a flexible range of services from advisories, roadside alerts, transit mobility enhancements, and pedestrian safety. The pilot will be conducted in three phases. Phase 1 includes planning for the CV pilot and developing the concept of operations. Phase 2 is the design, development, and testing phase. Phase 3 includes a real-world demonstration of the applications that were developed as part of this pilot.

Downtown Tampa is bordered by Ybor Channel (Cruise Ship and Commercial Port Channel) to the east, Garrison Channel (local waterway) to the south, Florida Avenue to the west, and Scott Street to the north. A virtually flat topography near sea level helps to simplify the evaluation of traffic flow parameters. Figure 1 below shows the focused pilot area and where the applications may interact with participants throughout the deployment area. There are specific locations where each application's performance will be monitored and measured.

Figure 1: CV Pilot Deployment Physical Overview



Source: Googlemaps.com, HNTB

THEA intends to deploy 13 different CV applications in the Tampa pilot region that fall under the four categories of V2I enabled safety applications, V2V enabled safety applications, mobility applications, and agency data applications. Figure 1 depicts the deployment area of the where the thirteen THEA CV pilot applications will be utilized. Each of the boxes describe the general functionality that are composed of the thirteen applications.

V2I Safety – V2I safety applications wirelessly exchange critical safety and operational data between vehicles and roadway infrastructure to help avoid motor vehicle crashes. V2I safety applications will complement V2V safety applications, enabling vehicles to have a 360-degree awareness and inform vehicle operators through advisories and warnings of hazards and situations they cannot see. The THEA CV pilot team plans to deploy the following V2I safety applications:

- End of Ramp Deceleration Warning (ERDW)

- Pedestrian in Signalized Crosswalk (PED-X)
- Pedestrian Collision Warning (PCW)
- Pedestrian Transit Movement Warning (PTMW)
- Wrong Way Entry (WWE)

V2V Safety – V2V safety applications wirelessly exchange data among vehicles traveling in the same vicinity to offer significant safety improvements. Each equipped vehicle on the roadway – including automobiles, trucks, transit vehicles, and motorcycles – will be able to communicate with other vehicles. This rich set of data and communications will support a suite of active safety applications and systems. Vehicles will communicate with one another broadcasting basic safety messages (BSMs) that will inform vehicle operators of hazards and situations they cannot see. These applications will only function when the involved vehicles are both equipped with V2V devices. The THEA CV pilot team plans to deploy the following V2V safety applications:

- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Vehicle Turning Right in Front of a Transit Vehicle (VTRFTV).

V2I Mobility – V2I mobility applications communicate operational data between vehicles and infrastructure, intended primarily to increase mobility and enable additional safety, mobility, and environmental benefits. Applications may use real-time data to increase safety and operational efficiency while minimizing the impact on the environment and enabling travelers to make better-informed travel decisions. The THEA CV pilot team plans to deploy the following V2I mobility applications:

- Intelligent Traffic Signal System (I-SIG)
- Transit Signal Priority (TSP)
- Mobile Accessible Pedestrian Signal (PED-SIG).

Agency Data – Agency Data applications use probe data obtained from equipped vehicles along the corridor to support Traffic Management Center (TMC) operations. Vehicle data can be used to detect changes in vehicle speeds indicating congestion or a disruption of traffic flow as well as calculate travel times. When a TMC notices a slow down on a corridor, the TMC may decide to take action such as altering signal timing based on traffic flows. The THEA CV pilot team plans to deploy the following Agency Data applications:

- Probe Data Enabled Traffic Monitoring (PDETM)

1.3 References

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1.4 Approach

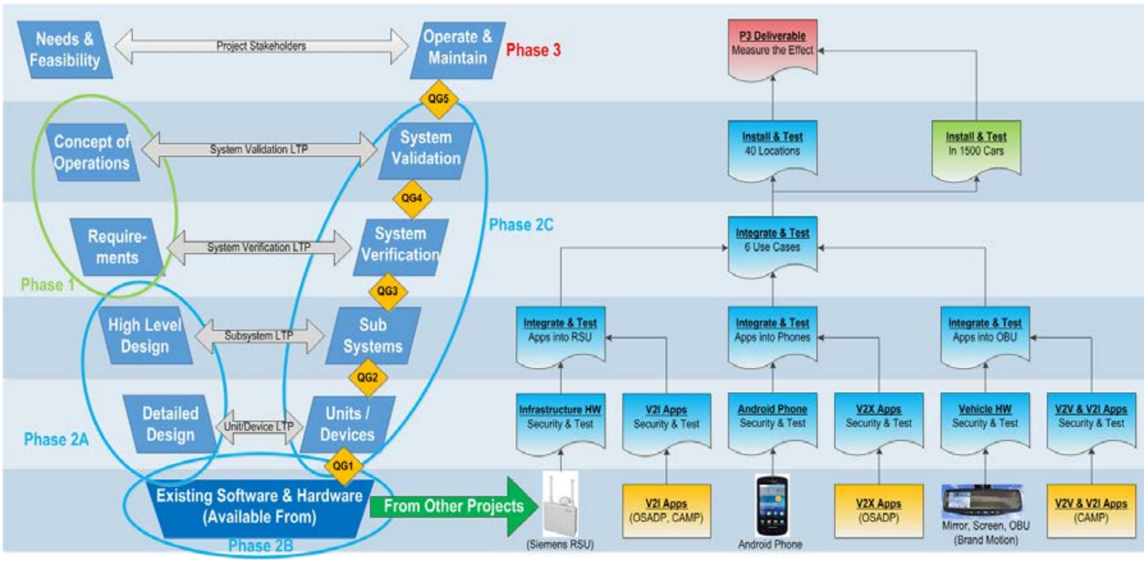
The SAD is based on ISO/IEC/IEEE 42010 2011 Systems and Software engineering – Architecture description. The 42010 standard provides guidance on the contents of the SAD but does not prescribe an outline or table of contents. Additionally, in the spirt of collaboration, the THEA SAD table of contents is loosely based on the Wyoming Department of Transportation SAD table of contents.

The SAD is organized as follow:

- Section 1 – provides the introduction and scope of the project
- Section 2 – provides an explanation of the stakeholders and concerns for the pilot.
- Section 3 – discusses the system of interest.
- Section 4 – provides the viewpoints and views.
- Appendix A – contains the interface triples spreadsheet
- Appendix B – contains the message set definitions
- Appendix C – contains the SET-IT files

The CV Pilot is following the System Engineering approach. As seen in Figure 2, THEA's CV Pilot is currently at the lower left of the Vee denoted as Phase 2A.

Figure 2: THEA CV Pilot System Engineering Approach



Source: Siemens

1.4.1 Architecture Evaluations

Beginning in 2007, Siemens supplied the roadside signal controllers, controller software and central TMC software for:

- USDOT pilots in Novi MI and Telegraph Road
- USDOT Safety Pilot in Ann Arbor MI
- World Congress 2011 on International Drive and Universal Drive in Orlando FL
- Corridors near the COBO center for World Congress 2014 in Detroit MI

Based on Lessons Learned, the architecture has evolved to include:

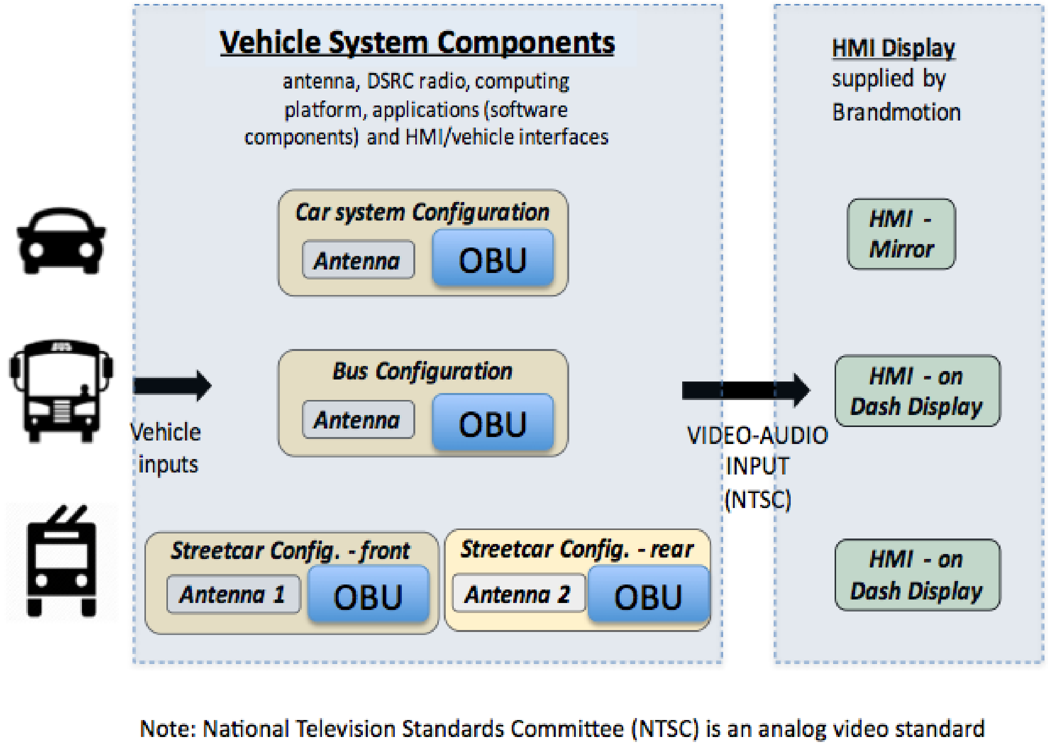
- Central Roadside Unit (RSU) management to monitor status and update software
- Standardized area maps indicating the RSU locations as status
- Separate timekeeping for RSU and TMC management systems
- Firm adherence to NTCIP 1202 communications from controllers to TMC and NTCIP Center to Center communications between RSU and Traffic systems

Brandmotion® evaluated various vehicle system design alternatives to address the following challenges of the THEA pilot:

- Implement the complete set of applications that address the rich variety of traffic, mobility, and safety situations
- A flexible and complete solution for a wide variety of vehicle configurations and users
- Quality and performance over the life of the pilot and potentially longer
- Simplicity and ease of installation
- Non-distracting user interface
- Affordability

Figure 3 below, depicts the variety of vehicle configurations that will be used in the pilot program. The three types of vehicles will each have their own In-Vehicle System Configurations that would be connected to a display in order to present messages to the driver.

Figure 3: In-Vehicle Overview



Source: THEA

1.5 Rationale for Key Decisions

Key decisions are reached based on Section 3.5.1.1.2 and Figure 6 of the Comprehensive Deployment Plan as follows:

- A Quality Gate must be fulfilled before advancing to the next level
- Each Quality Gate includes Requirements Management where the Change Control Board agrees that any changes to Requirements do not break traceability to User Needs.
- Each Quality Gate includes updates to project schedule
- Each Quality Gate includes Configuration Management such that the Work Product of each Level is documented and reproducible.

Scope of the Vehicle Systems:

- Onboard Unit (OBU) with applications and interface to the Human Machine Interface (HMI) supplied by Brandmotion
- GPS and Dedicated Short-Range Communications (DSRC) Antennas.
- Vehicle harnesses
- Documentation, participant training and technical support
- Installation services and test

Global-5, with the assistance of other THEA team members, will gather information on the vehicles used by drivers in the THEA community. This information guides the design and installation approach to safely and seamlessly integrate the vehicle system into the participant vehicles.

Existing application software developed by the OBU suppliers will be modified to meet the specific needs of the THEA pilot and the requirements of the ConOps. The OBU will contain all the necessary application software and will send the appropriate message and alert screens to the HMI. The HMI for light vehicles will be imbedded into the rearview mirror. Busses and streetcars will use an instrument mounted display as the user interface. A robust and affordable video interface is used between the OBU and HMI.

In addition to the 1,500 OBUs from other suppliers, 84 OBUs using a SiriusXM platform will be included in the pilot. SiriusXM's platform includes an integrated satellite receiver system which will enable the THEA pilot to deploy satellite features and capture key metrics which will quantify the benefits of augmenting OBUs with satellite data distribution.

In addition to performing the baseline V2X functions required for THEA Pilot System Operation (i.e., same applications as the 1,500 OBUs), the SiriusXM hardware will enable characterization of V2X satellite data distribution including Certificate Revocation List delivery, Certificate Distribution Control delivery, Traveler Information Message delivery and the delivery of geo-fenced emergency audio messages. For vehicles using non-SiriusXM OBUs, Certification Revocation List delivery is still to be determined as there is no current consensus on how this will be done.

Scope of Roadside Infrastructure

- RSUs with applications to perform V2I applications
- Dedicated Short-Range Communications Antennas
- Documentation
- Installation, Test and Support Services

RSUs will be deployed in forty-one locations in the CV Pilot deployment area. RSUs will communicate with vehicles using DSRC and with Android phones using WiFi. WiFi was chosen as it minimizes the battery usage as the application will periodically wake up and see if a connection is available. RSUs will communicate with the Master Server through a communications network that may include fiber and wireless technologies.

The RSU will host applications modified by Siemens to provide the required functionality. The RSU will collect data from OBUs and store and forward the data to the Master Server as well as its own data it has captured. The data is transmitted from the OBU to RSU to meet the Over the Air (OTA) requirement of USDOT.

The Master Server will receive the CV data from the RSUs, archive it, send the raw data to the Performance Measurement Evaluators (PME). The PMEs will review the data, sanitize the data, and send the sanitized data to the Research Data Exchange and Independent Evaluators.

Scope of Pedestrian Smartphone (Android)

- Qualified pedestrians will be allowed to install the CV Pilot applications
- WiFi will be used for communications
- Documentation
- Test and Support Services

Pedestrians who meet the requirements will be able to download and utilize the CV Pilot Pedestrian applications. The applications are limited to people who have met the requirements including training, signing an informed consent document, agreeing to provide access to the phone, and other qualifications. As stated previously WiFi is used to minimize battery drain.

1.6 System Architecture Document Lifecycle

The SAD is a living document that will be updated as the project progresses through design. It is not anticipated that there will be significant changes to the system architecture as the project progresses. However, as some items are still in flux, THEA has developed the following approach to updating the architecture and the SAD.

- THEA will collaborate with USDOT and the other pilot sites to finalize outstanding items that affect the architecture
- THEA will maintain the architecture to the extent possible using the SET-IT tool and the Connected Vehicle Reference Implementation Architecture (CVRIA).
- THEA will provide the latest SET-IT files and Visio files (as needed) as part of the SAD.
- THEA will update the SAD after the SAD Workbook Walkthrough
- THEA will update the SAD as needed during the design to ensure that the design is derived from the architecture.

2 Stakeholders and Concerns

This section discusses how the architecture addresses stakeholders and their concerns. A stakeholder concern is one or more stakeholder interests in the THEA CV Pilot system. A concern pertains to any influence on the THEA CV Pilot system in its environment, including developmental, technological, business, operational, organizational, political, economic, legal, regulatory, ecological and social influences. The stakeholders are divided into categories based on their user type. These user types are:

- Participants
- System Operators
- System Owners
- System Suppliers
- System Maintainers
- System Beneficiaries (i.e., local venues like Amalie Arena and non-local like insurance companies)

Each of these user types has a role to play in the overall activity of the CV Pilot system. See Figure 19 for a pictorial view of the stakeholders and stakeholder interactions.

2.1 Participants

Participants are the end users who will receive safety and mobility benefits from using the system (i.e., being part of the CV Pilot deployment). These participants can be further divided into specific categories.

- Passenger Vehicle
- Smart Phone
- Bus
- Streetcar

A Passenger Vehicle participant is someone who was recruited, went through the registration and training process, and was approved to be part of the CV Pilot. The person will allow an OBU to be installed in their personal light passenger vehicle. These participants' vehicles will utilize the OBU applications when they are within the geographic area in which the applications operate. Generally speaking, the geographic area is the CBD. Note that V2V applications will work anywhere two equipped vehicles meet and the proper conditions are met. The current plan is to have 1,584 participants; 1,500 using an OBU from selected OBU vendors and 84 from SiriusXM.

A Smart Phone participant is someone who was recruited, went through the registration and training process, and was approved to be part of the CV Pilot. This person will allow the Pedestrian Mobility application to be downloaded onto their smart phone (currently only support Android phones). These participants will utilize the Pedestrian Mobility application when they are within the geographic area in which the application operates. The current plan is to have a minimum of 500 Participants. While there is no limit, in theory, to the number of Smart Phone participants, THEA may decide to set a maximum ceiling.

Bus participants are the bus drivers on the Hillsborough Area Regional Transit (HART) buses selected for use in the CV Pilot. These bus operators will be selected by HART and trained on how to interact with the OBUs installed on the buses. The bus applications will be utilized while the bus is traversing the selected downtown streets where RSUs are installed and operating the transit application. The current plan is to have 10 buses.

Streetcar participants are the streetcar carmen who operate the streetcars selected for use in the CV Pilot. HART will provide the streetcar carmen who will be trained on how to interface with the OBUs installed on the streetcar. The streetcar applications will be utilized at two locations along the Channelside route. The current plan is to outfit 10 streetcars.

2.2 System Operators

System operators are those individuals who are involved in the day to day running of the CV Pilot system. The individuals are the TMC operators. These operators are City of Tampa (COT) employees. THEA and COT have an agreement whereby THEA provides space for COT staff to manage their signal system and COT staff manage THEA's Reversible Express Lane (REL). The operators will receive information from the Master Server informing them of alerts, providing travel times or other critical data within the CV Pilot deployment.

2.3 System Owner

THEA is the owner of the system. THEA owns and operates the REL and Meridian Avenue on which a portion of the pilot is deployed. The remainder of the pilot is deployed along roadways in COT. The relationship between THEA and COT is such that THEA is seen as the owner of the CV Pilot. COT is a stakeholder as isthe Florida Department of Transportation District 7. THEA is responsible for the Pilot from beginning (Phase 1) to end (Phase 3). THEA has included Connected Vehicle in its twenty-year work plan, paving the way for continued support and expansion of the CV Pilot.

2.4 System Suppliers

The CV Pilot is organized by creating an infrastructure integrator, an in-vehicle integrator, and a personal information device (PID) integrator. The infrastructure integrator is Siemens. Siemens is responsible for the RSUs and the Master Server. This includes any hardware procurement needed as well as any application development, licensing, etc. Previous to the start of the CV Pilot, Siemens went through a standard procurement process to select their RSU vendor. After selection, Siemens repackaged the hardware into a Siemens RSU. Siemens is required to integrate with the in-vehicle integrator and the PID integrator.

Siemens is also the PID integrator. Siemens will develop the application for use on an Android smart phone. Siemens will be responsible for the correct operation of the application and the integration with the RSU.

Brandmotion is the in-vehicle integrator. Brandmotion is responsible for all installs in light vehicles, buses, and streetcars. Brandmotion completed its procurement process, which was reviewed with the THEA team, and has selected two OBU vendors for the 1,500 units. Brandmotion is responsible for ensuring the OBU vendors provide the necessary applications for the CV Pilot, meet the 2016 standards, and are certified and interoperable. Brandmotion will perform all the installs using facilities at Hillsborough Community College (HCC) and will work alongside students so they attain skills that will be valuable as CV technology begins to roll out.

2.5 System Maintainers

For the life of the CV Pilot, Siemens and Brandmotion, along with their suppliers, will maintain the system. HNTB will be the front facing customer representative who will field calls and direct them to the appropriate party. At the conclusion of the CV Pilot, THEA and COT will continue to maintain the CV Pilot. It is anticipated by the end of the CV Pilot, there will not only be additional CV growth, but also other Smart Cities technology with which the CV Pilot will integrate.

2.6 System Beneficiaries

The USDOT, Independent Evaluators, the New York and Wyoming Pilots, and future pilot deployments are beneficiaries of the THEA CV Pilot. These entities will benefit from the successes and lessons learned from the THEA CV Pilot. The citizens of Tampa and those who travel downtown will benefit from improvements in mobility and traffic information.

3 System of Interest

3.1 Connected Vehicle Pilot System Overview

This section describes the CV Pilot based on its six Use Cases and the components of the system. The overview provides a description of the applications used by each use case, how the infrastructure, in-vehicle devices and PIDs are used as part of the use case. The components are the infrastructure and in-vehicle support subsystems, the Master Server subsystem, and the driver interaction subsystem.

Table 1 below is the physical locations of the deployed system. It lists the RSU locations, the applications running on each RSU, the in-vehicle and PID applications that could interact with the RSUs. The table was originally published in the Comprehensive Deployment Plan. The table has been updated to reflect the latest deployment concept.

Table 1: Physical Locations of Hardware Objects and Software Applications

Location	HW Object	SW Application	
REL	RSU 1	V2I	ERDW
			ISM
	Detector Lane 1 Detector Lane 2 Detector Lane 3	Infrastructure	Detection
	OBU	V2I	ERDW
		V2V	EEBL
			FCW
Twiggs & Meridian	RSU 2	V2I	I-SIG
			WWE
		Agency	PDETM
	OBU	V2V	IMA
		V2I	WWE
	PID	V2I	PED-SIG
	Detector Ingress 1 Detector Ingress 2 Detector Ingress 3 Detector Right Turn	Infrastructure	Detection
Twiggs & Courthouse	RSU 3	V2I	PSM
	Crosswalk Detector Curbside Detector 1 Curbside Detector 2	Infrastructure	Detection
	PID	V2I	PED-X
	OBU		PCW
Marion & Tyler	RSU 4	V2I	I-SIG

Location	HW Object	SW Application	
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Cass	RSU 5	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Polk	RSU 6	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Zack	RSU 7	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Twiggs	RSU 8	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Madison	RSU 9	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Kennedy	RSU 10	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Marion & Jackson	RSU 11	V2I	I-SIG
			TSP
	OBU	V2I	TSP
		V2V	IMA
	PID	V2I	PTMW
Morgan & Jackson	RSU 12	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Pierce & Jackson	RSU 13	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Jefferson & Jackson	RSU 14	V2I	I-SIG
			TSP
	OBU	V2I	TSP
	PID	V2I	PTMW
Morgan & Kennedy	RSU 15	V2I	I-SIG

Location	HW Object	SW Application	
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Pierce & Kennedy	RSU 16	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Jefferson & Kennedy	RSU 17	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Tampa & Kennedy	RSU 19	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Tampa & Jackson	RSU 20	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Tampa & Whiting	RSU 21	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Florida & Whiting	RSU 22	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Florida & Kennedy	RSU 39	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Florida & Whiting	RSU 40	V2I	I-SIG
			TSP
	OBU	V2V	IMA
		V2I	TSP
	PID	V2I	PTMW
Channelside & Adamo	RSU 24	V2I	I-SIG
			PED-SIG

Location	HW Object	SW Application	
	OBU	V2V	VTRFTV
	PID	V2I	PTMW
Kennedy & Meridian	RSU 25	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Jackson & Meridian	RSU 41	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Whiting & Meridian (Currently, under construction)	RSU 27	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Cumberland & Meridian	RSU 28	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Channelside & Meridian	RSU 29	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Channelside & Morgan	RSU 18	V2I	I-SIG
			PED-SIG
		Agency	PDETM
	OBU	V2V	IMA
Nebraska & Cass	RSU 30	V2I	I-SIG
Nebraska & Twiggs	RSU 31	V2I	I-SIG
Nebraska & Kennedy	RSU 32	V2I	I-SIG
Florida & Tyler	RSU 33	V2I	I-SIG
Florida & Cass	RSU 34	V2I	I-SIG
Florida & Polk	RSU 35	V2I	I-SIG
Florida & Zack	RSU 36	V2I	I-SIG
Florida & Twiggs	RSU 37	V2I	I-SIG
Florida & Madison	RSU 38	V2I	I-SIG
REL Gantry Pole on the REL W/Cabinet at the base	RSU 42A	V2I	OTA
			Data Logging
REL Mile 7.2	RSU 43B	V2I	OTA
			Data Logging
REL Mile 8.2	RSU 44A	V2I	OTA
			Data Logging
REL Mile 10.0	RSU 45A	V2I	OTA
			Data Logging
REL	RSU 46	V2I	OTA

Location	HW Object	SW Application	
Mile 11.4			Data Logging

Source: Siemens

Table 2 below identifies the applications running on each device and the source from which it is based. In addition to using the source code developed by the University of Arizona (U of AZ), Dr. Larry Head of U of AZ will provide technical expertise to the THEA team.

Table 2: Application Source

CV Device	Installed Applications	Source
RSU	I-SIG	U of AZ
	TSP	U of AZ
	PDETM	Siemens
	PED-SIG	U of AZ
	PED-X	Siemens
	ERDW	Siemens
	WWE	Siemens
OBU	ERDW	Licensed
	FCW	Licensed
	EEBL	Licensed
	IMA	Licensed
	WWE	Licensed
	TSP	U of AZ
	VTRFTV	Licensed
	PCW	Licensed
PID	PED-SIG	U of AZ
	PED-X	Siemens
	PTMW	Siemens

Source: Siemens

The following six tables and corresponding figures provide an overview of which applications' performance will be measured and what RSUs are involved as part of the Use Case.

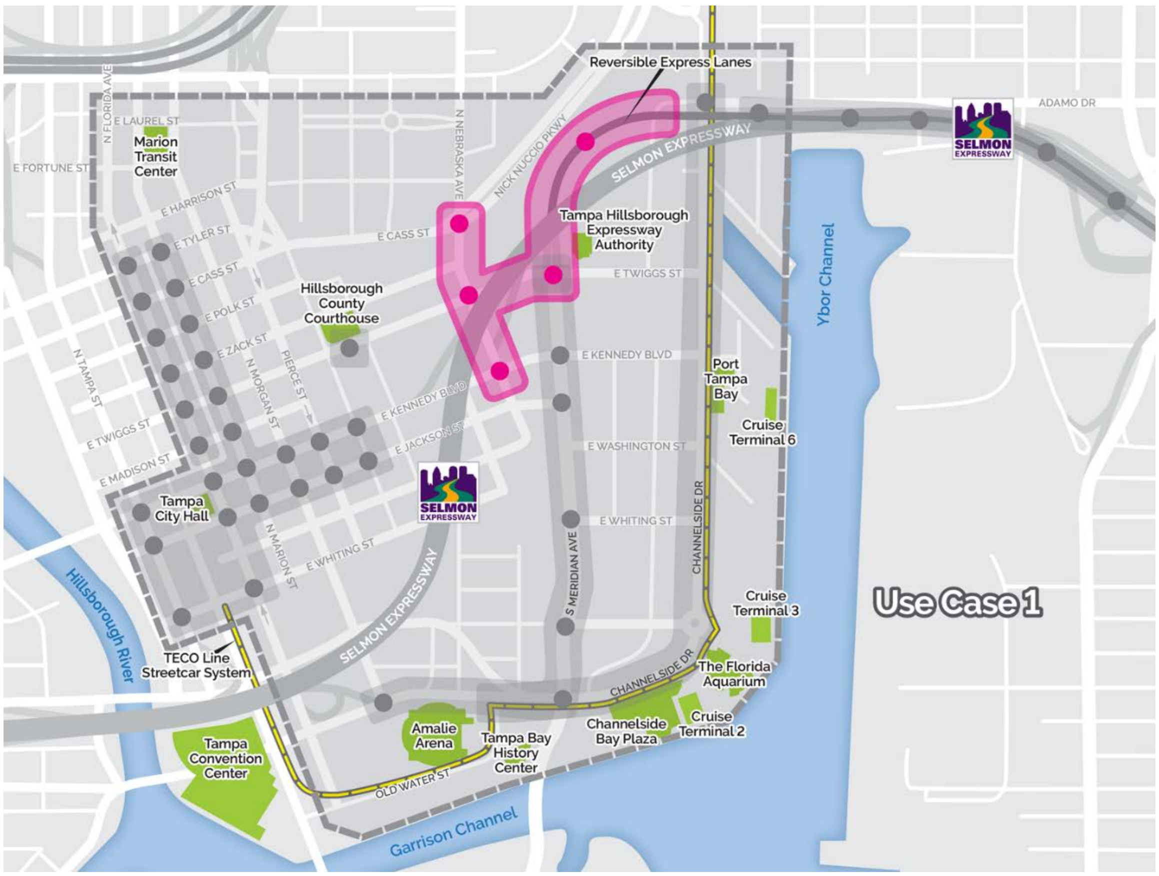
For Use Case 1, Table 3 and Figure 4 represent the functional locations of the applications where their performance will be measured.

Table 3: Use Case 1 Morning Backups RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Morning Backups	RSU 1 - REL RSU 2 - Twiggs & Meridian RSU 30 - Nebraska & Cass RSU 31 - Nebraska & Twiggs RSU 32 - Nebraska & Kennedy	ERDW EEBL FCW I-SIG

Source: Siemens

Figure 4: Use Case 1 Morning Backups: RSUs and Applications Measured Performance



Source: Googlemaps.com, HNTB

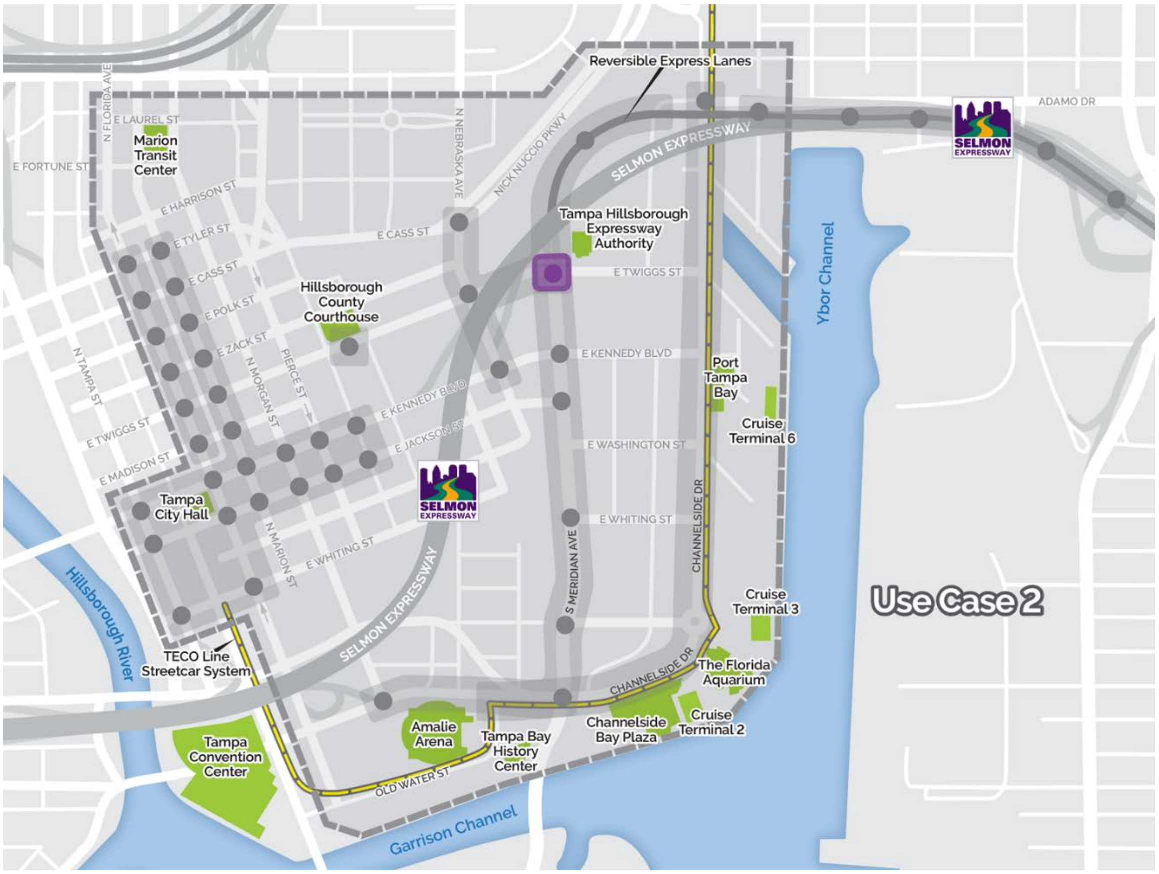
For Use Case 2, Table 4 and Figure 5 represent the functional locations of the applications where their performance will be measured.

Table 4: Use Case 2 Wrong Way Entry RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Wrong-Way Entry	RSU 1 – REL RSU 2 - Twiggs & Meridian	WWE

Source: Siemens

Figure 5: Use Case 2 Wrong Way Entry: RSUs and Applications Measured Performance



Source: Googlemaps.com, HNTB

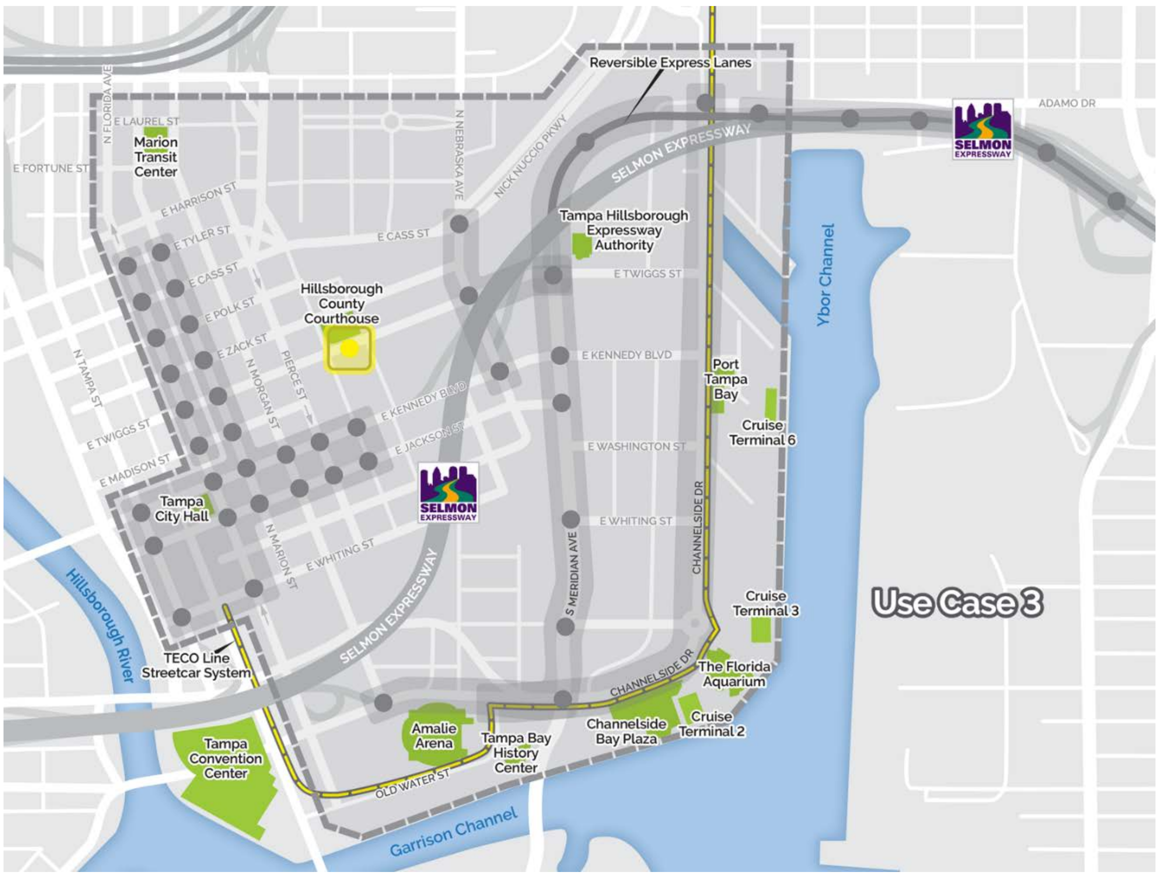
Table 5 and Figure 6 represent the functional locations of the applications where their performance will be measured.

Table 5: Use Case 3 Pedestrian Safety RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Pedestrian Safety	RSU 3 - Twiggs & Courthouse	PED-X PCW

Source: Siemens

Figure 6: Use Case 3 Pedestrian Safety: RSUs and Applications Measured Performance



Source: Googlemaps.com, HNTB

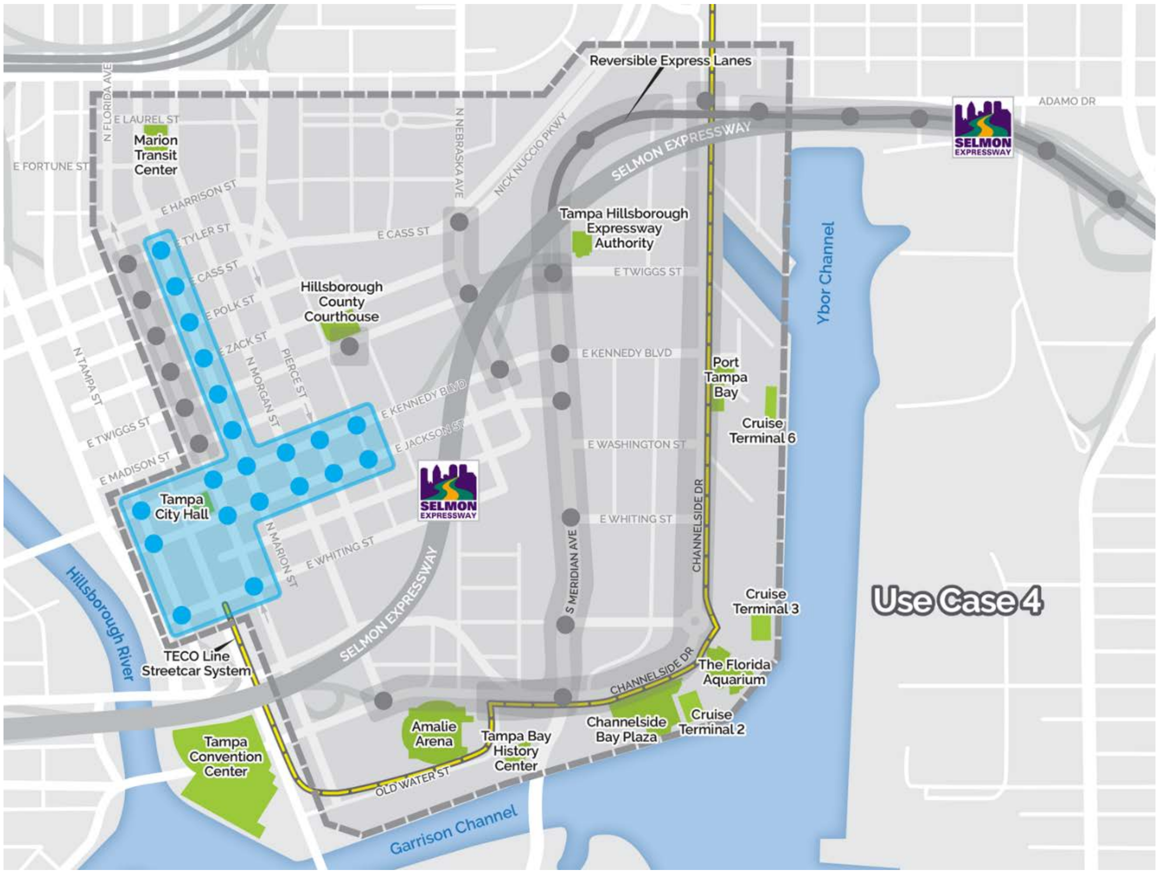
For Use Case 4, Table 6 and Figure 7 represent the functional locations of the applications where their performance will be measured.

Table 6: Use Case 4 TSP: RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Transit Signal Priority	RSU 4 - Marion & Tyler RSU 5 - Marion & Cass RSU 6 - Marion & Polk RSU 7 - Marion & Zack RSU 8 - Marion & Twiggs RSU 9 - Marion & Madison RSU 10 - Marion & Kennedy RSU 11 - Marion & Jackson RSU 12 - Morgan & Jackson RSU 13 - Pierce & Jackson RSU 14 - Jefferson & Jackson RSU 15 - Morgan & Kennedy RSU 16 - Pierce & Kennedy RSU 17 - Jefferson & Kennedy RSU 19 - Tampa & Kennedy RSU 20 - Tampa & Jackson RSU 21 - Tampa & Whiting RSU 22 - Florida & Whiting RSU 39 - Florida & Kennedy RSU 40 - Florida & Jackson	TSP IMA (at Kennedy locations only, except at Marion; also includes Marion and Jackson) I-SIG PTMW

Source: Siemens

Figure 7: Use Case 4 TSP: RSUs and Applications Measured Performance



Source: Googlemaps.com, HNTB

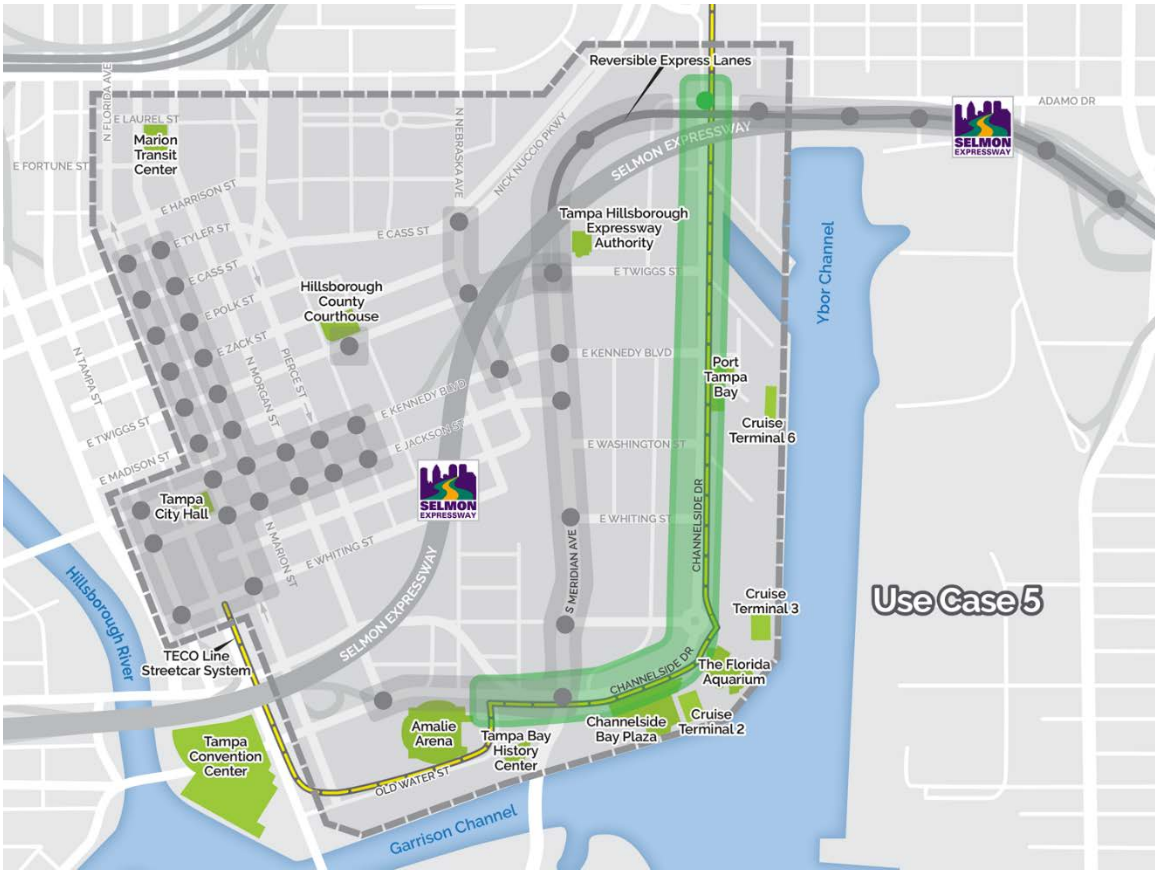
For Use Case 5, Table 7 and Figure 8 represent the functional locations of the applications where their performance will be measured.

Table 7: Use Case 5 Streetcar Conflicts RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Streetcar Conflicts	RSU 24 - Channelside & Adamo	VTRFTV & PTMW

Source: Siemens

Figure 8: Use Case 5 Streetcar Conflicts: RSUs and Applications Measured Performance



Source: Googlemaps.com, HNTB

For Use Case 6, Table 8 and Figure 9 represent the functional locations of the applications where their performance will be measured.

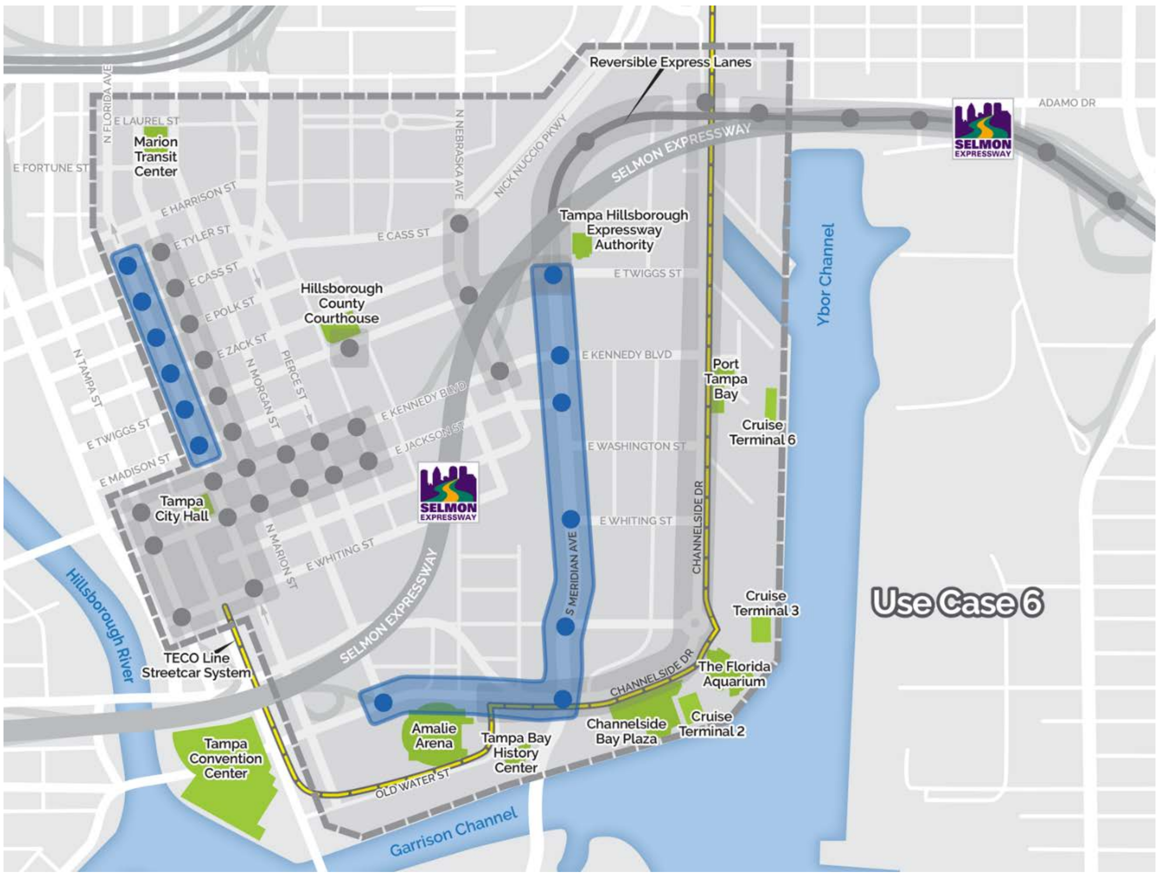
Table 8: Use Case 6 Traffic Progression: RSUs and Applications Measured Performance

Use Case	Location	Applications Needed to Measure Performance
Traffic Progression	RSU 2 - Twiggs & Meridian RSU 25 - Kennedy & Meridian RSU 27 - Whiting & Meridian RSU 28 - Cumberland & Meridian RSU 29 - Channelside & Meridian RSU 33 - Florida & Tyler RSU 34 - Florida & Cass RSU 35 - Florida & Polk RSU 36 - Florida & Zack RSU 37 - Florida & Twiggs	I-SIG PDETM PED-SIG (on Meridian only)

Use Case	Location	Applications Needed to Measure Performance
	RSU 38 - Florida & Madison RSU 18 - Channelside & Morgan RSU 41 – Jackson and Meridian	

Source: Siemens

Figure 9: Use Case 6 Traffic Progression: RSUs and Applications Measured Performance



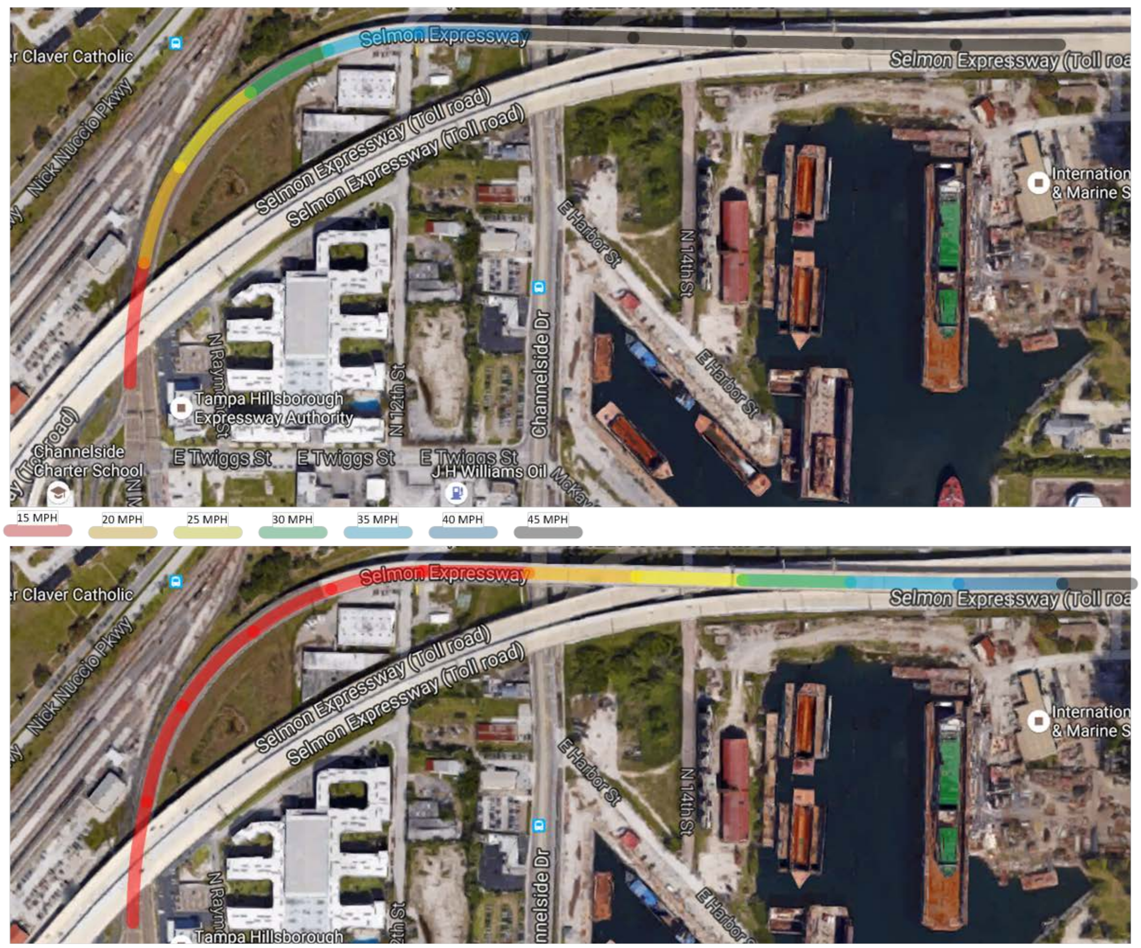
Source: Googlemaps.com, HNTB

3.1.1 Use Case 1 Morning Backups

As vehicles exit the inbound Selmon Expressway REL and make right turns onto East Twiggs 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, potentially causing them to hard brake, attempt a rapid lane change or crash. The ERDW, I-SIG, EEBL, and FCW applications will be deployed to address this Use Case. The performance of these applications will be measured to see how effective they are at addressing the issues.

Figure 10 below shows the Use Case 1 area. The area starts at the blue and ends at the red. The colors depict the possible zones that could be setup for ERDW.

Figure 10: Use Case 1 Morning Backups



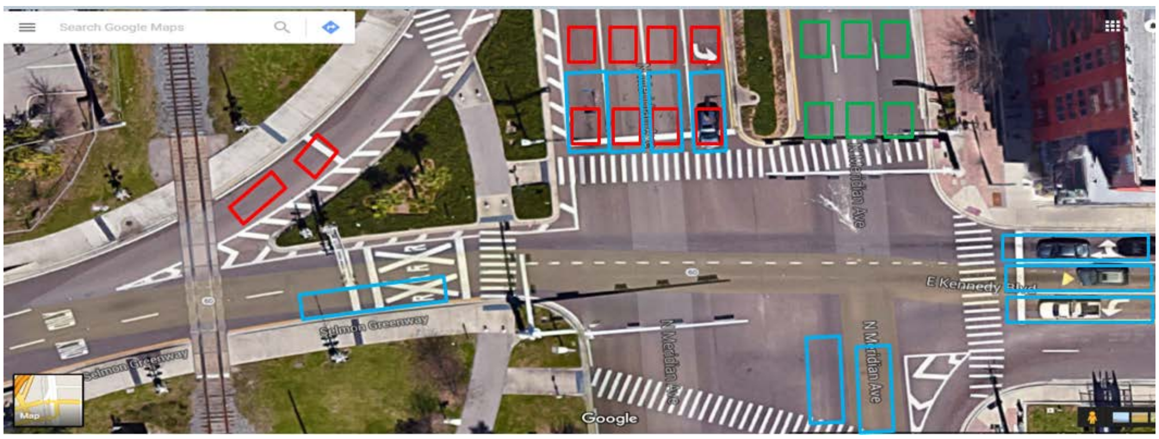
Source: Googlemaps.com, HNTB

3.1.2 Use Case 2 Wrong Way Entry

When the REL is flowing in the inbound direction, beginning in the Brandon area and exiting at Meridian and Twiggs, drivers can inadvertently enter the REL going the wrong way. Drivers approaching the REL on Twiggs from downtown may attempt a left turn onto the REL. Drivers coming from Channelside may attempt a right turn onto the REL. Driver coming down Meridian toward the REL may veer slightly to the left and enter the REL. In each case, drivers are entering the REL going in the wrong direction. In order to detect these potential wrong way drivers, MAP and SPaT messages are broadcast at the REL/Twiggs/Meridian Intersection. Within the SPaT message, the revocable lane bit is set for the wrong way lanes. If a vehicle initiates a move into the REL going the wrong way, the OBU Wrong Way Entry application determines the vehicle is entering a revoked lane and issues a warning that is presented to the driver warning them they are on a trajectory predicted to enter the Wrong Way. If the driver continues up the REL, the OBU Wrong Way Entry application alerts the driver, they are going the wrong way. The RSU Wrong Way Entry application determines the vehicle is headed in the wrong direction and begins broadcasting a TIM, that approaching equipped vehicles will receive, that a vehicle traveling in the wrong direction is approaching them. The RSU application sends a wrong way alert to the TMC; where TMC operators are alerted of the wrong way driver. It is incumbent on the TMC operator to alert law enforcement. BSMs from all involved vehicles are recorded as agency data by PDETM in the form of vehicle counts, speeds, locations and travel times. The TMC operator manually reverses the egress lanes protected by the barrier. I-SIG operating at Twiggs and Meridian receives the command to include or omit the northbound phase to match the barrier operation.

Figure 11 below shows the Use Case 2 intersection at Meridian/Twiggs/end of REL. This view of the intersection illustrates vehicles entering the REL the wrong way shown by the red rectangles.

Figure 11: Use Case 2 Wrong Way Entry



Source: Googlemaps.com, HNTB

3.1.3 Use Case 3 Pedestrian Safety

On Twiggs street, a few blocks from the REL, there is a non-signalized crosswalk which provides pedestrians access from a parking garage to the courthouse. At this location, an RSU is deployed, along with a Light Detection and Ranging (LIDAR) sensor. The LIDAR determines pedestrian position in the cross-walk. The RSU receives Pedestrian Safety Messages (PSM) from pedestrians who have the PID application installed on their Android Smart Phone. The RSU application using the LIDAR data tracks all pedestrians, whether they have the PID application or not who are in the crosswalk and creates PSMs. The PSMs are broadcast using DSRC. Any approaching OBU equipped vehicles receive the PSMs via DSRC and use the data to determine if the pedestrian and the vehicle are on a collision trajectory using the Pedestrian Collision Warning application (PCW). PCW provides the appropriate warning to the driver if the determination is made the driver's vehicle is on a collision course with a pedestrian.

Conversely, the RSU receives BSMs from OBU equipped vehicles and broadcasts those BSMs via Wi-Fi (IEEE 802.11). Any pedestrians who have the PID application installed on their Android Smart Phone will receive the BSMs and use them to determine if the vehicle is on a collision trajectory with a pedestrian. If the PID application determines the pedestrian and vehicle are on a collision course, the data will be recorded. Because of the questionable accuracy of GPS on a smartphone, the feasibility of warning the pedestrian will be determined during testing.

3.1.4 Use Case 4 Transit Signal Priority

Along Kennedy, Jackson, and Marion streets, RSUs are deployed to perform TSP operations. HART will provide the bus schedules, which will be loaded into the Master Server. These schedules will be used to determine if a bus is ahead, behind, or on schedule.

As a bus approaches one of the RSU equipped intersections, the bus OBU requests priority using a Signal Request Message (SRM). The bus OBU broadcasts the SRM via DSRC. The intersection RSU receives the SRM via DSRC. The intersection RSU transmits the SRM to the Transit Server. The Transit server compares the time of the SRM request to the actual schedule based on the intersection the bus is approaching. If the Transit Server (part of the Master Server) determines the bus is on schedule or ahead of schedule, the Transit Server does nothing and the SRM is not serviced. If the Transit Server determines the bus is behind schedule, the Transit Server sends a SRM to the RSU which in turn will transmit a priority request to the signal controller to extend the green in the bus direction of travel and inform the bus driver that priority has been granted.

3.1.5 Use Case 5 Streetcar Conflicts

The VTRFTV application is a V2V application that is installed on OBU equipped vehicles and on OBU equipped streetcars. As a streetcar traverses Channelside, if the streetcar OBU determines that a vehicle is turning in front of the streetcar on a collision trajectory with the streetcar, the streetcar OBU will warn the streetcar carmen (i.e., person who is responsible for the operation of the streetcar) of the potential collision. It is up to the streetcar carmen to take any necessary actions. At the same time, OBU equipped vehicles warn the driver that they are about to turn right in front of the moving streetcar. At Channelside and Adamo, there will be opportunities to communicate streetcar stopping/starting warnings using the PTMW app.

3.1.6 Use Case 6 Traffic Progression

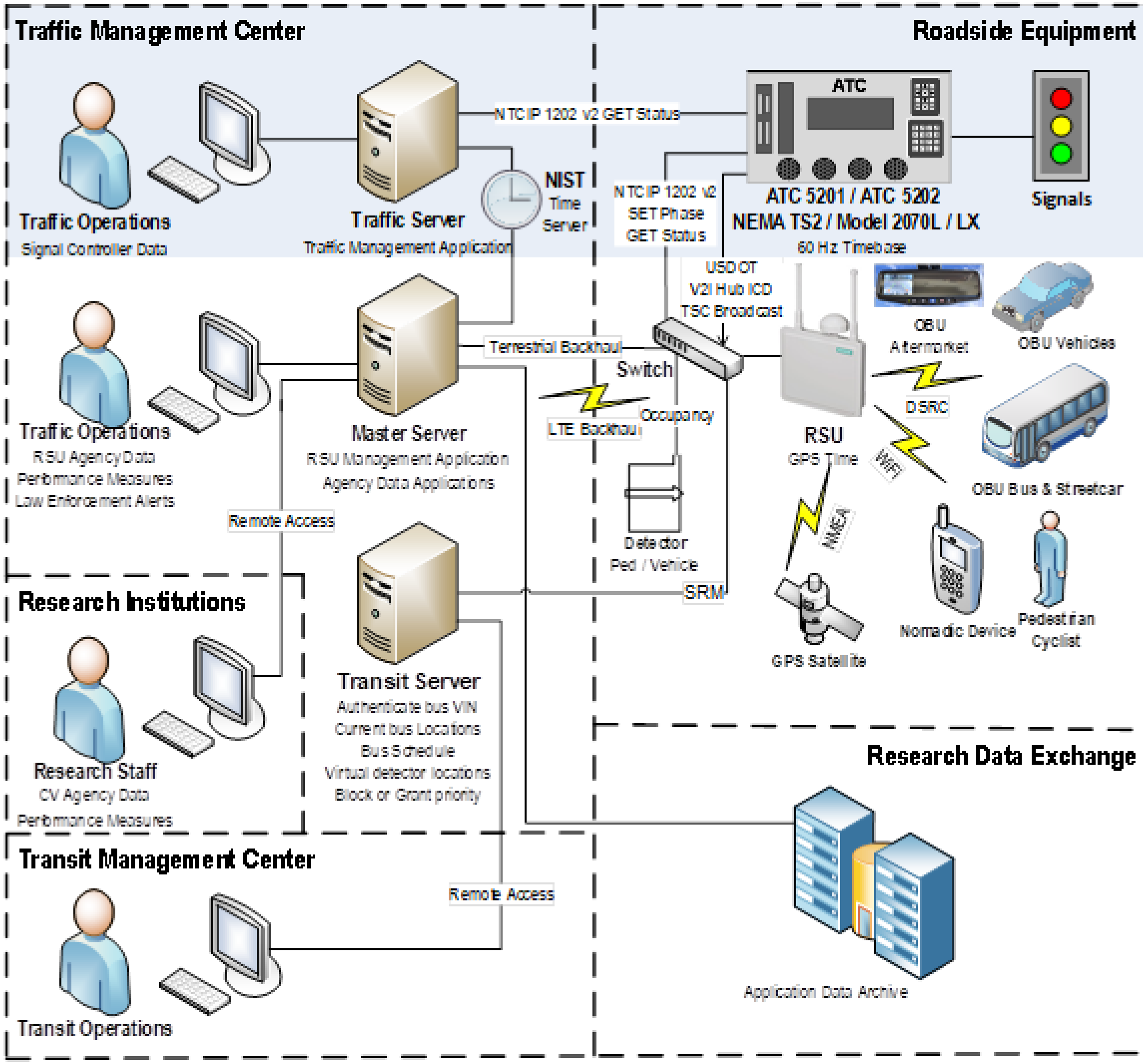
Along Meridian Avenue, Florida Avenue, and part of Nebraska, OBU equipped vehicles broadcast their BSMs via DSRC to the RSU. RSUs in these corridors receive this data to aggregate BSMs into vehicle counts (traffic volume) and average vehicle speeds which are sent to the Master Server as Agency Data. The Master Server calculates the travel time along these corridors in both directions of travel as a means for measuring their performance. The I-SIG application on the RSU further uses the received BSMs to improve traffic progression along the routes.

3.1.7 Infrastructure Support Sub-System

3.1.7.1 RSU Management Application

Per the Phase 1 Comprehensive Deployment Plan (CDP) system architecture shown in Figure 12, the Infrastructure Support Sub-System consists of an RSU Management Application running on the Master Server that is physically located in the Tampa TMC. The Master Server is connected to each RSU via either a cellular or terrestrial backhaul.

Figure 12: System Architecture



Source: Siemens

The shaded portion of Figure 12 depicts the system elements already in place and in operation. The unshaded portion indicates the equipment added by this project.

The RSU Management Application function includes:

- Display area maps of the project study area in central Tampa FL
- Display locations of each RSU shown on the area map
- Display operational status of each RSU
- Display operational status of each communications channel
- Download new versions of RSU software
- Query the current version of RSU software at each map location
- Access the application software at each map location
- Geo fence for each RSU reception area to avoid a vehicle reception on multiple RSUs
- Display aggregated speed of vehicles traveling within each RSU reception area
- Display counts (volume) of vehicles traveling within each RSU reception area

3.1.7.2 Relationship to Traffic Management System

Although the RSU Management Application is physically located in the Tampa TMC, the existing Traffic Management Applications, such as the Traffic Signal software, is not disturbed by RSU management. The Traffic Management Application manages a wide area network of traffic signal controllers, while the RSU Management Application independently manages a wide area network of RSUs. Both the Traffic and the RSU Management Applications conform to NTCIP standards for Center to Center communications, meaning that the signal controllers, cameras and other devices known to the Traffic Management Application could be indicated on the RSU Management area maps outside the scope of this project.

3.1.7.3 Timekeeping

Both the Traffic Management Application and the RSU Management Application obtain the identical accurate time of day from the NIST time server, accessed from the TMC. Both systems push identical accurate time of day to the connected devices. In the event of TMC failure, the signal controllers continue to stay in synchronization with other signal controllers using the service power frequency, while the RSUs stay in synchronization with each other and with the vehicles via GPS time of day. The Signal Phase and Timing (SPaT) countdown to signal phase change is pushed from the signal controllers to the RSUs without a controller time stamp.

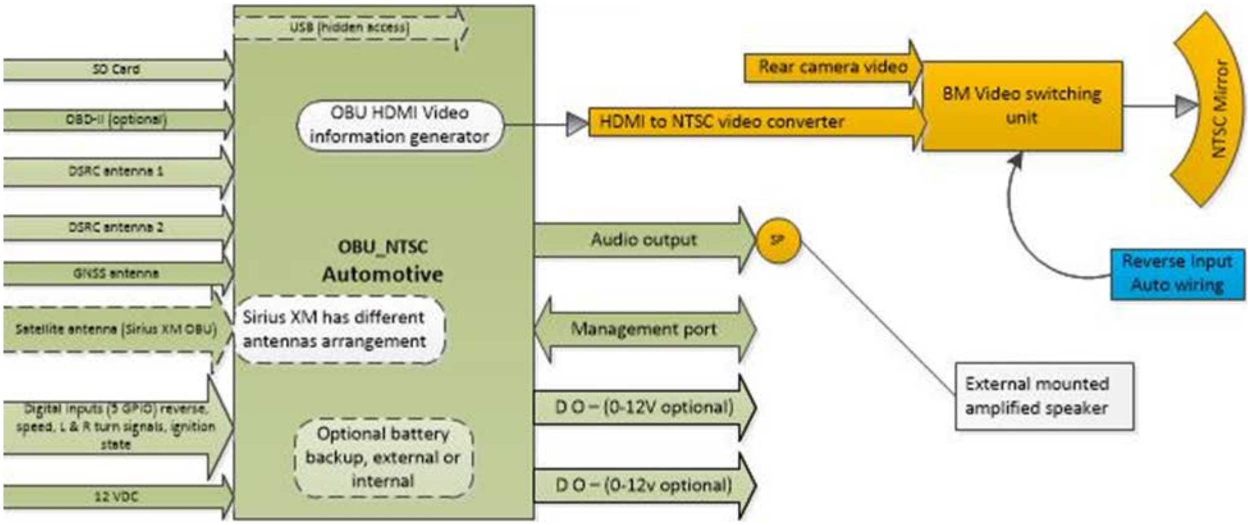
3.1.8 In-Vehicle Support Subsystem

The following information provides a description of the vehicle subsystem. Note Vehicle System and Vehicle Subsystem are identical terms. The vehicle system reference design includes the following components and interfaces:

- Onboard Unit (OBU) packaged securely in the trunk, under the dash or package tray area of a light vehicle or in specific equipment closures of the streetcar or bus,
- User interface, or HMI either as:
    - modified rear view mirror. or V2X display for the 1580 vehicles
        - Mirror supports rear vision camera system as well as the new THEA V2X applications
    - instrument panel mounted display for the 10 buses and 10 streetcars, and possibly for light vehicles that cannot support replacement of mirrors with a new mirror with V2X display
- Wired speaker
- Wiring harness customized and installed by Brandmotion
- DSRC antenna(s) mounted on the vehicle roof
- GPS antenna mounted on the vehicle roof or deck lid
- Satellite antenna input for SiriusXM OBUs for an additional, wide-area channel for security certificate and CRL distribution
- The following are the various subsystem interfaces
    - Pulse Width Modulator input to convert streetcar transmission speed
    - Support of Over-the-Air-Update
    - Vehicle Power
    - Battery back-up optional
    - Additional switch inputs for vehicle status information, such as turn indicators
    - Vehicle Reverse sense output
    - Composite video (National Television System Committee [NTSC]) for HMI display
    - USB/SD Card interface mechanically accessible only to developers

The following vehicle system diagrams are for reference only:

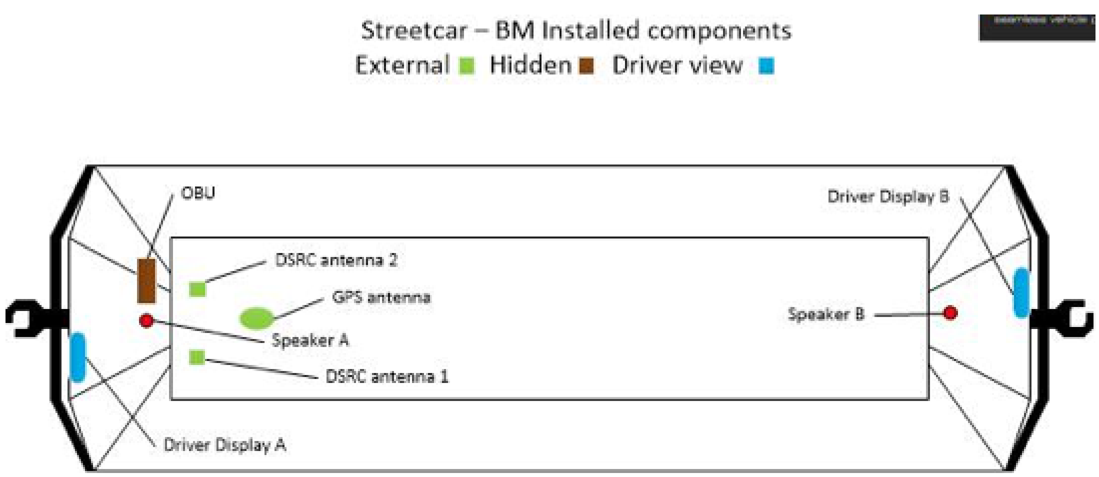
Figure 13: Vehicle Interface



Source: Brandmotion

The streetcar physical architecture requires two separate vehicle systems, as shown in Figure 14 because the streetcar reverses direction and the operator moves to the other end of the streetcar.

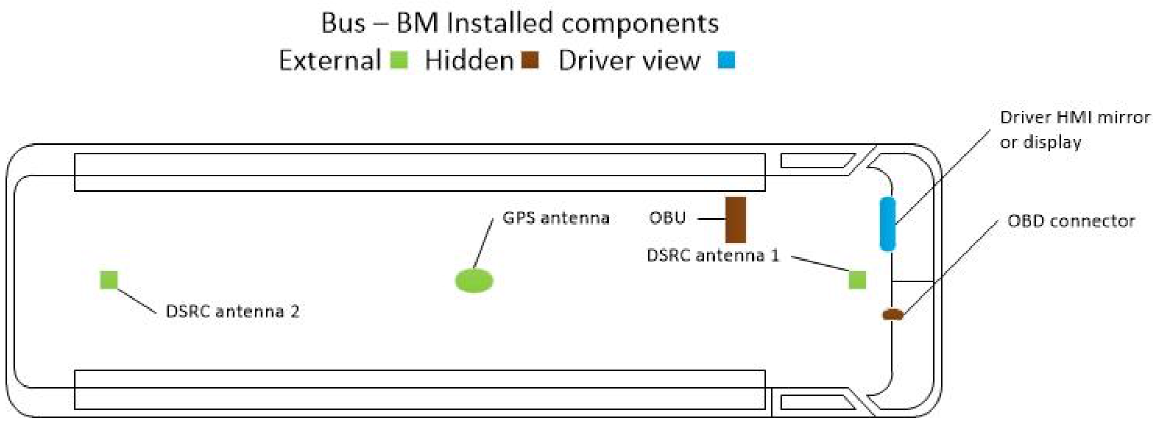
Figure 14: Streetcar Physical Architecture



Source: Brandmotion

The bus physical architecture is shown in Figure 15 below and is similar to a light vehicle except for an instrument panel mounted display.

Figure 15: Bus Physical Architecture



Source: Brandmotion

The following table defines key vehicle system requirements:

Table 9: Key Vehicle System Requirements

Identifier	Requirement/Constraint	Comment
Vehicle System	The vehicle system is the OBU, HMI (supplied by Brandmotion), vehicle interfaces and antennas (DSRC and GPS) with applications (software components).	Brandmotion, as the Vehicle Integrator, is responsible for vehicle installation and test with technical support from supplier.
Vehicle System Interfaces	Vehicle System shall provide the interfaces as defined in Technical Requirements section of the RFQ.	Optional interfaces identified in *italics (e.g. HDMI and CAN).*
Vehicle System Application Scope	The vehicle system operational in the CV pilot deployment regions as defined by the USDOT	Supplier provides Brandmotion a license to use applications in testbeds and deployments nationwide.
Vehicle System Useful Life and Reliability	The vehicle systems as installed and tested in vehicles shall meet all requirements for at least three years after installation.	
Vehicle System Applications	The OBU software components must meet the requirements as set forth in the USDOT referenced documents listed in the Technical Requirements section of the RFQ.	Supplier to provide software components previously demonstrated and tested, to be modified for the pilot.

Identifier	Requirement/Constraint	Comment
Vehicle System Data Logging	The OBU shall capture, time-stamp and record in memory for each application the most recent state and parameters to be accessible through an SD card interface and through an Over-the-Air (OTA) using the DSRC interface. Data generated and received by OBUs shall be on a storage device connected locally to OBU.	Data to be sent to a “master server” data archive via the local RSUs. The supplier to submit a proposal on specific diagnostic information to be captured and recorded.
Vehicle System Update	The OBU shall have a provision for firmware and application updates by the USB interface and Over-the-Air (OTA) using the DSRC interface.	The supplier to submit a proposal on specific update process and requirements.
Vehicle Systems Environmental Conditions	The vehicle systems are automotive grade and shall meet a temperature range of -40 to 85 degrees Celsius, automotive humidity, vibration, shock and drop test requirements according to the SAE J1211 standard.	Supplier will provide technical support and guidance as to environmentally robust packaging locations.
Vehicle System Security and data privacy	The Vehicle System shall have security as defined by the Security Certificate Management System and provide data privacy. Human Use and Privacy requirements to be developed	The supplier shall provide the specifics for the implementation of security and data privacy.

Identifier	Requirement/Constraint	Comment
Interoperability and Certification	The vehicle system shall demonstrate interoperability and the required certifications for the appropriate regulatory and standard organizations. Equipment, software, processes, and interfaces shall comply with IEEE and SAE standards and shall be tested for interoperability before deployment to ensure they meet those standards for interoperability. A review with the Florida DOT Traffic Engineering Research Laboratory (TERL) shall be supported.	The vehicle integrator, with THEA team concurrence, will provide an interoperability process and the supplier a plan for certification.
Open Software	The applications shall provide the capability for delivery to the Open Source Application Development Portal (OSADP) and upload guidelines as agreed upon by the supplier and Brandmotion. Open sources declarations to be updated	The supplier shall determine what aspects of the applications of their software components can be considered "open"
Technical Documentation and Standards	Technical information shall be provided to the Vehicle Integrator to assist in installation and driver training. Equipment, software, processes, and interfaces shall comply with IEEE and SAE Standards.	
Vehicle Systems Verified and Validated	The vehicle system shall be verified against specifications as part of system testing with other vehicles and with Tampa Road-Side Units (RSUs). The supplier shall validate the applications to meet the ConOps and other referenced USDOT specifications.	The supplier shall provide other verification testing such as unit software testing as needed
Replacement Systems, service parts and spares	The supplier shall provide additional spare units to the installation facility to be used as replacements of defective units that were deployed.	The supplier shall provide a replacement, service part and spare plan to be approved by Brandmotion

Source: THEA

3.1.9 Master Server Subsystem

Our proposed system is based on the existing Concert Advanced Traffic Management System product, along with the existing NextConnect data integration platform. The modular design of these products makes it easy to integrate many different types of data sources and devices into a single, unified management platform.

The Concert Advanced Traffic Management System (ATMS) provides:

Flexibility and scalability

Concert is a scalable platform for individual requirements. The function modules capitalize on a central core and can be expanded or combined modularly at any time as required. This makes it possible to apply tailor-made solutions and if required, also small entry-level solutions which can be successively extended to meet any needs.

Continuity

All modules work together and access a common pool of data. Redundant data entry into multiple systems is not necessary, which saves time and avoids errors. Tools support the traffic engineer, the operator and the service technician equally in their various roles and work processes.

Simple, intuitive operation

The user interface has been designed to accommodate the multiple workflows of a traffic control center. Flexible configuration capabilities make it possible to tailor operation to specific needs. It bundles the important functions, allows faster switching between various contexts and supports navigation through the multifunctional GIS map. This makes the system simple and intuitive to operate.

Openness

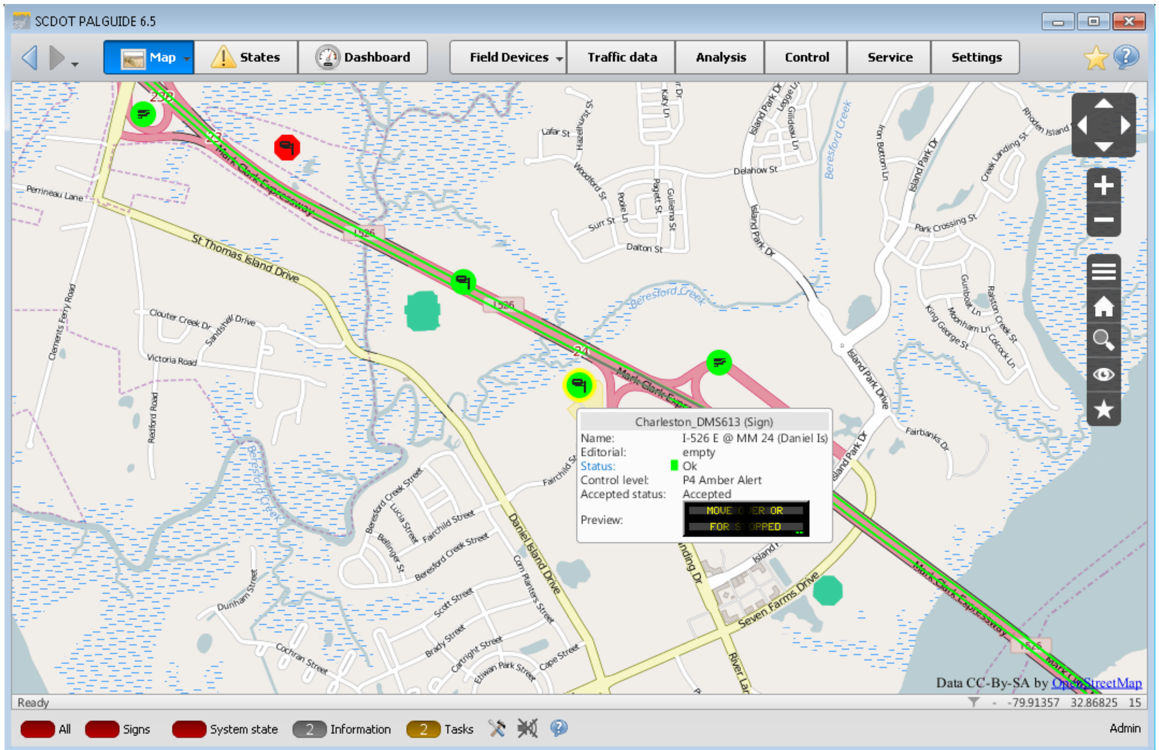
Open interfaces allow for a smooth exchange between various heterogeneous systems as well as the connection of field devices of various ages and origins. Standards ensure maximum integration capacity.

Browser-based HTML5 Remote Access

The standard Concert user interface is a Java-based Thin Client application. This application is easily installed with a single click and is designed to provide fast response times within the agency intranet. For remote users, or users who do not wish to install the Java client, a browser-based user interface is available that works with any modern HTML5-compliant web browser. The HTML5 interface can be used inside the agency intranet, or on the public Internet, through a secure proxy server installed in the agency's DMZ. The browser-based interface looks identical to the Java interface, so no additional user training is required.

For the THEA CV Pilot, the system includes all modules necessary for operation of Concert such as basic system services and a GIS map. Further it would include the Central Management System (CMS) module responsible for monitoring and management of Siemens RSUs plus the incident management module, and secure remote access to the Research staff.

Figure 16: Example View of the GIS Map



Source: THEA

The previous figure shows an example of the Concert GIS map display with icons for various device types and details for a DMS status. RSUs will display on the map in a similar fashion along with health status.

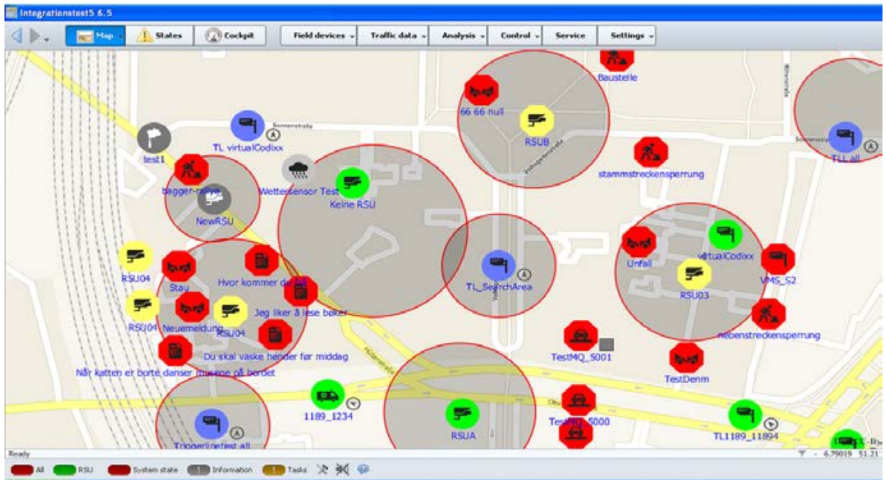
Connected Vehicles

As part of Connected Vehicle testbeds in the US and Europe, Siemens has implemented CV features at the controller, Roadside Unit (RSU) and CMS, with Concert as the management platform, which will be reused here.

As part of Concert, Connected Vehicle technology provides:

- Sensor Data: An RSU receiving information from connected vehicles collects a huge amount of data. In addition to real-time features implemented at the controller level, the RSU can aggregate this data into standard formats (volume, occupancy, speed) to replace conventional detection at the ATMS level. This capability has been implemented in Concert. In the future, additional information can be derived from the messages received from vehicles, such as pavement condition, weather information, and incident information.

Figure 17: CV Map Display Example



Source: THEA

Figure 17 shows an example of Concert handles traveler information messages via geographical areas from which they are being broadcast. Geo fence is placed to eliminate duplicate BSMs on nearby RSUs. All BSMs are received within range, but only those located within the geo fence are used by the software application.

3.1.10 Driver Interaction

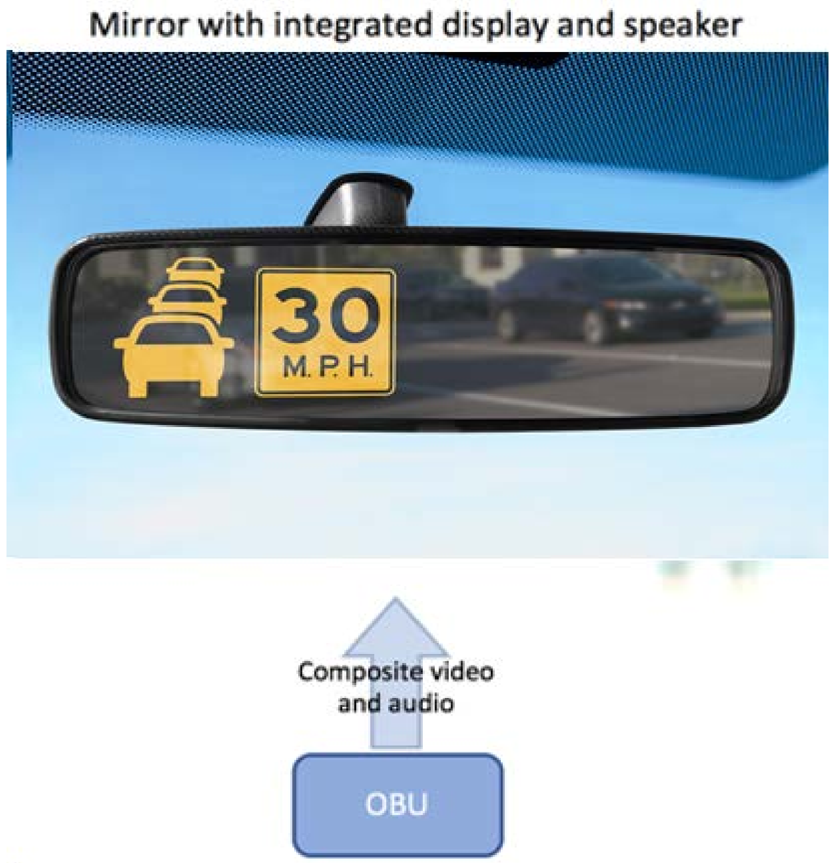
Drivers of all vehicle types, light vehicles, streetcars and buses require a flexible HMI approach to address the variety of vehicle types, that:

- Provides the necessary application information to ensure timely driving decisions
- Easy to read or hear, non-distracting
- Well integrated to the vehicle

The design approach to driver interaction is multimodal using visual and auditory information for example:

- Display for key information, e.g. curve speed and various warnings, e.g. "End of Ramp Deceleration Speed Advisory" (See Figure 18)
- Auditory and directional alerts, e.g. "Caution, pedestrian ahead to the left"

Figure 18: OBU Human Machine Interface



Source: Brandmotion

A multimodal user interface engages both the visual and auditory senses of the user:

- Audio indicators, speaker mounted inside of the mirror of light vehicles.
- Two levels of alerts to be used: warning (amber), potential of a safety issue and, immediate (red), a high probability of a safety issue if action not taken by the driver
- Multiple application alerts will require prioritization and timing for display and auditory content for relevant warnings, alerts, and other information. Concurrent and individual message scenarios will be developed for each use case and vehicle type. The prioritization scheme involves time available for a vehicle operator to avoid an incident.

The following Human-Machine Interface (HMI) or user interface standards listed in Table 10 are under review as they may provide guidance and direction to the user interface. For example, user interface design literature will refer to the Rockwell's "two second rule" as the not exceed glance duration, that is how long a driver will feel comfortable in taking their eyes of the road to perform secondary tasks. Screen sizes of 3-4 inches in diagonal are common for review-mirror rear-camera displays and are in this design adapted to meet legibility guidelines for alphanumeric and graphic displays. Brandmotion will consult with experienced automotive user interface engineers, who are experts in automotive user interface standards, best practices and experienced in the design. The standards to be used will be finalized during the detailed design.

Table 10: Standards Overview

Standard	Summary	Applicability
SAE Standards		
SAE J 2395-2002	The recommended practice describes the method for prioritizing ITS in-vehicle messages and/or displayed information based on a defined set of criteria.	Determining the order that warnings should be conveyed to the driver.
SAE J 2395-2002	This standard explains factors which affect the results of video based visual allocation (VBVA) studies.	Make use of the standard to determine best HMI display options.
Federal Motor Vehicle Safety Standards (FMSS)		
FMVSS (111)	This standard specifies requirements for rear visibility devices and systems. Applies to passenger cars, multipurpose passenger vehicles, trucks, buses, school buses, motorcycles and low-speed vehicles.	Ensure rearview mirror (HMI display) meets all requirements.
Alliance of Automobile Manufacturers: (AAMA) Guidelines		
Principle 1.1	The system should be located and fitted in accordance with relevant regulations, standards, and the vehicle and component manufacturers' instructions for installing the systems in vehicles.	HMI display should meet all government and manufacturer's standards for system installations.
Principle 1.2	No part of the system should obstruct the driver's field of view as defined by applicable regulations.	The HMI display should not block the driver's view.
Principle 1.3	No part of the physical system should obstruct any vehicle controls or displays required for the driving task.	The HMI display should not block any vehicle controls or the driver's visibility.
Principle 1.4	Visual displays that carry information relevant to the driving task and visually-intensive information should be positioned as close as practicable to the driver's forward line of sight	HMI display should be positioned as close to the driver as possible.
Principle 2.1	Systems with visual displays should be designed such that the driver can complete the desired task with sequential glances that are brief enough not to adversely affect driving.	HMI design should not be too distracting.
Principle 2.2	Where appropriate, internationally agreed upon standards or recognized industry practice relating to legibility, icons, symbols, words, acronyms, or abbreviations should be used. Where no standards exist, relevant design guidelines or empirical data should be used.	HMI displays should meet industry specifications for vehicle connectivity icons.

Standard	Summary	Applicability
Principle 2.3	Available information relevant to the driving task should be timely and accurate under routine driving conditions	All warnings should be based on accurate situations.
Principle 2.4	The system should not produce uncontrollable sound levels liable to mask warnings from within the vehicle or outside or to cause distraction or irritation.	All audio warnings must meet established guidelines.
Principle 3.1	The system should allow the driver to leave at least one hand on the steering control.	HMI displays should not require the use of both driver's hands.
Principle 3.3	The system should not require uninterruptible sequences of manual/visual interactions. The driver should be able to resume an operator-interrupted sequence of manual/visual interactions with the system at the point of interruption or at another logical point in the sequence.	The series of HMI warnings should not overwhelm or impose too many distractions to the driver.
Principle 3.4	In general, (but with specific exceptions) the driver should be able to control the pace of interaction with the system. The system should not require the driver to make time-critical responses when providing input to the system.	The driver should have the capability to control the frequency of warnings. Also, the HMI display should not place time requirements on the driver.
Principle 3.5	The system's response (e.g. feedback, confirmation) following driver input should be timely and clearly perceptible.	The HMI warnings should be clearly communicated to the driver.
Principle 3.6	Systems providing non-safety-related dynamic (i.e. moving spatially) visual information should be capable of a means by which that information is not provided to the driver.	Driver should be able to stop non-safety-related information.
Principle 4.1	Visual information not related to driving that is likely to distract the driver significantly (e.g., video and continuously moving images and automatically scrolling text) should be disabled while the vehicle is in motion or should be only presented in such a way that the driver cannot see it while the vehicle is in motion.	While the vehicle is in motion, animated warnings should be disabled or blocked from the driver's view.
Principle 4.2(a)	System functions not intended to be used by the driver while driving should be made inaccessible for driver interaction while the vehicle is in motion.	While the vehicle is in motion, car functions not intended to be controlled by the driver should be made inaccessible to the driver.

Standard	Summary	Applicability
Principle 4.2 (b)	The system should clearly distinguish between those aspects of the system, which are intended for use by the driver while driving, and those aspects (e.g. specific functions, menus, etc.) that are not intended to be used while driving.	The system should clearly separate functions that can and cannot be controlled by the driver.
Principle 4.3	Information about status, and any detected malfunction, within the system that is likely to have an adverse impact on safety should be presented to the driver.	Any HMI display problems should be communicated to the driver.
Principle 5.1	The system should have adequate instructions for the driver covering proper use and safety-relevant aspects of installation and maintenance.	Proper instructions regarding the HMI display should be provided to the driver.
Principle 5.2	Safety instructions should be correct and simple.	HMI instructions should be easy to understand.
Principle 5.3	System instructions should be in a language or form designed to be understood by drivers in accordance with mandated or accepted regional practice.	HMI instructions should be presented in a clear format.
Principle 5.4	The instructions should distinguish clearly between those aspects of the system that are intended for use by the driver while driving, and those aspects (e.g. specific functions, menus, etc.) that are not intended to be used while driving	The instructions should clearly explain which components of the HMI display the driver can control, and which components he/she cannot.
Principle 5.5	Product information should make it clear if special skills are required to use the system or if the product is unsuitable for users.	If special skills are needed to operate the HMI display, these requirements should be explained to the driver.
Principle 5.6	Representations of system use (e.g. descriptions, photographs, and sketches) provided to the customer with the system should neither create unrealistic expectations on the part of potential users, nor encourage unsafe or illegal use.	Unrealistic, unsafe, or illegal expectations of the HMI display should not be promised to the driver.
ISO Standards		
ISO 15623	System that prompts the driver to take an avoidance maneuver by activating a warning system whenever the vehicle in front is too close, to prevent rear-end collision. Specification of the detection range, detection performance and evaluation method for the vehicle in front.	HMI display should base warnings on proper detection procedures.

Source: THEA

4 Viewpoints and Views

4.1 Enterprise Architecture View

The Enterprise Architecture View depicts the project stakeholders and their relationships with one another. As part of the project, a Stakeholder Registry was created and delivered identifying the stakeholders for the pilot and identified in Table 4 of the Concept of Operations, listed by Stakeholder Category:

- Core team stakeholders are the members of the project team.
- 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 are those entities that are supporting the USDOT in conducting the pilot project.
- Pilot participants such as drivers, pedestrians, bus drivers, and streetcar carmen are user stakeholders. Because the number of participants is large, these participants will be represented by other stakeholders such as TECO Streetcar Line, HART, or MacDill Air Force Base (MAFB) Public Affairs Office.

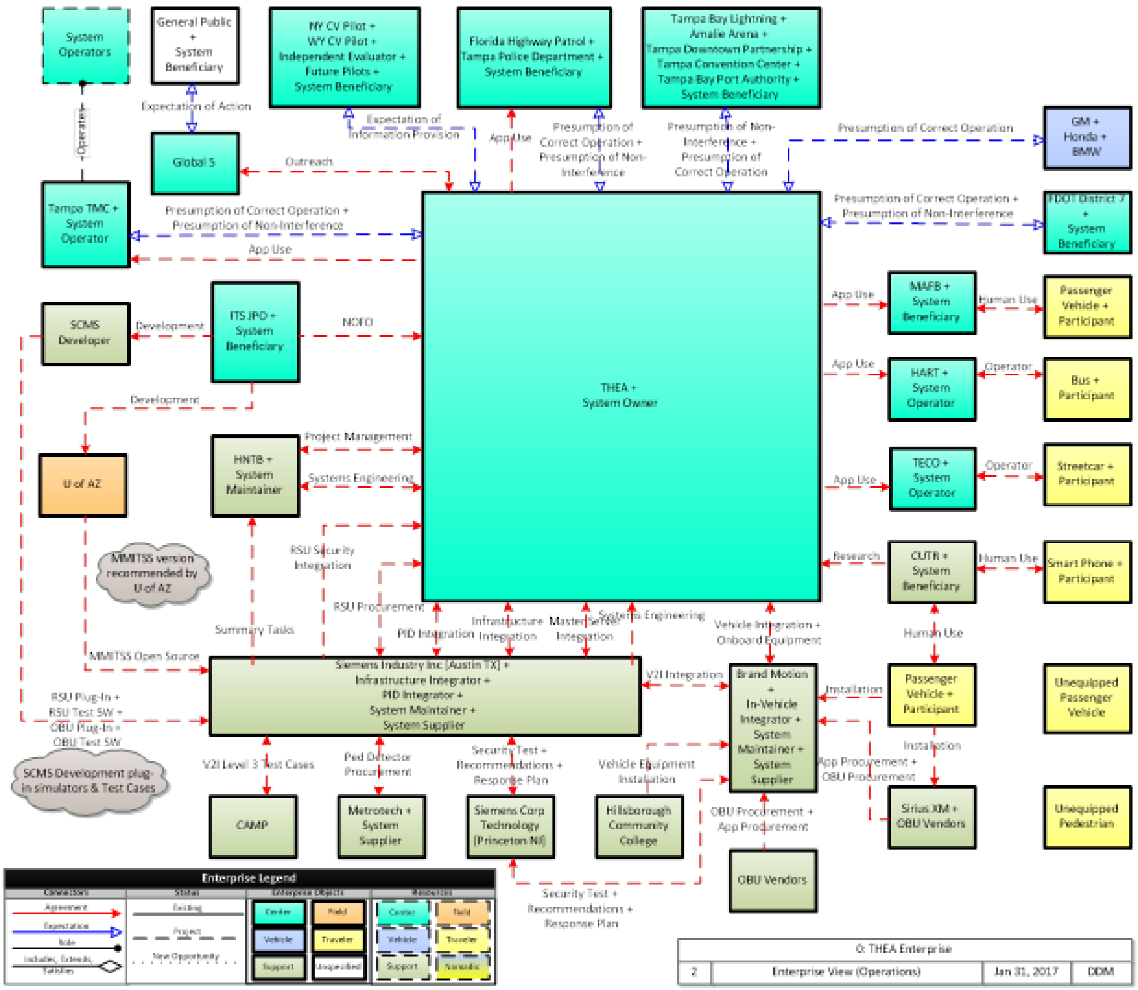
Organizational updates at transitioning from Phase 1 to Phase 2 of the project include:

- Booze Allen Hamilton completed work on the Security Management Operational Concept (SMOC) at the end of Phase 1.
- Siemens Corporate Technology was added as a stakeholder to implement security elements of the SMOC, including hardening tests, hardening recommendations, response planning and security training for stakeholders
- Brandmotion was added as a Core Team Member responsible for vehicle equipment procurement and installation.
- Sirius XM was added as a supplier for a portion of the Onboard Unit procurements.
- University of Arizona was added as an advisor for integration of the MMITSS software
- A software developer was added by USDOT for generation of security certificates

The relationship of the stakeholders is shown in Figure 19: CV Pilot Enterprise Architecture. The following list identifies stakeholders' role and their effect on the system:

- Non-interference: Current operations are unaffected by the addition of the CV system.
- Correct operation: Interfaces to adjacent systems are tested for future use, such as Center to Center. Those stakeholders are future users.
- FHP, TPD, FDOT, Amalie arena and other system beneficiaries are future users
- Future CV-equipped cars will randomly enter the study zone
- Private driver and pedestrian are not equipped with a device that can be connected.

Figure 19: CV Pilot Enterprise Architecture

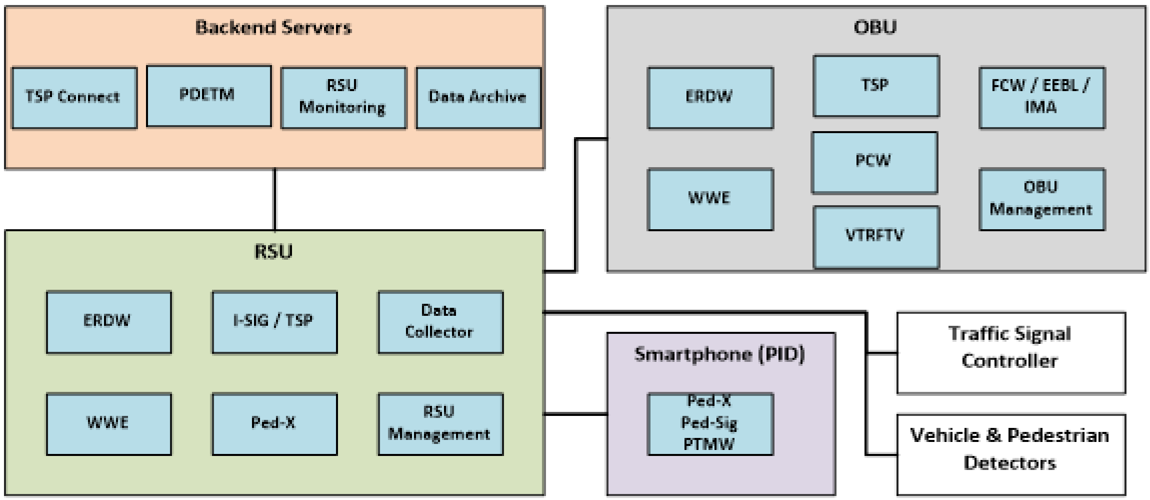


Source: THEA

4.2 Functional Architecture View

The Functional Architecture View depicts each element of overall system and the logical interfaces among them.

Figure 20: Functional Architecture Overview



Source: Siemens

The THEA CV System has functionality distributed across backend servers, roadside units (RSUs), onboard units (OBUs), and smartphones (PIDs). RSUs interface with Traffic Signal Controllers as well as Vehicle & Pedestrian Detectors. The tables below describe the applications in Figure 20.

Table 11: Backend Server Functions

Functionality	Description
TSP Connect	Siemens application granting or denying priority service requests from buses
RSU Monitoring	Siemens application monitoring connected RSUs for basic operation and health
Data Archive	Siemens application storing log data received from RSUs

Source: Siemens

Table 12: RSU Functions

Functionality	Description
ERDW	See the application description in Section 4.2.1
WWE	See the application description in Section 4.2.2
I-SIG / TSP	See the application description in Sections 4.2.10 and 4.2.6
Ped-X	See the application description in Section 4.2.4
Data Collector	Application responsible for collection of log data (e.g. BSMs, TIMs, alerts, etc.) and forwarding of that data to the backend server
RSU Management	Support functions for managing basic RSU operations such as broadcast of MAP and SPaT messages. Functions for application lifecycle management, health monitoring, and browser-based user access. Functions for configuration of core RSU services such as Message Forwarder. Functions for log collection and software update management.

Source: Siemens

Table 13: OBU Functions

Functionality	Description
ERDW	See the application description in Section 4.2.1
WWE	See the application description in Section 4.2.2
TSP	See the application description in Section 4.2.6
VTRFTV	See the application description in Section 4.2.5
FCW / EEBL / IMA	See the application description in Sections 4.2.7, 4.2.8, 4.2.9
PCW	See the application description in Section 4.2.12
OBU Management	Support functionality for managing basic OBU operations such as broadcast of BSMs. Functions for application lifecycle management, health monitoring, and human machine interface. Functions for log collection and software update management.

Source: Siemens

Table 14: Smartphone Functions

Functionality	Description
Ped-X	See the application description in Section 4.2.4

Source: Siemens

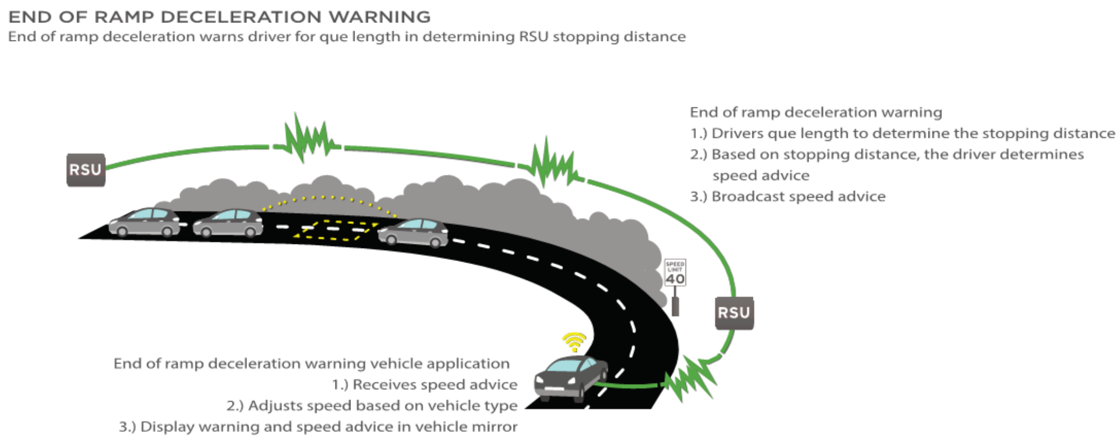
The following sections are functional views of the CV Pilot applications. Nine of the eleven applications are discussed. I-SIG and PDETM are omitted as they are overarching applications with no specific user functionality.

4.2.1 End of Ramp Deceleration Warning

This app computes a geo location of stopped traffic / vehicle queue based on the longest lane queue length computed by I-SIG. In this case, overlapping I-SIG app at Twiggs and Meridian estimates the queue length from the end of the Reversible Express Lane (REL). An Infrastructure Sensor Message (ISM) is generated for each detection event of a vehicle passing a traditional vehicle detector (e.g. radar or video) and provided to I-SIG only. I-SIG uses the ISM to enhance its queue length estimation. The REL is divided into one or more speed zones extending from Twiggs to the Selmon main lanes. Based on the end of queue location for the end of queue, the RSU sends a TIM that describes the recommended speed for each zone based on the safe stopping distance based on the Florida driver's manual. As the driver approaches the end of queue, the recommended speed TIM drops to within the safe stopping distance or the posted speed, whichever is lower for that zone.

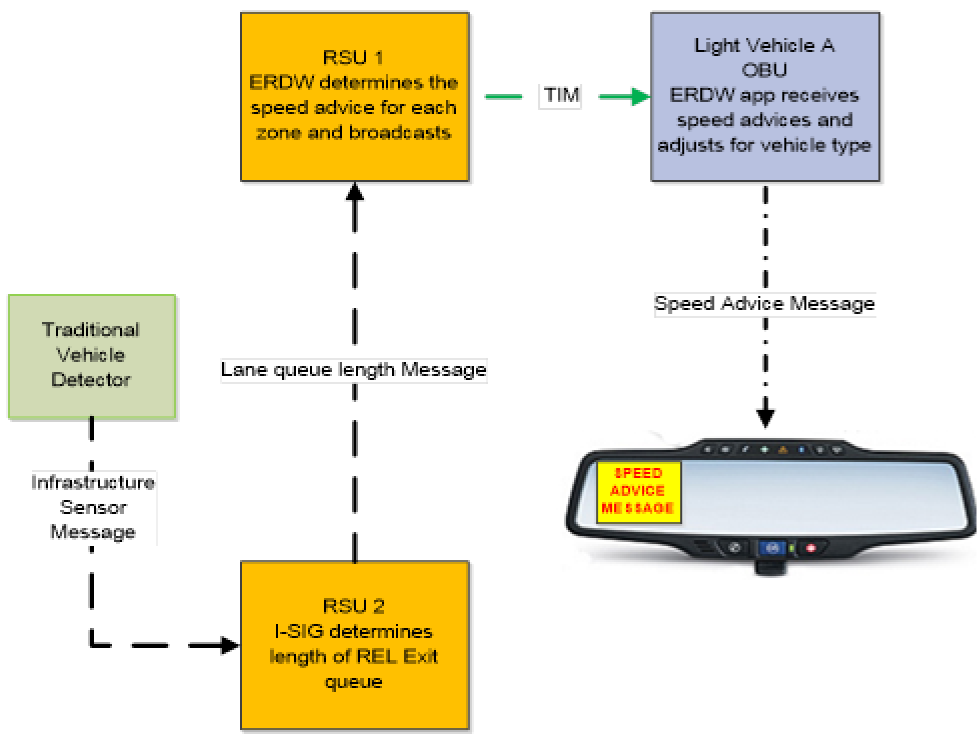
There is a complementary OBU app that receives the recommended safe speeds as TIMs. The OBU app adjusts the recommended safe speed based on the vehicle's type and sends a message to the HMI for display to the driver. For example, a loaded heavy truck would adjust the TIM speed to a lower speed for that stopping distance and the vehicle weight for each zone. See Figure 21 and Figure 22.

Figure 21: ERDW Functional Overview



Source: THEA

Figure 22: ERDW Functional Flows

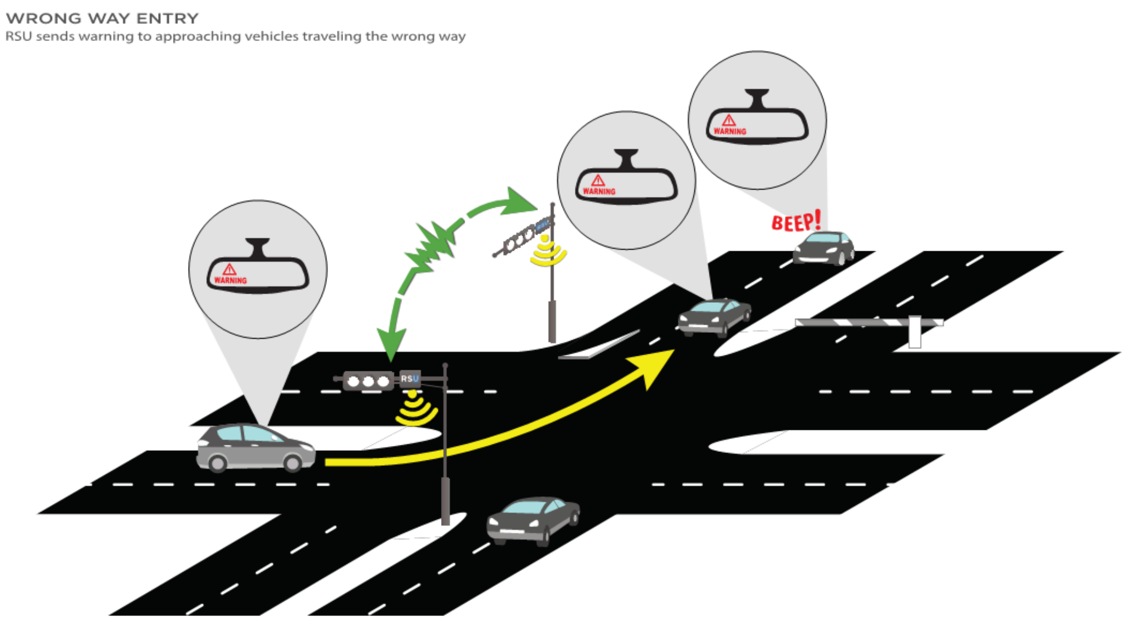


Source: THEA

4.2.2 Wrong Way Entry

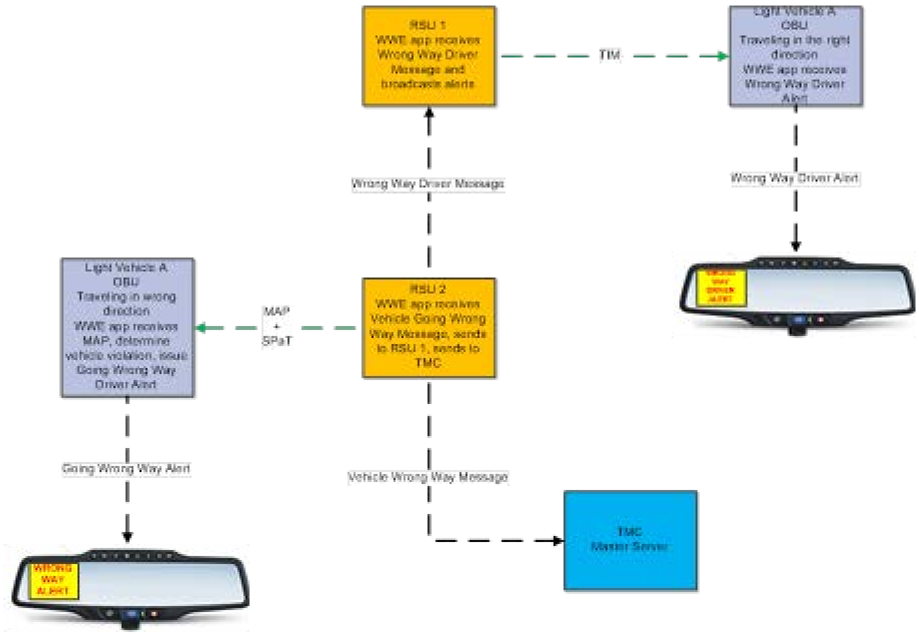
The RSU app broadcasts the MAP and Signal and Phasing Timing (SPaT). According to J2735_201603, each MAP lane includes an allowed direction of vehicle travel, plus a revocable indication for each lane. In this case, seven lanes are present at the end of the REL. The MAP will contain lanes for both inbound and outbound operation of the REL which will all be marked as revocable. The RSU sends SPaT message which contains the current enabled status for each revocable lane according to the operating mode of the REL. The current operating mode of the REL, inbound or outbound, is determined based on external detection input to the traffic signal cabinet at the intersection. The OBU issues an alert to a driver approaching the inbound lanes from the wrong direction. A secondary, non CV detection point is used as confirmation of continued counter-flow entry and generates a warning to the TMC. The RSU app provides an alert to the TMC that a vehicle is going the wrong way and provides a warning to upstream RSUs that a vehicle is approaching going the wrong way. The RSUs' app begins broadcasting wrong way vehicle ahead. OBU equipped vehicles receive the wrong way vehicle ahead message that warn the driver of the approaching wrong way vehicle. The OBU can also issue an alert to a driver approaching a lane that has been revoked at that time of day according to the SPaT message. See Figure 23 and Figure 24.

Figure 23: WWE Functional Overview



Source: THEA

Figure 24: WWE Functional Flow

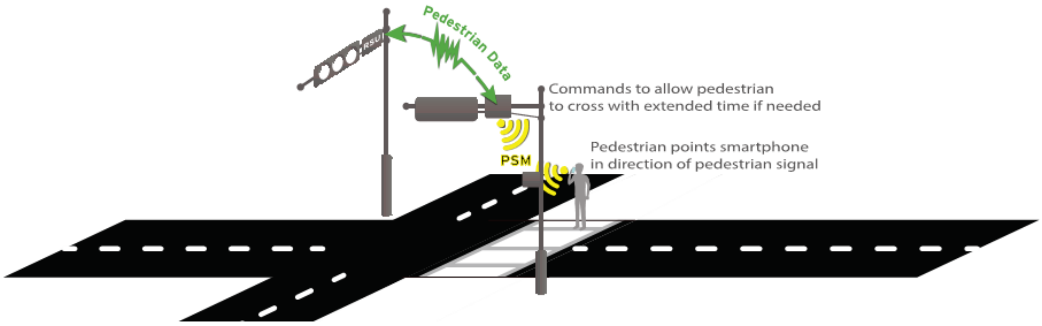


Source: THEA

4.2.3 Mobile Accessible Pedestrian Signal

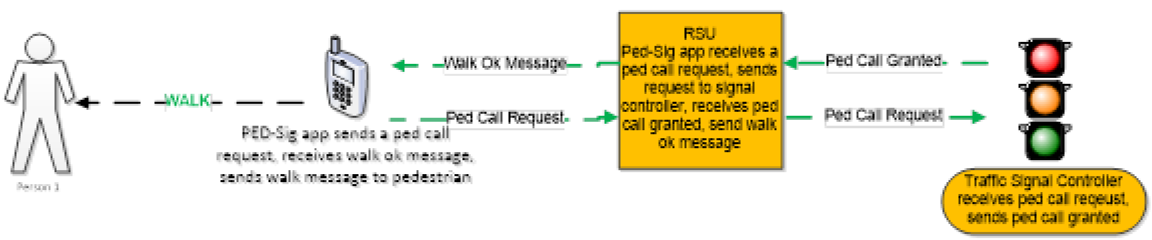
PED-SIG is composed of two software objects; one on the personal information device (PID) and the second on the RSU. The pedestrian points the PID in the direction they want to cross the intersection. When the pedestrian touches the “Cross” button on the PID app, it generates and provides a request to the RSU for a pedestrian call. The RSU app interprets the PID app request, sends the automated pedestrian call command to the signal controller, receives concurrence from the Signal controller, and sends a confirmation to the PID app. If the ability to request extended walk time is provided by the signal controller, the RSU will request extended walk time when performing the automated pedestrian call to the signal controller. See Figure 25 and Figure 26.

Figure 25: PED-SIG Functional Overview



Source: THEA

Figure 26: PED-SIG Functional Flows

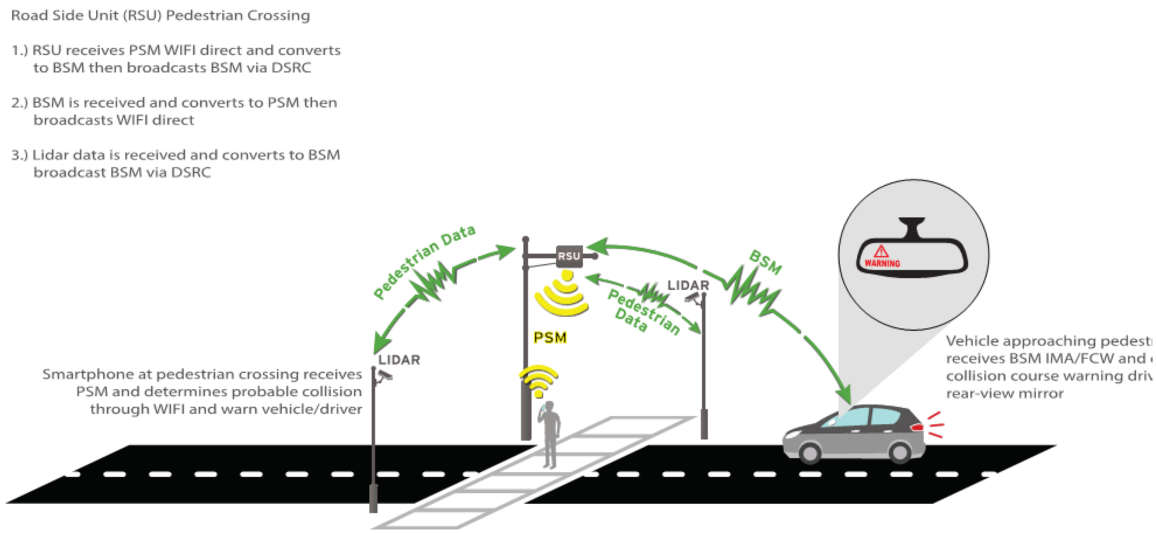


Source: THEA

4.2.4 Pedestrian in a Signalized Crosswalk

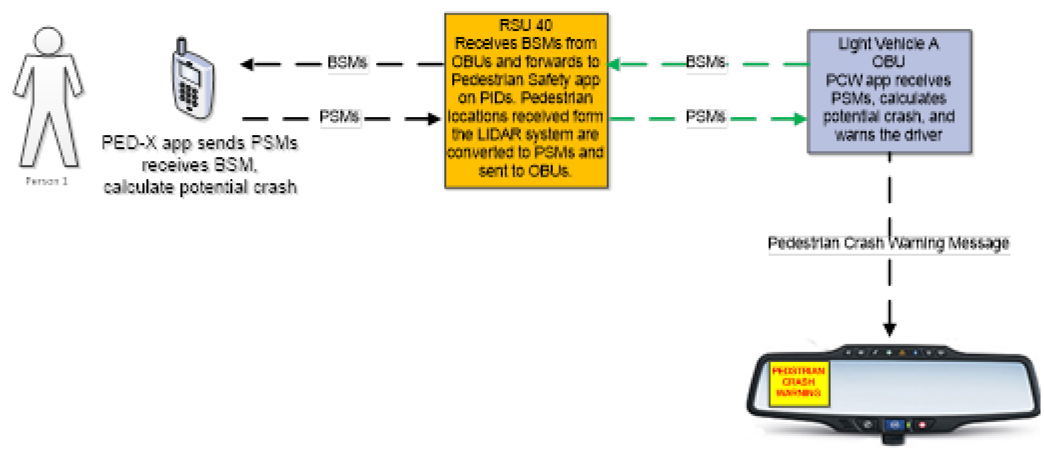
An application that translates WiFi to DSRC used to warn cars when pedestrians, within the crosswalk, are in the intended path of the car. The complementary Personal Information Device (PID) application receives PSMs from the RSU that a vehicle is approaching a crosswalk. As the PID GPS is unpredictable, the feasibility of warning the pedestrian that they may collide with a vehicle will be analyzed, but the pedestrian will not be warned. Equipped vehicles using the PCW app warn the driver of a crash course with pedestrian in the roadway. There is no detection of unequipped vehicles. See Figure 27 and Figure 28

Figure 27: PED-X Functional Overview



Source: THEA

Figure 28: PED-X Functional Flows

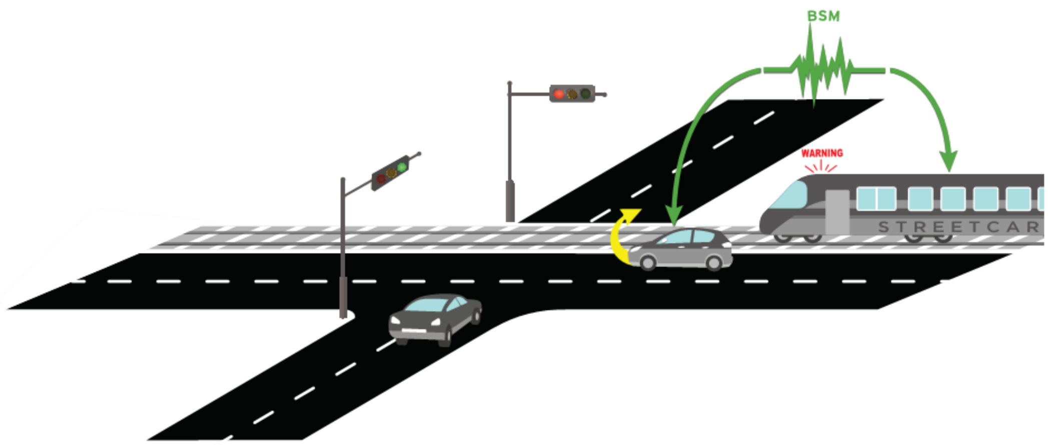


Source: THEA

4.2.5 Vehicle Turning Right in Front of Transit Vehicle

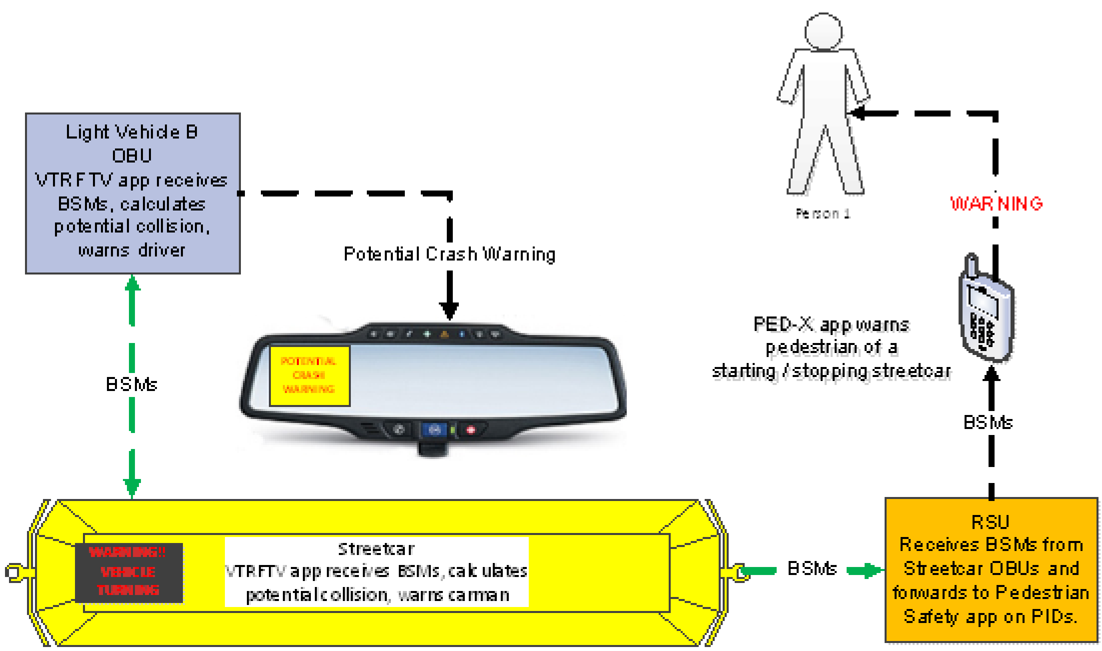
This app warns the streetcar carmen of a vehicle turning right at the intersection the streetcar is approaching, using the BSMs that are being sent and received, if the app determines the vehicles are on a potential collision trajectory. Equipped vehicles receive a similar warning that they are on a collision course with streetcars. See Figure 29 and Figure 30.

Figure 29: VTRFTV Functional Overview



Source: THEA

Figure 30: VTRFTV Functional Flows



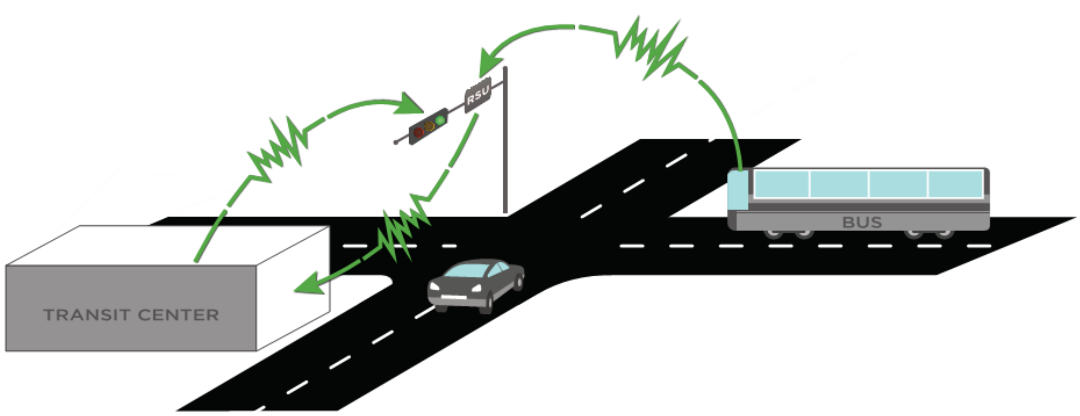
Source: THEA

4.2.6 Transit Signal Priority

The app provides signal priority to transit at intersections along arterial corridors, only if the bus is behind schedule. TSP is part of MMITSS.

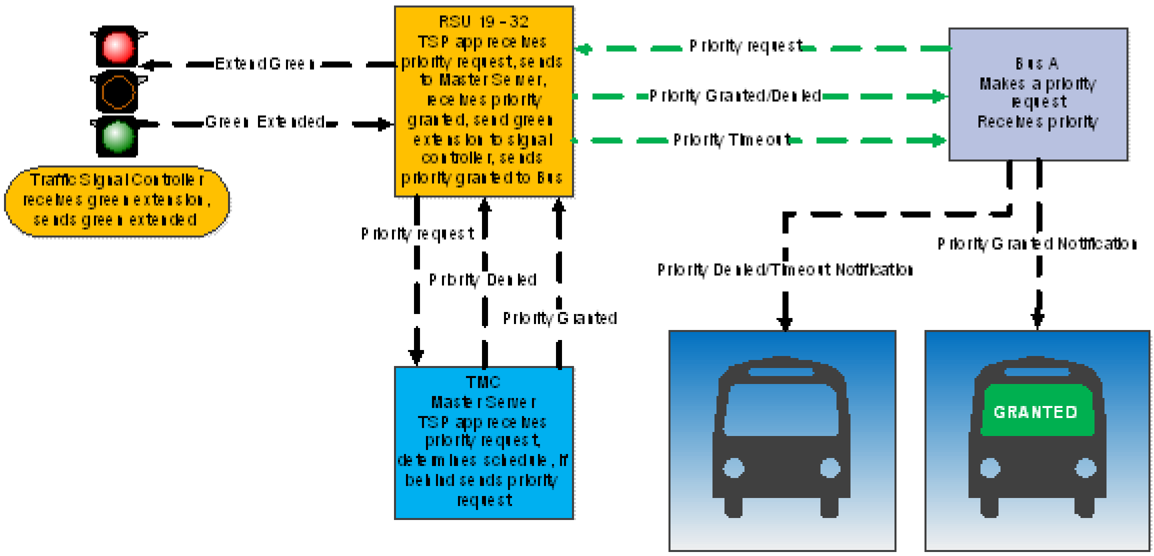
If the bus is behind schedule, priority will be granted for the bus. The OBU sends an SRM to the RSU. The RSU forwards that to the Transit Server at the TMC. The Transit Server determines if the bus is behind schedule. If the bus is behind schedule, the SRM is returned from the Transit Server to the RSU. If the signal is green in the bus's travel direction, the RSU selects the controller phase via NTCIP objects to extend the green, allowing the bus to proceed through the intersection. If the signal is yellow or red in the bus's travel direction, the RSU request the shortest cycle via NTCIP objects to provide a green to the bus as quickly as possible. At the same time, RSU sends the Signal Status Message (SSM) to the approaching bus to inform them that they have received priority. See Figure 31 and Figure 32.

Figure 31: TSP Functional Overview



Source: THEA

Figure 32: TSP Functional Flows



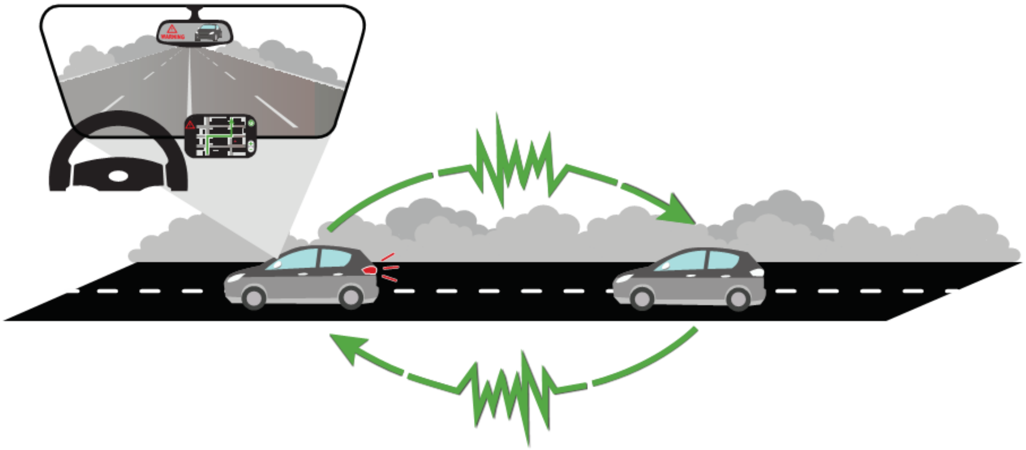
Source: THEA

4.2.7 Forward Collision Warning

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. FCW works lane by lane.

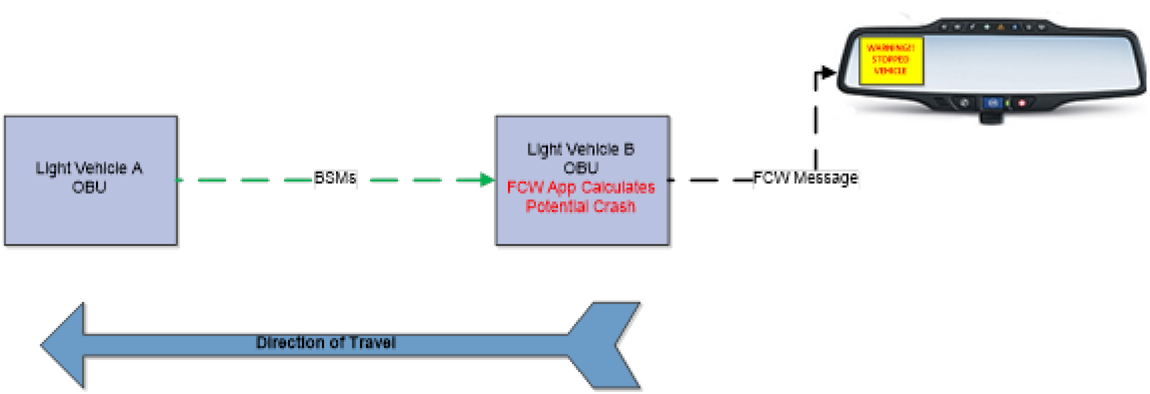
Anywhere two equipped vehicles interact, FCW will work and provide a driver alert if the right conditions occur as follows: one vehicle following the other; the lead vehicle brakes causing the closing distances to decrease (as calculated) to warrant an alert of a potential collision. See Figure 33 and Figure 34

Figure 33: FCW Functional Overview



Source: THEA

Figure 34: FCW Functional Flows

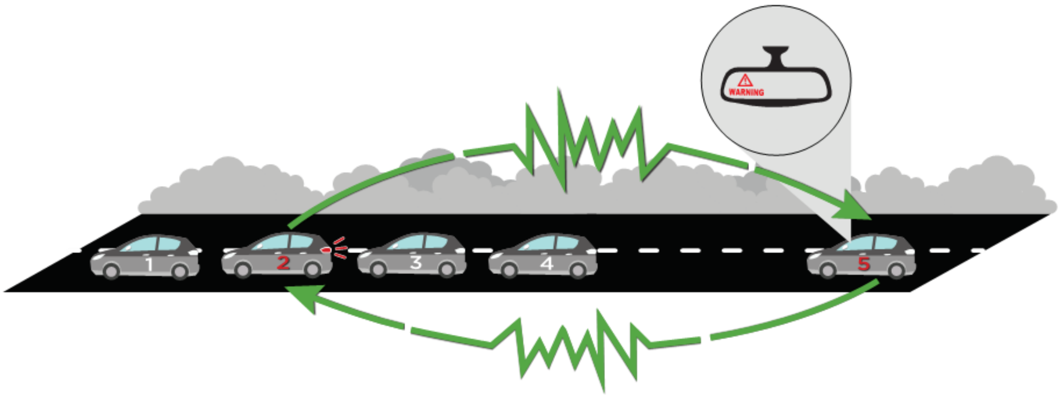


Source: THEA

4.2.8 Emergency Electronic Brake Light Warning

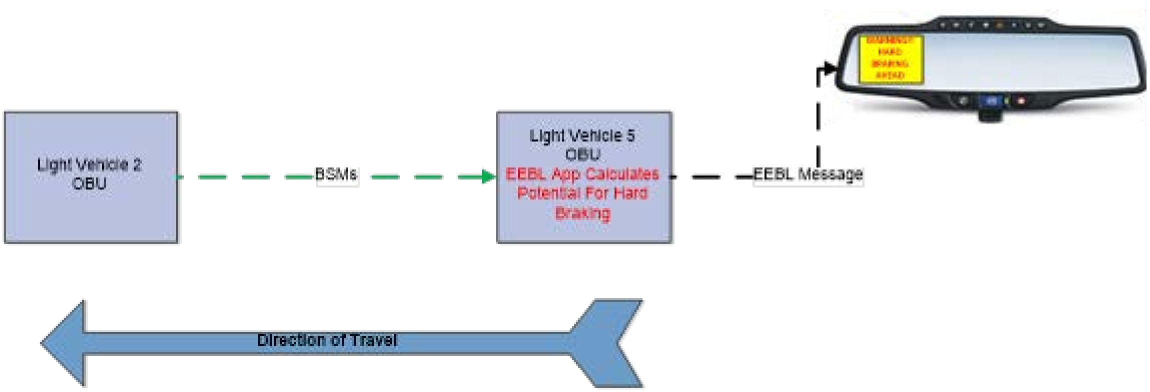
An application where the driver is alerted to hard braking in the traffic stream ahead. This alert is received from one or more vehicles in the same lane ahead but not the immediate vehicle ahead. This provides the driver with additional time to look for and assess situations developing ahead. See Figure 35 and Figure 36.

Figure 35: EEBL Functional Overview



Source: THEA

Figure 36: EEBL Functional Flows

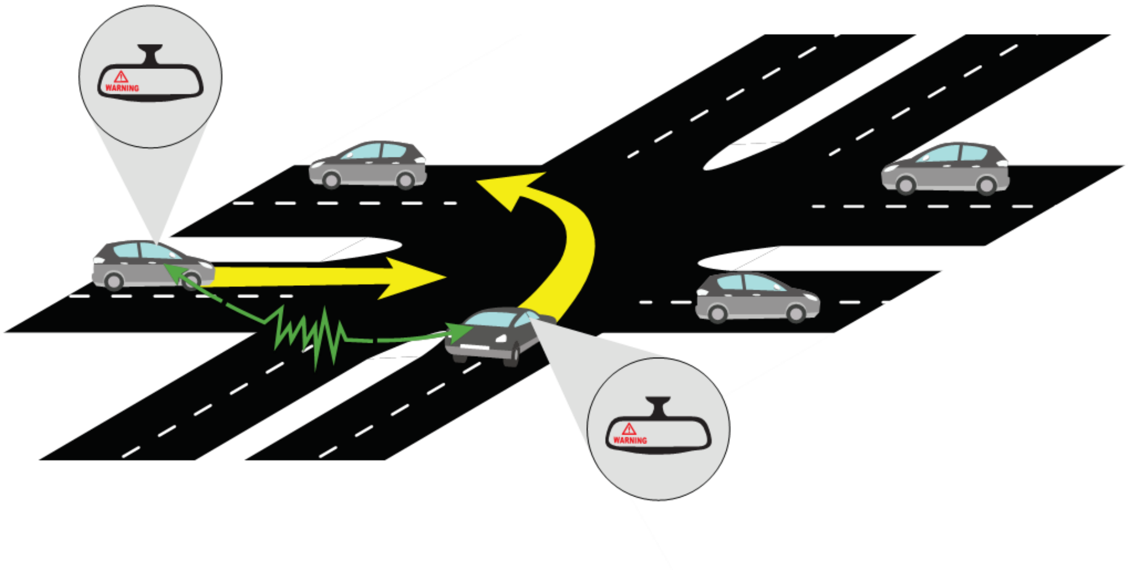


Source: THEA

4.2.9 Intersection Movement Assist

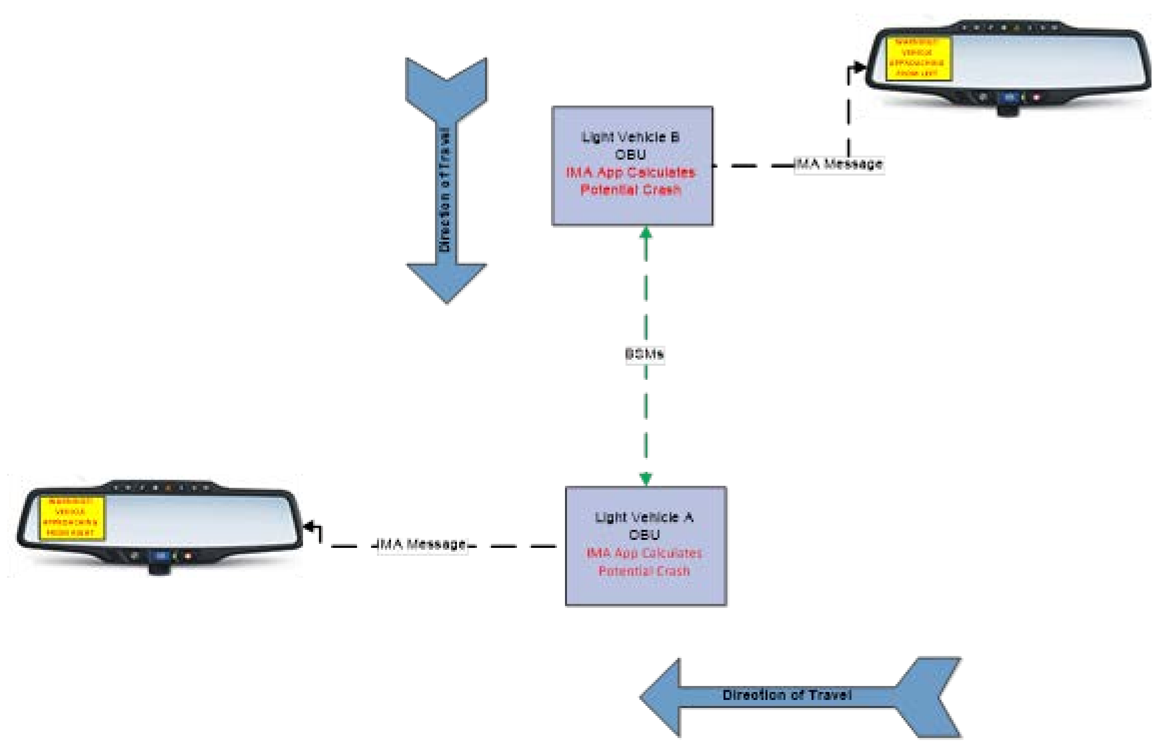
An application that warns the driver of a potential crash when two or more vehicles are approaching one another using the relative position, speed and heading of those vehicles. The IMA app receives BSMs from approaching vehicles adjacent to the vehicle equipped with IMA. If IMA determines there is a high probability of a crash, the app warns the driver. See Figure 37 and Figure 38.

Figure 37: IMA Functional Overview



Source: THEA

Figure 38: IMA Functional Flows



Source: THEA

4.2.10 Intelligent Signal System (I-SIG)

I-SIG receives BSMs from vehicles approaching the intersection and ITS traffic detectors (e.g., radar or video) to determine the length of the queue at the intersection. I-SIG uses the queue length to determine the cycle length in order to move traffic efficiently through the intersection and through the corridor.

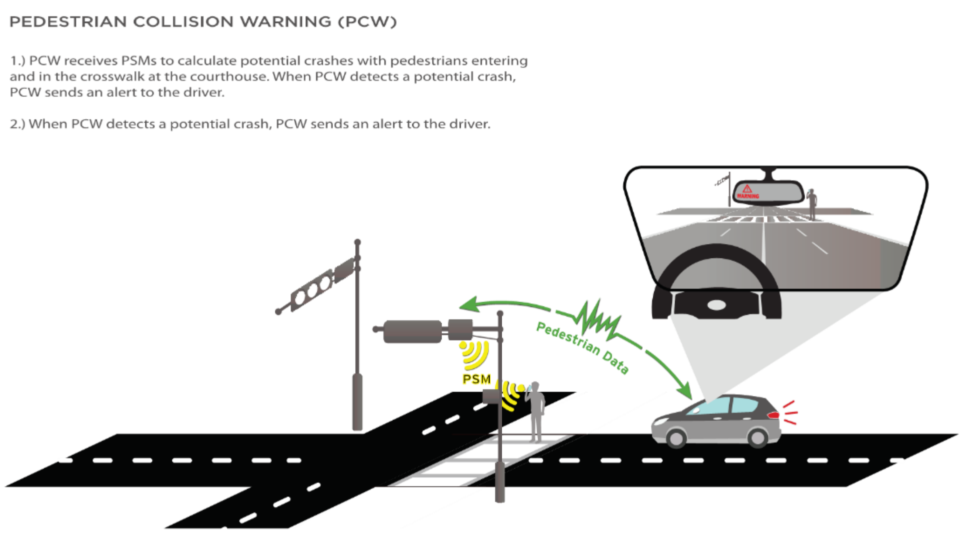
4.2.11 Probe Data Enabled Traffic Monitoring (PDETM)

PDETM receives BSMs, speeds, and traffic counts (traffic volume) from RSUs along a corridor. These RSUs receive BSMs from vehicles traveling along the corridor. PDETM uses these BSMs to calculate travel times along the corridor. PDETM resides on the Master Server. PDETM stores the travel times for use in measuring performance of the corridor.

4.2.12 Pedestrian Collision Warning (PCW)

PCW receives PSMs to calculate potential collision with pedestrians entering and in the crosswalk at the courthouse. If PCW detects a high probability of a crash, PCW alerts the driver. See Figure 39

Figure 39: PCW Functional Overview

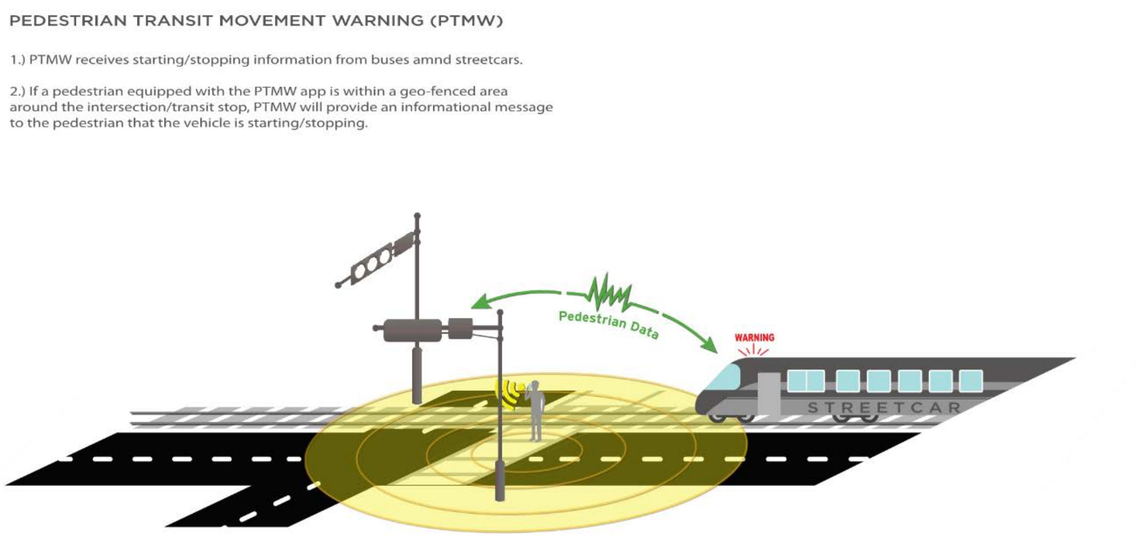


Source: THEA

4.2.13 Pedestrian Transit Movement Warning (PTMW)

PTMW receives starting/stopping information from buses and streetcars. If a pedestrian equipped with the PTMW app is within a geo-fenced area around the intersection/transit stop, PTMW will provide an informational message to the pedestrian that the vehicle is starting/stopping.

Figure 40: PTMW Functional Overview

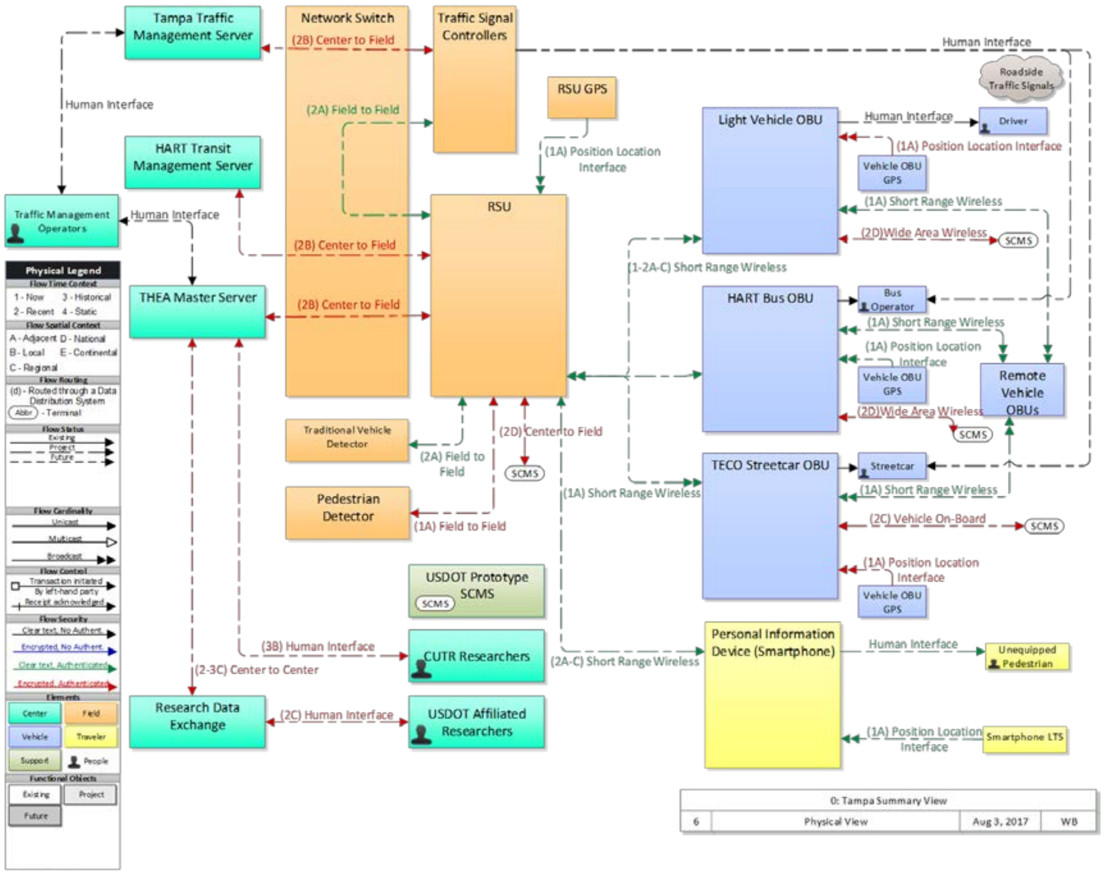


Source: THEA

4.3 Physical Architecture View

The Physical Architecture View, Figure 41, depicts the hardware objects, the software objects supported by each hardware object and the interfaces among them.

Figure 41: Physical Architecture View



Source: THEA

Table 15 lists the major elements of the Figure 41: Physical Architecture View along with a description of each major element.

Table 15: Elements and Applications

Name	Description
Tampa TMC	The traffic management center operated by the COT
HART Transit Central	The 'HART Transit Central' hosts central software applications monitoring HART bus operations. This system provides bus schedule status information
TMC Operator	The human operator at the traffic management center of the City of Tampa
THEA Master Server	The central server monitoring the roadside units and collecting traffic data operated by the Tampa Hillsborough Expressway Authority (THEA)
Traffic Signal Controllers	The traffic signal controller deployed in the field controlling the traffic lights

Name	Description
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies such as cellular, WiFi and Bluetooth. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
RSU GPS	The 'RSU GPS' provides position and time information for roadside equipment devices. The Global Positioning System (GPS) Receiver provides location and time within the accuracy constraints inherent to GPS technology.
Traditional Vehicle Detector	A traditional vehicle detector providing vehicle presence information. Depending on the type further information like count, occupancy and speed may also be available.
Light Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. For light vehicles, the OBU includes an HMI In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
Driver	The 'Driver' represents the person that operates a vehicle on the roadway. Included are operators of private, transit, commercial, and emergency vehicles where the interactions are not particular to the type of vehicle (e.g., interactions supporting vehicle safety applications). The Driver originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification. Information and interactions which are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered by separate objects.
Vehicle OBU GPS	The 'Vehicle OBU GPS' provides position and time information for vehicle-based mobile devices. The Global Positioning System (GPS) Receiver provides location and time within the accuracy constraints inherent to GPS technology.

Name	Description
HART Bus OBU	The 'HART Bus OBU' is installed onboard a HART bus. It hosts the standard vehicle basic safety applications. Additionally, it also runs transit applications that provide priority service to buses at signalized intersections among other things.
Bus Operator	The 'Bus Operator' represents the person that receives and provides additional information that is specific to operating the ITS functions in all types of HART transit vehicles. The information received by the operator would include status of on-board systems. Additional information received depends upon the type of transit vehicle. In the case of fixed route transit vehicles, the Transit Vehicle Operator would receive operator instructions that might include actions to take to correct schedule deviations. In the case of flexible fixed routes and demand response routes the information would also include dynamic routing or passenger pickup information.
Remote Vehicle OBUs	'Remote Vehicle OBUs' represents other connected vehicles that are communicating with the host vehicle. This includes all connected motorized vehicles including passenger cars, trucks, and motorcycles and specialty vehicles (e.g., maintenance vehicles, transit vehicles) that also include the basic 'Vehicle OBU' functionality that supports V2V communications. In CVRIA, this object provides a source and destination for information transfers between connected vehicles. The host vehicle on-board equipment, represented by the Vehicle OBU physical object, sends information to, and receives information from the Remote Vehicle OBUs to model all connected vehicle V2V communications in CVRIA.
TECO Streetcar OBU	The 'TECO Streetcar OBU' is installed onboard a TECO streetcar. It hosts the standard vehicle basic safety applications. Additionally, it runs applications that provide safety for detecting and warning of pedestrians in the crosswalk as well as vehicles turning right in front of a streetcar.
Streetcar Carmen	The 'Streetcar Carmen' represents the person that receives and provides additional information that is specific to operating the ITS functions in a streetcar. This would include warning messages about vehicles turning right in front of the streetcar and also pedestrians being in potential conflict with the streetcar's path. The information received by the operator would include status of on-board systems as well.
USDOT Prototype SCMS	USDOT-provided Security Credential Management System (SCMS) prototype to be used by the CV pilots. See corresponding USDOT specification documents for details.
Pedestrian	For the study pedestrians will be equipped with PIDs. Per Florida statute, cyclists are considered to be pedestrians.
Pedestrian Detector	A sensor system detecting pedestrians and their location. For example this could be a LiDAR system providing accurate pedestrian location and movement data.
RDE	USDOT Data Archive
CUTR Researchers	Center for Urban Transportation Research, University of South Florida
USDOT Affiliated Researchers	USDOT Connected Vehicle researchers with access to the Research Data Exchange

Source: THEA

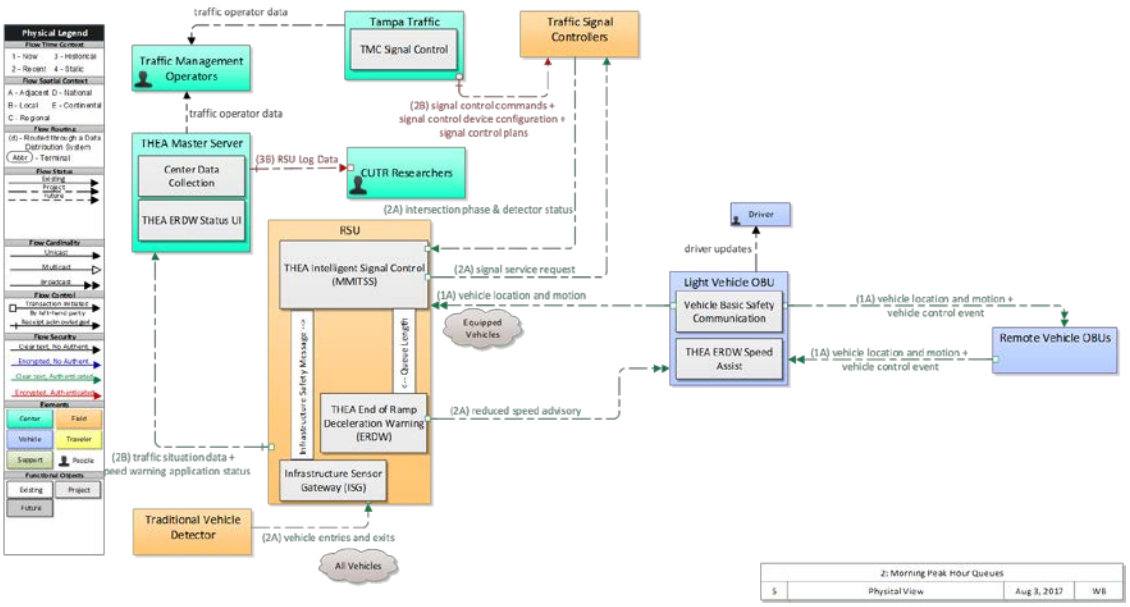
Table 16: Information Flows

Flow Name	Description	Standard
Center to Field	A communications link that provides communications between centers and field devices. It may be implemented using a variety of public or private communication networks and technologies.	NTCIP 1202 v2
Field to Field	Communications between field devices, including RSEs and traditional ITS equipment such as traffic signal controllers.	V2I Hub ICD
Human Machine Interface	Interface between a person and a device. Can be a user interface to a computer system, an operator interface, or the driver's interface to a vehicle.	None, visual and/or haptic
Position Location Interface	Interface between position location equipment and an ITS device that uses location information. This typically represents the interface between GPS equipment and a vehicle or mobile device, but it covers any interface between a location provider and a location consumer application.	NMEA 0183
Short-Range Wireless	A wireless communications channel used for close-proximity communications between vehicles and between vehicles and/or personal information devices and the immediate infrastructure.	802.11p DSRC
Vehicle On-Board	Communications between components within an individual vehicle. This may represent communications across an intelligent vehicle bus or any other communications medium internal to the vehicle.	Bluetooth
Wide-Area Wireless	A wireless communications system that offers broad coverage, enabling communications with vehicles and traveler mobile devices at any location on or off the road network. Note that a broad, relatively dense network of interconnected RSEs could also satisfy the requirements for this link.	LTE or other to be determined during detailed design
Master Server to TMC Operators	Access by TMC operators to RSU management, such as RSU status, RSU maintenance, PDETM data such as vehicle counts, speeds, travel times created by BSMs.	Remote access to be determined in detailed design

Source: THEA

4.3.1 Use Case 1 Morning Backups

Figure 42: Use Case 1 - Morning Backups – Physical Architecture



Source: THEA

Table 17: Use Case 1 - Morning Backups - Elements and Applications

Name	Description
TMC Operator	The human operator at the traffic management center of the City of Tampa
Tampa TMC	The traffic management center operated by the COT
TMC Signal Control	The central system used by COT to monitor and control intersection controllers
Traffic Signal Controllers	The traffic signal controller deployed in the field controlling the traffic lights
THEA Master Server	The central server monitoring the roadside units and collecting traffic data operated by the Tampa Hillsborough Expressway Authority (THEA)
Center Data Collection	'Center Data Collection' collects and stores information that it receives from RSUs. The data is stored securely and made available to the ODE for further processing.
THEA ERDW Status UI	The ERDW user interface displays status of the ERDW such as current queue length to the operator.

Name	Description
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
Infrastructure Sensor Message (ISM)	The I-SIG application sends an ISM message for unequipped vehicles detected by a traditional vehicle detector to I-SIG.
THEA End of Ramp Deceleration Warning (ERDW)	See application descriptions in Section 4.2.1
THEA Intelligent Signal Control (MMITSS)	The THEA Intelligent Signal Control (I-SIG) application is a deployment of the Multi-Modal Intelligent Traffic Signal System (MMITSS) developed by the University of Arizona. MMITSS aims to control traffic at an intersection by using CV data and combining it with available traditional detector data. MMITSS also has the ability to handle priority service requests for transit vehicles (e.g. buses).
Traditional Vehicle Detector	A traditional vehicle detector providing vehicle presence information. Depending on the type further information like count, occupancy and speed may also be available.
Driver	The 'Driver' represents the person that operates a vehicle on the roadway. Included are operators of private, transit, commercial, and emergency vehicles where the interactions are not particular to the type of vehicle (e.g., interactions supporting vehicle safety applications). The Driver originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification. Information and interactions which are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered by separate objects.

Name	Description
Light Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
Vehicle Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. This feature is also often referred to as 'Forward Collision Warning' (FCW) and 'Intersection Movement Assist' (IMA). If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) is also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices (VAD) that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.
THEA ERDW Speed Assist	'THEA ERDW Speed Assist' assists the driver in operating the vehicle and approach the end of a queue on the ramp at safe speeds for stopping. The current speed recommendation is displayed. Driver warnings are issued when unsafe or excessive speeds are detected based on the provided speed recommendation.

Name	Description
Remote Vehicle OBUs	'Remote Vehicle OBUs' represents other connected vehicles that are communicating with the host vehicle. This includes all connected motorized vehicles including passenger cars, trucks, and motorcycles and specialty vehicles (e.g., maintenance vehicles, transit vehicles) that also include the basic 'Vehicle OBU' functionality that supports V2V communications. In CVRIA, this object provides a source and destination for information transfers between connected vehicles. The host vehicle on-board equipment, represented by the Vehicle OBU physical object, sends information to, and receives information from the Remote Vehicle OBUs to model all connected vehicle V2V communications in CVRIA.

Source: THEA

Table 18: Use Case 1 - Morning Backups- Information Flows

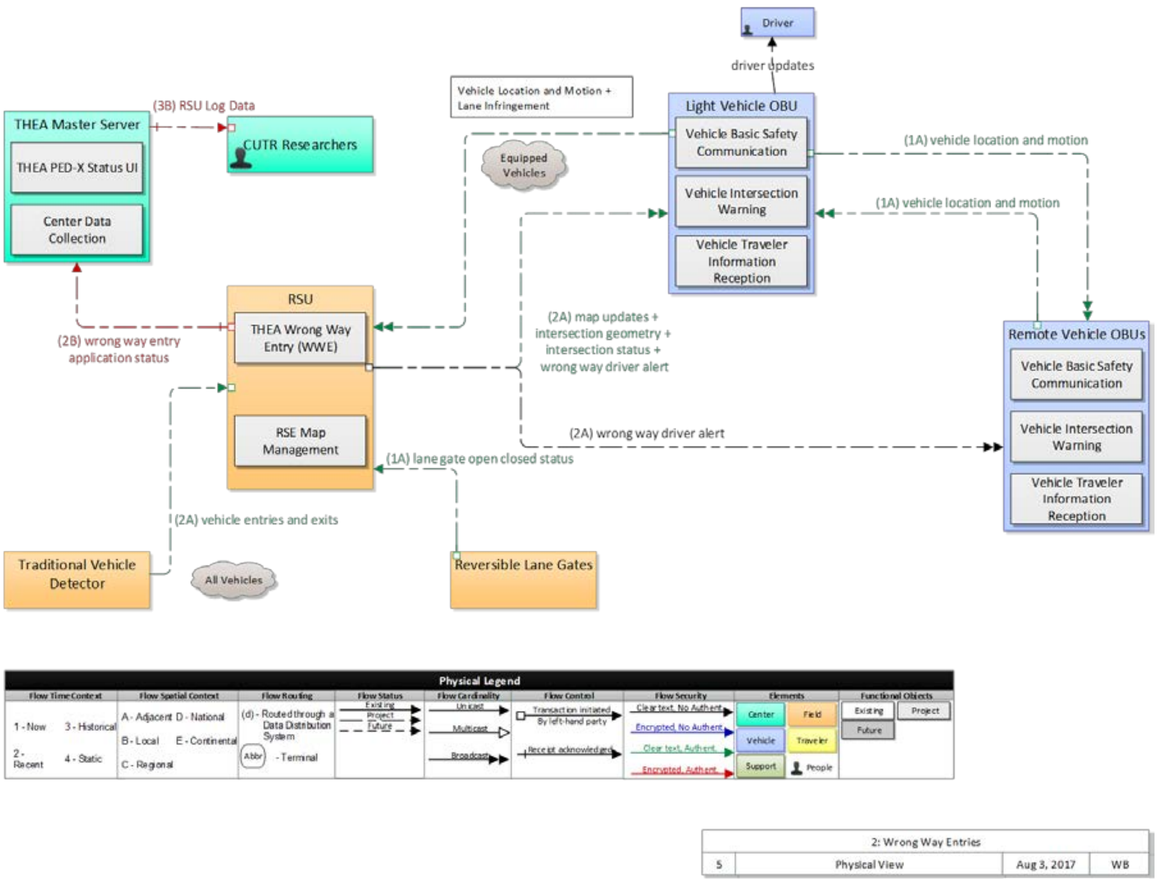
Flow Name	Description
Driver Updates	Information provided to the driver including visual displays, audible information and warnings, and haptic feedback. The updates inform the driver about current conditions, potential hazards, and the current status of vehicle on-board equipment.
Intersection Phase & Detector Status	Status data provided by the traffic signal controller including phase information, detector information (e.g. volume), alarm status, and priority/preempt status.
Detected Vehicle Location and Motion	Data describing a vehicle's approximate location derived from the fact that it just passed a traditional vehicle detector. If the detector also provides single vehicle speed, then speed will also be provided.
Reduced Speed Advisory	Reduced speed advisory zone information provided to passing vehicles. This flow provides the reduced speed advisory, the location and extent of the reduced speed zone, and associated warning information.
Reduced Speed Warning Status	Speed warning application status reported by the RSE. This includes current operational state and status of the RSE and a record of measured vehicle speeds and notifications, alerts, and warnings issued.
RSU Log Data	Log data sent by the RSU to the Master Server consisting of Wave Short Messages (WSMs) received and sent by the RSU, safety logs from PIDs, and OBU data logs. WSMs are protocol messages of the WAVE standard
Signal Control Commands	Control of traffic signal controllers or field masters including clock synchronization.
Signal Control Device Configuration	Data used to configure traffic signal control equipment including local controllers and system masters.
Signal Control Plans	Traffic signal timing parameters including minimum green time and interval durations for basic operation and cycle length, splits, offset, phase sequence, etc. for coordinated systems.
Signal Service Request	A call for service or extension for a signal control phase that is issued by the RSE for connected vehicles approaching an intersection and/or pedestrians at a crosswalk. This flow identifies the desired phase and service time.

Flow Name	Description
Traffic Operator Data	Presentation of traffic operations data to the operator including traffic conditions, current operating status of field equipment, maintenance activity status, incident status, video images, security alerts, emergency response plan updates and other information. This data keeps the operator appraised of current road network status, provides feedback to the operator as traffic control actions are implemented, provides transportation security inputs, and supports review of historical data and preparation for future traffic operations activities.
Traffic Situation Data	Current, aggregate traffic data collected from connected vehicles that can be used to supplement or replace information collected by roadside traffic detectors. It includes raw and/or processed reported vehicle speeds, counts, and other derived measures. Raw and/or filtered vehicle control events may also be included to support incident detection.
Vehicle Control Event	Notification that the vehicle has performed an emergency maneuver that could impact the safety of surrounding vehicles. This includes hard braking and activation of traction/stability control systems or other maneuvers that warrant immediate notification of surrounding vehicles. The information flow conveys the current vehicle location, path, and current control actions.
Vehicle Entries and Exits	Information exchanged between an RSE and ITS Roadway Equipment that supports detection of non-equipped vehicles in an automated lane, low emissions zone, or other facility where V2I communications is used to monitor vehicles at entry or exit points. This exchange also supports identification of non-equipped vehicles where an RSE is used for payment collection. This generic exchange can be implemented by any approach that compares vehicle detections with V2I communications by the RSE to identify vehicles that are not equipped or are otherwise unable to communicate with the RSE.
Vehicle Location and Motion	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.
Vehicle Location and Motion For Surveillance	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size. This flow represents monitoring of basic safety data ('vehicle location and motion') broadcast by passing connected vehicles for use in vehicle detection and traffic monitoring applications.

Source: THEA

4.3.2 Use Case 2 Wrong Way Entries

Figure 43: Use Case 2 – Wrong Way Entries – Physical Architecture



Source: THEA

Table 19: Use Case 2 – Wrong Way Entries – Elements and Applications

Name	Description
THEA Master Server	The central server monitoring the roadside units and collecting traffic data operated by the Tampa Hillsborough Expressway Authority (THEA)
Center Data Collection	'Center Data Collection' collects and stores information that it receives from RSUs. The data is stored securely and made available to the ODE for further processing.
THEA WWE Status UI	'THEA WWE Status UI' displays status information from the THEA WWE application to the user. This includes alerts regarding any recent wrong way incident detected.

Name	Description
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
THEA Wrong Way Entry (WWE)	'THEA Wrong Way Entry' application receives detector input from a traditional vehicle detector which senses vehicles driving / entering the intersection ingress the wrong-way. It alerts other drivers within the vicinity of the safety threat via DSRC.
RSE Map Management	'RSE Map Management' provides the map functionality necessary to support map data updates to passing vehicles. It collects current map and geometry data and provides current map and geometry data to connected vehicles. This information is used by the Vehicle Basic Safety application to detect wrong way driving.
Traditional Vehicle Detector	A traditional vehicle detector providing vehicle presence information. Depending on the type further information like count, occupancy and speed may also be available.
Reversible Lane Gates	The gates blocking access to the expressway ramp when operating in inbound traffic mode. The gates provide a status indication of whether they are open or closed.
Driver	The 'Driver' represents the person that operates a vehicle on the roadway. Included are operators of private, transit, commercial, and emergency vehicles where the interactions are not particular to the type of vehicle (e.g., interactions supporting vehicle safety applications). The Driver originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification. Information and interactions which are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered by separate objects.

Name	Description
Light Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
Vehicle Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. This feature is also often referred to as 'Forward Collision Warning' (FCW) and 'Intersection Movement Assist' (IMA). If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) is also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices (VAD) that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.
Vehicle Intersection Warning	'Vehicle Intersection Warning' uses V2V and V2I communications to monitor other connected vehicles at intersections and support the safe movement of the vehicle through the intersection. Driver warnings are provided and the application may also optionally take control of the vehicle to avoid collisions. The application will also notify the infrastructure and other vehicles if it detects an unsafe infringement on the intersection. In the THEA context, this application detects the wrong way driving infringement.
Vehicle Traveler Information Reception	'Vehicle Traveler Information Reception' provides the capability for drivers to receive general transportation information including traffic and road conditions, incident information, maintenance and construction information, event information, transit information, parking information, weather information, and broadcast alerts. In this use case this application warns the driver of a wrong way driver in the vicinity.

Name	Description
Remote Vehicle OBUs	'Remote Vehicle OBUs' represents other connected vehicles that are communicating with the host vehicle. This includes all connected motorized vehicles including passenger cars, trucks, and motorcycles and specialty vehicles (e.g., maintenance vehicles, transit vehicles) that also include the basic 'Vehicle OBU' functionality that supports V2V communications. In CVRIA, this object provides a source and destination for information transfers between connected vehicles. The host vehicle on-board equipment, represented by the Vehicle OBU physical object, sends information to, and receives information from the Remote Vehicle OBUs to model all connected vehicle V2V communications in CVRIA.

Source: THEA

Table 20: Use Case 2 – Wrong Way Entries – Information Flows

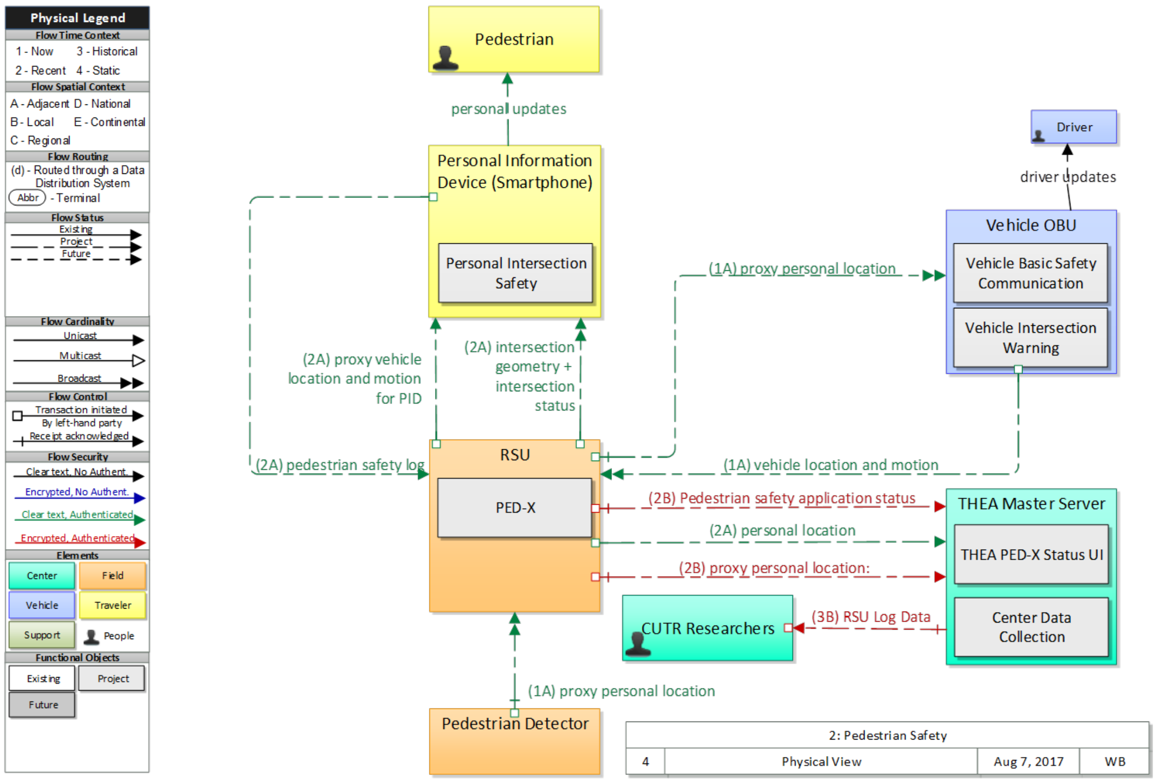
Flow Name	Description
Driver Updates	Information provided to the driver including visual displays, audible information and warnings, and haptic feedback. The updates inform the driver about current conditions, potential hazards, and the current status of vehicle on-board equipment.
Intersection Geometry	The physical geometry of an intersection covering the location and width of each approaching lane, egress lane, and valid paths between approaches and egresses. This flow also defines the location of stop lines, cross walks, specific traffic law restrictions for the intersection (e.g., turning movement restrictions), and other elements that support calculation of a safe and legal vehicle path through the intersection.
Intersection Infringement Info	Vehicle path information sent by a vehicle that is performing an unpermitted movement at an intersection such as a stop sign violation or running a red light.
Intersection Status	Current signal phase and timing information for all lanes at a signalized intersection. This flow identifies active lanes and lanes that are being stopped and specifies the length of time that the current state will persist for each lane. It also identifies signal priority and preemption status and pedestrian crossing status information where applicable.
Lane Gate Open Closed Status	Status of the gates blocking outbound lanes at Selmon Expressway access ramp at intersection Meridian / Twiggs. Lanes are closed when gates are closed. Lanes are open when gates are open.
Map Updates	Map update which could include a new underlying static or real-time map or map layer(s) update.

Flow Name	Description
RSU Log Data	Log data sent by the RSU to the master server consisting of WSMs received and sent by the RSU, safety logs from PIDs, OBU data logs
Vehicle Entries and Exits	Information exchanged between an RSE and ITS Roadway Equipment that supports detection of non-equipped vehicles in an automated lane, low emissions zone, or other facility where V2I communications is used to monitor vehicles at entry or exit points. This exchange also supports identification of non-equipped vehicles where an RSE is used for payment collection. This generic exchange can be implemented by any approach that compares vehicle detections with V2I communications by the RSE to identify vehicles that are not equipped or are otherwise unable to communicate with the RSE.
Vehicle Location and Motion	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.
Vehicle Location and Motion For Surveillance	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size. This flow represents monitoring of basic safety data ('vehicle location and motion') broadcast by passing connected vehicles for use in vehicle detection and traffic monitoring applications.
Wrong Way Driver Alert	Wrong way driver alert. This flow includes information about a wrong way driver incident in the vicinity and may also contain the location of the infringing vehicle.
Wrong Way Entry Application Status	Wrong way entry safety application status reported by the RSE. This includes current operational state and status of the RSE and a record of wrong way entry incidents identified and alerts and warnings issued.

Source: THEA

4.3.3 Use Case 3 Pedestrian Safety

Figure 44: Use Case 3 – Pedestrian Safety – Physical Architecture



Source: THEA

Table 21: Use Case 3 – Pedestrian Safety – Elements and Applications

Name	Description
Pedestrian	'Pedestrians' participate in connected vehicle applications that support safe, shared use of the transportation network by motorized and non-motorized transportation modes. Representing those using non-motorized travel modes, pedestrians provide input (e.g. a call signal requesting right of way at an intersection) and may be detected by connected vehicle applications to improve safety. Note that pedestrians represent all non-motorized users, including bicyclists.
Pedestrian Detector	The 'Pedestrian Detector provides the capability to detect all pedestrians within the crosswalk. The detector (LIDAR) communicates with nearby RSUs using ethernet. This enables the detector to exchange messages with vehicles that use Dedicated Short-Range Communications (DSRC) with the RSU acting as a gateway.

Name	Description
Personal Information Device	The 'Personal Information Device' (PID) provides the capability for pedestrians to run CV applications which communicate with nearby RSUs using WiFi. This enables PIDs like a standard Android smartphone to exchange messages with vehicles that use Dedicated Short-Range Communications (DSRC) with the RSU acting as a gateway.
Personal Pedestrian Safety	The 'Personal Pedestrian Safety' application improves pedestrian safety by providing pedestrian location information to the infrastructure that can be used to avoid collisions involving pedestrians. The application may also alert the pedestrian of unsafe conditions, augmenting or extending information provided by signals and signs. The information provided and the user interface delivery mechanism (visual, audible, or haptic) can also be tailored to the needs of the user that is carrying or wearing the device that hosts the application. In the context of THEA this application is also called PED-X.
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
PED-X	Application which will send out a DSRC personal safety message (PSM) on behalf of pedestrian detected by the sensor system (e.g. LiDAR). This application also communicates with the PID which is connected to the RSU via WiFi. The application will forward any received basic safety messages (BSM) from OBUs to the PID. This application also provides the PID with map information about the intersection including nearby crosswalks.
Driver	The 'Driver' represents the person that operates a vehicle on the roadway. Included are operators of private, transit, commercial, and emergency vehicles where the interactions are not particular to the type of vehicle (e.g., interactions supporting vehicle safety applications). The Driver originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification. Information and interactions which are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered by separate objects.

Name	Description
Light Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
Vehicle Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. This feature is also often referred to as 'Forward Collision Warning' (FCW) and 'Intersection Movement Assist' (IMA). If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) is also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices (VAD) that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.
Vehicle Intersection Warning	'Vehicle Intersection Warning' uses V2V and V2I communications to monitor other connected vehicles at intersections and support the safe movement of the vehicle through the intersection. Driver warnings are provided and the application may also optionally take control of the vehicle to avoid collisions. The application will also notify the infrastructure and other vehicles if it detects an unsafe infringement on the intersection. In the THEA context this application detects the wrong way driving infringement.

Source: THEA

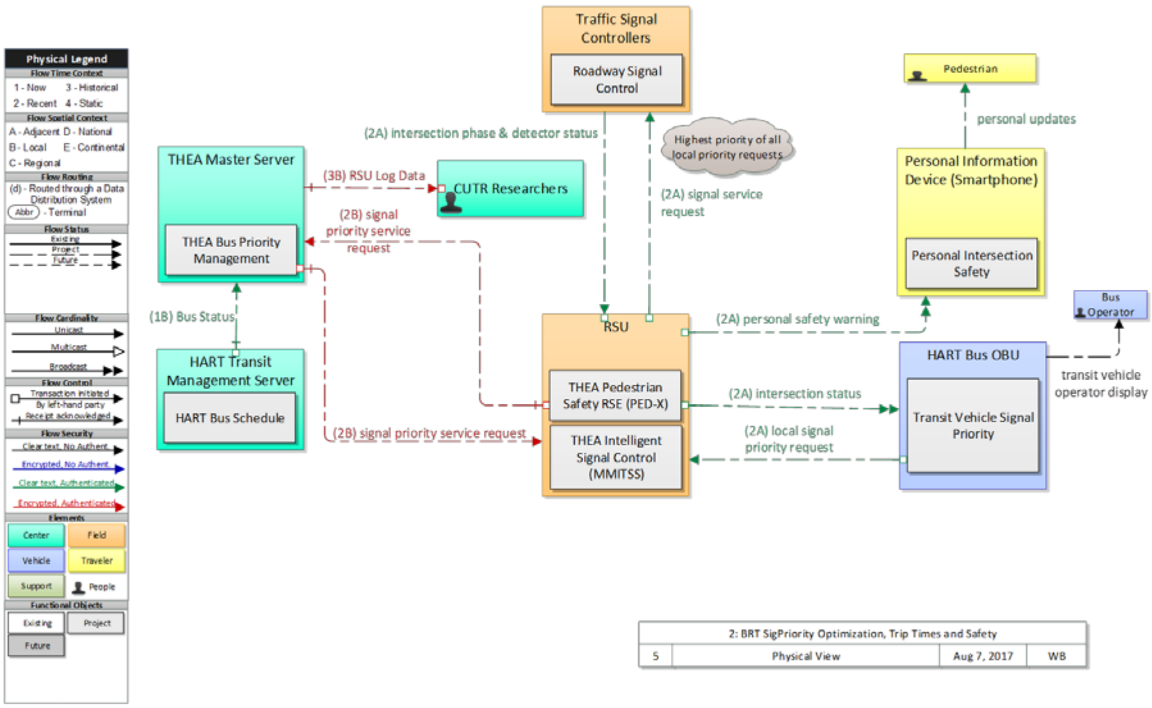
Table 22: Use Case 3 – Pedestrian Safety – Information Flows

Flow Name	Description
Driver Updates	Information provided to the driver including visual displays, audible information and warnings, and haptic feedback. The updates inform the driver about current conditions, potential hazards, and the current status of vehicle on-board equipment.
Intersection Geometry	The physical geometry of an intersection covering the location and width of each approaching lane, egress lane, and valid paths between approaches and egresses. This flow also defines the location of stop lines, cross walks, specific traffic law restrictions for the intersection (e.g., turning movement restrictions), and other elements that support calculation of a safe and legal vehicle path through the intersection.
Pedestrian Safety Log	Log data from the PID including PID location and collision alerts calculated by the PID.
Personal Location	The current location (latitude, longitude, and elevation) reported by the personal information device
Personal Updates	Personal information, alerts, and warnings provided to pedestrians, work crew members, and other individuals in a mixed use area. This includes visual, audio, and haptic outputs that may be customized to support individual needs.
PSM	Data forwarded from the RSU to the PID for a vehicle describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.
RSU Log Data	Log data sent by the RSU to the master server consisting of WSMs received and sent by the RSU, safety logs from PIDs, OBU data logs
Vehicle Location and Motion	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.

Source: THEA

4.3.4 Use Case 4 Transit Signal Priority

Figure 45: Use Case 4 – Transit Signal Priority – Physical Architecture



Source: THEA

Table 23: Use Case 4 – Transit Signal Priority – Elements and Applications

Name	Description
HART Transit Central	The 'HART Transit Central' hosts central software applications monitoring HART bus operations.
THEA Bus Priority Management	'THEA Bus Priority Management' receives current bus schedule adherence status from the HART Transit Management Server. It handles priority requests for buses received from RSUs and determines if the priority request should be granted. It then returns the decision to the RSU.
HART Bus Schedule	HART owned and operated system for monitoring bus location and schedule adherence. This system provides current schedule deviation for HART buses.
Traffic Signal Controllers	The traffic signal controller deployed in the field controlling the traffic lights

Name	Description
Roadway Signal Control	'Roadway Signal Control' includes the field elements that monitor and control signalized intersections. It includes the traffic signal controllers, detectors, conflict monitors, signal heads, and other ancillary equipment that supports traffic signal control. It also includes field masters, and equipment that supports communications with a central monitoring and/or control system, as applicable. The communications link supports upload and download of signal timings and other parameters and reporting of current intersection status. It represents the field equipment used in all levels of traffic signal control from basic actuated systems that operate on fixed timing plans through adaptive systems. It also supports all signalized intersection configurations, including those that accommodate pedestrians. In advanced, future implementations, environmental data may be monitored and used to support dilemma zone processing and other aspects of signal control that are sensitive to local environmental conditions.
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
THEA Pedestrian Safety RSE (PED-X)	'PED-X' informs pedestrians (PIDs) that a bus or streetcar is stopping or starting in the intersection.
THEA Intelligent Signal Control (MMITSS)	The THEA Intelligent Signal Control (I-SIG) application is a deployment of the Multi-Modal Intelligent Traffic Signal System (MMITSS) developed by the University of Arizona. MMITSS aims to control traffic at an intersection by using CV data and combining it with available traditional detector data. MMITSS also has the ability to handle priority service requests for transit vehicles (e.g. buses).
Pedestrian	'Pedestrians' participate in connected vehicle applications that support safe, shared use of the transportation network by motorized and non-motorized transportation modes. Representing those using non-motorized travel modes, pedestrians provide input (e.g. a call signal requesting right of way at an intersection) and may be detected by connected vehicle applications to improve safety. Note that pedestrians represent all non-motorized users, including bicyclists.
Personal Information Device	The 'Personal Information Device' (PID) provides the capability for pedestrians to run CV applications which communicate with nearby RSUs using WiFi. This enables PIDs like a standard Android smartphone to exchange messages with vehicles that use Dedicated Short-Range Communications (DSRC) with the RSU acting as a gateway.

Name	Description
Personal Pedestrian Safety	The 'Personal Pedestrian Safety' application improves pedestrian safety by providing pedestrian location information to the infrastructure that can be used to avoid collisions involving pedestrians. The application may also alert the pedestrian of unsafe conditions, augmenting or extending information provided by signals and signs. The information provided and the user interface delivery mechanism (visual, audible, or haptic) can also be tailored to the needs of the user that is carrying or wearing the device that hosts the application. In the context of THEA this application is also called PED-X.
HART Bus OBU	The 'HART Bus OBU' is installed onboard a HART bus. It hosts the standard vehicle basic safety applications. Additionally, it also runs transit applications that provide priority service to buses at signalized intersections among other things.
Transit Vehicle Signal Priority	'Transit Vehicle Signal Priority' provides the capability for transit vehicles to determine eligibility for priority and request signal priority at signalized intersections, ramps, and interchanges through short-range communication with traffic control equipment at the roadside. When granted, priority extends the green time when the bus is behind schedule.
Bus Operator	The 'Bus Operator' represents the person that receives and provides additional information that is specific to operating the ITS functions in all types of transit vehicles. The information received by the operator would include status of on-board systems. Additional information received depends upon the type of transit vehicle. In the case of fixed route transit vehicles, the Transit Vehicle Operator would receive operator instructions that might include actions to take to correct schedule deviations. In the case of flexible fixed routes and demand response routes the information would also include dynamic routing or passenger pickup information.

Source: THEA

Table 24: Use Case 4 – Transit Signal Priority – Information Flows

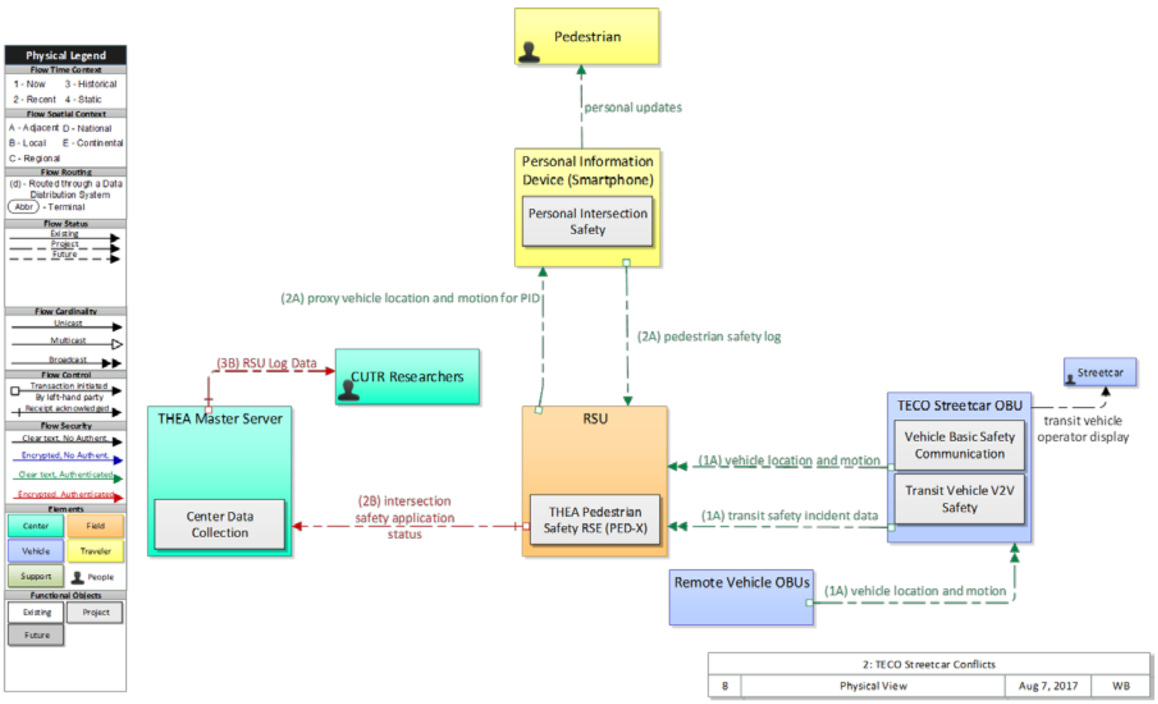
Flow Name	Description
Intersection Phase & Detector Status	Status data provided by the traffic signal controller including phase information, detector information (e.g. volume), alarm status, and priority/preempt status.
Intersection Status	Current signal phase and timing information for all lanes at a signalized intersection. This flow identifies active lanes and lanes that are being stopped and specifies the length of time that the current state will persist for each lane. It also identifies signal priority and preemption status and pedestrian crossing status information where applicable.
Local Signal Priority Request	Request from a vehicle to a signalized intersection for priority at that intersection. This flow also allows the vehicle to cancel a priority request (for example, when the vehicle clears the intersection).

Flow Name	Description
Personal Safety Warning	Safety alerts and warnings provided to a personal information device. The provided information would identify safety threats (e.g., vehicle encroachment into a work area, personal infringement into a travel lane)
Personal Updates	Personal information, alerts, and warnings provided to pedestrians, work crew members, and other individuals in a mixed-use area. This includes visual, audio, and haptic outputs that may be customized to support individual needs.
Rsu Log Data	Log data sent by the RSU to the master server consisting of WSMs received and sent by the RSU, safety logs from PIDs, and OBU data logs
Signal Priority Service Request	A service request for vehicle priority issued to a traffic signal controller that results in green extension or other accommodation for the priority vehicle, within the current signal timing plan. The request includes the priority level, the desired time and duration of service, and the intended travel path through the intersection. This flow also allows the RSE to cancel a previously issued request for priority.
Signal Service Request	A call for service or extension for a signal control phase that is issued by the RSE for connected vehicles approaching an intersection and/or pedestrians at a crosswalk. This flow identifies the desired phase and service time.
Transit Vehicle Location Data	Current transit vehicle location and related operational conditions data provided by a transit vehicle.
Transit Vehicle Operator Display	Visual, audible, and tactile outputs to the transit vehicle operator including vehicle surveillance information, alarm information, vehicle system status, information from the operations center, and information indicating the status of all other on-board ITS services.

Source: THEA

4.3.5 Use Case 5 Streetcar Conflicts

Figure 46: Use Case 5 - Streetcar Conflicts – Physical Architecture



Source: THEA

Table 25: Use Case 5 - Streetcar Conflicts – Elements and Applications

Name	Description
THEA Master Server	The central server monitoring the roadside units and collecting traffic data operated by the Tampa Hillsborough Expressway Authority (THEA)
Center Data Collection	'Center Data Collection' collects and stores information that it receives from RSUs (RSU Log Data). The data is stored securely and made available to the ODE for further processing.
Pedestrian	'Pedestrians' participate in connected vehicle applications that support safe, shared use of the transportation network by motorized and non-motorized transportation modes. Representing those using non-motorized travel modes, pedestrians provide input (e.g. a call signal requesting right of way at an intersection) and may be detected by connected vehicle applications to improve safety. Note that pedestrians represent all non-motorized users, including bicyclists.
Personal Information Device	The 'Personal Information Device' (PID) provides the capability for pedestrians to run CV applications which communicate with nearby RSUs using WiFi. This enables PIDs like a standard Android smartphone to exchange messages with vehicles that use Dedicated Short-Range Communications (DSRC) with the RSU acting as a gateway.

Name	Description
Personal Pedestrian Safety	The 'Personal Pedestrian Safety' application improves pedestrian safety by providing pedestrian location information to the infrastructure that can be used to avoid collisions involving pedestrians. The application may also alert the pedestrian of unsafe conditions, augmenting or extending information provided by signals and signs. The information provided and the user interface delivery mechanism (visual, audible, or haptic) can also be tailored to the needs of the user that is carrying or wearing the device that hosts the application. In the context of THEA this application is also called PED-X.
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
THEA Pedestrian Safety RSE (PED-X)	'PED-X' informs pedestrians (PIDs) that a streetcar is stopping or starting in the intersection. It further picks up any transit-related conflict warnings issued by streetcar OBUs and sends them to the master server (e.g. vehicle turning right in front of streetcar warning issued by streetcar).
TECO Streetcar OBU	The 'TECO Streetcar OBU' is installed onboard a TECO streetcar. It hosts the standard vehicle basic safety applications. Additionally, it also runs applications that provide additional safety for detecting and warning of pedestrians in the crosswalk as well as vehicles turning right in front of the streetcar.
Vehicle Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) are also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.

Name	Description
Transit Vehicle V2V Safety	'Transit Vehicle V2V Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to predict vehicle paths, and notifies the driver when the potential for an impending collision is detected. Information from on-board sensors (e.g., radars and image processing) are used to augment the V2V communications, if available. In addition to notifying the driver, control information can also be provided to support automated control functions that can avoid the collision. This object is similar to the 'Vehicle Basic V2V Safety', but it accounts for crash scenarios that are unique to transit vehicles (e.g., Vehicle Turning Right in Front of Bus). It is also stop-aware since stop locations pose specific crash threats for transit vehicles. Finally, the detection and control algorithms, filters, and timing account for bus performance and risk profiles associated with remote vehicles that are unique to transit.
Streetcar Carmen	‘The Streetcar Carmen’ represents the person that receives and provides additional information that is specific to operating the ITS functions in a streetcar. This would include warning messages about vehicles turning right in front of the streetcar and also pedestrians being in potential conflict with the streetcar’s path. The information received by the operator would include status of on-board systems as well.

Source: THEA

Table 26: Use Case 5 - Streetcar Conflicts – Information Flows

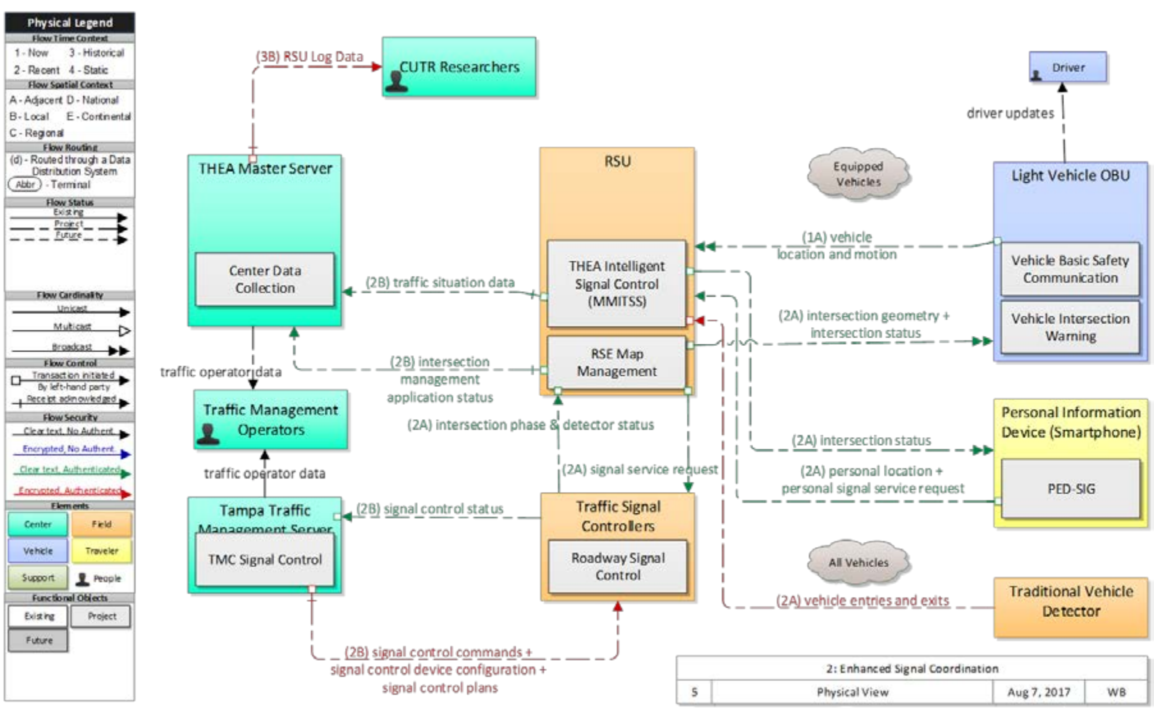
Flow Name	Description
Detected Vehicle Location and Motion For PID	Data forwarded from the RSU to the PID for a vehicle describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.
Intersection Safety Application Status	Infrastructure safety application status reported by the RSE. This includes current operational state and status of the RSE and a record of intersection safety issues identified and alerts and warnings issued.
Pedestrian Safety Log	Log data from the PID including PID location and collision alerts calculated by the PID.
Personal Safety Warning	Safety alerts and warnings provided to a personal information device. The provided information would identify safety threats (e.g., vehicle encroachment into a work area, personal infringement into a travel lane)
Personal Updates	Personal information, alerts, and warnings provided to pedestrians, work crew members, and other individuals in a mixed-use area. This includes visual, audio, and haptic outputs that may be customized to support individual needs.

Flow Name	Description
RSU Log Data	Log data sent by the RSU to the master server consisting of WSMs received and sent by the RSU, safety logs from PIDs, and OBU data logs
Transit Safety Incident Data	This flow represents safety incidents detected by the transit vehicle safety app onboard streetcars such as "vehicle turning right in front of transit vehicle".
Transit Vehicle Operator Display	Visual, audible, and tactile outputs to the transit vehicle operator including vehicle surveillance information, alarm information, vehicle system status, information from the operations center, and information indicating the status of all other on-board ITS services.
Vehicle Location and Motion	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size.

Source: THEA

4.3.6 Use Case 6 Traffic Progression

Figure 47: Use Case 6 - Traffic Progression – Physical Architecture



Source: THEA

Table 27: Use Case 6 - Traffic Progression – Elements and Applications

Name	Description
TMC Operator	The human operator at the traffic management center of the City of Tampa
THEA Master Server	The central server monitoring the roadside units and collecting traffic data operated by the Tampa Hillsborough Expressway Authority (THEA)
Center Data Collection	'Center Data Collection' collects and stores information that it receives from RSUs. The data is stored securely and made available to the ODE for further processing.
Tampa TMC	The traffic management center operated by the COT
TMC Signal Control	The central system used by COT to monitor and control intersection controllers
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
THEA Intelligent Signal Control (MMITSS)	The THEA Intelligent Signal Control (I-SIG) application is a deployment of the Multi-Modal Intelligent Traffic Signal System (MMITSS) developed by the University of Arizona. MMITSS aims to control traffic at an intersection by using CV data and combining it with available traditional detector data. MMITSS also has the ability to handle priority service requests for transit vehicles (e.g. buses).
Traditional Vehicle Detector	A traditional vehicle detector providing vehicle presence information. Depending on the type further information like count, occupancy and speed may also be available.
RSE Map Management	'RSE Map Management' provides the map functionality necessary to support map data updates to passing vehicles. It collects current map and geometry data and provides current map and geometry data to connected vehicles.
Traffic Signal Controllers	The traffic signal controller deployed in the field controlling the traffic lights

Name	Description
Roadway Signal Control	'Roadway Signal Control' includes the field elements that monitor and control signalized intersections. It includes the traffic signal controllers, detectors, conflict monitors, signal heads, and other ancillary equipment that supports traffic signal control. It also includes field masters, and equipment that supports communications with a central monitoring and/or control system, as applicable. The communications link supports upload and download of signal timings and other parameters and reporting of current intersection status. It represents the field equipment used in all levels of traffic signal control from basic actuated systems that operate on fixed timing plans through adaptive systems. It also supports all signalized intersection configurations, including those that accommodate pedestrians. In advanced, future implementations, environmental data may be monitored and used to support dilemma zone processing and other aspects of signal control that are sensitive to local environmental conditions.
Driver	The 'Driver' represents the person that operates a vehicle on the roadway. Included are operators of private, transit, commercial, and emergency vehicles where the interactions are not particular to the type of vehicle (e.g., interactions supporting vehicle safety applications). The Driver originates driver requests and receives driver information that reflects the interactions which might be useful to all drivers, regardless of vehicle classification. Information and interactions which are unique to drivers of a specific vehicle type (e.g., fleet interactions with transit, commercial, or emergency vehicle drivers) are covered by separate objects.
Light Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.

Name	Description
Vehicle Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. This feature is also often referred to as 'Forward Collision Warning' (FCW) and 'Intersection Movement Assist' (IMA). If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) is also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices (VAD) that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.
Vehicle Intersection Warning	'Vehicle Intersection Warning' uses V2V and V2I communications to monitor other connected vehicles at intersections and support the safe movement of the vehicle through the intersection. Driver warnings are provided and the application may also optionally take control of the vehicle to avoid collisions. The application will also notify the infrastructure and other vehicles if it detects an unsafe infringement on the intersection. In the THEA context, this application detects the wrong way driving infringement.

Source: THEA

Table 28: Use Case 6 - Traffic Progression – Information Flows

Flow Name	Description
Driver Updates	Information provided to the driver including visual displays, audible information and warnings, and haptic feedback. The updates inform the driver about current conditions, potential hazards, and the current status of vehicle on-board equipment.
Intersection Management Application Status	Infrastructure application status reported by the RSE. This includes current operational state and status of the RSE and a log of operations.
Intersection Phase & Detector Status	Status data provided by the traffic signal controller including phase information, detector information (e.g. volume), alarm status, and priority/preempt status.

Flow Name	Description
Intersection Safety Warning	A warning of an imminent unsafe vehicle infringement at an intersection that may endanger other vehicles or pedestrians. This allows vehicles approaching the intersection to be warned in the event of an imminent red light or stop sign violation or potential infringement on an occupied crosswalk. All connected vehicles at the intersection receive the warning, including both the infringing vehicle and other vehicles at or near the intersection.
RSU Log Data	Log data sent by the RSU to the master server consisting of WSMs received and sent by the RSU, safety logs from PIDs, OBU data logs
Signal Control Commands	Control of traffic signal controllers or field masters including clock synchronization.
Signal Control Device Configuration	Data used to configure traffic signal control equipment including local controllers and system masters.
Signal Control Plans	Traffic signal timing parameters including minimum green time and interval durations for basic operation and cycle length, splits, offset, phase sequence, etc. for coordinated systems.
Signal Control Status	Operational and status data of traffic signal control equipment including operating condition and current indications.
Signal Service Request	A call for service or extension for a signal control phase that is issued by the RSE for connected vehicles approaching an intersection and/or pedestrians at a crosswalk. This flow identifies the desired phase and service time.
Traffic Operator Data	Presentation of traffic operations data to the operator including traffic conditions, current operating status of field equipment, maintenance activity status, incident status, video images, security alerts, emergency response plan updates and other information. This data keeps the operator appraised of current road network status, provides feedback to the operator as traffic control actions are implemented, provides transportation security inputs, and supports review of historical data and preparation for future traffic operations activities.
Traffic Situation Data	Current, aggregate traffic data collected from connected vehicles that can be used to supplement or replace information collected by roadside traffic detectors. It includes raw and/or processed reported vehicle speeds, counts, and other derived measures. Raw and/or filtered vehicle control events may also be included to support incident detection.

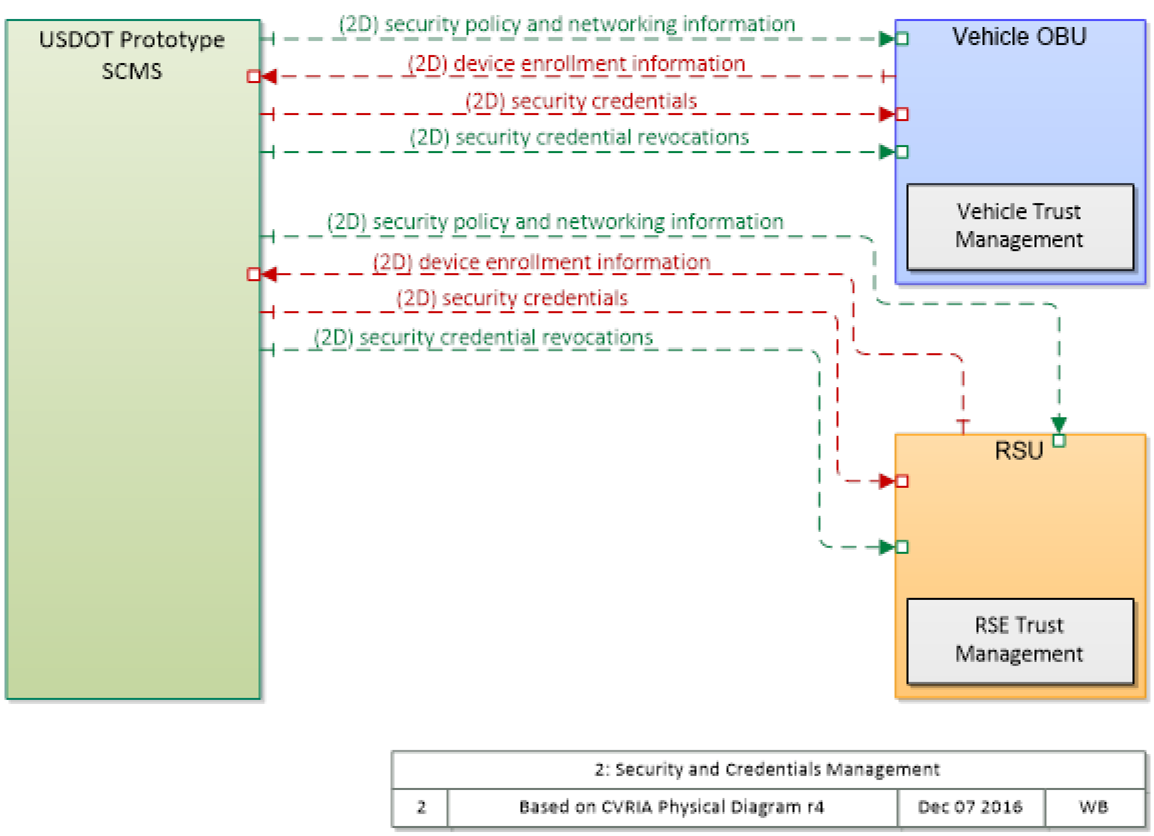
Flow Name	Description
Vehicle Location and Motion For Surveillance	Data describing the vehicle's location in three dimensions, heading, speed, acceleration, braking status, and size. This flow represents monitoring of basic safety data ('vehicle location and motion') broadcast by passing connected vehicles for use in vehicle detection and traffic monitoring applications.

Source: THEA

4.3.7 Security Architectural View

The Security Architectural View depicts how security is implemented using the third party SCMS.

Figure 48: Security Architecture View



Source: THEA

Table 29: Security Architecture - Elements and Applications

Name	Description
USDOT Prototype SCMS	USDOT-provided Security Credential Management System (SCMS) prototype to be used by the CV pilots. See corresponding USDOT specification documents for details.
Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
Vehicle Trust Management	'Vehicle Trust Management' manages the certificates and associated keys that are used to sign, encrypt, decrypt, and authenticate messages. It communicates with the Security and Credentials Management System to maintain a current, valid set of security certificates and identifies, logs, and reports events that may indicate a threat to the Connected Vehicle Environment security. The expectation is that USDOT will provide portable software for RSU and OBU manufacturers to integrate this functionality into their devices.
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.

Name	Description
RSE Trust Management	'RSE Trust Management' manages the certificates and associated keys that are used to sign, encrypt, decrypt, and authenticate messages. It communicates with the Security and Credentials Management System to maintain a current, valid set of security certificates and keys and identifies, logs, and reports events that may indicate a threat to Connected Vehicle Environment security. The expectation is that USDOT will provide portable software for RSU and OBU manufacturers to integrate this functionality into their devices.

Source: THEA

Table 30: Security Architecture - Information Flows

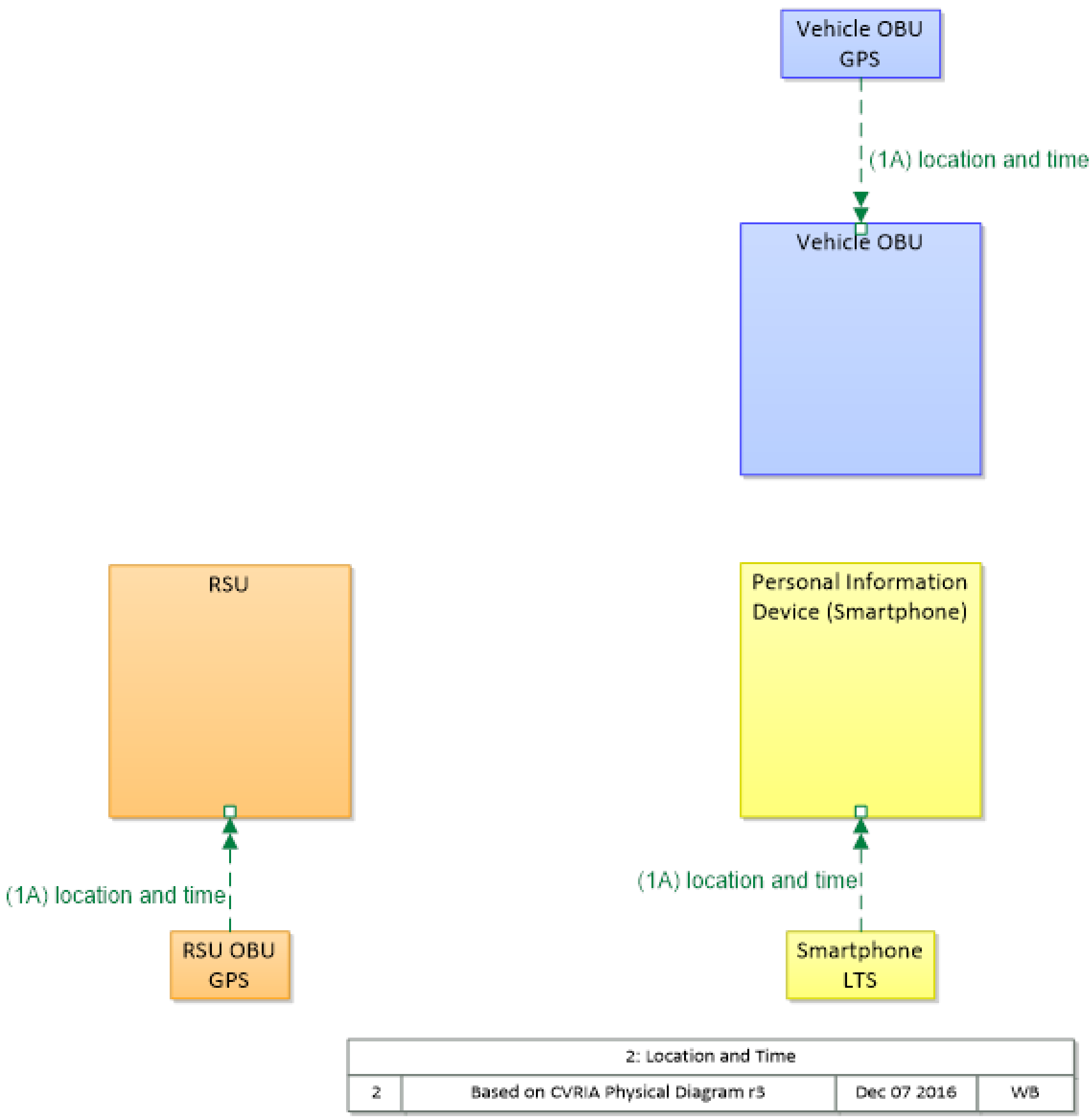
Flow Name	Description
Device Enrollment Information	Information provided by an end entity to support enrollment and authorization for the Connected Vehicle environment. This includes device identification, requested permissions and restrictions, and security credentials used to establish the current level of trust and eligibility for enrollment and authorization.
Security Credential Revocations	Certificate Revocation List; lists the certificates whose trust has been revoked by the CCMS.
Security Credentials	The material used by an end-entity (vehicle, personal device, field device, center system etc.) to ensure privacy, integrity and authenticity of its data transmissions. This includes certificates with associated public and private verifying/signing and decrypting/encrypting keys.
Security Policy and Networking Information	Security policy information describing the CCMS' enrollment, authorization, misbehavior and revocation policies, and communications information related to CCMS components; including contact information and public credentials of those components.

Source: THEA

4.3.8 Time and Location View

The Time and Location View describes how OBUs and RSUs will receive time.

Figure 49: Time and Location View



Source: THEA

Table 31: Time and Location - Elements and Applications

Name	Description
Vehicle OBU GPS	The 'Vehicle OBU GPS' provides position and time information for vehicle-based mobile devices. The Global Positioning System (GPS) Receiver provides location and time within the accuracy constraints inherent to GPS technology.
Vehicle OBU	The Vehicle On-Board Unit (OBU) provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications. In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.
RSU	'Roadside Unit' (RSU) represents the Connected Vehicle roadside devices that are used to send messages to, and receive messages from, nearby vehicles using Dedicated Short-Range Communications (DSRC) or other alternative wireless communications technologies. Communications with adjacent field equipment and back office centers that monitor and control the RSE are also supported. This device operates from a fixed position and may be permanently deployed or a portable device that is located temporarily in the vicinity of a traffic incident, road construction, or a special event. It includes a processor, data storage, and communications capabilities that support secure communications with passing vehicles, other field equipment, and centers.
RSU OBU GPS	The 'RSU OBU GPS' provides position and time information for roadside equipment devices. The Global Positioning System (GPS) Receiver provides location and time within the accuracy constraints inherent to GPS technology.
Smartphone LTS	The 'Smartphone LTS' provides position and time information for smartphones used as personal information devices (PIDs). Typically Smartphones receive their time from the cellular network but can also run on their own time source. Typically, Smartphones use a Global Positioning System (GPS) Receiver to get location within the accuracy constraints inherent to GPS technology and the quality of the GPS receiver used.

Source: THEA

Table 32: Time and Location - Information Flows

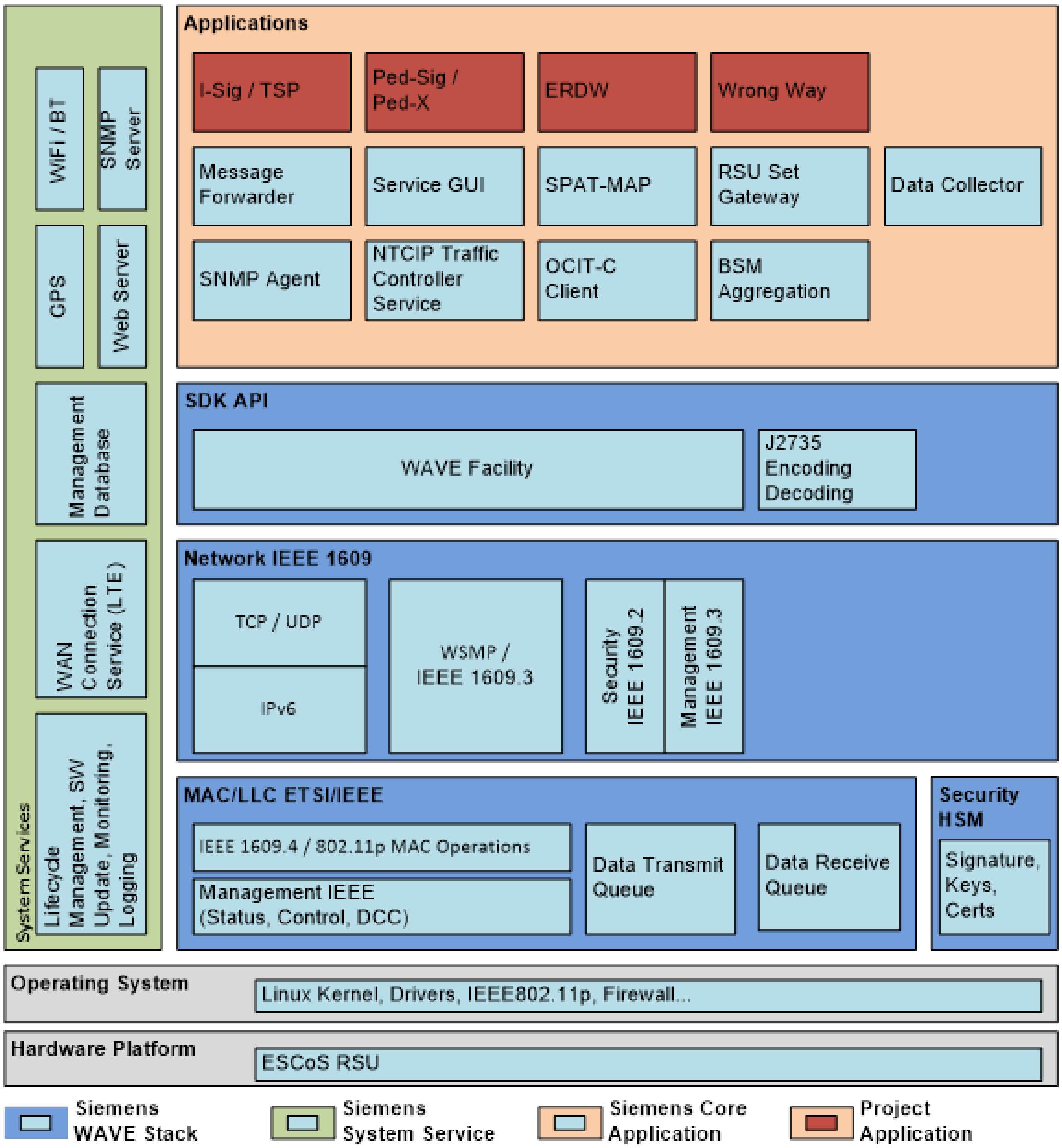
Flow Name	Description
Location and Time	The current geographic location in three dimensions (latitude, longitude, elevation) and the current time.

Source: THEA

4.3.9 Infrastructure Support Subsystem

The Infrastructure Support Subsystem is based on the Siemens Roadside Unit software architecture. This architecture follows a layered architecture approach. On top of the hardware platform and standard operating system services the following layers are implemented. The Bluetooth (BT) conforms to Personal Area Network (PAN) profile.

Figure 50: Siemens Roadside Unit Architecture



Source: THEA

Table 33: MAC/LLC ETS/IEEE

Component	Description
IEEE 1609.4 / 802.11p MAC Operations	Medium access for IEEE 1609.4 and IEEE 802.11p
Management IEEE	Management functionality for connection status and control
Data Transmit Queue	Queue or outgoing communication packets
Data Receive Queue	Queue for incoming communication packets

Source: THEA

Table 34: Security HSM

Component	Description
Signature, Keys, Certs	Secure access and storage for keys and certificates as well as message signature support

Source: THEA

Table 35: Network IEEE 1609

Component	Description
TCP / UDP	TCP and UDP protocol implementation for wireless communication via DSRC using IPv6
IPv6	IPv6 implementation for DSRC
WSMP / IEEE 1609.3	WAVE Short Message Protocol implementation per IEEE 1609.3
Security IEEE 1609.2	Interface for message signing and encryption per IEEE 1609.2
Management IEEE 1609.3	WAVE Management Entity (WSE), WAVE Service Advertisement (WSA)

Source: THEA

Table 36: SDK API

Component	Description
WAVE Facility	API providing access to the underlying IEEE 1609 network stack to applications
J2735 Encoding / Decoding	Support functions for UPER and XER encoding and decoding of J2735 payloads

Source: THEA

Table 37: System Services

Component	Description
Lifecycle Management	Global RSU operating mode and management of application lifecycle

Component	Description
SW Update	Software update support for secure remote software maintenance
Monitoring	Monitoring of interfaces and system services
Logging	Centralized logging of system and application events
WAN Connection Service (LTE)	Wide area network connection service including virtual private network capabilities for connections via LTE (or other network ports)
Management Database	Central database for storage of configuration and status data
GPS	GPS management and location tracking
WiFi / BT	WiFi and Bluetooth communication support
Web Server	Web server for remote access and data transfer
SNMP Server	Simple Network Management Protocol Server for MIB support

Source: THEA

Table 38: Siemens Core Applications

Component	Description
Message Forwarder	Implementation of store-and-repeat as well as immediate forward functionality for messages
SNMP Agent	Implementation of RSU MIB objects
Service GUI	Web GUI for RSU and application monitoring
NTCIP Traffic Controller Service	Service for interaction with a traffic controller using NTCIP MIB objects
SPaT-MAP	Application responsible for continuous broadcast of MAP data and SPaT updates received from a connected traffic controller
OCIT-C	Backend server communication interface
Data Collector	Application responsible for collection of log data (e.g. BSMs, TIMs, alerts, etc.) and forwarding of that data to the backend server
BSM Aggregator	Application computing count and speed information from BSMs

Source: THEA

Table 39: Project Applications

Component	Description
I-SIG / TSP	See application descriptions in Section 4.2.10 and 4.2.6
Ped-SIG	See application description in Section 4.2.3
Ped-X	See application description in Section 4.2.4
ERDW	See application description in Section 4.2.1
Wrong Way	See application description in 4.2.2

Source: THEA

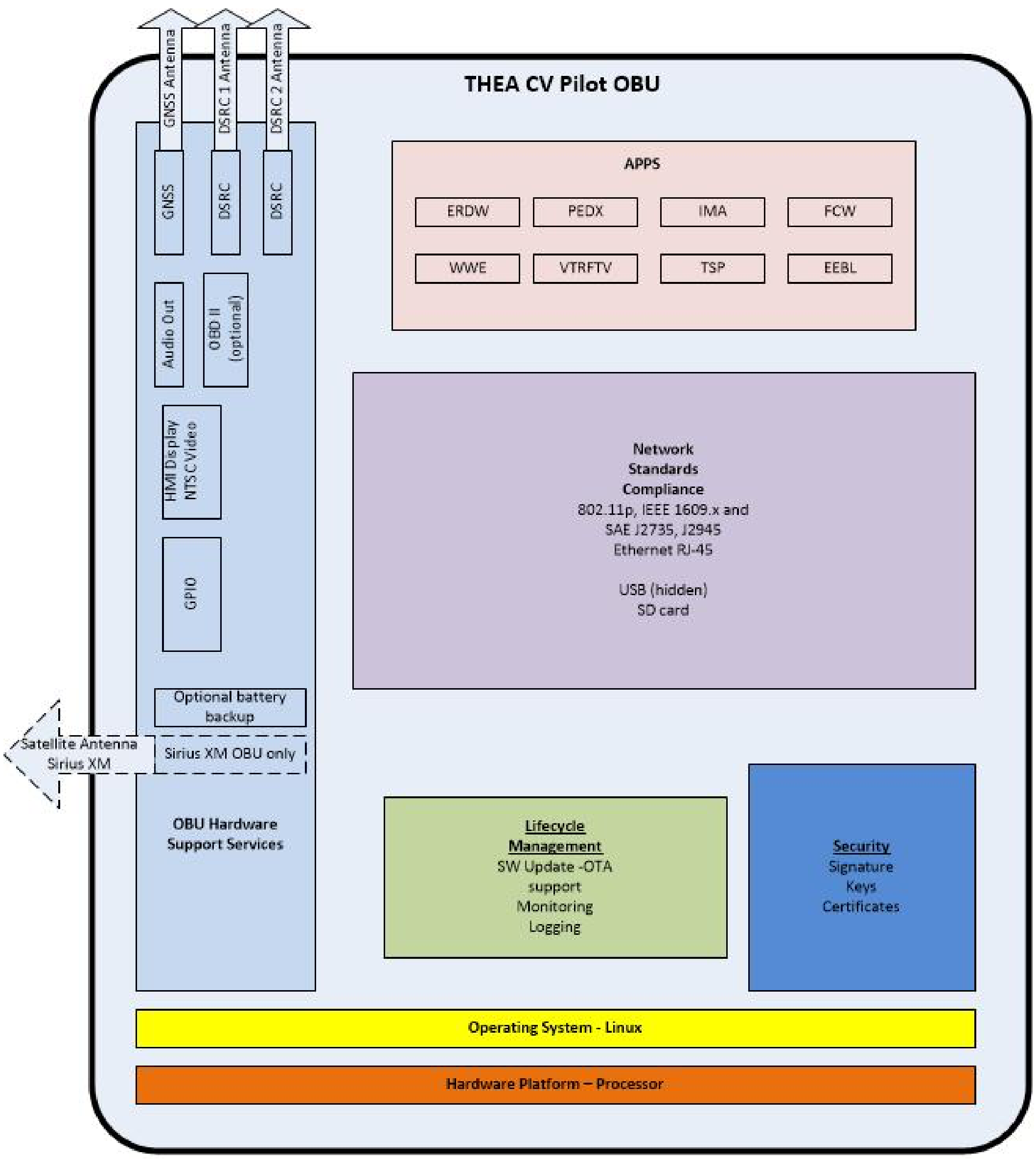
4.3.10 In-Vehicle Support Subsystem

The following is a description of the Vehicle Support Subsystem components consisting of the OBU, rear view mirror as the HMI, speaker and GPS/DSRC antenna(s).

The Vehicle On-Board Unit (OBU) shown in Figure 51, provides the vehicle-based processing, storage, and communications functions necessary to support connected vehicle operations. The radio(s) supporting V2V and V2I communications are a key component of the Vehicle OBU. This communication platform is augmented with processing and data storage capability that supports the connected vehicle applications.

In CVRIA, the Vehicle OBU includes the functions and interfaces that support connected vehicle applications for passenger cars, trucks, and motorcycles. Many of these applications (e.g., V2V Safety applications) apply to all vehicle types including personal vehicles, commercial vehicles, emergency vehicles, transit vehicles, and maintenance vehicles. From this perspective, the Vehicle OBU includes the common interfaces and functions that apply to all motorized vehicles.

Figure 51: THEA CVP OBU



Source: THEA

Table 40: OBU Hardware Support

Component	Description
Optional Battery Backup	Recommended battery backup to be used in the case of an unexpected vehicle power interruption or electrical shutdown. Also will assist in smoothing any severe EMC wiring induced spike occurring in the vehicle electrical systems. Allows all OBU internal GPS location, Apps in progress, alerts and displays to safely shut down. Conversely upon an instantaneous re-start all previously stored data will be enabled or restored.
GPIO	General Purpose Input Output (GPIO) Bus will be utilized for potential discrete outputs
Discrete Inputs	Discrete inputs shall be used to provide zero to twelve-volt (0-12v) vehicle inputs to the OBU. For example, vehicles equipped with "*Rear Camera Video Mirrors,"* the OBU will monitor the "*Reverse Signal"* so the OBU will switch the mirror display from rear camera video to OBU App driven alerts. There is also a spare DI for future use.
HMI Display/NTSC Video	All current rearview camera mirrors are NTSC driven. The OBU will decide which video to display, rear view camera video or OBU App alerts. The vehicle mirror displays are NTSC driven.
CAN	Vehicle electrical communication Bus information is available via the vehicle On-Board Diagnostics connector (OBD). Many vehicle signals are available that could enhance future App alerts algorithms and also enhance the GPS while in a *"Dead Reckoning Mode."* Another example is utilizing the vehicle "steering wheel angle" signal.
DSRC	Dedicated Short-Range Communications (DSRC), this is the radio communications protocol and frequencies allocated for the CV project. Intelligent Transportation Systems (ITS) Radio Service in the 5.850-5.925 GHz band (5.9 GHz band).
GPS	GPS management and location tracking
SiriusXM Antenna Input	Satellite antenna to be used for security certificate and CRL distribution on SiriusXM supplied OBUs.

Source: THEA

Table 41: Lifecycle Management

Component	Description
SW Update	Software update support for secure remote software maintenance. Will be securely inputted via OTA or OBU mounted encrypted SD Card input.
Monitoring	Monitoring of interfaces and system services
Logging	Centralized logging of system and application events

Table 42: Security

Component	Description
Signature, Keys, Certs	Secure access and storage for keys and certificates as well as message signature support

Source: THEA

Table 43: Network Standards Compliance

Component	Description
IEEE 802.11p	Dedicated Short-Range Communication (DSRC) and wireless access vehicular environments (WAVE) are the communication standards on which these transportation services are provided. These communication standards are based on IEEE **802.11p** PHY/MAC and DSRC wireless communication and messaging protocols.
IEEE 1609.x	• The IEEE 1609 Family of Standards for Wireless Access in Vehicular Environments (WAVE) defines: – the architecture, – communications model, – management structure, – security mechanisms and – physical access for high speed (up to 27 Mb/s) short-range (up to 1000m) low latency
SAE J2735	Basic Safety Message (BSM) Set definitions Standard
SAE J2945	This standard specifies the system requirements for an on-board vehicle-to-vehicle (V2V) safety communications system for light vehicles , including standards profiles, functional requirements, and performance requirements. The system is capable of transmitting and receiving the Society of Automotive Engineers (SAE) J2735-defined Basic Safety Message (BSM) [1] over a Dedicated Short-Range Communications (DSRC) wireless communications link as defined in the Institute of Electrical and Electronics Engineers (IEEE) 1609 suite and IEEE 802.11 standards [2] – [6].
Ethernet RJ-45	Ethernet Communications and connector standardized as the 8P8C modular connector used with CAT5 cables
USB (hidden)	Universal Serial Bus (USB) will be used for software and firmware updates. Port will be hidden and encrypted to prevent malicious data entry.
SD Card	Secure Digital (SD) card port/reader, encrypted, will be used to provide software and firmware updates.

Source: THEA

Table 44: Operating System

Component	Description
Linux	Operating system running main system functions of the OBU

Source: THEA

Table 45: Hardware Platform

Component	Description
Processor	Core microprocessor to be specified by OBU supplier

Source: THEA

HMI –Display all video alerts generated by the OBU. For the CV Pilot program, the video displays will be the following:

Private passenger automobiles and light duty trucks – Each respective OEM rear view mirror will be replaced with a compatible rear-view mirror, that is maintaining all original mirror functions, that will have a LCD video display imbedded. In the case of a rear camera video equipped mirror, the reverse signal will override any alerts generated by the OBU.

Buses and Streetcars – Each bus and streetcar will have a LCD video display box that will be packaged directly in the driver's field of view. In the case of a streetcar there will be two displays, that is one on each end due to the streetcar reversing driving direction. *(note streetcars do not drive in reverse, rather the driver moves to the opposite side of the streetcar to drive in the other direction).*

Speaker –Sound an audible alert generated by the OBU. Locations for the speaker in automobiles, light duty trucks, buses and streetcars will be determined and optimized by HMI and safety experts.

DSRC Antennas – Each vehicle will have dedicated DSRC antennas connected to two OBU internal radios. Locations and number of antennas will be:

Private passenger automobiles and light duty trucks – Each vehicle will have two DSRC antennas with each respective antenna supporting a DSRC radio channel. Antenna locations will be determined by in-vehicle testing.

Buses – Will have 2 DSRC antennas located on the roof. Locations will be determined by in-vehicle testing.

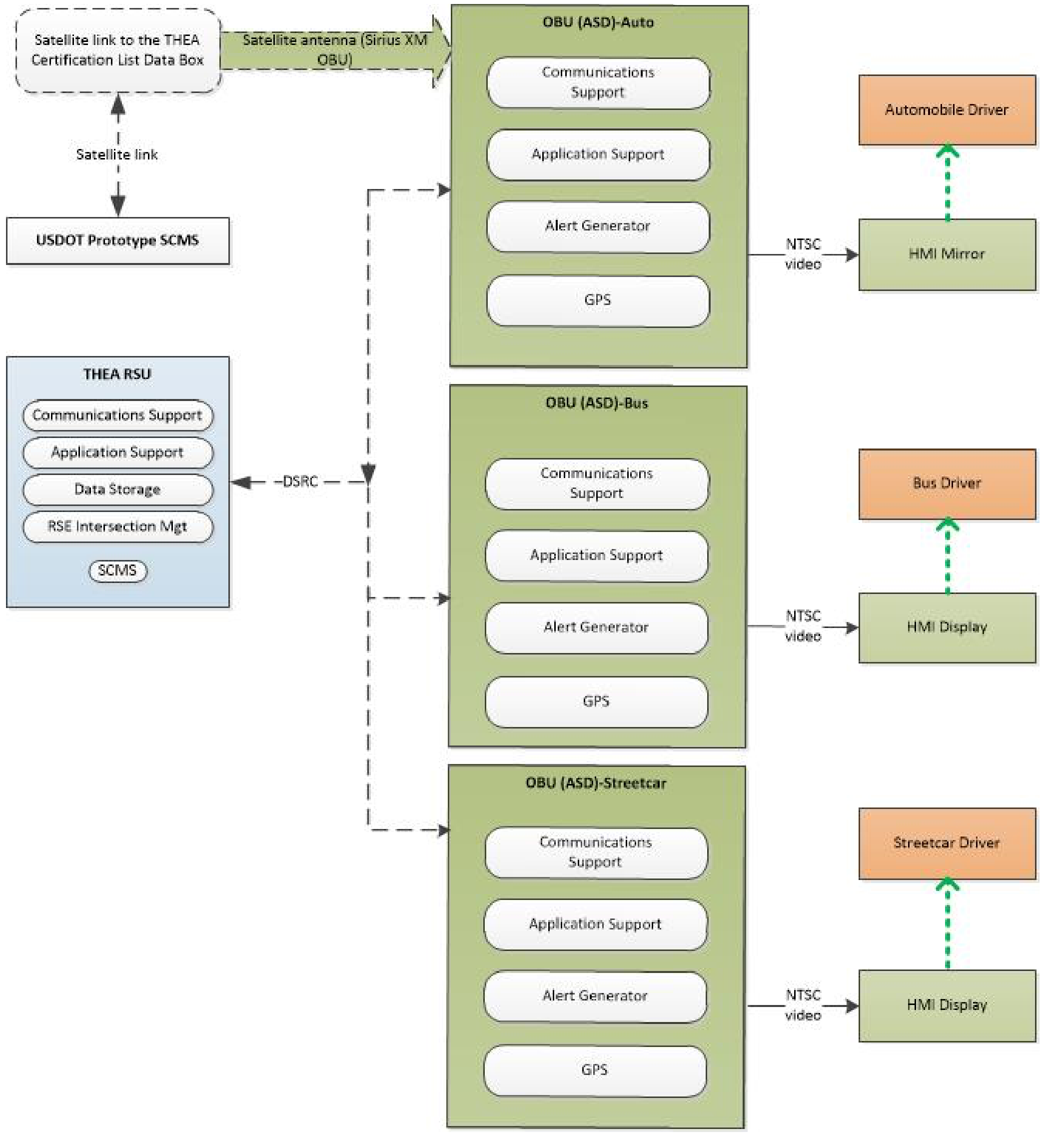
Streetcars – Will have 2 DSRC antennas located on the roof of the streetcar. Locations will be determined by in-vehicle testing.

GPS Antennas - Each vehicle will have one GPS antenna. Location will be:

Private passenger automobiles and light duty trucks – Each vehicle will have one GPS antenna. Antenna locations will be determined by in-vehicle testing. *(may be mag- mount or adhesive mount)*

Buses and Streetcars – Will have one GPS antenna located on the roof. Locations will be determined by in-vehicle testing.

Figure 52: THEA CVP OBU System Physical Description



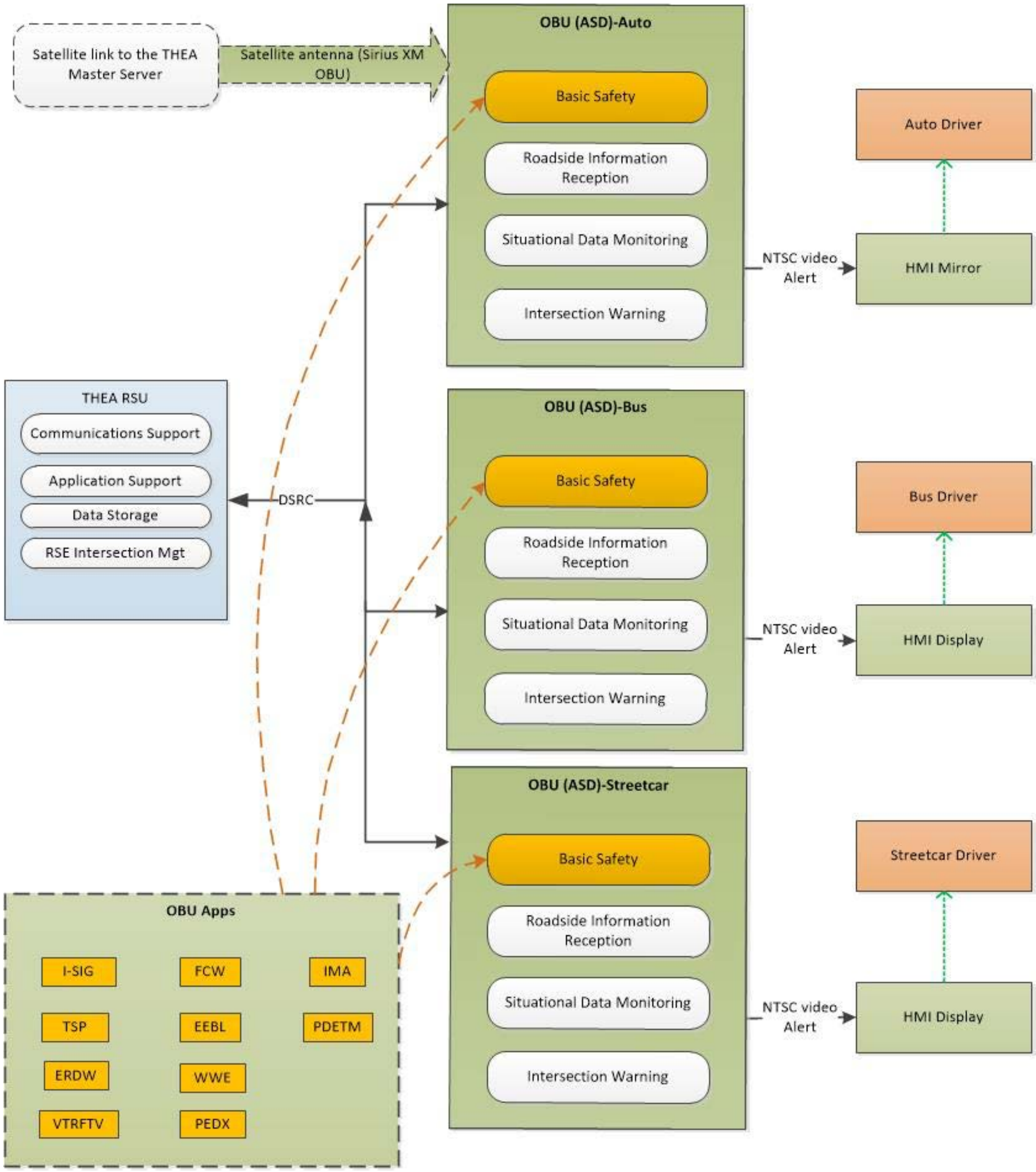
Source: THEA

Table 46: Physical Description Layer 0 Description

Component	Description
DSRC	Dedicated short-range communication (DSRC) and wireless access vehicular environments (WAVE) are the communication standards on which these transportation services are provided. These communication standards are based on IEEE **802.11p** PHY/MAC and DSRC wireless communication and messaging protocols.
SCMS	Security Credential Management System
Communications Support	OBU DSRC physical radio circuitry and DSRC antennas.
Application Support	Dedicated OBU SW support algorithms, processing and generation of alerts.
Alert Generator	Defined alert signals including graphics converted to NTSC video for HMI output display to driver.
NTSC Video	Analog Composite video is in standard format NTSC
GPS	Global Positioning System (GPS) support
HMI Display	Human Machine Interface display for autos will be LCD in Rear View Mirror. For buses and streetcars LCD will be a discrete display box located in the drivers view.
SD Card	Secure Digital (SD) card port/reader, encrypted, will be used for data storage such as diagnostic data, and could be used for updates. Primary approach is OTA.
SiriusXM Antenna Input	Satellite antenna to be used for security certificate and CRL distribution on SiriusXM supplied OBUs.

Source: THEA

Figure 53: Physical Description Layer 1 (Auto, Bus, & Streetcar)



Source: THEA

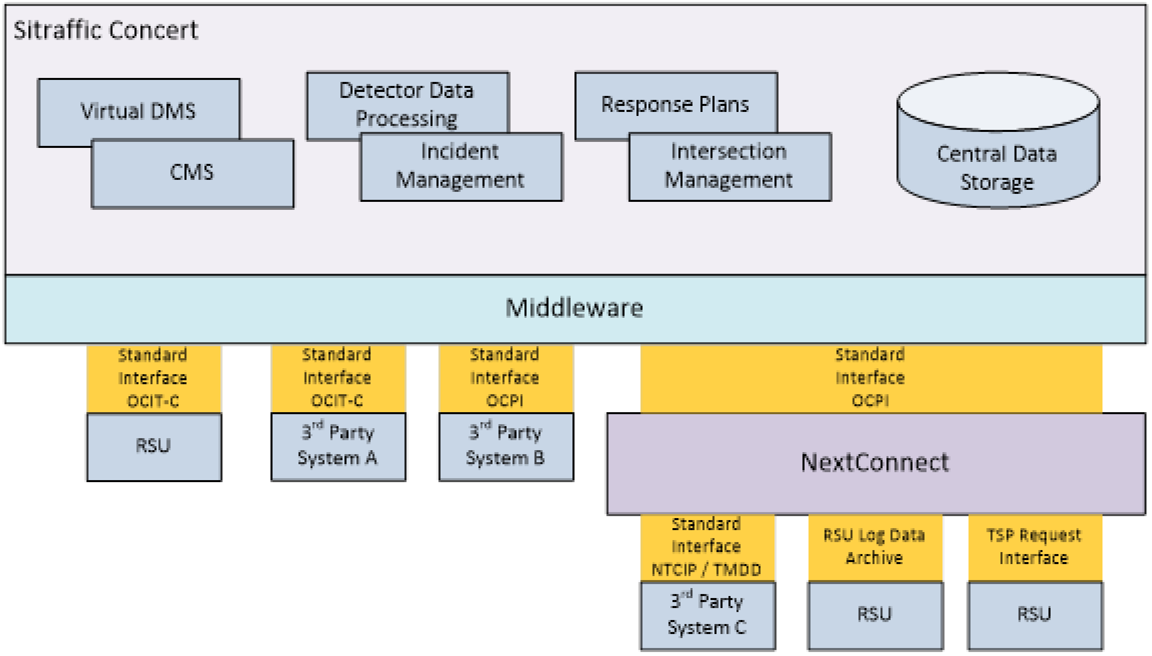
Table 47: Physical Description Layer 1 Description

Component	Description
Alert Generator	Defined alert signals including graphics converted to NTSC video for HMI output display to driver.
NTSC Video	Analog Composite video is in standard format NTSC method to display driver warning video messages on the driver's rear view mirror (Auto), or HMI LCD display on bus or streetcar.
Basic Safety	'Vehicle Basic Safety' exchanges current vehicle location and motion information with other vehicles in the vicinity, uses that information to calculate vehicle paths, and warns the driver when the potential for an impending collision is detected. This feature is also often referred to as 'Forward Collision Warning' (FCW) and 'Intersection Movement Assist' (IMA). If available, map data is used to filter and interpret the relative location and motion of vehicles in the vicinity. Information from on-board sensors (e.g., radars and image processing) is also used, if available, in combination with the V2V communications to detect non-equipped vehicles and corroborate connected vehicle data. Vehicle location and motion broadcasts are also received by the infrastructure and used by the infrastructure to support a wide range of roadside safety and mobility applications. This object represents a broad range of implementations ranging from basic Vehicle Awareness Devices (VAD) that only broadcast vehicle location and motion and provide no driver warnings to advanced integrated safety systems that may, in addition to warning the driver, provide collision warning information to support automated control functions that can support control intervention.
Roadside Information Reception	RSE information received and processed by OBU.
Vehicle Intersection Warning	'Vehicle Intersection Warning' uses V2V and V2I communications to monitor other connected vehicles at intersections and support the safe movement of the vehicle through the intersection. Driver warnings are provided and the application may also optionally take control of the vehicle to avoid collisions. The application will also notify the infrastructure and other vehicles if it detects an unsafe infringement on the intersection. In the THEA context this application detects the wrong way driving infringement.
Situational Data Monitoring	OBU monitoring of interfaces and system services.
OBU Apps	Described in Section 4.2
THEA RSU	Described in RSU descriptions figure 27 and all related RSU describing pages.
HMI Display	Human Machine Interface display for autos will be LCD in Rear View Mirror. For buses and streetcars LCD will be a discrete display box located in the drivers view.
SiriusXM Antenna Input	Satellite antenna to be used for security certificate and CRL distribution on SiriusXM supplied OBUs.

Source: THEA

4.3.11 Master Server Subsystem

Figure 54: Siemens Concert System Architecture



Source: Siemens

The above figure depicts the Siemens Concert architecture as is applies to the THEA CV pilot project. Since Concert is an existing Siemens product with a vast number of features and interfaces, not all details can be shown here. Concert is in use in the United States and Europe. The product will be integrated and test as part of the THEA CV Pilot.

Concert has a modular system architecture with various application modules. These application modules communicate with each other and subsystem interface via a proprietary middleware. Status information and configuration data is stored in a central data storage. External 3rd party systems can be connected via OCIT-C, OCPI, or NTCIP/WSM interfaces.

Concert communicates with connected RSUs via its OCIT-C interface for health monitoring and detector data collection as well as traveler information. Project-specific add-on interfaces are typically implemented using the NextConnect subsystem of Concert. In the case of the THEA CV Pilot these interfaces are the “RSU Log Data Archive” and the “TSP Request Interface”.

“RSU Log Data Archive” implements the “traffic situation data” flows from the RSUs in order to support CV data archiving. The archived data can then be made available to the IE.

“TSP Request Interface” implements the “signal priority service request”-response flow from the RSU. This flow requests permission to grant an approaching bus priority service at a specific intersection. The response contains the “grant” or “deny” decision made by NextConnect at the transit central. NextConnect makes the decision based on bus schedule adherence status for the bus requesting priority.

4.3.12 Driver Interaction

The architecture has two distinct physical implementations to implement a multimodal interface for the driver:

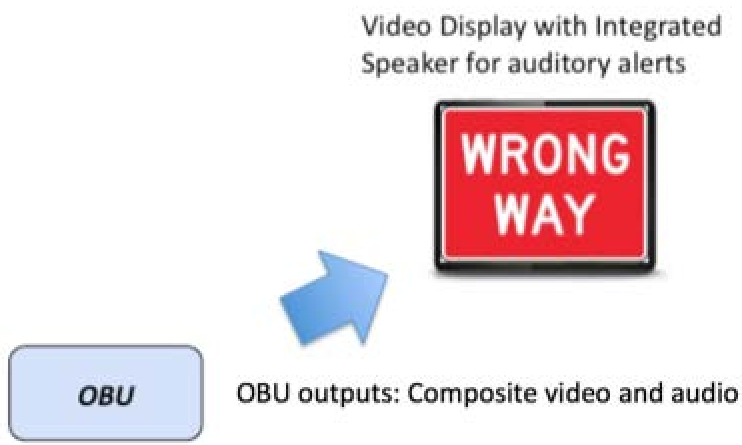
1. Rear view mirror with integral display and speaker for auditory warnings. All vehicle types with existing rearview mirrors will employ this physical implementation, see figure below.

Figure 55 Multimodal Driver Interface

Source: Brandmotion

2. Dash mounted video display (nominally 4 – 6-inch diagonal) with integrated speaker will be used for streetcars and buses as shown below.

Figure 56: Multimodal Driver Interface for Buses and Streetcars



Source: Brandmotion

4.4 Communications Architecture View

4.4.1 Communication profiles used:

Table 48: Communications Profiles

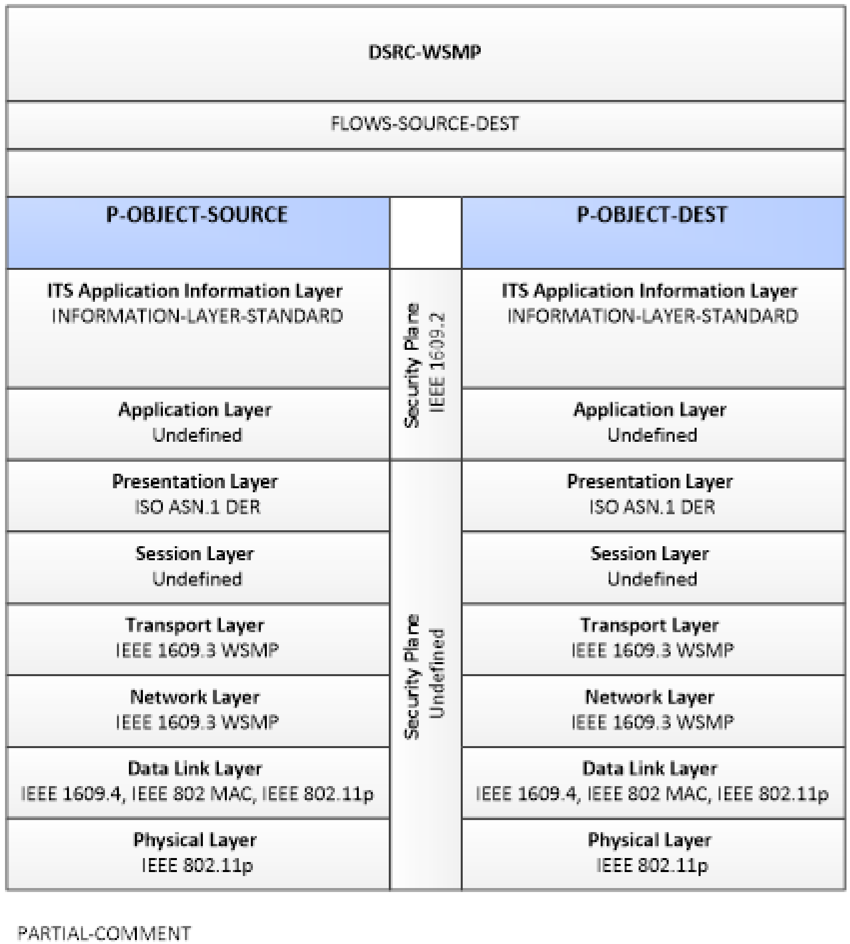
Profile	Flows using profile
DSRC-WSMP	All flows between RSU and OBU. Information layer is J2735-201603 for all flows. Lower layers are standardized by IEEE 1609-2016.
Wi-Fi-Direct-JSON	All flows between RSU and PID. Information layer uses a non-standardized JSON representation of relevant data fields corresponding to the J2735 messages exchanged. Transport layer uses UDP. Lower layers are determined by the Wi-Fi Direct ® specification.
NTCIP-SNMP	All flows between RSU and "Traffic Signal Controller" as well as "Traditional Vehicle Detector". Information layer uses NTCIP-1202v0219f. Lower layers are determined by the NTCIP standards applicable to SNMP-based communication (2301) via UDP (2202) over Ethernet (2104).
WAW-WWW Browser-JSON	All flows between RSU and the "THEA Master Server". Information layer uses a non-standardized JSON representation. Lower layers are determined by the Web Socket protocol specification RFC 6455 using HTTPS with TLS.
Bluetooth	Personal Area Network (PAN)

Source: THEA

4.4.2 SET-IT Communications Diagrams

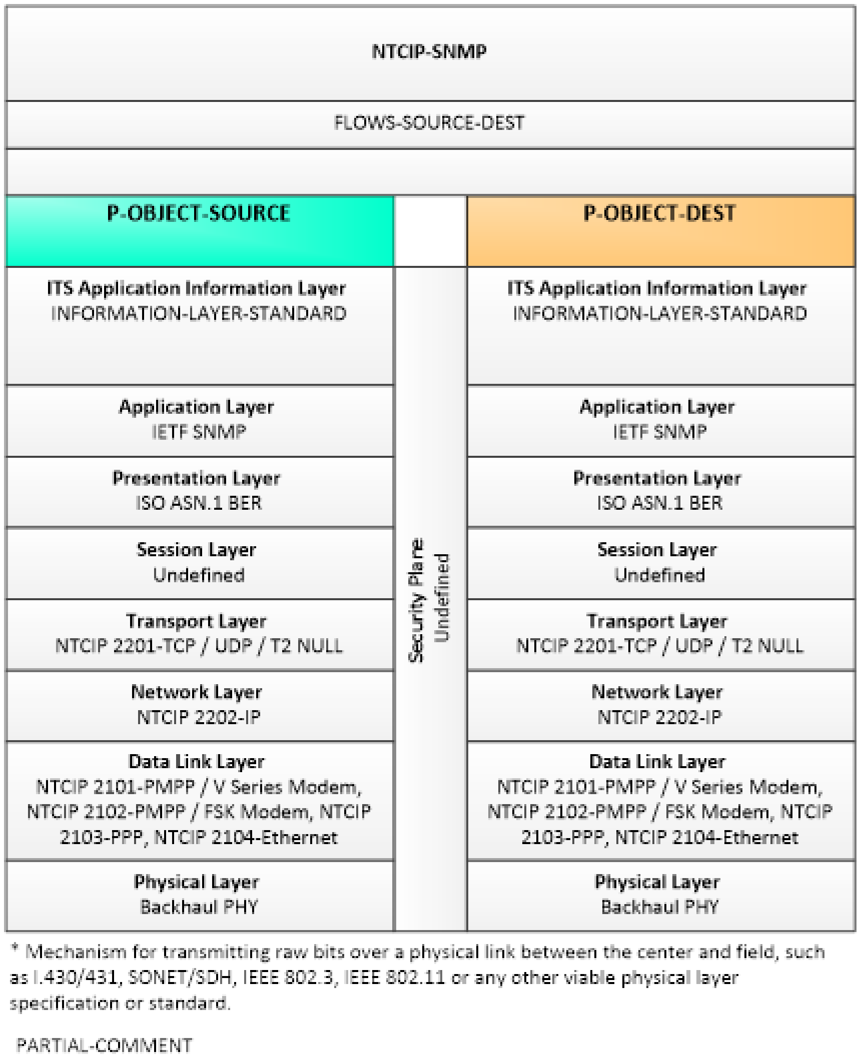
The following diagrams define the communication for the CV Pilot using SET-IT.

Figure 57: DSRC Communications Diagram



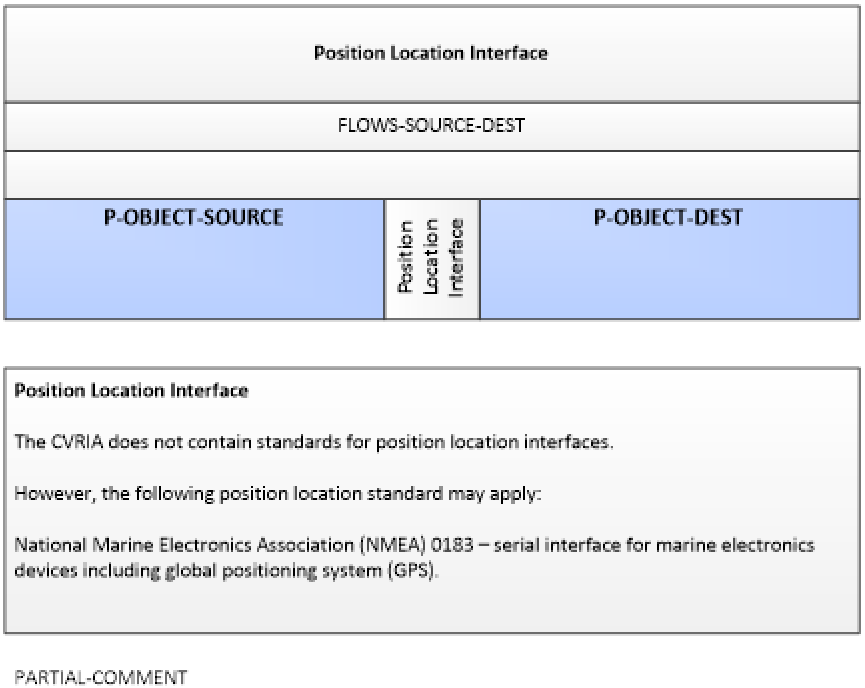
Source: THEA

Figure 58: NTCIP Communications View



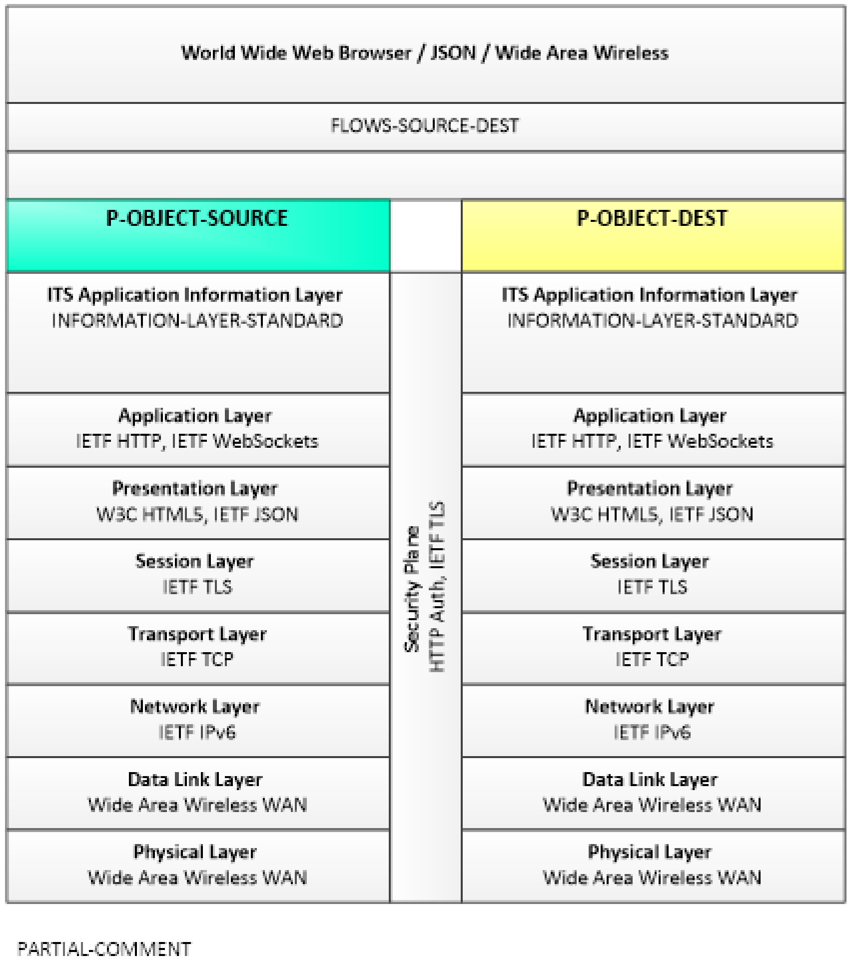
Source: THEA

Figure 59: Position Location Communications View



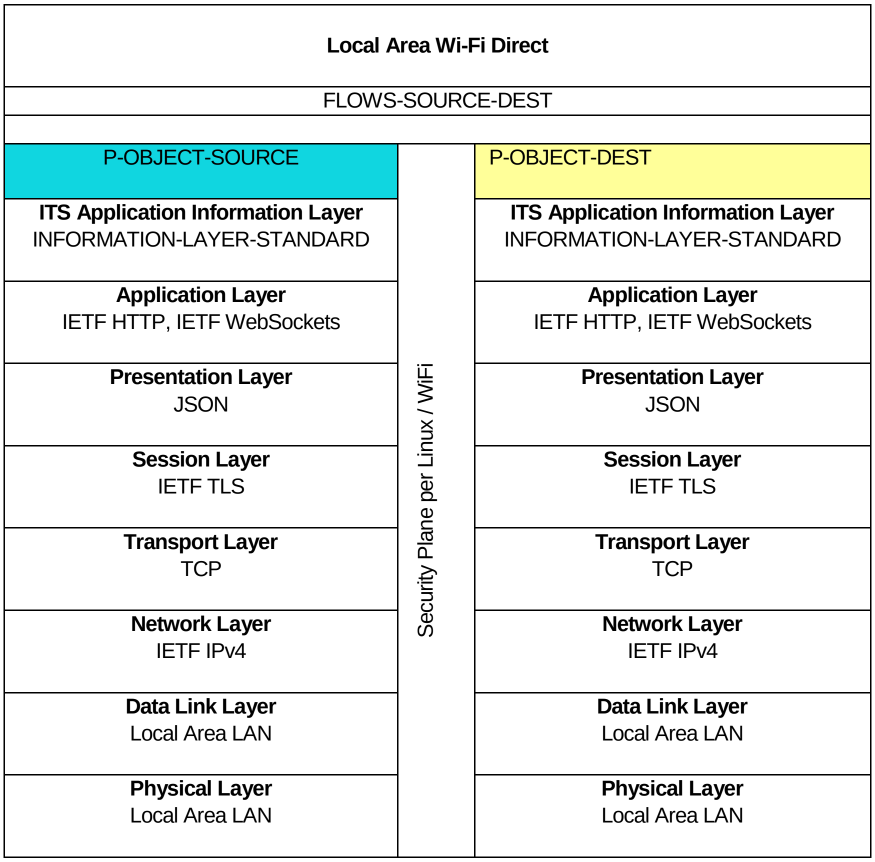
Source: THEA

Figure 60: Web Interface Communications View



Source: THEA

Figure 61: Local Area Wi-Fi Communications View



Source: THEA

5 ITS Standards Plan

5.1 Standards Used in the Project

- This project uses standards that were balloted and published prior to January 1, 2017, including:
    - SAE J2735-2016
    - SAE J2945/1
    - IEEE 1609.2-2016
    - IEEE 1609.3-2016
    - IEEE 802.11p 2016
    - NTCIP 1202 v2
    - USDOT Roadside Unit Requirements Specification version 4.1
- This project excludes unpublished standards under development on January 1, 2017, such as NTCIP 1202 version 3, and are not used.
- Controller to RSU interface used in this project is described in the USDOT "V2I Hub Interface Control Document" available on the OSADP, derived from "SPaT MIB Support Document" dated June 19, 2012 that was developed on USDOT contract DTFH61-06-D-00007 "SIGNAL PHASE AND TIMING AND RELATED MESSAGES FOR V-I APPLICATIONS".
- Master Server to RSU management has no published USA standard. This project uses elements of OCIT-C standard used in Europe for RSU management and data exchange.

5.2 ITS Standards Development Plan Recommendations

- The Standards Development Plan is recommended to include the Controller Unit to RSU interface as a standards development task, identical to the "SPaT MIB Support Document" dated June 19, 2012 that was developed under USDOT contract DTFH61-06-D-00007 "SIGNAL PHASE AND TIMING AND RELATED MESSAGES FOR V-I APPLICATIONS".
- The Standards Development Plan is recommended to include the RSU to Master Server interface by investigating the applicable portions of the OCIT-C standard as a starting point that are used in this project.

Appendix A Interface Triples Spreadsheet

Interface Assessment

The three CV Pilots' system architectures were developed in SET-IT using the teams' System Requirements Specifications and Concepts of Operations. The information flows in these architectures were then examined together to determine which flows were identical, similar or distinct between projects. Flows were categorized according to the following strawman:

1. Interfaces appear identical and are being designed to be fully interoperable
2. Interfaces appear identical and should be designed to be fully interoperable, either
    a. To share development burden and lessen overall cost, and/or
    b. To facilitate the distribution of this interface as a 'typical' Cooperative-ITS deployment interface
3. Interfaces appear similar and should be considered to be made identical and designed to be fully interoperable. Also used for interfaces that exist in only one pilot but may need to be duplicated in the others
4. Interfaces appear similar but substantial needs differences exist that justify them being distinct and not fully interoperable;
    a. some level of interoperability would be of benefit
    b. interoperability would provide no benefit
5. For interfaces with no obvious parallel, the interface appears to be distinct and unique, so interoperability is not a relevant concern.
6. Interfaces may appear the same, similar or distinct, but were implemented prior to the project and are part of the system architecture as legacy items.
7. Interface not accurate and to be deleted from the architectures

During the course of the roundtable, all of the flows identified as '3' were recategorized to one of the other ratings. All flows identified as '7' were removed. This left the group with:

- 9 interfaces that are already being defined to be interoperable (Group 1)
- 21 interfaces that will be/should be defined to be interoperable (Group 2)
- 75 interfaces that will be defined to be distinct (Groups 4 and 5)
- 17 interfaces that have already been defined and are distinct, all of which can be considered legacy flows (Group 6)

An interface in this context represents a collection of similar or identical information flows between similar or identical physical objects. Note that not all interfaces are created equal. Many of the group 1 and 2 interfaces appear as information flows in many application and between many devices, while most of the group 5 interfaces are singular and related to an existing, often proprietary system on one end of the flow.

The following tables summarize the flows that are rated 1 and 2, meaning they either are already or should be designed to be interoperable. These tables also include an assessment of which pilots should be involved in cooperative design activity on each flow and identify any applicable standards. Some condensing of physical objects was also performed. For example, the TMC (Traffic

Management Center) may represent the NYC TMC, the THEA Master Server, or the Wyoming Pikalert/ODE combination. The source tables, as well as similar tables identifying the interfaces rated 4, 5 and 6, are in the associated spreadsheet.

Table 49: Information Flows That Appear Identical and Are Being Designed to Be Fully Interoperable

ID	NYC	TPA	WYO	Flow	Source	Destination	Notes
1	Yes	Yes	Yes	Vehicle location and motion	All vehicles	All vehicles and RSUs	SAE J2735 and SAE J2945/1: BSM
2	Yes	Yes	Yes	Vehicle location and motion for surveillance	All vehicles	RSU	SAE J2735 and SAE J2945/1: BSM
3	Yes	Yes		Intersection geometry	RSU	All vehicles	SAE J2735: MAP
4			Yes	Emergency notification	All vehicles	All vehicles, RSU	
5		Yes		Intersection infringement	Light vehicles	RSU	SAE J2735: BSM (event flags)
6		Yes		Local signal priority request	TPA Bus	RSU	SAE J2735: SRM
7	Yes	Yes		Location correction	RSU	All vehicles and PID	Constrained by available technology
8	Yes	Yes		Pedestrian crossing and vehicle signal status	Signal controller	RSU	V2I Hub ICD
9		Yes		Personal location	RSU	All vehicles	PSM

Source: THEA

Table 50: Information Flows That Appear Similar and Will Be Designed to Be Fully Interoperable

ID	NYC	TPA	WYO	Flow	Source	Destination	Notes
10	Yes	Yes		Vehicle control event	All vehicles	All vehicles	SAE J2735 and SAE J2945/1: BSM vehicle event flags
11	yes		Yes	Vehicle situation data parameters	RSU	All vehicles	SAE J2735: PDM
12	Yes	Yes		Intersection status	RSU	All vehicles	SAE J2735: SpaT
13			yes	Alerts for vehicles	OER	All vehicles	SAE J2735: TIM
	Yes			emergency traveler information	OER	NYC TMC	
14	Yes	Yes		Intersection safety warning	RSU	All vehicles	SAE J2735: TIM SAE J2735: RSA
	Yes		Yes	Lane closure information			

ID	NYC	TPA	WYO	Flow	Source	Destination	Notes
	Yes	Yes	Yes	Reduced speed notification			
			Yes	Road closure information			
			Yes	Road weather advisories			
			yes	Vehicle signage data			
15	Yes	Yes		Device identification	Vehicles, RSU	TMC	For acquiring SSPs
16	Yes	Yes	Yes	Equipment configuration settings	TMC	RSU	WYO and THEA to replicate flow
17	Yes	Yes	Yes	Equipment control commands	TMC	RSU	WYO and THEA to replicate flow
18	Yes	Yes	Yes	Equipment status	RSU	TMC	WYO and THEA to replicate one or both
19	Yes	Yes	Yes	Equipment status	RSU	Service Mon	WYO and THEA to replicate one or both
20	Yes	Yes	Yes	Vehicle status	Databus	Vehicle	On-board interfaces intent to design the same wherever practical
21	Yes	Yes		Intersection management application info	RSU	TMC	All RSU status and information setting considered as one interface. Architecturally consistent and should be implementable using the same scheme.
	Yes	yes		Intersection management application status	TMC	RSU	
	Yes	yes		Intersection safety application info	RSU	TMC	
	Yes	yes		Intersection safety application status	TMC	RSU	
	Yes	Yes	Yes	Reduced speed warning application info	RSU	TMC	
	Yes	Yes	Yes	Reduced speed warning application status	TMC	RSU	
	Yes		Yes	Situation data collection parameters	RSU	TMC	
	Yes		Yes	Speed management application info	RSU	TMC	
	Yes		Yes	Speed management application status	TMC	RSU	

ID	NYC	TPA	WYO	Flow	Source	Destination	Notes
	Yes		Yes	Traffic monitoring application info	RSU	TMC	
	Yes		Yes	Traffic monitoring application status	TMC	RSU	
	Yes		Yes	Traveler information application info	RSU	TMC	
22	Yes	Yes	Yes	Location and time	Loc. & Time Source	[device]	All mobile need this; most RSUs need this; constrained by available technology
23	Yes	Yes		Personal location	PID	RSU	SAE J2735: PSM
24		Yes		Safety application log event	Bus	TMC	Some similarity to event logging, unclear but others may duplicate
25		Yes		Signal priority service request	RSU	Signal Controller, Transit Center	SAE J2735: SRM
				Signal priority service request	Transit Center	RSU	
26	Yes			Speed management information	RSE	All vehicles	SAE J2735: MAP (WYO and TPA do this same thing with TIM)
27	Yes	Yes	Yes	Traffic situation data	RSU	TMC	
28	Yes	Yes		User permission sets	TMC	SCMS	Needed by any site that needs SSPs
29	Yes	Yes	yes	Various safety warnings	All vehicles	TMC	Some similarity to event logging
125			yes	Vehicle environmental data	All vehicles	RSU	SAE J2735: BSMpart2; SAE J2735: PDM for control

Source: THEA

Appendix B. Message Sets

Message Set Overview

Table 51 lists the SAE J2735 messages used in the project. The proposed payload for BSM was submitted by THEA for interoperability with the other pilot sites. The remainder of the message list from the three teams is being compiled and prioritized to match the project schedule

Table 51: Message Set Overview

Message	Description
BSM	Basic Safety Message
MAP	Map Message
SPaT	Signal Phase and Timing Message
TIM	Traveler Information Message
SRM	Signal Request Message
SSM	Signal Status Message
PSM	Personal Safety Message
BSM	Basic Safety Message

Source: THEA

Basic Safety Message

Table 52: Basic Safety Message

Identifier		Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
BasicSafetyMessage		MSG_BasicSafetyMessage			M	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-002]	M
	coreData	BSMcoreData	SEQUENCE		M	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]	M
	msgCnt	MsgCount		INTEGER (0..127)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	id	TemporaryID		OCTET STRING (SIZE (4))	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	secMark	Dsecond		INTEGER (0..65535)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	lat	Latitude		INTEGER (-900000000..900000001)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	long	Longitude		INTEGER (-1799999999..1800000001)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	elev	Elevation		INTEGER (-4906..61439)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	accuracy	PositionalAccuracy	SEQUENCE		M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M

Identifier		Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
	transmission	TransmissionState		ENUMERATED (0..7)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	speed	Speed		INTEGER (0..8191)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	heading	Heading		INTEGER (0..28800)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	angle	SteeringWheelAngle		INTEGER (-126..127)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	accelSet	AccelerationSet4Way	SEQUENCE		M	M	J2945/1[6.1.6-V2V-STD-J2735-005]	M
	long	Acceleration		INTEGER (-2000..2001)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	lat	Acceleration		INTEGER (-2000..2001)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	vert	VerticalAcceleration		INTEGER (-127..127)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	yaw	YawRate		INTEGER (-32767..32767)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	brakes	BrakeSystemStatus	SEQUENCE		M	M	J2945/1[6.1.6-V2V-STD-J2735-006]	M
	wheelBrakes	BrakeAppliedStatus		BIT STRING (SIZE (5))	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	traction	TractionControlStatus		ENUMERATED (0..3)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	abs	AntiLockBrakeStatus		ENUMERATED (0..3)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	scs	StabilityControlStatus		ENUMERATED (0..3)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M

Identifier		Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
	brakeBoost	BrakeBoostApplied		ENUMERATED (0..2)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	auxBrakes	AuxiliaryBrakeStatus		ENUMERATED (0..3)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	size	VehicleSize	SEQUENCE		M	M	J2945/1[6.1.6-V2V-STD-J2735-014]	M
	width	VehicleWidth		INTEGER (0..1023)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	length	VehicleLength		INTEGER (0..4095)	M	M	J2945/1[6.1.6-V2V-STD-J2735-007]	M
	partII	PartIIcontent {{ BSMpartIIExtension }}	SEQUENCE (SIZE (1..8))		O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]	M
	partII-Id	PartII-Id		INTEGER (0..63)	M	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]	M
	partII-Value	BSMpartIIExtension		IDENTIFIED BY partII-Id	M	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]	M
	vehicleSafetyExtensions	VehicleSafetyExtensions	SEQUENCE	IDENTIFIED BY partII-Id = vehicleSafetyExt	O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]	M
	events	VehicleEventFlags		BIT STRING (SIZE (13, …))	O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-006]	M
	pathHistory	PathHistory	SEQUENCE		O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]	M
	initialPosition	FullPositionVector	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
utcTime	DDateTime	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
year	DYear		INTEGER (0..4095)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
month	DMonth		INTEGER (0..12)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
day	DDay		INTEGER (0..31)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
hour	DHour		INTEGER (0..31)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
minute	DMinute		INTEGER (0..60)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
second	DSecond		INTEGER (0..65535)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
offset	DOffset		INTEGER (-840..840)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
long	Longitude		INTEGER (-1799999999..1800000001)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
lat	Latitude		INTEGER (-900000000..900000001)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
elevation	Elevation		INTEGER (-4906..61439)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-	Ex

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
						DATAACC-038]	
heading	Heading		INTEGER (0..28800)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
speed	TransmissionAndSpeed	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
transmission	TransmissionState		ENUMERATED (0..7)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
speed	Velocity		INTEGER (0..8191)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
posAccuracy	PositionalAccuracy	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
timeConfidence	TimeConfidence		ENUMERATED (0..39)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
posConfidence	PositionConfidenceSet	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
pos	PositionConfidence		ENUMERATED (0..15)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
elevation	ElevationConfidence		ENUMERATED (0..15)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
speedConfidence	SpeedandHeadingandThrottleConfidence			O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
heading	HeadingConfidence		ENUMERATED (0..7)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
speed	SpeedConfidence		ENUMERATED (0..7)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
throttle	ThrottleConfidence		ENUMERATED (0..3)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
currGNSSstatus	GNSSStatus		BIT STRING (SIZE (8))	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
crumbData	PathHistoryPointList	SEQUENCE (SIZE (1..23))		M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-036]	M
crumbData[n]	PathHistoryPoint			M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]	M
latOffset	OffsetLL-B18		INTEGER (-131072..131071)	M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]	M
lonOffset	OffsetLL-B18		INTEGER (-131072..131071)	M	M	J2945/1[6.3.6-V2V-BSMTX-	M

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
						DATAACC-037]	
elevationOffset	VertOffset-B12		INTEGER (-2048..2047)	M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]	M
timeOffset	TimeOffset		INTEGER (1..65535)	M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]	M
speed	Speed		INTEGER (0..8191)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
posAccuracy	PositionalAccuracy	SEQUENCE		O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	M	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
heading	CoarseHeading		INTEGER (0..240)	O	Exclude	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]	Ex
pathPrediction	PathPrediction	SEQUENCE		O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]	M
radiusOfCurve	RadiusOfCurvature		INTEGER (-32767..32767)	M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-045]	M

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
confidence	Confidence		INTEGER (0..200)	M	M	J2945/1[6.3.6-V2V-BSMTX-DATAACC-045]	M
lights	ExteriorLights		BIT STRING (SIZE (9, …))	O	M	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-005]	M
specialVehicleExtensions	SpecialVehicleExtensions	SEQUENCE	IDENTIFIED BY partII-Id = specialVehicleExt	O	-		M
vehicleAlerts	EmergencyDetails			O	-		-
sspRights	SSPindex		INTEGER (0..31)	M	-		-
sirenUse	SirenInUse		ENUMERATED (0..3)	M	-		-
lightsUse	LightbarInUse		ENUMERATED (0..7)	M	-		-
multi	MultiVehicleResponse		ENUMERATED (0..3)	M	-		-
events	PrivilegedEvents	SEQUENCE		O	-		-
sspRights	SSPindex		INTEGER (0..31)	M	-		-
event	PrivilegedEventFlags		BIT STRING (SIZE (16))	M	-		-
responseType	ResponseType		ENUMERATED (0..6)	O	-		-
description	EventDescription	SEQUENCE		O	-		M
typeEvent	ITIS.ITIScodes		ITIScodes	M	-		M
description	ITIS.ITIScodes	SEQUENCE (SIZE(1..8)	ITIScodes	O	-		M
priority	Priority		OCTET STRING (SIZE(1)	O	-		-
heading	HeadingSlice		BIT STRING	O	-		-
extent	Extent		ENUMERATED	O	-		-
regional	RegionalExtension {{REGION.Reg-EventDescription}}	SEQUENCE (SIZE(1..4)		O	-		-
trailers	TrailerData	SEQUENCE		O	-		-
sspRights	SSPindex		INTEGER (0..31)	M	-		-
connection	PivotPointDescription	SEQUENCE		M	-		-
pivotOffset	Offset-B11		INTEGER (-1024..1023)	M	-		-
pivotAngle	Angle		INTEGER (0..28800)	M	-		-
pivots	PivotingAllowed		BOOLEAN	M	-		-
units	TrailerUnitDescriptionList	SEQUENCE (SIZE(1..8))		M	-		-
units[n]	TrailerUnitDescription	SEQUENCE		M	-		-
isDolly	IsDolly		BOOLEAN	M	-		-
width	VehicleWidth		INTEGER (0..1023)	M	-		-
length	VehicleLength		INTEGER (0..4095)	M	-		-

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
height	VehicleHeight		INTEGER (0..127)	O	-		-
mass	TrailerMass		INTEGER (0..255)	O	-		-
bumperHeights	BumperHeights	SEQUENCE		O	-		-
front	BumperHeight		INTEGER (0..127)	M	-		-
rear	BumperHeight		INTEGER (0..127)	M	-		-
centerOfGravity	VehicleHeight		INTEGER (0..127)	O	-		-
frontPivot	PivotPointDescription	SEQUENCE		M	-		-
pivotOffset	Offset-B11		INTEGER (-1024..1023)	M	-		-
pivotAngle	Angle		INTEGER (0..28800)	M	-		-
pivots	PivotingAllowed		BOOLEAN	M	-		-
rearPivot	PivotPointDescription	SEQUENCE		O	-		-
pivotOffset	Offset-B11		INTEGER (-1024..1023)	M	-		-
pivotAngle	Angle		INTEGER (0..28800)	M	-		-
pivots	PivotingAllowed		BOOLEAN	M	-		-
rearWheelOffset	Offset-B12		INTEGER (-2048..2047)	O	-		-
positionOffset	Node-XY-24b	SEQUENCE		M	-		-
x	Offset-B12		INTEGER (-2048..2047)	M	-		-
y	Offset-B12		INTEGER (-2048..2047)	M	-		-
elevationOffset	VertOffset-B07		INTEGER (-64..63)	O	-		-
crumbData	TrailerHistoryPointList	SEQUENCE (SIZE (1..23))		O	-		-
crumbData[n]	TrailerHistoryPoint			M	-		-
pivotAngle	Angle		INTEGER (0..28800)	M	-		-
timeOffset	TimeOffset		INTEGER (0..65535)	M	-		-
positionOffset	Node-XY-24b	SEQUENCE		M	-		-
x	Offset-B12		INTEGER (-2048..2047)	M	-		-
y	Offset-B12		INTEGER (-2048..2047)	M	-		-
elevationOffset	VertOffset-B07		INTEGER (-64..63)	O	-		-
heading	CoarseHeading		INTEGER (0..240)	O	-		-
supplementalVehicleExtensions	SupplementalVehicleExtensions	SEQUENCE	IDENTIFIED BY partII-Id = supplementalVehicleExt	O	-		M
classification	BasicVehicleClass		INTEGER (0..255)	O	-		-
classDetails	VehicleClassification			O	-		M
keyType	BasicVehicleClass		INTEGER (0..255)	O	-		M
role	BasicVehicleRole		ENUMERATED (0..22)	O	-		M
iso3883	Iso3883VehicleType		INTEGER (0..100)	O	-		-
hpmsType	VehicleType		ENUMERATED (0..15)	O	Om	[6.3.1] omits this DE for	M

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
						light-duty vehicles	
vehicleType	ITIS.VehicleGroupAffected		ENUMERATED (9217..9251)	O	-		-
responseEquip	ITIS.IncidentResponseEquipment		ENUMERATED (9985..10113)	O	-		-
responderType	ITIS.ResponderGroupAffected		ENUMERATED (9729..9742)	O	-		-
fuelType	FuelType		INTEGER (0..15)	O	-		-
regional		SEQUENCE (SIZE (1..4))		O	-		-
vehicleData	VehicleData	SEQUENCE		O	-		M
height	VehicleHeight		INTEGER (0..127)	O	-		O
bumpers	BumperHeights	SEQUENCE		O	-		-
front	BumperHeight		INTEGER (0..127)	M	-		-
rear	BumperHeight		INTEGER (0..127)	M	-		-
mass	VehicleMass		INTEGER (0..255)	O	-		O
trailerWeight	TrailerWeight		INTEGER (0..64255)	O	-		O
weatherReport	WeatherReport	SEQUENCE		O	-		-
isRaining	NTCIP.EssPrecipYesNo		ENUMERATED (0..3)	M	-		-
rainRate	NTCIP.EssPrecipRate		INTEGER (0..65535)	O	-		-
precipSituation	NTCIP.EssPrecipSituation		ENUMERATED (0..15)	O	-		-
solarRadiation	NTCIP.EssSolarRadiation		INTEGER (0..65535)	O	-		-
friction	NTCIP.EssMobileFriction		INTEGER (0..101)	O	-		-
roadFriction	CoefficientOfFriction		INTEGER (0..50)	O	-		-
weatherProbe	WeatherProbe	SEQUENCE		O	-		-
airTemp	AmbientAirTemperature		INTEGER (0..191)	O	-		-
airPressure	AmbientAirPressure		INTEGER (0..255)	O	-		-
rainRates	WiperSet	SEQUENCE		O	-		-
statusFront	WiperStatus		ENUMERATED (0..6)	M	-		-
rateFront	WiperRate		INTEGER (0..127)	M	-		-
statusRear	WiperStatus		ENUMERATED (0..6)	O	-		-
rateRear	WiperRate		INTEGER (0..127)	O	-		-
obstacle	ObstacleDetection	SEQUENCE		O	-		-
obDist	ObstacleDistance		INTEGER (0..32767)	M	-		-
obDirect	ObstacleDirection		INTEGER (0..28800)	M	-		-
description	ITIS.ITIScodes(523..541)			O	-		-
locationDetials	ITIS.GenericLocations			O	-		-
dateTime	DDateTime	SEQUENCE		M	-		-
year	DYear		INTEGER (0..4095)	O	-		-
month	DMonth		INTEGER (0..12)	O	-		-
day	DDay		INTEGER (0..31)	O	-		-

Identifier	Identifier Type	ASN.1 Structural Type	ASN.1 Primitive Type	J2735 Conform	J2945/1 Conform	Requirement Reference	Tampa Conform
hour	DHour		INTEGER (0..31)	O	-		-
minute	DMinute		INTEGER (0..60)	O	-		-
second	DSecond		INTEGER (0..65535)	O	-		-
offset	DOffset		INTEGER (-840..840)	O	-		-
vertEvent	VerticalAccelerationThreshold		BIT STRING (SIZE (5))	O	-		-
status	DisabledVehicle	SEQUENCE		O	-		-
statusDetails	ITIS.ITIScodes (523..541)			M	-		-
locationDetails	ITIS.GenericLocations			O	-		-
speedProfile	SpeedProfile	SEQUENCE		O	-		-
speedReports	SpeedProfileMeasurementList	SEQUENCE (SIZE (1..20))		M	-		-
speedReports[n]	GrossSpeed		INTEGER (0..31)	M	-		-
theRTCM	RTCMPackage	SEQUENCE		O	-		-
rtcmHeader	RTCMheader	SEQUENCE		O	-		-
status	GNSSstatus		BIT STRING (SIZE (8))	M	-		-
offsetSet	AntennaOffsetSet	SEQUENCE		M	-		-
antOffsetX	Offset-B12		INTEGER (-2048..2047)	M	-		-
antOffsetY	Offset-B09		INTEGER (-256..255)	M	-		-
antOffsetZ	Offset-B10		INTEGER (-512..511)	M	-		-
msgs	RTCMmessageList	SEQUENCE (SIZE (1..5))		M	-		-
msgs[n]	RTCMmessage		OCTET STRING (SIZE (1..1023))	M	-		-
regional		SEQUENCE (SIZE (1..4))		O	-		-
regional	RegionalExtension {{REGION.Reg-BasicSafetyMessage}}	SEQUENCE (SIZE(1..4)		O	-		-

Source: THEA

Traveler Information Message

Table 53: Traveler Information Message

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
TravelerInformation	MSG_TravelerInformation Message	M	M	Yes	yes	yes
msgCnt	MsgCount	M	M	Yes	yes	yes
timeStamp	MinuteOfTheYear	O	O	Yes	optional	optional
packetID	UniqueMSGID	O	O	Yes	optional	optional
urlB	URL-Base	O	-	Yes	no	no
dataFrames	TravelerDataFrameList	M	M	Yes	yes	yes
dataFrames[n]	TravelerDataFrame	M	M	Yes	yes	yes
sspTimRights	SSPindex	M	M	Yes	yes	yes
frameType	TravelerInfoType	M	M	Yes	yes	yes
msgId		M	M	Yes	yes	yes
furtherInfoId	FurtherInfoID	M	-	Yes	no	no
roadSignID	RoadSignID	M	M	Yes	yes	yes
position3D	Position3D	M	M	Yes	yes	yes
lat	Latitude	M	M	Yes	yes	yes
long	Longitude	M	M	Yes	yes	yes
elevation	Elevation	O	M	Yes	yes	yes
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
viewAngle	HeadingSlice	M	M	Yes	yes	yes
mutcdCode	MUTCDCode	O	O	Yes	optional	optional
msgCrc	MsgCRC	O	-	Yes	no	no
startYear	DYear	O	O	Yes	optional	optional
startTime	MinuteOfTheYear	M	M	Yes	yes	yes
duratonTime	MinutesDuration	M	M	Yes	yes	yes
priority	SignPriority	M	M	Yes	yes	yes
sspLocationRights	SSPindex	M	M	Yes	yes	yes
regions		M	M	Yes	yes	yes
regions[n]	GeographicalPath	M		Yes	yes	yes
name	DescriptiveName	O	O	Yes	optional	optional

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
id	RoadSegmentReferenceID	O	O	Yes	optional	optional
region	RoadRegulatorID	O	O	Yes	optional	optional
id	RoadSegmentID	M	O	Yes	optional	optional
anchor	Position3D	O	M	Yes	yes	yes
lat	Latitude	M	M	Yes	yes	yes
long	Longitude	M	M	Yes	yes	yes
elevation	Elevation	O	M	Yes	yes	yes
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
laneWidth	LaneWidth	O	M	Yes	yes	yes
directionality	DirectionOfUse	O	M	Yes	yes	yes
closedPath	BOOLEAN	O	-	Yes	no	no
direction	HeadingSlice	O	O	Yes	optional	optional
description		M	M	Yes	yes	yes
path	OffsetSystem	M	M	Yes	yes	yes
scale	Zoom	O	-	Yes	no	no
offset		M	M	Yes	yes	yes
xy	NodeListXY	M	M	Yes	yes	yes
nodes	NodeSetXY	M	M	Yes	yes	yes
nodes[n]	NodeXY	M	M	Yes	yes	yes
delta	NodeOffsetPointXY	M	M	Yes	yes	yes
node-XY1	Node-XY-20b	M	O	Yes	optional	optional
x	Offset-B10	M	O	Yes	optional	optional
y	Offset-B10	M	O	Yes	optional	optional
node-XY2	Node-XY-22b	M	O	Yes	optional	optional
x	Offset-B11	M	O	Yes	optional	optional
y	Offset-B11	M	O	Yes	optional	optional
node-XY3	Node-XY-24b	M	O	Yes	optional	optional
x	Offset-B12	M	O	Yes	optional	optional
y	Offset-B12	M	O	Yes	optional	optional
node-XY4	Node-XY-26b	M	O	Yes	optional	optional
x	Offset-B13	M	O	Yes	optional	optional
y	Offset-B13	M	O	Yes	optional	optional

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
node-XY5	Node-XY-28b	M	O	Yes	optional	optional
x	Offset-B14	M	O	Yes	optional	optional
y	Offset-B14	M	O	Yes	optional	optional
node-XY6	Node-XY-32b	M	O	Yes	optional	optional
x	Offset-B16	M	O	Yes	optional	optional
y	Offset-B16	M	O	Yes	optional	optional
node-LatLon	Node-LLmD-64b	M	O	Yes	optional	optional
lon	Longitude	M	O	Yes	optional	optional
lat	Latitude	M	O	Yes	optional	optional
regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointXY }}	M	-	Yes	no	no
attributes	NodeAttributeSetXY	O	M	Yes	yes	yes
localNode	NodeAttributeXYList	O	-	Yes	no	no
localNode[n]	NodeAttributeXY	M	-	Yes	no	no
disabled	SegmentAttributeXYList	O	-	Yes	no	no
disabled[n]	SegmentAttributeXY	M	-	Yes	no	no
enabled	SegmentAttributeXYList	O	-	Yes	no	no
enabled[n]	SegmentAttributeXY	M	-	Yes	no	no
data	LaneDataAttributeList	O	-	Yes	no	no
data[n]	LaneDataAttribute	M	-	Yes	no	no
pathEndPointAngle	DeltaAngle	M	-	Yes	no	no
laneCrownPointCenter	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointLeft	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointRight	RoadwayCrownAngle	M	-	Yes	no	no
laneAngle	MergeDivideNodeAngle	M	-	Yes	no	no
speedLimits	SpeedLimitList	M	-	Yes	no	no
speedLimits[n]	RegulatorySpeedLimit	M	-	Yes	no	no
type	SpeedLimitType	M	-	Yes	no	no
speed	Velocity	M	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}	M	-	Yes	no	no
dWidth	Offset-B10	O	M	Yes	yes	yes
dElevation	Offset-B10	O	M	Yes	yes	yes
regional		O	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetXY }}	M	-	Yes	no	no
computed	ComputedLane	M	-	Yes	no	no
referenceLaneId	LaneID	M	-	Yes	no	no
offsetXaxis		M	-	Yes	no	no
small	DrivenLineOffsetSm	M	-	Yes	no	no
large	DrivenLineOffsetLg	M	-	Yes	no	no
offsetYaxis		M	-	Yes	no	no
small	DrivenLineOffsetSm	M	-	Yes	no	no
large	DrivenLineOffsetLg	M	-	Yes	no	no
rotateXY	Angle	O	-	Yes	no	no
scaleXaxis	Scale-B12	O	-	Yes	no	no
scaleYaxis	Scale-B12	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-ComputedLane }}	M	-	Yes	no	no
ll	NodeListLL	M	-	Yes	no	no
nodes	NodeSetLL	M	-	Yes	no	no
nodes[n]	NodeLL	M	-	Yes	no	no
delta	NodeOffsetPointLL	M	-	Yes	no	no
node-LL1	Node-LL-24B	M	-	Yes	no	no
lon	OffsetLL-B12	M	-	Yes	no	no
lat	OffsetLL-B12	M	-	Yes	no	no
node-LL2	Node-LL-28B	M	-	Yes	no	no
lon	OffsetLL-B14	M	-	Yes	no	no
lat	OffsetLL-B14	M	-	Yes	no	no
node-LL3	Node-LL-32B	M	-	Yes	no	no
lon	OffsetLL-B16	M	-	Yes	no	no
lat	OffsetLL-B16	M	-	Yes	no	no
node-LL4	Node-LL-36B	M	-	Yes	no	no
lon	OffsetLL-B18	M	-	Yes	no	no
lat	OffsetLL-B18	M	-	Yes	no	no
node-LL5	Node-LL-44B	M	-	Yes	no	no
lon	OffsetLL-B22	M	-	Yes	no	no
lat	OffsetLL-B22	M	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
node-LL6	NodeLL-48B	M	-	Yes	no	no
lon	OffsetLL-B24	M	-	Yes	no	no
lat	OffsetLL-B24	M	-	Yes	no	no
node-LatLon	Node-LLmD-64b	M	-	Yes	no	no
lon	Longitude	M	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointLL }}	M	-	Yes	no	no
attributes	NodeAttributeSetLL	O	-	Yes	no	no
localNode	NodeAttributeLLList	O	-	Yes	no	no
localNode[n]	NodeAttributeLL	M	-	Yes	no	no
disabled	SegmentAttributeLLList	O	-	Yes	no	no
disabled[n]	SegmentAttributeLL	M	-	Yes	no	no
enabled	SegmentAttributeLLList	O	-	Yes	no	no
enabled[n]	SegmentAttributeLL	M	-	Yes	no	no
data	LaneDataAttributeList	O	-	Yes	no	no
data[n]	LaneDataAttribute	M	-	Yes	no	no
pathEndPointAngle	DeltaAngle	M	-	Yes	no	no
laneCrownPointCenter	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointLeft	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointRight	RoadwayCrownAngle	M	-	Yes	no	no
laneAngle	MergeDivideNodeAngle	M	-	Yes	no	no
speedLimits	SpeedLimitList	M	-	Yes	no	no
speedLimits[n]	RegulatorySpeedLimit	M	-	Yes	no	no
type	SpeedLimitType	M	-	Yes	no	no
speed	Velocity	M	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}	M	-	Yes	no	no
dWidth	Offset-B10	O	-	Yes	no	no
dElevation	Offset-B10	O	-	Yes	no	no
regional		M	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetLL }}	M	-	Yes	no	no
geometry	GeometricProjection	M	-	Yes	no	no
direciton	HeadingSlice	M	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
extent	Extent	O	-	Yes	no	no
laneWidth	LaneWidth	O	-	Yes	no	no
circle	Circle	M	-	Yes	no	no
center	Position3D	M	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
long	Longitude	M	-	Yes	no	no
elevation	Elevation	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
radius	Radius-B12	M	-	Yes	no	no
units	DistanceUnits	M	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-GeometricProjection }}	M	-	Yes	no	no
oldRegion	ValidRegion	M	-	Yes	no	no
direction	HeadingSlice	M	-	Yes	no	no
extent	Extent	O	-	Yes	no	no
area		M	-	Yes	no	no
shapePointSet	ShapePointSet	M	-	Yes	no	no
anchor	Position3D	O	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
long	Longitude	M	-	Yes	no	no
elevation	Elevation	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
laneWidth	LaneWidth	O	-	Yes	no	no
directionality	DirectionOfUse	O	-	Yes	no	no
nodeList	NodeListXY	M	-	Yes	no	no
nodes	NodeSetXY	M	-	Yes	no	no
nodes[n]	NodeXY	M	-	Yes	no	no
delta	NodeOffsetPointXY	M	-	Yes	no	no
node-XY1	Node-XY-20b	M	-	Yes	no	no
x	Offset-B10	M	-	Yes	no	no
y	Offset-B10	M	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
node-XY2	Node-XY-22b	M	-	Yes	no	no
x	Offset-B11	M	-	Yes	no	no
y	Offset-B11	M	-	Yes	no	no
node-XY3	Node-XY-24b	M	-	Yes	no	no
x	Offset-B12	M	-	Yes	no	no
y	Offset-B12	M	-	Yes	no	no
node-XY4	Node-XY-26b	M	-	Yes	no	no
x	Offset-B13	M	-	Yes	no	no
y	Offset-B13	M	-	Yes	no	no
node-XY5	Node-XY-28b	M	-	Yes	no	no
x	Offset-B14	M	-	Yes	no	no
y	Offset-B14	M	-	Yes	no	no
node-XY6	Node-XY-32b	M	-	Yes	no	no
x	Offset-B16	M	-	Yes	no	no
y	Offset-B16	M	-	Yes	no	no
node-LatLon	Node-LLmD-64b	M	-	Yes	no	no
lon	Longitude	M	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointXY }}	M	-	Yes	no	no
attributes	NodeAttributeSetXY	O	-	Yes	no	no
localNode	NodeAttributeXYList	O	-	Yes	no	no
localNode[n]	NodeAttributeXY	M	-	Yes	no	no
disabled	SegmentAttributeXYList	O	-	Yes	no	no
disabled[n]	SegmentAttributeXY	M	-	Yes	no	no
enabled	SegmentAttributeXYList	O	-	Yes	no	no
enabled[n]	SegmentAttributeXY	M	-	Yes	no	no
data	LaneDataAttributeList	O	-	Yes	no	no
data[n]	LaneDataAttribute	M	-	Yes	no	no
pathEndPointAngle	DeltaAngle	M	-	Yes	no	no
laneCrownPointCenter	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointLeft	RoadwayCrownAngle	M	-	Yes	no	no
laneCrownPointRight	RoadwayCrownAngle	M	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
laneAngle	MergeDivideNodeAngle	M	-	Yes	no	no
speedLimits	SpeedLimitList	O	-	Yes	no	no
speedLimits[n]	RegulatorySpeedLimit	M	-	Yes	no	no
type	SpeedLimitType	M	-	Yes	no	no
speed	Velocity	M	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}	M	-	Yes	no	no
dWidth	Offset-B10	O	-	Yes	no	no
dElevation	Offset-B10	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetXY }}	M	-	Yes	no	no
computed	ComputedLane	M	-	Yes	no	no
referenceLaneId	LaneID	M	-	Yes	no	no
offsetXaxis		M	-	Yes	no	no
small	DrivenLineOffsetSm	M	-	Yes	no	no
large	DrivenLineOffsetLg	M	-	Yes	no	no
offsetYaxis		M	-	Yes	no	no
small	DrivenLineOffsetSm	M	-	Yes	no	no
large	DrivenLineOffsetLg	M	-	Yes	no	no
rotateXY	Angle	O	-	Yes	no	no
scaleXaxis	Scale-B12	O	-	Yes	no	no
scaleYaxis	Scale-B12	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-ComputedLane }}	M	-	Yes	no	no
circle	Circle	M	-	Yes	no	no
center	Position3D	M	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
long	Longitude	M	-	Yes	no	no
elevation	Elevation	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
radius	Radius-B12	M	-	Yes	no	no
units	DistanceUnits	M	-	Yes	no	no

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
regionPointSet	RegionPointSet	M	-	Yes	no	no
anchor	Position3D	O	-	Yes	no	no
lat	Latitude	M	-	Yes	no	no
long	Longitude	M	-	Yes	no	no
elevation	Elevation	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}	M	-	Yes	no	no
scale	Zoom	O	-	Yes	no	no
nodeList	RegionList	M	-	Yes	no	no
nodeList[n]	RegionOffsets	M	-	Yes	no	no
xOffset	OffsetLL-B16	M	-	Yes	no	no
yOffset	OffsetLL-B16	M	-	Yes	no	no
zOffset	OffsetLL-B16	O	-	Yes	no	no
any	##other	O	-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-GeographicalPath	M	-	Yes	no	no
sspMsgRights1	SSPindex	M	M	Yes	yes	yes
sspMsgRights2	SSPindex	M	M	Yes	yes	yes
content		M	M	Yes	yes	yes
advisory	ITIS.ITIScodesAndText	M	M	Yes	yes	yes
advisory[n]		M		Yes	yes	yes
item		M	M	Yes	yes	yes
itis	ITIScodes	M	M	Yes	yes	yes
text	ITIStext	M	-	Yes	no	no
workZone	WorkZone	M	-	Yes	no	no
workZone[n]		M		Yes	no	no
item		M	-	Yes	no	no
itis	ITIS.ITIScodes	M	-	Yes	no	no
text	ITIStextPhrase	M	-	Yes	no	no
genericSign	GenericSignage	M	O	Yes	optional	optional
genericSign[n]		M		Yes	optional	optional
item		M	O	Yes	optional	optional
itis	ITIS.ITIScodes	M	O	Yes	optional	optional

Identifier	Identifier Type	J2735 Conform	Tampa Conform	SSP Rqmt	ERDW	WWE
text	ITIStextPhrase	M	-	Yes	no	no
speedLimit	SpeedLimit	M	M	Yes	yes	yes
speedLimit[n]		M		Yes	yes	yes
item		M	M	Yes	yes	yes
itis	ITIS.ITIScodes	M	M	Yes	yes	yes
text	ITIStextPhrase	M	-	Yes	no	no
exitService	ExitService	M	-	Yes	no	no
exitService[n]		M		Yes	no	no
item		M	-	Yes	no	no
itis	ITIS.ITIScodes	M	-	Yes	no	no
text	ITIStextPhrase	M	-	Yes	no	no
url	URL-Short	O	-	Yes	no	no
any	##other		-	Yes	no	no
regional		O	-	Yes	no	no
regional[n]	RegionalExtension {{ REGION.Reg-TravelerInformation }}	M	-	Yes	no	no
any	##other		-	Yes	no	no

Source: THEA

MAP Message

Table 54: MAP Message

Tampa	J2735 Map Data Object	Field Type	Comment
Y	MapData		
O	MinuteOfTheYear	OPTIONAL	
Y	MsgCount		Revision Number
O	LayerType	OPTIONAL	
O	LayerID	OPTIONAL	
Y	IntersectionGeometryList	OPTIONAL	
Y	IntersectionGeometry		1 to 32
O	DescriptiveName	OPTIONAL	
Y	IntersectionReferenceID		
Y	MsgCount		Revision Number
Y	Position3D		
Y	LaneWidth	OPTIONAL	
O	SpeedLimitList	OPTIONAL	
O	RegulatorySpeedLimit		
O	SpeedLimitType		
O	Velocity		
Y	LaneList		
Y	GenericLane	1 to 255	
Y	LaneID		LaneID "1" is the left most lane of northbound approach, ApproachID 1. Lanes are numbered counterclockwise and include Egress Lanes
O	DescriptiveName	OPTIONAL	

Tampa	J2735 Map Data Object	Field Type	Comment
Y	ApproachID	OPTIONAL	ingress (inbound)
Y	ApproachID	OPTIONAL	egress (outbound)
Y	LaneAttributes		
Y	LaneDirection		
O	LaneSharing		
Y	LaneTypeAttributes	CHOICE	
Y	LaneAttributes-vehicle		
Y	LaneAttributes-Crosswalk		
O	LaneAttributes-bike		
O	LaneAttributes-sidewalk		
O	LaneAttributes-barrier		
O	LaneAttributes-striping		
O	LaneAttributes-trackedvehicle		
O	LaneAttributes-parking		
Y	AllowedManeuvers	OPTIONAL	
Y	NodeListXY	OPTIONAL	For ingress, Node 1 is the Stop Bar. For egress, Node 1 is where the outbound lane begins; after traversing the intersection
Y	NodeSetXY		
Y	NodeXY		
Y	NodeOffsetPointXY	CHOICE	
O	Node-XY-20b		
O	Node-XY-22b		
O	Node-XY-24b		
O	Node-XY-26b		
O	Node-XY-28b		
Y	Node-XY-32b		
O	Node-LLmD-64b		
O	NodeAttributedSetXY	OPTIONAL	
O	NodeAttributeXYList	OPTIONAL	Attribute states which pertain to this node point

Tampa	J2735 Map Data Object	Field Type	Comment
O	NodeAttributeXY		
O	SegmentAttributeXYList	OPTIONAL	Attribute states which are disabled at this node point
O	SegmentAttributeXY		
O	SegmentAttributeXYList	OPTIONAL	Attribute states which are enabled at this node point and which remain enabled until disabled or the lane ends
O	SegmentAttributeXY		
O	LaneDataAttributeList	OPTIONAL	Attributes which require an additional data values some of these are local to the node point, while others persist with the provided values until changed and this is indicated in each entry
O	LaneDataAttribute		
O	DeltaAngle		adjusts final point/width slant of the lane to align with the stop line
O	RoadwayCrownAngle		sets the canter of the road bed from centerline point
O	RoadwayCrownAngle		sets the canter of the road bed from left edge
O	RoadwayCrownAngle		sets the canter of the road bed from right edge
O	MergeDivergeNodeAngle		the angle or direction of another lane this is required to support Japan style when a merge point angle is required
R	SpeedLimitList		Reference regulatory speed limits used by all segments
O	Offset-B10	OPTIONAL	A value added to the current lane width at this node and from this node onwards, in 1cm steps lane width between nodes are a linear taper between pts the value of zero shall not be sent here
O	Offset-B10	OPTIONAL	A value added to the current Elevation at this node from this node onwards, in 10cm steps elevations between nodes are a linear taper between pts the value of zero shall not be sent here
O	ComputedLane		
O	LaneID		
O	offsetXaxis	CHOICE	
O	DrivenLineOffsetSm		
O	DrivenLineOffsetLg		
O	offsetYaxis	CHOICE	
O	DrivenLineOffsetSm		

Tampa	J2735 Map Data Object	Field Type	Comment
O	DrivenLineOffsetLg		
O	Angle	OPTIONAL	
O	Scale-B12	OPTIONAL	
O	Scale-B12	OPTIONAL	
Y	ConnectsToList	OPTIONAL	
Y	Connection		
Y	ConnectingLane		
Y	LaneID		
O	AllowedManeuvers	OPTIONAL	
O	IntersectionReferenceID	OPTIONAL	
O	RoadRegulatorID	OPTIONAL	
O	IntersectionID		
Y	SignalGroupID	OPTIONAL	
O	RestrictionClassID	OPTIONAL	
Y	LaneConnectionID	OPTIONAL	
O	OverlayLaneList	OPTIONAL	
O	LaneID		
O	RoadSegmentList	OPTIONAL	
O	RoadSegment		
O	DataParameters	OPTIONAL	
O	RestrictionClassList	OPTIONAL	
O	RestrictionClassAssignment		
O	RestrictionClassID		
O	RestrictionUserTypeList		
O	RestrictionUserType		

Source: THEA

Signal Phase and Timing Message

Table 55: Signal Phase and Timing Message

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
Y	MSG_SignalPhaseAndTiming				
O	timeStamp	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)	
Optional	name	DescriptiveName	OPTIONAL	IA5String (SIZE (1..63))	
Y	intersections	IntersectionStateList	SEQUENCE (SIZE (1..32))		
Y	intersections[n]	IntersectionState			
O	name	DescriptiveName	OPTIONAL	IA5String (SIZE (1..63))	
Y	id	IntersectionReferenceID			
O	region	RoadRegulatorID	OPTIONAL	INTEGER (0..65535)	
Y	id	IntersectionID		INTEGER (0..65535)	
Y	revision	MsgCount		INTEGER (0..127)	
Y	status	IntersectionStatusObject		BIT STRING (SIZE (16))	
O	moy	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)	
O	timeStamp	DSecond	OPTIONAL	INTEGER (0..65535)	
Y	enabledLanes	EnabledLaneList	OPTIONAL SEQUENCE (SIZE (1..16))		only for intersection Meridian / Twiggs
Y	enabledLanes[n]	LaneID		INTEGER (0..255)	
Y	states	MovementList	SEQUENCE (SIZE (1..255))		
Y	states[n]	MovementState			
No	movementName	DescriptiveName	OPTIONAL	IA5String (SIZE (1..63))	currently not planned
Y	signalGroup	SignalGroupID		INTEGER (0..255)	
Y	state-time-speed	MovementEventList	SEQUENCE (SIZE (1..16))		
Y	state-time-speed[n]	MovementEvent			
Y	eventState	MovementPhaseState		ENUMERATED (0..9)	
Y	timing	TimeChangeDetails	OPTIONAL		
N	startTime	TimeMark	OPTIONAL	INTEGER (0..36001)	
Y	minEndTime	TimeMark		INTEGER (0..36001)	
Y	maxEndTime	TimeMark	OPTIONAL	INTEGER (0..36001)	
N	likelyTime	TimeMark	OPTIONAL	INTEGER (0..36001)	
N	confidence	TimeIntervalConfidence	OPTIONAL	INTEGER (0..15)	
N	nextTime	TimeMark	OPTIONAL	INTEGER (0..36001)	
N	speeds	AdvisorySpeedList	OPTIONAL SEQUENCE (SIZE (1..16))		currently not planned

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
N	speeds[n]	AdvisorySpeed			
N	type	AdvisorySpeedType		ENUMERATED (0..3)	
N	speed	SpeedAdvice	OPTIONAL	INTEGER (0..500)	
N	confidence	SpeedConfidence	OPTIONAL	ENUMERATED (0..7)	
N	distance	ZoneLength	OPTIONAL	INTEGER (0..10000)	
N	class	RestrictionClassID	OPTIONAL	INTEGER (0..255)	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-AdvisorySpeed }}			
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtenstion {{ REGION.Reg-MovementEvent }}			
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtenstion {{ REGION.Reg-MovementState }}			
N	maneuverAssistList	ManeuverAssistList	OPTIONAL SEQUENCE (SIZE (1..16))		currently not planned
N	maneuverAssistList[n]	ConnectionManeuverAssist			
N	connectionID	LaneConnectionID		INTEGER (0..255)	
N	queueLength	ZoneLength	OPTIONAL	INTEGER (0..10000)	
N	availableStorageLength	ZoneLength	OPTIONAL	INTEGER (0..10000)	
N	waitOnStop	WaitOnStopline	OPTIONAL	BOOLEAN	
N	pedBicycleDetect	PedestrianBicycleDetect	OPTIONAL	BOOLEAN	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-ConnectionManeuverAssist }}			
N	maneuverAssistList	ManeuverAssistList	OPTIONAL SEQUENCE (SIZE (1..16))		currently not planned
N	maneuverAssistList[n]	ConnectionManeuverAssist			
N	connectionID	LaneConnectionID		INTEGER (0..255)	
N	queueLength	ZoneLength	OPTIONAL	INTEGER (0..10000)	
N	availableStorageLength	ZoneLength	OPTIONAL	INTEGER (0..10000)	
N	waitOnStop	WaitOnStopline	OPTIONAL	BOOLEAN	
N	pedBicycleDetect	PedestrianBicycleDetect	OPTIONAL	BOOLEAN	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-ConnectionManeuverAssist }}			
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-IntersectionState }}			
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-SPAT }}			

Source: THEA

Roadside Alert Message

Table 56: Roadside Alert Message

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
Y	MSG_RoadSideAlert				
Y	msgCnt	MsgCount		INTEGER (0..127)	
O	timeStamp	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)	
Y	typeEvent	ITIS.ITIScodes		INTEGER (0..65535)	
O	description		OPTIONAL SEQUENCE (SIZE (1..8))		
O	description[n]	ITIS.ITIScodes		INTEGER (0..65535)	
O	priority	Priority	OPTIONAL	OCTET STRING (SIZE (1))	
O	heading	HeadingSlice	OPTIONAL	BIT STRING (SIZE (16))	
O	extent	Extent	OPTIONAL	ENUMERATED (1..15)	
Y	position	FullPositionVector	OPTIONAL		
Y	utcTime	DDateTime	OPTIONAL		
Y	year	DYear		INTEGER (0..4095)	
Y	month	DMonth		INTEGER (0..12)	
Y	day	DDay		INTEGER (0..31)	
Y	hour	DHour		INTEGER (0..31)	
Y	minute	DMinute		INTEGER (0..60)	
Y	second	DSecond		INTEGER (0..65535)	
Y	offset	DOffset		INTEGER (-840..840)	
Y	long	Longitude		INTEGER (-1799999999..1800000001)	
Y	lat	Latitude		INTEGER (-900000000..900000001)	
O	elevation	Elevation	OPTIONAL	INTEGER (-4906..61439)	
O	speed	TransmissionAndSpeed	OPTIONAL		If sent from OBU, not if sent from RSU
Y	transmission	TransmissionState		ENUMERATED (0..7)	If sent from OBU, not if sent from RSU
Y	speed	Velocity		INTEGER (0..8191)	If sent from OBU, not if sent from RSU
O	posAccuracy	PositionalAccuracy	OPTIONAL		If sent from OBU, not if sent from RSU
Y	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	If sent from OBU, not if sent from RSU

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
Y	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	If sent from OBU, not if sent from RSU
Y	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	If sent from OBU, not if sent from RSU
N	timeConfidence	TimeConfidence	OPTIONAL	ENUMERATED (0..39)	
N	posConfidence	PositionConfidenceSet			
N	pos	PositionConfidence		ENUMERATED (0..15)	
N	elevation	ElevationConfidence		ENUMERATED (0..15)	
N	speedConfidence	SpeedandHeadingandThrottleConfidence	OPTIONAL		
N	heading	HeadingConfidence		ENUMERATED (0..7)	
N	speed	SpeedConfidence		ENUMERATED (0..7)	
N	throttle	ThrottleConfidence		ENUMERATED (0..3)	
N	furtherInfoID	FurtherInfoID	OPTIONAL	OCTET STRING (SIZE (2))	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-RoadSideAlert }}			

Source: THEA

Personal Safety Message

Table 57: Personal Safety Message

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type
Y	MSG_PersonalSafetyMessage			
Y	basicType	PersonalDeviceUserType		ENUMERATED (0..4)
Y	secMark	DSecond		INTEGER (0..65535)
Y	msgCnt	MsgCount		INTEGER (0..127)
Y	id	TemporaryID		OCTET STRING (SIZE (4))
Y	position	Position3D		
Y	lat	Latitude		INTEGER (-900000000..900000001)
Y	long	Longitude		INTEGER (-1799999999.. 1800000001)
O	elevation	Elevation	OPTIONAL	INTEGER (-4906..61439)
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))	
N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}		
Y	accuracy	PositionalAccuracy		
Y	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)
Y	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)
Y	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)
Y	speed	Velocity		INTEGER (0..8191)
Y	heading	Heading		INTEGER (0..28800)
N	accelSet	AccelerationSet4Way	OPTIONAL	
N	long	Acceleration		INTEGER (-2000..2001)
N	lat	Acceleration		INTEGER (-2000..2001)
N	vert	VerticalAcceleration		INTEGER (-127..127)
N	yaw	YawRate		INTEGER (-32767..32767)
O	pathHistory	PathHistory	OPTIONAL	
N	initialPosition	FullPositionVector	OPTIONAL	
N	utcTime	DDateTime	OPTIONAL	
N	year	DYear		INTEGER (0..4095)
N	month	DMonth		INTEGER (0..12)
N	day	DDay		INTEGER (0..31)
N	hour	DHour		INTEGER (0..31)

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type
N	minute	DMinute		INTEGER (0..60)
N	second	DSecond		INTEGER (0..65535)
N	offset	DOffset		INTEGER (-840..840)
N	long	Longitude		INTEGER (-1799999999..1800000001)
N	lat	Latitude		INTEGER (-900000000..900000001)
N	elevation	Elevation	OPTIONAL	INTEGER (-4906..61439)
N	speed	TransmissionAndSpeed	OPTIONAL	
N	transmission	TransmissionState		ENUMERATED (0..7)
N	speed	Velocity		INTEGER (0..8191)
N	posAccuracy	PositionalAccuracy	OPTIONAL	
N	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)
N	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)
N	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)
N	timeConfidence	TimeConfidence	OPTIONAL	ENUMERATED (0..39)
N	posConfidence	PositionConfidenceSet		
N	pos	PositionConfidence		ENUMERATED (0..15)
N	elevation	ElevationConfidence		ENUMERATED (0..15)
N	speedConfidence	SpeedandHeadingandThrottleConfidence	OPTIONAL	
N	heading	HeadingConfidence		ENUMERATED (0..7)
N	speed	SpeedConfidence		ENUMERATED (0..7)
N	throttle	ThrottleConfidence		ENUMERATED (0..3)
N	currGNSSstatus	GNSSStatus	OPTIONAL	BIT STRING (SIZE (8))
Y	crumbData	PathHistoryPointList	SEQUENCE (SIZE (1..23))	
Y	crumbData[n]	PathHistoryPoint		
Y	latOffset	OffsetLL-B18		INTEGER (-131072..131071)
Y	lonOffset	OffsetLL-B18		INTEGER (-131072..131071)
Y	elevationOffset	VertOffset-B12		INTEGER (-2048..2047)
Y	timeOffset	TimeOffset		INTEGER (1..65535)
Y	speed	Velocity		INTEGER (0..8191)
N	posAccuracy	PositionalAccuracy	OPTIONAL	
N	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)
N	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)
N	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type
Y	heading	CoarseHeading	OPTIONAL	INTEGER (0..240)
Y	pathPrediction	PathPrediction	OPTIONAL	
Y	radiusOfCurve	RadiusOfCurvature		INTEGER (-32767..32767)
Y	confidence	Confidence		INTEGER (0..200)
N	propulsion	PropelledInformation	OPTIONAL CHOICE	
N	human	HumanPropelledType		ENUMERATED (0..5)
N	animal	AnimalPropelledType		ENUMERATED (0..3)
N	motor	MotorizedPropelledType		ENUMERATED (0..5)
N	useState	PersonalDeviceUsageState	OPTIONAL	BIT STRING (SIZE (9))
N	crossRequest	PersonalCrossingRequest	OPTIONAL	BOOLEAN
N	crossState	PersonalCrossingInProgress	OPTIONAL	BOOLEAN
N	clusterSize	NumberOfParticipantsInCluster	OPTIONAL	ENUMERATED (0..3)
N	clusterRadius	PersonalClusterRadius	OPTIONAL	INTEGER (0..100)
N	eventResponderType	PublicSafetyEventResponderWorkerType	OPTIONAL	ENUMERATED (0..7)
N	activityType	PublicSafetyAndRoadWorkerActivity	OPTIONAL	BIT STRING (SIZE (6))
N	activitySubType	PublicSafetyDirectingTrafficSubType	OPTIONAL	BIT STRING (SIZE(7))
N	assistType	PersonalAssistive	OPTIONAL	BIT STRING (SIZE (6))
N	sizing	UserSizeAndBehavior	OPTIONAL	BIT STRING (SIZE (5))
N	attachment	Attachment	OPTIONAL	ENUMERATED (0..6)
N	attachmentRadius	AttachmentRadius	OPTIONAL	INTEGER (0..200)
N	animalType	AnimalType	OPTIONAL	ENUMERATED (0..3)
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))	
N	regional[n]	RegionalExtension {{ REGION.Reg-PersonalSafetyMessage }}		

Source: THEA

Signal Request Message

Table 58: Signal Request Message

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
Y	MSG_SignalRequestMessage				
O	timeStamp	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)	
O	second	DSecond		INTEGER (0..65535)	
O	sequenceNumber	MsgCount	OPTIONAL		
Y	requests	SignalRequestList	OPTIONAL SEQUENCE (SIZE (1..32))		
Y	requests[n]	SignalRequestPackage			
Y	request	SignalRequest			
Y	id	IntersectionReferenceID			
O	region	RoadRegulatorID	OPTIONAL	INTEGER (0..65535)	
Y	id	IntersectionID		INTEGER (0..65535)	
Y	requestID	RequestID		INTEGER (0..255)	
Y	requestType	PriorityRequestType		ENUMERATED (0..3)	
Y	inBoundLane	IntersectionAccessPoint	CHOICE		
O	lane	LaneID		INTEGER (0..255)	depends on what value is chosen to identify required phase
O	approach	ApproachID		INTEGER (0..15)	depends on what value is chosen to identify required phase
O	connection	LaneConnectionID		INTEGER (0..255)	depends on what value is chosen to identify required phase
O	outBoundLane	IntersectionAccessPoint	OPTIONAL CHOICE		
O	lane	LaneID		INTEGER (0..255)	
O	approach	ApproachID		INTEGER (0..15)	
O	connection	LaneConnectionID		INTEGER (0..255)	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalRequest }}			
Y	minute	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)	
Y	second	DSecond	OPTIONAL	INTEGER (0..65535)	
Y	duration	DSecond	OPTIONAL	INTEGER (0..65535)	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalRequestPackage }}			

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Tampa Comments
Y	requestor	RequestorDescription			
Y	id	VehicleID	CHOICE		
Y	entityID	TemporaryID		OCTET STRING (SIZE (4))	
N	stationID	StationID		INTEGER (0..4294967295)	
Y	type	RequestorType	OPTIONAL		
Y	role	BasicVehicleRole		ENUMERATED (0..22)	
O	subrole	RequestSubRole	OPTIONAL	ENUMERATED (0..15)	
N	request	RequestImportanceLevel	OPTIONAL	ENUMERATED (0..15)	
N	iso3883	Iso3833VehicleType	OPTIONAL	INTEGER (0..100)	
N	hpmsType	VehicleType	OPTIONAL	ENUMERATED (0..15)	
N	regional	RegionalExtension {{ REGION.Reg-RequestorType }}	OPTIONAL		
O	position	RequestorPositionVector	OPTIONAL		
O	position	Position3D			
O	lat	Latitude		INTEGER (-900000000..900000001)	
O	long	Longitude		INTEGER (-1799999999..1800000001)	
O	elevation	Elevation	OPTIONAL	INTEGER (-4906..61439)	
O	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
O	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
O	heading	Angle	OPTIONAL	INTEGER (0..28800)	
O	speed	TransmissionAndSpeed	OPTIONAL		
O	transmission	TransmissionState		ENUMERATED (0..7)	
O	speed	Velocity		INTEGER (0..8191)	
Y	name	DescriptiveName	OPTIONAL	IA5String (SIZE (1..63))	contains VIN
O	routeName	DescriptiveName	OPTIONAL	IA5String (SIZE (1..63))	
O	transitStatus	TransitVehicleStatus	OPTIONAL	BIT STRING (SIZE (8))	
O	transitOccupancy	TransitVehicleOccupancy	OPTIONAL	ENUMERATED (0..7)	
O	transitSchedule	DeltaTime	OPTIONAL	INTEGER (-122..121)	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-RequestorDescription }}			
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalRequestMessage }}			

Source: THEA

Signal Status Message

Table 59: Signal Status Message

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type
Y	MSG_SignalStatusMessage			
O	timeStamp	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)
Y	second	Dsecond		
O	sequenceNumber	MsgCount	OPTIONAL	INTEGER (0..127)
Y	status	SignalStatusList	SEQUENCE (SIZE (1..32))	
Y	status[n]	SignalStatus		
Y	sequenceNumber	MsgCount		INTEGER (0..127)
Y	id	IntersectionReferenceID		
O	region	RoadRegulatorID	OPTIONAL	INTEGER (0..65535)
Y	id	IntersectionID		INTEGER (0..65535)
Y	sigStatus	SignalStatusPackageList	SEQUENCE (SIZE (1..32))	
Y	sigStatus[n]	SignalStatusPackage		
Y	requester	SignalRequesterInfo	OPTIONAL	
Y	id	VehicleID	CHOICE	
Y	entityID	TemporaryID		OCTET STRING (SIZE (4))
N	stationID	StationID		INTEGER (0..4294967295)
Y	request	RequestID		INTEGER (0..255)
Y	sequenceNumber	MsgCount		INTEGER (0..127)
O	role	BasicVehicleRole	OPTIONAL	ENUMERATED (0..22)
N	type	RequestorType	OPTIONAL	
N	role	BasicVehicleRole		ENUMERATED (0..22)
N	subrole	RequestSubRole	OPTIONAL	ENUMERATED (0..15)
N	request	RequestImportanceLevel	OPTIONAL	ENUMERATED (0..15)
N	iso3883	Iso3833VehicleType	OPTIONAL	INTEGER (0..100)
N	hpmsType	VehicleType	OPTIONAL	ENUMERATED (0..15)
N	regional	RegionalExtension {{ REGION.Reg-RequestorType }}	OPTIONAL	
Y	inboundOn	IntersectionAccessPoint		
O	lane	LaneID		INTEGER (0..255)
O	approach	ApproachID		INTEGER (0..15)
O	connection	LaneConnectionID		INTEGER (0..255)

Tampa	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type
O	outboundOn	IntersectionAccessPoint	OPTIONAL	
O	lane	LaneID		INTEGER (0..255)
O	approach	ApproachID		INTEGER (0..15)
O	connection	LaneConnectionID		INTEGER (0..255)
Y	minute	MinuteOfTheYear	OPTIONAL	INTEGER (0..527040)
Y	second	DSecond	OPTIONAL	INTEGER (0..65535)
Y	duration	DSecond	OPTIONAL	INTEGER (0..65535)
Y	status	PrioritizationResponseStatus		ENUMERATED (0..7)
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))	
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalStatusPackage }}		
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))	
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalStatus }}		
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))	
N	regional[n]	RegionalExtension {{ REGION.Reg-SignalStatusMessage }}		

Source: THEA

Appendix C SET-IT files

Files are provided matching this document.

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free “Help Line” 866-367-7487
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