Connected Vehicle Pilot Deployment Program Phase 2

System Architecture – New York City

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Notice

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16. Abstract

This System Architecture Document (SAD) describes the technical architecture of the proposed New York City (NYC) Connected Vehicle Pilot Deployment (CVPD) system. It is a continuation of the systems engineering work in Phase 1 deliverables including the Concept of Operations (ConOps), System Requirements Specification (SyRS), and Comprehensive Deployment Plan. Its objective is to develop an architecture for the site deployment concept and prepare a detailed system design based on that architecture that exemplifies the CVPD concept. This document defines the stakeholders and their concerns in illustrating the enterprise, physical, communication, and functional viewpoints of the system architecture. Also, it includes a Standards Plan that identifies the required interfaces to other CVPD systems based on existing available ITS standards.

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Finally, the team wants to thank the USDOT for sponsoring this project and laying the foundation for future connected vehicle deployments.

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Chapter 1. Introduction

This document describes the System Architecture Document (SAD) for the New York City Department of Transportation (NYCDOT) Connected Vehicle Pilot Deployment (CVPD) Project. This SAD describes the hardware, software, organizations, and stakeholder concerns that encompass the system goal. It also presents a high-level design of the New York City (NYC) CVPD system through four architecture views (Enterprise, Physical, Communication, Functional) and how they relate to each other.

It is the first of several documents for the CVPD Program, Phase 2 project funded by the United States Department of Transportation (USDOT). Other documents from Phase 1 of the project that influence this SAD include the Concept of Operations (ConOps) and System Requirements Specification (SyRS). Upon completion of project planning in Phase 1, Phase 2 started in September, 2016 and consists of the design, deployment, and test activities through December, 2020. A maintain and operate period comprises Phase 3 of the project over a 12-month period through December, 2021.

The document is organized to meet the requirements of the USDOT System Engineering Process and ISO/IEC/IEEE 42010-2011 standard as required by USDOT's Notice of Funding Opportunity (NOFO) for Phases 2 and 3 of the CVPD Program.

1.1 Identifying information

This document is identified as:

Agency:	New York City Department of Transportation
Organization:	Bureau of Traffic Operations
Project Name:	New York City (NYC) Connected Vehicle Pilot Deployment (CVPD)
Title:	Connected Vehicle Pilot Deployment Program Phase 2
Subtitle:	System Architecture Document (SAD) - New York City
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Date:	4/15/2021
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1.2 Supplementary information

The NYC CVPD project is one of three initial CV deployment projects that establish a base for growing a nation-wide connected vehicle system. As such, its focus is on utilizing standards to build basic infrastructure in a manner that provides a foundation for future deployments of connected vehicle technology.

The NYC CVPD project provides a real demonstration and evaluation of the benefits of the CV technology in a dense urban environment. NYC has deployed a robust infrastructure with advanced traffic controllers (ATC), an advanced adaptive traffic signal control system which currently uses travel times as part of its operational algorithms, an aggressive maintenance program, and a ubiquitous high speed wireless network (NYCWiN). By deploying Aftermarket Safety Devices (ASD) and Roadside Units (RSU), our team can bring the benefits of the CV paradigm to NYC's Vision Zero initiative and provide the opportunity to evaluate the benefits with a significant number of vehicles that are regularly driving in the area.

This project will also provide the Federal Highway Administration (FHWA) the opportunity to showcase the benefits of CV technology without replacing the vehicle fleet – which is likely to be the situation for many years to come. At the same time, the NYC CVPD will be used to demonstrate the benefits to vulnerable road users who suffer the most from roadway fatalities in NYC.

1.3 Other information

1.3.1 Project scope and approach

The key concept for the NYC CVPD project is to equip a large fleet of vehicles with CV technology in order to advance towards the Vision Zero goal of eliminating injuries and fatalities from traffic crashes. To that end, the project approach is to acquire ASDs and RSUs that communicate over Dedicated Short Range Communications (DSRC) network and applications to provide drivers with alerts about identifiable safety situations. Other existing and new infrastructure will be used to support the accumulation of data for performance measurement and ongoing operations of the system.

The ASDs and RSUs will communicate over Dedicated Short Range Communications (DSRC) network using protocols covered by IEEE 802.11 and 1609 standards. They will utilize safety applications to provide drivers with alerts about identifiable safety situations. Also, they will connect with back-office applications to support information exchanges for data management and system operations. The multiple architecture views in this document illustrate the high-level architectural framework and are decomposed into more detailed functions for conducting the detailed system design. This document approach will entail translating the ConOps and SyRS to physical, logical data flows needed to build the NYC CVPD system architecture.

1.3.2 Rationale for key decisions

1.3.2.1 Existing Conditions and Constraints

The NYC CVPD team has identified existing conditions and constraints regarding the data collection of the Basic Safety Messages (BSM) generated by the ASDs. The rationale for key decisions on the NYC CVPD system architecture developed are based on those conditions and constraints as defined herein:

a. There are ~13,000 signalized intersections connected to the NYCDOT Traffic Management Center (TMC) via a cellular wireless/wireline network (NYCWiN) that provides real time data to the TMC; the system uses dynamically configured exception based reporting (NTCIP 1103) and polled data retrieval.

b. Past mechanisms for the physical collection of CV data (i.e. removable storage) are not practical due to the fleet size and costs. All data must be collected through "casual" Over-the-Air (OTA) communications.

c. All vehicle-to-infrastructure (V2I) and infrastructure-to-vehicle (I2V) communications will use DSRC (5.9 GHz); we plan to use one or more service channels to upload all data collected on the vehicles and download applications and operating parameters.

d. The backhaul bandwidth is limited – whether it is on NYCWiN (New York City's private shared cellular network) or common carrier (3G/4G/LTE); we have a dense collection of field devices and are planning for a relatively dense collection of interacting vehicles. There are variable latencies and bandwidth limitations – as well as the fact that this is a shared media with other users (i.e. police and fire), including video. Thus, there are latencies and delays on the order of 200-750 ms on average, with significant deviations under "busy" conditions for all backhaul exchanges.

e. All of our pilot project vehicles are "fleet" owned – and hence return to a "barn" typically once per day – sometimes several times per day (i.e. driver shift change). Note that we estimate the average vehicle runtime (ignition on, engine running) is between 13-14 hours per day due to the nature of the fleet operations.

f. The total vehicle fleet size was reduced from an initial 10,000 to 8,000 and then to 3,000 vehicles. Nonetheless, the RSU deployment has grown from ~350 RSUs to 450 RSUs with additional sites in and out of the NYC CV pilot corridors for other support services including over-the-air (OTA) download, upload, SCMS update, and V2XLocate.

g. There are traffic operational restrictions [in the City] including the 25 mph speed limit (most all surface streets) and right-turn-on-red (RTOR) prohibition which are not common in other parts of the US and may impact the driver behavior, especially for individuals not familiar with the NYC environment and traffic laws.

h. NYC is a litigious place – and data collected can and will be subpoenaed and subject to Freedom of Information Act (FOIA) requests for all sorts of tort cases and "investigations" and hence, it must be aggregated, normalized, and obfuscated before it is stored in any location within NYC – except for New York University (NYU), where access is very limited and is protected by an Independent Review Board (IRB). It is important to note that time and location data (BSM) has the potential to become personally identifiable information (PII) if it can be tied to other records such as police reports and used in legal, disciplinary, and insurance proceedings, hence, all such data will be immediately processed as noted.

i. Many of the initial stakeholder organizations that had expressed interest in the NYC CV pilot program did not continue their support. Hence, organizations such as TLC, taxi fleets, UPS, and DSNY ended up deciding not to participate. MTA allowed installation in eleven (11) of its buses, but ultimately it also chose to discontinue allowing further ASD installations in its buses.

j. Pedestrian application for the PID to be used by visually-impaired pedestrians encountered many issues that led to delays as well. The PID deployment number was also decreased from 100 devices to 10 prototype PIDs to be used for testing and evaluation of the technology.

k. Procuring turnkey devices proved to be challenging. This led to delays in release, testing, and validation of prototype and production devices. The amount of time and effort expended into procurement, testing, and validation has been well above the original expectations made during planning stages of the NYC CV pilot project. Additional details can be found in the As-Built Addendum section at the end of this document.

1.3.2.2 Interoperability through Information Flow Triples

Another premise of the NYC CVPD system architecture will involve achieving and enhancing interoperability. The NYC team has been coordinating with the Wyoming and Tampa Hillsborough Expressway Authority (THEA) CVPD teams through USDOT's biweekly technical roundtable teleconferences. The three teams met in Tampa, Florida in October 25-27, 2016 to discuss the information flow triples (i.e. data flow, source, destination) in each system architecture and determine which flows are identical, similar, or distinct from each other. The information flows in Table 1 were considered to appear identical while the ones in Table 2 were considered to be similar across all three sites.

Table 1. Information Flow Triples Considered to be Identical from THEA Technical Roundtable

NYC	TPA	WYO	Data Flow	Source	Destination	Notes
yes	yes	yes	vehicle location and motion	All vehicles	All vehicles and RSUs	SAE J2735 (2016-03) and SAE J2945/1 (2016-03): BSM
yes	yes	yes	vehicle location and motion for surveillance	All vehicles	RSU	SAE J2735 (2016-03) and SAE J2945/1 (2016-03): BSM
yes	yes		location correction	RSU	All vehicles	Constrained by available technology
yes	yes		pedestrian crossing status	Signal Controller	RSU	SAE J2735 (2016-03): SPaT

Table 2. Information Flow Triples Considered to be Similar from THEA Technical Roundtable

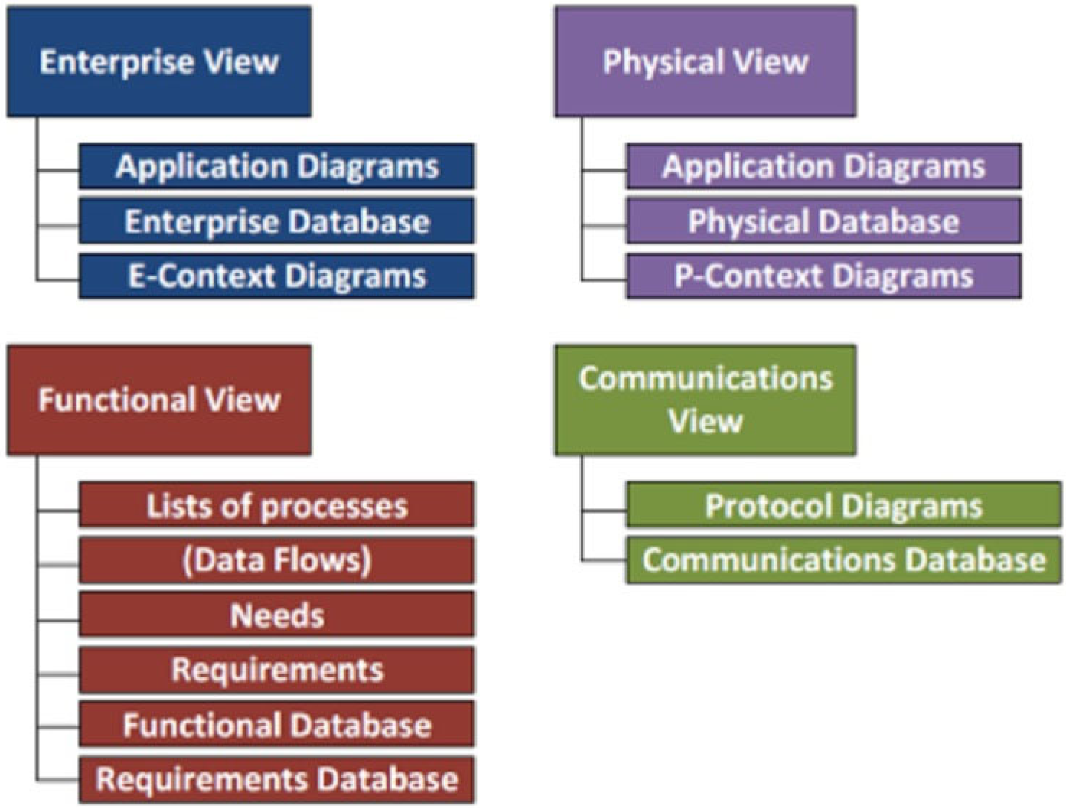
NYC	TPA	WYO	Data Flow	Source	Destination	Notes
yes	yes		vehicle control event	All vehicles	All vehicles	SAE J2735 (2016-03) and SAE J2945/1 (2016-03): BSM vehicle event flags
yes	yes	yes	location and time	loc & time source (i.e. GPS)	[device]	All mobile need this; most RSUs need this; constrained by available technology
yes			emergency traveler information	OER	NYC TMC	SAE J2735 (2016-03): TIM
yes		yes	vehicle situation data parameters	RSU	All vehicles	SAE J2735 (2016-03): probe vehicle data/probe data management (PVD/PDM)
yes	yes		intersection status	RSU	All vehicles	SAE J2735 (2016-03): SPaT
yes	yes		intersection safety warning	RSU	All vehicles	SAE J2735 (2016-03): SPaT
yes		yes	lane closure information	RSU	All vehicles	SAE J2735 (2016-03): TIM

NYC	TPA	WYO	Data Flow	Source	Destination	Notes
yes			speed management information	RSU	All vehicles	SAE J2735 (2016-03): MAP (TPA and WYO are doing the same with TIM)
yes	yes	yes	traffic situation data	RSU	TMC	
yes	yes		device identification	RSU, all vehicles	TMC	For acquiring service specific permissions (SSP)
yes			equipment configuration settings	TMC	RSU	
yes			equipment control commands	TMC	RSU	
yes	yes		user permission sets	ASD, PID, RSU Vendors	SCMS	Needed by any site that needs SSPs

As shown in the above tables, each information flow triple defines the source and destination or the sender and recipient of each data flow. The Physical and Communication architectures specify what and how the data is transmitted from its source to destination. The triples identified in this SAD represent the building blocks for the NYC CVPD system and trace to the architecture views. They will be critical in achieving interoperability across all three CV pilot sites during system design. The complete set of the merged triples is listed in 3.4.3.3APPENDIX B.

1.3.3 Architecture Views

As stated in the beginning of this chapter, the NYC CVPD SAD consists of four primary architecture views: Enterprise, Physical, Communication, and Functional. This sub-section provides a textual description of each view's context, relationships between the views, and plans to maintain the SAD as the NYC CVPD project moves forward. The framework of each architecture view is illustrated in Figure 1 below.



Source: USDOT, 2016

Figure 1. Four Primary Architecture Views Based on the CVRIA

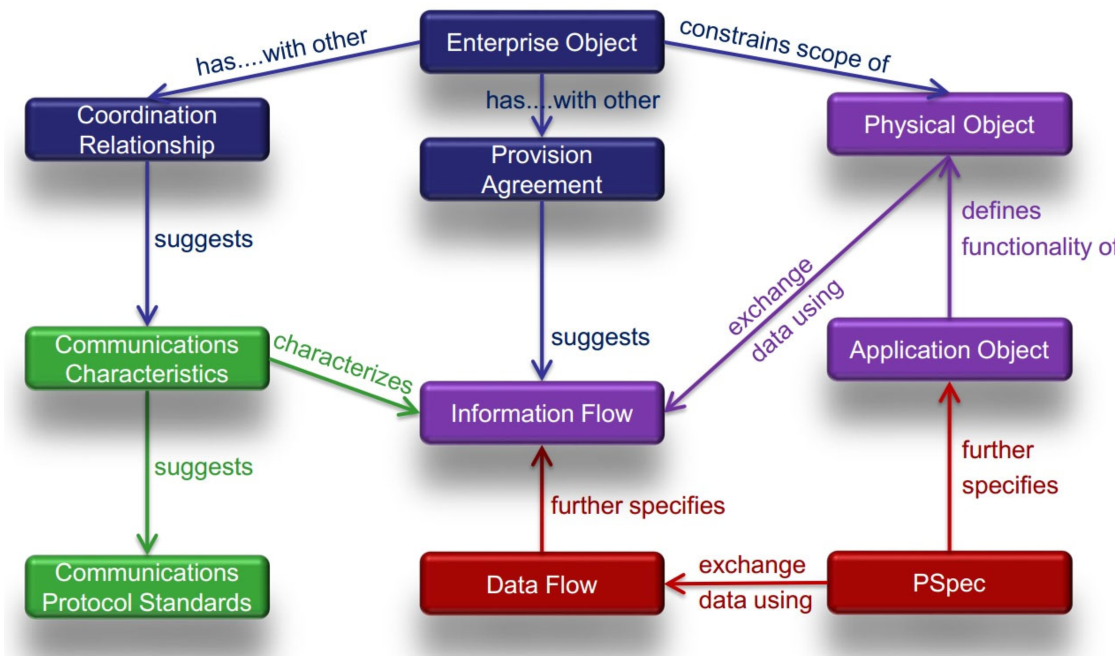
The Enterprise View describes the relationships between stakeholder organizations that support the overall system architecture. The enterprise viewpoint in Section 3.1 will highlight the stakeholders and their concerns. It will also address the roles and responsibilities of each stakeholder, including their operational relationships, agreements, and limitations. They are based on the descriptions in NYC ConOps Section 4.3 and SyRS Section 2.6. Also, the Enterprise View context diagrams from Section 5.3.2.1 in the ConOps have been updated and included in Section 3.1 of this SAD.

The Physical View describes the physical devices and systems that are known as physical objects or elements by the Connected Vehicle Reference Implementation Architecture (CVRIA). It also depicts their application objects and high-level interfaces between the physical objects or elements. It decomposes the functional architecture in a logical manner into specific applications, interfaces, devices, systems, and the messages or data flows exchanged between them. The safety and support application diagrams in Section 3.2 of this SAD demonstrate the NYC CVPD system's physical architecture.

The Communication View describes the communication protocols for the data flows between the application objects and devices. It utilizes layers to denote specific ITS standards used by each data flow. For certain standards such as Society of Automotive Engineers (SAE) J2735 and J2945/1, the latest version is dated March, 2016. Hence, they have been cited with '2016-03' at the end of their names in the communication architecture diagrams. Based on the CVRIA, each data flow has been associated with a specific communication profile. The communication protocol diagrams in Section 3.3 describe how the data flows for each profile are transmitted from the source to destination.

The Functional View describes the abstract processes and their corresponding logical interactions that satisfy and comply with the system requirements. For the NYC CVPD project, event data lifecycle will be a critical function in the system. As DSRC messages are transmitted and data is collected, not all of it will be stored in the devices and the data warehouse. Instead, event logs will be generated based on the data collected by the messages. They will be uploaded and processed to eliminate private data and PII. Section 3.4 explains the general NYC CVPD system context and how it ties into these event data processes. This reflects the approach to data collection, management, and processing that the NYC CVPD team has developed and included in the ConOps and SyRS documents.

Figure 2 below highlights the interactions between the various architecture viewpoints. The objects and the flows in dark blue describe the enterprise agreements, relationships, and provisions. The ones in purple entail data exchanges between the physical objects and safety and support applications. The green elements represent the communication mechanisms that support the protocols and define how the information flows will occur. Finally, the red elements entail functions that provide additional detail on the applications and the data flows in the system architecture.



Source: USDOT, 2016

Figure 2. Relationships Between CVRIA Architecture Viewpoints

The System Engineering Tool for Intelligent Transportation (SET-IT) is a free software application that integrates database and drawing tools with the CVRIA for developing project architectures for pilot and early deployment CV projects. Currently, it supports the following three of the four architecture views: Enterprise, Physical, and Communication. However, the Enterprise View in SET-IT only suggests default relationships between owners and operators based on the CVRIA. For this reason, the enterprise architecture was modified and expanded in Microsoft Visio. The SET-IT tool was used to build the Physical and Communication architectures and maintain their information flow triples. For the functional architecture, Microsoft Visio was also used to create the architecture and context diagrams.

Note that this SAD is a living document that is subject to change throughout the NYC CVPD system lifecycle. As the system architecture evolves, the SAD will be updated to reflect the changes to the architecture views. The NYC team will note the revision dates and comments in a separate log. It will also maintain version control of individual documents for tracking the specific changes. Along with the SAD, the information flow triples will also be updated as all three pilot sites identify out-of-date terms. The three teams will send their feedback to the CVRIA team for improving the SET-IT software over time.

1.3.4 DSRC Message Sets

In addition the triples spreadsheet, each CVPD team has completed DSRC message set spreadsheets. It has identified whether the data elements in the message structures for the basic safety message (BSM), map data message (MAP), and travel information message (TIM) as specified in the SAE J2735 (2016-03) standard are required, optional, or not needed. Any use of optional data elements and discrepancies from the ITS standards are noted in 3.4.3.3APPENDIX C - 3.4.3.3APPENDIX E. While other messages including the signal, phasing, and timing (SPaT) will be part of the system architecture, the message structure information has not been finalized and is not presented in this document. The NYC CVPD system will not incorporate the probe vehicle data / probe data management (PVD/PDM) message set and instead utilize an alternative packaging to support its performance measurement needs. However, the DSRC message set spreadsheets will be updated as needed, similar to the merged triples. The relationships between the message set and the triples spreadsheets will be maintained throughout the NYC CVPD project.

Chapter 2. Stakeholders and Concerns

2.1 Overview

This section describes the stakeholders and their concerns regarding the NYC CVPD system. Based on the ISO/IEC/IEEE 42010 standard, the stakeholders of a system have concerns about the system of interest in relation to its environment. As concerns are identified throughout the system life cycle, it could be held by one or multiple stakeholders.

2.2 Stakeholders

The users and stakeholders of the NYC CVPD system are classified into the groups defined in this section.

2.2.1 System Owner

As the prime contractor for the NYC CV Pilot project, NYCDOT will be the owner of the NYC CVPD system. In supporting the goals of Vision Zero, its traffic managers' responsibilities will include managing the speed on surface streets to 25 mph regulatory speed limit; reducing vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) crashes and between vehicles and visually/audibly-impaired pedestrians; informing drivers of serious incidents; and providing mobility information in heavily congested areas.

2.2.1.1 NYCDOT ASD Monitoring Personnel

The NYCDOT ASD monitoring personnel is responsible for checking the health status and radio frequency (RF) footprint of the communication to and from ASDs in the NYC CVPD. The ASD will collect log information on its operational status and sent for review. When equipment faults are detected, the monitoring personnel will notify and dispatch the maintenance personnel to the vehicle fleet barn, where troubleshooting and repair works will be performed.

2.2.1.2 NYCDOT RSU Monitoring Personnel

The NYCDOT RSU monitoring personnel is responsible for checking the health status and RF footprint of the communication to and from RSUs in the NYC CVPD. When equipment failures are detected, they will notify and dispatch the maintenance personnel to the RSU. The proposed RSU locations consist of signalized intersection, vehicle fleet terminal, bridge/tunnel crossings, and other designated locations that may be outside the NYC CVPD pilot area.

2.2.2 User

The roadway users in the NYC CVPD include vehicle fleet owners, drivers/operators, pedestrians, and performance management users. Based on stakeholder meetings with the participating fleet owners, the need for privacy and management of the CV applications for the traffic environment will apply to both fleet owners and roadway users.

2.2.2.1 Fleet Owner

In the NYC CVPD system, the fleet manager will be responsible for overseeing the vehicle equipment installation, coordinating maintenance activities, and daily operation of the vehicles. Their roles include managing equipment maintenance, and daily operations of the vehicle fleets. Also, their major concern on potential use of the data for enforcement or driver performance assessment will be addressed by establishing the need to have privacy of vehicles and drivers in the CV system.

2.2.2.1.1 NYCDOT Fleets

NYCDOT Fleets represent the fleet owners that manage maintenance vehicles, trucks, and passenger cars from NYCDOT for its daily operation. They include light-duty and heavy vehicles such as inspector's cars, passenger trucks, asphalt trucks, and other construction vehicles. Approximately 800 NYCDOT vehicles are expected to be deployed in the NYC CVPD program.

2.2.2.1.2 Department of Citywide Administrative Services (DCAS)

DCAS in NYC is the agency that provides shared services to support City operations. It administers citywide fleet management including maintenance and operation of motor vehicle pool. Due to TLC/taxi fleets, UPS, and DSNY no longer deciding to participate in NYC CVPD, NYCDOT has been able to coordinate with DCAS fleet owners in obtaining additional vehicles for ASD installation and deployment. About 1759 DCAS fleet vehicles are expected to be deployed in the NYC CVPD program.

2.2.2.1.3 Metropolitan Transportation Authority (MTA)

MTA is the agency responsible for operation and maintenance of local and express buses in NYC's five boroughs. It manages about a total of 5,900 buses that belong to ~16 different bus models. In the NYC CVPD project, about 700 buses are expected to be deployed.

2.2.2.2 Fleet Driver

Drivers represent the vehicle operators from each participating fleet owner in the NYC CVPD system. With the project plan to instrument 3,000 vehicles, the project will be dealing with a potentially much larger pool of driver/operators. This is due to the nature of the fleets and that multiple drivers may be used to operate the vehicles. Many of the fleet vehicles will be in service more than five days a week and for periods well beyond an eight (8)-hour shift. If the ASD in the vehicle experiences a fault, the driver will be responsible for reporting to the fleet owner who will then notify the NYCDOT and coordinate maintenance activities.

Vehicle driver/operators will also be responsible for identifying issues with their vehicles and bringing those issues to the attention of the vehicle owners for repair. In the case of the vehicle fleets, some fleet owners have internal organizations for vehicle maintenance. Other fleet owners utilize third-party maintenance providers for vehicle maintenance on a contract basis.

2.2.2.3 Pedestrian

Pedestrians represent the people that walk along the roadways. In the NYC CVPD system, they are classified into two distinct groups. The first group includes the visual-impaired pedestrians who are participating in the NYC CV pilot, and equipped with personal information devices (PID). Each participant will carry the PID which will be used for the Mobile Accessible Pedestrian Signal System (PED-SIG) application in assisting the visually-impaired pedestrian to cross the intersection safely. Pedestrians for Accessible and Safe Streets (PASS) is the coalition that works to promote safe access to sidewalks and streets for the visually-impaired and audibly-impaired pedestrians in NYC. PASS is expected to be a stakeholder that will aid in recruiting the visually-impaired pedestrians for the NYC CV pilot.

The second group consists of pedestrians who are not participants and not carrying any PIDs. They may be crossing intersections that are proposed to be equipped with new pedestrian detection equipment. These intersections are listed in see Table 35 in NYC CVPD Phase 1 ConOps, FHWA-JPO-16-299. This pedestrian detection data will be used for the Pedestrian in Signalized Crosswalk (PEDINXWALK) application and alerting the driver of the pedestrian crossing. More details on the distinction between the PED-SIG and PEDINXWALK applications are found in Section 3.2.1.2.

2.2.2.4 Performance Measurement User

Performance measurement users will be responsible for viewing the daily event log history, the log uploading process, and batch processing of the data. They will be able to see and understand how much data and how many events are generated and recorded. Also, they will be the first point people for noticing any anomalies in the CV device operation, such as errors in time synchronization in the ASDs via Global Navigation Satellite System (GNSS) devices.

2.2.2.4.1 New York University (NYCDOT IRB)

NYU will be the IRB and perform the initial assessment of the vehicle and pedestrian data and the ensuing safety benefits. The CV application performance will also be analyzed in consideration of the dense urban environment where intersections are tightly clustered together (e.g. ~250 feet) and location referencing will be a technical challenge due to the “urban canyon effect” from tall buildings and limited views of the GNSS devices.

2.2.2.4.2 Texas Transportation Institute (USDOT IE)

The USDOT will engage Texas Transportation Institute (TTI) as the independent evaluator (IE) to analyze the project’s performance with respect to USDOT's goals that may or may not include goals identified by the NYC pilot site. TTI will be responsible for analyzing the processed event data and the safety benefits of the NYC CVPD program. In addition to the safety benefits, the USDOT is interested in exploring what additional benefits such as mobility, environmental, and public agency efficiency are attained with the NYC CVPD. To measure the CV application’s benefits, the project will incorporate a before/after evaluation using the CV equipment installed in fleet vehicles. The ASD equipment will be used to collect information regarding the performance of the CV applications in the project’s geographic and traffic environment.

2.2.3 Operator

The NYCDOT Traffic Management Center (TMC) operators are responsible for operating the citywide TMC. They interact with the traffic control system (TCS) and provide operator data and command inputs to the system operations. Status on field equipment such as wired and wireless communication networks and the advanced solid-state traffic controller (ASTC) upgrades will be communicated with other NYC CV system users.

The TMC operators will also communicate with the RSUs in the NYC CVPD to monitor and manage traffic flow and roadway conditions. For minor traffic accidents and work zone activities, they will work with the City's traffic surveillance system, traffic information system, work zone management system to monitor traffic in and around the areas of influence. In the event of major disasters, they will coordinate incident management activities and exchange information with NYCDOT Office of Emergency Response (OER).

2.2.4 Maintainer

The maintainers of the NYC CVPD system will consist of NYCDOT and NYC DoITT.

2.2.4.1 NYCDOT Maintenance Personnel

The NYCDOT maintenance personnel will be responsible for troubleshooting and repairing faults in the CV equipment software and hardware. The RSUs' operation will be checked for issues by the NYCDOT monitoring personnel who will determine whether site visits and field repairs will be required. Once the issues are diagnosed, the maintenance technicians will be dispatched to the RSU locations, perform the repairs, and report back to the monitoring staff.

The maintenance technician will also monitor the RF footprint of the communication to and from the device. When new firmware version becomes available, the technician will makes sure the firmware update is transmitted from the RSU and installed in the ASD. Also, the CV application configurations will be downloaded and tweaked as needed from the vehicle's OBD II/CAN bus port.

For software and firmware updates, the NYCDOT maintenance staff will work with the TMC to install them via the RSU at each vehicle fleet barn. Once the vehicle returns to its garage after normal operation, the RSU will communicate with the ASD to check its firmware version. When an upgrade is needed, the ASD will request the OTA firmware upgrade package which will be installed via the RSU.

2.2.4.2 NYC DoITT

As NYC's communication infrastructure owner/operator, the NYC Department of Information Technology and Telecommunications (DoITT) will be responsible for the back-office environment through NYCWiN. It will also work with NYCDOT in resolving compatibility issues with NYCWiN's existing IPv4 network backhaul with NYC CVPD system's IPv6 infrastructure. In conjunction with NYCDOT, NYC DoITT will maintain the security and reliability of NYC's communications infrastructure for the NYC CVPD system operation.

2.2.4.3 NYCDOT Traffic Management Center (TMC) Back Office

The back-office facilities in the NYCDOT TMC will provide for the following management functions in the NYC CVPD:

- Managing RSU performance (failure identification, repair, maintenance)
- Managing RSU RF footprints
- Managing CV application configuration
- Distributing obfuscated data externally to USDOT Independent Evaluator (IE)
- Collecting data from the RSU/ASD
- Aggregating, normalizing, and obfuscating the CV data
- Assessing the NYC CVPD system performance and safety benefits

The support environment for the NYC CVPD system's core services will include the following elements:

- USDOT Production SCMS
- Operational Data Environment (ODE)
- Object Registration and Discovery Service (ORDS)
- Location and Time Source (LTS)
- Service Monitor (SM) Device Management
- Wide Area Information Disseminator (WAID)

The Security Credential Management System (SCMS), Operational Data Environment (ODE), and Object Registration Discovery Service (ORDS) are expected to be developed and provided by the USDOT. The ODE has replaced the Data Distribution System (DDS) as the platform for routing the data from multiple data sources to a common, integrated format for subscribers to software applications such as CV applications. The Location and Time Source (LTS), Service Monitor (SM) System, and Wide Area Information Disseminator (WAID) will be provided by NYCDOT as the owner of the NYC CVPD system.

2.2.5 Supplier

The device suppliers will be responsible for developing, integrating, and installing the ASDs, RSUs, and the PIDs for the NYC CVPD system.

2.2.5.1 Developer

NYCDOT will issue requests for quote (RFQ) to vendors for procuring the ASDs, RSUs, and PIDs. Two vendors will be selected for each device procurement to develop the prototype and production devices for the NYC CVPD system.

2.2.5.2 Integrator

NYCDOT will be the main integrator of the ASDs, RSUs and PIDs. The selected vendors as stated in Section 2.2.5.1 will provide engineering support services for assisting in the integration and installation efforts.

2.2.5.3 Installer

Each fleet group in the NYC CVPD will install the ASDs to its vehicles. The owners will provide the instruction to the proper installers and coordinate the installation activities for its fleet. NYCDOT will install the RSUs on the city-owned infrastructure throughout the pilot-area intersections and additional sites designated for RSUs. PASS is expected to coordinate with NYCDOT in providing the PIDs to the select number of pedestrians.

2.2.6 Acquirer

NYCDOT is the acquirer that will inherit the NYC CVPD system upon completion of Phase 3. The procurement of devices and system design in Phase 2 has started in September, 2016 and is scheduled to be complete in May, 2018. Phase 3 will involve deployment and operation of the system and is expected to be from June, 2018 to November, 2019.

2.3 Concerns

This section describes the concerns of each stakeholder in the NYC CVPD system. According to the International Standard, concern means "any topic of interest pertaining to the system. The concerns are held by the stakeholders and govern the system architecture.

2.3.1 Owner Concerns

As the system owner, NYCDOT is expected to make sure that the NYC CVPD system complies with the national standards and specifications (i.e. CAMP, IEEE, ISO, SAE, USDOT). As the equipment becomes obsolete, updates to these national standards will be issued. This will be a concern as the components and subsystems will have to be checked and updated or replaced as needed. In addition, the system requirements will be revised to reflect the changes and ensure that the system remains in compliance.

The Memoranda of understanding (MOU) between NYCDOT and each stakeholder (fleet owner) external to NYCDOT will need to be executed for the equipment installation to be complete in time for deployment in Phase 3. This concern is part of the schedule's critical path and will impact the project schedule. Though not an official deliverable, risk identification, logging, and evaluation will be an ongoing concern throughout the project lifecycle. Also, the concern lies on whether the NYC CVPD system will achieve the expected safety benefits upon system deployment in reducing the crash frequencies in the pilot areas.

2.3.2 User Concerns

A major user concern for fleet owners, fleet drivers, and pedestrians is the potential use of the data for enforcement or driver performance assessment. Although USDOT and NHTSA have policies stating that V2V DSRC data will not be used for these purposes, the potential that stored data could be the subject to subpoena or Freedom of Information Act (FOIA) requests exists. Due to the stored data’s time and location content, it has the potential to be cross-referenced with external system data (e.g., crash reports, employment timecards, driving records) and isolated so that it loses its inherent anonymity and becomes PII.

The owners join the NYC CVPD project for many reasons however they are supporting the Vision Zero goals by participating in the project. They are concerned about improving the safe operation of their fleets while minimizing the potential for distraction of the vehicle driver/operator. Since these vehicles generate revenue, the owners are also interested in the installation, maintenance of the equipment so that vehicles can be operated with minimal down-time.

For drivers, how loud, frequent, and loud the warnings from the ASDs are will play a role in their driving behavior. Several stakeholder groups have revealed that their vehicles are already equipped with other in-vehicle equipment. This raises the potential for the ASDs to distract the drivers from their normal operations. Also, the drivers and pedestrians may become too reliant on the CV technology over their decision-making abilities as they achieve familiarity with the system. Therefore, safety will be a critical concern throughout the project lifecycle.

2.3.3 Operator Concerns

The operators' concern at the NYCDOT TMC will be on integrating the NYC CVPD system with NYC's external systems specified in Section 2.2.3. This effort will involve collaboration with the maintainers of the system to achieve compatibility and interoperability among the subsystems.

2.3.4 Maintainer Concerns

A critical task for NYCDOT and NYC DoITT will be on achieving and maintaining system security. The USDOT has required all three CVPD sites to utilize its national SCMS, but it is currently in its prototype stage. This poses a concern on system security which will be mitigated once the SCMS is finalized and released.

Along with the TMC operators, the maintainers will resolve any compatibility issues with the existing network backhaul, including the CVPD system's IPv6 and NYCWiN's IPv4 infrastructure. Also, they will be integrating the NYC CVPD system with TCS and NYC's ASTC controllers.

The reliability of the NYC CVPD system will be another concern for both NYCDOT. Also, the reliability of the existing communications infrastructure will be a concern for NYC DoITT. The testing of the maintenance requirements for the NYC CVPD system will be vital in maintaining the health of the system and its components.

2.3.5 Supplier Concerns

Common concerns for the developer, integrator, and installer are the availability of completed design requirements, accomplishing equipment quality and reliability, and meeting the project schedule to procure, integrate, and install the devices prior to Phase 3 deployment.

2.3.5.1 Developer Concerns

At this time, a major concern for the vendor is the ability to complete the detailed development, design, and testing on time to deliver the prototype and production ASDs, RSUs, and PIDs. In particular, the potential for the ASD to interfere with other existing in-vehicle devices will be a concern. This will need to be addressed during design to prevent such issue. Threat arbitration for the CV application alerts will need to be established and tuned by vehicle type in the NYC CVPD system. The device supplier will also need to provide clear set of instructions and requirements to the installers to streamline the installation process.

Another vital concern involves the availability of USDOT Production SCMS and the SCMS end-entity interface for certifying the devices and signing the messages and certificates. The selected vendors are expected to interface with the USDOT Certification Operating Council (COC) and the SCMS in a stable platform, but the production SCMS has yet to be released at this time. The USDOT COC is expected to support the SCMS and develop certification services for the NYC CVPD equipment. The ASD, RSU, and PID vendors selected during procurement will be required to certify the devices in compliance with the USDOT COC and the SCMS. More details are found in Sections 3.1.2.2 and 3.4.1.5.

2.3.5.2 Integrator Concerns

Similar to the developer, the NYCDOT's concern will be on completing the integration process as scheduled to avoid delays in schedule. As the integrator, NYCDOT will coordinate with the developer and the installers to diagnose any issues and determine the steps to mitigate and resolve them. Threat arbitration and fine-tuning the CV application triggers and alerts will be critical and require close collaboration with the vendors.

Also, location accuracy in NYC's urban canyon will be critical in the ASDs transmitting their BSMs and alerting the drivers. Without a location correction mechanism, the alerts may occur when they should not. While the MAP data will be pre-configured and loaded onto the devices, the location correction mechanisms will occur from the RSUs and be received by the ASDs. Time synchronization across all subsystems and with external systems is another concern for NYCDOT. The NYC CVPD system clock and other systems' time sources will need to be kept the same. Any discrepancies in time may lead to issues such as system malfunction. More details regarding location and time accuracy are found in Section 3.2.2.

2.3.5.3 Installer Concerns

For the ASD installation, assigned crew's major concern will be on the ability to access the ASD, the vehicle, and any applicable ports in the vehicle. The potential for the ASD to conflict with other in-vehicle devices will be addressed during design. Although the RSU installation will not involve vehicles, the installers will still need to access the RSU and the infrastructure while practicing safe installation protocol. Also, the chance of the installers misinterpreting the instructions and requirements will need to be considered by the vendor that procures the equipment.

2.3.6 Acquirer Concerns

NYCDOT will be the acquirer of the NYC CVPD system. Its major concerns include meeting the schedule set forth by USDOT and considering the system's evolvement and modifications beyond Phase 3 of the project. Another concern based on phases 2 and 3 will be on achieving and enhancing interoperability with Wyoming and THEA CVPD sites, which will serve as guidelines for other future CVPD sites.

2.3.7 Independent Evaluator Concerns

The Independent Evaluator (IE) is generally concerned with the generation, transport, storage, processing and measurement of the data produced by the system for evaluating the system's performance.

2.4 Concern-Stakeholder Traceability

Table 3 below summarizes the concerns discussed in Section 2.3 and traces them to each stakeholder and stakeholder group in the NYC CVPD system.

Table 3. Concern-Stakeholder Traceability Matrix

Concern	Stakeholder Group	Stakeholder
Accessibility of device, vehicle, and infrastructure during installation	Supplier	Installer
Alert clarity	User	Fleet driver
Alert frequency and threshold levels by application	User	Fleet driver
Alert volume (i.e. ability to distinguish from other sounds in the vehicle, variability in volume based on alert type)	User	Fleet driver
Availability of SCMS end-entity interface with the USDOT COC and SCMS	Supplier	Developer
Budget	System owner	NYCDOT
Compatibility with existing backhaul	Maintainer	NYCDOT
Compatibility with existing backhaul	Maintainer	NYC DoITT
Completion of detailed design and testing	Supplier	Developer
Completion of detailed design and testing	Supplier	Integrator
Compliance with national standards	System owner	NYCDOT
Coordination of CV operation with external systems	Operator	NYCDOT
Data processing	Performance measurement user	NYU (NYCDOT IRB)
Data processing	Performance measurement user	TTI (USDOT IE)
Dependency on CV technology	User	Fleet driver
Design requirements	Supplier	Developer
Design requirements	Supplier	Integrator
Design requirements	Supplier	Installer
Device quality and reliability	Supplier	Developer
Device quality and reliability	Supplier	Integrator
Device quality and reliability	Supplier	Installer
Disruption of ASD to normal operation	User	Fleet owner
Disruption of ASD to normal operation	User	Fleet driver
Execution of the MOU with each fleet	System owner	NYCDOT

Concern	Stakeholder Group	Stakeholder
Execution of the MOU with each fleet	User	Fleet owner
Interference of ASD with other existing in-vehicle devices	Supplier	Developer
Interference of ASD with other existing in-vehicle devices	Supplier	Installer
Interoperability with other CVPD sites	Acquirer	NYCDOT
Installation instructions and requirements	Supplier	Installer
Integration of DSRC and backhaul network	Maintainer	NYC DoITT
Integration of DSRC and backhaul network	Supplier	Integrator
Location and time accuracy	Supplier	Integrator
Maintenance requirements	Maintainer	NYCDOT
Maintenance requirements	Maintainer	NYC DoITT
Performance evaluation	User	Performance measurement user
Performance requirements	User	Performance measurement user
Performance requirements	Supplier	Developer
Privacy of data (protection of PII from enforcement or assessment)	User	Fleet owner
Privacy of data (protection of PII from enforcement or assessment)	User	Fleet driver
Privacy of data (protection of PII from enforcement or assessment)	Pedestrian	Pedestrian
Procurement requirements	Supplier	Developer
Reliability of NYC CVPD System	Maintainer	NYCDOT
Reliability of existing communication infrastructure	Maintainer	NYC DoITT
Risk Assessment	System owner	NYCDOT
Safety during driving	User	Fleet owner
Safety during driving	User	Fleet Driver
Safety during installation	User	Fleet owner
Safety during installation	Supplier	Installer
Safety benefits	System owner	NYCDOT
Schedule	Acquirer	NYCDOT
Schedule	Supplier	Developer
Schedule	Supplier	Integrator

Concern	Stakeholder Group	Stakeholder
Schedule	Supplier	Installer
Schedule	System owner	NYCDOT
System evolvability and modifiability	Acquirer	NYCDOT
System requirements	System owner	NYCDOT
System requirements	Supplier	Integrator
System security	Maintainer	NYCDOT
Threat arbitration of CV application alerts	Supplier	Developer
Threat arbitration of CV application alerts	Supplier	Integrator
Utilization of national SCMS	Maintainer	NYCDOT

Chapter 3. Architectural Views

An architectural viewpoint provides the context for its associated architectural view. As such, it provides information about the construction of the view, the stakeholders served and their concerns (as well as “anti-concerns”),and the tools for understanding the architecture view as well as the methods used to create, interpret, analyze, and implement the view. An architecture view describes the architecture of the system in accordance with its corresponding architecture viewpoint. It addresses the concerns it frames for stakeholders and the conventions it sets on the architecture views. This section provides the four high-level architectural views presented for the NYC CVPD system: Enterprise, Physical, Communication, and Functional.

3.1 Enterprise View

The enterprise view includes the active stakeholders, i.e., those directly related to the deployment of the CVPD and responsible for some aspect of its operation. It does not consist of stakeholders who would be involved in the future as the system expands both geographically and operationally. The NYC CVPD project goal is driven by Vision Zero and NYCDOT is the primary stakeholder that will own and manage the NYC CVPD system. As the traffic manager, NYCDOT is bringing CV technology to its urban area in anticipation of the safety benefits for Vision Zero.

3.1.1 Stakeholders Involved

All project stakeholders are represented by the enterprise view architecture. They are described in detail in Section 2.2 above and listed in Table 4 below.

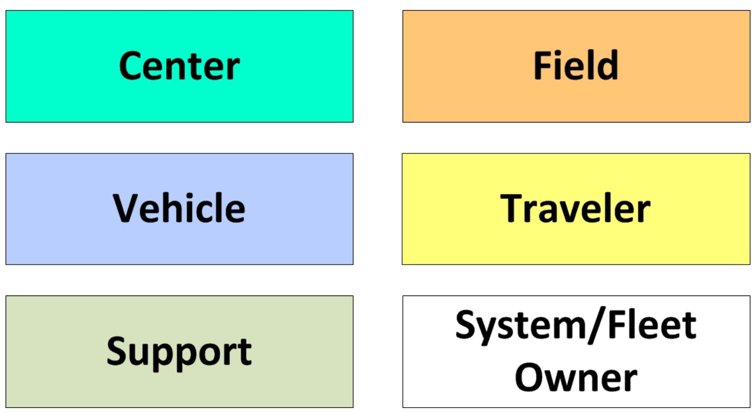
Table 4. Users and Stakeholders

User	User Class
DCAS Drivers	Fleet Driver
DCAS Fleets	Fleet Owner, Installer
MTA	Fleet Owner, Installer
MTA Bus Operators	Fleet Driver
New York University (NYU)	Performance Measurement User
NYC DoITT	Maintainer
NYCDOT	System Owner/ Traffic Manager, Integrator, Acquirer
NYCDOT Drivers	Fleet Driver
NYCDOT Fleets	Fleet Owner, Installer
NYCDOT Maintenance Personnel	Maintainer

User	User Class
NYCDOT Traffic Management Center (TMC) Operator	Operator
Pedestrian	Pedestrian
Pedestrians for Accessible and Safe Streets (PASS)	Pedestrian
Texas Transportation Institute (TTI)	Performance Measurement User
Vendor for ASD, PID, RSU	Supplier

3.1.2 Relationship Diagrams

The high-level (layer 0) Enterprise View of the NYC CVPD system is described through three architecture diagrams. The first diagram defines which enterprises own, operate, maintain, and regulate their target objects. The second diagram describes the specific relationships between each stakeholder organization pair through expectations and agreements forming those relationships. The third diagram focuses on NYCDOT as the system owner and its interactions with various stakeholders and participating organizations. The color schemes in the diagrams are based on the CVRIA and the SET-IT tool, the software tool used to generate the Physical and Communication View diagrams. The legend for distinguishing the types of stakeholders and external organizations is shown in Figure 3 below.



Source: CVRIA, 2016

Figure 3. NYC CVPD System Enterprise View Diagram Legend

3.1.2.1 Owner/Operator

The first Enterprise View diagram defines the roles that various stakeholders have with the physical devices, back-office facilities, and external systems comprising of the NYC CVPD system infrastructure. NYCDOT owns multiple existing organizations as well as proposed devices in the NYC CVPD system. Those participants and the devices will also be operated by their assigned operators and drivers. Table 5 below defines the roles the stakeholders perform in the enterprise view.

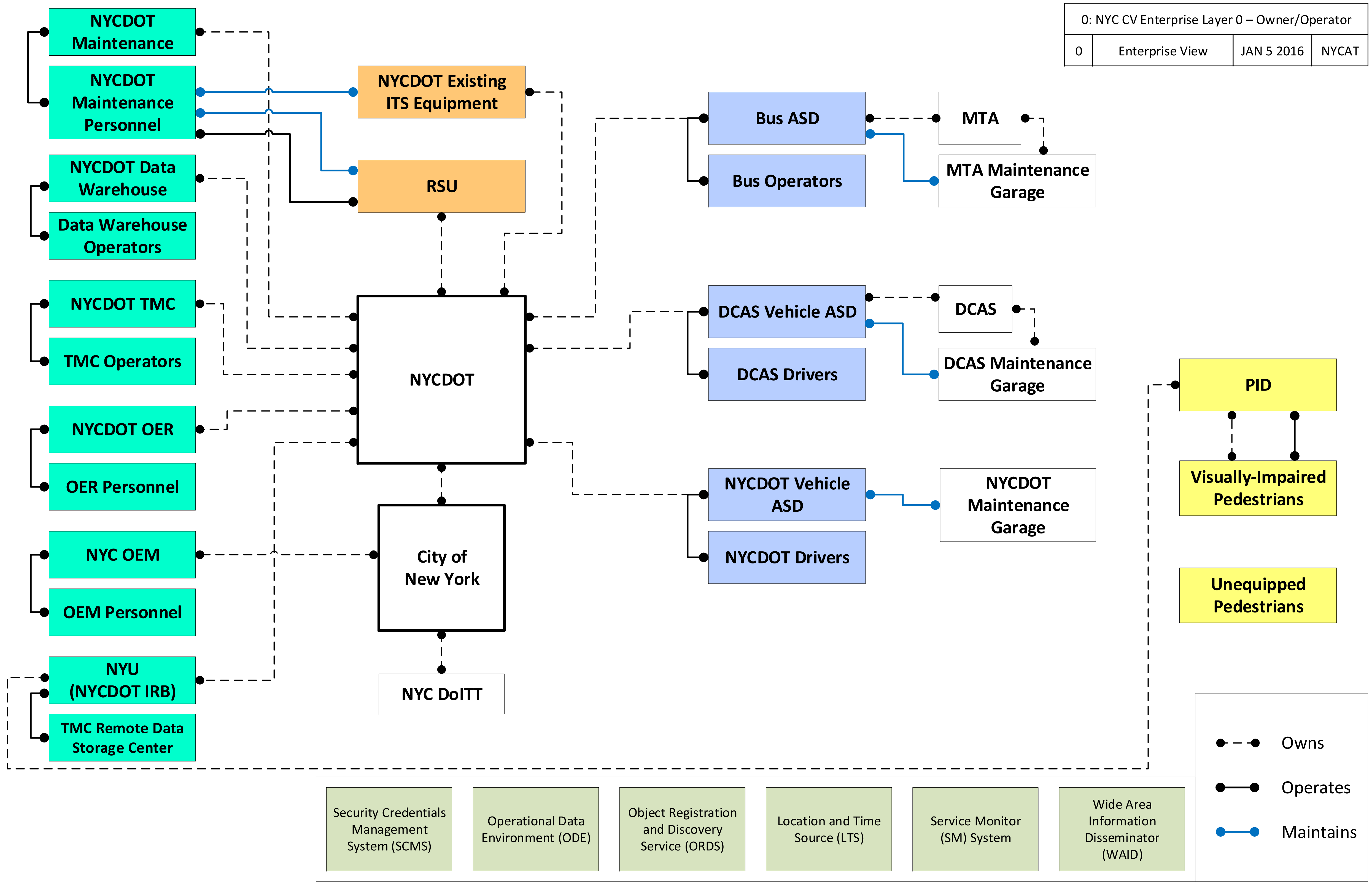
Table 5. Enterprise View Stakeholder Roles

Role Name	Description
Operates	An Enterprise controls the functionality and state of the target object.
Owns	An Enterprise has financial ownership and control over the target object.
Maintains	An Enterprise controls the identification of target object failures and their repair.

Figure 4 illustrates the roles of the participating enterprises in the NYC CVPD system. During the installation and deployment of the pilot, the devices will be owned by NYCDOT. However, upon completion of the pilot the ownership will be turned over from NYCDOT to each fleet owner group.

As the NYCDOT IRB, NYU will own the PIDs during deployment while the visually-impaired pedestrians will take over the ownership role after the deployment phase. The unequipped pedestrians refer to pedestrians that will be sensed by the proposed pedestrian detectors at designated locations (i.e. 23rd Street) in the NYC CVPD pilot area. These intersections are listed in see Table 35 in NYC CVPD Phase 1 ConOps, FHWA-JPO-16-299. They will not carry any CV devices or interact with the enterprises in the NYC CVPD system.

The support interfaces are shown at the bottom of Figure 4. The Security Credential Management System (SCMS), Operational Data Environment (ODE), and Object Registration Discovery Service (ORDS) are expected to be developed and provided by the USDOT. The ODE has replaced the Data Distribution System (DDS) as the platform for routing the data from multiple data sources to a common, integrated format for subscribers to software applications such as CV applications. The Location and Time Source (LTS), Service Monitor (SM) System, and Wide Area Information Disseminator (WAID) will be provided by NYCDOT as the owner of the NYC CVPD system.



Source: NYCDOT, 2016

Figure 4. NYC CVPD System Enterprise View: Roles

3.1.2.2 Relationships

The second Enterprise View diagram describes the relationships among the stakeholder organizations and their operators or personnel. Multiple relationship types are expected in the NYC CVPD system, and TablesTable 6 -Table 10 below list the pairs of enterprises that assume each relationship type. The overall representation of the various relationships is displayed in Figure 5.

Table 6 below identifies the stakeholder pairs with employment and operations agreements. The City of New York oversees NYCDOT and NYC DoITT, while NYCDOT consists of many key organizations that play distinct roles in the overall Enterprise architecture.

Table 6. Enterprises with Employment and Operations Agreements

Enterprise 1	Enterprise 2
City of New York	NYCDOT
City of New York	NYC DoITT
NYCDOT	NYC OEM
NYCDOT	NYCDOT Data Warehouse
NYCDOT	NYCDOT Maintenance
NYCDOT	NYCDOT OER
NYCDOT	NYCDOT TMC

Table 7 below presents the stakeholders that are expected to exchange enrollment certifications. The USDOT Certification Operating Council (COC) is expected to support the SCMS and develop certification services for the NYC CVPD equipment. The ASD, RSU, and PID vendors selected during procurement will be required to certify the devices in compliance with the USDOT COC and the SCMS.

Table 7. Enterprises with Enrollment Certifications

Enterprise 1	Enterprise 2
ASD, RSU, PID Vendors	Certification Operating Council (COC)
Certification Operating Council (COC)	USDOT SCMS

Table 8 below lists the stakeholder pairs with expectations of data or information exchange. This relationship type will occur whenever data is flown from one source to its destination in the NYC CVPD system. NYCDOT will be expected to interact with NYC DoITT which will monitor the communications data. Also, each fleet owner will be expected to exchange information with their respective drivers or operators.

Table 8. Enterprises with Expectations of Data or Information Exchange

Enterprise 1	Enterprise 2
DCAS	DCAS Drivers
MTA	Bus Operators
NYC DoITT	MTA
NYCDOT	NYC DoITT
NYCDOT	NYCDOT Fleet
NYCDOT	USDOT SCMS
NYCDOT Data Warehouse	TTI (USDOT IE)
NYCDOT Fleet	NYCDOT Drivers
NYCDOT TMC	NYCDOT Data Warehouse
NYU (NYCDOT IRB)	Visually-Impaired Pedestrians
TMC Remote Data Storage Center	NYCDOT Data Warehouse
TTI (USDOT IE)	USDOT SCMS

Table 9 shows the enterprise pairs with MOU and ASD usage agreements. This relationship type will be between NYCDOT and each fleet owner. Because NYCDOT is also a fleet owner, Figure 5 does not include this flow between NYCDOT and NYCDOT Fleet.

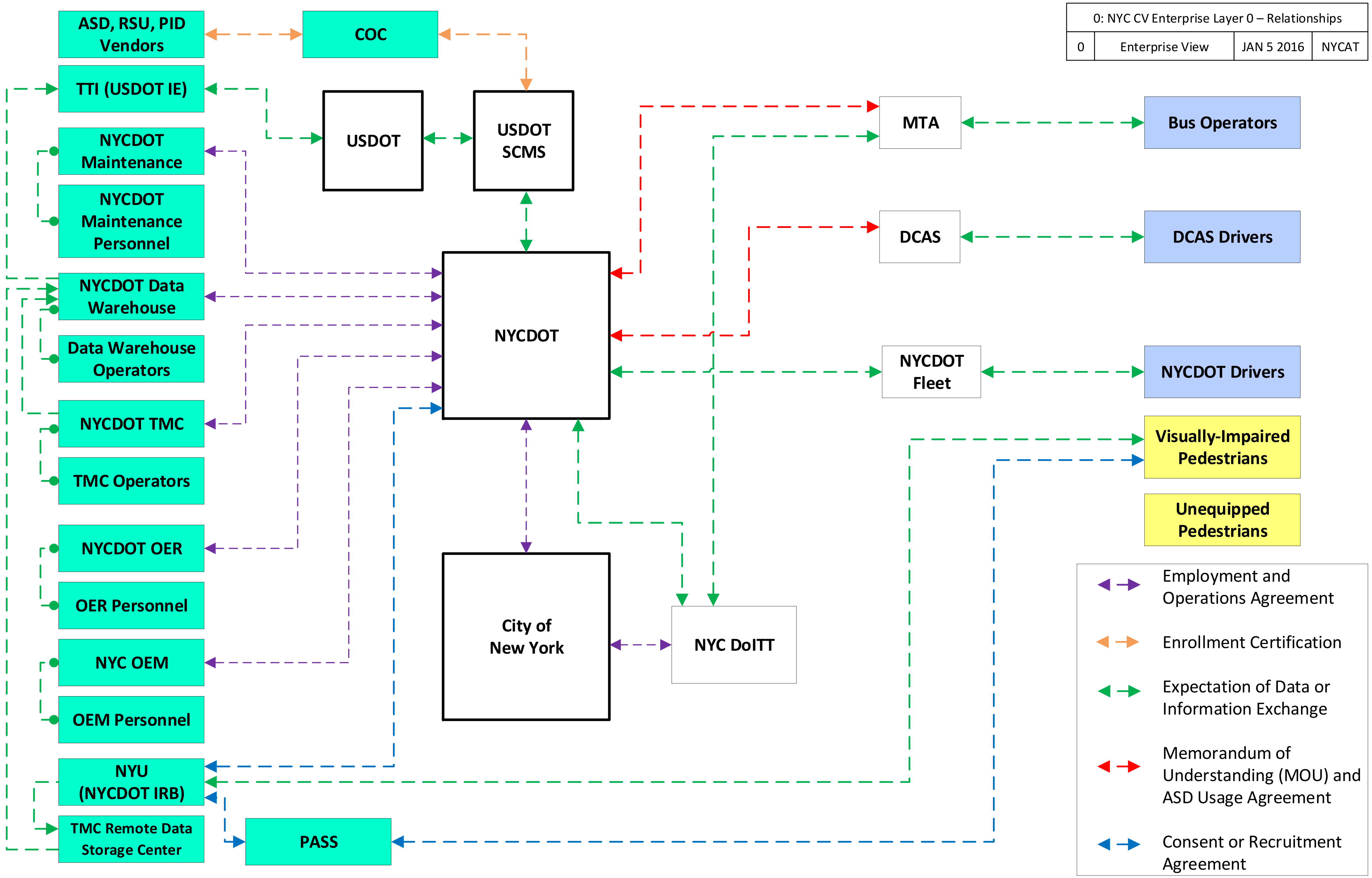
Table 9. Enterprises with MOU and ASD Usage Agreements

Enterprise 1	Enterprise 2
NYCDOT	DCAS
NYCDOT	MTA

Table 10 reveals the enterprise pairs with consent or recruitment agreements. NYU as the NYCDOT IRB will obtain consent from NYCDOT to conduct its own data collection from the PIDs. It will work with PASS to obtain consent, recruit, and collect data from participating visually-impaired pedestrians. Upon collecting the necessary data, it will send the data to the TMC Remote Data Storage Center where any PII detected will be scrubbed and sanitized. The post-processed data will then be sent to the NYCDOT Data Warehouse for a final check before being submitted it to TTI in order for USDOT to conduct its own evaluation of the NYC CVPD safety benefits.

Table 10. Enterprises with Consent or Recruitment Agreements

Enterprise 1	Enterprise 2
NYU (NYCDOT IRB)	NYCDOT
NYU (NYCDOT IRB)	PASS
PASS	Visually-Impaired Pedestrians

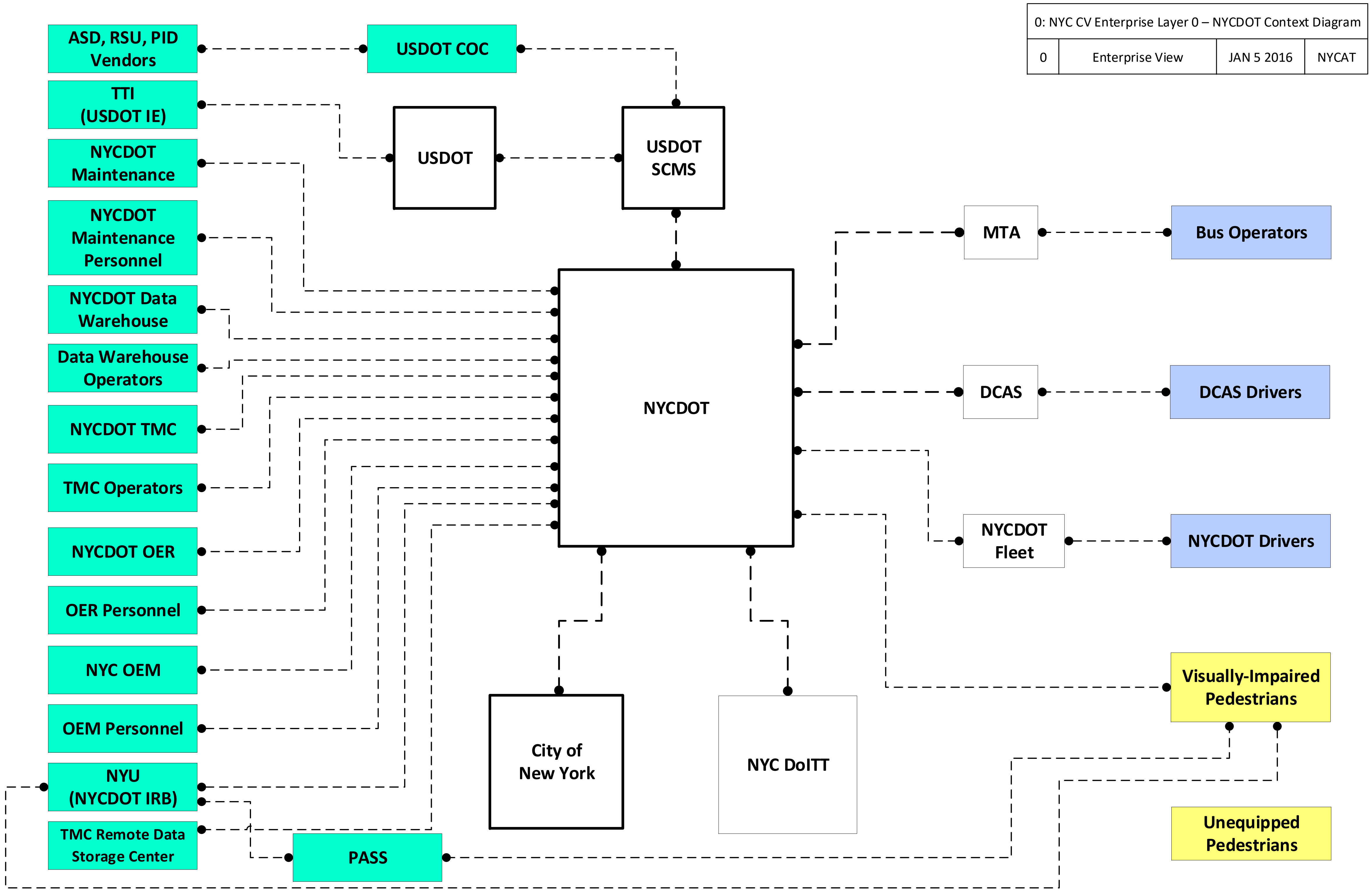


Source: NYCDOT, 2016

Figure 5. NYC CVPD System Enterprise View: Relationships

3.1.2.3 NYCDOT Context

A context diagram provides the context for a system stakeholder by showing all of the interfaces for that stakeholder. This section includes a context diagram for NYCDOT, the primary stakeholder and the system owner as stated in Section 2.2.1. The NYCDOT enterprise diagram in Figure 6 focuses on the NYCDOT and its interactions with the other system stakeholders. It also indicates the context of the NYCDOT and its interfaces to the various operators and personnel of the participating fleet organizations.

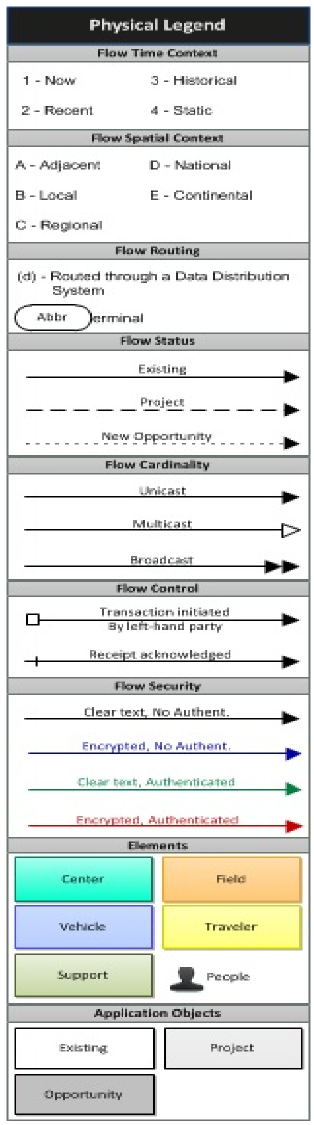


Source: NYCDOT, 2016

Figure 6. NYC CVPD Enterprise View: NYCDOT Context Diagram

3.2 Physical View

According to the CVRIA, the physical views of the system describe the devices, facilities, and external interfaces that comprise the system. The devices may be mobile (e.g. ASD) or statically located (e.g. RSU), and the facilities could be concentrated or distributed over a geographic region. This section presents the NYC CVPD system's physical architecture in terms of the safety and support applications. Also, a high-level diagram is used to describe how all physical objects or system elements are connected by information flow triplets, which contains the specific data flow, the source element, and the destination element. The legend for interpreting the physical view diagrams in this document is shown in Figure 7 below:



Source: SET-IT

Figure 7. NYC CVPD System Physical View Diagram Legend

3.2.1 Safety Applications (Layer 2)

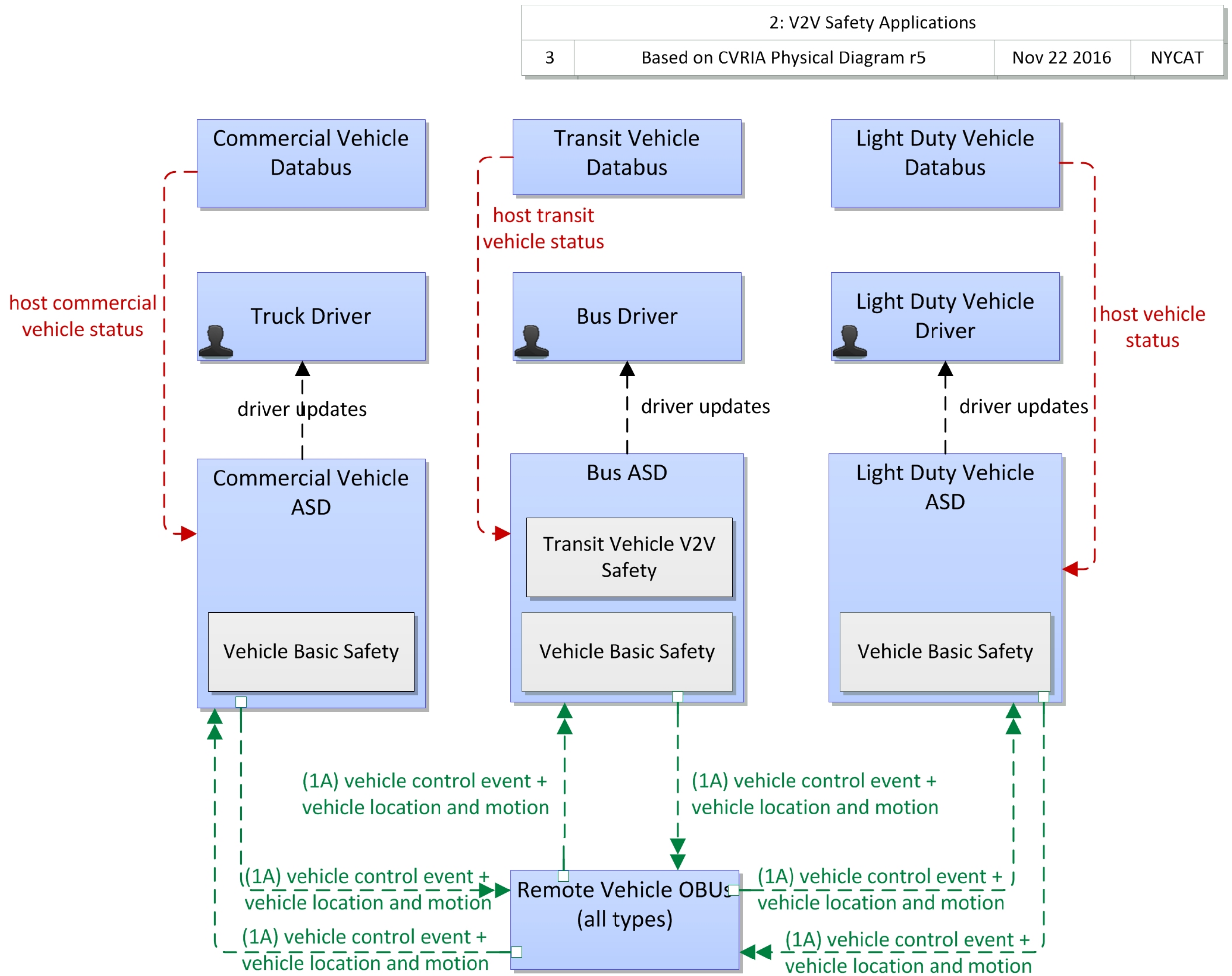
3.2.1.1 V2V Safety Applications

The NYC CVPD system will operate six V2V safety applications which will remain unchanged from their initial ConOps. These applications will not need to be re-engineered as components of this project as this work has already been completed. The applications and references for them are listed in Table 11 below.

Table 11. CV V2V Application ConOps References

CV Application	ConOps Reference
Forward Crash Warning (FCW)	NHTSA DOT HS 811 492A
Emergency Electronic Brake Lights (EEBL)	NHTSA DOT HS 811 492A
Blind Spot Warning (BSW)	NHTSA DOT HS 811 492A
Lane Change Warning (LCW)	NHTSA DOT HS 811 492A
Intersection Movement Assist (IMA)	NHTSA DOT HS 811 492A

Figure 8 below illustrates the physical architecture of the V2V safety applications. The ASD in the host vehicles will broadcast BSMs to and from other remote vehicle on-board units (OBU) via DSRC channel 172. This is shown by the Vehicle Basic Safety application object in each ASD type. The vehicle control event information flow refers to the event data generated based on hard braking, and the vehicle location and motion information flow indicates the vehicle's location in three dimensions (X, Y, Z coordinates), positional accuracy, speed, acceleration, heading, size, and type. While not illustrated in the V2V application diagram, the MAP message data stored in the ASDs will be updated as they pass by RSUs assigned to schedule the MAP message by day of the week (DOW) (i.e. Monday-Friday, Saturday, Sunday) and/or time of day (TOD) depending on changes to the geometry and/or lane access restrictions. Such scheduling and configuration will originate from the NYCDOT TMC and transmitted to designated RSUs which will be capable of storing multiple MAP messages.



Source: NYCDOT, 2016

Figure 8. NYC CVPD Physical View: V2V Applications

3.2.1.2 V2I Safety Applications

Speed Compliance (SPDCOMP) application will provide warnings to drivers when they exceed the posted regulatory speed limit. If the vehicle is approaching a curve, the Curve Speed Compliance (CSPD-COMP) application will activate and warn the driver. This application is expected to focus on Franklin D. Roosevelt (FDR) Drive in Manhattan because the other avenues and cross-streets in the pilot areas of Manhattan and Brooklyn do not consist of curve sections. Similarly, if the vehicle is approaching a designated work or school zone, the Speed Compliance in Work Zone (SPDCOMPWZ) application will be triggered. Figure 9 displays the physical architecture of the three speed compliance applications. The NYCDOT TMC will transmit the MAP message containing the regulatory speed and the TIM message that consists of the RSU's surrounding geometry (i.e. curve, lane restriction by DOW or TOD) and information on any existing lane closure or work zone near the RSU. Then, depending on whether the vehicle speed is faster than the speed limit either in any pilot corridor, curved section where the RSU is present, or a pre-configured work or closure zone, the ASDs in the vehicles will alert the drivers that they are traveling above the regulatory speed.

Red Light Violation Warning (RLVW) application will warn drivers when the ASD determines that they will run the red light. Figure 10 illustrates the physical architecture of the RLVW application. The communication between the NYCDOT TMC and the signal controllers already exists through the NYCWiN network backhaul. The TMC will transmit the applicable MAP message to the RSU based on the DOW or TOD. Also, the RSU at each signalized intersection will receive the SPaT message from the signal controller and broadcast it to the ASDs. As the ASDs alert the drivers, they will create event logs based on the BSMs and upload them to designated support RSUs at their fleet barns. Then, these support RSUs will transmit the data from the ASDs to the TMC.

Oversize Vehicle Compliance (OVC) application will warn the driver of impending height-restricted infrastructure such as bridge or tunnel entrance.

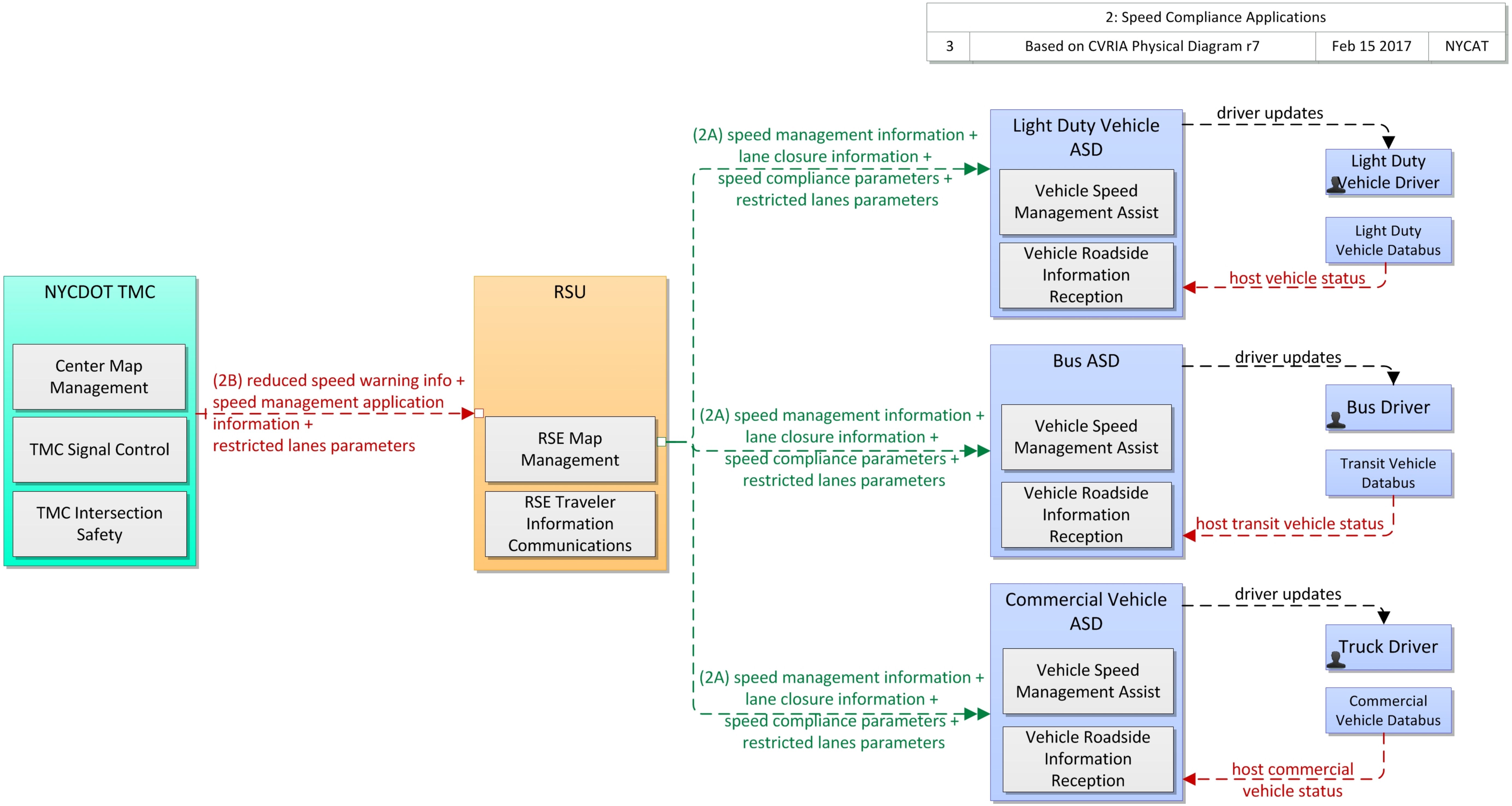
Figure 11 describes the physical architecture of the OVC application. This application will operate on ASDs of commercial vehicles accessing FDR Drive in Manhattan. The infrastructure restriction information will be sent to the TMC from the NYCDOT Office of Freight Mobility (OFM). The TMC will transmit this information to the RSUs at the bridge or tunnel entrance locations on FDR Drive. Using the ASD's pre-configured vehicle height information, the ASD will determine whether the vehicle is able to pass through the bridge or tunnel. If the vehicle height exceeds the vertical clearance, then the ASD will alert the driver to avoid the potential crash.

Emergency Communications and Evacuation Information (EVAC) application will support NYC's emergency communications and dissemination of evacuation traveler information. Figure 12 shows the physical architecture of the EVAC application. The NYCDOT Office of Emergency Response (OER) will send the emergency traveler information to the TMC, which will determine the zone in which the emergency applies to and transmit the emergency traveler information to the RSUs within that particular zone. Then, the RSUs will broadcast the TIM message to the ASDs that pass by them.

Pedestrian in Signalized Crosswalk (PEDINXWALK) application will utilize the pedestrian detection data to warn drivers about the presence of pedestrians in a crosswalk at signalized intersections. Figure 13 lays out the physical architecture of the PEDINXWALK application. As a pedestrian passes through a crosswalk at a signalized intersection with additional pedestrian detection equipment installed, the pedestrian’s presence will be detected by the traffic control system. Then, the traffic control system will notify the ASD of a pedestrian's presence in the crosswalk. The ASD will receive SPaT and MAP messages that indicate the intersection signal status and alert the driver in advance of the crosswalk location based on the intersection geometry configured and scheduled by the NYCDOT TMC.

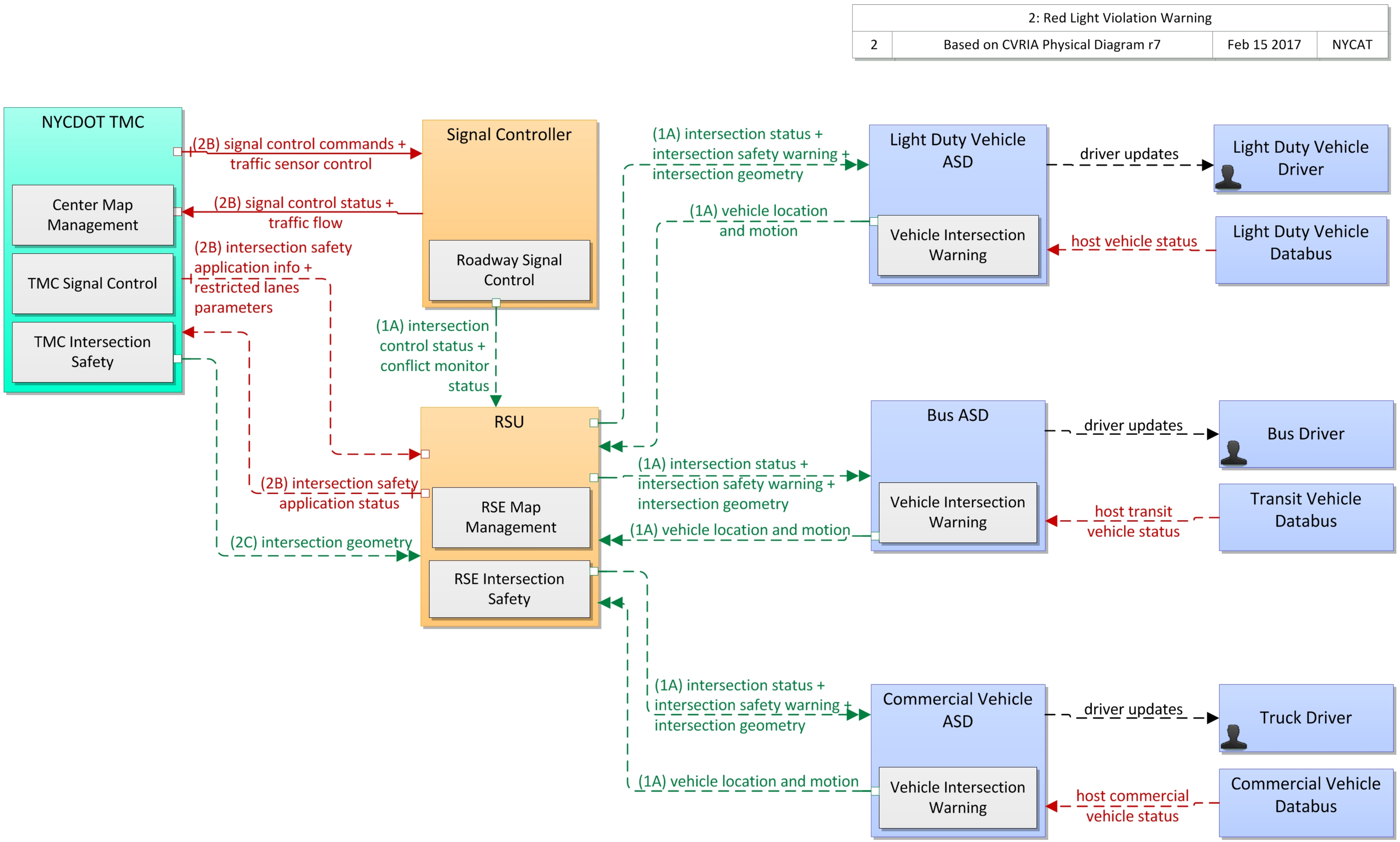
Mobile Accessible Pedestrian Signal System (PED-SIG) application will support the visually-impaired pedestrians crossing the street. The physical architecture of the PED-SIG application is shown in Figure 14 below. Unlike the PEDINXWALK application, the select number of visually-impaired pedestrians will carry personal information devices (PID) that will broadcast its location to and receive the intersection signal and geometry information from the TMC via cellular communications (4G, LTE) instead of DSRC media from the local RSU. The PID will receive SPaT and MAP messages from the TMC via Amazon Web Service (AWS) cloud that indicate the pedestrian signal status and guide the pedestrian in crossing the intersection.

As stated in Section 3.2.1.1, The NYCDOT TMC will be able to configure and schedule the MAP messages at RSU locations as needed. Hence, each RSU will be able to store several MAP messages to allow the TMC to schedule them by DOW and TOD. This will be critical at intersections and pilot corridor segments with lanes with limited access by TOD (i.e. bus-only lanes) and temporary work zones.



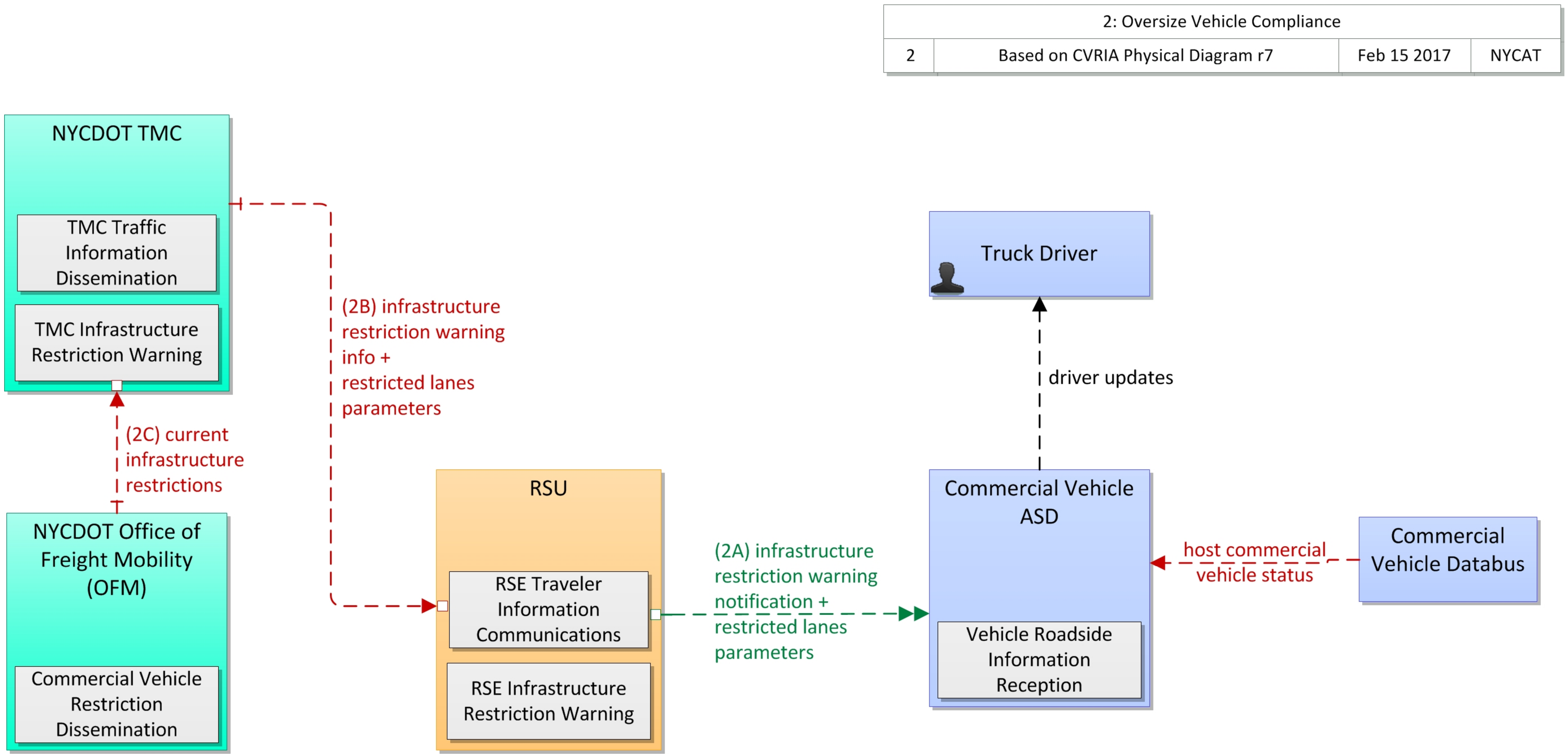
Source: NYCDOT, 2016

Figure 9. NYC CVPD Physical View: Speed Compliance Applications



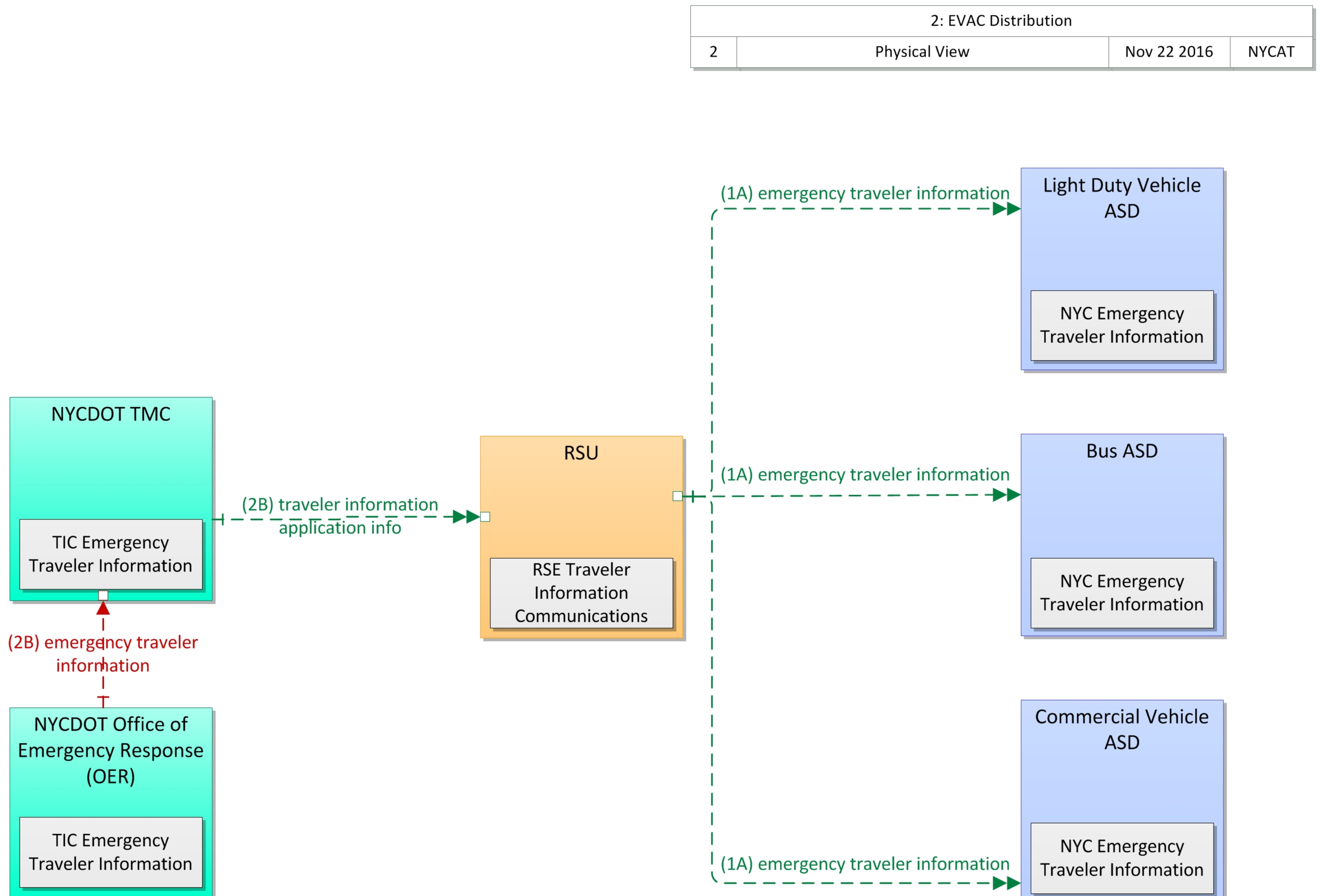
Source: NYCDOT, 2016

Figure 10. NYC CVPD Physical View: Red Light Violation Warning



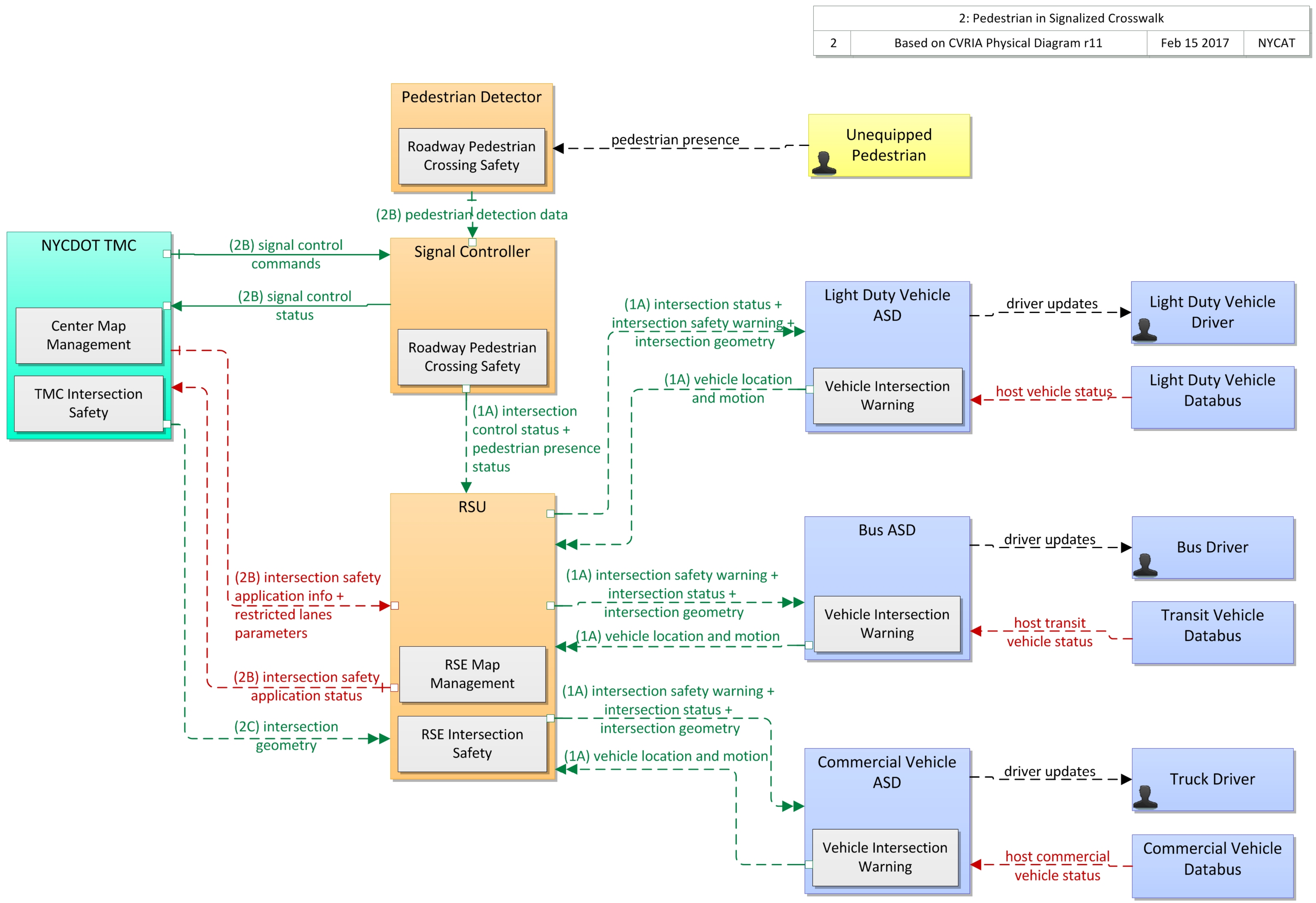
Source: NYCDOT, 2016

Figure 11. NYC CVPD Physical View: Oversize Vehicle Compliance



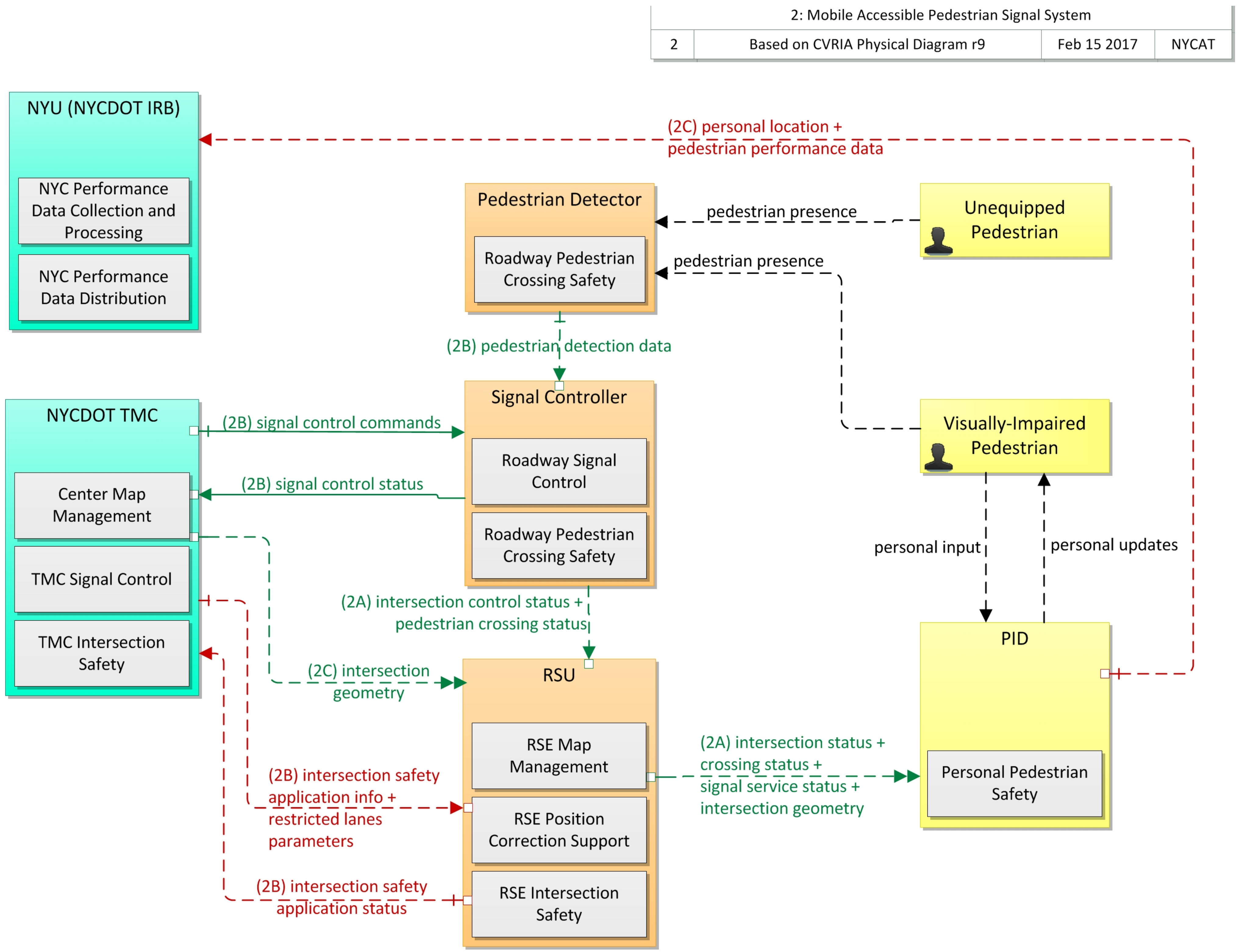
Source: NYCDOT, 2016

Figure 12. NYC CVPD Physical View: EVAC Distribution



Source: NYCDOT, 2016

Figure 13. NYC CVPD Physical View: Pedestrian in Signalized Crosswalk



Source: NYCDOT, 2016

Figure 14. NYC CVPD Physical View: Mobile Accessible Pedestrian Signal System

3.2.2 Support Applications (Layer 2)

In addition to the safety applications, the NYC CVPD system will also consist of support applications for managing the core services. The support applications will monitor, manage, and control services for applications and equipment that are operating in the CV system environment. In the NYC CVPD, it will enable CV applications to provide services including device management, time synchronization, and trust management.

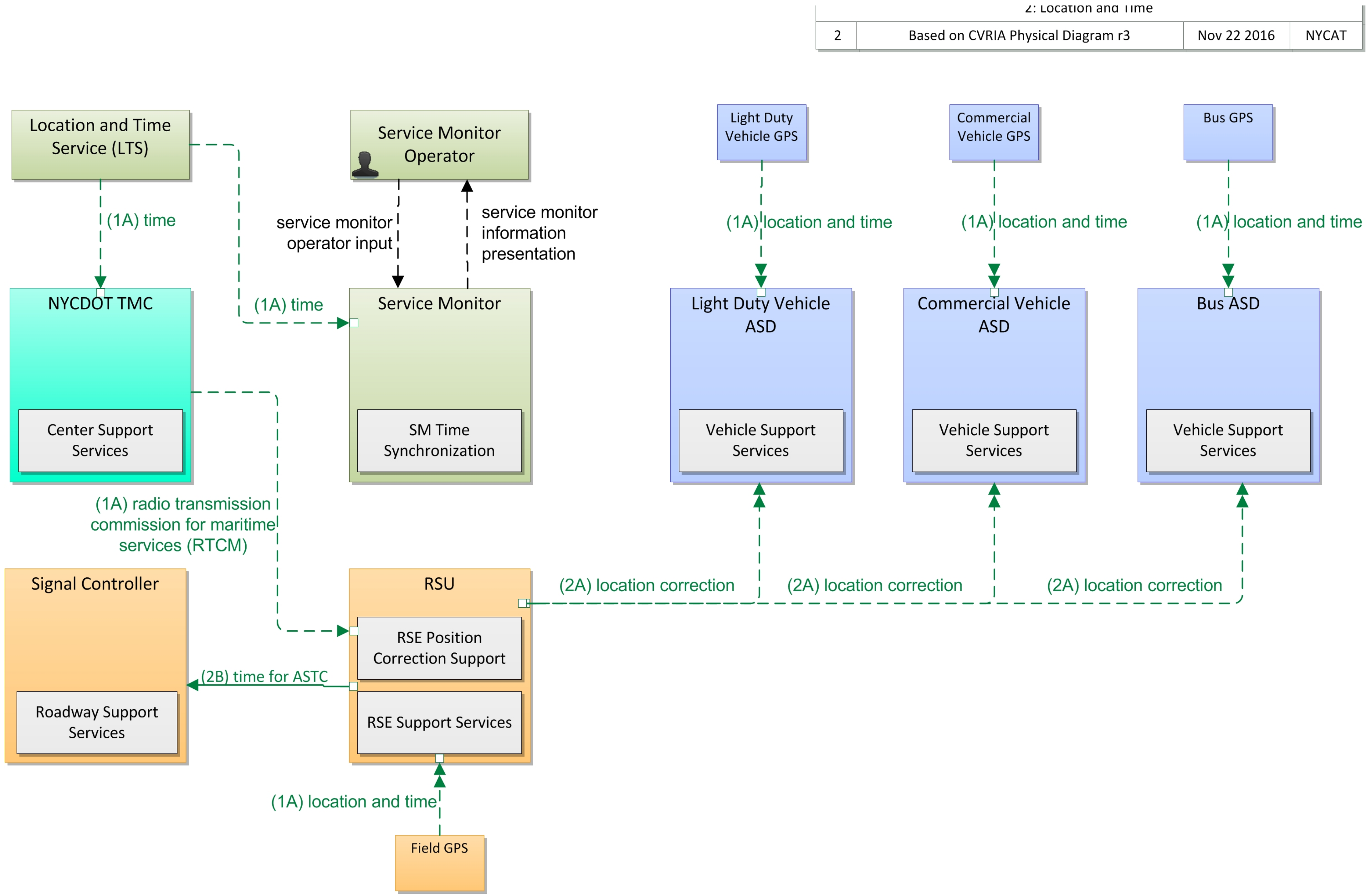
Location and Time Service (LTS) will be critical as the ASD-equipped vehicles travel through the dense environments in Manhattan and Brooklyn. As shown in the LTS physical architecture in Figure 15, the GPS in the ASD and field GPS for the RSU will be the baseline mechanisms for establishing the location referencing. However, as the urban canyon effect influences the location accuracy, the RSU triangulation/trilateration via V2XLocate will be available for location correction and accuracy. For time synchronization and accuracy, ASTC controllers maintain their time with the NYCDOT TMC based on the electric grid's line frequency clock (LFC). This time source is different than the GNSS time source used by the CV equipment, but the ASTCs will be modified to use the GNSS time source for coordination with the CV infrastructure.

Infrastructure Management will be used for software and firmware upgrades, parameter configuration, and transmission of ASD and RSU radio frequency (RF) data. Figure 16 illustrates the physical architecture of the Infrastructure Management application. For the application and firmware updates, the NYCDOT TMC will send the update packages to the fleet barn RSUs, which will perform OTA upgrades as they encounter the ASDs. The ASD will verify its firmware version against the advertised available version from the RSU and, if needed, initiate the firmware update transaction. The configuration parameters for the ASD may be uploaded to the support RSUs from the NYCDOT TMC and downloaded to the ASDs during installation. Also, the RF monitoring data for checking the status and health of the equipment and network communications will be sent to the TMC from the devices.

Core Authorization will allow the ASD, PID, and RSU vendors to define roles and responsibilities for the CV devices, users, and the centers. Figure 17 identifies the physical architecture of the Core Authorization application. For device identification, the ASDs, PIDs, and RSUs will contain encrypted data and communicate directly with the vendors. This will be separate from the DSRC message data from the ASDs or PIDs, which will occur through the RSUs. The vendors will determine the authorized and restricted functions for each entity. This information will be communicated to the USDOT Production SCMS.

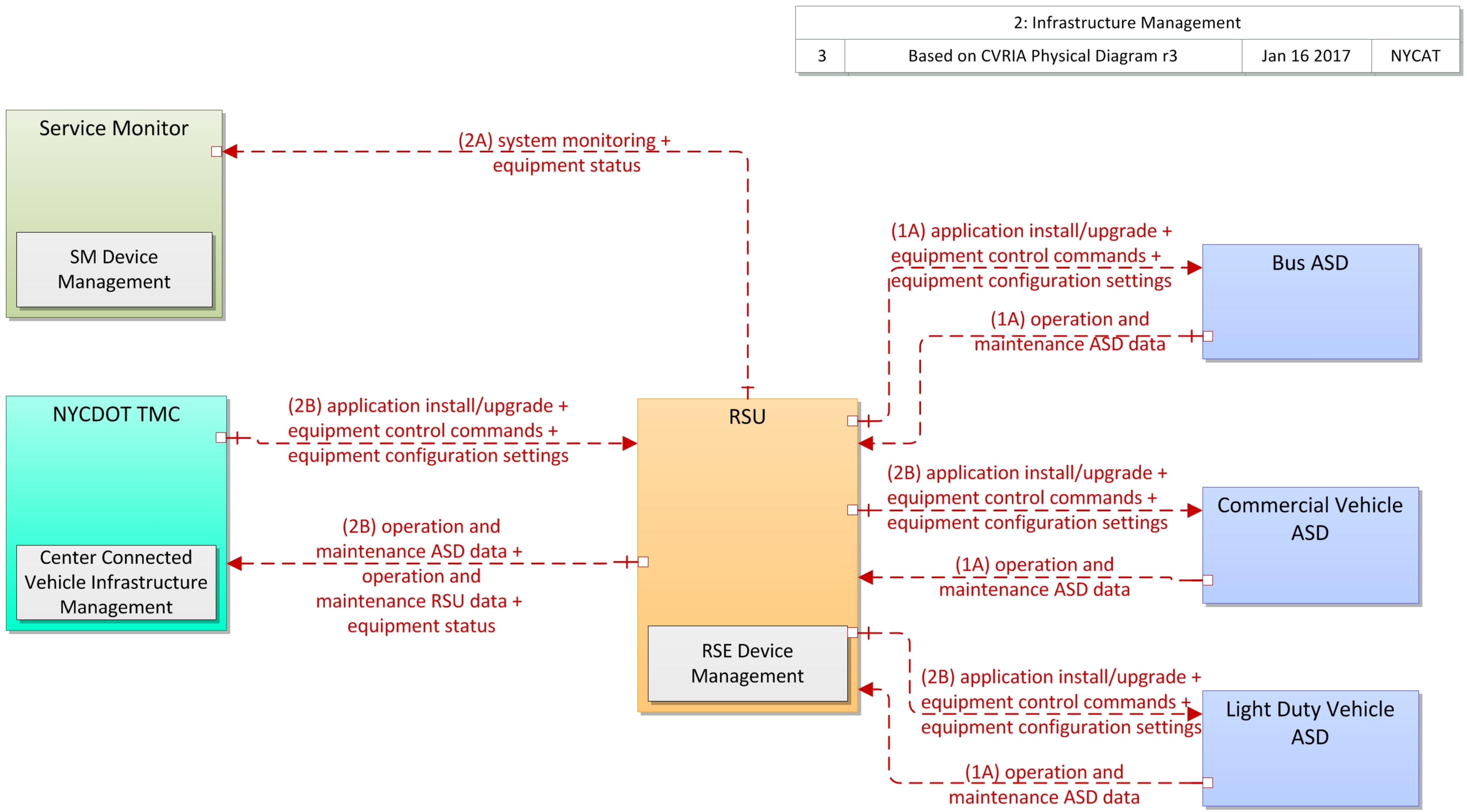
Figure 18 defines the physical architecture of the communications between the NYC CVPD System and the USDOT Production SCMS. It represents the interconnected CV system that will enable trusted exchanges between the devices (ASD, RSU) and the USDOT Production SCMS. Currently, it is being developed by USDOT to protect the CV system and its data from unauthorized access. It will mandate security policy and support the secure distribution, use, and revocation of trust credentials while receiving enrollment certificates from the NYC CVPD system. In addition to security and trust management of the devices, the NYCDOT TMC will need security credentials for scheduling and configuring the specific MAP messages in the RSUs by day of the week (DOW) and time of day (TOD). This is denoted by the Center Map Management application object within the NYCDOT TMC element in Figure 18. Each MAP message stored in the RSU transmitted by the NYCDOT TMC will be validated or authenticated. The vendors selected during procurement will be setting their own device enrollment certificates for communicating with the SCMS and ensuring that the field RSUs receive the necessary security credentials.

The back office facilities at NYCDOT Traffic Management Center (TMC) will not be used for the security credentials management system (SCMS) functions, security enrollment certificates signing, and DSRC messages (BSM, SPaT, MAP, TIM) signing. Instead, these operations will be allocated to the field RSUs as supported by the latest USDOT RSU specification. Another option for consideration entailed utilizing a separate RSU within the TMC in lieu of the back office proxy server for managing the SCMS and signing of the enrollment certificates, pseudonym certificates, and safety messages transmitted by the devices. However, the method of allowing individual RSUs to sign the data has been selected to mitigate risks on schedule and cost.



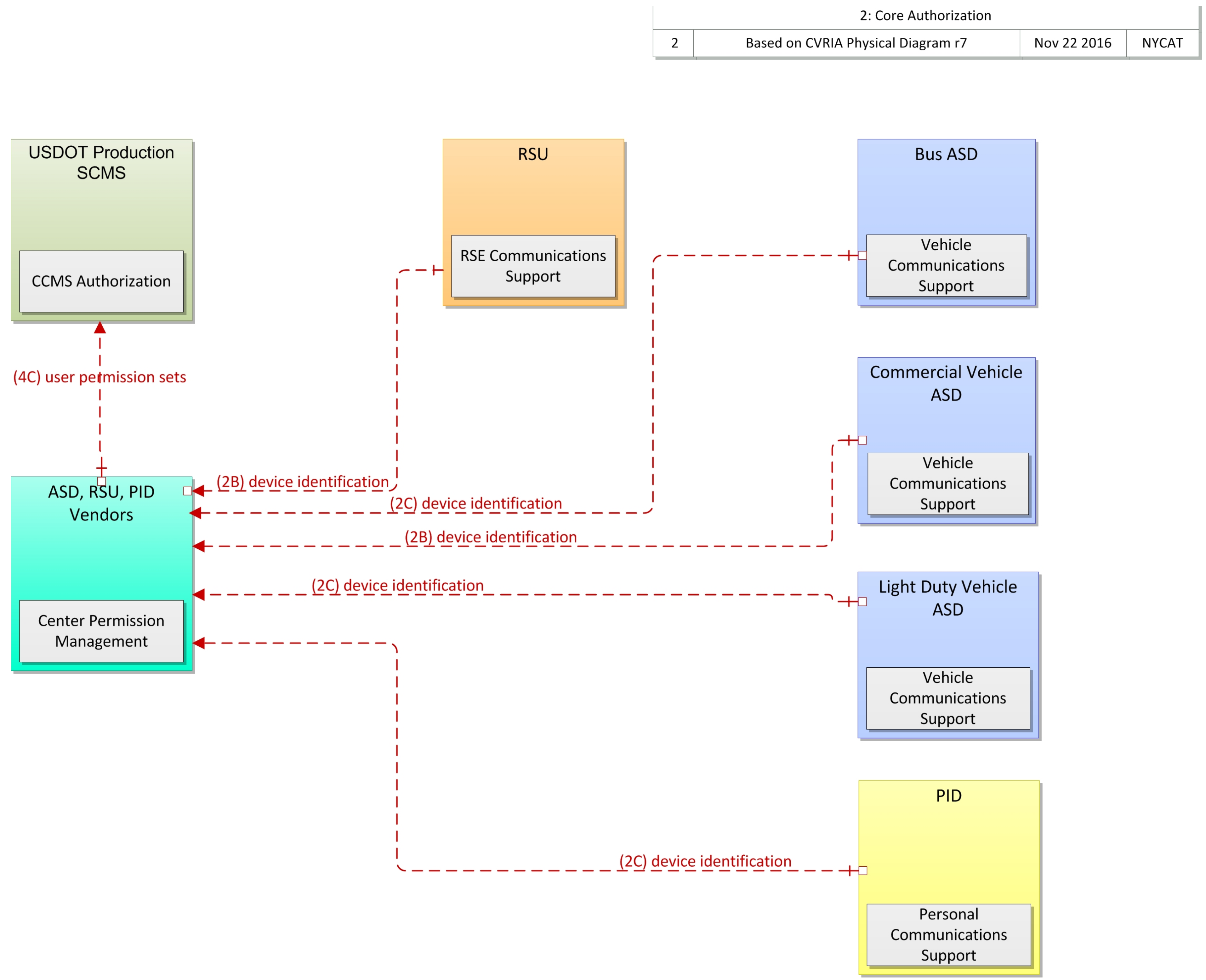
Source: NYCDOT, 2016

Figure 15. NYC CVPD Physical View: Location and Time



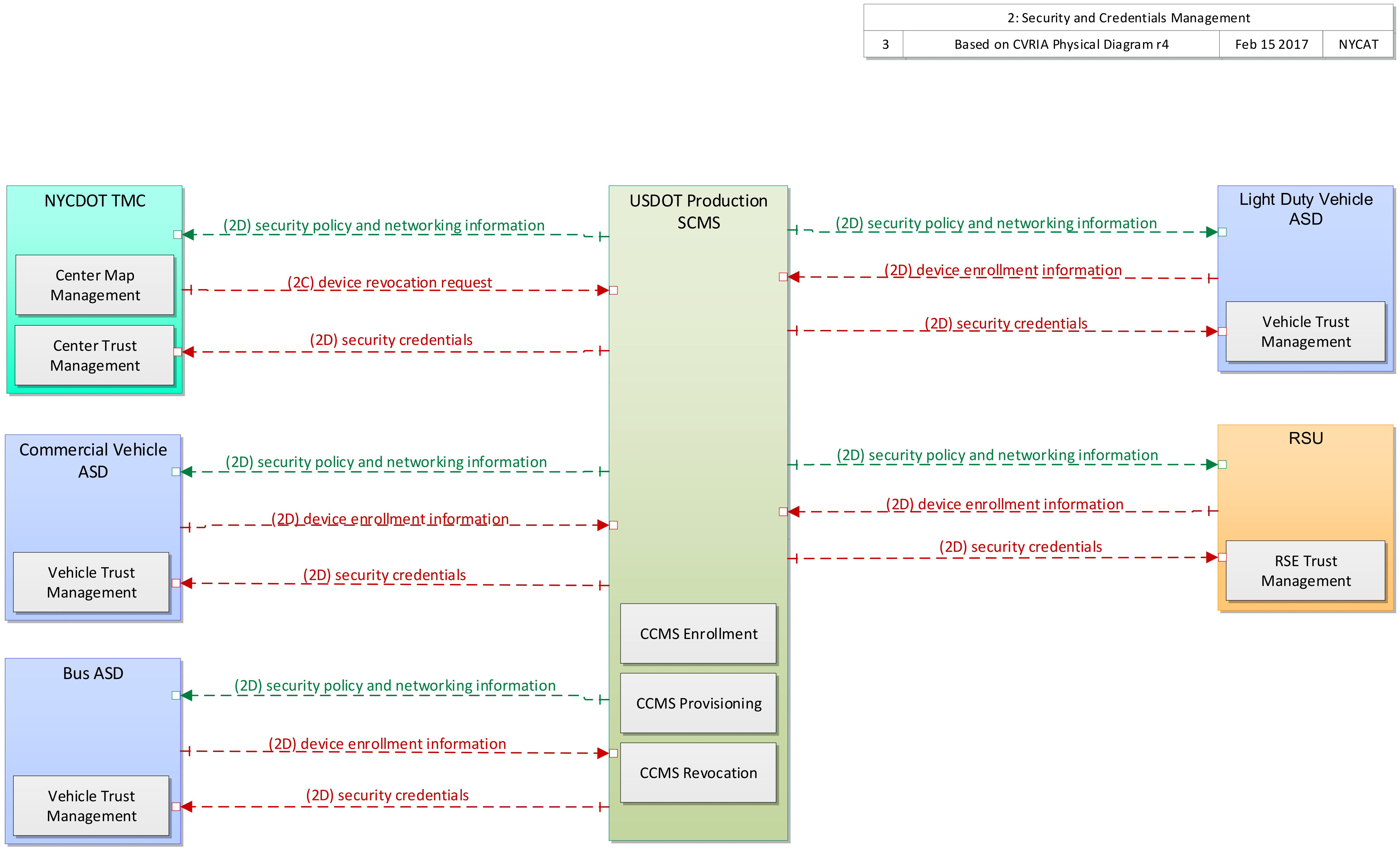
Source: NYCDOT, 2016

Figure 16. NYC CVPD Physical View: Infrastructure Management



Source: NYCDOT, 2016

Figure 17. NYC CVPD Physical View: Core Authorization



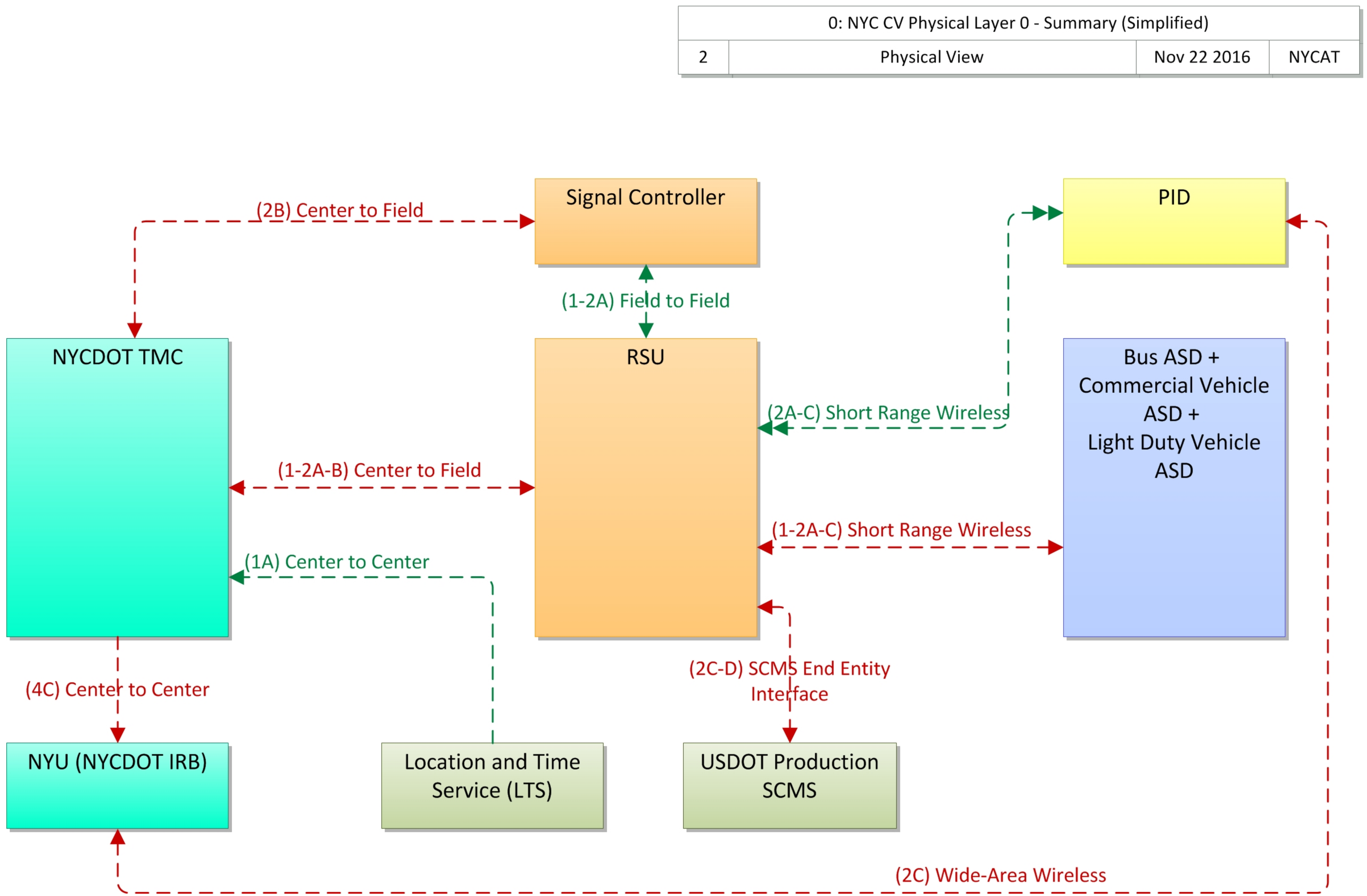
Source: NYCDOT, 2016

Figure 18. NYC CVPD Physical View: USDOT SCMS

3.2.3 High-Level (Layer 0) Physical Architecture

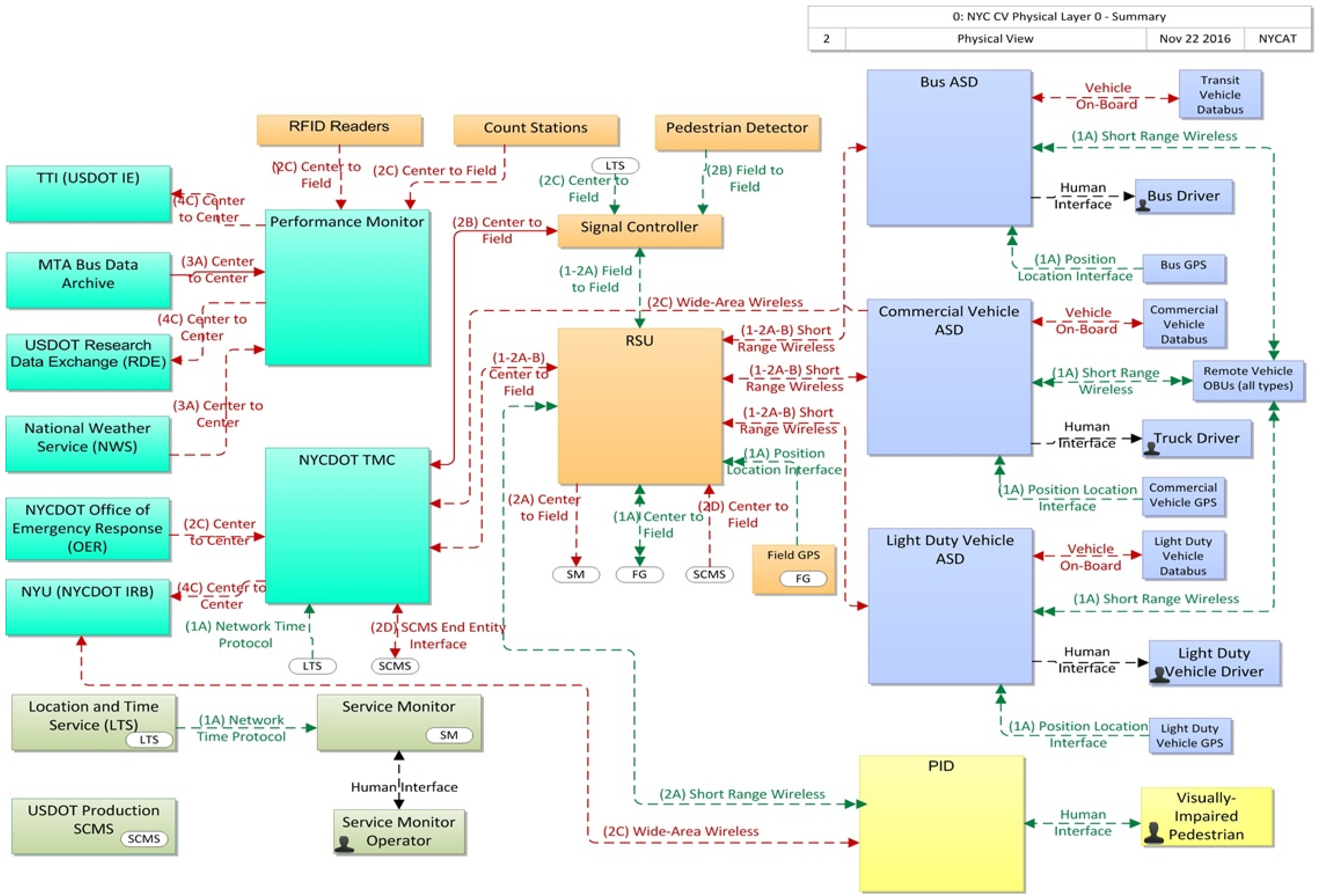
This section describes the top-level drawings that reveal the interactions among all elements and physical objects in the NYC CVPD system architecture. All centers, external systems, CV equipment, fleet owners, drivers/operators, and pedestrians that comprise of the NYC CVPD system are represented in the architecture diagrams. They are connected by physical interconnects (P-Interconnect) that define the type of required communications.

Figure 19 provides a simplified view of the NYC CVPD physical architecture. It focuses on the CV devices and how they are linked to the TMC and the existing ASTC controllers. Also, it shows the transfer method for the pedestrian data from the PIDs to NYU, the NYCDOT IRB for this project. The USDOT Production SCMS, LTS, and their connections to the TMC and the RSU are also labeled in this diagram. A more detailed high-level view of the physical architecture is depicted in Figure 20. This diagram includes the external systems that will communicate with the NYC CVPD system and additional field devices (i.e. detectors, field GPS) that will be installed and deployed.



Source: NYCDOT, 2016

Figure 19. NYC CVPD Physical View: Simplified Layer 0



Source: NYCDOT, 2016

Figure 20. NYC CVPD Physical View: Detailed Layer 0

3.3 Communication View

The Communication View describes the communications protocols between the application objects. The protocols are needed to establish interoperability between the physical objects in the physical view described in Section 3.2. In the SET-IT tool, the information triple from the Physical View is mapped to one or more data dictionary standards or also known by CVRIA as information layer standards. These are used to build communication profiles that identify the communications protocols necessary for determining the data being transmitted based on its corresponding information flow

Each communications view diagram contains layers that refer to abstract parts of the communication protocol diagrams or profiles. These layers are needed to achieve interoperability based on the CVRIA Communications Model. The eight (8) layer types are defined in Table 12 below.

Table 12. CVRIA Communication View Layers

Acronym / Abbreviation	Definition
ITS Application Information Layer	Structure, meaning, and control exchange of information between two end points
Application Layer	Rules and procedures for exchanging encoded data
Presentation Layer	Rules for representing the bits and bytes of information content to be transferred
Session Layer	Mechanism for opening, closing and managing a dialogue between application processes
Transport Layer	Rules and procedures for exchanging application data between endpoints on a network
Network Layer	Routing, message disassembly/re-assembly and network management functions
Data Link Layer	Rules and procedures for exchanging data between two adjacent devices over some communications media
Physical Layer	Signaling standards that are typically developed for specific communications media and industry needs and address the needs of WAVE/DSRC (with the exception of IEEE802.11p (air interface to the 5.9GHz spectrum))

Source: CVRIA

3.3.1 Communication Profiles

In the CVRIA, the communication profiles reflect implementation choices have been developed and assigned, where applicable, to information triples. They follow closely the naming practices of the Open Systems Interconnection (OSI) Model. The communication profiles used in the NYC CVPD system architecture can be found in the CVRIA website and the SET-IT tool.

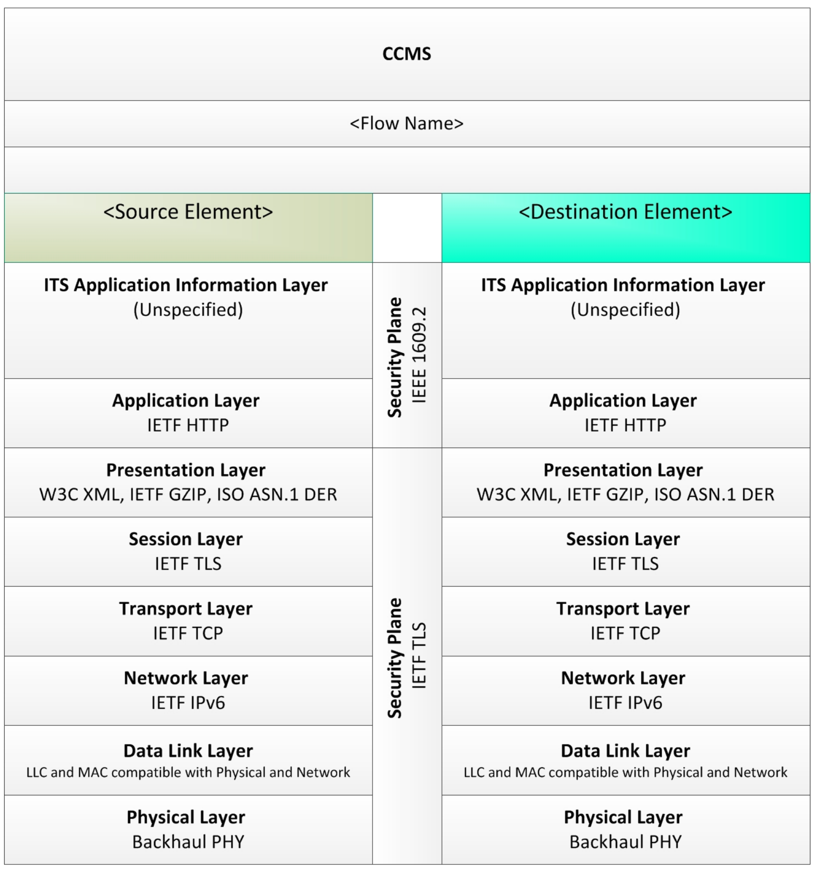
Based on the NYC CVPD system architecture in SET-IT, a total of 17 communication profiles were identified. Each profile is represented by its communication protocol diagram and its associated information flow triples. The information flows identified during the THEA Technical Roundtable and follow-up roundtable meetings are listed in Section 3.3.2. However, the triples involving humans (i.e. driver updates, pedestrian presence, personal input, personal updates) are not identified in the communication view architecture.

3.3.2 Protocol Diagrams

Each communications view diagram includes the specific communication profile and information triple at the top. Below the information triple, the source, destination, and their potential communications protocols are shown in a layered stack. The diagram also consists of the security plane which is located in the middle between the source and destination columns. The security plane identifies the standards that specify policies and system-to-system authentication, as well as the encryption of data across one or more layers of the communications stack. For maintaining consistency with the language in the SET-IT tool, the profile names were not changed.

3.3.2.1 CCMS

The CCMS identifies applicable standards for secure communications with the Cooperative ITS Credentials Management System (CCMS), which currently is known as the SCMS. Figure 21 shows the protocol diagram for this profile, and Table 13 lists each data flow that uses this profile as well as its source, destination, and standard.



* Mechanism for transmitting raw bits over a physical link between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Source: NYCDOT, 2016

Figure 21. NYC CVPD Communication View: CCMS

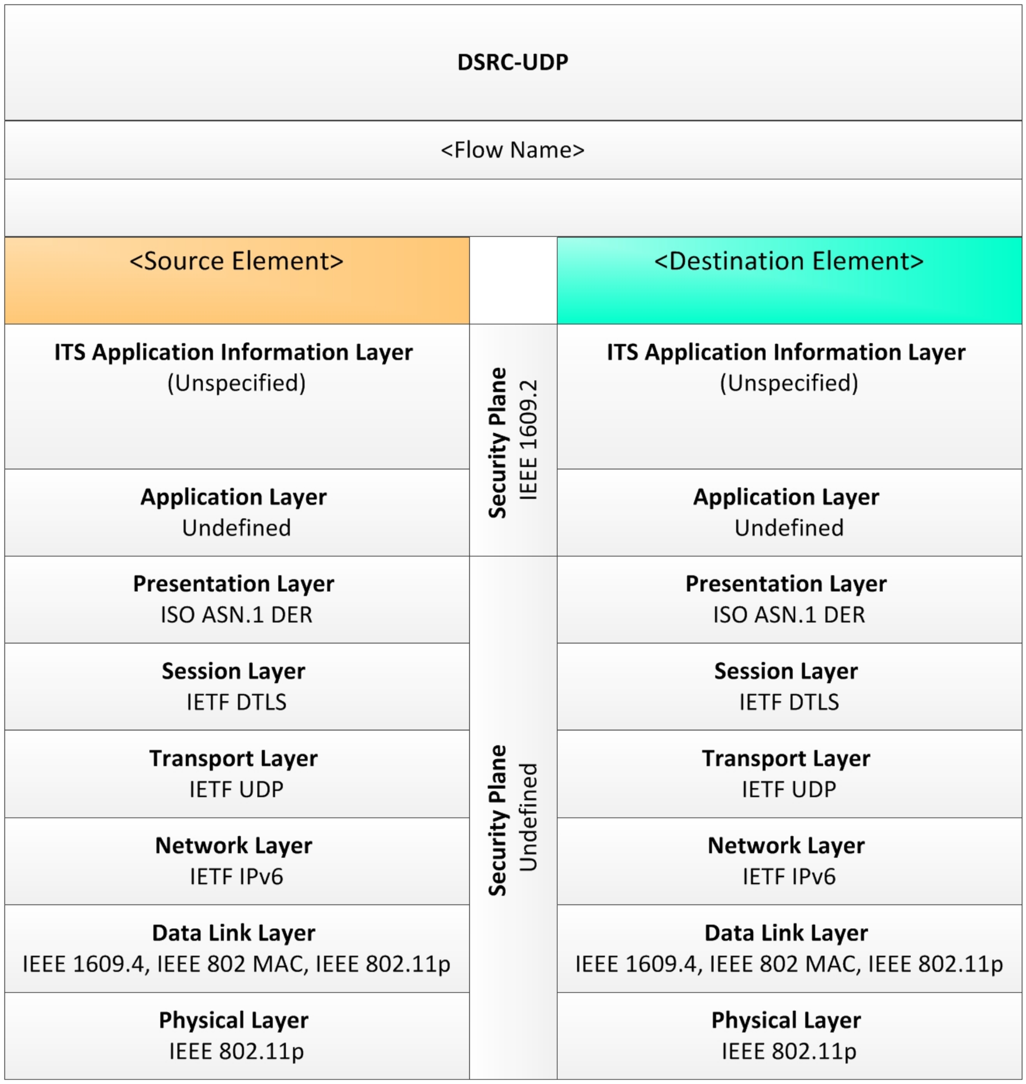
Table 13. NYC CVPD Communication View: CCMS Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
device enrollment information	Bus ASD	USDOT Production SCMS	(Unspecified)
device enrollment information	Commercial Vehicle ASD	USDOT Production SCMS	(Unspecified)
device enrollment information	Light Duty Vehicle ASD	USDOT Production SCMS	(Unspecified)
device revocation request	NYCDOT TMC	USDOT Production SCMS	(Unspecified)
user permission sets	ASD, RSU, PID Vendors	USDOT Production SCMS	(Unspecified)
device enrollment information	PID	USDOT Production SCMS	(Unspecified)
device enrollment information	RSU	USDOT Production SCMS	(Unspecified)
security credentials	USDOT Production SCMS	Bus ASD	(Unspecified)
security policy and networking information	USDOT Production SCMS	Bus ASD	(Unspecified)
security credentials	USDOT Production SCMS	Commercial Vehicle ASD	(Unspecified)
security policy and networking information	USDOT Production SCMS	Commercial Vehicle ASD	(Unspecified)
security credentials	USDOT Production SCMS	Light Duty Vehicle ASD	(Unspecified)
security policy and networking information	USDOT Production SCMS	Light Duty Vehicle ASD	(Unspecified)
security credentials	USDOT Production SCMS	PID	(Unspecified)
security policy and networking information	USDOT Production SCMS	PID	(Unspecified)
security credentials	USDOT Production SCMS	RSU	(Unspecified)
security policy and networking information	USDOT Production SCMS	RSU	(Unspecified)

Source: NYCDOT, 2016

3.3.2.2 DSRC-UDP

DSRC-UDP describes a set of standards applicable to broadcast, frequent (non-constant), medium latency vehicle- to-vehicle and vehicle-to-infrastructure communications using the User Datagram Protocol (UDP) over Internet Protocol version 6 (IPv6) over the 5.9GHz spectrum. Figure 22 illustrates the protocol diagram for this profile, and Table 14 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 22. NYC CVPD Communication View: DSRC-UDP

Table 14. NYC CVPD Communication View: DSRC-UDP Information Flow Triples

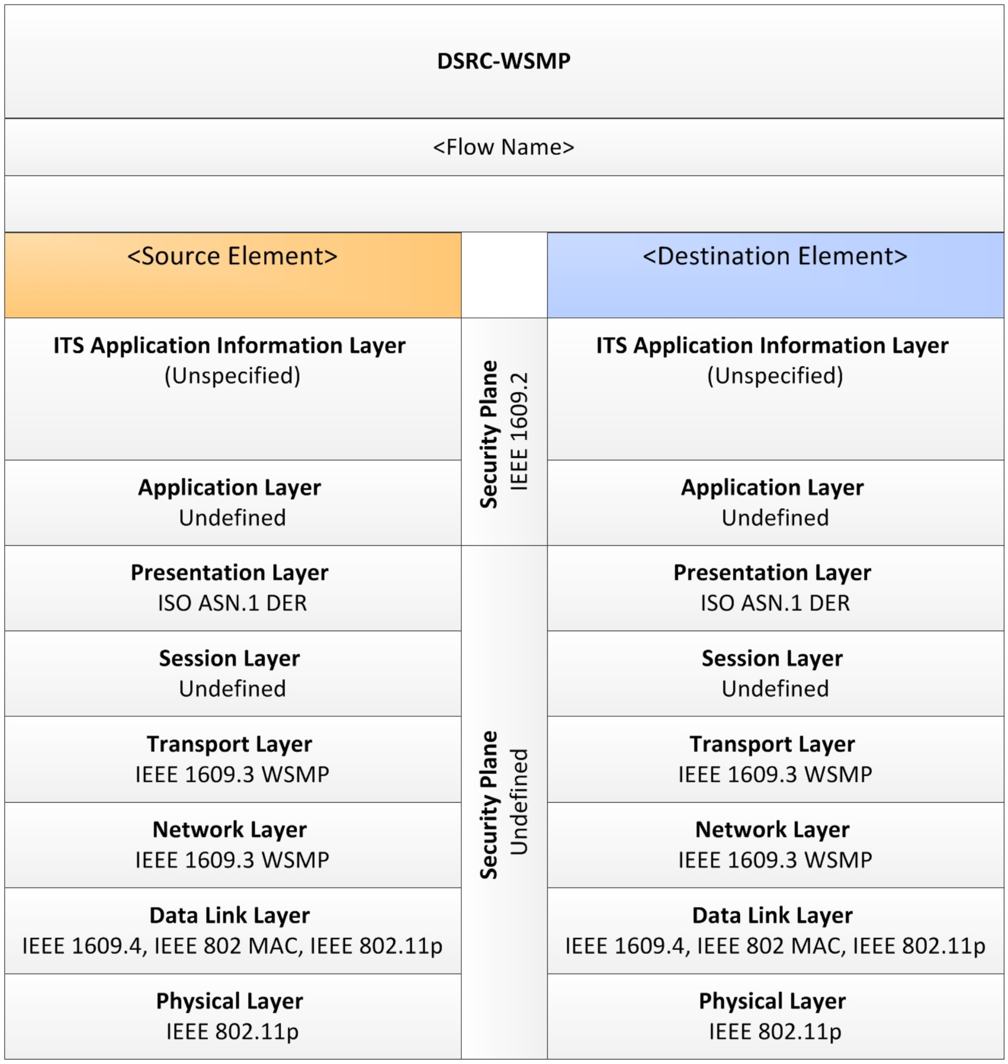
Flow Name	Source Element	Destination Element	Standard
operation and maintenance ASD data	Bus ASD	RSU	(Unspecified)
operation and maintenance ASD data	Commercial Vehicle ASD	RSU	(Unspecified)

Flow Name	Source Element	Destination Element	Standard
operation and maintenance ASD data	Light Duty Vehicle ASD	RSU	(Unspecified)
application install/upgrade	RSU	Bus ASD	(Unspecified)
emergency traveler information	RSU	Bus ASD	SAE J2735 (2016-03)
equipment configuration settings	RSU	Bus ASD	(Unspecified)
equipment control commands	RSU	Bus ASD	(Unspecified)
application install/upgrade	RSU	Commercial Vehicle ASD	(Unspecified)
equipment configuration settings	RSU	Commercial Vehicle ASD	(Unspecified)
equipment control commands	RSU	Commercial Vehicle ASD	(Unspecified)
application install/upgrade	RSU	Light Duty Vehicle ASD	(Unspecified)
equipment configuration settings	RSU	Light Duty Vehicle ASD	(Unspecified)
equipment control commands	RSU	Light Duty Vehicle ASD	(Unspecified)
operation and maintenance RSU data	RSU	NYCDOT TMC	(Unspecified)
intersection status monitoring	RSU	Signal Controller	(Unspecified)

Source: NYCDOT, 2016

3.3.2.3 DSRC-WSMP

DSRC-WSMP describes a set of standards applicable to broadcast, near constant, low latency vehicle- to-vehicle and vehicle-to-infrastructure communications using the WAVE Short Messaging Protocol (WSMP) over the 5.9GHz spectrum. Figure 23 displays the protocol diagram for this profile, and Table 15 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 23. NYC CVPD Communication View: DSRC-WSMP

Table 15. NYC CVPD Communication View: DSRC-WSMP Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
vehicle control event	Bus ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle control event	Bus ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)
vehicle location and motion	Bus ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle location and motion	Bus ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)

Flow Name	Source Element	Destination Element	Standard
vehicle location and motion	Bus ASD	RSU	SAE J2735 (2016-03)
vehicle location and motion	Bus ASD	RSU	SAE J2945/1 (2016-03)
vehicle location and motion for surveillance	Bus ASD	RSU	SAE J2735 (2016-03)
vehicle situation data	Bus ASD	RSU	SAE J2735 (2016-03)
vehicle control event	Commercial Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle control event	Commercial Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)
vehicle location and motion	Commercial Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle location and motion	Commercial Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)
vehicle location and motion	Commercial Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle location and motion	Commercial Vehicle ASD	RSU	SAE J2945/1 (2016-03)
vehicle location and motion for surveillance	Commercial Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle situation data	Commercial Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle control event	Light Duty Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle control event	Light Duty Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)
vehicle location and motion	Light Duty Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2735 (2016-03)
vehicle location and motion	Light Duty Vehicle ASD	Remote Vehicle OBUs (all types)	SAE J2945/1 (2016-03)
vehicle location and motion	Light Duty Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle location and motion	Light Duty Vehicle ASD	RSU	SAE J2945/1 (2016-03)
vehicle location and motion for surveillance	Light Duty Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle situation data	Light Duty Vehicle ASD	RSU	SAE J2735 (2016-03)
intersection geometry	NYCDOT TMC	RSU	SAE J2735 (2016-03)
personal location	PID	NYU	(Unspecified)

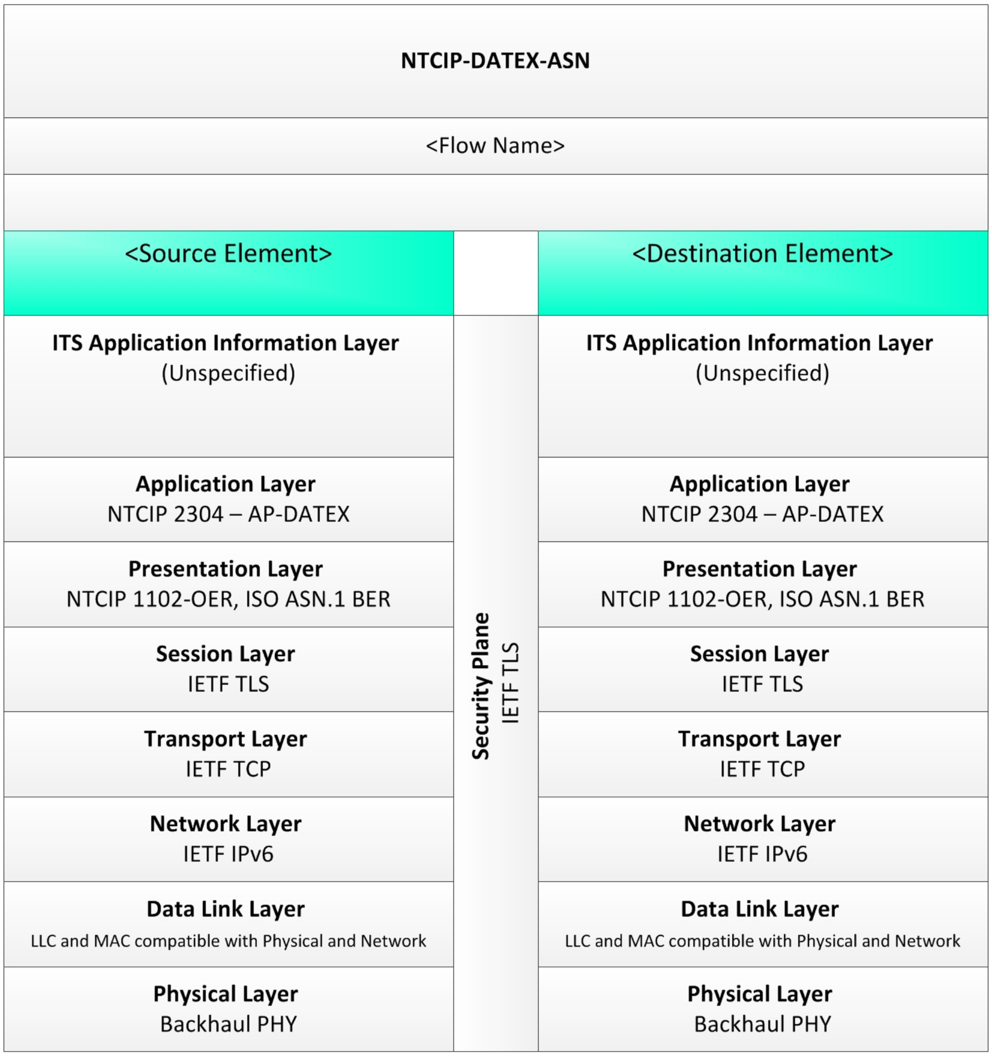
Flow Name	Source Element	Destination Element	Standard
vehicle control event	Remote Vehicle OBUs (all types)	Bus ASD	SAE J2735 (2016-03)
vehicle location and motion	Remote Vehicle OBUs (all types)	Bus ASD	SAE J2735 (2016-03)
vehicle control event	Remote Vehicle OBUs (all types)	Commercial Vehicle ASD	SAE J2735 (2016-03)
vehicle location and motion	Remote Vehicle OBUs (all types)	Commercial Vehicle ASD	SAE J2735 (2016-03)
vehicle control event	Remote Vehicle OBUs (all types)	Light Duty Vehicle ASD	SAE J2735 (2016-03)
vehicle location and motion	Remote Vehicle OBUs (all types)	Light Duty Vehicle ASD	SAE J2735 (2016-03)
intersection geometry	RSU	Bus ASD	SAE J2735 (2016-03)
intersection safety warning	RSU	Bus ASD	SAE J2735 (2016-03)
intersection status	RSU	Bus ASD	SAE J2735 (2016-03)
lane closure information	RSU	Bus ASD	(Unspecified)
location correction	RSU	Bus ASD	SAE J2735 (2016-03)
speed compliance parameters	RSU	Bus ASD	(Unspecified)
speed management information	RSU	Bus ASD	SAE J2735 (2016-03)
vehicle situation data parameters	RSU	Bus ASD	SAE J2735 (2016-03)
emergency traveler information	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
infrastructure restriction warning notification	RSU	Commercial Vehicle ASD	(Unspecified)
intersection geometry	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
intersection safety warning	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
intersection status	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
lane closure information	RSU	Commercial Vehicle ASD	(Unspecified)
location correction	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
reduced speed notification	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)

Flow Name	Source Element	Destination Element	Standard
speed compliance parameters	RSU	Commercial Vehicle ASD	(Unspecified)
speed management information	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
vehicle situation data parameters	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
emergency traveler information	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
intersection geometry	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
intersection safety warning	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
intersection status	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
lane closure information	RSU	Light Duty Vehicle ASD	(Unspecified)
location correction	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
speed compliance parameters	RSU	Light Duty Vehicle ASD	(Unspecified)
speed management information	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
vehicle situation data parameters	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
crossing status	RSU	PID	SAE J2735 (2016-03)
intersection geometry	RSU	PID	SAE J2735 (2016-03)
intersection status	RSU	PID	SAE J2735 (2016-03)
signal service status	RSU	PID	NTCIP 1202-ASC

Source: NYCDOT, 2016

3.3.2.4 NTCIP-DATEX

NTCIP-DATEX describes an alternative set of standards applicable to communications between entities using ISO TC204 WG9 DATa Exchange(DATEX). Information messages are encoded using the NTCIP Octet Encoding Rules. Figure 24 presents the protocol diagram for this profile, and Table 16 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 24. NYC CVPD Communication View: NTCIP-DATEX

Table 16. NYC CVPD Communication View: NTCIP-DATEX Information Flow Triples

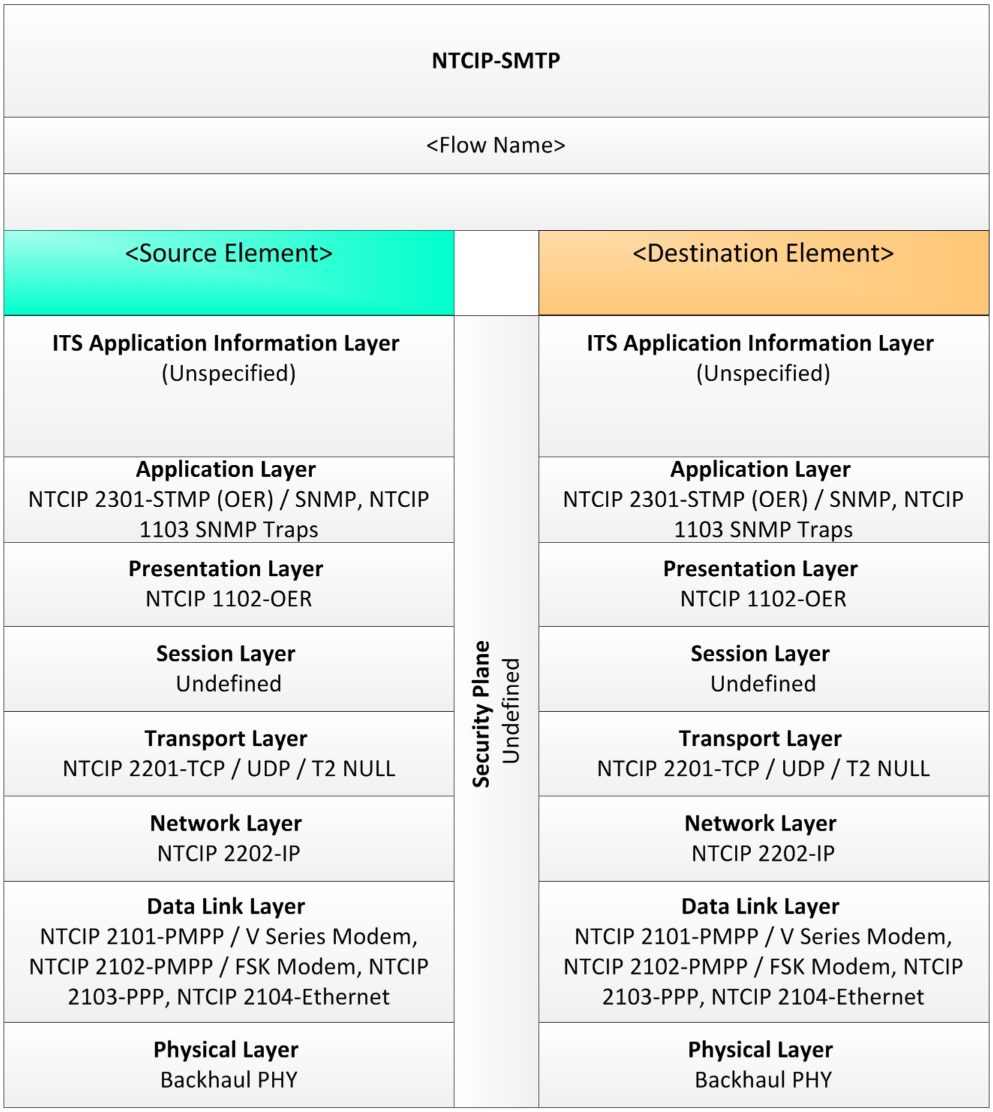
Flow Name	Source Element	Destination Element	Standard
MTA bus GPS travel time data	MTA Bus Data Archive	Performance Monitor	(Unspecified)
weather data	National Weather Service (NWS)	Performance Monitor	(Unspecified)
emergency traveler information	NYCDOT Office of Emergency Response (OER)	NYCDOT TMC	SAE J2735 (2016-03)
current infrastructure restrictions	NYCDOT Office of Freight Mobility (OFM)	NYCDOT TMC	ITE TMDD

Flow Name	Source Element	Destination Element	Standard
operation and maintenance ASD data	NYCDOT TMC	Performance Monitor	(Unspecified)
operation and maintenance RSU data	NYCDOT TMC	Performance Monitor	(Unspecified)
PID operational status	NYU (NYCDOT IRB)	Performance Monitor	(Unspecified)
obfuscated data sets	Performance Monitor	TTI (USDOT IE)	(Unspecified)
obfuscated data sets	Performance Monitor	USDOT Research Data Exchange (RDE)	(Unspecified)

Source: NYCDOT, 2016

3.3.2.5 NTCIP-SMTP

NTCIP-SMTP describes an alternative set of standards used to communicate with existing ITS Roadway Devices that uses the NTCIP Octet Encoding Rules, a standard developed specifically for the transportation industry. In the NYC CVPD system, the ITS Roadway Devices refers to existing equipment such as the signal controller, variable message sign (VMS), count stations, and radio frequency identification (RFID) Readers that are denoted as elements in the physical architecture. This template is used primarily for communication with traffic signal controllers, where second-per-second communications is required. Figure 25 depicts the protocol diagram for this profile, and Table 17 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 25. NYC CVPD Communication View: NTCIP-SMTP

Table 17. NYC CVPD Communication View: NTCIP-SMTP Information Flow Triples

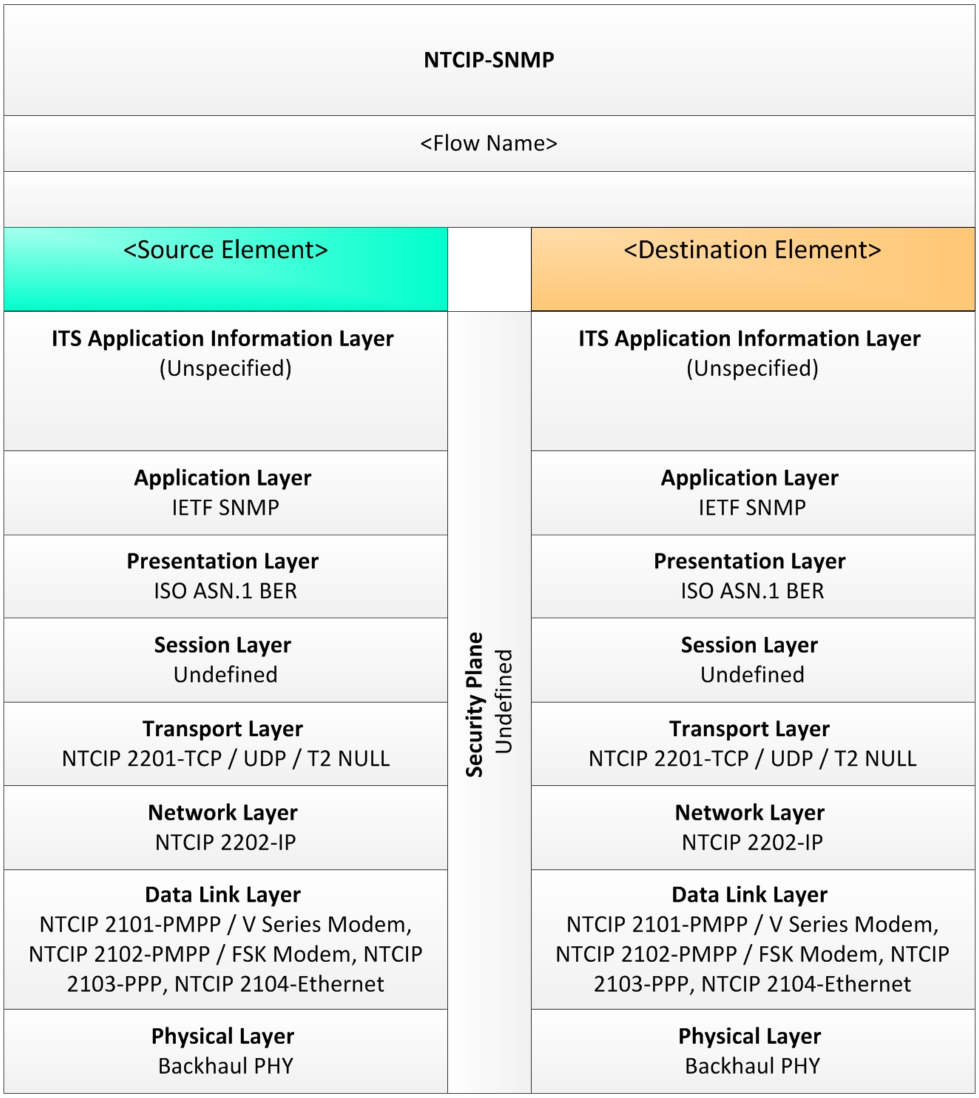
Flow Name	Source Element	Destination Element	Standard
volume counts	Count Stations	Performance Monitor	(Unspecified)
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP

Flow Name	Source Element	Destination Element	Standard
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
time for ASTC	RSU	Signal Controller	(Unspecified)
traffic sensor control	NYCDOT TMC	Signal Controller	NTCIP 1209-TSS
travel time records	RFID Readers	Performance Monitor	(Unspecified)
signal control status	Signal Controller	NYCDOT TMC	NTCIP 1202-ASC
signal control status	Signal Controller	NYCDOT TMC	NTCIP 1210-FMS
traffic flow	Signal Controller	NYCDOT TMC	NTCIP 1209-TSS

Source: NYCDOT, 2016

3.3.2.6 NTCIP-SNMP

NTCIP-SNMP describes applicable standards for communicating between with ITS Roadway Devices using the simple network management protocol (SNMP). Figure 26 presents the protocol diagram for this profile, and Table 18 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 26. NYC CVPD Communication View: NTCIP-SNMP

Table 18. NYC CVPD Communication View: NTCIP-SNMP Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
volume counts	Count Stations	Performance Monitor	(Unspecified)
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control commands	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP

Flow Name	Source Element	Destination Element	Standard
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control device configuration	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal control plans	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1202-ASC
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1210-FMS
signal system configuration	NYCDOT TMC	Signal Controller	NTCIP 1211-SCP
time for ASTC	RSU	Signal Controller	(Unspecified)
traffic sensor control	NYCDOT TMC	Signal Controller	NTCIP 1209-TSS
travel time records	RFID Readers	Performance Monitor	(Unspecified)
signal control status	Signal Controller	NYCDOT TMC	NTCIP 1202-ASC
signal control status	Signal Controller	NYCDOT TMC	NTCIP 1210-FMS
traffic flow	Signal Controller	NYCDOT TMC	NTCIP 1209-TSS

Source: NYCDOT, 2016

3.3.2.7 Position-Location Interface

The Position-Location-Interface is a partial profile that describes the communications between connected vehicle equipment and on board geolocation equipment such as a GPS receiver. According to the CVRIA, a standard for position location interfaces does not exist. For this reason a communications view diagram is not shown for this profile. However, it states that the National Marine Electronic Association (NMEA), which is the serial interface for marine electronics devices including GPS, may apply. Table 19 lists each data flow that uses this profile as well as its source, destination, and standard.

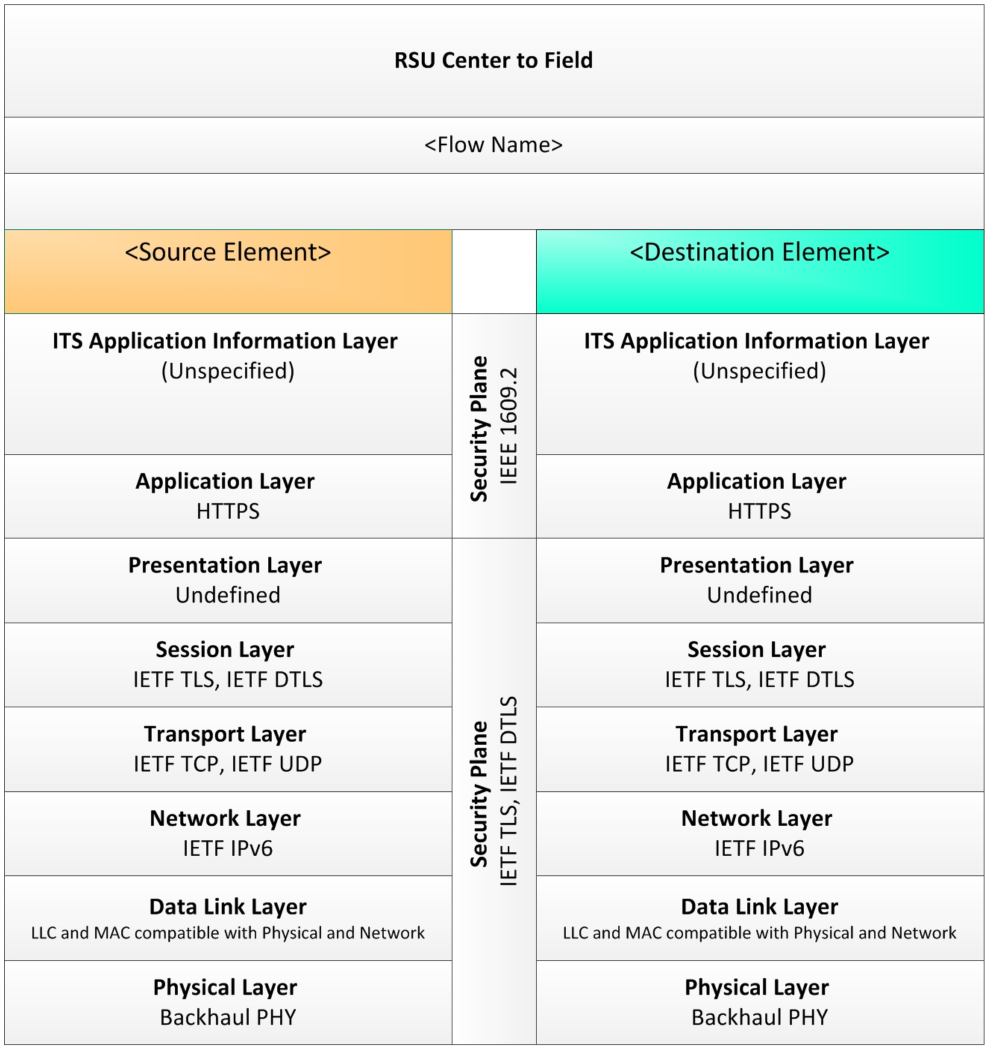
Table 19. NYC CVPD Communication View: Position-Location-Interface Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
location and time	Bus GPS	Bus ASD	(Unspecified)
location and time	Commercial Vehicle GPS	Commercial Vehicle ASD	(Unspecified)
location and time	Field GPS	RSU	(Unspecified)
location and time	Light Duty Vehicle GPS	Light Duty Vehicle ASD	(Unspecified)

Source: NYCDOT, 2016

3.3.2.8 RSU-C2F

RSU-C2F describes applicable standards for Center to Field (C2F) communications with RSUs. Common internet standards (i.e. HTTPS and TCP) are used in this profile. In SET-IT, this profile is called RSE-C2F. However, it has been renamed to RSU-C2F in this document to be consistent with the USDOT terminology. Thus, all communication profile names that contain 'RSE' have been revised to denote 'RSU'. Figure 27 illustrates the protocol diagram for this profile, and Table 20 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 27. NYC CVPD Communication View: RSU-C2F

Table 20. NYC CVPD Communication View: RSU-C2F Information Flow Triples

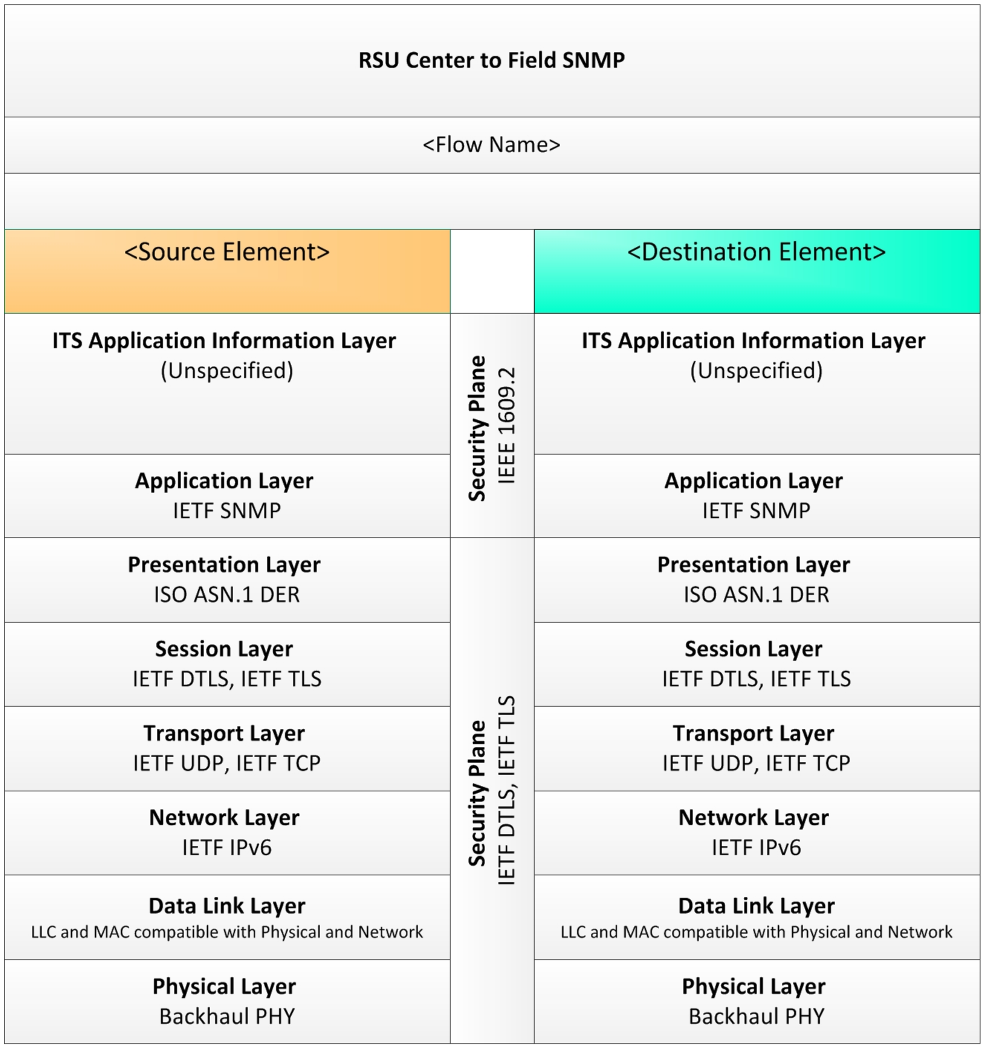
Flow Name	Source Element	Destination Element	Standard
application install/upgrade	NYCDOT TMC	RSU	(Unspecified)
equipment configuration settings	NYCDOT TMC	RSU	(Unspecified)
equipment control commands	NYCDOT TMC	RSU	(Unspecified)
infrastructure restriction warning info	NYCDOT TMC	RSU	(Unspecified)
intersection management application info	NYCDOT TMC	RSU	(Unspecified)
intersection safety application info	NYCDOT TMC	RSU	(Unspecified)

Flow Name	Source Element	Destination Element	Standard
reduced speed warning info	NYCDOT TMC	RSU	(Unspecified)
restricted lanes parameters	NYCDOT TMC	RSU	SAE J2735 (2016-03)
situation data collection parameters	NYCDOT TMC	RSU	(Unspecified)
speed management application information	NYCDOT TMC	RSU	(Unspecified)
traffic monitoring application info	NYCDOT TMC	RSU	(Unspecified)
traveler information application info	NYCDOT TMC	RSU	(Unspecified)
device identification	RSU	NYCDOT TMC	(Unspecified)
equipment status	RSU	NYCDOT TMC	(Unspecified)
intersection management application status	RSU	NYCDOT TMC	(Unspecified)
intersection safety application status	RSU	NYCDOT TMC	(Unspecified)
reduced speed warning status	RSU	NYCDOT TMC	(Unspecified)
speed management application status	RSU	NYCDOT TMC	(Unspecified)
traffic monitoring application status	RSU	NYCDOT TMC	(Unspecified)
traffic situation data	RSU	NYCDOT TMC	(Unspecified)
system monitoring	RSU	Service Monitor	(Unspecified)
device enrollment information	RSU	USDOT Production SCMS	(Unspecified)
security credentials	USDOT Production SCMS	RSU	(Unspecified)
security policy and networking information	USDOT Production SCMS	RSU	(Unspecified)

Source: NYCDOT, 2016

3.3.2.9 RSU-C2F-SNMP

The RSU-C2F-SNMP identifies applicable standards for C2F communications with RSUs. This profile uses SNMP, an Internet-standard protocol for managing devices on IP networks. Same as the RSU-C2F profile, the RSE part of its name has been revised to RSU. Figure 28 shows the protocol diagram for this profile, and Table 21 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 28. NYC CVPD Communication View: RSU-C2F-SNMP

Table 21. NYC CVPD Communication View: RSU-C2F-SNMP Information Flow Triples

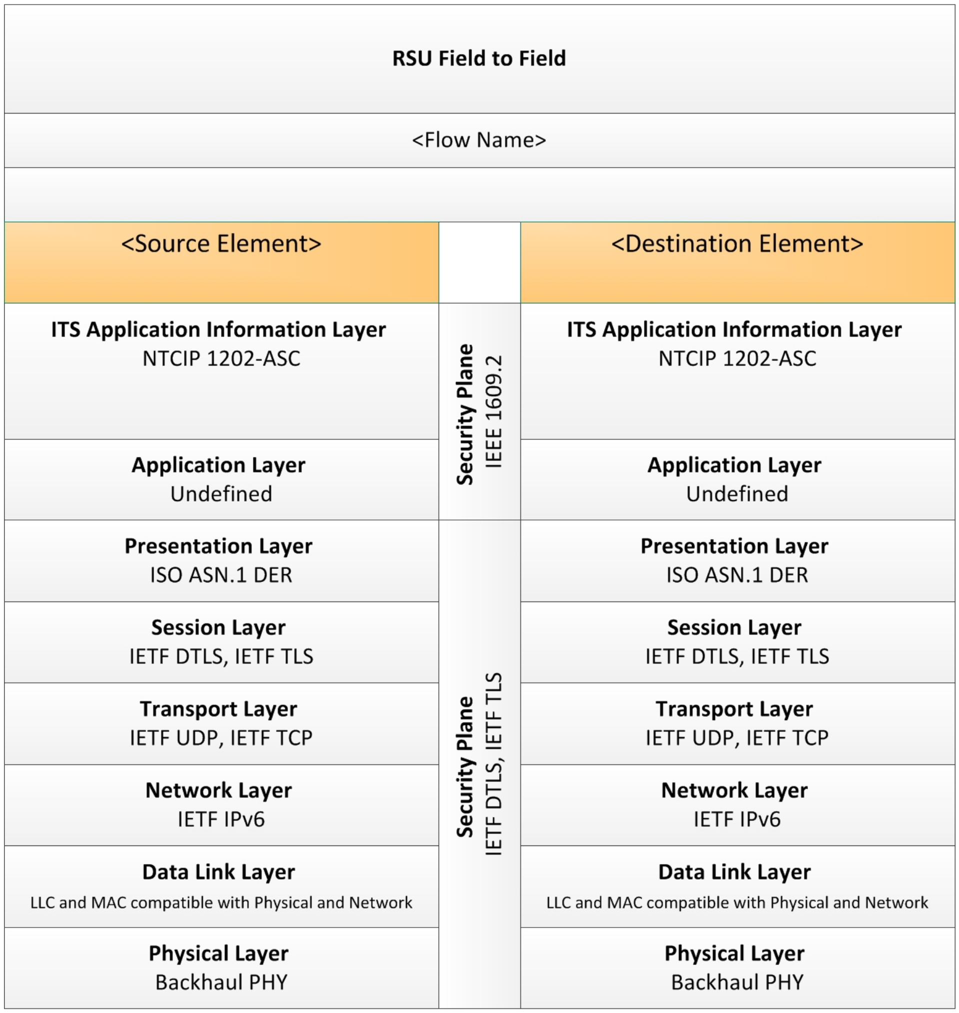
Flow Name	Source Element	Destination Element	Standard
application install/upgrade	NYCDOT TMC	RSU	(Unspecified)
equipment configuration settings	NYCDOT TMC	RSU	(Unspecified)
equipment control commands	NYCDOT TMC	RSU	(Unspecified)
infrastructure restriction warning info	NYCDOT TMC	RSU	(Unspecified)
intersection management application info	NYCDOT TMC	RSU	(Unspecified)
intersection safety application info	NYCDOT TMC	RSU	(Unspecified)

Flow Name	Source Element	Destination Element	Standard
reduced speed warning info	NYCDOT TMC	RSU	(Unspecified)
restricted lanes parameters	NYCDOT TMC	RSU	SAE J2735 (2016-03)
situation data collection parameters	NYCDOT TMC	RSU	(Unspecified)
speed management application information	NYCDOT TMC	RSU	(Unspecified)
traffic monitoring application info	NYCDOT TMC	RSU	(Unspecified)
traveler information application info	NYCDOT TMC	RSU	(Unspecified)
device identification	RSU	NYCDOT TMC	(Unspecified)
equipment status	RSU	NYCDOT TMC	(Unspecified)
intersection management application status	RSU	NYCDOT TMC	(Unspecified)
intersection safety application status	RSU	NYCDOT TMC	(Unspecified)
reduced speed warning status	RSU	NYCDOT TMC	(Unspecified)
speed management application status	RSU	NYCDOT TMC	(Unspecified)
traffic monitoring application status	RSU	NYCDOT TMC	(Unspecified)
system monitoring	RSU	Service Monitor	(Unspecified)
device enrollment information	RSU	USDOT Production SCMS	(Unspecified)
security credentials	USDOT Production SCMS	RSU	(Unspecified)
security policy and networking information	USDOT Production SCMS	RSU	(Unspecified)

Source: NYCDOT, 2016

3.3.2.10 RSU-F2F

RSU-F2F describes standards applicable to communications between the RSUs and other field equipment such as traffic signal controllers and detection devices. Figure 29 describes the protocol diagram for this profile, and Table 22 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 29. NYC CVPD Communication View: RSU-F2F

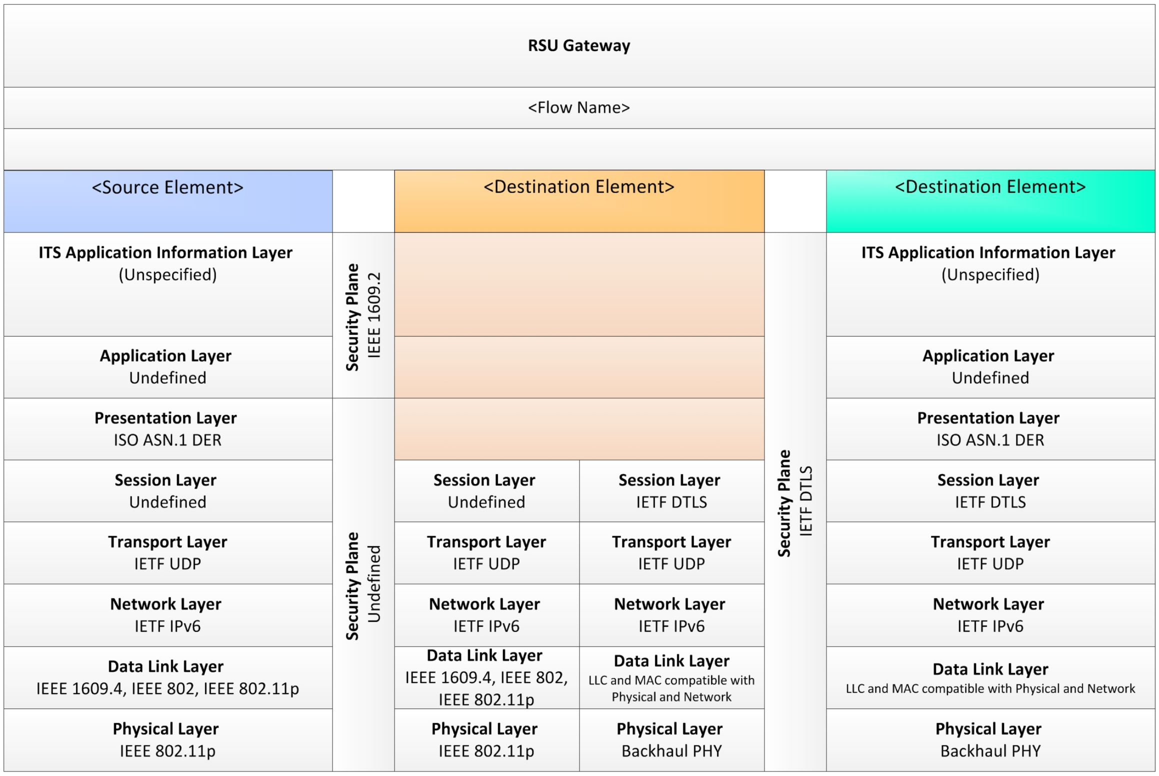
Table 22. NYC CVPD Communication View: RSU-F2F Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
pedestrian detection data	Pedestrian Detector	Signal Controller	(Unspecified)
time	RSU	Signal Controller	(Unspecified)
conflict monitor status	Signal Controller	RSU	(Unspecified)
intersection control status	Signal Controller	RSU	NTCIP 1202-ASC
pedestrian crossing status	Signal Controller	RSU	NTCIP 1202-ASC
pedestrian presence status	Signal Controller	RSU	(Unspecified)

Source: NYCDOT, 2016

3.3.2.11 RSUGateway-VehicleSource

RSUGateway-VehicleSource describes an alternative set of standards used in vehicle communications where one or more RSUs act as a gateway with the vehicle as source. Figure 30 presents the protocol diagram for this profile, and Table 23 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 30. NYC CVPD Communication View: RSUGateway-VehicleSource

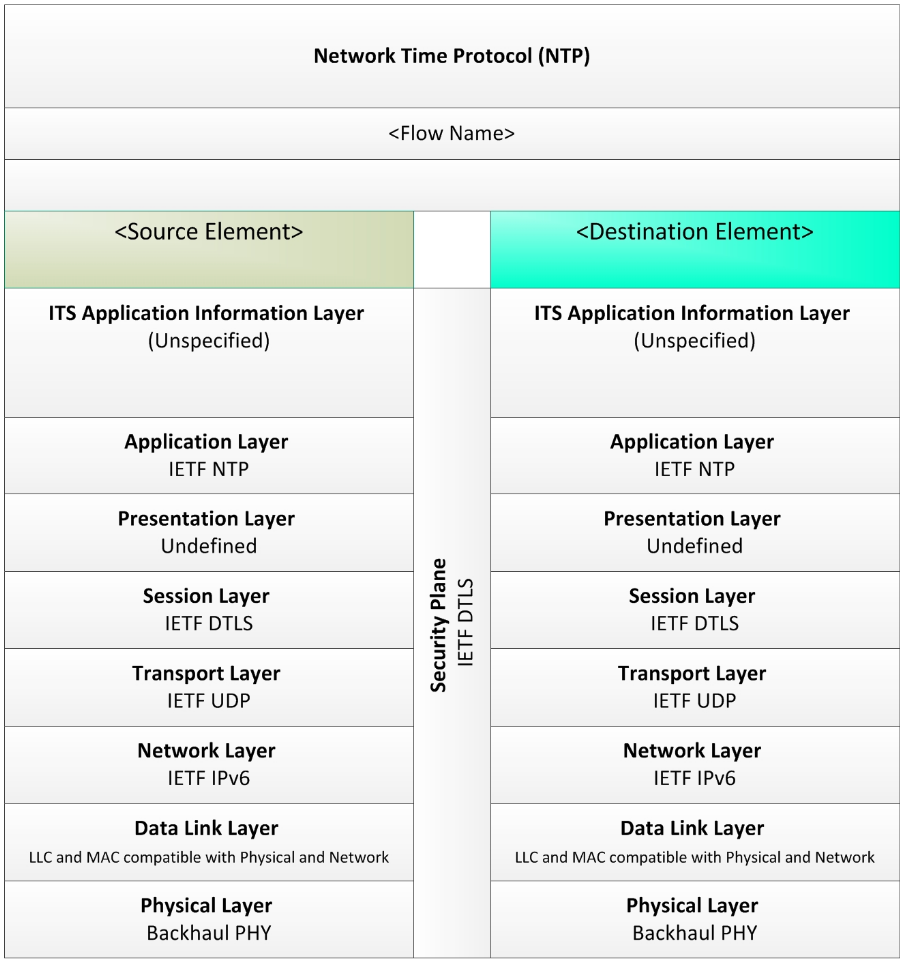
Table 23. NYC CVPD Communication View: RSUGateway-VehicleSource Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
device identification	Bus ASD	NYCDOT TMC	(Unspecified)
device identification	Commercial Vehicle ASD	NYCDOT TMC	(Unspecified)
device identification	Light Duty Vehicle ASD	NYCDOT TMC	(Unspecified)

Source: NYCDOT, 2016

3.3.2.12 Time

Time includes a collection of standards that support the Network Time Protocol (NTP) that allows NTP servers to provide time synchronization services to other NTP servers and clients. Figure 31 depicts the protocol diagram for this profile, and Table 24 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 31. NYC CVPD Communication View: Time

Table 24. NYC CVPD Communication View: Time Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
time	Location and Time Service (LTS)	NYCDOT TMC	(Unspecified)
time	Location and Time Service (LTS)	Service Monitor	(Unspecified)

Source: NYCDOT, 2016

3.3.2.13 Vehicle-On-Board

Vehicle-On-Board describes the communications between equipment that reside on the vehicle. The CVRIA does not contain any specific information on standards for on-board vehicle communications. For this reason a communications view diagram is not shown for this profile. However, it states that the Controller Area Network (CAN) - ISO 11898 and SAE J1939 may apply. Table 25 lists each data flow that uses this profile as well as its source, destination, and standard.

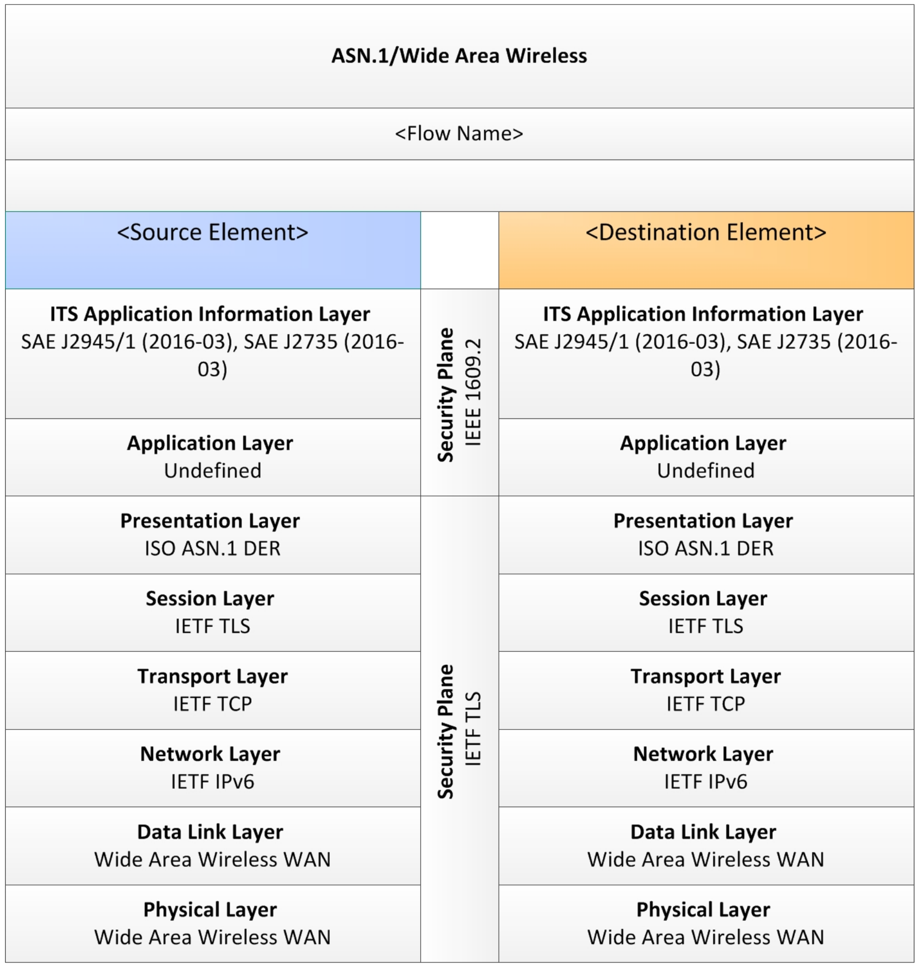
Table 25. NYC CVPD Communication View: Vehicle-On-Board Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
collision warning information	Bus ASD	Transit Vehicle Databus	(Unspecified)
driver update information	Bus ASD	Transit Vehicle Databus	(Unspecified)
collision warning information	Commercial Vehicle ASD	Commercial Vehicle Databus	(Unspecified)
driver update information	Commercial Vehicle ASD	Commercial Vehicle Databus	(Unspecified)
host commercial vehicle status	Commercial Vehicle Databus	Commercial Vehicle ASD	(Unspecified)
host vehicle status	Commercial Vehicle Databus	Commercial Vehicle ASD	(Unspecified)
collision warning information	Light Duty Vehicle ASD	Light Duty Vehicle Databus	(Unspecified)
driver update information	Light Duty Vehicle ASD	Light Duty Vehicle Databus	(Unspecified)
host vehicle status	Light Duty Vehicle Databus	Light Duty Vehicle ASD	(Unspecified)
host transit vehicle status	Transit Vehicle Databus	Bus ASD	(Unspecified)
host vehicle status	Transit Vehicle Databus	Bus ASD	(Unspecified)

Source: NYCDOT, 2016

3.3.2.14 WAW-ASN1

WAW-ASN1 describes applicable ASN.1 standards used in transmissions over wide area wireless (WAW) communications. Figure 32 displays the protocol diagram for this profile, and Table 26 lists each data flow that uses this profile as well as its source, destination, and standard.



* IEEE 1609.2 is an available standard to consider depending on physical device in the vehicle.

Source: NYCDOT, 2016

Figure 32. NYC CVPD Communication View: WAW-ASN1

Table 26. NYC CVPD Communication View: WAW-ASN1 Information Flow Triples

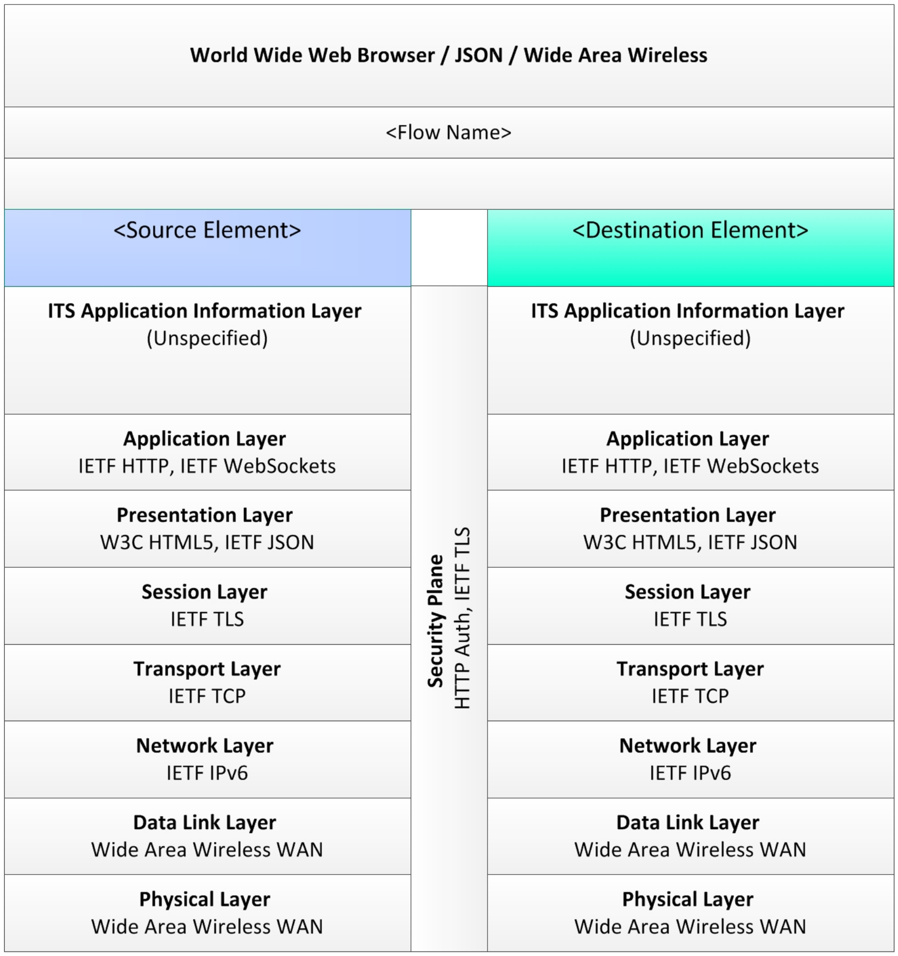
Flow Name	Source Element	Destination Element	Standard
device identification	Bus ASD	NYCDOT TMC	(Unspecified)
device identification	Commercial Vehicle ASD	NYCDOT TMC	(Unspecified)
vehicle location and motion	Commercial Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle location and motion	Commercial Vehicle ASD	RSU	SAE J2945/1 (2016-03)
device identification	Light Duty Vehicle ASD	NYCDOT TMC	(Unspecified)

Flow Name	Source Element	Destination Element	Standard
vehicle location and motion	Light Duty Vehicle ASD	RSU	SAE J2735 (2016-03)
vehicle location and motion	Light Duty Vehicle ASD	RSU	SAE J2945/1 (2016-03)
device identification	PID	NYCDOT TMC	(Unspecified)
pedestrian performance data	PID	NYU (NYCDOT IRB)	(Unspecified)
emergency traveler information	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
intersection status	RSU	Commercial Vehicle ASD	SAE J2735 (2016-03)
speed compliance parameters	RSU	Commercial Vehicle ASD	(Unspecified)
emergency traveler information	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
intersection status	RSU	Light Duty Vehicle ASD	SAE J2735 (2016-03)
speed compliance parameters	RSU	Light Duty Vehicle ASD	(Unspecified)

Source: NYCDOT, 2016

3.3.2.15 WAW-WWWBrowser-JSON

WAW-WWWBrowser-JSON describes applicable Internet Engineering Task Force (IETF) JavaScript Object Notation (JSON) and World Wide Web Consortium (W3C) web browser standards (e.g., HTML5 and Web Sockets) for transmissions over WAW communications. Figure 33 illustrates the protocol diagram for this profile, and Table 27 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 33. NYC CVPD Communication View: WAW-WWWBrowser-JSON

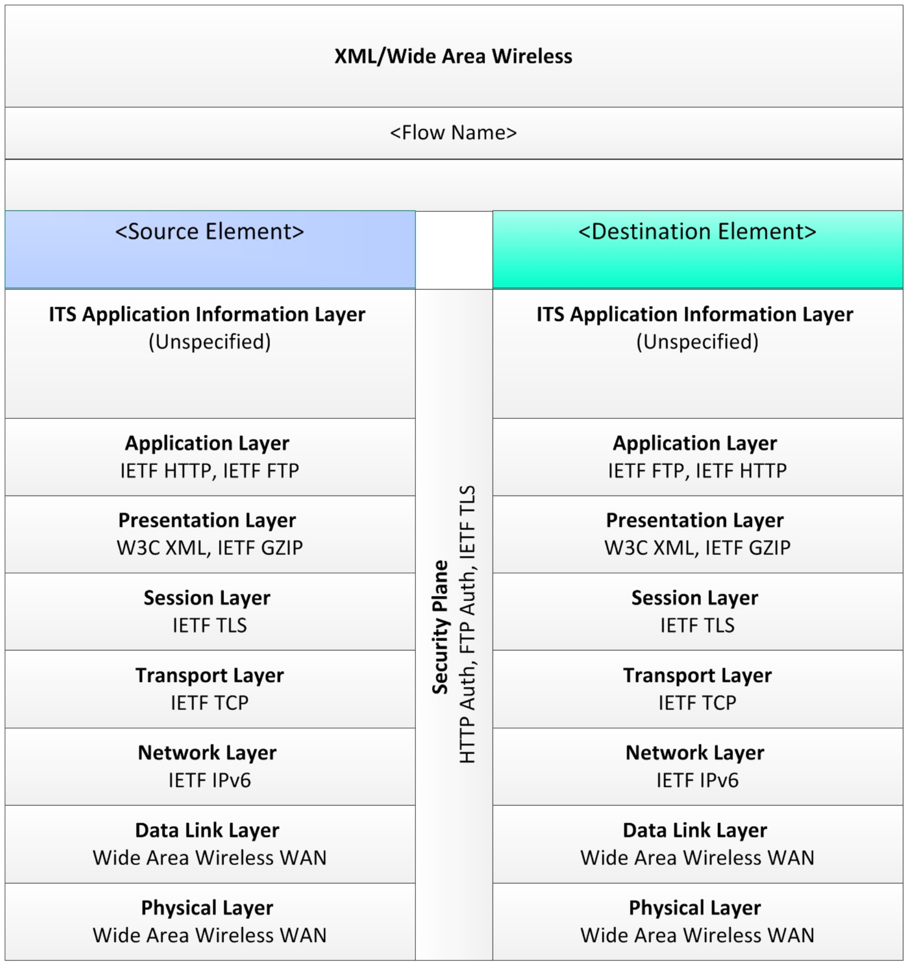
Table 27. NYC CVPD Communication View: WAW-WWWBrowser-JSON Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
device identification	Bus ASD	NYCDOT TMC	(Unspecified)
device identification	Commercial Vehicle ASD	NYCDOT TMC	(Unspecified)
device identification	Light Duty Vehicle ASD	NYCDOT TMC	(Unspecified)
device identification	PID	NYCDOT TMC	(Unspecified)
pedestrian performance data	PID	NYU (NYCDOT IRB)	(Unspecified)

Source: NYCDOT, 2016

3.3.2.16 WAW-XML

WAW-XML describes applicable eXtensible Markup Language (XML) and W3C web services standards used in transmissions over WAW communications. Figure 34 presents the protocol diagram for this profile, and Table 28 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 34. NYC CVPD Communication View: WAW-XML

Table 28. NYC CVPD Communication View: WAW-XML Information Flow Triples

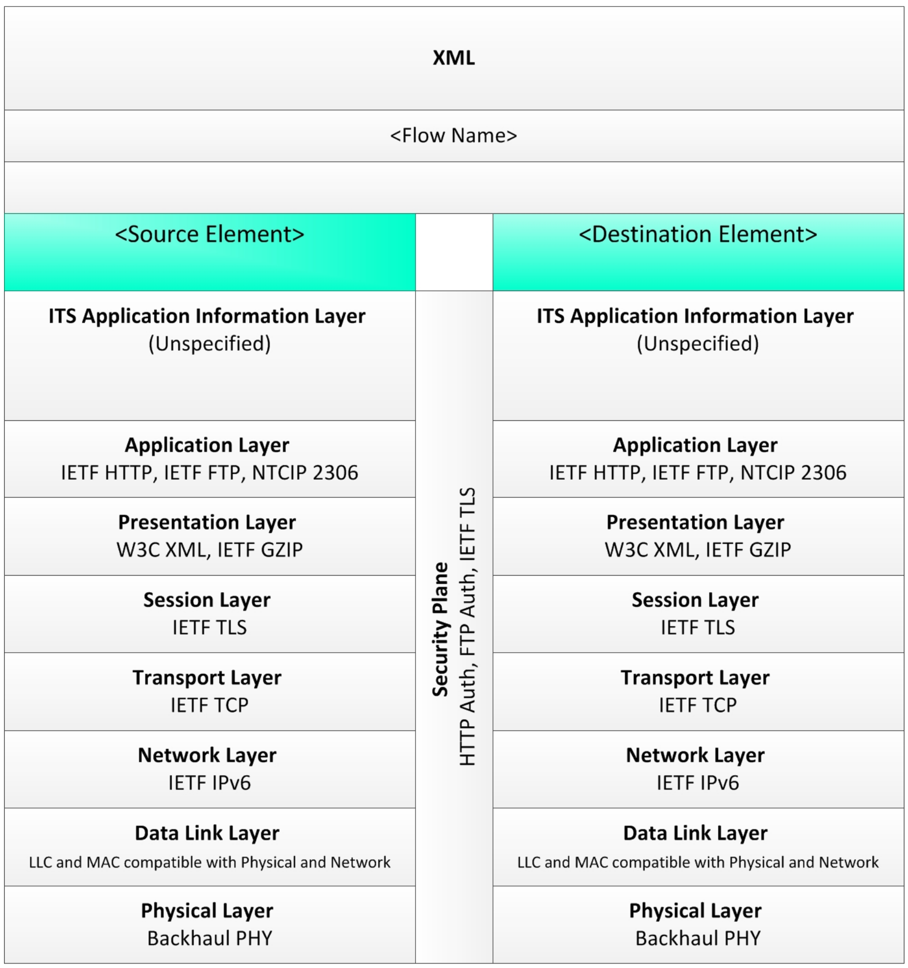
Flow Name	Source Element	Destination Element	Standard
device identification	Bus ASD	NYCDOT TMC	(Unspecified)
device identification	Commercial Vehicle ASD	NYCDOT TMC	(Unspecified)
device identification	Light Duty Vehicle ASD	NYCDOT TMC	(Unspecified)

Flow Name	Source Element	Destination Element	Standard
device identification	PID	NYCDOT TMC	(Unspecified)
pedestrian performance data	PID	NYU (NYCDOT IRB)	(Unspecified)

Source: NYCDOT, 2016

3.3.2.17 XML

XML describes a set of standards applicable to communications between entities using the Web Services standards of the W3C and the IETF. Information messages are encoded using the XML. Figure 35 presents the protocol diagram for this profile, and Table 29 lists each data flow that uses this profile as well as its source, destination, and standard.



Source: NYCDOT, 2016

Figure 35. NYC CVPD Communication View: XML

Table 29. NYC CVPD Communication View: XML Information Flow Triples

Flow Name	Source Element	Destination Element	Standard
MTA bus GPS travel time data	MTA Bus Data Archive	Performance Monitor	(Unspecified)
weather data	National Weather Service (NWS)	Performance Monitor	(Unspecified)
emergency traveler information	NYCDOT Office of Emergency Response (OER)	NYCDOT TMC	SAE J2735 (2016-03)
current infrastructure restrictions	NYCDOT Office of Freight Mobility (OFM)	NYCDOT TMC	ITE TMDD
operation and maintenance ASD data	NYCDOT TMC	Performance Monitor	(Unspecified)
operation and maintenance RSU data	NYCDOT TMC	Performance Monitor	(Unspecified)
PID operational status	NYU (NYCDOT IRB)	Performance Monitor	(Unspecified)
obfuscated data sets	Performance Monitor	TTI (USDOT IE)	(Unspecified)
obfuscated data sets	Performance Monitor	USDOT Research Data Exchange (RDE)	(Unspecified)

Source: NYCDOT, 2016

3.4 Functional View

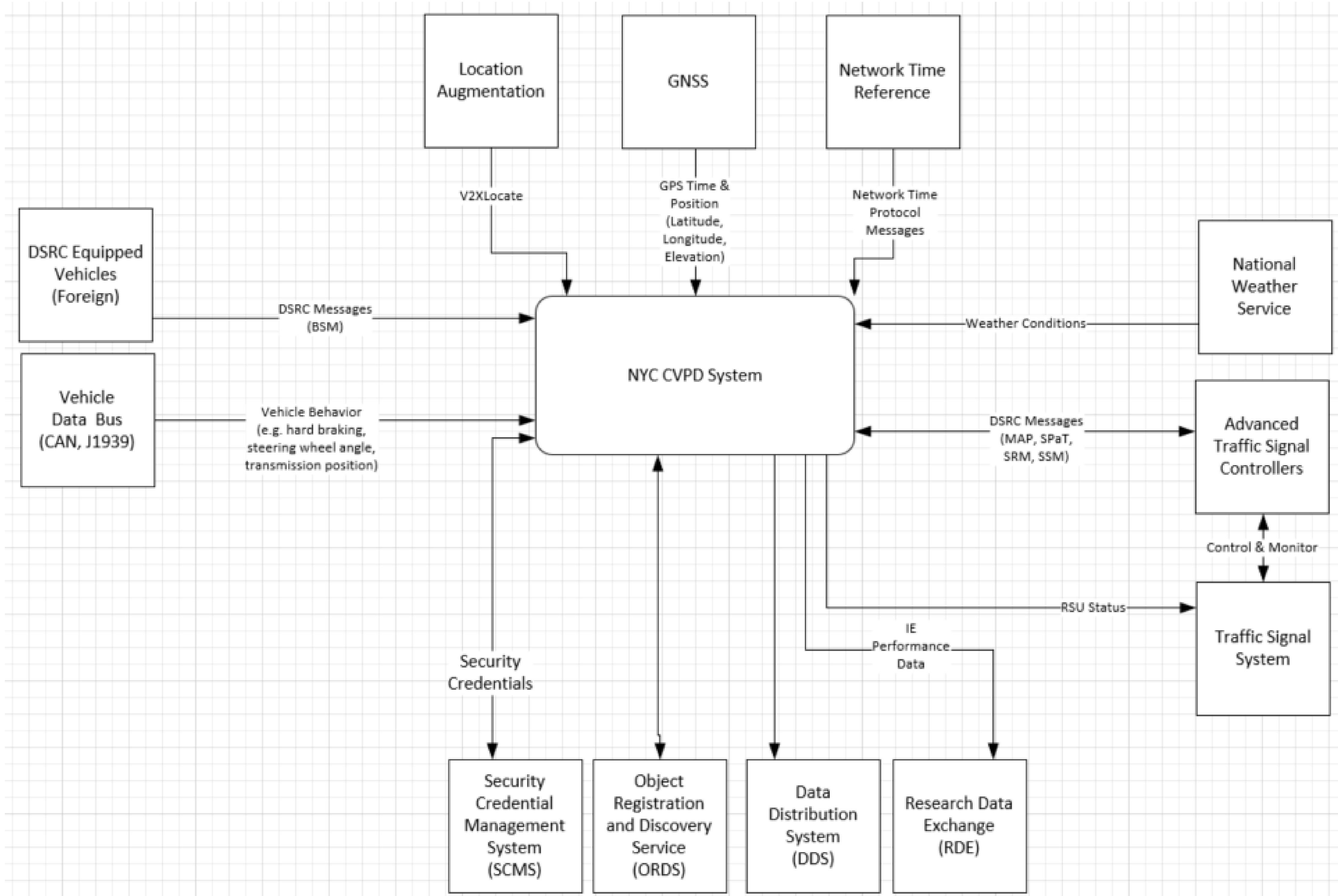
The Functional View describes the abstract functional elements and their logical interactions that satisfy the system requirements. It contains a set of processes or functions that control and manage system behaviors and perform actions to achieve application objectives or support actions of other processes. It also describes data processing functions, data stores and the logical flows of information among these elements. The CVRIA recommends that the reader use the Physical view diagrams for graphical representations of the system behavior.

Performance data and event data lifecycle will serve as critical functions in the NYC CVPD system. As the data is collected from the ASDs in the vehicles, it will be logged, stored, processed, and sanitized of PII and location and time information. These are vital steps in evaluating the safety benefits before and after system deployment. This section provides the context of the NYC CVPD system and describes the performance and event data components and their lifecycle.

3.4.1 NYC CVPD System Context

Figure 36 provides a detailed context of the NYC CVPD system. It defines the technical subsystems and interfaces that cross the system boundaries and the high-level interactions among the various components.

The left side of the context diagram represents the vehicles equipped with ASD and DSRC communication and their internal data bus. The right side identifies the traffic signal system, the advanced traffic signal controllers, and the National Weather Service (NWS) that will feed external data and DSRC messages to the NYC CVPD system. The top part of the diagram shows the location augmentation via V2XLocate, the GNSS for synchronizing the GPS time and position data (latitude, longitude, elevation), and the Network Time Reference for transmitting the Network Time Protocol (NTP) messages. The bottom portion of the diagram presents the SCMS for maintaining the security credentials, the Object Registration and Discovery Service (ORDS) for object registration and search, Operational Data Environment (ODE) for distribution of CV data, and Research Data Exchange (RDE) for exchange of Independent Evaluator (IE) performance data with USDOT. The ODE has replaced the Data Distribution System (DDS) as the platform for routing the data from multiple data sources to a common, integrated format for subscribers to software applications such as CV applications. However, at this time the USDOT ODE is not expected to play a role and interact directly with the NYC CVPD system.



Source: NYCDOT, 2016

Figure 36. NYC CVPD System Context Diagram

3.4.1.1 DSRC Communication with Vehicles

All vehicles participating in the NYC CVPD system will be equipped with ASDs. The ASDs will communicate with the Vehicle Communications Bus (Controller Area Network (CAN), SAE J1939) and obtain vehicle behavior information (i.e. hard braking, steering wheel angle, transmission position, etc.). Based on the data collected, the DSRC-equipped vehicles will transmit messages in the form of BSMs to nearby RSUs, which will then forward it to the NYCDOT TMC for initial post-processing.

3.4.1.2 Location and Time Source (LTS)

In the NYC CVPD system, location augmentation will occur through RSU triangulation/trilateration in V2XLocate technology. As shown in Figure 2 1, the ASD and RSU will depend on the Global Navigation Satellite System (GNSS) or Global Positioning System (GPS) time source for determining their time and position (latitude, longitude, and elevation). The Network Time Protocol (NTP) messages will serve as an external time source for synchronizing the location and time of non-CV equipment (i.e. Advanced Solid-State Traffic Controllers (ASTC), Traffic Control System (TCS), National Weather Service (NWS)) with the NYC CVPD infrastructure.

3.4.1.3 Existing External Systems

The National Weather Service (NWS) data on existing weather conditions will be captured and tied to the recorded CV application event data. To further remove the possibility of unusual weather events to particular dates, the precise nature of the weather events may be summarized as sunny, cloudy, light rain, heavy rain, light snow, heavy snow (or similar) instead of precise precipitation amounts or rates.

ASTC is the standard traffic signal controller device used in NYC. The controllers will be provisioned with CV capabilities to be able to exchange DSRC messages (i.e. SPaT, MAP) with the NYC CVPD system. They are denoted by the physical element Signal Controller in the physical and functional architecture diagrams. They will be monitored and controlled by Traffic Control System (TCS) in the TMC for communicating with the RSUs and monitoring their operational status.

3.4.1.4 Performance Measurement

The USDOT ODE will be responsible for collecting, processing, and distributing near real-time CV data such as BSM, MAP, SPaT, and TIM messages. It will link the data produced by the roadway users with the USDOT situation data clearinghouse and warehouse facilities. In the NYC CVPD system, the NYCDOT TMC will post-process and obfuscate the time, date, and location data in the BSMs received by the vehicles and SPaT, MAP, and TIM messages broadcasted by the RSUs. It will utilize its own algorithm to aggregate, sanitize, and strip the data of any PII. At this time, the USDOT ODE is not expected to play a role and interact directly with the NYC CVPD.

The Research Data Exchange (RDE) is USDOT ITS-JPO's web-based data resource for its real-time Connected Data Systems (CDS) program which collects, manages, and provides archived and real-time multi-source and multi-modal data to support the development and testing of ITS applications. The post-processed data from the NYC CVPD system will be sent to TTI, USDOT's IE for additional performance measurement analysis. After this process, the IE may elect to share the data on the ODE.

3.4.1.5 Security

The USDOT SCMS represents the interconnected NYC CV system that enable trusted communications between the ASDs, RSUs, and the TMC to protect the system and its data from unauthorized access. It will support the secure distribution, use, and revocation of security credentials in the NYC CVPD system. Currently, it is being developed by USDOT for utilization in the three pilot sites.

The back office facilities at NYCDOT Traffic Management Center (TMC) will not be used for the security credentials management system (SCMS) functions, security enrollment certificates signing, and DSRC messages (BSM, SPaT, MAP, TIM) signing. Instead, these operations will be allocated to the field RSUs as supported by the latest USDOT RSU specification. Another option for consideration entailed utilizing a separate RSU within the TMC in lieu of the back office proxy server for managing the SCMS and signing of the enrollment certificates, pseudonym certificates, and safety messages transmitted by the devices. However, the method of allowing individual RSUs to sign the data has been selected to mitigate risks on schedule and cost.

The ORDS will provide registration and look-up services for allowing objects to locate other objects in the CV environment for communication purposes. It will be used to provide registration and discovery services for enabling the secure data transfer applications in the NYC CVPD system.

3.4.2 Performance Data

Figure 37 delineates the Performance Monitoring process and the functional data flow exchanges from and to the Performance Monitoring server that will reside at the NYCDOT TMC. The operation and maintenance (O&M) data will be collected to determine the range or radio frequency (RF) over which ASDs and RSUs are transmitting to and receiving the data from vehicles. Also, mobility data collected by the ASD will consist of vehicle situation data and its historical location and speed. This 'breadcrumb' data will be uploaded to the RSUs for obtaining travel times and comparing with NYCDOT's existing travel time data. Other data sets from external sources including the MTA, National Weather Service (NWS), volume data from Automatic Traffic Recorder (ATR) counts, and existing travel time records from RFID readers will be pulled and included in the performance evaluation process.

3.4.2.1 Operation and Maintenance (O&M) Data

3.4.2.1.1 ASD RF Monitoring

The O&M data collected by the ASDs will consist of V2V (ASD to ASD) and V2I (ASD to RSU) sightings for measuring the ASD's RF status and performance. It will be used to detect the presence or absence of ASDs by tracing the RF radiation issues to a specific vehicle in the NYC CVPD system. In the V2V case, the ASD will log its own as well as the remote vehicle's available power level information and the BSMs. However, it will only store the first and last data during the encounter. Similarly, in the V2I case the ASD will log its own RF and BSM and the nearby RSU's RF and SPaT message. If it continues to receive the data from the same RSU, the latest set of messages will replace the last message log entry each time. When no further entries are recorded, the first and last messages during the encounter will be logged.

This O&M data will be uploaded when the ASD encounters a support RSU that is programmed to look for nearby ASDs. When this occurs, the RSU will collect the ASD O&M data through a properly signed WSA on the identified service channel. Once the RSU acknowledges receipt and processes the RF log entries, the ASD will purge the log entries transmitted to the RSU. Then, it will forward the ASD O&M data to the Performance Monitor server in the TMC via available network backhaul bandwidth. The ASD RF monitoring data will support NYC CVPD system's Infrastructure Management (see Figure 16). It will not be encrypted since no PII data and transient data will be collected.

3.4.2.1.2 The RSU RF monitoring

When an ASD receives a SPaT message from a specific RSU for the first time, it will record its own BSM, the SPaT message content from the RSU, and the RF power level of the received signals into first and last entries of its record. It will continue to receive and replace the last entry until a configurable timeout occurs and ends the encounter. In a similar manner, the ASD will also record the first and last MAP message it receives from each RSU it sees. The RSU will receive this set of first and last log data on the ASDs and upload it to the Performance Monitor server in the TMC for post-processing and obfuscation. Figure 16 for the Infrastructure Management physical view diagram illustrates this data upload process. The data transmission to the RSU will be secure, and data collection will occur only when activated by the RSU and the TMC's back office CV data processing center for a specified duration. The RSU RF monitoring data will support NYC CVPD system's Infrastructure Management (see Figure 16). It will not be encrypted since no PII data and transient data will be collected.

3.4.2.1.3 PID Operational Status

Unlike the ASDs and the RSUs, the PIDs will not collect and record their RF signal level information. However, whether each device is in operational or not will be logged by NYU (NYCDOT IRB). While only NYU will record the operating PIDs and their locations, any PII will be scrubbed prior to being uploaded to TMC's Performance Monitoring server for final post-processing and obfuscation (see Figure 37). While the PIDs will receive SPaT messages via DSRC 5.9 GHz, the data transmission is expected to occur through 3G/4G/LTE connection.

3.4.2.2 Mobility Data

In the NYC CVPD system, several types of mobility data will be collected for inclusion in the performance evaluation. The ASDs will broadcast BSMs from alerts by multiple V2V and V2I safety applications. They will collect additional 'breadcrumb' data that will contain configurable portions of the BSM data. The RSUs will also collect its breadcrumb data that will consist of a select number of BSMs as snapshots of the traffic conditions and the vehicles' previous trajectories. At this time, this will not be utilized by the current NYC CVPD project but in the future by NYCDOT. As the RSU transmits the BSMs from the ASDs to the NYCDOT TMC,

3.4.2.2.1 ASD Breadcrumb Data

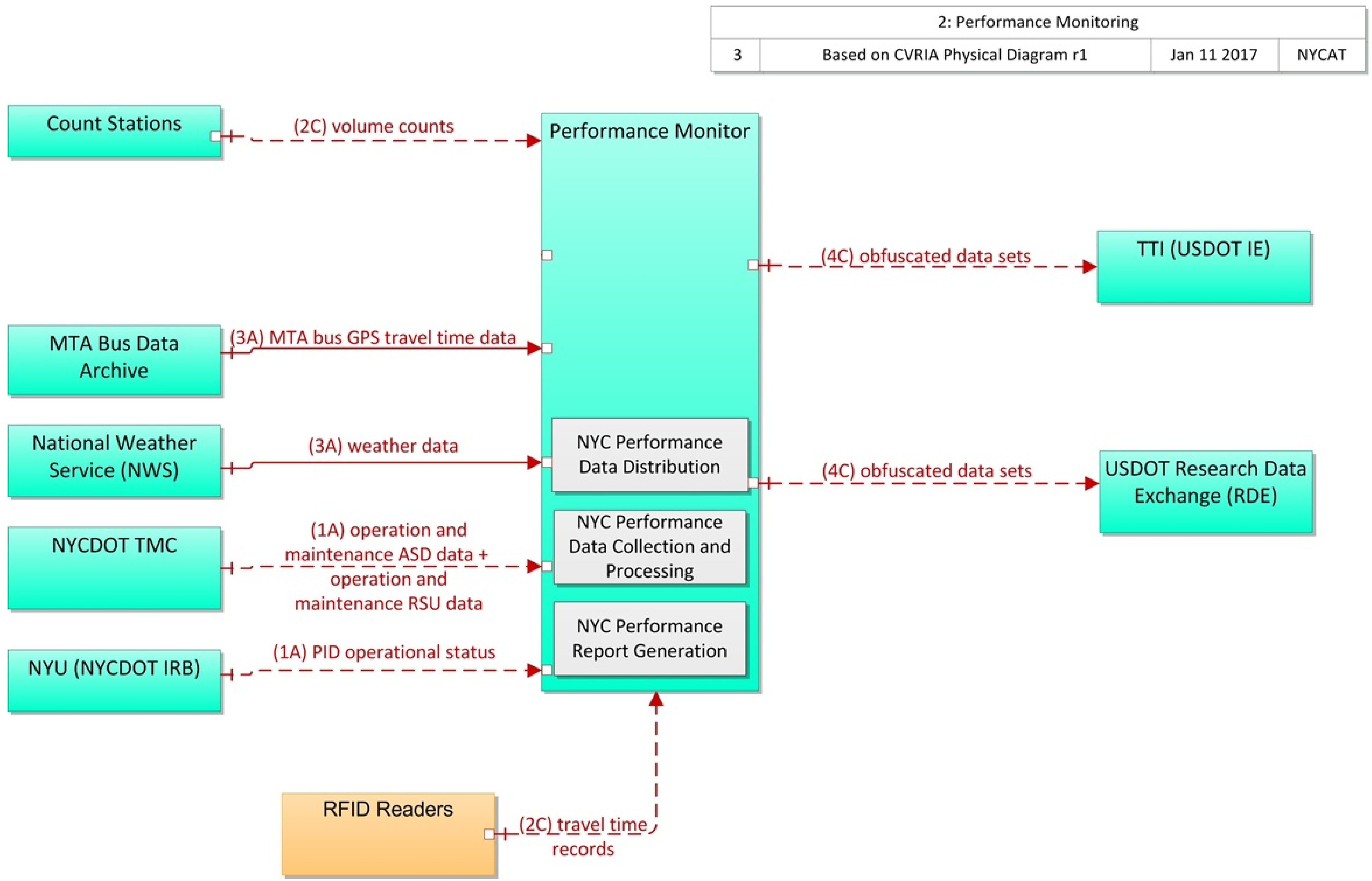
The ASD breadcrumb data will be less detailed than the event log data surrounding a CV safety application warning. Its data collection intervals will be configurable based on distance traveled (i.e. every 100 feet), time traveled (i.e. between 1-5 seconds), or both parameters depending on which one occurs first. It will not include detailed BSMs from remote vehicles surrounding the host vehicle, as the remote ASDs will generate their own breadcrumb information. PVD/PDM messages may be used to store the breadcrumbs with select number of BSMs (not at 10Hz) to generate probe data logs, which will contain the vehicle's location, heading, speed, and path history. The vehicle situation data flow triple denotes the ASD breadcrumb data and is illustrated in Figure 38 for Vehicle Data for Traffic Operations.

3.4.2.2.2 RSU Travel Time Data

The RSU will transmit select BSMs from ASD sightings to the TMC for calculating link travel times between designated intersections. Even if the certificates and the temporary vehicle IDs change, the computation will be conducted by matching the vehicle IDs between adjacent RSUs. This data collected by the NYC CVPD system will be compared to the existing data from RFID toll tag readers placed strategically for the Midtown in motion (MIM) adaptive control area. Based on the comparison results, the CV data may replace the existing mechanism for determining travel time and speed information by acting as an input to NYC's existing Adaptive Control Decision Support System (ACDSS). While this function is based on CVRIA's Intelligent Traffic Signal System (I-SIG) application, it will only be utilized as a vehicle traffic sensor application for calculating the travel times and examining the reliability of CV data. Figure 39 highlights the role of I-SIG in the travel time data collection.

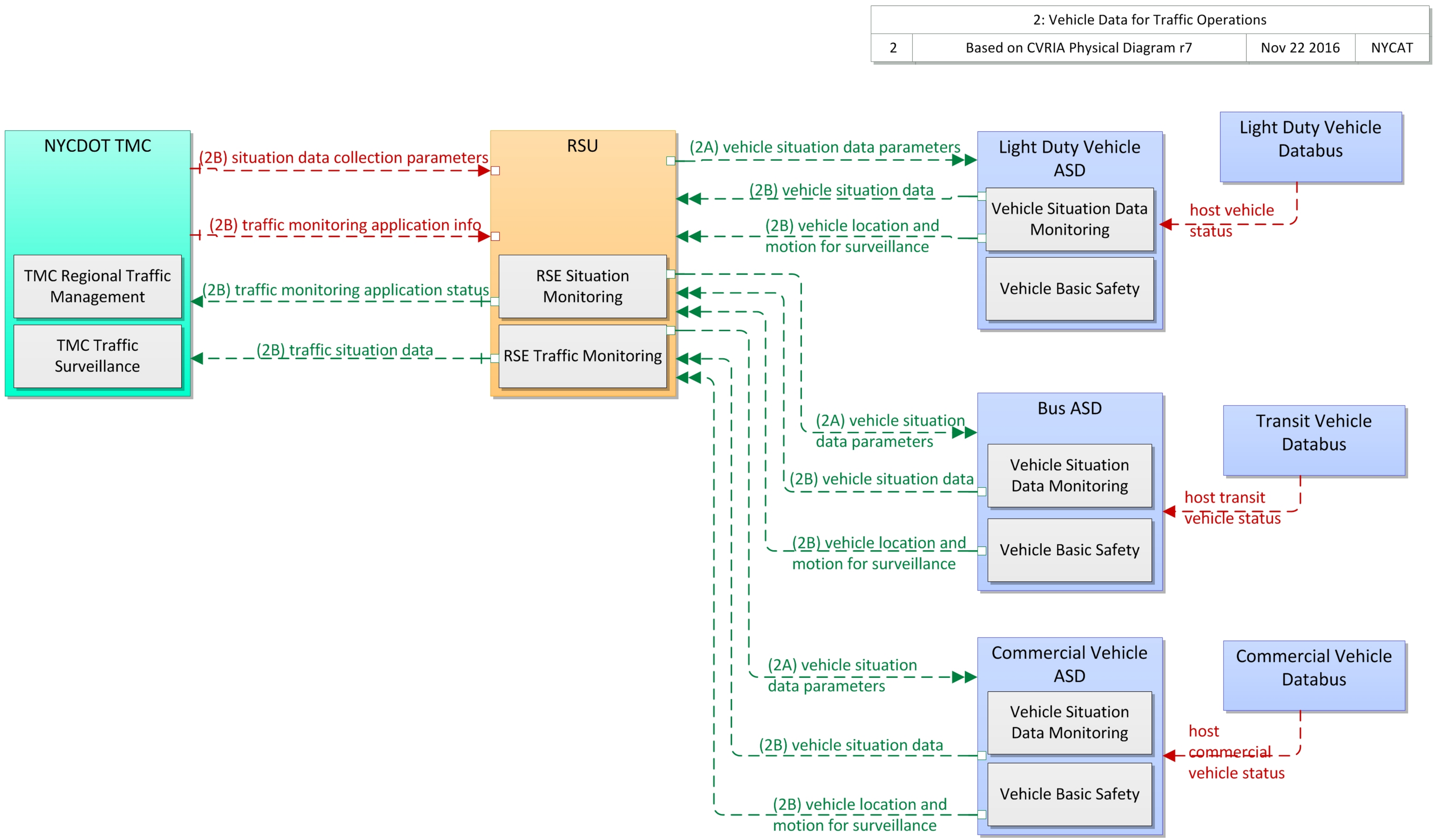
3.4.2.3 External Metadata

In addition to the O&M and mobility data, existing data will also be included in the performance evaluation. The metadata from external sources shown in Figure 37 are the MTA bus GPS travel time, and weather data from NWS. The external data feeds will be used to correlate with the CV performance and event data to find out if any confounding factors may have influenced the validity and reliability of the CV data. In addition, the volume data from NYCDOT's Automatic Traffic Recorder (ATR) counts and existing travel time records from RFID readers for comparing with I-SIG travel time data will be inputted as well into the performance evaluation process. As described in Figure 37, the performance monitor server in the TMC will assess the safety benefits before and after system deployment. It will also post-process, aggregate, sanitize, scrub, and obfuscate the data to ensure no PII remains in the data sets prior to sending them to TTI and RDE for additional evaluation and analysis by the USDOT.



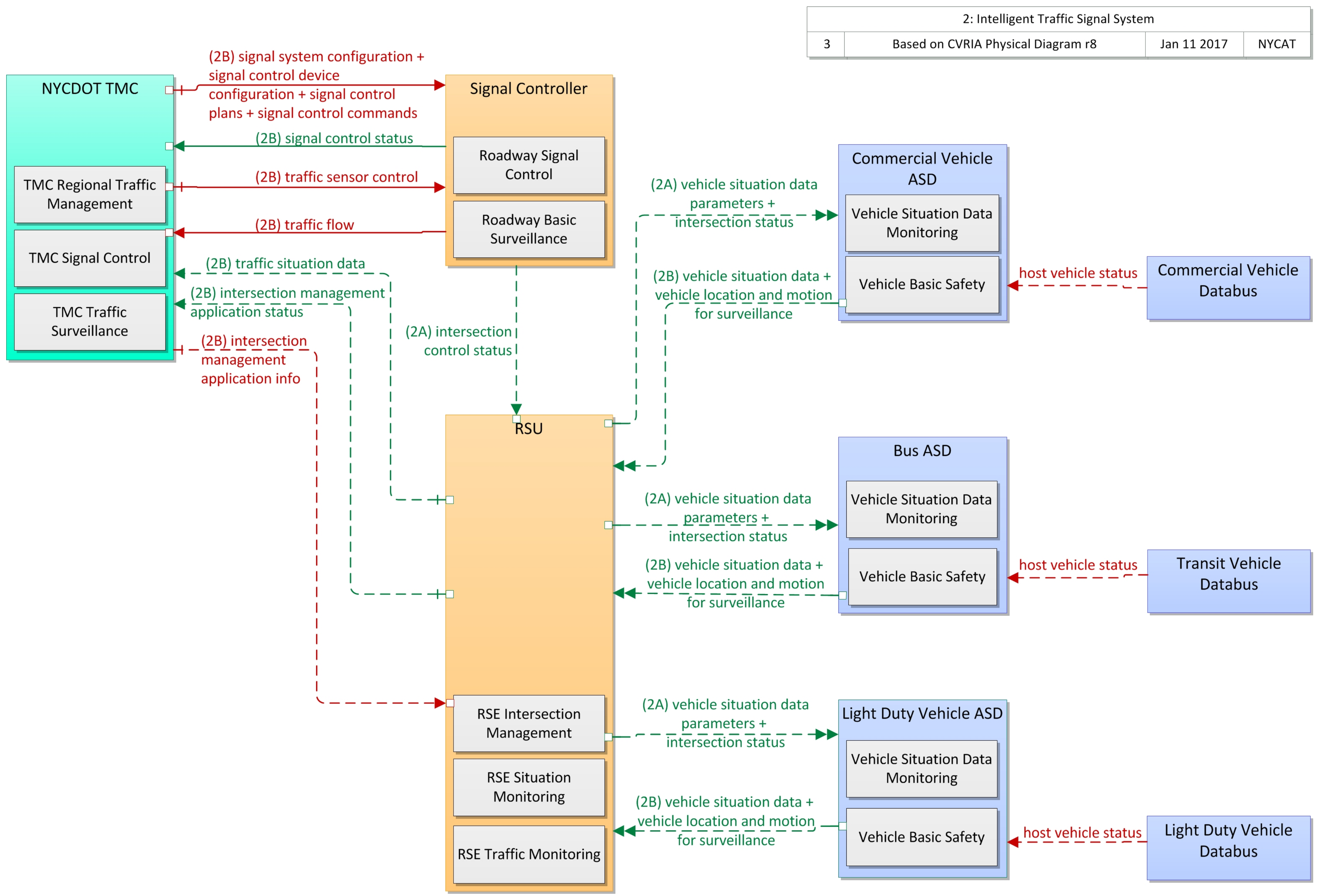
Source: NYCDOT, 2016

Figure 37. NYC CVPD Functional View: Performance Monitoring



Source: NYCDOT, 2016

Figure 38. NYC CVPD Functional View: Vehicle Data for Traffic Operations



Source: NYCDOT, 2016

Figure 39. NYC CVPD Functional View: Intelligent Traffic Signal System

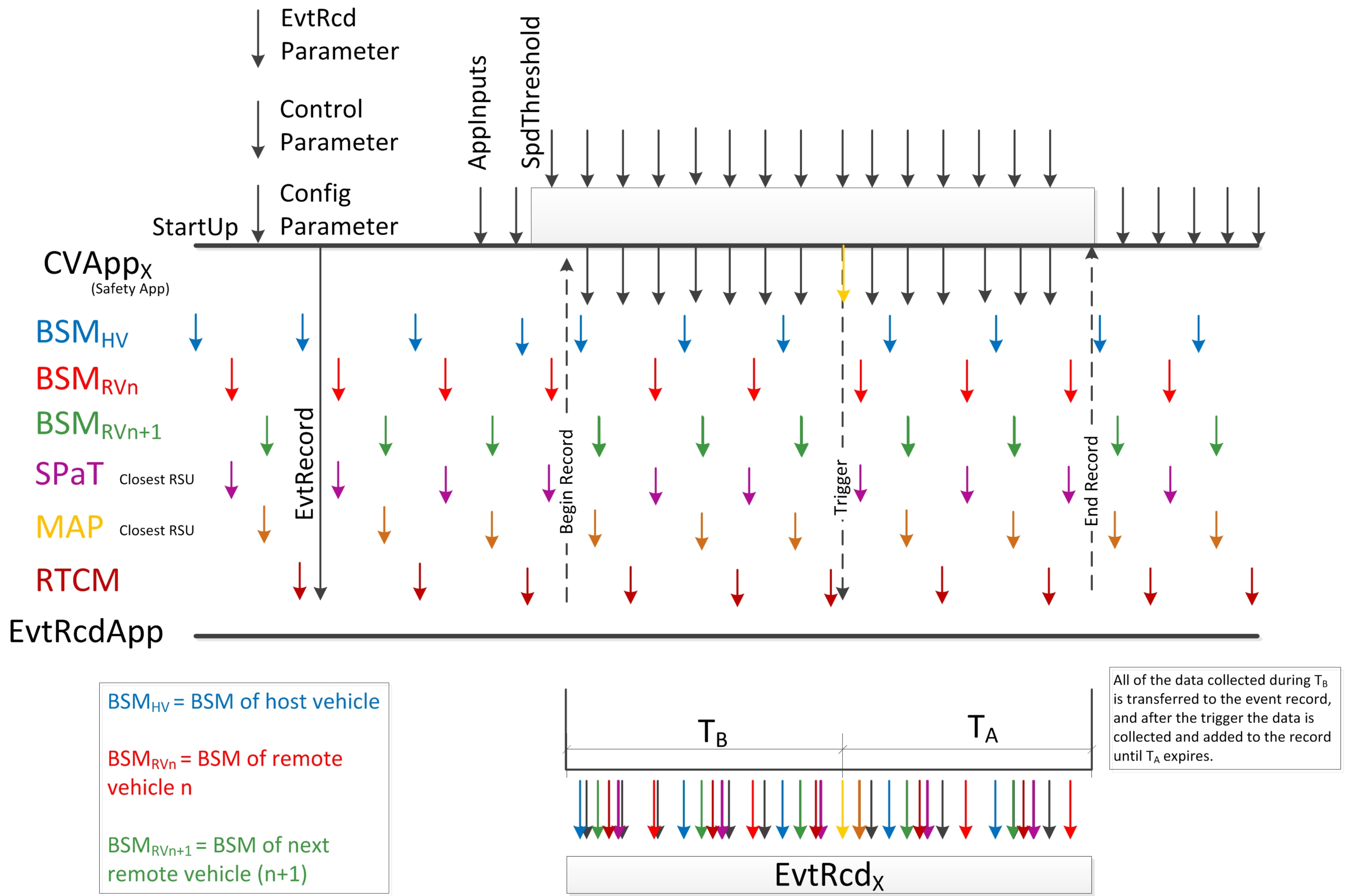
3.4.3 Event Data Life-cycle

An ASD event data contains the specific actions performed by the vehicle's driver or operator surrounding a warning by the triggered application. It includes the DSRC messages (i.e. BSM, SPaT, MAP, TIM) along with vehicle dynamics information such as directional signals, hard braking, steering wheel angle, trajectory, and speed obtained from the vehicle's OBD-II port, CAN bus, or another available bus. The duration of the before (i.e. 10-20 seconds) and after (i.e. 20-50 seconds) the event will vary and depend on the specific event type and which CV application triggered the warning. This section describes the event data lifecycle from its generation in the ASD to final binning, purging, and obfuscation processes at the NYCDOT TMC.

3.4.3.1 Event Recording Context

The ASDs will log the relevant information surrounding a triggered event as shown in Figure 40. The log entry will consist of the host vehicle (HV) BSMs (BSM_{HV}), remote vehicle (RV) n's BSMs (BSM_{RVn}), and the subsequent (denoted by n+1) remote vehicle's BSMs (BSM_{RVn+1}) from the ASDs. It will also record the SPaT, MAP, and TIM messages heard from the nearby RSU. The trigger will be configurable and will include the CV application warnings, acceleration criteria, brake system status, etc. The time periods for collecting data before and after the trigger event will be configurable for each event trigger based on the event record (EvtRcd), control, and configuration parameters. These periods will consist of a few seconds (e.g., 10-20) prior to and a few seconds (e.g., 30-40) following the trigger’s activation. The relevant information (data) will be limited to what the ASD provides, and it may include vehicle data when the ASD is connected to the vehicle’s data bus (i.e., CAN, J1939). For instance, each event log entry will include location (i.e., latitude, longitude, elevation, 3-axis acceleration), indicated warnings, and the action (i.e., lights, wipers, turn signals, steering angles, brakes) of the vehicle. More importantly, this event log will be stored on the vehicle for later retrieval when the vehicle returns to its fleet terminal where the data will be offloaded.

Note that the definition of an event will be configurable so it can be used to collect short-term driver behavioral data (hard break, steering turns, accelerations, etc.) for aggregation and performance measures. However, such data will be cleansed of any traceable personal data (exact location and time) to prevent from being correlated to other records such as police reports.



Source: NYCDOT, 2016

Figure 40. ASD Event Recording Context

3.4.3.2 Event Collection

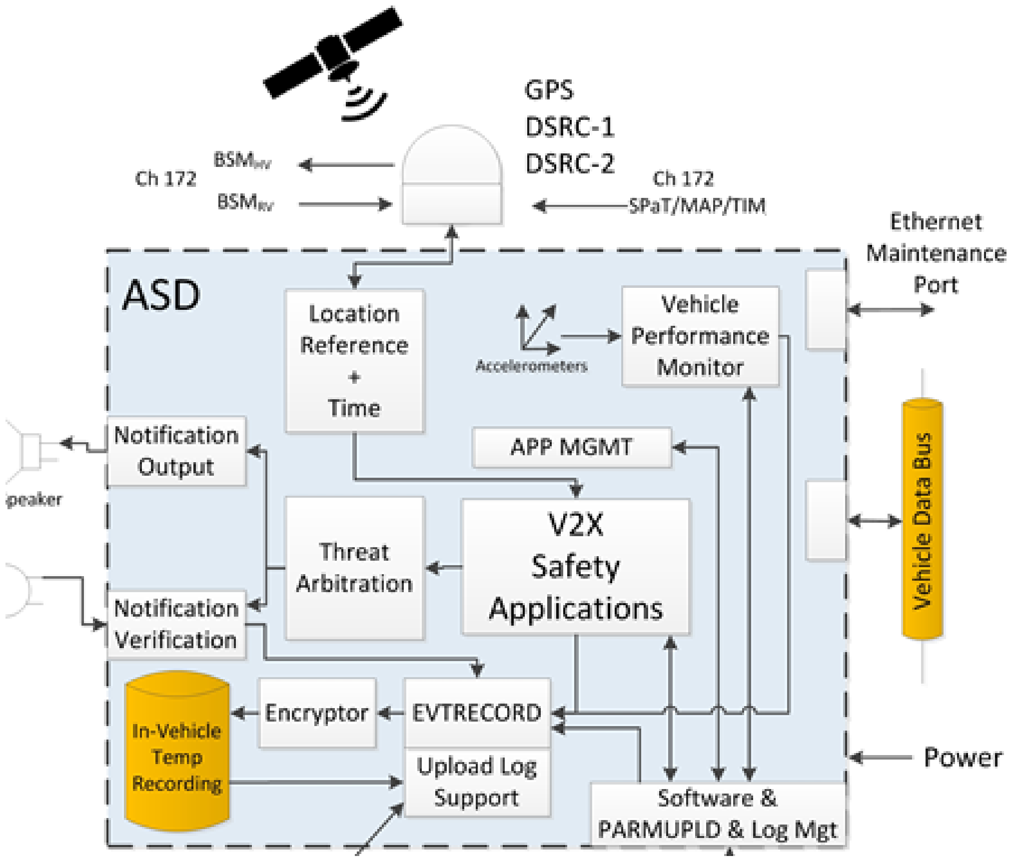
The ASD will log the information before and after a particular event as illustrated in Figure 41. The number of seconds before and after each event is to be determined, and it may depend on the type of warning generated by the ASD. What data is recorded will be subject to whether OBD-II/CAN bus is accessible and what data is produced by the ASD. This performance log data is expected to include time and location information from the BSMs, the warning issued by the ASD, any SPaT and MAP messages from any RSU it can hear, and the vehicle maneuver as a result of that warning. As the vehicle returns to its fleet terminal, the recorded data will be uploaded to the RSU at the terminal.

When the vehicle operator begins normal duties by turning on the ASD-equipped vehicle, the ASD will confirm whether it is ready for operation. If the ASD experiences a fault, it will generate a maintenance & operation (M&O) log data that contains the start-up event and the fault. When the vehicle returns to its fleet barn after normal operating hours, the ASD will communicate with the RSU to verify its firmware version against the advertised available version. If the ASD's version is outdated, then it will initiate the OTA software and firmware update transaction from the RSU at the vehicle's fleet barn.

As the driver returns the vehicle to its respective fleet barn, the event data log will be transmitted from the ASD to the RSU at the barn. Then, the RSU will receive the data, acknowledge the transaction, and send it to NYCDOT TMC’s back office CV data processing center. The event log data will be processed for analyzing the safety benefits of the NYC CVPD. Then, it will undergo extensive post-processing and normalization (i.e., cleansing) before being transmitted to the USDOT. As it is aggregated, the types of event counts will be incremented by time-of-day, location, and event type into collection bins. Any traceable and private information will be discarded. Once all errors are addressed and checked, the raw data will be purged. This log data will be used by the USDOT IE for additional evaluation and uploading onto its RDE portal.

3.4.3.3 Event Upload

Figure 41 below presents a detailed view of the ASD functional architecture. The host vehicle's ASD will transmit BSMs to and from other vehicle ASDs and receive SPaT, MAP, and TIM messages through DSRC channel 172. As their location and time information are recorded, the alerts for V2V and V2I applications will be triggered based on threat arbitration and configuration parameters set within the ASD. As the ASD receives the messages, the EVTRECORD function will collect event logs before and after the warnings. Ultimately, these DSRC messages will be collected, recorded, and logged within the ASD temporarily.

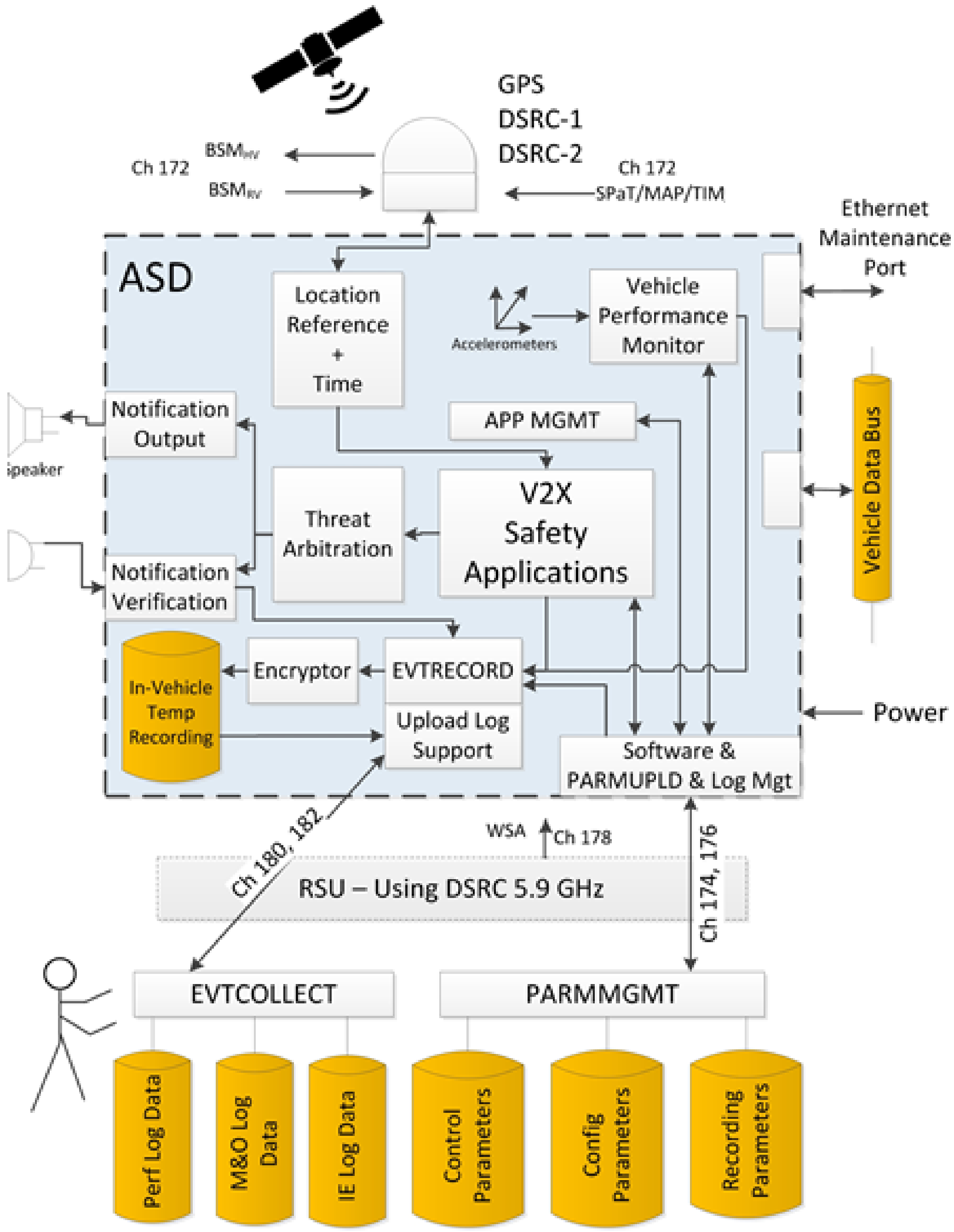


Source: NYCDOT, 2016

Figure 41. ASD Context Diagram

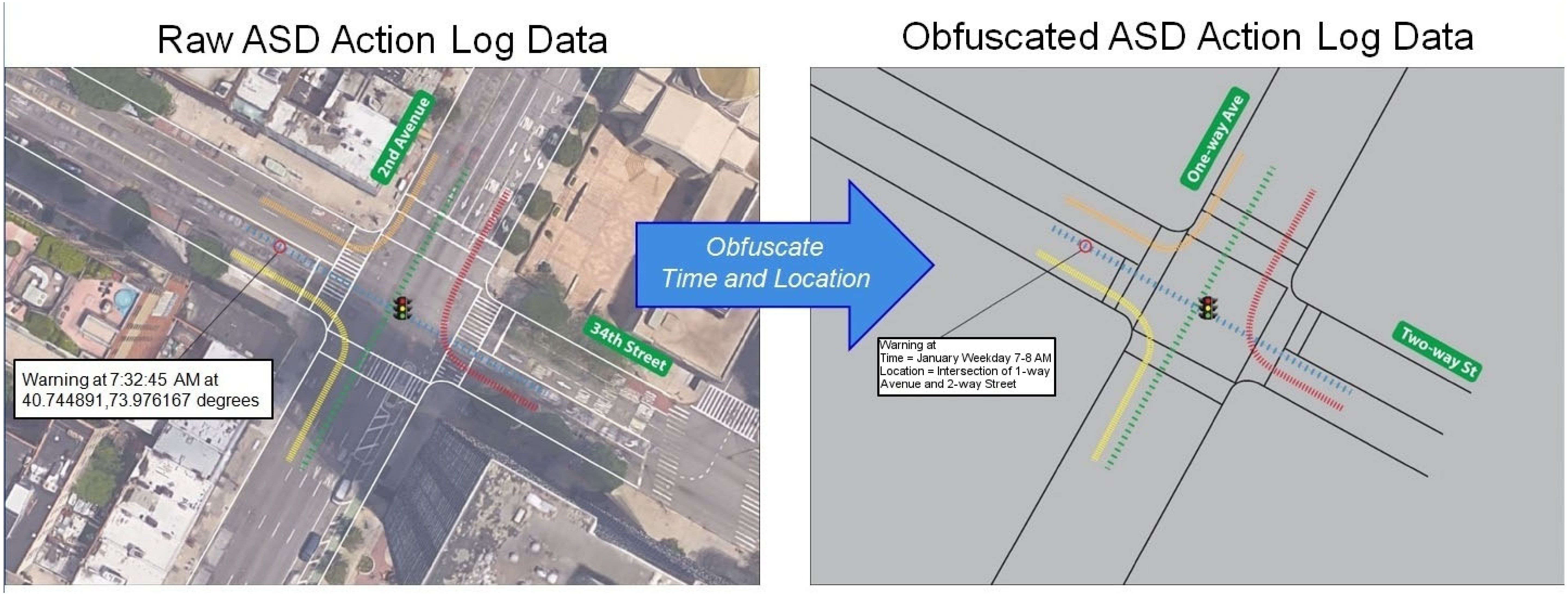
The ASDs will transmit the recorded event data to designated RSUs as the vehicle passes by them. This process is highlighted in Figure 42 below. As it collects event logs based on warnings from the V2V and V2I safety applications, it will upload them to the Event Collect (EVTCOLLECT) function in the designated RSUs via DSRC channels 180 and 182. This exchange will occur as the ASDs enter the range of a particular RSU and receive the WAVE Service Advertisement (WSA) message from the RSU via DSRC channel 178 at 5.9 GHz. For tuning the safety applications to the NYC traffic environment, the control, configuration, and recording parameters will be downloaded from the Parameter Management (PARMMGMT) application to the ASD via DSRC channels 174 and 176.

As the RSU collects the event record data from the ASDs, it will transmit the data to NYCDOT TMC's back-office performance monitoring data processing center, where it will undergo post-processing and obfuscation to eliminate PII and time and location breadcrumb information. Figure 43 exemplifies an intersection location after the data has been aggregated, purged, and obfuscated. Instead of a specific time, the processed information will state the type of day (i.e. weekday or weekend) and time range. Likewise, the location will only reveal the type of street (i.e. one-way or two-way, avenue or street) to prevent the ability to trace back to the exact location. After the data obfuscation process is complete, the data may be submitted to the USDOT for further evaluation (see Figure 37 for the functional architecture).



Source: NYCDOT, 2016

Figure 42. Event Data Logging and Uploading from ASD to RSU



Source: NYCDOT, 2016

Figure 43. Time and Location Event Log Data Obfuscation Process

References

Table 30 lists the references used to develop the concepts in this document. As some of the base standards referred to in the list are currently evolving, their identifiers have been temporarily highlighted to indicate that the version may change.

Table 30. References

#	Document (Title, source, version, date, location)
1	*Connected Vehicle Reference Implementation Architecture Website*, US Department of Transportation, Office of the Assistant Secretary of Transportation for Research and Technology. https://www.iteris.com/cvria
2	42010-2011 - ISO/IEC/IEEE Systems and software engineering - Architecture description http://standards.ieee.org/findstds/standard/42010-2011.html
3	Galgano, S., Talas, M., Benevelli, D., Rausch, R., Sim, S., Opie, K., Jensen, M., Stanley, C., Connected Vehicle Pilot Deployment Program Phase 1, Concept of Operations (ConOps) - New York City, April 8, 2016 FHWA-JPO-16-299.
4	Galgano, S., Talas, M., Benevelli, D., Rausch, R., Sim, S., Opie, K., Jensen, M., Stanley, C., Stephens, D., Pape, D., Connected Vehicle Pilot Deployment Program Phase 1, System Requirements Specification (SyRS) - New York City, July 26, 2016 FHWA-JPO-16-303.
5	*SAE J2735 - Dedicated Short Range Communications (DSRC) Message Set Dictionary™*, SAE International, March 30, 2016 http://standards.sae.org/j2735_201603/
6	*SAE J2945/1_201603 - On-Board System Requirements for V2V Safety Communications*, SAE International, March 30, 2016 http://standards.sae.org/j2945/1_201603/

APPENDIX A. Definitions, Acronyms, and Abbreviations

Table 31 defines selected project-specific acronyms used throughout this System Architecture Document.

Table 31. Acronym List

Acronym / Abbreviation	Definition
ACDSS	Adaptive Control Decision Support System
AO	Agreement Officer
AOR	Agreement Officer Representative
ASD	Aftermarket Safety Devices
ASN.1	Abstract Syntax Notation One
ASTC	Advanced Solid-state Traffic Controller
ATC	Advanced Traffic Controller
ATR	Automatic Traffic Recorder
BSM	Basic Safety Message
CAN	Controller Area Network
C2F	Center to Field
CAMP	Crash Avoidance Metrics Partnership
CCMS	Cooperative ITS Credentials Management System
CDS	Connected Data Systems
COC	Certification Operating Council
ConOps	Concept of Operations
CV	Connected Vehicle
CVPD	Connected Vehicle Pilot Deployment
CVRIA	Connected Vehicle Reference Implementation Architecture
DATEX	Data Exchange
DDS	Data Distribution System
DOW	Day of the Week
DSNY	City of New York Department of Sanitation
DSRC	Dedicated Short Range Communications
F2F	Field to Field
FHWA	Federal Highway Administration
FOIA	Freedom of Information Act
I2V	Infrasturcture-to-Vehicle
IE	Independent Evaluator
IEC	International Electrotechnical Commission

Acronym / Abbreviation	Definition
IETF	Internet Engineering Task Force
IRB	Institutional Review Board
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
JSON	JavaScript Object Notation
LFC	Line Frequency Clock
LTS	Location and Time Service
MAP	Map Data Message
MiM	Midtown-in-Motion
MTA	Metropolitan Transportation Authority
NMEA	National Marine Electronics Association
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
NTP	Network Time Protocol
NYC	New York City
NYC DoITT	New York City Department of Information Technology and Telecommunications
NYCDOT	New York City Department of Transportation
NYCWiN	New York City Wireless Network
O&M	Operation and Maintenance
OBE	On-Board Equipment
OBU	On-Board Unit
ODE	Operational Data Environment
OEM	Office of Emergency Management
OER	Office of Emergency Response
OFM	Office of Freight Mobility
OTA	Over-the-Air
PASS	Pedestrians for Accessible and Safe Streets
PDM	Probe Data Management
PED	Pedestrian
PID	Personal Information Device
PII	Personally Identifiable Information
PVD	Probe Vehicle Data
RDE	Research Data Exchange
RFID	Radio Frequency Identification
RFQ	Request for Quote
RSE	Roadside Equipment

Acronym / Abbreviation	Definition
RSU	Roadside Unit
RTOR	Right Turn On Red
SAD	Systems Architecture Document
SAE	Society of Automotive Engineers International
SCMS	Security Credential Management System
SET-IT	Systems Engineering Tool for Intelligent Transportation
SMTP	Simple Mail Transfer Protocol
SNMP	Simple Network Management Protocol
SPaT	Signal Phase and Timing
SyRS	System Requirements Specification
TCS	Traffic Control System
THEA	Tampa-Hillsborough Expressway Authority
TIM	Traveler Information Message
TMC	Traffic Management Center
TOD	Time of Day
TTI	Texas Transportation Institute
UDP	User Datagram Protocol
USDOT	United States Department of Transportation
UTRC	University Transportation Research Center
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
VMS	Variable Message Sign
W3C	World Wide Web Consortium
WAW	Wide Area Wireless
WSMP	Wave Short Message Protocol
WWW	World Wide Web
XML	Extensible Markup Language

APPENDIX B. Merged Information Flow Triples

Table 32 presents the revised merged triples table. The triples are categorized as either 'Unchanged', 'Revised', or 'New' to indicate the updates to their flow names. Some of the elements such as NYC Traffic Management Center has been corrected to NYCDOT TMC, while the flow name has remained the same. If only the source or destination element has changed instead of the flow name, the triple is marked as 'Unchanged' with a note on the name change. 'Revised' indicates a change in the flow name compared to the merged triples spreadsheet from the THEA technical roundtable. New triples have been generated after adding the RLVW and OVC applications to the physical architecture and identifying any missing triples to the existing system architecture.

Table 32. Revised Merged Information Flow Triples for the NYC CVPD System

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Bus ASD	Remote Vehicle OBEs (all types)	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Pedestrian in Signalized Crosswalk (PEDINXWALK)	vehicle location and motion	Bus ASD	RSU	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Commercial Vehicle ASD	Remote Vehicle OBEs (all types)	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Pedestrian in Signalized Crosswalk (PEDINXWALK)	vehicle location and motion	Commercial Vehicle ASD	RSU	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Light Duty Vehicle ASD	Remote Vehicle OBEs (all types)	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Pedestrian in Signalized Crosswalk (PEDINXWALK)	vehicle location and motion	Light Duty Vehicle ASD	RSU	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Remote Vehicle OBEs (all types)	Bus ASD	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Remote Vehicle OBEs (all types)	Commercial Vehicle ASD	Unchanged	
1	1	4	10004	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	V2V Applications	vehicle location and motion	Remote Vehicle OBEs (all types)	Light Duty Vehicle ASD	Unchanged	
1	2	6	10006	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle location and motion for surveillance	Bus ASD	RSU	Unchanged	
1	2	6	10006	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle location and motion for surveillance	Commercial Vehicle ASD	RSU	Unchanged	
1	2	6	10006	yes	yes	yes	yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735 DE definitions	SAE J2945/1	Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle location and motion for surveillance	Light Duty Vehicle ASD	RSU	Unchanged	
1	7	10	10010	yes	yes		yes				Location and Time	location correction	RSU	Bus ASD	Unchanged	
1	7	10	10010	yes	yes		yes				Location and Time	location correction	RSU	Commercial Vehicle ASD	Unchanged	
1	7	10	10010	yes	yes		yes				Location and Time	location correction	RSU	Light Duty Vehicle ASD	Unchanged	
1	8	11	10011	yes	yes		yes				Mobile Accessible Pedestrian Signal System (PED-SIG)	pedestrian crossing status	Signal Controller	RSU	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Bus ASD	Remote Vehicle OBEs (all types)	Unchanged	
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Commercial Vehicle ASD	Remote Vehicle OBEs (all types)	Unchanged	
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Light Duty Vehicle ASD	Remote Vehicle OBEs (all types)	Unchanged	
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Remote Vehicle OBEs (all types)	Bus ASD	Unchanged	
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Remote Vehicle OBEs (all types)	Commercial Vehicle ASD	Unchanged	
2	10	5	10005	yes	yes		yes	SAE J2735: BSM format; SAE J2945/1	SAE J2735: VehicleEventFlags	SAE J2945/1	V2V Applications	vehicle control event	Remote Vehicle OBEs (all types)	Light Duty Vehicle ASD	Unchanged	
2	11	38	10038	yes		yes	yes				"Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations"	vehicle situation data parameters	RSU	Bus ASD	Unchanged	
2	11	38	10038	yes		yes	yes				"Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations"	vehicle situation data parameters	RSU	Commercial Vehicle ASD	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	11	38	10038	yes		yes	yes				"Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations"	vehicle situation data parameters	RSU	Light Duty Vehicle ASD	Unchanged	
2	12	27	10027	yes	yes		yes	SAE J2735: SPAT	SAE J2735: SPAT		"Pedestrian in Signalized Crosswalk (PEDINXWALK); Intelligent Traffic Signal System (I-SIG)"	intersection status	RSU	Bus ASD	Unchanged	
2	12	27	10027	yes	yes		yes	SAE J2735: SPAT	SAE J2735: SPAT		"Pedestrian in Signalized Crosswalk (PEDINXWALK); Intelligent Traffic Signal System (I-SIG)"	intersection status	RSU	Commercial Vehicle ASD	Unchanged	
2	12	27	10027	yes	yes		yes	SAE J2735: SPAT	SAE J2735: SPAT		"Pedestrian in Signalized Crosswalk (PEDINXWALK); Intelligent Traffic Signal System (I-SIG)"	intersection status	RSU	Light Duty Vehicle ASD	Unchanged	
2	12	27	10027	yes	yes		yes	SAE J2735: SPAT	SAE J2735: SPAT		Mobile Accessible Pedestrian Signal System (PED-SIG)	intersection status	RSU	PID	Revised	Revised 'Personal Information Device' to 'PID'
2	13	16	10016	yes			yes	SAE J2735: TIM			EVAC Distribution	emergency traveler information	NYCDOT Office of Emergency Response (OER)	NYCDOT TMC	Revised	Revised 'NYC OER' to 'NYCDOT Office of Emergency Response (OER)' and 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	14	17	10017	yes			yes	SAE J2735: TIM			EVAC Distribution	emergency traveler information	RSU	Bus ASD	Unchanged	
2	14	17	10017	yes			yes	SAE J2735: TIM			EVAC Distribution	emergency traveler information	RSU	Commercial Vehicle ASD	Unchanged	
2	14	17	10017	yes			yes	SAE J2735: TIM			EVAC Distribution	emergency traveler information	RSU	Light Duty Vehicle ASD	Unchanged	
2	14	24	10024	yes	yes		yes	SAE J2735: SPaT			Pedestrian in Signalized Crosswalk (PEDINXWALK)	intersection safety warning	RSU	Bus ASD	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	14	24	10024	yes	yes		yes	SAE J2735: SPaT			Pedestrian in Signalized Crosswalk (PEDINXWALK)	intersection safety warning	RSU	Commercial Vehicle ASD	Unchanged	
2	14	24	10024	yes	yes		yes	SAE J2735: SPaT			Pedestrian in Signalized Crosswalk (PEDINXWALK)	intersection safety warning	RSU	Light Duty Vehicle ASD	Unchanged	
2	14	24	10024	yes		yes	yes	SAE J2735: TIM			Speed Compliance Applications	lane closure information	RSU	Bus ASD	Unchanged	
2	14	24	10024	yes		yes	yes	SAE J2735: TIM			Speed Compliance Applications	lane closure information	RSU	Commercial Vehicle ASD	Unchanged	
2	14	24	10024	yes		yes	yes	SAE J2735: TIM			Speed Compliance Applications	lane closure information	RSU	Light Duty Vehicle ASD	Unchanged	
2	15	15	10015	yes	yes		yes				Core Authorization	device identification	Bus ASD	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	15	15	10015	yes	yes		yes				Core Authorization	device identification	Commercial Vehicle ASD	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	15	15	10015	yes	yes		yes				Core Authorization	device identification	PID	NYCDOT TMC	Revised	Revised 'Personal Information Device' to 'PID' and 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	15	15	10015	yes	yes		yes				Core Authorization	device identification	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	16	18	10018	yes	yes	yes	yes				Infrastructure Management	equipment configuration settings	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	17	19	10019	yes	yes	yes	yes				Infrastructure Management	equipment control commands	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	18	20	10020	yes	yes	yes	yes				Infrastructure Management	equipment status	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	19	21	10021	yes	yes	yes	yes				Infrastructure Management	equipment status	RSU	Service Monitor	Unchanged	
2	20	22	10022	yes	yes	yes	yes				Speed Compliance Applications; Location and Time	host commercial vehicle status	Commercial Vehicle databus	Commercial Vehicle ASD	Unchanged	
2	20	22	10022	yes	yes	yes	yes				V2V Applications; Speed Compliance Applications; Location and Time	host transit vehicle status	Transit Vehicle Databus	Bus ASD	Unchanged	
2	20	22	10022	yes	yes	yes	yes				Oversize Vehicle Compliance; Vehicle Data for Traffic Operations	host vehicle status	Commercial Vehicle databus	Commercial Vehicle ASD	Unchanged	
2	20	22	10022	yes	yes	yes	yes				Intelligent Traffic Signal System (I-SIG); Location and Time; Pedestrian in Signalized Crosswalk (PEDINXWALK); Speed Compliance Applications; Vehicle Data for Traffic Operations	host vehicle status	Light Duty Vehicle databus	Light Duty Vehicle ASD	Unchanged	
2	20	22	10022	yes	yes	yes	yes				Vehicle Data for Traffic Operations	host vehicle status	Transit Vehicle Databus	Bus ASD	Unchanged	
2	21	26	10026		yes	yes					Intelligent Traffic Signal System (I	intersection management application info	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	21	26	10026		yes	yes					Intelligent Traffic Signal System (I	intersection management application status	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	21	26	10026		yes	yes					Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection safety application info	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	21	26	10026		yes	yes					Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection safety application status	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	23	32	10032		yes	yes					Mobile Accessible Pedestrian Signal System (PED-SIG)	personal location	PID	NYU	Revised	Revised 'Personal Information Device' to 'PID'
2	21	30	10030		yes		yes				Vehicle Data for Traffic Operations	situation data collection parameters	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	21	30	10030		yes		yes				Speed Compliance Applications	speed management application information	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	26	33	10033	yes			yes				Speed Compliance Applications	speed management information	RSU	Bus ASD	Unchanged	
2	26	33	10033	yes			yes				Speed Compliance Applications	speed management information	RSU	Commercial Vehicle ASD	Unchanged	
2	26	33	10033	yes			yes				Speed Compliance Applications	speed management information	RSU	Light Duty Vehicle ASD	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2	22	31	10031	yes			yes				Location and Time	time	LTS	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	22	31	10031	yes			yes				Location and Time	time	LTS	Service Monitor	Unchanged	
2	22	31	10031	yes			yes				Location and Time	time for ASTC	RSU	Signal Controller	Unchanged	
2	21	30	10030	yes		yes	yes				Vehicle Data for Traffic Operations	traffic monitoring application info	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	21	30	10030	yes		yes	yes				Vehicle Data for Traffic Operations	traffic monitoring application status	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	27	35	10035	yes	yes	yes	yes				Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	traffic situation data	RSU	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	21	30	10030	yes		yes	yes				EVAC Distribution	traveler information application info	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
2	28	36	10036	yes	yes		yes				Core Authorization	user permission sets	ASD, PID, RSU Vendors	USDOT Prototype SCMS	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
4	126	13001	13001	yes			yes				Infrastructure Management	application install/upgrade	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
4	34	13002	13002	yes			yes				Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications; V2V Applications	driver updates	Bus ASD	Bus Driver	Unchanged	
4	35	13002	13002	yes			yes				Oversize Vehicle Compliance (OVC); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications; V2V Applications	driver updates	Commercial Vehicle ASD	Truck Driver	Unchanged	
4	36	13002	13002	yes			yes				Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications; V2V Applications	driver updates	Light Duty Vehicle ASD	Light Duty Vehicle Driver	Unchanged	
4	50	13003	13003	yes	yes		yes				Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection control status	Signal Controller	RSU	Unchanged	
4	52	13005	13005	yes	yes	yes	yes				Infrastructure Management	system monitoring	RSU	Service Monitor	Unchanged	
4	53	13006	13006	yes		yes	yes				Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle situation data	Bus ASD	RSU	Unchanged	
4	53	13006	13006	yes		yes	yes				Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle situation data	Commercial Vehicle ASD	RSU	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
4	53	13006	13006	yes		yes	yes				Intelligent Traffic Signal System (I-SIG); Vehicle Data for Traffic Operations	vehicle situation data	Light Duty Vehicle ASD	RSU	Unchanged	
5	124	13007	13007	yes			yes	SAE J2735: SPAT	SAE J2735: SPAT		Mobile Accessible Pedestrian Signal System (PED-SIG)	crossing status	RSU	PID	Revised	Added 'SAE J2735: SPAT' under Data column. Revised 'Personal Information Device' to 'PID'.
5	72	13009	13009	yes			yes				Performance Monitoring	MTA bus GPS travel time data	MTA Bus Data Archive	Performance Monitor	Unchanged	
5	73	13010	13010	yes			yes				Performance Monitoring	obfuscated data sets	Performance Monitor	TTI (USDOT IE)	Revised	Revised 'USDOT Independent Evaluator' to 'TTI (USDOT IE)'
5	75	13014	13014	yes			yes				Mobile Accessible Pedestrian Signal System (PED-SIG)	personal input	Visually-Impaired Pedestrian	PID	Revised	Revised 'Pedestrian' to 'Visually-Impaired Pedestrian' and 'Personal Information Device' to 'PID'.
5	77	13015	13015	yes			yes				Mobile Accessible Pedestrian Signal System (PED-SIG)	personal updates	PID	Visually-Impaired Pedestrian	Revised	Revised 'Personal Information Device' to 'PID' and 'Pedestrian' to 'Visually-Impaired Pedestrian'
5	83	13017	13017	yes			yes				Speed Compliance Applications	reduced speed warning info	NYCDOT TMC	RSU	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
5	89	13018	13018	yes			yes				Intelligent Traffic Signal System (I-SIG)	signal control device configuration	NYCDOT TMC	Signal Controller	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
5	90	13019	13019	yes			yes				Intelligent Traffic Signal System (I-SIG)	signal system configuration	NYCDOT TMC	Signal Controller	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
5	92	13020	13020	yes			yes				Intelligent Traffic Signal System (I-SIG); Red Light Violation Warning (RLVW)	traffic sensor control	NYCDOT TMC	Signal Controller	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
5	94	13022	13022	yes			yes				Performance Monitoring	travel time records	RFID Readers	Performance Monitor	Unchanged	
5	98	13023	13023	yes			yes				Performance Monitoring	volume counts	Count Stations	Performance Monitor	Unchanged	
6	108	13024	13024	yes			yes				Location and Time	location and time	Bus GPS	Bus ASD	Unchanged	
6	109	13024	13024	yes			yes				Location and Time	location and time	Commercial Vehicle GPS	Commercial Vehicle ASD	Unchanged	
6	110	13024	13024	yes			yes				Location and Time	location and time	Field GPS	RSU	Unchanged	
6	111	13024	13024	yes			yes				Location and Time	location and time	Light Duty Vehicle GPS	Light Duty Vehicle ASD	Unchanged	
6	122	13026	13026	yes			yes				Pedestrian in Signalized Crosswalk (PEDINXWALK)	pedestrian presence status	Signal Controller	RSU	Revised	Revised 'ped presence status' to 'pedestrian presence status'
6	123	13025	13025	yes			yes				Mobile Accessible Pedestrian Signal System (PED-SIG)	pedestrian presence	Visually-Impaired Pedestrian	Pedestrian Detector	Revised	Revised 'Pedestrian' to 'Visually-Impaired Pedestrian'
6	112	13027	13027	yes			yes				Intelligent Traffic Signal System (I-SIG); Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	signal control commands	NYCDOT TMC	Signal Controller	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
6	114	13028	13028	yes			yes				Intelligent Traffic Signal System (I-SIG)	signal control plans	NYCDOT TMC	Signal Controller	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
6	116	13029	13029	yes			yes				Intelligent Traffic Signal System (I-SIG); Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	signal control status	Signal Controller	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
6	117	13030	13030	yes			yes				Intelligent Traffic Signal System (I-SIG); Red Light Violation Warning (RLVW); Speed Compliance Applications	traffic flow	Signal Controller	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	Bus ASD	USDOT Prototype SCMS	Unchanged	
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	Commercial Vehicle ASD	USDOT Prototype SCMS	Unchanged	
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	Light Duty Vehicle ASD	USDOT Prototype SCMS	Unchanged	
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	NYCDOT TMC	USDOT Prototype SCMS	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	PID	USDOT Prototype SCMS	Revised	Revised 'Personal Information Device' to 'PID'
1	118	1	10001	yes	yes	yes	no				USDOT SCMS	device enrollment information	RSU	USDOT Prototype SCMS	Unchanged	
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	Bus ASD	Unchanged	
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	Commercial Vehicle ASD	Unchanged	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	Light Duty Vehicle ASD	Unchanged	
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	PID	Revised	Revised 'Personal Information Device' to 'PID'
1	119	3	10003	yes	yes	yes	no				USDOT SCMS	security credentials	USDOT Prototype SCMS	RSU	Unchanged	
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	Bus ASD	Unchanged	
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	Commercial Vehicle ASD	Unchanged	
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	Light Duty Vehicle ASD	Unchanged	
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	NYCDOT TMC	Revised	Revised 'NYC Traffic Management Center' to 'NYCDOT TMC'
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	PID	Revised	Revised 'Personal Information Device' to 'PID'
1	120	2	10002	yes	yes	yes	no				USDOT SCMS	security policy and networking information	USDOT Prototype SCMS	RSU	Unchanged	
5		13008	13008	yes				SAE J2735: TIM			Oversize Vehicle Compliance (OVC)	current infrastructure restrictions	NYCDOT Office of Freight Mobility (OFM)	NYCDOT TMC	New	
2	15	15	10015	yes	yes						Core Authorization	device identification	Light Duty Vehicle ASD	NYCDOT TMC	New	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
2		23	10023	yes		yes		SAE J2735: TIM			Oversize Vehicle Compliance (OVC)	infrastructure restriction warning info	NYCDOT TMC	RSU	New	
2		24	10024	yes	yes	yes		SAE J2735: TIM			Oversize Vehicle Compliance (OVC)	infrastructure restriction warning notification	RSU	Commercial Vehicle ASD	New	
1		8	10008	yes	yes			SAE J2735: MAP	SAE J2735: MAP		Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection geometry	NYCDOT TMC	RSU	New	
1		8	10008	yes	yes			SAE J2735: MAP	SAE J2735: MAP		Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection geometry	RSU	Bus ASD	New	
1		8	10008	yes	yes			SAE J2735: MAP	SAE J2735: MAP		Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection geometry	RSU	Commercial Vehicle ASD	New	
1		8	10008	yes	yes			SAE J2735: MAP	SAE J2735: MAP		Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW)	intersection geometry	RSU	Light Duty Vehicle ASD	New	
1		8	10008	yes	yes			SAE J2735: MAP	SAE J2735: MAP		Mobile Accessible Pedestrian Signal System (PED-SIG)	intersection geometry	RSU	PID	New	
5		13010	13010	yes							Performance Monitoring	obfuscated data sets	Performance Monitor	USDOT Research Data Exchange (RDE)	New	
4		13004	13004	yes							Infrastructure Management	operation and maintenance ASD data	Bus ASD	RSU	New	
4		13004	13004	yes							Infrastructure Management	operation and maintenance ASD data	Commercial Vehicle ASD	RSU	New	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
4		13004	13004	yes							Infrastructure Management	operation and maintenance ASD data	Light Duty Vehicle ASD	RSU	New	
4		13004	13004	yes							Performance Monitoring	operation and maintenance ASD data	NYCDOT TMC	Performance Monitor	New	
4		13004	13004	yes							Performance Monitoring	operation and maintenance RSU data	NYCDOT TMC	Performance Monitor	New	
4		13004	13004	yes							Infrastructure Management	operation and maintenance RSU data	RSU	NYCDOT TMC	New	
5		13011	13011	yes							Mobile Accessible Pedestrian Signal System (PED-SIG); Pedestrian in Signalized Crosswalk (PEDINXWALK)	pedestrian detection data	Pedestrian Detector	Signal Controller	New	
5		13012	13012	yes							Mobile Accessible Pedestrian Signal System (PED-SIG)	pedestrian performance data	PID	NYU (NYCDOT IRB)	New	
5		13013	13013	yes							Pedestrian in Signalized Crosswalk (PEDINXWALK)	pedestrian presence	Unequipped Pedestrian	Pedestrian Detector	New	
5		13016	13016	yes							Performance Monitoring	PID operational status	NYU (NYCDOT IRB)	Performance Monitor	New	
1		13	10013	yes				SAE J2735: TIM			Mobile Accessible Pedestrian Signal System (PED-SIG); Oversize Vehicle Compliance (OVC); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications	restricted lanes parameters	NYCDOT TMC	RSU	New	

Cat	Old ID	Proposed New DocumentID	Proposed New InstanceID	NYC	TMP	WYO	CV Pilot responsible?	MSG	Data	Dialog	NYC Physical Architecture Diagram	Flow Name	Source Element	Destination Element	Status Since THEA Tech Roundtable	NYC CVPD Team's Revision Notes
1		13	10013	yes				SAE J2735: TIM			Mobile Accessible Pedestrian Signal System (PED-SIG); Oversize Vehicle Compliance (OVC); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications	restricted lanes parameters	RSU	Bus ASD	New	
1		13	10013	yes				SAE J2735: TIM			Mobile Accessible Pedestrian Signal System (PED-SIG); Oversize Vehicle Compliance (OVC); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications	restricted lanes parameters	RSU	Commercial Vehicle ASD	New	
1		13	10013	yes				SAE J2735: TIM			Mobile Accessible Pedestrian Signal System (PED-SIG); Oversize Vehicle Compliance (OVC); Pedestrian in Signalized Crosswalk (PEDINXWALK); Red Light Violation Warning (RLVW); Speed Compliance Applications	restricted lanes parameters	RSU	Light Duty Vehicle ASD	New	
1		14	10014	yes							Speed Compliance Applications	speed compliance parameters	RSU	Bus ASD	New	
1		14	10014	yes							Speed Compliance Applications	speed compliance parameters	RSU	Commercial Vehicle ASD	New	
1		14	10014	yes							Speed Compliance Applications	speed compliance parameters	RSU	Light Duty Vehicle ASD	New	
				yes							USDOT SCMS	device revocation request	NYCDOT TMC	USDOT Production SCMS	New	

APPENDIX C. Basic Safety Message (BSM)

Table 33 lists NYC CVPD BSM message set for achieving interoperability with the other two CV pilot sites based on the SAE J2735 (2016-03) or J2945/1 (2016-03) standards. If applicable, the data field may be associated with its corresponding requirement reference in either SAE standard.

Table 33. BSM Message Set for NYC CVPD System

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
R	BasicSafetyMessage	MSG_BasicSafetyMessage			J2945/1[6.3.1-V2V-BSMTX-BSMCONT-002]
	Part I, Sent at all times with each message				
R	coreData	BSMcoreData			J2945/1[6.1.6-V2V-STD-J2735-007]
R	msgCnt	MsgCount		INTEGER (0..127)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	id	TemporaryID		OCTET STRING (SIZE (4))	J2945/1[6.1.6-V2V-STD-J2735-007]
R	secMark	Dsecond		INTEGER (0..65535)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	lat	Latitude		INTEGER (-900000000..900000001)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	long	Longitude		INTEGER (-1799999999..1800000001)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	elev	Elevation		INTEGER (-4906..61439)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	accuracy	PositionalAccuracy			J2945/1[6.1.6-V2V-STD-J2735-007]
R	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	transmission	TransmissionState		ENUMERATED (0..7)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	speed	Speed		INTEGER (0..8191)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	heading	Heading		INTEGER (0..28800)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	angle	SteeringWheelAngle		INTEGER (-126..127)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	accelSet	AccelerationSet4Way			J2945/1[6.1.6-V2V-STD-J2735-007]

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
R	long	Acceleration		INTEGER (-2000..2001)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	lat	Acceleration		INTEGER (-2000..2001)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	vert	VerticalAcceleration		INTEGER (-127..127)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	yaw	YawRate		INTEGER (-32767..32767)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	brakes	BrakeSystemStatus			J2945/1[6.1.6-V2V-STD-J2735-007]
R	wheelBrakes	BrakeAppliedStatus		BIT STRING (SIZE (5))	J2945/1[6.1.6-V2V-STD-J2735-007]
R	traction	TractionControlStatus		ENUMERATED (0..3)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	abs	AntiLockBrakeStatus		ENUMERATED (0..3)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	scs	StabilityControlStatus		ENUMERATED (0..3)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	brakeBoost	BrakeBoostApplied		ENUMERATED (0..2)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	auxBrakes	AuxiliaryBrakeStatus		ENUMERATED (0..3)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	size	VehicleSize			J2945/1[6.1.6-V2V-STD-J2735-007]
R	width	VehicleWidth		INTEGER (0..1023)	J2945/1[6.1.6-V2V-STD-J2735-007]
R	length	VehicleLength		INTEGER (0..4095)	J2945/1[6.1.6-V2V-STD-J2735-007]
	Part II Content				
R	partII	PartIIcontent {{ BSMpartIIExtension }}	OPTIONAL SEQUENCE (SIZE (1..8))		J2735
R	partII-Id	PartII-Id		INTEGER (0..63)	J2735
R	partII-Value	BSMpartIIExtension	IDENTIFIED BY partII-Id		J2945/1[6.1.6-V2V-STD-J2735-004
R	vehicleSafetyExtensions	VehicleSafetyExtensions	IDENTIFIED BY partII-Id = vehicleSafetyExt		J2945/1[6.3.1-V2V-BSMTX-BSMCONT-003]
R	events	VehicleEventFlags	OPTIONAL	BIT STRING (SIZE (13, …))	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-006]
R	pathHistory	PathHistory	OPTIONAL		J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]
N	initialPosition	FullPositionVector	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
N	utcTime	DDateTime	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	year	DYear		INTEGER (0..4095)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	month	DMonth		INTEGER (0..12)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	day	DDay		INTEGER (0..31)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	hour	DHour		INTEGER (0..31)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	minute	DMinute		INTEGER (0..60)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	second	DSecond		INTEGER (0..65535)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	offset	DOffset		INTEGER (-840..840)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	long	Longitude		INTEGER (-1799999999..1800000001)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	lat	Latitude		INTEGER (-900000000..900000001)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	elevation	Elevation	OPTIONAL	INTEGER (-4906..61439)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	speed	TransmissionAndSpeed	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	transmission	TransmissionState		ENUMERATED (0..7)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	speed	Velocity		INTEGER (0..8191)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	posAccuracy	PositionalAccuracy	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	timeConfidence	TimeConfidence	OPTIONAL	ENUMERATED (0..39)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	posConfidence	PositionConfidenceSet			J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	pos	PositionConfidence		ENUMERATED (0..15)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
N	elevation	ElevationConfidence		ENUMERATED (0..15)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	speedConfidence	SpeedandHeadingandThrottleConfidence	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	heading	HeadingConfidence		ENUMERATED (0..7)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	speed	SpeedConfidence		ENUMERATED (0..7)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	throttle	ThrottleConfidence		ENUMERATED (0..3)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	currGNSSstatus	GNSSStatus	OPTIONAL	BIT STRING (SIZE (8))	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
R	crumbData	PathHistoryPointList	SEQUENCE (SIZE (1..23))		J2945/1[6.3.6-V2V-BSMTX-DATAACC-036]
R	crumbData[n]	PathHistoryPoint			J2945/1[6.3.6-V2V-BSMTX-DATAACC-039]
R	latOffset	OffsetLL-B18		INTEGER (-131072..131071)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]
R	lonOffset	OffsetLL-B18		INTEGER (-131072..131071)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]
R	elevationOffset	VertOffset-B12		INTEGER (-2048..2047)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]
R	timeOffset	TimeOffset		INTEGER (1..65535)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-037]
N	speed	Speed	OPTIONAL	INTEGER (0..8191)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	posAccuracy	PositionalAccuracy	OPTIONAL		J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	semiMajor	SemiMajorAxisAccuracy		INTEGER (0..255)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	semiMinor	SemiMinorAxisAccuracy		INTEGER (0..255)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	orienation	SemiMajorAxisOrientation		INTEGER (0..65535)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
N	heading	CoarseHeading	OPTIONAL	INTEGER (0..240)	J2945/1[6.3.6-V2V-BSMTX-DATAACC-038]
R	pathPrediction	PathPrediction	OPTIONAL		J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]
R	radiusOfCurve	RadiusOfCurvature		INTEGER (-32767..32767)	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]
R	confidence	Confidence		INTEGER (0..200)	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-004]

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
R	lights	ExteriorLights	OPTIONAL	BIT STRING (SIZE (9, …))	J2945/1[6.3.1-V2V-BSMTX-BSMCONT-005]
N	specialVehicleExtensions		IDENTIFIED BY partII-Id = specialVehicleExt		
N	vehicleAlerts	EmergencyDetails	OPTIONAL		
N	sspRights	SSPindex		INTEGER (0..31)	
N	sirenUse	SirenInUse		ENUMERATED (0..3)	
N	lightsUse	LightbarInUse		ENUMERATED (0..7)	
N	multi	MultiVehicleResponse		ENUMERATED (0..3)	
N	events	PrivilegedEvents	OPTIONAL		
N	sspRights	SSPindex		INTEGER (0..31)	
N	event	PrivilegedEventFlags		BIT STRING (SIZE (16))	
N	responseType	ResponseType	OPTIONAL	ENUMERATED (0..6)	
N	trailers	TrailerData	OPTIONAL		
N	sspRights	SSPindex		INTEGER (0..31)	
N	connection	PivotPointDescription			
N	pivotOffset	Offset-B11		INTEGER (-1024..1023)	
N	pivotAngle	Angle		INTEGER (0..28800)	
N	pivots	PivotingAllowed		BOOLEAN	
N	units	TrailerUnitDescriptionList	SEQUENCE (SIZE(1..8))		
N	units[n]	TrailerUnitDescription			
N	isDolly	IsDolly		BOOLEAN	
N	width	VehicleWidth		INTEGER (0..1023)	
N	length	VehicleLength		INTEGER (0..4095)	
N	height	VehicleHeight	OPTIONAL	INTEGER (0..127)	See height on Row 144 for NYC needs
N	mass	TrailerMass	OPTIONAL	INTEGER (0..255)	
N	frontPivot	PivotPointDescription			
N	pivotOffset	Offset-B11		INTEGER (-1024..1023)	
N	pivotAngle	Angle		INTEGER (0..28800)	
N	pivots	PivotingAllowed		BOOLEAN	
N	rearPivot	PivotPointDescription	OPTIONAL		
N	pivotOffset	Offset-B11		INTEGER (-1024..1023)	
N	pivotAngle	Angle		INTEGER (0..28800)	
N	pivots	PivotingAllowed		BOOLEAN	
N	rearWheelOffset	Offset-B12	OPTIONAL	INTEGER (-2048..2047)	
N	positionOffset	Node-XY-24b			
N	x	Offset-B12		INTEGER (-2048..2047)	

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
N	y	Offset-B12		INTEGER (-2048..2047)	
N	elevationOffset	VertOffset-B07	OPTIONAL	INTEGER (-64..63)	
N	crumbData	TrailerHistoryPointList	OPTIONAL SEQUENCE (SIZE (1..23))		
N	crumbData[n]	TrailerHistoryPoint			
N	pivotAngle	Angle		INTEGER (0..28800)	
N	timeOffset	TimeOffset		INTEGER (0..65535)	
N	positionOffset	Node-XY-24b			
N	x	Offset-B12		INTEGER (-2048..2047)	
N	y	Offset-B12		INTEGER (-2048..2047)	
N	elevationOffset	VertOffset-B07	OPTIONAL	INTEGER (-64..63)	
N	heading	CoarseHeading	OPTIONAL	INTEGER (0..240)	
NLDV:R	supplementalVehicleExtensions	SupplementalVehicleExtensions			Note: This DF is not transmitted by light-duty vehicles unless the light-duty vehicle is operating in a special purpose vehicle role at the time of transmission. This DF is transmitted by non-light-duty vehicles (e.g. buses, trucks) and special purpose light-duty vehicles (e.g. taxis).
N	classification	BasicVehicleClass	OPTIONAL	INTEGER (0..255)	
R	classDetails	VehicleClassification	OPTIONAL		Use classDetails
N	keyType	BasicVehicleClass	OPTIONAL	INTEGER (0..255)	
R	role	BasicVehicleRole	OPTIONAL	ENUMERATED (0..22)	Use role to support priority & vehicle privileges. Light-duty vehicles with transit role identify taxi vehicles.
N	iso3883	Iso3883VehicleType	OPTIONAL	INTEGER (0..100)	
R	hpmsType	VehicleType	OPTIONAL	ENUMERATED (0..15)	Use HPMS classes for chassis
N	vehicleType	ITIS.VehicleGroupAffected	OPTIONAL	ENUMERATED (9217..9251)	
N	responseEquip	ITIS.IncidentResponseEquipment	OPTIONAL	ENUMERATED (9985..10113)	
N	responderType	ITIS.ResponderGroupAffected	OPTIONAL	ENUMERATED (9729..9742)	
N	fuelType	FuelType	OPTIONAL	INTEGER (0..15)	
N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	regional[n]	RegionalExtension {{ REGION.Reg-VehicleClassification }}			

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
R	vehicleData	VehicleData	OPTIONAL		OVC Requirement
R	height	VehicleHeight	OPTIONAL	INTEGER (0..127)	OVC Requirement assuming single value per vehicle or combo-unit
N	bumpers	BumperHeights	OPTIONAL		
N	front	BumperHeight		INTEGER (0..127)	
N	rear	BumperHeight		INTEGER (0..127)	
O	mass	VehicleMass	OPTIONAL	INTEGER (0..255)	Optional to conform with WYO
O	trailerWeight	TrailerWeight	OPTIONAL	INTEGER (0..64255)	Optional to conform with WYO
N	weatherReport	WeatherReport	OPTIONAL		
N	isRaining	NTCIP.EssPrecipYesNo		ENUMERATED (0..3)	
N	rainRate	NTCIP.EssPrecipRate	OPTIONAL	INTEGER (0..65535)	
N	precipSituation	NTCIP.EssPrecipSituation	OPTIONAL	ENUMERATED (0..15)	
N	solarRadiation	NTCIP.EssSolarRadiation	OPTIONAL	INTEGER (0..65535)	
N	friction	NTCIP.EssMobileFriction	OPTIONAL	INTEGER (0..101)	
N	roadFriction	CoefficientOfFriction	OPTIONAL	INTEGER (0..50)	
N	weatherProbe	WeatherProbe	OPTIONAL		
N	airTemp	AmbientAirTemperature	OPTIONAL	INTEGER (0..191)	
N	airPressure	AmbientAirPressure	OPTIONAL	INTEGER (0..255)	
N	rainRates	WiperSet	OPTIONAL		
N	statusFront	WiperStatus		ENUMERATED (0..6)	
N	rateFront	WiperRate		INTEGER (0..127)	
N	statusRear	WiperStatus	OPTIONAL	ENUMERATED (0..6)	
N	rateRear	WiperRate	OPTIONAL	INTEGER (0..127)	
N	obstacle	ObstacleDetection	OPTIONAL		
N	obDist	ObstacleDistance		INTEGER (0..32767)	
N	obDirect	ObstacleDirection		INTEGER (0..28800)	
N	description	ITIS.ITIScodes(523..541)	OPTIONAL		
N	locationDetials	ITIS.GenericLocations	OPTIONAL		
N	dateTime	DDateTime			
N	year	DYear		INTEGER (0..4095)	
N	month	DMonth		INTEGER (0..12)	
N	day	DDay		INTEGER (0..31)	
N	hour	DHour		INTEGER (0..31)	
N	minute	DMinute		INTEGER (0..60)	
N	second	DSecond		INTEGER (0..65535)	

NY	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	Comments (Requirement Reference)
N	offset	DOffset		INTEGER (-840..840)	
N	vertEvent	VerticalAccelerationThreshold	OPTIONAL	BIT STRING (SIZE (5))	
N	status	DisabledVehicle	OPTIONAL		
N	statusDetails	ITIS.ITIScodes (523..541)			
N	locationDetails	ITIS.GenericLocations	OPTIONAL		
N	speedProfile	SpeedProfile	OPTIONAL		
N	speedReports	SpeedProfileMeasurementList	SEQUENCE (SIZE (1..20))		
N	speedReports[n]	GrossSpeed		INTEGER (0..31)	
N	theRTCM	RTCMPackage	OPTIONAL		
N	rtcmHeader	RTCMheader	OPTIONAL		
N	status	GNSSstatus		BIT STRING (SIZE (8))	
N	offsetSet	AntennaOffsetSet			
N	antOffsetX	Offset-B12		INTEGER (-2048..2047)	
N	antOffsetY	Offset-B09		INTEGER (-256..255)	
N	antOffsetZ	Offset-B10		INTEGER (-512..511)	
N	msgs	RTCMmessageList	SEQUENCE (SIZE (1..5))		
N	msgs[n]	RTCMmessage		OCTET STRING (SIZE (1..1023))	
N	regional	RegionalExtension {{ REGION.Reg-SupplementalVehicleExtensions }}	OPTIONAL SEQUENCE (SIZE (1..4))		

APPENDIX D. Map Data Message (MAP)

Table 34 below lists NYC CVPD MAP message set for achieving interoperability with the other two CV pilot sites. The SAE J2735 (2016-03) MAP data object recommendations are highlighted in yellow.

Table 34. MAP Message Set for NYC CVPD System

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
R	MapData			
O	MinuteOfTheYear	OPTIONAL		
R	MsgCount		Revision Number	
O	LayerType	OPTIONAL		
O	LayerID	OPTIONAL		
R	IntersectionGeometryList	OPTIONAL		
R	IntersectionGeometry		1 to 32	
O	DescriptiveName	OPTIONAL		Use for testing only
R	IntersectionReferenceID			
R	MsgCount		Revision Number	
R	Position3D			
R	LaneWidth	OPTIONAL		

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
R	SpeedLimitList	OPTIONAL		Required for Speed Compliance Applications
R	RegulatorySpeedLimit			
R	SpeedLimitType			
R	Velocity			
R	LaneList			
R	GenericLane	1 to 255		
R	LaneID		LaneID "1" is the left most lane of northbound approach, ApproachID 1. Lanes are numbered counterclockwise and include Egress Lanes	
O	DescriptiveName	OPTIONAL		Use for testing only
R	ApproachID	OPTIONAL	ingress (inbound)	
R	ApproachID	OPTIONAL	egress (outbound)	
R	LaneAttributes			
R	LaneDirection			
R	LaneSharing			Transit Use?
R	LaneTypeAttributes	CHOICE		
R	LaneAttributes-vehicle			
R	LaneAttributes-Crosswalk			
R	LaneAttributes-bike			
R	LaneAttributes-sidewalk			

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
O	LaneAttributes-barrier			
O	LaneAttributes-striping			
O	LaneAttributes-trackedvehicle			
R	LaneAttributes-parking			
R	AllowedManeuvers	OPTIONAL		
R	NodeListXY	OPTIONAL	For ingress, Node 1 is the Stop Bar. For egress, Node 1 is where the outbound lane begins; after traversing the intersection	
R	NodeSetXY			
R	NodeXY			
R	NodeOffsetPointXY	CHOICE		
O	Node-XY-20b			
O	Node-XY-22b			
O	Node-XY-24b			
O	Node-XY-26b			
O	Node-XY-28b			
R	Node-XY-32b			
O	Node-LLmD-64b			
O	NodeAttributedSetXY	OPTIONAL		
O	NodeAttributeXYList	OPTIONAL	Attribute states which pertain to this node point	
O	NodeAttributeXY			

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
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	

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
			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	
R	ComputedLane			Makes sense to use ComputedLanes in NYC to reduce MAP message size
R	LaneID			
R	offsetXaxis	CHOICE		
R	DrivenLineOffsetSm			
O	DrivenLineOffsetLg			
R	offsetYaxis	CHOICE		
R	DrivenLineOffsetSm			
O	DrivenLineOffsetLg			

NY	Field Type	ASN.1 Structural Type	Clarification	NY Comments
O	Angle	OPTIONAL		
O	Scale-B12	OPTIONAL		
O	Scale-B12	OPTIONAL		
R	ConnectsToList	OPTIONAL		
R	Connection			
R	ConnectingLane			
R	LaneID			
R	AllowedManeuvers	OPTIONAL		
O	IntersectionReferenceID	OPTIONAL		
O	RoadRegulatorID	OPTIONAL		
R	IntersectionID			
R	SignalGroupID	OPTIONAL		
R	RestrictionClassID	OPTIONAL		
R	LaneConnectionID	OPTIONAL		
O	OverlayLaneList	OPTIONAL		
O	LaneID			
O	RoadSegmentList	OPTIONAL		
O	RoadSegment			
O	DataParameters	OPTIONAL		Use for Bus Only Lanes
R	RestrictionClassList	OPTIONAL		
R	RestrictionClassAssignment			

NY	Field Type			ASN.1 Structural Type	Clarification	NY Comments
R			RestrictionClassID			
R			RestrictionUserTypeList			
R			RestrictionUserType			

APPENDIX E. Traveler Information Message (TIM)

Table 35 below lists the NYC CVPD TIM message set for achieving interoperability with the other CV pilot sites. The data frames and data elements in the table are based on the SAE J2735 (2016-03) standard for the TIM message. The four V2I safety applications (CSPD-COMP, SPDCOMPWZ, EVAC, and OVC) are listed separately because certain data frames and data elements may not apply to all of them.

Table 35. TIM Message Set for NYC CVPD System

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
R	R	R	R	TravelerInformation	MSG_TravelerInformation Message			
R	R	R	R	msgCnt	MsgCount			Use of MsgCount needs to be harmonized for all 3 sites.
R	R	R	R	timeStamp	MinuteOfTheYear	OPTIONAL		
O	O	O	O	packetID	UniqueMSGID	OPTIONAL		Use?
N	N	N	N	urlB	URL-Base	OPTIONAL		
R	R	R	R	dataFrames	TravelerDataFrameList	SEQUENCE(SIZE(1..8))		
R	R	R	R	dataFrames[n]	TravelerDataFrame			
				-- Part I, Frame Header				
R	R	R	R	sspTimRights	SSPindex		INTEGER (0..31)	
R	R	R	R	frameType	TravelerInfoType		ENUMERATED { 0..3 }	
R	R	R	R	msgId		CHOICE		
N	N	N	N	furtherInfoId	FurtherInfoID		OCTET STRING (SIZE(2))	
R	R	R	R	roadSignID	RoadSignID			
R	R	R	R	position3D	Position3D			
R	R	R	R	lat	Latitude		INTEGER (-900000000..900000001)	
R	R	R	R	long	Longitude		INTEGER (-1799999999..1800000001)	
R	R	R	R	elevation	Elevation	OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
R	R	R	R	viewAngle	HeadingSlice		BIT STRING (SIZE(16))	
R	R	R	R	mutcdCode	MUTCDCode	OPTIONAL	ENUMERATED { 0..6 }	
R	R	R	R	msgCrc	MsgCRC	OPTIONAL	OCTET STRING (SIZE(2))	Wrong place?
R	R	R	R	startYear	DYear	OPTIONAL		
R	R	R	R	startTime	MinuteOfTheYear		INTEGER (0..527040)	
R	R	R	R	durationTime	MinutesDuration		INTEGER (0..32000)	Definition of 0 in this field?
R	R	R	R	priority	SignPriority		INTEGER (0..7)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
				-- Part II, Applicable Regions of Use				
R	R	R	R	sspLocationRights	SSPindex		INTEGER (0..31)	
R	R	R	R	regions	GeographicalPath	SEQUENCE (SIZE(1..16))		
R	R	R	R	name	DescriptiveName	OPTIONAL	IA5String (SIZE(1..63))	
R	R	R	R	id	RoadSegmentReferenceID	OPTIONAL		
R	R	R	R	region	RoadRegulatorID	OPTIONAL	INTEGER (0..65535)	
R	R	R	R	id	RoadSegmentID		INTEGER (0..65535)	
R	R	R	R	anchor	Position3D	OPTIONAL		
R	R	R	R	lat	Latitude		INTEGER (-900000000..900000001)	
R	R	R	R	long	Longitude		INTEGER (-1799999999..1800000001)	
R	R	R	R	elevation	Elevation	OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
R	R	R	R	laneWidth	LaneWidth	OPTIONAL	INTEGER (0..32767)	
R	R	R	R	directionality	DirectionOfUse	OPTIONAL	ENUMERATED { 0..3 }	
R	R	R	R	closedPath	BOOLEAN	OPTIONAL		
R	R	R	R	direction	HeadingSlice	OPTIONAL	BIT STRING (SIZE(16))	
R	R	R	R	description		OPTIONAL CHOICE		
R	R	N	R	path	OffsetSystem			
R	R	N	R	scale	Zoom	OPTIONAL	INTEGER (0..15)	
R	R	N	R	offset		CHOICE		
N	N	N	N	xy	NodeListXY	CHOICE		
N	N	N	N	nodes	NodeSetXY	SEQUENCE (SIZE(2..63))		
N	N	N	N	nodes[n]	NodeXY			
N	N	N	N	delta	NodeOffsetPointXY	CHOICE		
N	N	N	N	node-XY1	Node-XY-20b			
N	N	N	N	x	Offset-B10		INTEGER (-512..511)	
N	N	N	N	y	Offset-B10		INTEGER (-512..511)	
N	N	N	N	node-XY2	Node-XY-22b			
N	N	N	N	x	Offset-B11		INTEGER (-1024..1023)	
N	N	N	N	y	Offset-B11		INTEGER (-1024..1023)	
N	N	N	N	node-XY3	Node-XY-24b			
N	N	N	N	x	Offset-B12		INTEGER (-2048..2047)	
N	N	N	N	y	Offset-B12		INTEGER (-2048..2047)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	node-XY4	Node-XY-26b			
N	N	N	N	x	Offset-B13		INTEGER (-4096..4095)	
N	N	N	N	y	Offset-B13		INTEGER (-4096..4095)	
N	N	N	N	node-XY5	Node-XY-28b			
N	N	N	N	x	Offset-B14		INTEGER (-8192..8192)	
N	N	N	N	y	Offset-B14		INTEGER (-8192..8192)	
N	N	N	N	node-XY6	Node-XY-32b			
N	N	N	N	x	Offset-B16		INTEGER (-32768..32768)	
N	N	N	N	y	Offset-B16		INTEGER (-32768..32768)	
N	N	N	N	node-LatLon	Node-LLmD-64b			
N	N	N	N	lon	Longitude		INTEGER (-1799999999..1800000001)	
N	N	N	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointXY }}			
N	N	N	N	attributes	NodeAttributeSetXY	OPTIONAL		
N	N	N	N	localNode	NodeAttributeXYList	OPTIONAL SEQUENCE (SIZE (1..8))		
N	N	N	N	localNode[n]	NodeAttributeXY		ENUMERATED	
N	N	N	N	disabled	SegmentAttributeXYList	OPTIONAL SEQUENCE (SIZE (1..8))		
N	N	N	N	disabled[n]	SegmentAttributeXY		ENUMERATED	
N	N	N	N	enabled	SegmentAttributeXYList	OPTIONAL		
N	N	N	N	enabled[n]	SegmentAttributeXY		ENUMERATED	
N	N	N	N	data	LaneDataAttributeList	OPTIONAL		
N	N	N	N	data[n]	LaneDataAttribute	CHOICE		
N	N	N	N	pathEndPointAngle	DeltaAngle		INTEGER (-150..150)	
N	N	N	N	laneCrownPointCenter	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointLeft	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointRight	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneAngle	MergeDivideNodeAngle		INTEGER (-180..180)	
N	N	N	N	speedLimits	SpeedLimitList	SEQUENCE (SIZE (1..9))		
N	N	N	N	speedLimits[n]	RegulatorySpeedLimit			
N	N	N	N	type	SpeedLimitType		ENUMERATED	
N	N	N	N	speed	Velocity		INTEGER (0..8191)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}			
N	N	N	N	dWidth	Offset-B10	OPTIONAL	INTEGER (-512..511)	
N	N	N	N	dElevation	Offset-B10	OPTIONAL	INTEGER (-512..511)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	regional		OPTIONAL SEQUENCE(SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetXY }}			
N	N	N	N	computed	ComputedLane			
N	N	N	N	referenceLaneId	LaneID		INTEGER (0..255)	
N	N	N	N	offsetXaxis		CHOICE		
N	N	N	N	small	DrivenLineOffsetSm		INTEGER (-2047..2047)	
N	N	N	N	large	DrivenLineOffsetLg		INTEGER (-32767..32767)	
N	N	N	N	offsetYaxis		CHOICE		
N	N	N	N	small	DrivenLineOffsetSm		INTEGER (-2047..2047)	
N	N	N	N	large	DrivenLineOffsetLg		INTEGER (-32767..32767)	
N	N	N	N	rotateXY	Angle	OPTIONAL	INTEGER (0.28800)	
N	N	N	N	scaleXaxis	Scale-B12	OPTIONAL	INTEGER (-2048..2047)	
N	N	N	N	scaleYaxis	Scale-B12	OPTIONAL	INTEGER (-2048..2047)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-ComputedLane }}			
R	R	N	R	ll	NodeListLL	CHOICE		
R	R	N	R	nodes	NodeSetLL		SEQUENCE (SIZE (2..63))	
R	R	N	R	nodes[n]	NodeLL			
R	R	N	R	delta	NodeOffsetPointLL	CHOICE		
N	N	N	N	node-LL1	Node-LL-24B			
N	N	N	N	lon	OffsetLL-B12		INTEGER (-2048..2047)	
N	N	N	N	lat	OffsetLL-B12		INTEGER (-2048..2047)	
N	N	N	N	node-LL2	Node-LL-28B			
N	N	N	N	lon	OffsetLL-B14		INTEGER (-8192..8191)	
N	N	N	N	lat	OffsetLL-B14		INTEGER (-8192..8191)	
N	N	N	N	node-LL3	Node-LL-32B			
N	N	N	N	lon	OffsetLL-B16		INTEGER (-32768..32767)	
N	N	N	N	lat	OffsetLL-B16		INTEGER (-32768..32767)	
N	N	N	N	node-LL4	Node-LL-36B			
N	N	N	N	lon	OffsetLL-B18		INTEGER (-131072..131071)	
N	N	N	N	lat	OffsetLL-B18		INTEGER (-131072..131071)	
N	N	N	N	node-LL5	Node-LL-44B			
N	N	N	N	lon	OffsetLL-B22		INTEGER (-2097152..2097151)	
N	N	N	N	lat	OffsetLL-B22		INTEGER (-2097152..2097151)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	node-LL6	NodeLL-48B			
N	N	N	N	lon	OffsetLL-B24		INTEGER (-8388608..8388607)	
N	N	N	N	lat	OffsetLL-B24		INTEGER (-8388608..8388607)	
R	R	N	R	node-LatLon	Node-LLmD-64b			
R	R	N	R	lon	Longitude		INTEGER (-1799999999..1800000001)	
R	R	N	R	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointLL }}			
R	R	N	R	attributes	NodeAttributeSetLL	OPTIONAL		
R	R	N	R	localNode	NodeAttributeLLList	OPTIONAL SEQUENCE (SIZE (1..8))		
R	R	N	R	localNode[n]	NodeAttributeLL		ENUMERATED	
N	N	N	N	disabled	SegmentAttributeLLList	OPTIONAL SEQUENCE (SIZE(1..8))		
N	N	N	N	disabled[n]	SegmentAttributeLL		ENUMERATED	
R	R	N	R	enabled	SegmentAttributeLLList	OPTIONAL SEQUENCE (SIZE(1..8))		
R	R	N	R	enabled[n]	SegmentAttributeLL		ENUMERATED	
R	R	N	R	data	LaneDataAttributeList	OPTIONAL SEQUENCE (SIZE(1..8))		
R	R	N	R	data[n]	LaneDataAttribute	CHOICE		
N	N	N	N	pathEndPointAngle	DeltaAngle		INTEGER (-150..150)	
N	N	N	N	laneCrownPointCenter	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointLeft	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointRight	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneAngle	MergeDivideNodeAngle		INTEGER (-180..180)	
R	R	R	R	speedLimits	SpeedLimitList	SEQUENCE (SIZE (1..9))		
R	R	R	R	speedLimits[n]	RegulatorySpeedLimit			
R	R	R	R	type	SpeedLimitType		ENUMERATED	
R	R	R	R	speed	Velocity		INTEGER (0..8191)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}			
N	N	N	N	dWidth	Offset-B10	OPTIONAL	INTEGER (-512..511)	
N	N	N	N	dElevation	Offset-B10	OPTIONAL	INTEGER (-512..511)	
N	N	N	N	regional		SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetLL }}			
N	N	N	N	geometry	GeometricProjection			
N	N	N	N	direction	HeadingSlice		BIT STRING (SIZE(16))	
N	N	N	N	extent	Extent	OPTIONAL	ENUMERATED	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	laneWidth	LaneWidth	OPTIONAL	INTEGER (0..32767)	
N	N	N	N	circle	Circle			
N	N	N	N	center	Position3D			
N	N	N	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	long	Longitude		INTEGER (-1799999999..1800000001)	
N	N	N	N	elevation	Elevation	OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
N	N			radius	Radius-B12		INTEGER (0..40695)	
N	N			units	DistanceUnits		ENUMERATED (0..7)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE (1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-GeometricProjection }}			
N	N	R	N	oldRegion	ValidRegion			
N	N	R	N	direction	HeadingSlice		BIT STRING (SIZE (16))	
N	N	R	N	extent	Extent	OPTIONAL	ENUMERATED { 0..15 }	
N	N	R	N	area		CHOICE		
N	N	N	N	shapePointSet	ShapePointSet			
N	N	N	N	anchor	Position3D	OPTIONAL		
N	N	N	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	long	Longitude		INTEGER (-1799999999..1800000001)	
N	N	N	N	elevation	Elevation	OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
N	N	N	N	laneWidth	LaneWidth	OPTIONAL	INTEGER (0..32767)	
N	N	N	N	directionality	DirectionOfUse	OPTIONAL	ENUMERATED { 0..3 }	
N	N	N	N	nodeList	NodeListXY			
N	N	N	N	nodes	NodeSetXY	SEQUENCE (SIZE(2..63))		
N	N	N	N	nodes[n]	NodeXY			
N	N	N	N	delta	NodeOffsetPointXY	CHOICE		
N	N	N	N	node-XY1	Node-XY-20b			
N	N	N	N	x	Offset-B10		INTEGER (-512..511)	
N	N	N	N	y	Offset-B10		INTEGER (-512..511)	
N	N	N	N	node-XY2	Node-XY-22b			
N	N	N	N	x	Offset-B11		INTEGER (-1024..1023)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	y	Offset-B11		INTEGER (-1024..1023)	
N	N	N	N	node-XY3	Node-XY-24b			
N	N	N	N	x	Offset-B12		INTEGER (-2048..2047)	
N	N	N	N	y	Offset-B12		INTEGER (-2048..2047)	
N	N	N	N	node-XY4	Node-XY-26b			
N	N	N	N	x	Offset-B13		INTEGER (-4096..4095)	
N	N	N	N	y	Offset-B13		INTEGER (-4096..4095)	
N	N	N	N	node-XY5	Node-XY-28b			
N	N	N	N	x	Offset-B14		INTEGER (-8192..8192)	
N	N	N	N	y	Offset-B14		INTEGER (-8192..8192)	
N	N	N	N	node-XY6	Node-XY-32b			
N	N	N	N	x	Offset-B16		INTEGER (-32768..32768)	
N	N	N	N	y	Offset-B16		INTEGER (-32768..32768)	
N	N	N	N	node-LatLon	Node-LLmD-64b			
N	N	N	N	lon	Longitude		INTEGER (-1799999999..1800000001)	
N	N	N	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	regional	RegionalExtension {{ REGION.Reg-NodeOffsetPointXY }}			
N	N	N	N	attributes	NodeAttributeSetXY	OPTIONAL		
N	N	N	N	localNode	NodeAttributeXYList	OPTIONAL SEQUENCE (SIZE (1..8))		
N	N	N	N	localNode[n]	NodeAttributeXY		ENUMERATED	
N	N	N	N	disabled	SegmentAttributeXYList	OPTIONAL SEQUENCE (SIZE (1..8))		
N	N	N	N	disabled[n]	SegmentAttributeXY		ENUMERATED	
N	N	N	N	enabled	SegmentAttributeXYList	OPTIONAL		
N	N	N	N	enabled[n]	SegmentAttributeXY		ENUMERATED	
N	N	N	N	data	LaneDataAttributeList	OPTIONAL SEQUENCE (SIZE (1..8))		
N	N	N	N	data[n]	LaneDataAttribute	CHOICE		
N	N	N	N	pathEndPointAngle	DeltaAngle		INTEGER (-150..150)	
N	N	N	N	laneCrownPointCenter	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointLeft	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneCrownPointRight	RoadwayCrownAngle		INTEGER (-128..127)	
N	N	N	N	laneAngle	MergeDivideNodeAngle		INTEGER (-180..180)	
N	N	N	N	speedLimits	SpeedLimitList	SEQUENCE (SIZE (1..9))		
N	N	N	N	speedLimits[n]	RegulatorySpeedLimit			
N	N	N	N	type	SpeedLimitType		ENUMERATED	
N	N	N	N	speed	Velocity		INTEGER (0..8191)	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-LaneDataAtrribute }}			
N	N	N	N	dWidth	Offset-B10	OPTIONAL	INTEGER (-512..511)	
N	N	N	N	dElevation	Offset-B10	OPTIONAL	INTEGER (-512..511)	
N	N	N	N	regional		OPTIONAL SEQUENCE(SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-NodeAttributeSetXY }}			
N	N	N	N	computed	ComputedLane			
N	N	N	N	referenceLaneId	LaneID		INTEGER (0..255)	
N	N	N	N	offsetXaxis		CHOICE		
N	N	N	N	small	DrivenLineOffsetSm		INTEGER (-2047..2047)	
N	N	N	N	large	DrivenLineOffsetLg		INTEGER (-32767..32767)	
N	N	N	N	offsetYaxis		CHOICE		
N	N	N	N	small	DrivenLineOffsetSm		INTEGER (-2047..2047)	
N	N	N	N	large	DrivenLineOffsetLg		INTEGER (-32767..32767)	
N	N	N	N	rotateXY	Angle	OPTIONAL	INTEGER (0.28800)	
N	N	N	N	scaleXaxis	Scale-B12	OPTIONAL	INTEGER (-2048..2047)	
N	N	N	N	scaleYaxis	Scale-B12	OPTIONAL	INTEGER (-2048..2047)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-ComputedLane }}			
N	N	N	N	circle	Circle			
N	N	N	N	center	Position3D			
N	N	N	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	N	N	long	Longitude		INTEGER (-1799999999..1800000001)	
N	N	N	N	elevation		OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
N	N	N	N	radius	Radius-B12		INTEGER (0..40695)	
N	N	N	N	units	DistanceUnits		ENUMERATED (0..7)	
N	N	R	N	regionPointSet	RegionPointSet			
N	N	R	N	anchor	Position3D	OPTIONAL		
N	N	R	N	lat	Latitude		INTEGER (-900000000..900000001)	
N	N	R	N	long	Longitude		INTEGER (-1799999999..1800000001)	
N	N	R	N	elevation	Elevation	OPTIONAL	INTEGER (-4096..61439)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-Position3D }}			
N	N	R	N	scale	Zoom	OPTIONAL	INTEGER (0..15)	
N	N	R	N	nodeList	RegionList	SEQUENCE (SIZE(1..64))		
N	N	R	N	nodeList[n]	RegionOffsets			
N	N	R	N	xOffset	OffsetLL-B16		INTEGER (-32768..32767)	
N	N	R	N	yOffset	OffsetLL-B16		INTEGER (-32768..32767)	
N	N	R	N	zOffset	OffsetLL-B16	OPTIONAL	INTEGER (-32768..32767)	
N	N	N	N	regional		OPTIONAL SEQUENCE (SIZE(1..4))		
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-GeographicalPath			
				-- Part III, Content				
R	R	R	R	sspMsgRights1	SSPindex		INTEGER (0..31)	
R	R	R	R	sspMsgRights2	SSPindex		INTEGER (0..31)	
R	R	R	R	content		CHOICE		
N	N	R	R	advisory	ITIS.ITIScodesAndText	SEQUENCE (SIZE(1..100))		
N	N	R	R	item		CHOICE		
N	N	R	R	itis	ITIScodes		INTEGER (0..65535)	
N	N	N	N	text	ITIStext		IA5String (SIZE(1.500))	
N	R	N	N	workZone	WorkZone	SEQUENCE (SIZE(1..16))		
N	R	N	N	item		CHOICE		
N	R	N	N	itis	ITIS.ITIScodes		INTEGER (0..65535)	
N	N	N	N	text	ITIStextPhrase		IA5String (SIZE(1..16))	
N	N	N	N	genericSign	GenericSignage	SEQUENCE (SIZE(1..16))		
N	N	N	N	item		CHOICE		
N	N	N	N	itis	ITIS.ITIScodes		INTEGER (0..65535)	
N	N	N	N	text	ITIStextPhrase		IA5String (SIZE(1..16))	
R	N	N	N	speedLimit	SpeedLimit	SEQUENCE (SIZE(1..16))		
R	N	N	N	item		CHOICE		
R	N	N	N	itis	ITIS.ITIScodes		INTEGER (0..65535)	
N	N	N	N	text	ITIStextPhrase		IA5String (SIZE(1..16))	
N	N	N	N	exitService	ExitService	SEQUENCE (SIZE(1..16))		
N	N	N	N	item		CHOICE		
N	N	N	N	itis	ITIS.ITIScodes		INTEGER (0..65535)	
N	N	N	N	text	ITIStextPhrase		IA5String (SIZE(1..16))	

CSPD-COMP	SPD COMP WZ	EVAC	OVC	Field Name	Field Type	ASN.1 Structural Type	ASN.1 Primitive Type	NY Comments
N	N	N	N	url	URL-Short	OPTIONAL	IA5String (SIZE(1..15))	
N	N	N	N	regional				
N	N	N	N	regional[n]	RegionalExtension {{ REGION.Reg-TravelerInformation }}			

As-Built Addendum

This section highlights changes made to the overall SAD due to the final deployment and the schedule of activity. Elements within this section supersede portions of the document not altered to reflect the details of the changes.

a. The architecture diagram (Figure 19 and Figure 20) shows that the PID will receive the SPaT and MAP information over a DSRC or local short range communications media. While a number of vendors had indicated that they could supply smart phones with DSRC capability, when the project attempted to pursue the use of such devices, they were no longer available. An alternate approach was used where the traffic controller (ASTC) sends the SPaT information to the TMC on a change driven basis and the MAP database is maintained at the TMC. The MAP data and the SPaT data are then transmitted to an Amazon Cloud (AWS) where it is processed and distributed using cellular service to the smartphones for use with the PID application. This same data flow (2A) shown in Figure 14 is now provided from the AWS cloud using a cellular service rather than directly to the PID using DSRC.

b. The PID application to assist the visually impaired pedestrian at CV equipped intersections has changed significantly. The SPaT information is received from the ASTC, combined with the MAP information stored at the TMC and sent to the AWS cloud where the SmartCross application process the data and distributes it to the appropriate PID using a cellular service. The data is then collected and exported to the NYU data collection system where it is evaluated. Instead of distributing PIDs to the user community for testing/trials and evaluation, the 10 prototypes will be used with selected participants who will test/trial the PID application in a protected and assisted environment. Evaluation of the preliminary results indicated that the application was not robust enough to be distributed without supervision in a protected environment. The detailed design is provided in a separate document. Section 3.2.1.2 has been updated accordingly. In addition, the PID will not be enrolled with the SCMS as previously described in Sections 2.3.5.1, 3.1.2.2, 3.2.2, and Figure 18.

c. Note that the communications between the TMC and the RSU uses 2 different protocols: SNMPv3 for management of the MIB objects supported by the RSU, and XFER a proprietary protocol developed by the RSU vendor for uploading and downloading files used for data collection, and RSU configuration. It should be noted that NTCIP 1218 had not been developed at the time of this project, and it was necessary to utilize the vendor's protocol to support these exchanges. The vendor has made this protocol readily and publicly available without restriction for use with their RSUs.

d. While there is some discussion of the use of UPS participation and the participation of the TAXI fleets/owners, both of these did not become active participants in the project, The fleet is primarily composed of various City fleets including DCAS, Parks, DOT, Department of Corrections (DOC), Department of Environmental Protection (DEP), Department of Health Services (DHS), and other service fleets operated by NYC. The City fleets are generally equipped with Geotab devices which monitors their general usage; this data has been available to the CVPD project to determine the general routes and locations frequented by the City fleets participating in the CVPD project. This data will be used to evaluate the accuracy of the data collected and to assist the project in monitoring the health of the CV equipped vehicles.

e. The HSM is a rack-mountable appliance installed at the TMC to expand TMC operations with direct-to-vehicle messaging over latest V2X network technology. Traveler Information, MAP, and other infrastructure messages are inspected and digitally signed to prevent hacking so TMC messages can be trusted. The HSM authenticates incoming messages and signs certificates for outgoing messages to and from the TMC. The HSM inspects and formats TMC messages for acceptance by V2X networked devices. Installed RSUs and ASDs do not require any additional components. In addition to the NYCDOT TMC back-office management functions listed in Section 2.2.4.3, the HSM has been critical for maintaining the security of the data being transmitted. Also known as the TMC Authority, provides complete support for IEEE 1609.2 algorithms and protocols including SAE J2735, and J2945/x. It also provides FIPS 140-2 Level 3 protection for V2X signing keys. The TMC Authority checks and digitally signs traffic management center messages for instant verification and acceptance, compliant with IEEE 1609.2 standards and cryptography. Data is secured inside and out with FIPS 140-2 Level 3 protection of keys and TLS v1.2 tunnels to TMC servers. High availability network failover is standard, including redundant power supplies and storage; the TMC Authority maintains trusted reliable operation, even in untrusted environments.
f. Achieving location augmentation has been critical especially in the urban canyon parts of the NYC CV Pilot area. To improve location accuracy for the DSRC devices in the NYC CV project, using the DSRC Radio Technical Commission for Maritime (RTCM) was considered first. As defined in SAE J2735, the RTCM messages would be transmitted along with the other DSRC messages over channel 172. However, the V2XLocate technology was chosen instead after multiple tests and demonstrations in the Manhattan grid section of the NYC CV pilot area.

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