Connected Vehicle Environment (CVE) Interface Control Document

for the Smart Columbus Demonstration Program

FINAL | April 8, 2019

Produced by the City of Columbus

Notice

Acknowledgement of Support

This material is based upon work supported by the U.S. Department of Transportation under Agreement No. DTFH6116H00013.

Disclaimer

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1. PROJECT BACKGROUND

In 2016, the U.S. Department of Transportation (USDOT) awarded $40 million to the City of Columbus, Ohio, as the winner of the Smart City Challenge. With this funding, Columbus intends to address the most pressing community-centric transportation problems by integrating an ecosystem of advanced and innovative technologies, applications, and services to bridge the sociotechnical gap and meet the needs of residents of all ages and abilities. In conjunction with the Smart City Challenge, Columbus was also awarded a $10 million grant from Paul G. Allen Philanthropies to accelerate the transition to an electrified, low-emissions transportation system.

With the award, the city established a strategic Smart Columbus program with the following vision and mission:

- **Smart Columbus Vision:** Empower residents to live their best lives through responsive, innovative, and safe mobility solutions
- **Smart Columbus Mission:** Demonstrate how Intelligent Transportation Systems (ITS) and equitable access to transportation can have positive impacts on every day challenges faced by cities

To enable these new capabilities, the Smart Columbus program is organized into three focus areas addressing unique user needs: enabling technologies, emerging technologies, and enhanced human services. The Connected Vehicle Environment (CVE) primarily addresses needs in the enabling technologies focus area. The CVE project is one of the eight projects in the Smart Columbus program and is a significant enabler to other technologies delivered through the other seven projects. The CVE project will integrate smart traveler applications, automated vehicles, connected vehicles, and smart sensors into its transportation network by focusing on deploying CV infrastructure and CV applications.

- **CV Infrastructure** – The project will focus on building out the physical and logical CV infrastructure, which will consist of CV hardware and software (e.g. roadside units (RSUs), on-board equipment (OBE), front and backhaul communications, equipment interfaces, etc.). The CVE will generate the needed transportation-related data that are used by applications.
- **CV Applications and Data** – The project scope also consists of deploying CV-specific applications that will leverage the data generated by the infrastructure to deliver real-time safety and mobility services. Data will be collected, related, stored, and made available for use in other Smart Columbus project applications.

The CVE is expected to enhance safety and mobility for vehicle operators and improve pedestrian safety in school zones by deploying CV infrastructure on the roadside and CV equipment in vehicles. The CVE will also provide sources of high-quality data for traffic management and safety purposes.

The foundation for the CVE is the Columbus Traffic Signal System (CTSS), which is a high-speed network backbone. When complete, the CTSS will interconnect 1,250 traffic signals in the Columbus region and provide uniform signal coordination capability throughout the system. CTSS Phase D, which will connect all CVE corridors except for Alum Creek Drive, is expected to be complete in Q2 2019. An expansion of the CTSS to connect Alum Creek Drive will be included in the CVE project.

The CV infrastructure deployment will occur along seven major corridors/areas. The deployment of in-vehicle devices will target populations that are located near or frequently used infrastructure deployment corridors. **Table 1** lists the improvements associated with the CVE.

Table 1: Connected Vehicle Environment Project Scope

Infrastructure		Applications and Data	
100+ RSUs The project will install RSUs and necessary communications equipment at ~90 signalized intersections in the project areas.	**1,500 – 1,800 OBUs** The project will install onboard units (OBUs) on participating private, fleet, emergency, transit, and freight vehicles.	**CV Applications** The project will deploy vehicle-to-vehicle (V2V) safety, vehicle-to-infrastructure (V2I) safety, and V2I mobility applications.	**Data Capture** The project will capture, relate, store, and respond to data generated by the infrastructure, used by the applications for traffic management.

Source: City of Columbus

The intent of the CVE project is to improve safety and mobility of travelers by deploying CV technology as part of a larger initiative within the City to improve the overall transportation system. CV technology will also be deployed to support the City's automated vehicle project and to support the improvement in freight operations, another of the City's goals.

Collectively, CV is just one component, but if it proves to be effective, other projects can also benefit from the positive outcomes. Recall that the goal of the CVE is not to develop applications to a high level of maturity. It is to leverage what has already been developed. Thus, it is important for the reader to understand that the ability of the CVE to address the user needs captured in the ConOps depends on the availability of hardware and software solutions that have been previously deployed (and subsequently improved upon). To this end, throughout the CVE systems engineering process, several applications have been considered – each application was scrutinized in detail to ensure that only applications that were considered to be ready for deployment are included in the deployment of the CVE. Performance requirements detailed in the System Requirements document (see V2V Safety, V2I Safety, and V2I Mobility functional groups), outline expectations for each application that is deployed. The implementation of software is expected to demonstrate efficacy of the deployed infrastructure.

The applications and technology to be deployed as part of the CVE are the same (or very similar) to applications and technology employed in other connected vehicle projects. As similar applications are developed and employed as part of the CV Pilot projects, their maturity will continue to increase. It is expected that prospective vendors are perpetually making improvements to applications based on experience in testing and implementation. Thus, the design and implementation of the CVE will draw on improvements made to applications through these development efforts.

The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT)[1] and its predecessor, the Connected Vehicle Reference Implementation Architecture (CVRIA)[2], are resources that provide descriptions of CV applications that have been researched in the context of the National ITS architecture. Furthermore, the Open Source Application Development Portal (OSADP) contains software for applications that have been developed.[3] When possible, applications on ARC-IT, CVRIA and OSADP will be used as-is or will have minimal modifications made to address user needs documented in the ConOps.

Given that the primary scope of the CVE is to realize the benefits of deploying CV technology into an operational environment, only applications that have demonstrated sufficient levels of development and testing are being considered for implementation. It is expected that prospective vendors are perpetually

[1] https://local.iteris.com/arc-it/

[2] https://local.iteris.com/cvria/

[3] *Open Source Application Development Portal.* https://www.itsforge.net/

making improvements to applications based on experience in testing and implementation. However, the CVE will be designed in such a way that added functionality concepts (not implemented as part of this project, that require further development) can be integrated with the CVE once development and testing have matured to a point where applications are deployment-ready. Additionally, due to the networked nature of devices in the CVE, several policies and constraints related to information technology (IT) and data security are expected to be developed as part of the deployment. The backhaul network which supports roadside equipment in the CVE will require the establishment of a new network (on existing dark fiber). City of Columbus Department of Technology (responsible for managing Columbus' fiber network) has been engaged to establish necessary network security policies and design.

1.1.1. Assumptions

Key assumptions pertaining to external components for the implementation of the Smart Columbus Connected Vehicle Environment include:

- OBU Integrator and RSU Integrator are expected to work with each other to ensure interoperability of systems. Equipment, software, processes, and interfaces will be tested for interoperability before deployment to ensure they meet those standards. As shown in Figure 2 (see Section **2.1**), the OBU Integrator and RSU Integrators will primarily need to coordinate messages communicated via DSRC between the roadside and vehicle OBUs.
- The Connected Vehicle Environment is expected to support data intake by the Smart Columbus Operating System
- CV applications are expected to be available from selected vendor. V2V and V2I Safety applications that output an alert from an OBU are expected to be previously-developed, commercial off the shelf software. Vendor proposals and past performance will be scrutinized to ensure the applications provided by a vendor is (or will be) capable of meeting performance requirements.
- City of Columbus Department of Public Service (DPS) will adhere to internal policies and best practices for executing signal priority and signal preemption strategies. The ability to receive signal priority or preemption will be limited to select vehicles. This will be managed though a list of authorized vehicles managed (and input to the CVE) by DPS.
- Performance measures will be used to assess the CVE
- Data that is used or stored in a center shall not contain PII. Filtering algorithms may be needed to be implemented to remove any PII.
- All CVE components that utilize DSRC are expected to comply with IEEE, SAE, and USDOT standards. These standards are specified in the System Requirements and in this document.
- DSRC is the medium for over-the-air message transmission. This technology has been previously proven as an effective means of communicating time-sensitive information for enabling safety and mobility applications that will be deployed as part of the CVE.
- Position correction information is expected to be derived from RTCM v3.0 Type 1001/1005 messages. This information is available through the Ohio CORS.
- The SPaT message is expected to be generated by the Traffic Signal Controller (TSC). As part of this project, signal controllers that are capable of outputting a SPaT message will be installed at intersections along the corridors of interest.
- SCMS is expected to be available from DriveOhio at the time of deployment. Arrangements are currently being made to procure this from Integrity Security Systems (ISS). ISS expected to leverage outcomes made available from USDOT pilot sites regarding wireless communications security (e.g. misbehavior detection)

1.1.2. Constraints

System constraints of the CVE can be grouped in several distinct categories which include equipment selection, network security and operations, user privacy and data collection, and impact to traffic operations.

Smart Columbus and the CVE serves as a deployment of CV technology. There is an expectation to maximize the implementation of commercial off-the-shelf hardware and software to meet the needs of users and stakeholders. Thus, the choice of devices to be deployed and the configuration of these devices are limited versus what might be expected for the CV Pilot projects – where detailed system design is required to meet project level goals. Specifically, and as noted in the ConOps, driver-focused safety and mobility applications which have met technology readiness level 6 were selected for inclusion. Applications that serve the needs of local management agencies (Vehicle Data for Traffic Operations, Transit Vehicle Interaction Event Recording), despite limited development, will be implemented as these applications primarily involve the transfer of data – which is expected to require minimal amount of development to operate effectively in a deployment environment.

It is fully expected that DSRC will be deployed as the wireless interface. RSUs will support bi-directional communications with vehicles via the DSRC interface, but are not required to include Wi-Fi, Bluetooth or any other wireless technology. Likewise, OBUs will be limited in the data they collect and the methods for both disseminating information to the LDV Operator, as well as capturing data from the Transit Vehicle OBU. Only Light-Duty Vehicles (LDV) are expected to have a human-machine interface (HMI). Only Transit Vehicles belonging to the transit agency, COTA, are expected to log onboard events. All other data capture will be via the active J2735 messages, such as BSM, SPaT, MAP, RSM, SSM, SRM and RTCM.

The City has deployed several hundred miles of fiber and is in the process of connecting nearly every traffic signal controller in the Columbus region to this network. The CVE will be connected to many of these same traffic signal controllers. Presently, the traffic signal controller network is a private, internal DPS network. The CVE requires access to external, public resources, including SCMS, CORS and the Smart Columbus Operating System. Connecting the existing controller network to CVE will potentially expose the controller to security risks associated with a public facing interface. Thus, the CVE must implement an architecture that isolates it from the existing network, providing a reasonable assurance that the former will not compromise the latter. This may require upgrading field equipment, installing additional and possibly redundant equipment, and using spare communications links.

Throughout all meetings with the project stakeholders, the stakeholders expressed that privacy must be maintained. Time and location information constitutes potentially Personally Identifiable Information (PII) because it could be merged with other records (e.g., police crash reports) and used in legal proceedings, disciplinary proceedings, or insurance negotiations. Keeping data with this time/location information is a potential infringement of an individual's privacy. The Smart Columbus Data Privacy Plan and Data Management Plan address specific methods to handle this, but given the limited data collection available, all data generated will be captured and handled accordingly.

Signal preemption and priority have potential impact on emergency services (police and fire), transit operations, and the movement of freight. Installation of signal preemption systems for Emergency Vehicles (EVs) has been shown to decrease response times. A review of signal preemption system deployments in the United States shows decreases in response times between 14 and 50% for systems in several cities.[4] Active transit signal priority can reduce transit delay significantly. In some cases, bus travel times have been

[4] *Signalized Intersection Safety Strategies – Employ Emergency Vehicle Preemption. U.S. Department of Transportation – Federal Highway Administration.* https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa08008/sa5_emergency_vehicle.pdf.

reduced around 10%, and delay was reduced up to 50% at target intersections.[5] Freight Signal Priority is similarly expected to improve travel time and flow of freight. The system is expected to be capable of demonstrating, at a minimum, that preempt, or priority could have an overall positive net effect (e.g. reduced response/travel time) in these cases. Primarily, the CVE is focused on demonstrating that the technology can support this function. The City may decide to limit or eliminate specific locations or corridors planned to support preempt/prioritization, it may also require additional, conditional elements not presently specified.

1.1.3. Risks

Key risks associated with the interfaces described here include:

Risk: While an SCMS service is in the process of being procured, there is currently not an operating SCMS for the CVE. Given that the SCMS will be an external system that the CVE will need to access, information regarding the required data that is required to flow to/from the SCMS cannot be specified in detail at this time (OBU Pseudonym Certificate, OBU Pseudonym Certificate Request, RSU Application Certificate, RSU Application Certificate Request, Misbehavior report, Revocation List).

Mitigation: RSU and OBU vendors will be expected to coordinate with the SCMS vendor to have any equipment provisioned with the correct security certificates prior to shipment or as it aligns with the project goals. Each OBU is expected to be pre-loaded with 3 years of certificates, and will receive additional certificates (to maintain 3 years of certificates) via deployed RSUs.

Risk: RTCM may be insufficient to meet project needs. The quality of data obtained from GNSS data may not be adequate for enabling safety applications that require a high level of positional precision.

Mitigation: In these cases, it will be up to the vendor to determine if the data that is available is accurate enough to provide a trusted output to a vehicle operator. Regardless of whether an output is provided, the driver will still be expected to follow regulations governing the operation of motor vehicles.

Risk: All safety applications have been previously deployed (and subsequently improved upon). However, they are also expected to adhere to the interfaces that are defined in the document. The CVE has been specified and designed in such a way that the data necessary to support these applications over standardized interfaces are made available in a timely, correct, and secure manner. It is recognized that vendors that have already deployed many of the same applications that are being proposed in this project. Still, vendors will be responsible for making modifications to previously-developed applications, if necessary, to adhere to the specifications provided in this document.

Mitigation: The project team is evaluating capabilities of vendors to ensure that software will adhere to functional requirements set in the system requirements document. All deployed devices are expected to be OmniAir Certified at the time of deployment. Periodic pre-deployment testing will be performed to ensure that functional and performance requirements are met – this testing will be especially important when multiple vendors are involved so that progress (interoperability and adherence to requirements and design) can be assessed and verified throughout the pre-deployment collaboration process.

[5] Transit Street Design Guide – Active Transit Signal Priority. National Association of City Transportation Officials. https://nacto.org/publication/transit-street-design-guide/intersections/signals-operations/active-transit-signal-priority/.

Risk: Devices procured from different vendors may not be interoperable out-of-the-box.

Mitigation: As stated above, all devices that are deployed are expected to be interoperable and should adhere to the standards that have been identified. As stated above, all deployed devices are expected to be OmniAir Certified at the time of deployment. Hardware vendors and integrators may need to make modifications to ensure that standards are being interpreted in the same manner so that interoperability can be achieved. Testing will be especially important in instances where multiple vendors are involved so that progress (interoperability and adherence to requirements and design) can be assessed and verified throughout the pre-deployment collaboration process. To improve the likelihood of successful deployment, evidence of successful interoperability testing will be expected to be provided (along with any relevant demonstrations) from vendors prior to deployment. Specific tests (defined through the DriveOhio program) will be followed to ensure that any hardware follows the SAE published standards. At a minimum, this will include validation that SAE J2735, J2945/0, and J2945/1, including RF signal quality, are being followed.

Risk: There are several other data flows that are not capable of being defined at this time, such as the school zone signal indicator, network communications metadata, performance measures, and performance measure parameters.

Mitigation: The selected vendor will have to work with the project team to enable these data flows once there is enough information available to specify those data flows. A feedback loop between vendors and the project team is one mitigation strategy that could be employed to ensure system interfaces are ultimately designed in a fashion that allows the system to operate as intended adhering to relevant ITS standards, as appropriate.

1.2. PURPOSE

The purpose of this ICD is to capture and document the necessary information required to define the interfaces for the Smart Columbus Connected Vehicle Environment. The purpose of this ICD is to clearly communicate all possible inputs and outputs for all potential actions whether they are internal to the system or transparent to system users. The intended audience for this document is system engineers, system architects and developers.

The document describes the purpose of each interface between system entities within the system of interest or between the system of interest and an external interface, message structure and protocol, size and frequency of transmission of data, security, timing and sequencing.

1.3. RELATED DOCUMENTS

To enable the realization of a successful Connected Vehicle Environment, the systems engineering process is being utilized. To this end, a Concept of Operations and System Requirements Specification have been developed. The project team has held webinars corresponding to the release of each document to formally present information to the public and external stakeholders and to receive feedback on information in each document. Also, this Interface Control Document is directly referenced in the Request for Proposals that have been issued for the procurement, development, configuration, installation, test, and maintenance of the in-vehicle and roadside components that comprise the CVE (in the case of private vehicles this includes the possible removal of equipment). The list of related documents is summarized in the list below.

- Smart Columbus – Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program (8/7/18) https://smart.columbus.gov/uploadedFiles/Projects/Connected%20Vehicle%20ConOps%208.30.18.pdf
- Smart Columbus Connected Vehicle Environment Concept of Operations Webinar (7/25/18)
- Presentation: https://smart.columbus.gov/uploadedFiles/Projects/180720_CV%20Environment%20ConOps%20Webinar_Final%20(2).pdf
- Webinar Recording: https://itsa.adobeconnect.com/_a932559885/p7axm0b2yle2?proto=true
- Smart Columbus – System Requirements for Connected Vehicle Environment for the Smart Columbus Demonstration Program (11/30/18)
- https://smart.columbus.gov/uploadedFiles/Projects/SCC-B-SysReq-CVE-FINAL_wo%20lines.pdf
- Smart Columbus Connected Vehicle Environment System Requirements Webinar (11/5/18)
- Presentation:https://smart.columbus.gov/uploadedFiles/Projects/18_11_05_CVE_SyRS_Webinar_slides_PDF.PDF
- Webinar Recording: https://itsa.adobeconnect.com/_a932559885/psnntx55r2jt/?proto=true
- Request for Proposals for Connected Vehicle Environment In-Vehicle System Integration (RFQ011270) (1/29/19)
- Request for Proposals for Connected Vehicle Environment Infrastructure System Integration (RFQ011273) (1/29/19)

Chapter 2. System Description

2.1. FUNCTIONAL SYSTEM OVERVIEW

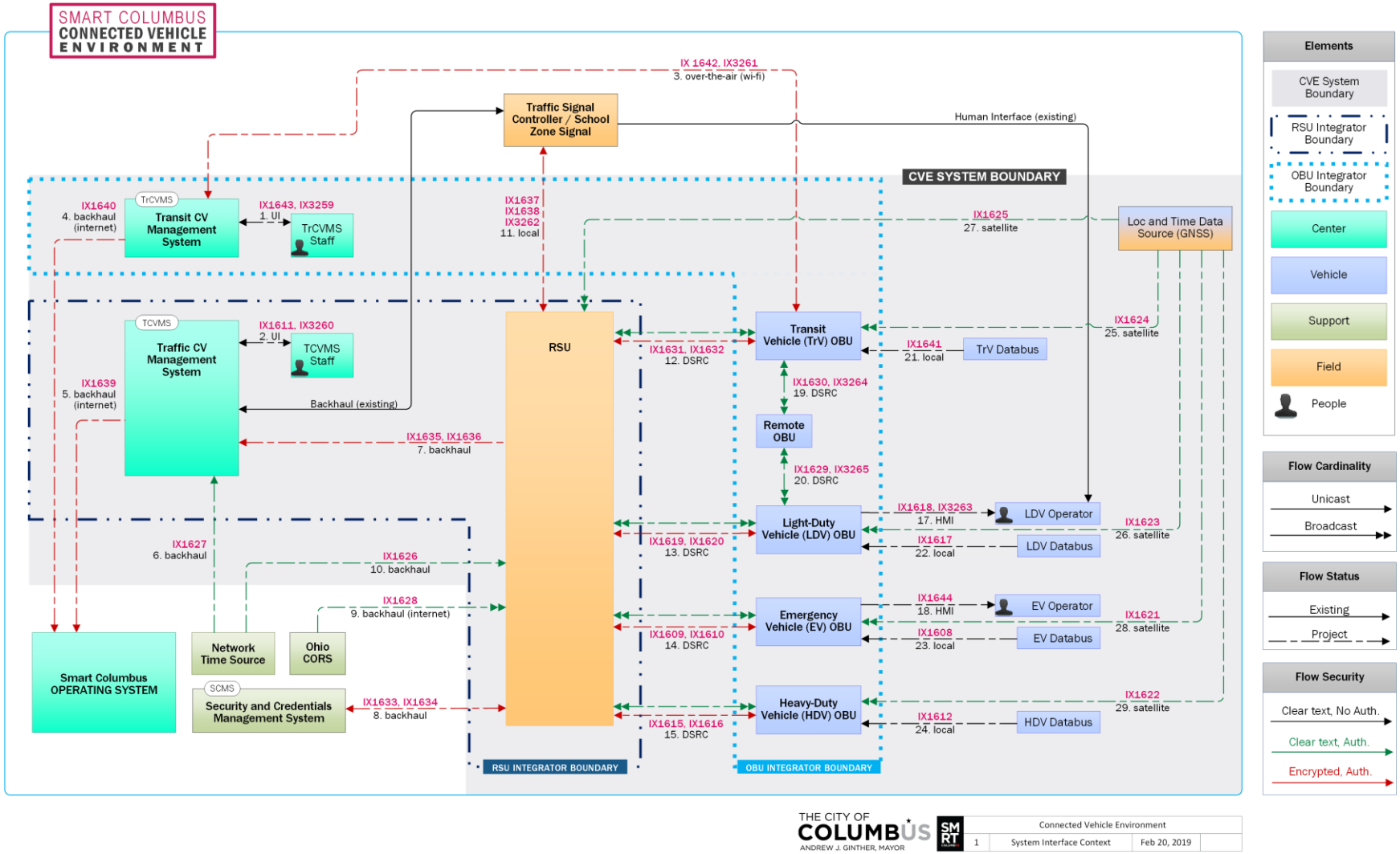
The CVE can be described as a combination of subsystems that work together: a system of roadside equipment, a system of in-vehicle equipment, and a system of backhaul networks for agency data. On the roadside, the fundamental functions of the RSUs are to obtain several types of status information from roadside ITS devices and broadcast this information to vehicles in the vicinity.

Subsequently, in a vehicle, the fundamental functions of OBUs are to obtain various types of status information from the vehicle and broadcast this information to other vehicles and infrastructure in the vicinity. The OBU may utilize status information from the vehicle (this includes interfaces with other in-vehicle devices deployed as part of the Smart Columbus program), other OBU-equipped vehicles, the roadside, and location and time data (obtained from a location and time source), such as Global Navigation Satellite System (GNSS) to support safety and mobility applications. Similarly, the RSU exchanges information with the roadside ITS equipment, OBU-equipped vehicles, and location and time data to support mobility applications. Note that internal processes on OBUs and RSUs (that allow applications to function as intended) will be elaborated upon in the System Design Document. OBUs will be comprised of DSRC radios, and depending on their applications, may include a Human Machine Interface (HMI) and/or connect to vehicle data systems. Both the OBU and RSU utilize the Security and Credentials Management System (SCMS) to make sure that it is working with data from trusted sources, and the roadside device saves operational data on the Smart Columbus Operating System (Operating System).

Figure 1 shows Vehicle-to-Infrastructure (V2I) communication between vehicles and roadside devices (via DSRC); communication between roadside devices and data management systems (via backhaul); and Vehicle-to-Vehicle (V2V) communication between onboard devices (via DSRC). As described earlier, the system will be procured in two separate efforts – with a system integrator responsible for deploying the portion of the CVE in vehicles, and a system integrator responsible for deploying the portion of the CVE on the roadside. The blue and orange boundaries on the diagram indicate the portions of the system each integrator is responsible for. All objects that fall outside of this boundary are external systems. Regarding communications that occur over the boundary between these two systems (Interfaces 12, 13, 14, and 15 – DSRC between RSU and OBUs), vendors will be subject to testing throughout the pre-deployment collaboration process to assess interoperability and adherence to requirements and design.

Due to the discontinuation of the Data Assisted Truck Platooning Project, the interface between the HDV OBU and the Platooning Provider Central Management System (Interface 16) is no longer indicated on the system diagram. To remain consistent with previous documentation other interfaces will continue to be numbered the same. It is important to note that a non-platooning based Freight Signal Priority will continue to be implemented as part of the CVE.

Figure 1: Physical View of the Smart Columbus Conneted Vehicle Environment



Source: City of Columbus

2.2. LIST OF INTERFACES

Table 3 provides a summary of the interfaces that are contained in the CV Environment. They correspond to the numbers shown on the interfaces in **Figure 1**. The Interface ID corresponds to the list of interface IDs that were developed in the System Requirements document. The Source Element and Destination Element columns provide the names of the elements on each "end" of the interface. Note that each interface may be broken up into multiple parts to differentiate between the directionality of data flows. The Data Flow column provides the names of data flows that flow between the listed Source Element and Destination Element. Finally, the Communications Media columns specifies the basis for a communications solution that will satisfy the data flow and establish a baseline for communications interoperability. Sequence diagrams that detail data exchanges that occur over each interface to support each application and system function are provided in **Chapter 3**. Only the data flows that are shown in the summary table for a given interface will be found on the sequence diagram for that given interface. Communications profiles for data flowing over external interfaces or between the OBU and the RSU subsystems are specified in **Chapter 4**. Each data flow is described and details are provided for required data elements that are included in the data flow. As stated above, due to the discontinuation of the Data Assisted Truck Platooning Project, the interface between the HDV OBU and the Platooning Provider Central Management System (Interface 16) is no longer indicated on the system diagram. To keep consistent the various systems engineering documents associated with the CVE, Interface 16 is intentionally omitted, and the remaining interface numbering remains the same.

The DSRC spectrum is divided into seven 10Mhz channels over which message exchanges occur along with a 5MHz guard band. In an effort to manage the spectrum, communications are expected to occur over a specified channel depending on the type of message being sent and its purpose. The channel map provided in **Table 2** specifies the DSRC channels over which each message type is expected to flow. Channel 178 is standardized in that it provides an "advertisement" to specify communications that occur over other channels in the spectrum (172, 174, 176, 180, 182, 184). Though not standardized, use of these channels is defined in a fashion that is consistent with channel use conventions employed in other implementations of CV technology.

Table 2: Channel Map for DSRC Messages

Channel	Message	Description
172	BSM, MAP, SPAT, RTCM, RSM	Continuous Mode - Safety Channel
174	SRM, SSM	Support for signal priority and preempt
176	SCMS (IPv6)	SCMS Services
178	WSA	Advertisement for SRM, SSM, OTA Updates and SCMS
180	Unused	-
182	OTA Updates	OTA Firmware Updates
184	Unused	Emergency / Public Safety Allocated

Source: City of Columbus

Table 3: Smart Columbus CV Environment High-Level Interface Overview

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX1643-V01 • CVE-IF1277-V01 • CVE-IF1473-V01	Interface 1.1	TrCVMS	TrCVMS Staff	• CV transit operational administrative coordination: o Archive data and query responses	N/A (user interface)
• CVE-IX3259-V01 • CVE-IF1277-V01	Interface 1.2	TrCVMS Staff	TrCVMS	• CV transit operational administrative coordination: o Transit vehicle interaction event data parameters o Archived data query	
• CVE-IX3260-V01 • CVE-IF3044-V01	Interface 2.1	TCVMS	TCVMS Staff	• CV traffic operations and administrative coordination: o Archived Data Return o Performance Measure o RSU Status (DSRC Channel Traffic/Utilization, RSU Transmit Power, etc.) o RSU Limited Connectivity Alert o RSU Channel Congestion Alert o Cabinet Tamper Status o Cabinet Tamper Alert o OBU Tamper Alert o Unauthorized Access Alert	N/A (user interface)
• CVE-IX1611-V01 • CVE-IF3044-V01	Interface 2.2	TCVMS Staff	TCVMS	• CV traffic operations and administrative coordination: o MAP Data o RSM Data o Signal Priority Authorization List o Archived Data Query o Performance Measure Parameters o Channel Congestion Parameter o RSU Status Query o Cabinet Status Query	

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX3261-V01 • CVE-IF3214-V01	Interface 3.1	TrCVMS	Transit Vehicle OBU (COTA Garage Communications)	• Transit Vehicle Interaction Event Data Parameters	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3, IEEE 802.11 • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
• CVE-IX1642-V01 • CVE-IF3214-V01	Interface 3.2	Transit Vehicle OBU (COTA Garage Communications)	TrCVMS	• Transit Vehicle Interaction Data	
• CVE-IX1640-V01 • CVE-IF1472-V01	Interface 4	TrCVMS	Smart Columbus Operating System	• Performance measures, (processed and PII-removed Transit Vehicle Interaction Events)	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: 802.3 • Security Plane: IEEE 1609.2

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX1639-V01	Interface 5	TCVMS	Smart Columbus Operating System	• Performance measures, (processed and PII-removed BSM, SRM, SSM, SPaT)	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: 802.3 • Security Plane: IEEE 1609.2
• CVE-IX1627-V01	Interface 6	Network Time Source	TCVMS	• Network Time Data	• Application Layer: IETF NTP • Transport Layer: IETF UDP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.3
• CVE-IX1635-V01	Interface 7.1	RSU	TCVMS	• All logged messages (BSM Part I and II, SPaT, SRM, SSM) • Priority Authorization Query • RSU Status (DSRC Channel Traffic/Utilization, RSU Transmit Power, etc.) • Cabinet Tamper Status • OBU Tamper Status • Network Communications Metadata	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX1636-V01 • CVE-IF1342-V01 • CVE-IF1341-V01	Interface 7.2	TCVMS	RSU	• Priority Authorization Result • MAP • RSM	• Network Layer: IETF IPv6/IETF IPv4 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
• CVE-IX1633-V01 • CVE-IF1354-V01 • CVE-IF1353-V01	Interface 8.1	RSU	SCMS	• RSU Enrollment Request • OBU Enrollment Request • RSU Application Certificate Request • OBU Pseudonym Certificate Request • Misbehavior Report	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS
• CVE-IX1634-V01 • CVE-IF1344-V01 • CVE-IF1354-V01	Interface 8.2	SCMS	RSU	• RSU Enrollment Certificate • OBU Enrollment Certificate • RSU Application Certificate • OBU Pseudonym Certificate • Revocation List	
• CVE-IX1628-V01 • CVE-IF1339-V01	Interface 9	Ohio CORS	RSU	• RTCM data	• ITS Application Information Layer: RTCM 10410.1 • Application Layer: HTTPS

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
					• Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
• CVE-IX1626-V01	Interface 10	Network Time Source	RSU	• Network Time Data	• Application Layer: IETF NTP • Transport Layer: IETF UDP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.3
• CVE-IX1637-V01 • CVE-IF1347-V01	Interface 11.1	RSU	Traffic Signal Controller	• SRM data (signal preemption request data)	• ITS Application Information Layer: NTCIP 1202-ASC • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IETF UDP, IETF TCP
• CVE-IX1638-V01 • CVE-IF1340-V01 • CVE-IF1345-V01 • CVE-IF1346-V01	Interface 11.2	Traffic Signal Controller	RSU	• SPaT data • SSM Data	

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
					• Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (local Ethernet) • Security Plane: IEEE 1609.2
• CVE-IX3262-V01	Interface 11.3	School Zone Signal	RSU	• School Zone Indicator (0/24V)	TBD
• CVE-IX1631-V01 • CVE-IF3247-V01 • CVE-IF1231-V01 • CVE-IF1235-V01 • CVE-IF1227-V01 • CVE-IF1238-V01 • CVE-IF2985-V01 • CVE-IF2978-V01	Interface 12.1	RSU	Transit Vehicle OBU	• SPaT • MAP • RTCM • SSM • RSM	• ITS Application Information Layer: SAE J2735_201603, SAE J2945 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2
• CVE-IX3262-V01 • CVE-IF3247-V01 • CVE-IF1250-V01 • CVE-IF1361-V01	Interface 12.2	Transit Vehicle OBU	RSU	• BSM (Part I) • SRM	
• CVE-IX1631-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	Interface 12.1	RSU	Transit Vehicle OBU	• OBU Enrollment Certificate • OBU Pseudonym Certificate • Revocation List	• Application Layer: IETF HTTP • Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER
• CVE-IX1632-V01 • CVE-IF3247-V01	Interface 12.2	Transit Vehicle OBU	RSU	• OBU Tamper Status • OBU Enrollment Request	

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IF1361-V01				• OBU Pseudonym Certificate Request • Misbehavior Report	• Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS
• CVE-IX1619-V01 • CVE-IF3247-V01 • CVE-IF1362-V01 • CVE-IF1361-V01	Interface 13.1	LDV OBU	RSU	• BSM (Part I)	• ITS Application Information Layer: SAE J2735_201603, SAE J2945 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
• CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1229-V01 • CVE-IF1240-V01 • CVE-IF1233-V01 • CVE-IF1225-V01 • CVE-IF1357-V01 • CVE-IF1358-V01 • CVE-IF1356-V01 • CVE-IF1360-V01	Interface 13.2	RSU	LDV OBU	• SPaT • MAP • RTCM • RSM	
• CVE-IX1619-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF1361-V01	Interface 13.1	LDV OBU	RSU	• OBU Tamper Status • OBU Enrollment Request • OBU Pseudonym Certificate Request • Misbehavior Report	• Application Layer: IETF HTTP

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF3210-V01	Interface 13.2	RSU	LDV OBU	• OBU Enrollment Certificate • OBU Pseudonym Certificate • Revocation List	• Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS
• CVE-IX1609-V01 • CVE-IF3247-V01 • CVE-IF1248-V01 • CVE-IF1251-V01 • CVE-IF1361-V01	Interface 14.1	EV OBU	RSU	• BSM (Part I) • SRM	• ITS Application Information Layer: SAE J2735_201603, SAE J2945 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
• CVE-IX1610-V01 • CVE-IF3247-V01 • CVE-IF1232-V01 • CVE-IF1236-V01 • CVE-IF1228-V01 • CVE-IF1239-V01 • CVE-IF2986-V01	Interface 14.2	RSU	EV OBU	• SPaT • MAP • RTCM • SSM	
• CVE-IX1609-V01 • CVE-IF3247-V01	Interface 14.1	EV OBU	RSU	• OBU Tamper Status • OBU Enrollment Request	• Application Layer: IETF HTTP

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IF1248-V01 • CVE-IF1361-V01				• OBU Pseudonym Certificate Request • Misbehavior Report	• Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS
• CVE-IX1610-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	Interface 14.2	RSU	EV OBU	• OBU Enrollment Certificate • OBU Pseudonym Certificate • Revocation List	
• CVE-IX1615-V01 • CVE-IF3247-V01 • CVE-IF1249-V01 • CVE-IF1363-V01 • CVE-IF1361-V01	Interface 15.1	HDV OBU	RSU	• BSM (Parts I and II) • SRM	• ITS Application Information Layer: SAE J2735_201603, SAE J2945 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
• CVE-IX1616-V01 • CVE-IF3247-V01 • CVE-IF1230-V01 • CVE-IF1234-V01 • CVE-IF1226-V01 • CVE-IF1237-V01 • CVE-IF1359-V01	Interface 15.2	RSU	HDV OBU	• SPaT • MAP • SSM • RTCM	
• CVE-IX1615-V01 • CVE-IF3247-V01	Interface 15.1	HDV OBU	RSU	• OBU Tamper Status • OBU Enrollment Request	Application Layer: IETF HTTP

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IF1361-V01				• OBU Pseudonym Certificate Request • Misbehavior Report	Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER Session Layer: IETF TLS Transport Layer: IETF TCP Network Layer: IETF IPv6 Data Link Layer: LLC and MAC Compatible with Physical and Network Physical Layer: IEEE 802.11p Security Plane: IEEE 1609.2, IETF TLS
• CVE-IX1616-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	Interface 15.2	RSU	HDV OBU	• OBU Enrollment Certificate • OBU Pseudonym Certificate • Revocation List	
• CVE-IX1618-V01 • CVE-IF3197-V01 • CVE-IF3019-V01 • CVE-IF1222-V01 • CVE-IF1246-V01	Interface 17.1	LDV OBU	LDV Operator	• Alert, Application Availability • System Status Information • Pending Updates • Power Status	N/A (human machine interface)
• CVE-IX3263-V01 • CVE-IF3019-V01	Interface 17.2	LDV Operator	LDV OBU	• OBU Start-Up Indication • Setting Adjustment	
• CVE-IX1644-V01 • CVE-IF1247-V01	Interface 18	EV OBU	EV Operator	• Signal Preempt Notification	N/A (human machine interface)
• CVE-IX3264-V01	Interface 19.1	Transit Vehicle OBU	Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)	• BSM (Part I)	• ITS Application Information Layer: SAE J2735_201603 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP
• CVE-IX1630-V01 • CVE-IF1224-V01	Interface 19.2	Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)	Transit Vehicle OBU	• BSM (Parts I and II)	

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
					• Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
• CVE-IX3265-V01 • CVE-IF1218-V01	Interface 20.1	LDV OBU	Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)	• BSM (Part I)	• ITS Application Information Layer: SAE J2735_201603 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
• CVE-IX1629-V01 • CVE-IF1220-V01 • CVE-IF1221-V01 • CVE-IF1219-V01 • CVE-IF1223-V01	Interface 20.2	Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)	LDV OBU	• BSM (Parts I and II)	
• CVE-IX1641-V01 • CVE-IF1244-V01 • CVE-IF1245-V01	Interface 21	Vehicle Databus	Transit Vehicle OBU	• CAN Bus Data (optional)	• Controller Area Network (CAN) – ISO 11898 • SAE J1939
• CVE-IX1617-V01	Interface 22	Vehicle Databus	LDV OBU	• CAN Bus Data (optional)	• Controller Area Network (CAN) – ISO 11898
• CVE-IX1608-V01	Interface 23	Vehicle Databus	EV OBU	• CAN Bus Data (optional)	• Controller Area Network (CAN) – ISO 11898
• CVE-IX1612-V01	Interface 24	Vehicle Databus	HDV OBU	• CAN Bus Data (optional)	• Controller Area Network (CAN) – ISO 11898 • SAE J1939

Related Interface Requirements	Reference	Source Element	Destination Element	Data Flow	Communications Media
• CVE-IX1624-V01	Interface 25	GNSS	Transit Vehicle OBU	• Location and Time Data	• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)
• CVE-IX1623-V01 • CVE-IF1242-V01	Interface 26	GNSS	LDV OBU	• Location and Time Data	• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)
• CVE-IX1625-V01 • CVE-IF1343-V01	Interface 27	GNSS	RSU	• Location and Time Data	• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)
• CVE-IX1621-V01	Interface 28	GNSS	EV OBU	• Location and Time Data	• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)
• CVE-IX1622-V01	Interface 29	GNSS	HDV OBU	• Location and Time Data	• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)

Source: City of Columbus

2.3. FACILITIES

The CVE requires access to external, public resources, including SCMS, CORS, Traffic CV Management System (TCVMS), Transit CV Management System (TrCVMS), and the Smart Columbus Operating System.

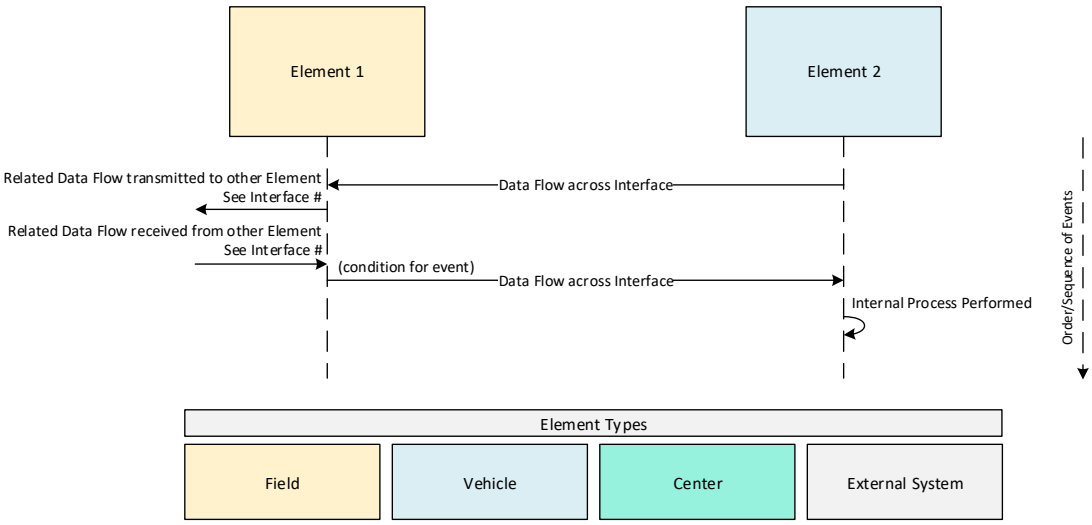
- A SCMS is designed to provide trusted, secure V2V and V2I communications. It employs highly innovative methods and encryption and certificate management techniques to ensure communications security between entities that previously have not encountered each other—but also wish to remain anonymous (as is the case when vehicle operators encounter each other on the road). This allows devices that have never encountered each other to have confidence that the data received is trustworthy. Certificates will be transmitted to RSUs via backhaul and to OBUs over the air via the RSU. At this time, the SCMS will be provided by a third-party, however, the interface for this service has been minimally defined. OBU and RSU integrators will be required to coordinate with the SCMS provider to enable system functions associated with the SCMS.
- The ODOT operators Continuously Operating Reference Station (CORS) will be used as a source of RTCM positions corrections data. This data allows GNSS location data to be corrected due to errors resulting from atmospheric conditions. This is an existing system for which interfaces are defined by the existing ODOT CORS.
- The Traffic CV Management System will receive messages that are captured by roadside equipment and allow Traffic CV Management staff to monitor activity on the network as well as the status of equipment deployed for the CVE. Traffic CV Management Staff can specify performance metrics (captured messages are processed to obtain near-real-time system operations and performance data) to improve their ability to manage traffic. Captured messages are filtered to remove PII and archived on the Operating System. This facility is part of the CVE and is developed by the RSU vendor. Its interfaces with other elements in the CVE will be the responsibility of the RSU vendor to develop as specified in this document
- The Transit CV Management System will receive Transit Vehicle Interaction Event Data. This event data is a concise representation of an event that would have resulted in a notification or warning issued to a transit vehicle operator. Transit CV Management Staff are responsible for adjusting parameters of the event data. This vehicle interaction data is received by the transit manager and is used to determine if outputs from a CV system could improve safety and to determine if the transit vehicle operator can handle such outputs without negatively impacting the transit vehicle operator's awareness of the roadway environment. Transit Vehicle Interaction Event Data is PII removed and archived on the Operating System. This facility is part of the CVE and is developed by the OBU vendor. Its interfaces with other elements in the CVE will be the responsibility of the OBU vendor to develop as specified in this document
- The Operating System is an open-source information portal for the Smart Columbus program where CVE performance data will be archived. It is expected that data stored on the Operating System will be free of PII. The Operating System will also serve as an outlet for CVE data for use in traffic/transit/freight/public safety management uses and filtered to calculate performance metrics that are stored on the Operating System. The Operating System is being developed and implemented in parallel with the CVE. The Operating System is expected to be developed using an agile process. During development, it will be essential for the OBU integrator and RSU integrator to coordinate with the SCMS development team to ensure the two systems are compatible.

Chapter 3. System Interfaces

This section provides sequence diagrams that indicate flows of events and message exchanges by each pair of objects to accomplish a given operation. A sequence diagram shows, for an interface, the events that external actors generate, and the internal processes and communications that occur to perform the operation that is described in the caption above each figure. It intends to allow a developer to better understand the flow of events that allow the system to operate as intended. A summary of data flows for each interface is provided in **Section 2.2**, and details regarding the content contained in each message is provided in **Chapter 4**.

Figure 2 provides a means for interpreting the sequence diagrams presented in this section. Each element is represented by a large rectangle at the top of the diagram and are colored according to the OBU/RSU Integrator System Boundary shown in **Figure 1** – Grey boxes represent objects external to the CVE. Events, messages exchanges, and internal processes occur in order, from top to bottom. Horizontal lines represent the exchange of messages over the indicated interface, with the name of the message exchange indicated in the center of the line. Any conditions placed on the message being sent are indicated along the horizontal line near the message source element. Internal processes are represented by loops and are defined and are described in text next to the loop. Messages sent to or received from other elements are represented by horizontal lines pointing away from or pointing in toward either element.

Figure 2: Sequence Diagram Legend

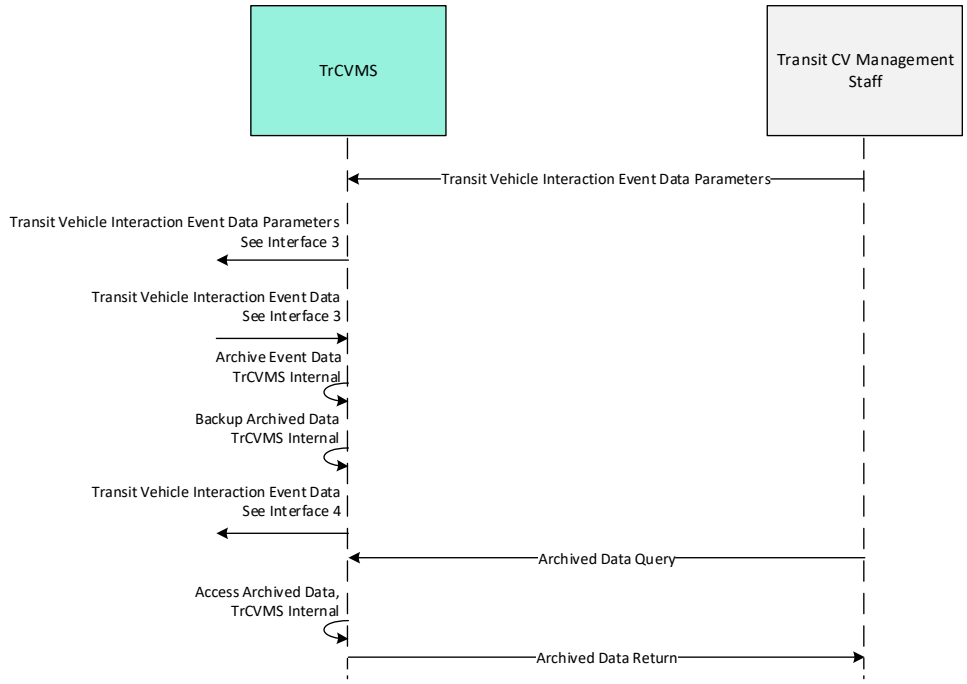


Source: City of Columbus

Interfaces in this section are ordered by number. Due to the discontinuation of the Data Assisted Truck Platooning project, Interface, 16 – between the HDV OBU and the Platooning Provider Central Management System – has been removed. To keep continuity between various systems engineering documents associated with the CVE, Interface 16 is intentionally omitted, and the remaining interface numbering will remain the same (this note is repeated at the beginning of the Interface 17 section). Decomposition of sequence diagrams for applications and system functions has been undertaken to provide an interface-by-interface view of the sequence of data exchanges and functions that support each application or function. This is expected to give the reader a better understanding of the sequence of events that support various portions of the system.

3.1. INTERFACE 1: TRANSIT CONNECTED VEHICLE MANAGEMENT SYSTEM – TRANSIT CV MANAGEMENT STAFF

Figure 3: Interface 1 Sequence Diagram – Transit Vehicle Interaction Event Recording



TrCVMS-Related Sequence Diagrams	TrCVMS Staff-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 4 → **Figure 13**	• *None*

Data Flow Communications Profiles

- **Table 6: Archived Data Query Communication Profile**
- **Table 7: Archived Data Return Communication Profile**
- **Table 50: Transit Vehicle Interaction Event Data Parameters Communication Profile**

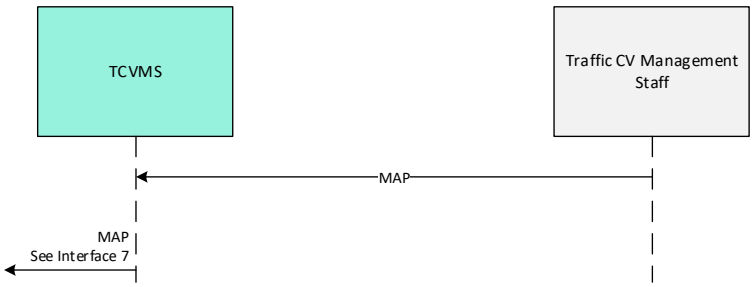
Interface Requirements Traceability

- CVE-IX1643-V01 CVE-IF1473-V01, CVE-IX3259-V01 CVE-IF1277-V01

Source: City of Columbus

3.2. INTERFACE 2: TRAFFIC CONNECTED VEHICLE MANAGEMENT SYSTEM – TRAFFIC CV MANAGEMENT STAFF

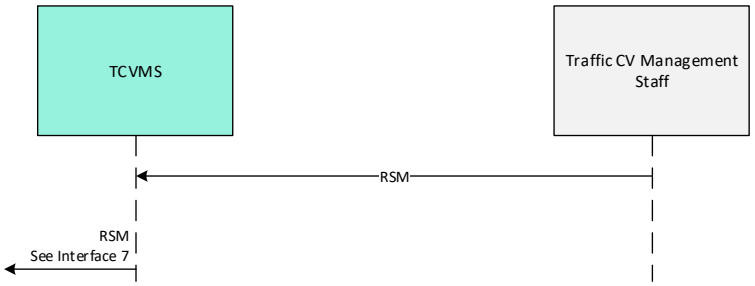
Figure 4: Interface 2 Sequence Diagram – Red Light Violation Warning and Signal Priority/Preemption



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 7 → **Figure 19**	• *None*
Data Flow Communications Profiles • **Table 15: MapData Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability • CVE-IX1611-V01	

Source: City of Columbus

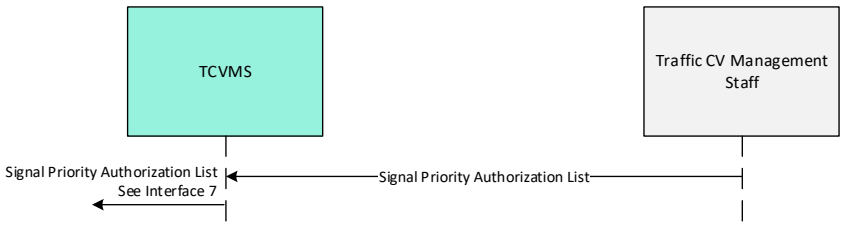
Figure 5: Interface 2 Sequence Diagram – Reduced Speed School Zone



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
Interface 7 → **Figure 20**	• *None*
Data Flow Communications Profiles • **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**	
Interface Requirements Traceability • CVE-IX1611-V01	

Source: City of Columbus

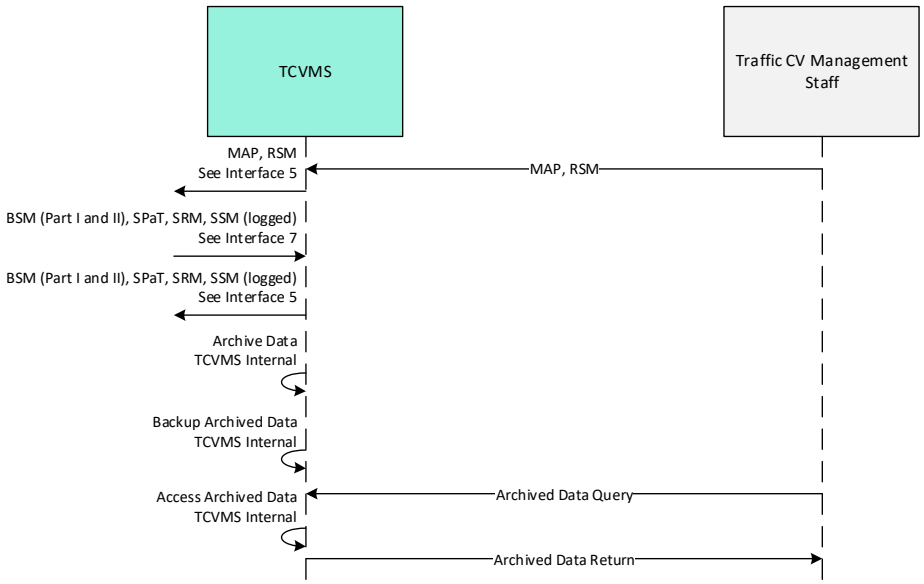
Figure 6: Interface 2 Sequence Diagram – Signal Priority/Preemption



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 7 → **Figure 18**	• *None*
Data Flow Communications Profiles • **Table 42: Signal Priority Authorization List Communication Profile**	
Interface Requirements Traceability • CVE-IX1611-V01	

Source: City of Columbus

Figure 7: Interface 2 Sequence Diagram – Vehicle Data for Traffic Operations



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 5 → **Figure 14** • Interface 7 → **Figure 17**	• *None*

Data Flow Communications Profiles

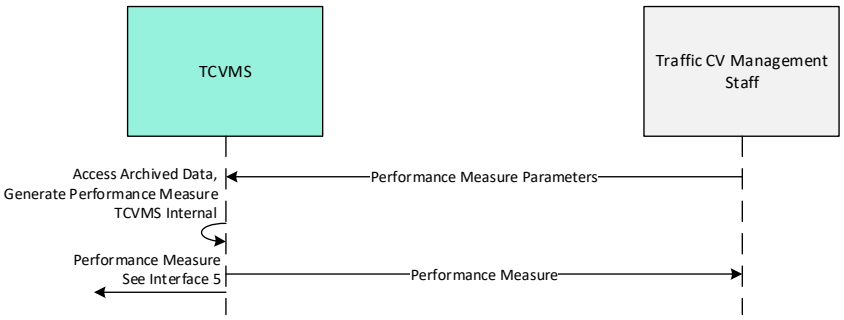
- **Table 6: Archived Data Query Communication Profile**
- **Table 7: Archived Data Return Communication Profile**
- **Table 15: MapData Message (SAE J2735) Communication Profile**
- **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**

Interface Requirements Traceability

- CVE-IX3260-V01 CVE-IF3044-V01, CVE-IX1611-V01

Source: City of Columbus

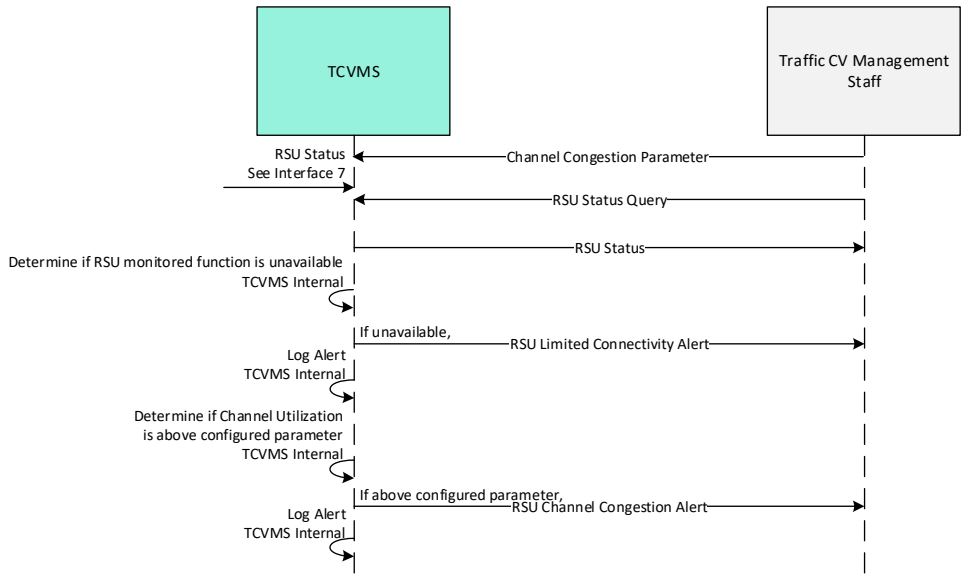
Figure 8: Interface 2 Sequence Diagram – System Performance Measurement



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 5 → **Figure 15**	• *None*
Data Flow Communications Profiles • **Table 25: Performance Measure Communication Profile** • **Table 26: Performance Measure Parameters Communication Profile**	
Interface Requirements Traceability • CVE-IX3260-V01 CVE-IF3044-V01, CVE-IX1611-V01	

Source: City of Columbus

Figure 9: Interface 2 Sequence Diagram – System Status: RSU Status



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 7 → **Figure 21**	• *None*

Data Flow Communications Profiles

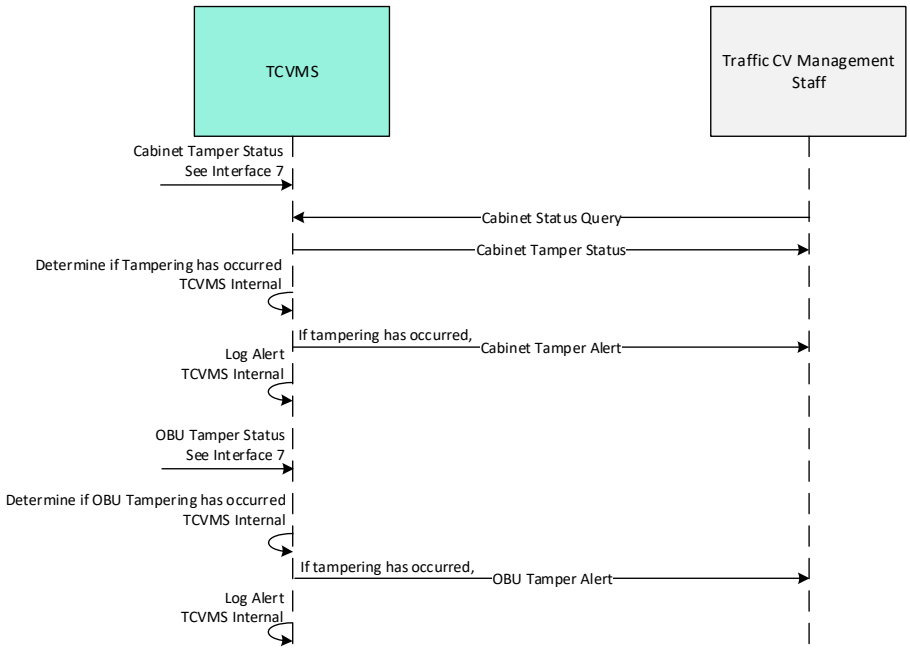
- **Table 14: Channel Congestion Parameter Communication Profile**
- **Table 33: RSU Channel Congestion Alert Communication Profile**
- **Table 34: RSU Limited Connectivity Alert Communication Profile**
- **Table 35: RSU Status Communication Profile**
- **Table 36: RSU Status Query Communication Profile**

Interface Requirements Traceability

- CVE-IX3260-V01 CVE-IF3044-V01, CVE-IX1611-V01

Source: City of Columbus

Figure 10: Interface 2 Sequence Diagram – System Status: Cabinet Status and OBU Status



TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 7 → **Figure 22**	• *None*

Data Flow Communications Profiles

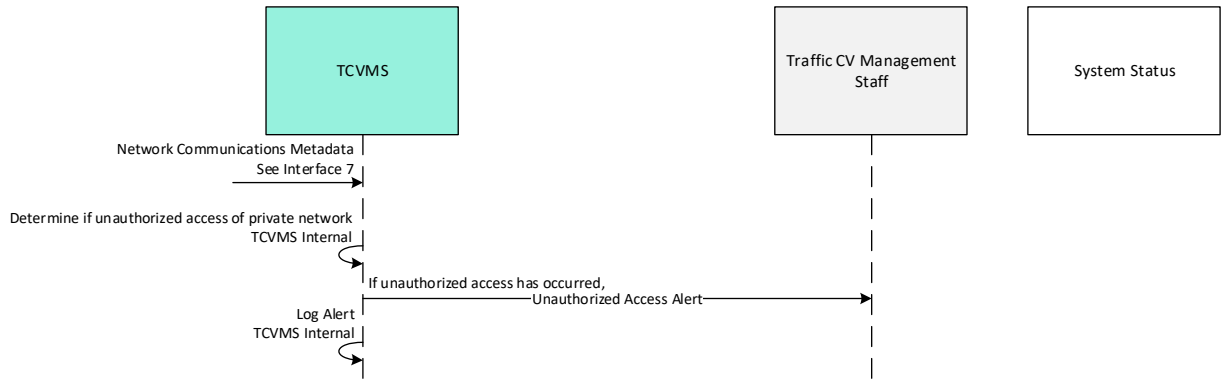
- **Table 10: Cabinet Status Query Communication Profile**
- **Table 11: Cabinet Tamper Alert Communication Profile**
- **Table 12: Cabinet Tamper Status Communication Profile**
- **Table 22: OBU Tamper Alert Communication Profile**

Interface Requirements Traceability

CVE-IX3260-V01 CVE-IF3044-V01, CVE-IX1611-V01

Source: City of Columbus

Figure 11: Interface 2 Sequence Diagram – System Status: Network Status

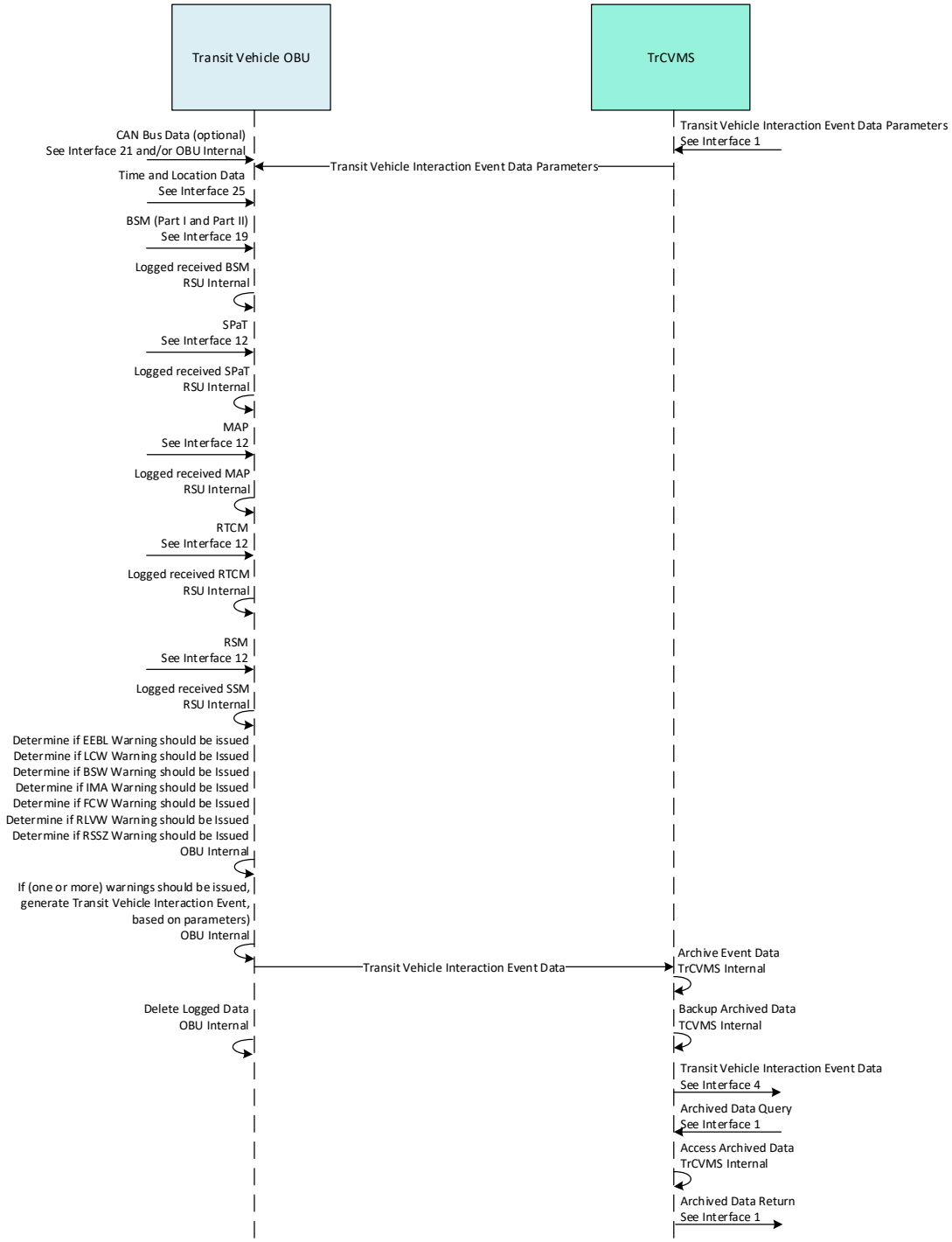


TCVMS-Related Sequence Diagrams	TCVMS Staff-Related Sequence Diagrams
• Interface 7 → **Figure 23**	• *None*
Data Flow Communications Profiles	
• **Table 51: Unauthorized Access Alert Communication Profile**	
Interface Requirements Traceability	
• CVE-IX3260-V01 CVE-IF3044-V01	

Source: City of Columbus

3.3. INTERFACE 3: TRANSIT VEHICLE ONBOARD UNIT – TRANSIT CONNECTED VEHICLE MANAGEMENT SYSTEM

Figure 12: Interface 3 Sequence Diagram – Transit Vehicle Interaction Event Recording

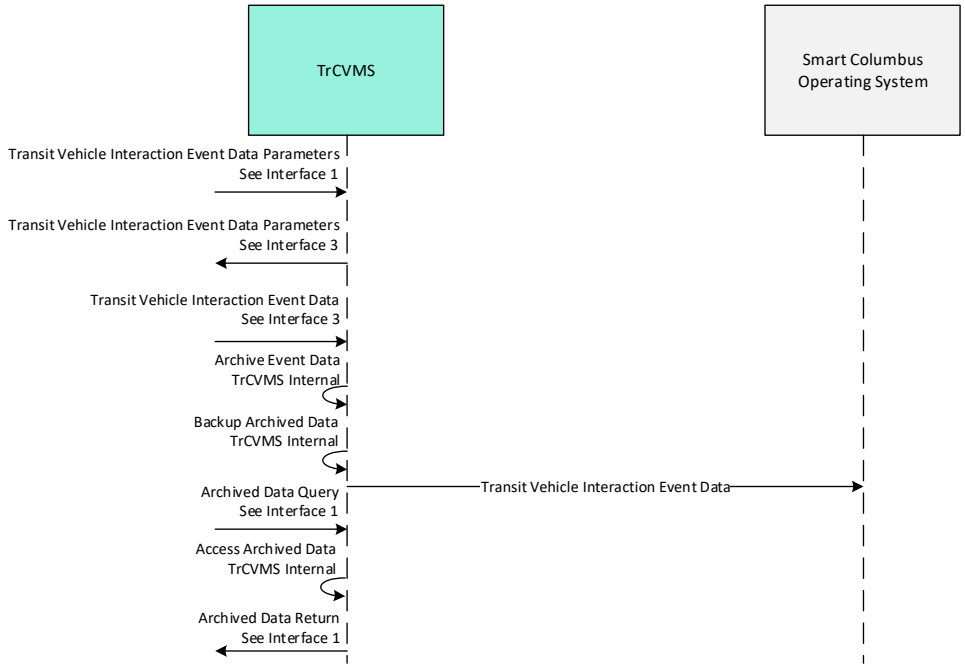


Transit Veh OBU-Related Sequence Diagrams • Interface 12 → **Figure 35**, **Figure 36** • Interface 19 → **Figure 62** • Interface 21 → **Figure 66**, **Figure 67**, **Figure 68**, • Interface 25 → **Figure 82, Figure 83**, **Figure 84**	**TrCVMS-Related Sequence Diagrams** • Interface 1 → **Figure 3** • Interface 4 → **Figure 13**
Data Flow Communications Profiles • **Table 49: Transit Vehicle Interaction Event Data Communication Profile** • **Table 50: Transit Vehicle Interaction Event Data Parameters Communication Profile**	
Interface Requirements Traceability • CVE-IX3261-V01 CVE-IF3214-V01, CVE-IX1642-V01	

Source: City of Columbus

3.4. INTERFACE 4: TRANSIT CONNECTED VEHICLE MANAGEMENT SYSTEM – SMART COLUMBUS OPERATING SYSTEM

Figure 13: Interface 4 Sequence Diagram – Transit Vehicle Interaction Event Recording

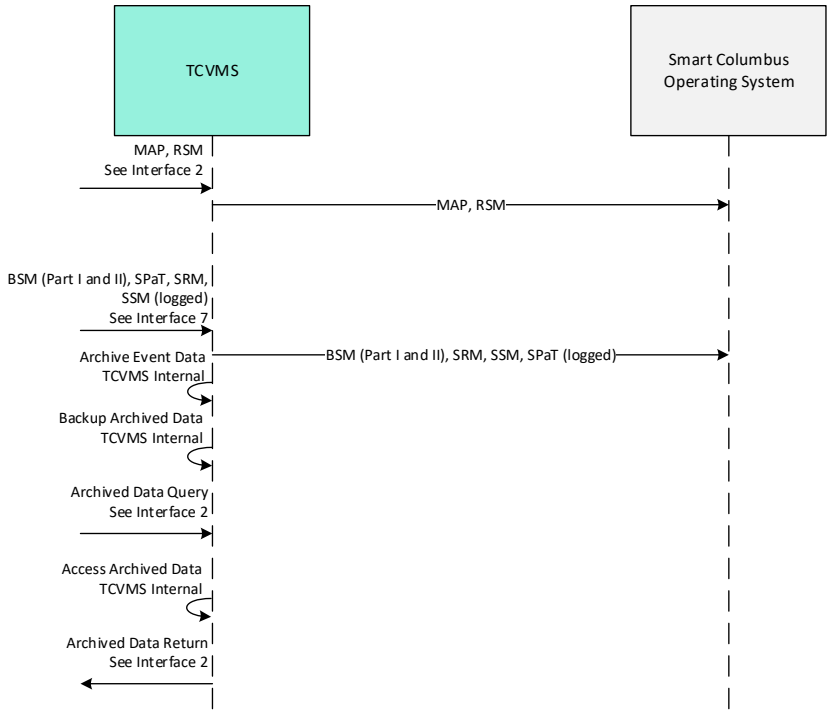


TrCVMS-Related Sequence Diagrams	Operating System-Related Sequence Diagrams
• Interface 1 → **Figure 3** • Interface 3 → **Figure 12**	• *None*
Data Flow Communications Profiles • **Table 49: Transit Vehicle Interaction Event Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1640-V01, CVE-IF1472-V01	

Source: City of Columbus

3.5. INTERFACE 5: TRAFFIC CONNECTED VEHICLE MANAGEMENT SYSTEM – SMART COLUMBUS OPERATING SYSTEM

Figure 14: Interface 5 Sequence Diagram – Vehicle Data for Traffic Operations



TCVMS-Related Sequence Diagrams	Operating System-Related Sequence Diagrams
• Interface 2 → **Figure 7** • Interface 7 → **Figure 17**	• *None*

Data Flow Communications Profiles

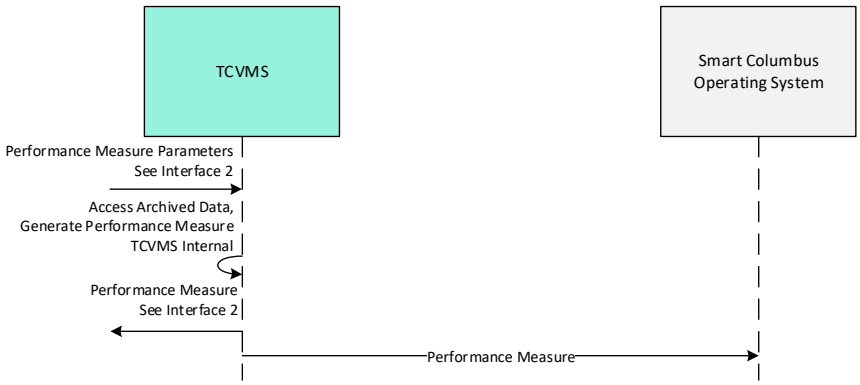
- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile**
- **Table 15: MapData Message (SAE J2735) Communication Profile**
- **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**
- **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile**
- **Table 43: Signal Request Message (SAE J2735) Communication Profile**
- **Table 45: Signal Status Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1639-V01

Source: City of Columbus

Figure 15: Interface 5 Sequence Diagram – System Performance Measurement

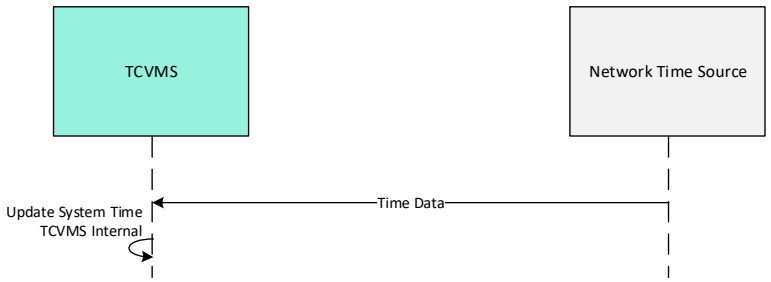


TCVMS-Related Sequence Diagrams	Operating System-Related Sequence Diagrams
• Interface 2 → **Figure 8**	• *None*
Data Flow Communications Profiles • **Table 25: Performance Measure Communication Profile**	
Interface Requirements Traceability • CVE-IX1639-V01	

Source: City of Columbus

3.6. INTERFACE 6: TRAFFIC CONNECTED VEHICLE MANAGEMENT SYSTEM – NETWORK TIME SOURCE

Figure 16: Interface 6 Sequence Diagram – Traffic Connected Vehicle Management System Time Synchronization

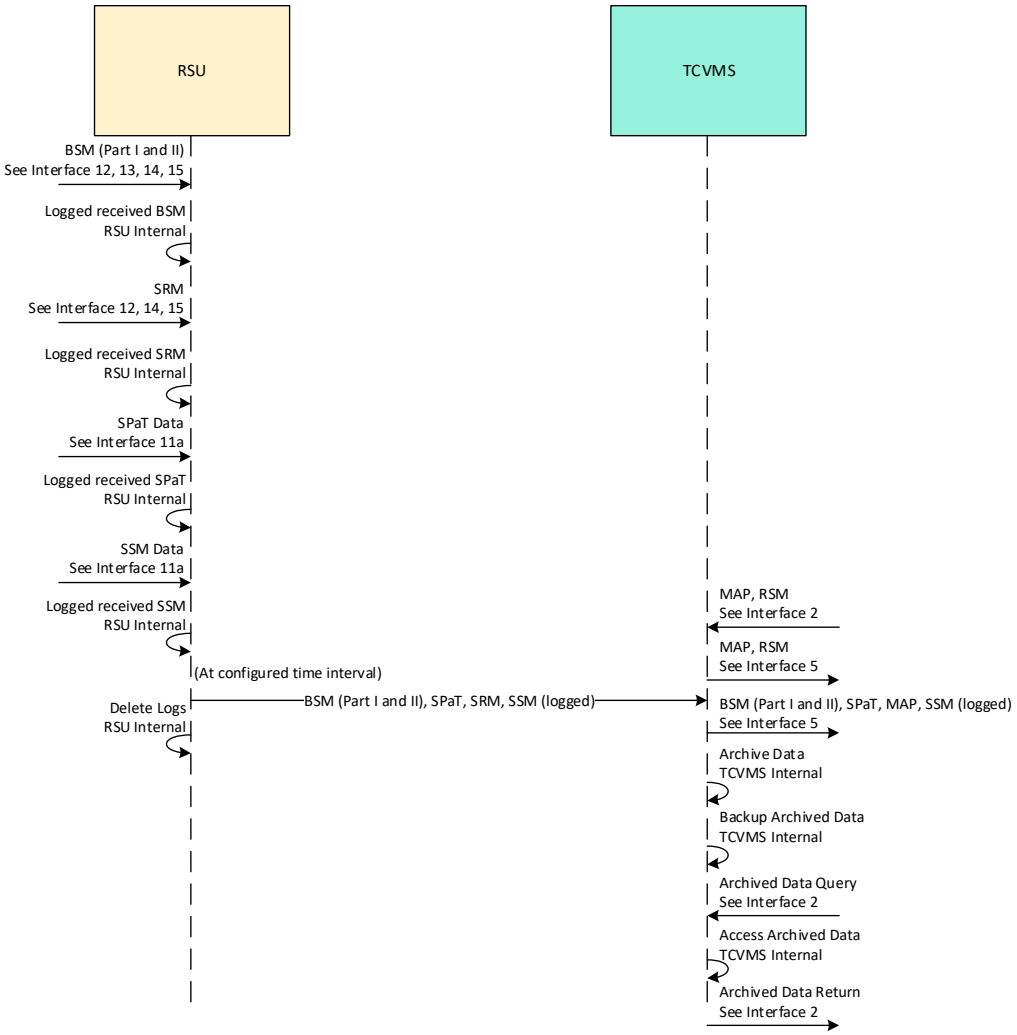


TCVMS-Related Sequence Diagrams	NTS-Related Sequence Diagrams
• *None*	• *None*
Data Flow Communications Profiles	
• **Table 48: Time Data Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1627-V01	

Source: City of Columbus

3.7. INTERFACE 7: ROADSIDE UNIT – TRAFFIC CONNECTED VEHICLE MANAGEMENT SYSTEM

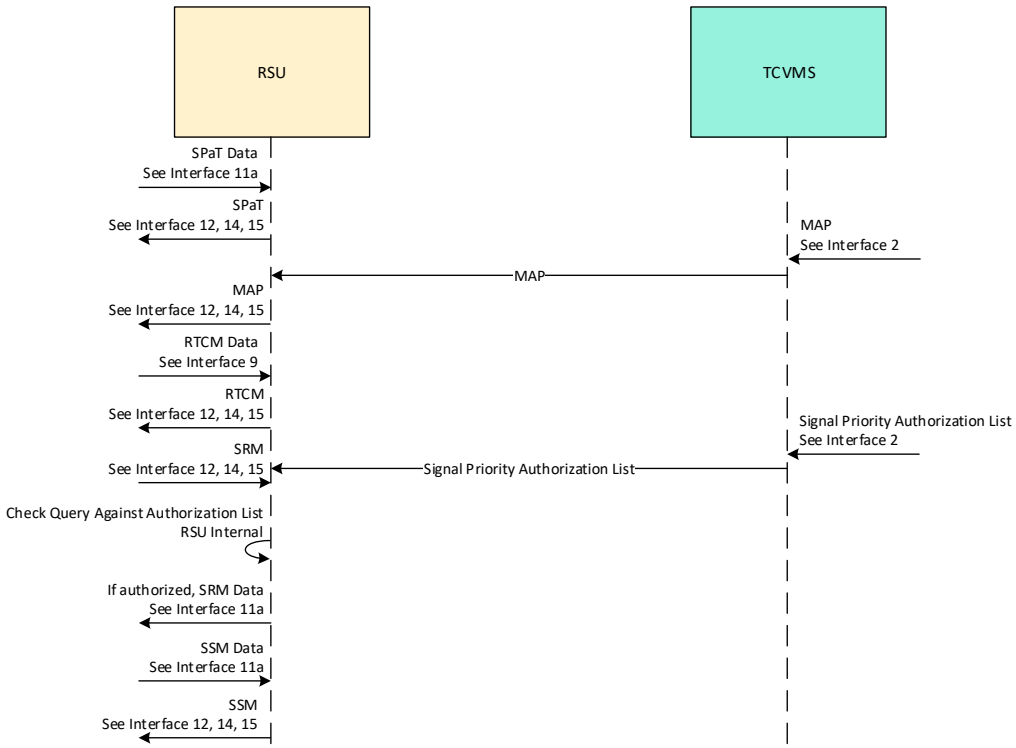
Figure 17: Interface 7 Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
• Interface 11a → **Figure 31** • Interface 12 → **Figure 37** • Interface 13 → **Figure 43** • Interface 14 → **Figure 48** • Interface 15 → **Figure 53**	• Interface 2 → **Figure 7** • Interface 5 → **Figure 14**
Data Flow Communications Profiles • **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile** • **Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile** • **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile** • **Table 43: Signal Request Message (SAE J2735) Communication Profile** • **Table 45: Signal Status Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability CVE-IX1635-V01	

Source: City of Columbus

Figure 18: Interface 7 Sequence Diagram – Signal Priority/Preemption



RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
Interface 9 → **Figure 28** Interface 11a → **Figure 32** Interface 12 → **Figure 34** Interface 14 → **Figure 47** Interface 15 → **Figure 52**	Interface 2 → **Figure 6**

Data Flow Communications Profiles

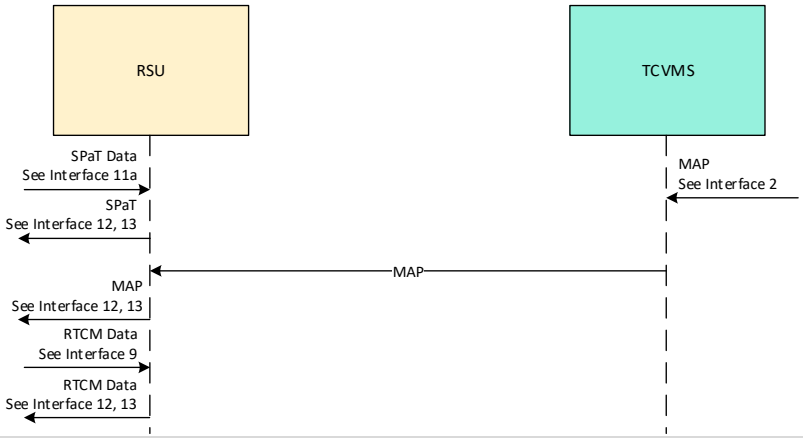
- **Table 15: MapData Message (SAE J2735) Communication Profile**
- **Table 42: Signal Priority Authorization List Communication Profile**

Interface Requirements Traceability

- CVE-IX1636-V01
- CVE-IF1342-V01

Source: City of Columbus

Figure 19: Interface 7 Sequence Diagram – Red Light Violation Warning



RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
Interface 9 → **Figure 26** Interface 11a → **Figure 30** Interface 12 → **Figure 35** Interface 13 → **Figure 41**	Interface 2 → **Figure 4**

Data Flow Communications Profiles

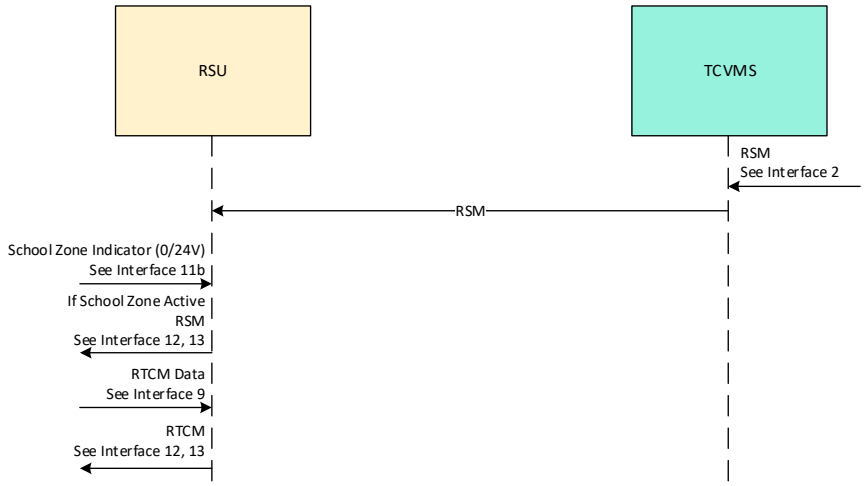
- **Table 15: MapData Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1636-V01
- CVE-IF1342-V01

Source: City of Columbus

Figure 20: Interface 7 Sequence Diagram – Reduced Speed School Zone



RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
Interface 9 → **Figure 27** Interface 11b → **Figure 33** Interface 12 → **Figure 36** Interface 13 → **Figure 42**	Interface 2 → **Figure 5**

Data Flow Communications Profiles

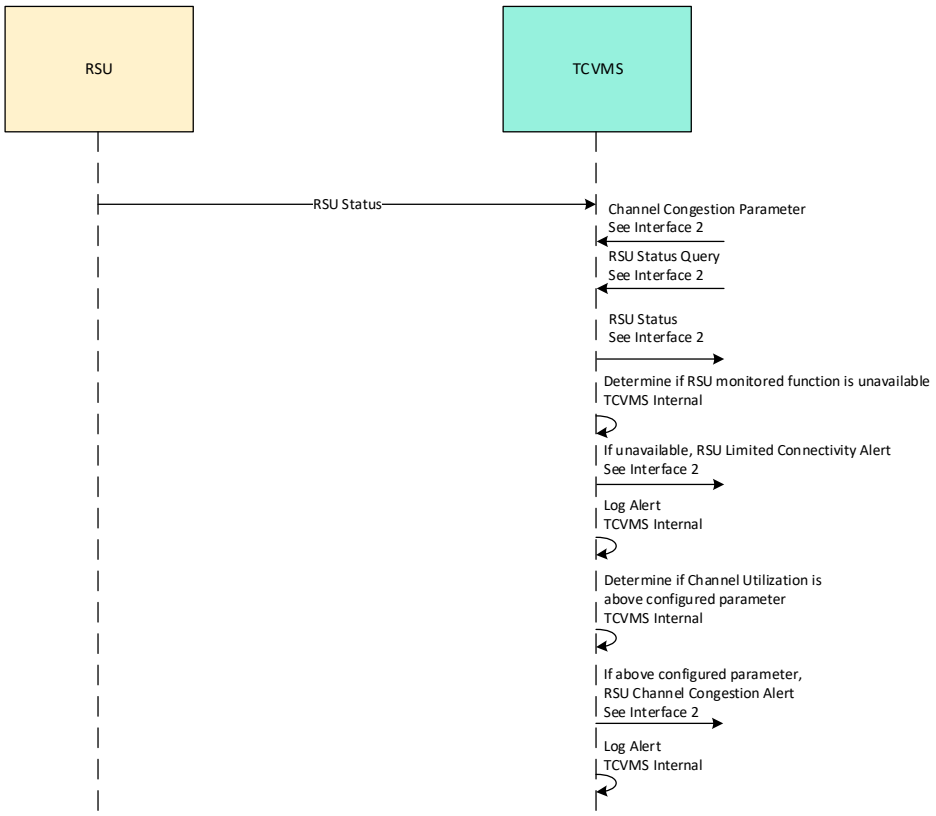
- **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**

Interface Requirements Traceability

- CVE-IX1636-V01
- CVE-IF1341-V01

Source: City of Columbus

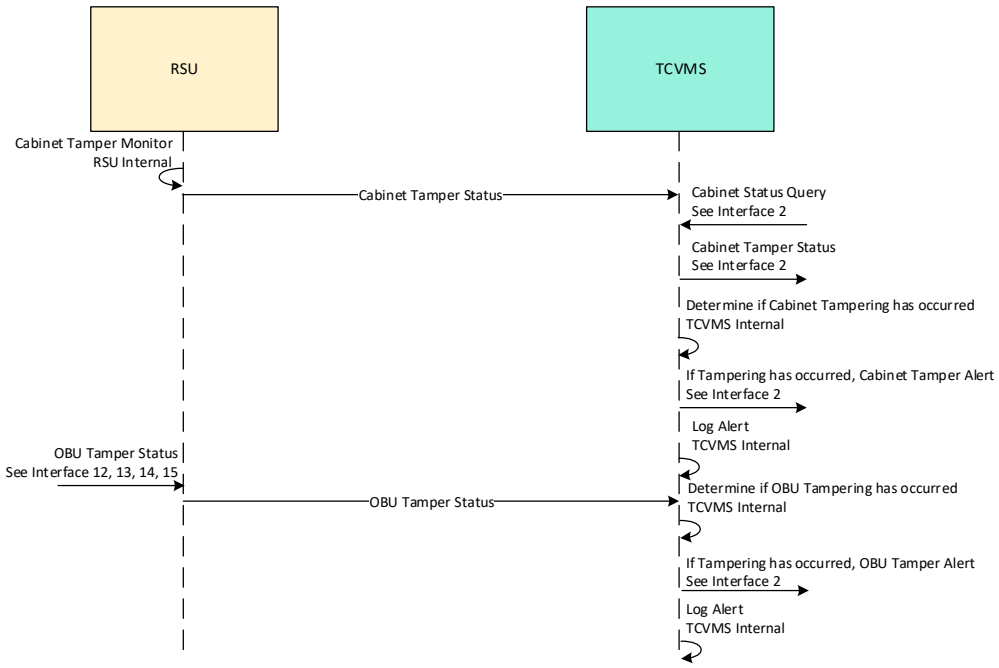
Figure 21: Interface 7 Sequence Diagram – System Status: Roadside Unit Status



RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
• *None*	• Interface 2 → **Figure 9**
Data Flow Communications Profiles • **Table 35: RSU Status Communication Profile**	
Interface Requirements Traceability • CVE-IX1635-V01	

Source: City of Columbus

Figure 22: Interface 7 Sequence Diagram – System Status: Cabinet and Onboard Unit Status



RSU-Related Sequence Diagrams

- Interface 12 → **Figure 40**
- Interface 13 → **Figure 46**
- Interface 14 → **Figure 51**
- Interface 15 → **Figure 56**

TCVMS-Related Sequence Diagrams

- Interface 2 → **Figure 10**

Data Flow Communications Profiles

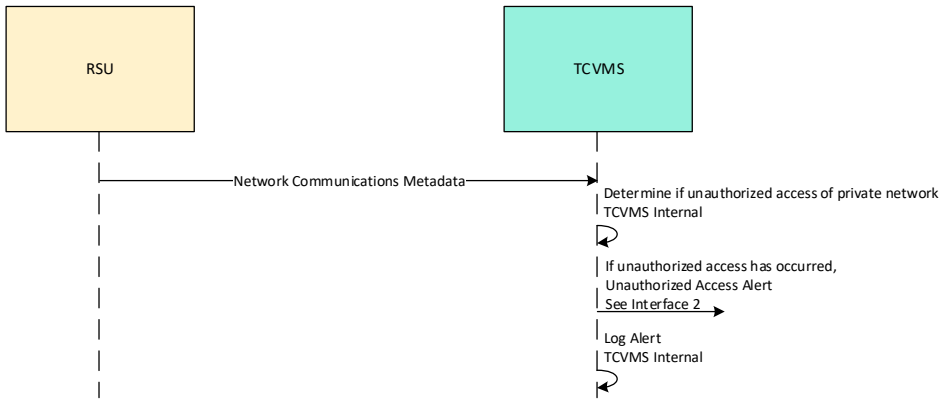
- **Table 12: Cabinet Tamper Status Communication Profile**
- **Table 23: OBU Tamper Status Communication Profile**

Interface Requirements Traceability

- CVE-IX1635-V01

Source: City of Columbus

Figure 23: Interface 7 Sequence Diagram – System Status: Network Status

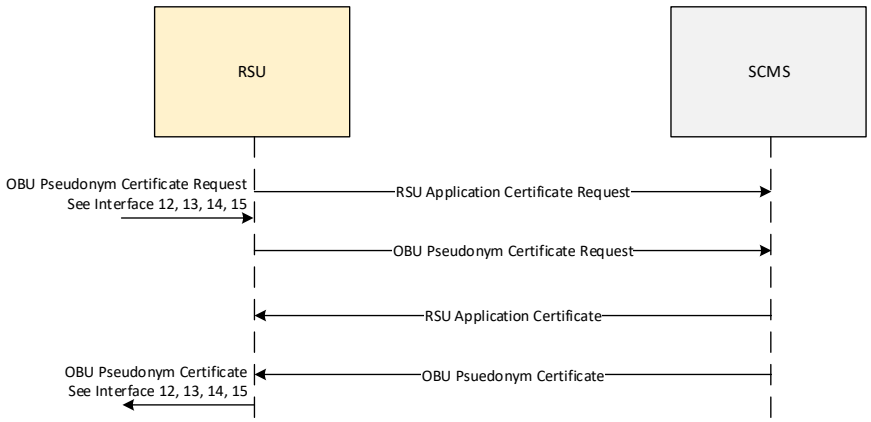


RSU-Related Sequence Diagrams	TCVMS-Related Sequence Diagrams
• *None*	• Interface 2 → **Figure 11**
Data Flow Communications Profiles	
• **Table 17: Network Communications Metadata Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1635-V01	

Source: City of Columbus

3.8. INTERFACE 8: ROADSIDE UNIT – SECURITY AND CREDENTIALS MANAGEMENT SYSTEM

Figure 24: Interface 8 Sequence Diagram – Wireless Communications Security: RSU Application Certificates and OBU Pseudonym Certificates



RSU-Related Sequence Diagrams	SCMS-Related Sequence Diagrams
• Interface 12 → **Figure 38** • Interface 13 → **Figure 44** • Interface 14 → **Figure 49** • Interface 15 → **Figure 54**	• *None*

Data Flow Communications Profiles

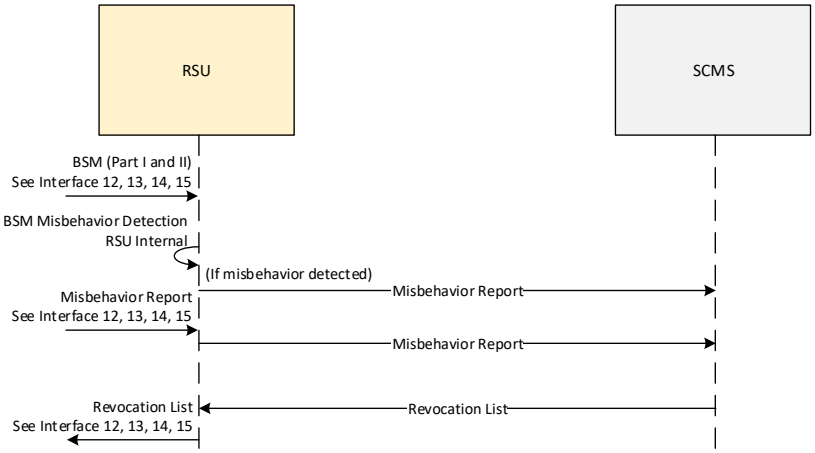
- **Table 19: OBU Pseudonym Certificate Communication Profile**
- **Table 20: OBU Pseudonym Certificate Request Communication Profile**
- **Table 31: RSU Application Certificate Communication Profile**
- **Table 32: RSU Application Certificate Request Communication Profile**

Interface Requirements Traceability

- CVE-IX1633-V01
- CVE-IF1354-V01
- CVE-IF1353-V01
- CVE-IX1634-V01
- CVE-IF1344-V01

Source: City of Columbus

Figure 25: Interface 8 Sequence Diagram – Wireless Communications Security: Roadside Unit Misbehavior Detection, Misbehavior Reporting and Revocation List



RSU-Related Sequence Diagrams	SCMS-Related Sequence Diagrams
• Interface 12 → **Figure 39** • Interface 13 → **Figure 45** • Interface 14 → **Figure 50** • Interface 15 → **Figure 55**	• *None*

Data Flow Communications Profiles

- **Table 16: Misbehavior Report Communication Profile**
- **Table 29: Revocation List Communication Profile**

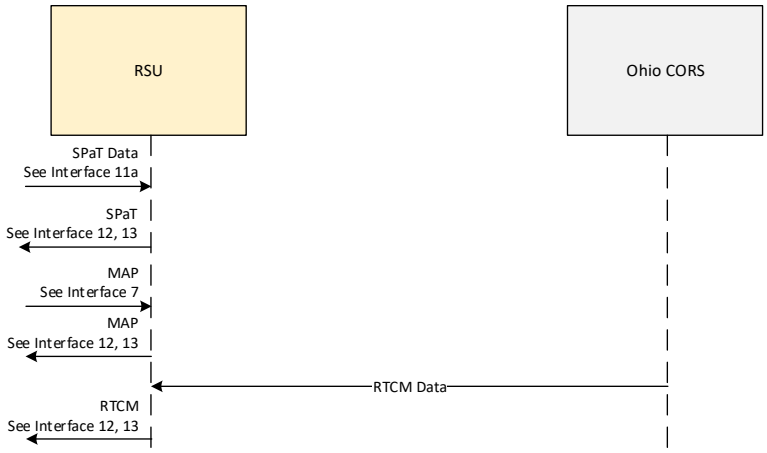
Interface Requirements Traceability

- CVE-IX1633-V01
- CVE-IF1354-V01
- CVE-IF1353-V01
- CVE-IX1634-V01
- CVE-IF1344-V01

Source: City of Columbus

3.9. INTERFACE 9: ROADSIDE UNIT – OHIO CONTINUOUSLY OPERATING REFERENCE STATION

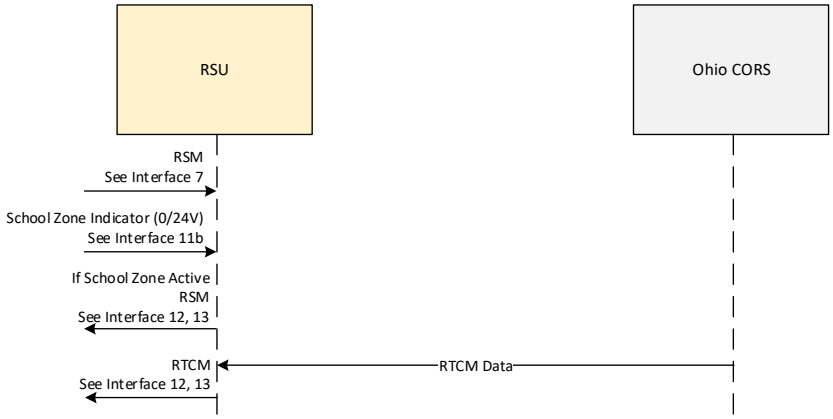
Figure 26: Interface 9 Sequence Diagram – Red Light Violation Warning



RSU-Related Sequence Diagrams	CORS-Related Sequence Diagrams
• Interface 7 → **Figure 19** • Interface 11a → **Figure 30** • Interface 12 → **Figure 35** • Interface 13 → **Figure 41**	• *None*
Data Flow Communications Profiles • **Table 37: RTCM Data (RTCM 10410.1) Communication Profile**	
Interface Requirements Traceability • CVE-IX1628-V01 • CVE-IF1339-V01	

Source: City of Columbus

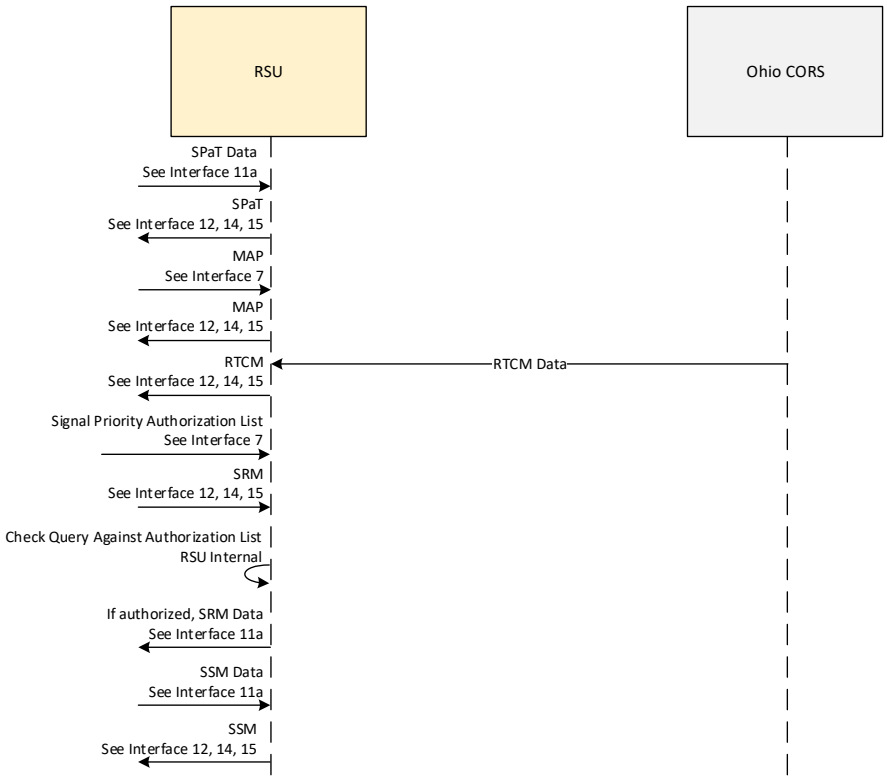
Figure 27: Interface 9 Sequence Diagram – Reduced Speed School Zone



RSU-Related Sequence Diagrams	CORS-Related Sequence Diagrams
• Interface 7 → **Figure 20** • Interface 11b → **Figure 33** • Interface 12 → **Figure 36** • Interface 13 → **Figure 42**	• *None*
Data Flow Communications Profiles • **Table 37: RTCM Data (RTCM 10410.1) Communication Profile**	
Interface Requirements Traceability • CVE-IX1628-V01 • CVE-IF1339-V01	

Source: City of Columbus

Figure 28: Interface 9 Sequence Diagram – Signal Priority/Preemption



RSU-Related Sequence Diagrams	CORS-Related Sequence Diagrams
• Interface 7 → **Figure 18** • Interface 11a → **Figure 32** • Interface 12 → **Figure 34** • Interface 14 → **Figure 47** • Interface 15 → **Figure 52**	• *None*

Data Flow Communications Profiles

- **Table 37: RTCM Data (RTCM 10410.1) Communication Profile**

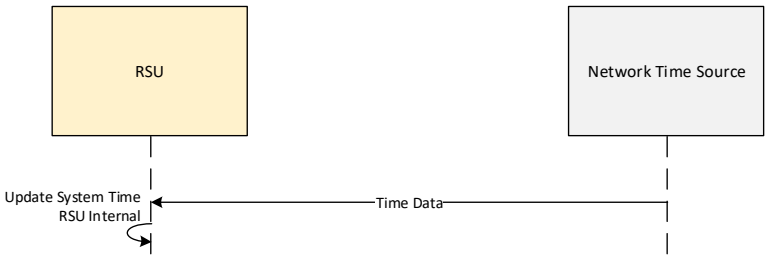
Interface Requirements Traceability

- CVE-IX1628-V01
- CVE-IF1339-V01

Source: City of Columbus

3.10. INTERFACE 10: ROADSIDE UNIT – NETWORK TIME SOURCE

Figure 29: Interface 10 Sequence Diagram – RSU Time Synchronization

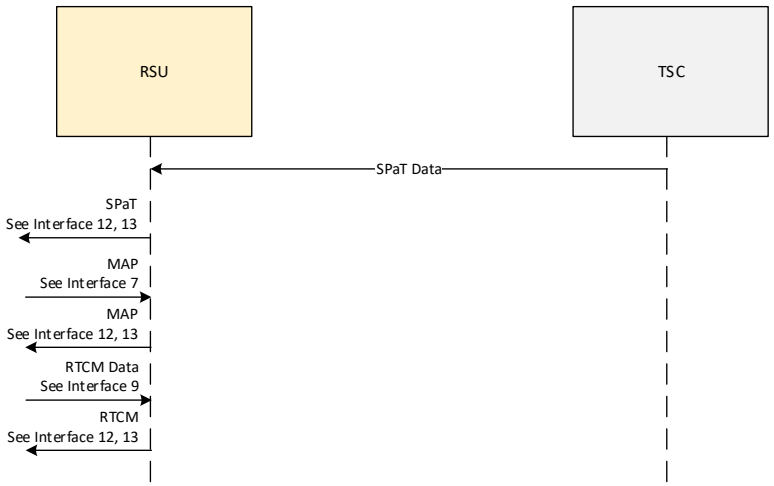


RSU-Related Sequence Diagrams • *None*	**NTS-Related Sequence Diagrams** • *None*
Data Flow Communications Profiles • **Table 48: Time Data Communication Profile**	
Interface Requirements Traceability **CVE-IX1626-V01**	

Source: City of Columbus

3.11. INTERFACE 11A: ROADSIDE UNIT – TRAFFIC SIGNAL CONTROLLER

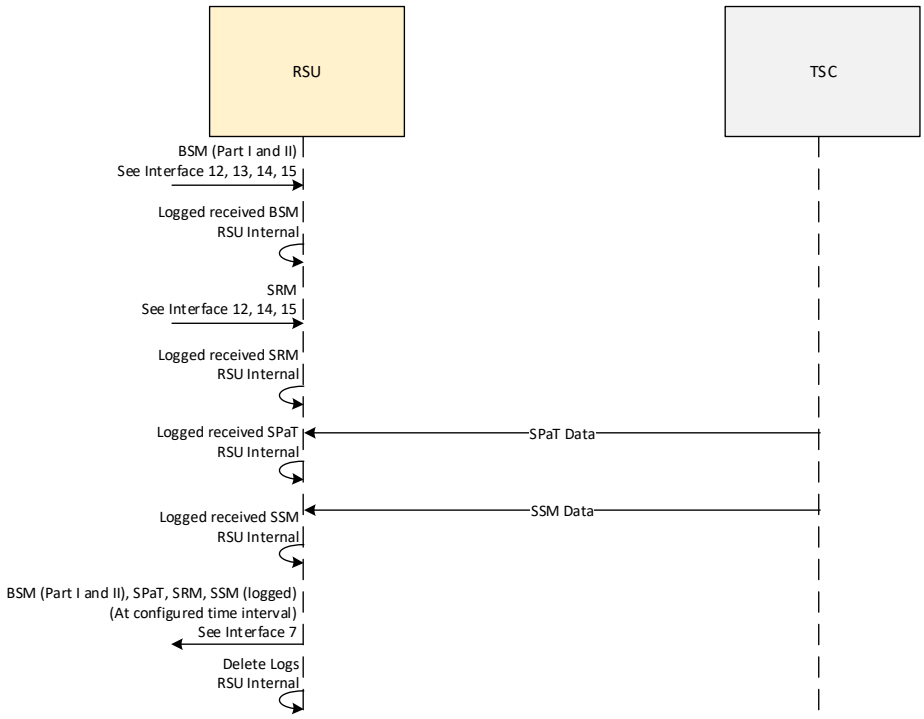
Figure 30: Interface 11a Sequence Diagram – Red Light Violation Warning



RSU-Related Sequence Diagrams	TSC-Related Sequence Diagrams
• Interface 7 → **Figure 19** • Interface 9 → **Figure 26** • Interface 12 → **Figure 35** • Interface 13 → **Figure 41**	• *None*
Data Flow Communications Profiles • **Table 41: Signal Phase and Timing Data (NTCIP 1202) Communication Profile**	
Interface Requirements Traceability • CVE-IX1638-V01 • CVE-IF1345-V01	

Source: City of Columbus

Figure 31: Interface 11a Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 17**
- Interface 12 → **Figure 37**
- Interface 13 → **Figure 43**
- Interface 14 → **Figure 48**
- Interface 15 → **Figure 53**

TSC-Related Sequence Diagrams

- *None*

Data Flow Communications Profiles

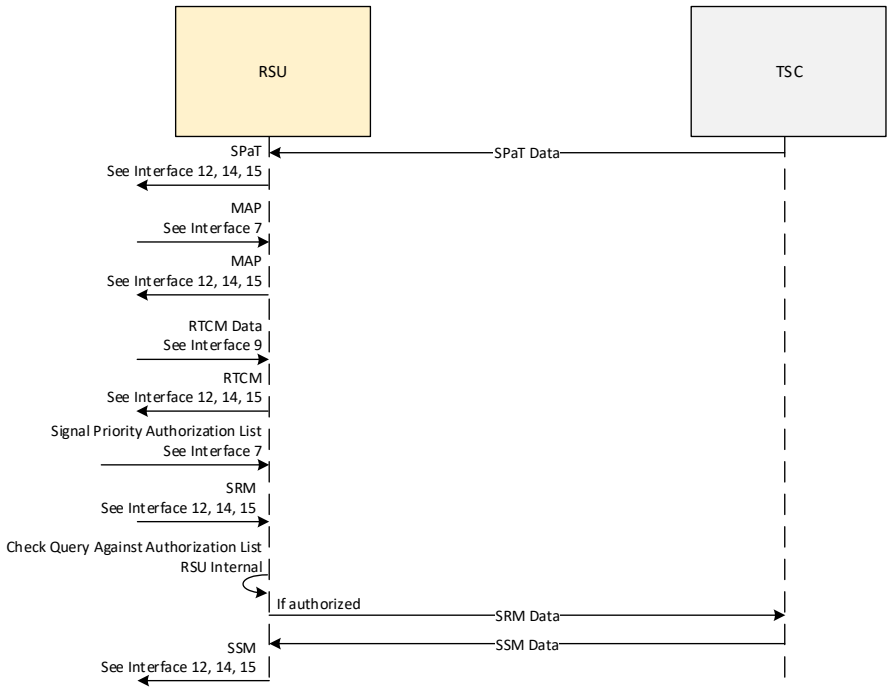
- **Table 41: Signal Phase and Timing Data (NTCIP 1202) Communication Profile**
- **Table 46: Signal Status Message (NTCIP 1202) Communication Profile**

Interface Requirements Traceability

- CVE-IX1638-V01
- CVE-IF1340-V01
- CVE-IF1345-V01
- CVE-IF1346-V01

Source: City of Columbus

Figure 32: Interface 11a Sequence Diagram – Signal Priority/Preemption



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 18**
- Interface 9 → **Figure 28**
- Interface 12 → **Figure 34**
- Interface 14 → **Figure 47**
- Interface 15 → **Figure 52**

TSC-Related Sequence Diagrams

- *None*

Data Flow Communications Profiles

- **Table 41: Signal Phase and Timing Data (NTCIP 1202) Communication Profile**
- **Table 44: Signal Request Message Data (NTCIP 1202) Communication Profile**
- **Table 46: Signal Status Message (NTCIP 1202) Communication Profile**

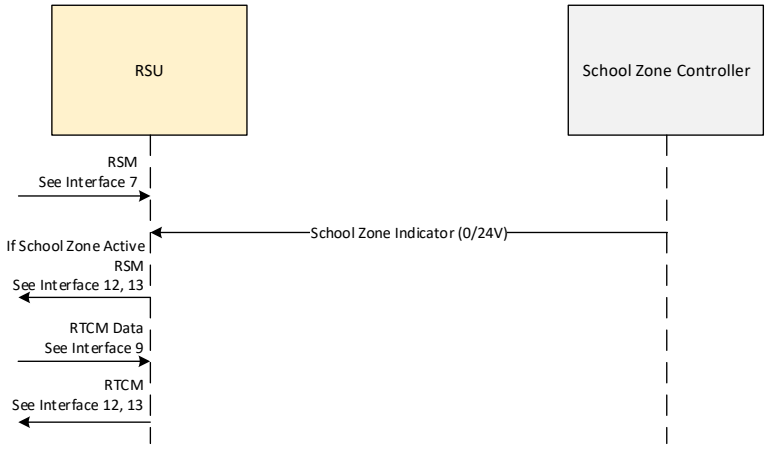
Interface Requirements Traceability

- CVE-IX1637-V01
- CVE-IF1347-V01
- CVE-IX1638-V01
- CVE-IF1340-V01
- CVE-IF1345-V01
- CVE-IF1346-V01

Source: City of Columbus

3.12. INTERFACE 11B: ROADSIDE UNIT – SCHOOL ZONE CONTROLLER

Figure 33: Interface 11b Sequence Diagram – Reduced Speed School Zone



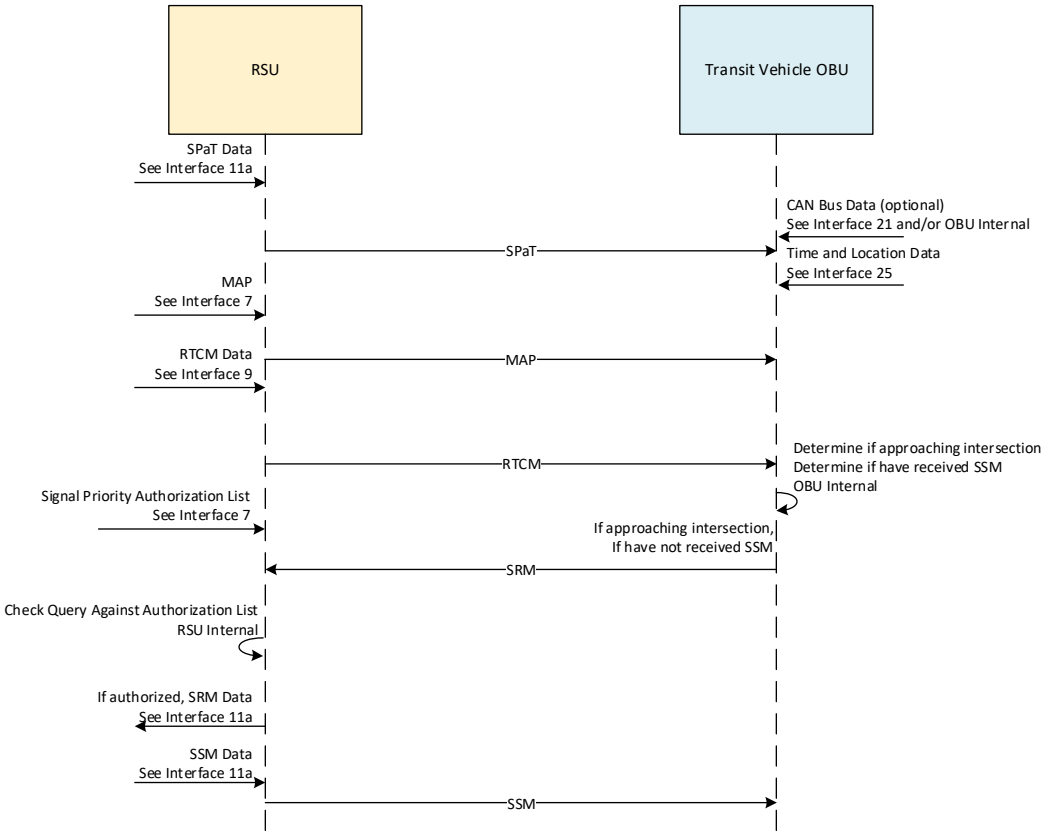
RSU-Related Sequence Diagrams	School Zone Con.-Related Sequence Diagrams
• Interface 7 → **Figure 20** • Interface 9 → **Figure 27** • Interface 12 → **Figure 36** • Interface 13 → **Figure 42**	• *None*
Data Flow Communications Profiles • **Table 38: School Zone Indicator Communication Profile**	
Interface Requirements Traceability • CVE-IX3262-V01	

Source: City of Columbus

3.13. INTERFACE 12: ROADSIDE UNIT – TRANSIT VEHICLE ONBOARD UNIT

See **Figure 2** in **Chapter 2** for the proposed DSRC channel map.

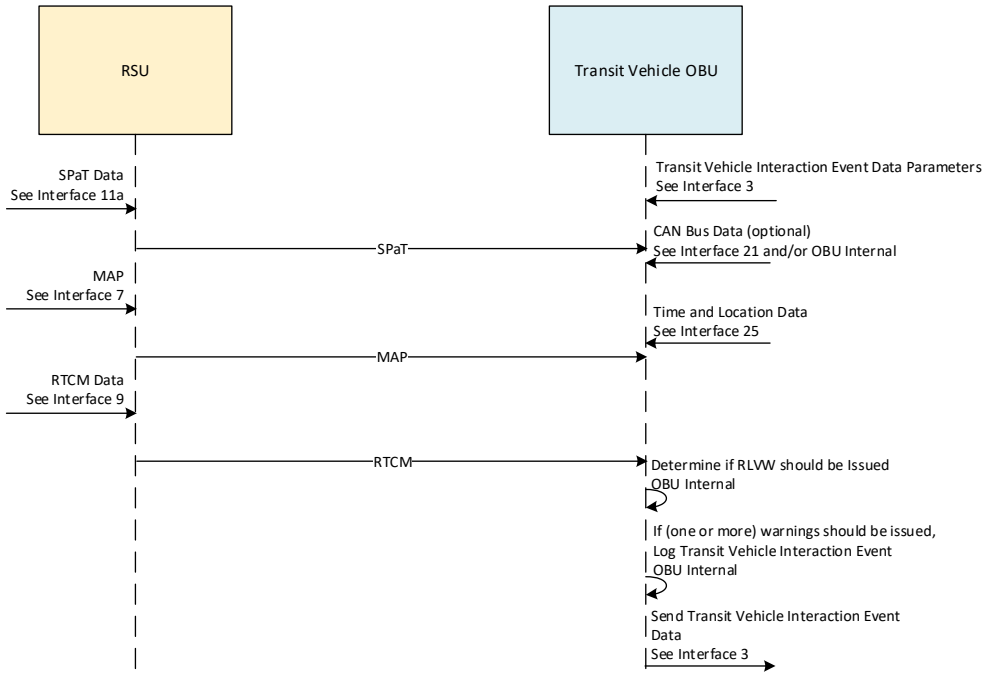
Figure 34: Interface 12 Sequence Diagram – Transit Signal Priority



RSU-Related Sequence Diagrams	Transit Veh OBU-Related Sequence Diagrams
• Interface 7 → **Figure 18** • Interface 9 → **Figure 28** • Interface 11a → **Figure 32**	• Interface 21 → **Figure 69** • Interface 25 → **Figure 85**
Data Flow Communications Profiles • **Table 15: MapData Message (SAE J2735) Communication Profile** • **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile** • **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile** • **Table 43: Signal Request Message (SAE J2735) Communication Profile** • **Table 45: Signal Status Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability • CVE-IX1631-V01 • CVE-IF3247-V01 • CVE-IF1231-V01 • CVE-IF1235-V01 • CVE-IF1227-V01 • CVE-IF1238-V01 • CVE-IF2985-V01 • CVE-IF2978-V01 • CVE-IX3262-V01 • CVE-IF1250-V01 • CVE-IF1361-V01	

Source: City of Columbus

Figure 35: Interface 12 Sequence Diagram – Red Light Violation Warning for Transit Vehicle Interaction Event Recording



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 19**
- Interface 9 → **Figure 26**
- Interface 11a → **Figure 30**

Transit Veh OBU-Related Sequence Diagrams

- Interface 3 → **Figure 12**
- Interface 21 → **Figure 67**
- Interface 25 → **Figure 83**

Data Flow Communications Profiles

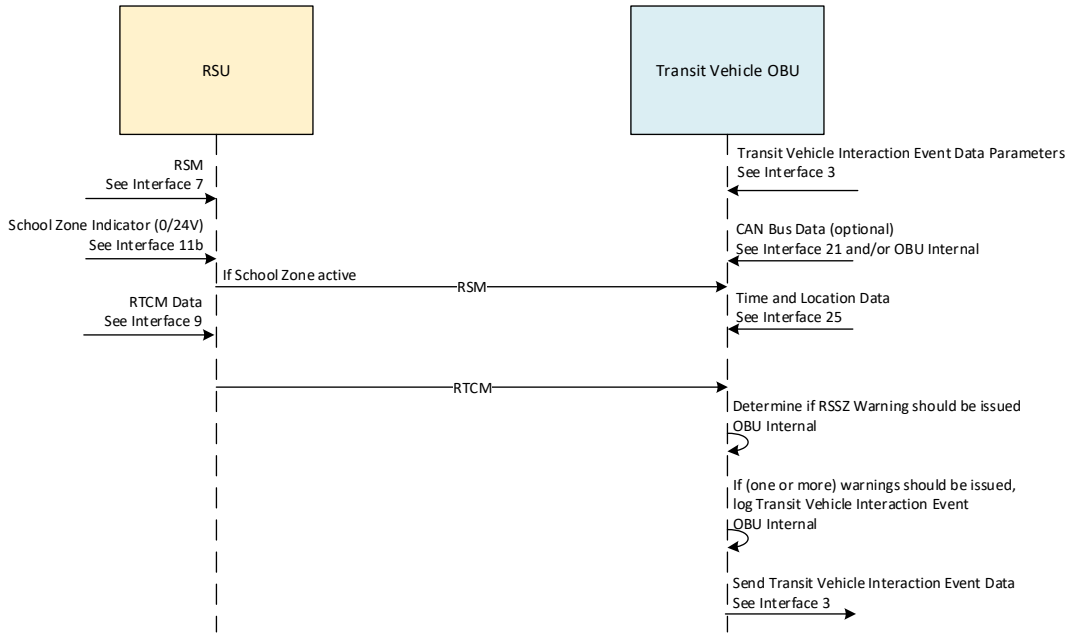
- **Table 15: MapData Message (SAE J2735) Communication Profile**
- **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile**
- **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1631-V01
- CVE-IF3247-V01
- CVE-IF1231-V01
- CVE-IF1235-V01
- CVE-IF1227-V01

Source: City of Columbus

Figure 36: Interface 12 Sequence Diagram – Reduced Speed School Zone for Transit Vehicle Interaction Event Recording



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 20**
- Interface 9 → **Figure 27**
- Interface 11b → **Figure 33**

Transit Veh OBU-Related Sequence Diagrams

- Interface 3 → **Figure 12**
- Interface 21 → **Figure 68**
- Interface 25 → **Figure 84**

Data Flow Communications Profiles

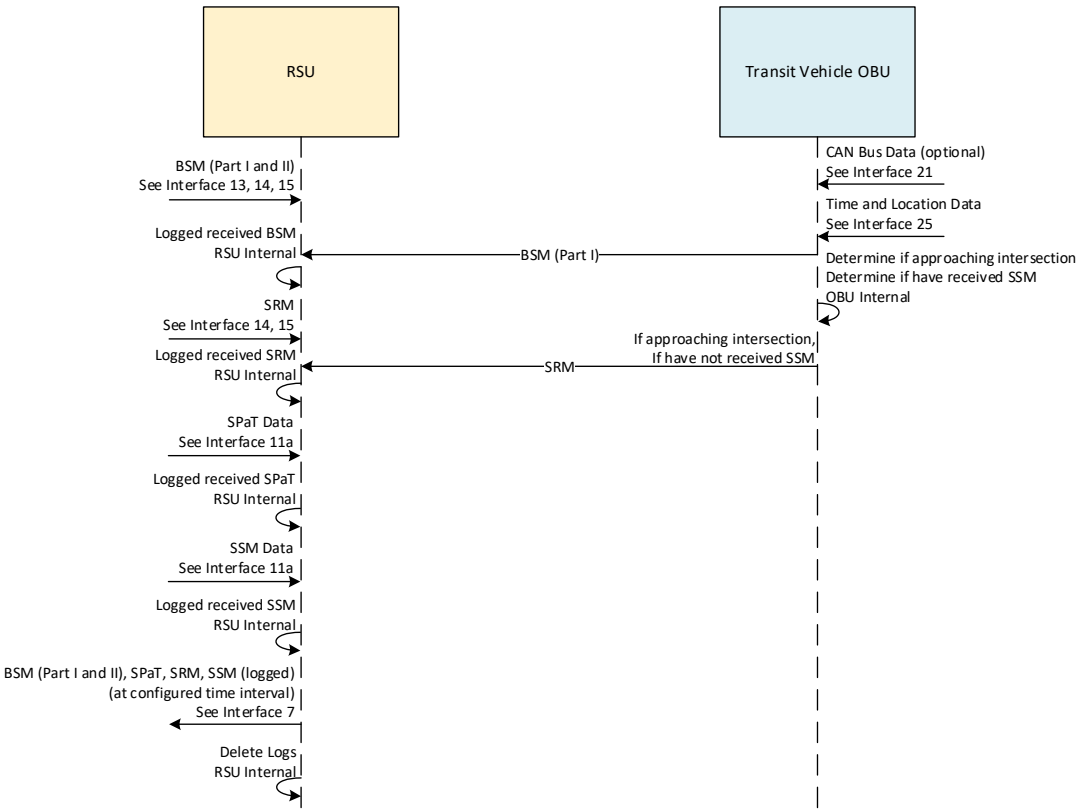
- **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile**
- **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**

Interface Requirements Traceability

- CVE-IX1631-V01
- CVE-IF3247-V01
- CVE-IF1235-V01
- CVE-IF2978-V01

Source: City of Columbus

Figure 37: Interface 12 Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 17**
- Interface 11a → **Figure 31**
- Interface 13 → **Figure 43**
- Interface 14 → **Figure 48**
- Interface 15 → **Figure 53**

Transit Veh OBU-Related Sequence Diagrams

- Interface 21 → **Figure 65**
- Interface 25 → **Figure 81**

Data Flow Communications Profiles

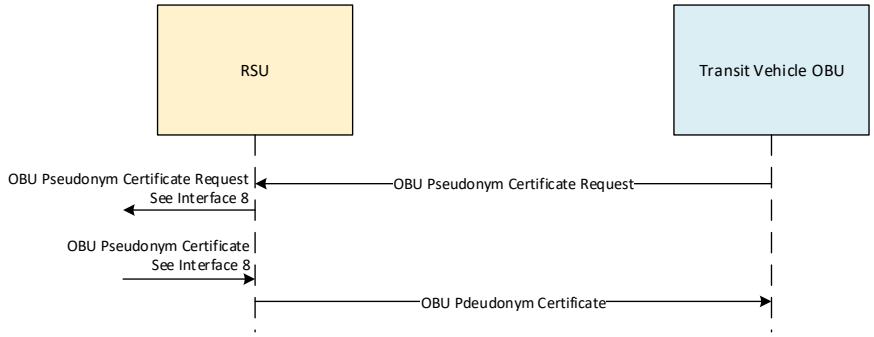
- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 43: Signal Request Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX3262-V01
- CVE-IF3247-V01
- CVE-IF1250-V01
- CVE-IF1361-V01

Source: City of Columbus

Figure 38: Interface 12 Sequence Diagram – Wireless Communications Security: OBU Pseudonym Certificates (via RSU)



RSU-Related Sequence Diagrams	Transit Veh OBU-Related Sequence Diagrams
• Interface 8 → **Figure 24**	• *None*

Data Flow Communications Profiles

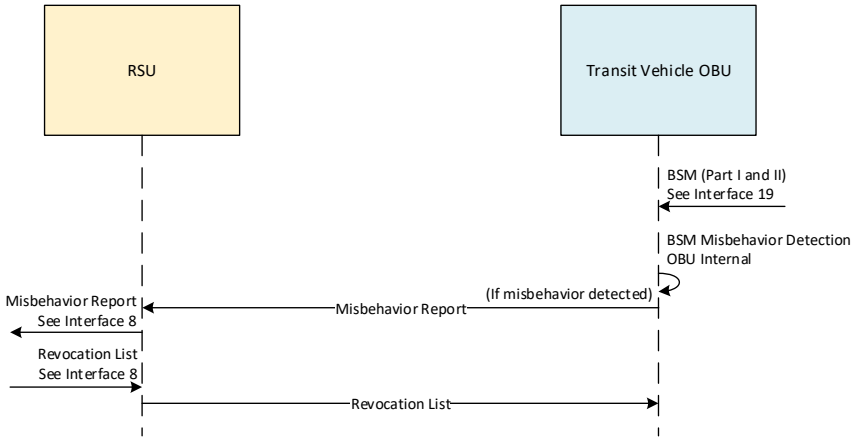
- **Table 19: OBU Pseudonym Certificate Communication Profile**
- **Table 20: OBU Pseudonym Certificate Request Communication Profile**

Interface Requirements Traceability

- CVE-IX1631-V01
- CVE-IF3247-V01
- CVE-IF3210-V01
- CVE-IX1632-V01
- CVE-IF3247-V01
- CVE-IF1361-V01

Source: City of Columbus

Figure 39: Interface 12 Sequence Diagram – Wireless Communications Security: OBU Misbehavior Detection, Misbehavior Reporting, and Revocation List (via RSU)



RSU-Related Sequence Diagrams	Transit Veh OBU-Related Sequence Diagrams
• Interface 8 → **Figure 25**	• Interface 19 → **Figure 62**

Data Flow Communications Profiles

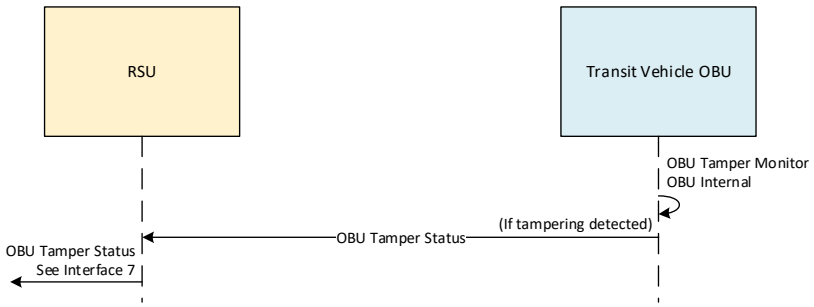
- Table 16: Misbehavior Report Communication Profile
- Table 29: Revocation List Communication Profile

Interface Requirements Traceability

- CVE-IX1631-V01
- CVE-IF3247-V01
- CVE-IF3210-V01
- CVE-IX1632-V01
- CVE-IF3247-V01
- CVE-IF1361-V01

Source: City of Columbus

Figure 40: Interface 12 Sequence Diagram – System Status: OBU Status



RSU-Related Sequence Diagrams	Transit Veh OBU-Related Sequence Diagrams
• Interface 7 → **Figure 22**	• *None*

Data Flow Communications Profiles

- **Table 23: OBU Tamper Status Communication Profile**

Interface Requirements Traceability

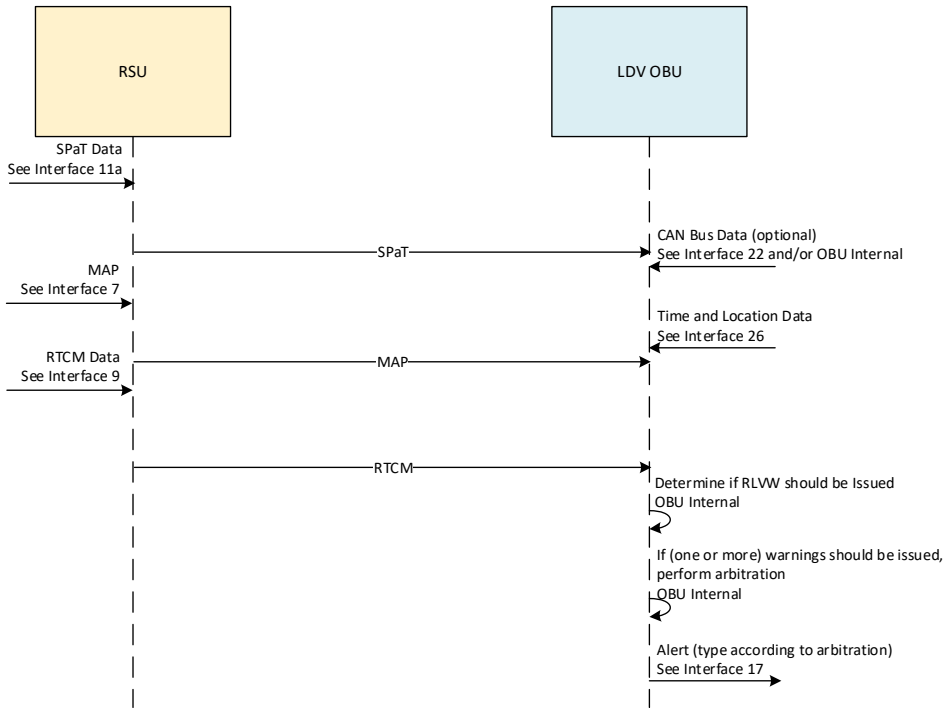
- CVE-IX1631-V01
- CVE-IF3247-V01
- CVE-IF3210-V01
- CVE-IX1632-V01
- CVE-IF3247-V01
- CVE-IF1361-V01

Source: City of Columbus

3.14. INTERFACE 13: ROADSIDE UNIT – LIGHT-DUTY VEHICLE ONBOARD UNIT

See **Figure 2** in **Chapter 2** for the proposed DSRC channel map.

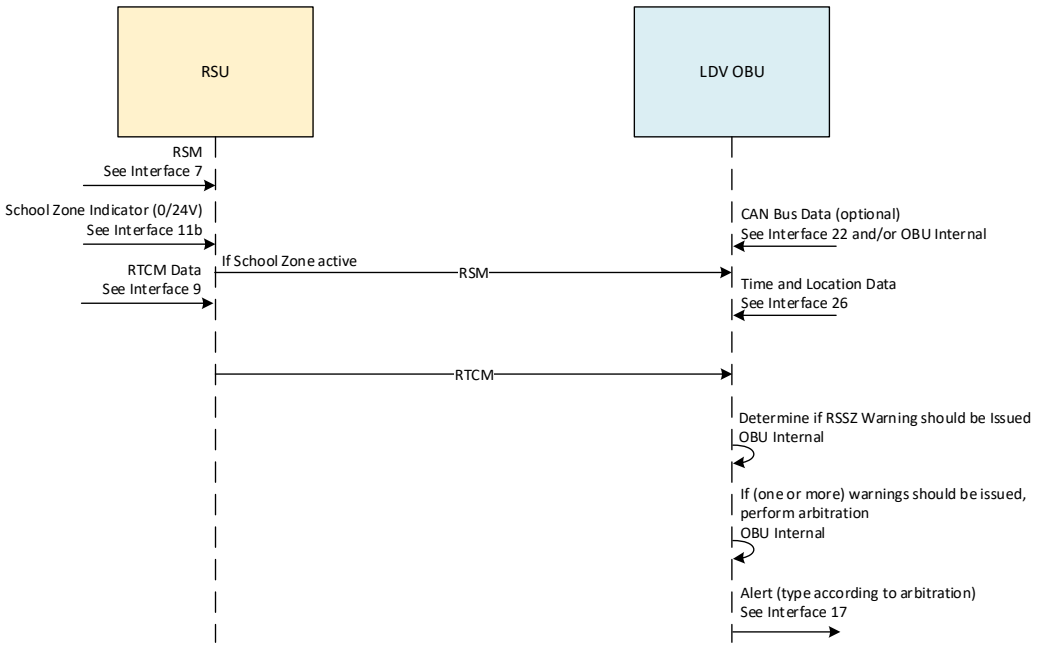
Figure 41: Interface 13 Sequence Diagram – Red Light Violation Warning



RSU-Related Sequence Diagrams	LDV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 19** • Interface 9 → **Figure 26** • Interface 11a → **Figure 30**	• Interface 17 → **Figure 58** • Interface 22 → **Figure 72** • Interface 26 → **Figure 88**
Data Flow Communications Profiles • **Table 15: MapData Message (SAE J2735) Communication Profile** • **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile** • **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability • CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1229-V01 • CVE-IF1233-V01	• CVE-IF1225-V01 • CVE-IF1357-V01 • CVE-IF1358-V01 • CVE-IF1356-V01

Source: City of Columbus

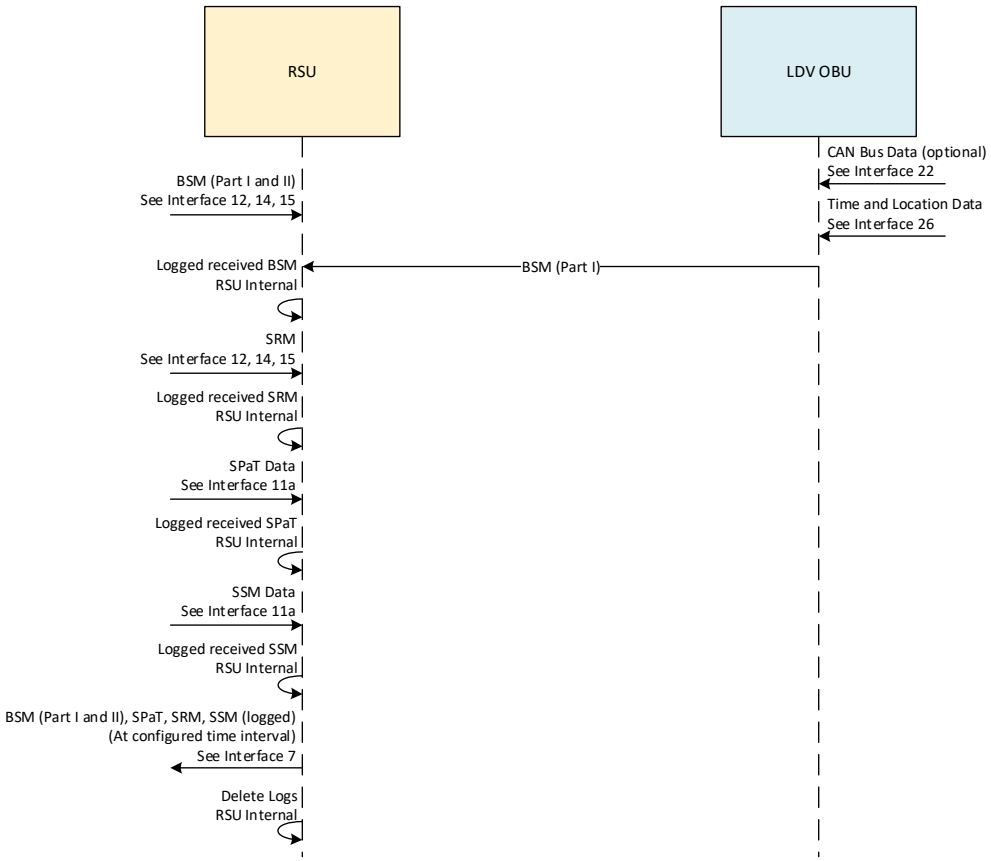
Figure 42: Interface 13 Sequence Diagram – Reduced Speed School Zone



RSU-Related Sequence Diagrams	LDV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 20** • Interface 9 → **Figure 27** • Interface 11b → **Figure 33**	• Interface 17 → **Figure 59** • Interface 22 → **Figure 73** • Interface 26 → **Figure 89**
Data Flow Communications Profiles	
• **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile** • **Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1240-V01 • CVE-IF1233-V01 • CVE-IF1358-V01 • CVE-IF1360-V01	

Source: City of Columbus

Figure 43: Interface 13 Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 17**
- Interface 11a → **Figure 31**
- Interface 12 → **Figure 37**
- Interface 14 → **Figure 48**
- Interface 15 → **Figure 53**

LDV OBU-Related Sequence Diagrams

- Interface 22 → **Figure 70**
- Interface 26 → **Figure 86**

Data Flow Communications Profiles

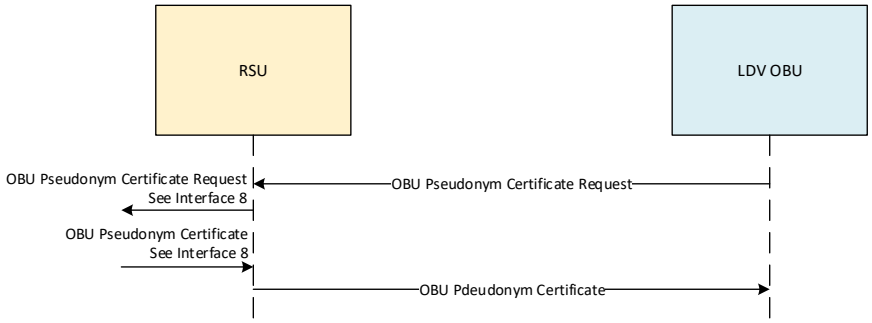
- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1619-V01
- CVE-IF3247-V01
- CVE-IF1362-V01
- CVE-IF1361-V01

Source: City of Columbus

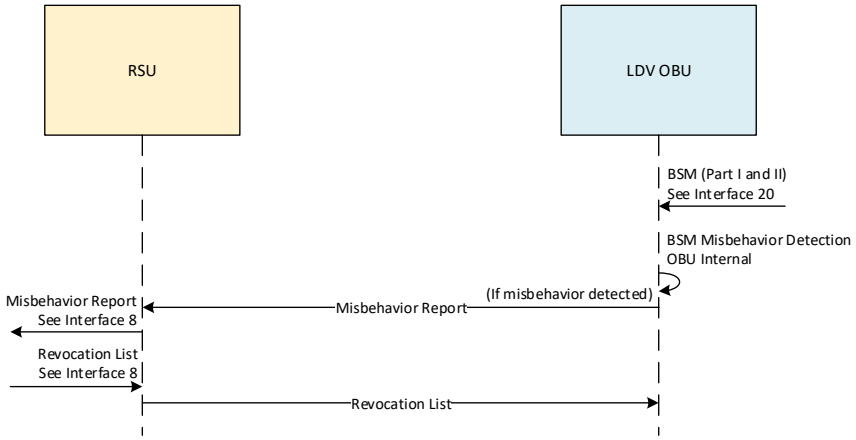
Figure 44: Interface 13 Sequence Diagram – Wireless Communications Security: Onboard Unit Pseudonym Certificates (via Roadside Unit)



RSU-Related Sequence Diagrams	LDV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 24**	• *None*
Data Flow Communications Profiles • **Table 19: OBU Pseudonym Certificate Communication Profile** • **Table 20: OBU Pseudonym Certificate Request Communication Profile**	
Interface Requirements Traceability • CVE-IX1619-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF1361-V01 • CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF3210-V01	

Source: City of Columbus

Figure 45: Interface 13 Sequence Diagram – Wireless Communications Security: Onboard Unit Misbehavior Detection, Misbehavior Reporting and Revocation List (via Roadside Unit)



RSU-Related Sequence Diagrams	LDV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 25**	• Interface 20 → **Figure 63**

Data Flow Communications Profiles

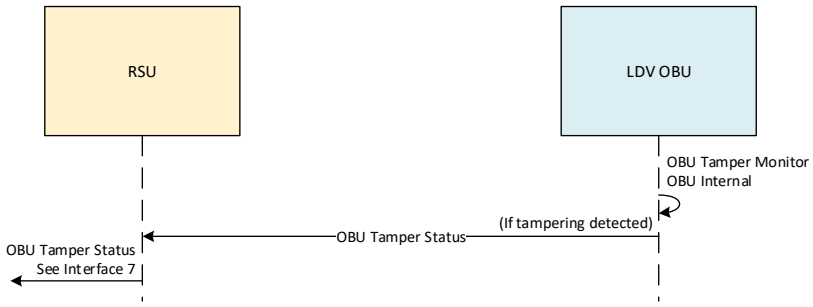
- **Table 16: Misbehavior Report Communication Profile**
- **Table 29: Revocation List Communication Profile**

Interface Requirements Traceability

- CVE-IX1619-V01
- CVE-IF3247-V01
- CVE-IF1243-V01
- CVE-IF1361-V01
- CVE-IX1620-V01
- CVE-IF3247-V01
- CVE-IF1243-V01
- CVE-IF3210-V01

Source: City of Columbus

Figure 46: Interface 13 Sequence Diagram – System Status: Onboard Unit Status



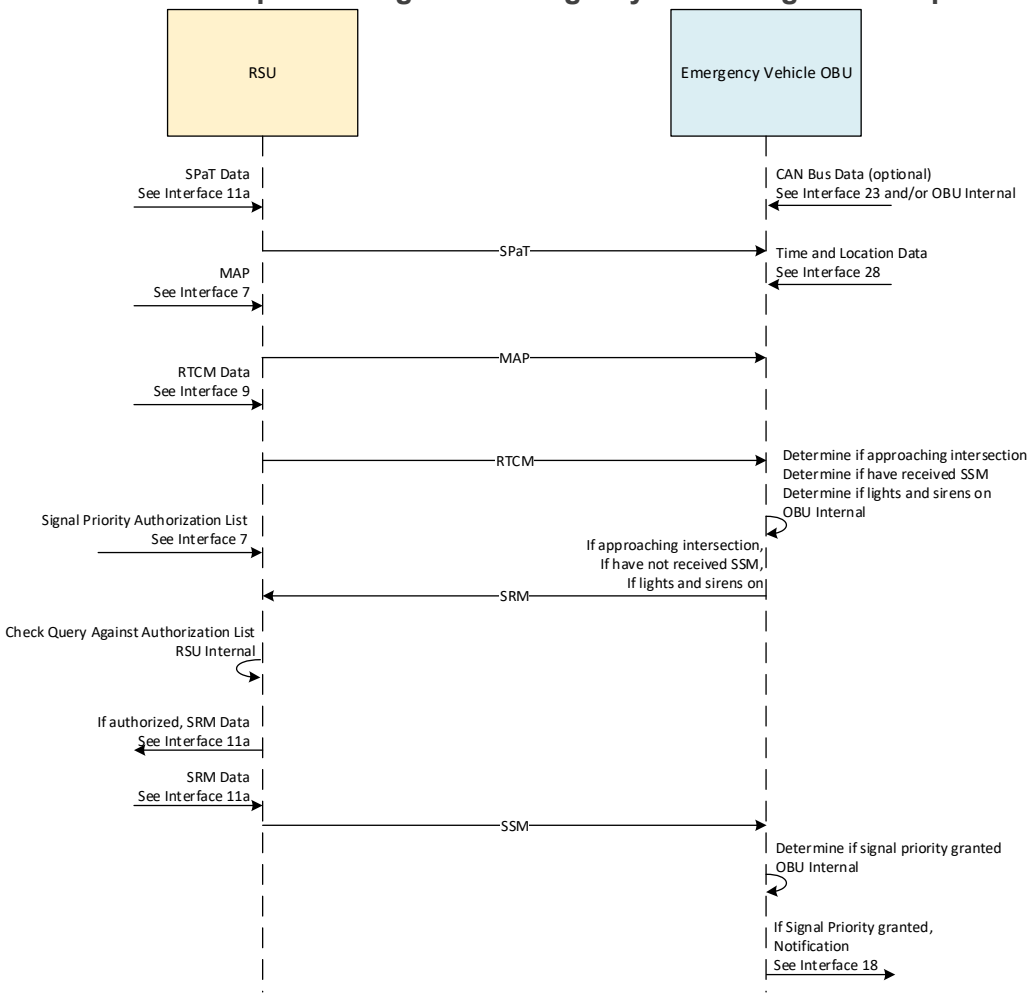
RSU-Related Sequence Diagrams	LDV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 22**	• *None*
Data Flow Communications Profiles • **Table 23: OBU Tamper Status Communication Profile**	
Interface Requirements Traceability • CVE-IX1619-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF1361-V01 • CVE-IX1620-V01 • CVE-IF3247-V01 • CVE-IF1243-V01 • CVE-IF3210-V01	

Source: City of Columbus

3.15. INTERFACE 14: ROADSIDE UNIT – EMERGENCY VEHICLE ONBOARD UNIT

See **Figure 2** in Chapter 2 for the proposed DSRC channel map.

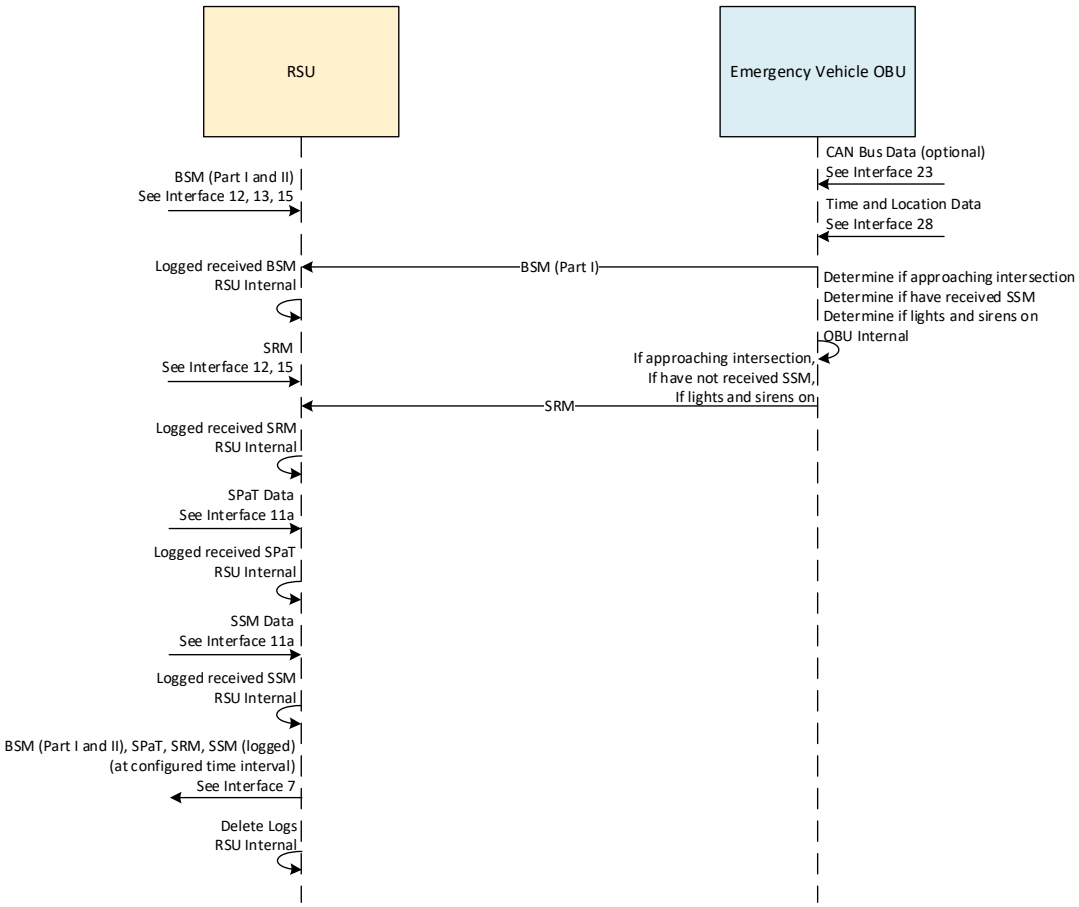
Figure 47: Interface 14 Sequence Diagram – Emergency Vehicle Signal Preemption



RSU-Related Sequence Diagrams	EV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 18** • Interface 9 → **Figure 28** • Interface 11a → **Figure 32**	• Interface 18 → **Figure 61** • Interface 23 → **Figure 76** • Interface 28 → **Figure 93**
Data Flow Communications Profiles • **Table 15: MapData Message (SAE J2735) Communication Profile** • **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile** • **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile** • **Table 43: Signal Request Message (SAE J2735) Communication Profile** • **Table 45: Signal Status Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability • CVE-IX1609-V01 • CVE-IF3247-V01 • CVE-IF1248-V01 • CVE-IF1251-V01 • CVE-IF1361-V01 • CVE-IX1610-V01 • CVE-IF1232-V01 • CVE-IF1236-V01 • CVE-IF1228-V01 • CVE-IF1239-V01 • CVE-IF2986-V01	

Source: City of Columbus

Figure 48: Interface 14 Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 17**
- Interface 11a → **Figure 31**
- Interface 12 → **Figure 37**
- Interface 13 → **Figure 43**
- Interface 15 → **Figure 53**

EV OBU-Related Sequence Diagrams

- Interface 23 → **Figure 75**
- Interface 28 → **Figure 92**

Data Flow Communications Profiles

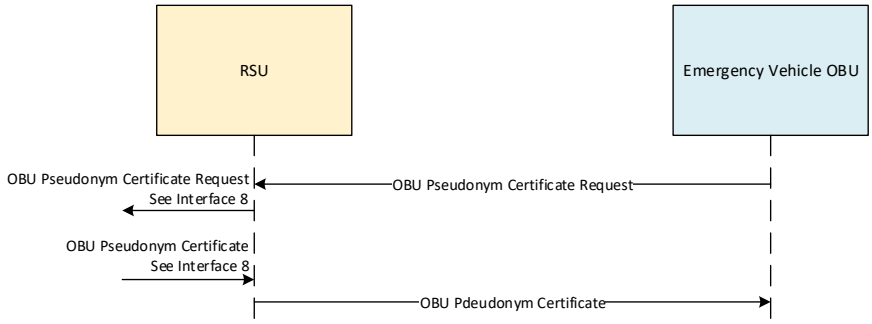
- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 43: Signal Request Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1609-V01
- CVE-IF3247-V01
- CVE-IF1248-V01
- CVE-IF1251-V01
- CVE-IF1361-V01

Source: City of Columbus

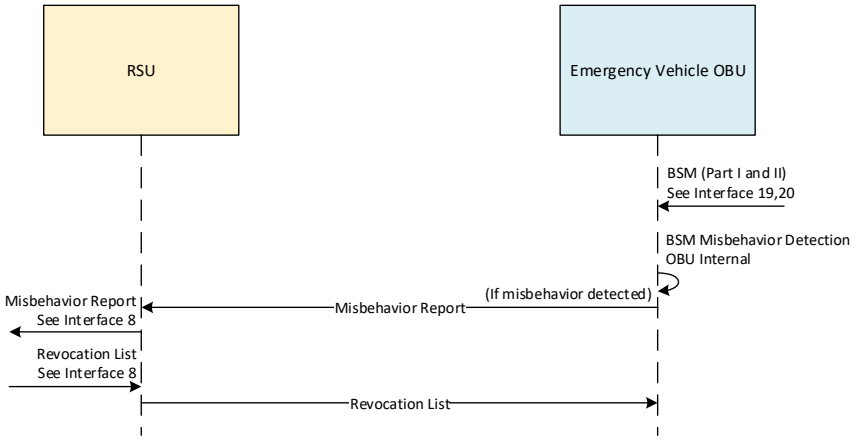
Figure 49: Interface 14 Sequence Diagram – Wireless Communications Security: Onboard Unit Pseudonym Certificates (via Roadside Unit)



RSU-Related Sequence Diagrams	EV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 24**	• *None*
Data Flow Communications Profiles • **Table 19: OBU Pseudonym Certificate Communication Profile** • **Table 20: OBU Pseudonym Certificate Request Communication Profile**	
Interface Requirements Traceability • CVE-IX1609-V01 • CVE-IF3247-V01 • CVE-IF1248-V01 • CVE-IF1361-V01 • CVE-IX1610-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	

Source: City of Columbus

Figure 50: Interface 14 Sequence Diagram – Wireless Communications Security: Onboard Unit Misbehavior Detection, Misbehavior Reporting and Revocation List (via Roadside Unit)



RSU-Related Sequence Diagrams	EV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 25**	• Interface 19 → **Figure 62** • Interface 20 → **Figure 63**

Data Flow Communications Profiles

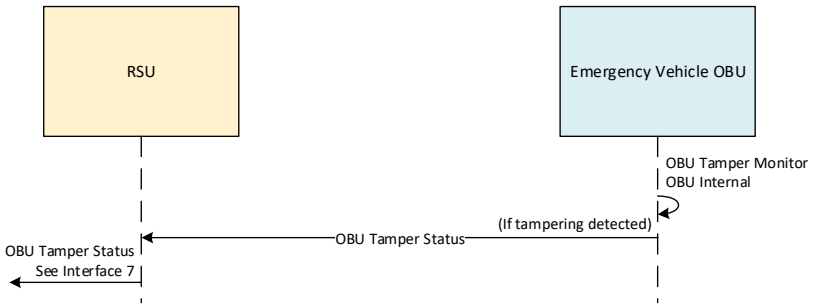
- **Table 16: Misbehavior Report Communication Profile**
- **Table 29: Revocation List Communication Profile**

Interface Requirements Traceability

- CVE-IX1609-V01
- CVE-IF3247-V01
- CVE-IF1248-V01
- CVE-IF1361-V01
- CVE-IX1610-V01
- CVE-IF3247-V01
- CVE-IF3210-V01

Source: City of Columbus

Figure 51: Interface 14 Sequence Diagram – System Status: Onboard Unit Status



RSU-Related Sequence Diagrams	EV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 22**	• *None*

Data Flow Communications Profiles

- **Table 23: OBU Tamper Status Communication Profile**

Interface Requirements Traceability

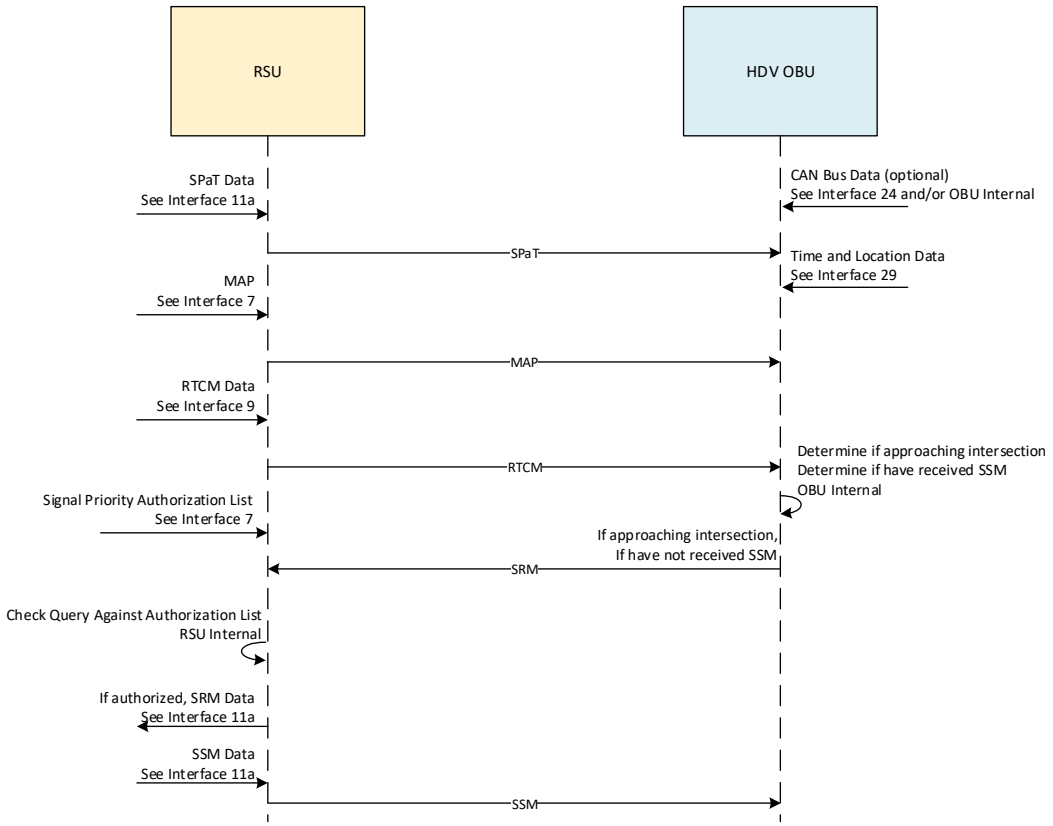
- CVE-IX1609-V01
- CVE-IF3247-V01
- CVE-IF1248-V01
- CVE-IF1361-V01
- CVE-IX1610-V01
- CVE-IF3247-V01
- CVE-IF3210-V01

Source: City of Columbus

3.16. INTERFACE 15: ROADSIDE UNIT – HEAVY-DUTY VEHICLE ONBOARD UNIT

See **Figure 2** in **Chapter 2** for the proposed DSRC channel map.

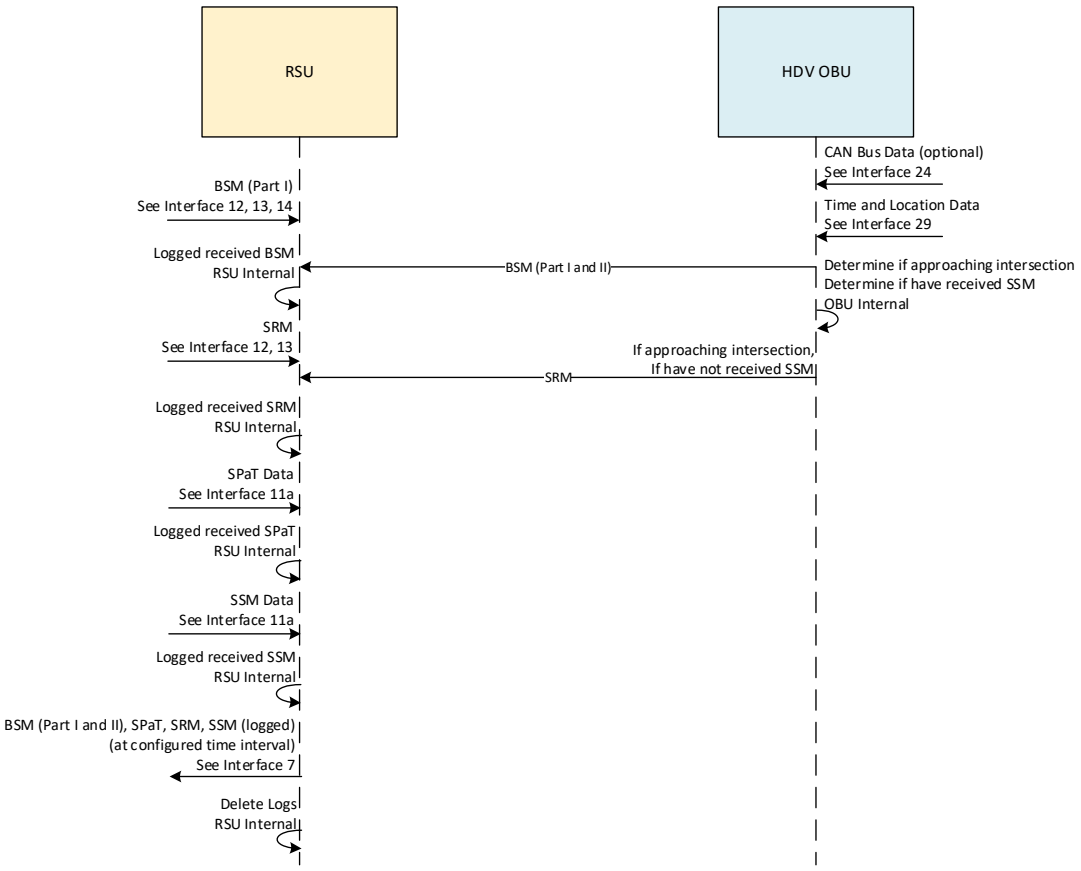
Figure 52: Interface 15 Sequence Diagram – Freight Signal Priority



RSU-Related Sequence Diagrams	HDV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 18** • Interface 9 → **Figure 28** • Interface 11a → **Figure 32**	• Interface 24 → **Figure 79** • Interface 29 → **Figure 96**
Data Flow Communications Profiles • **Table 15: MapData Message (SAE J2735) Communication Profile** • **Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile** • **Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile** • **Table 43: Signal Request Message (SAE J2735) Communication Profile** • **Table 45: Signal Status Message (SAE J2735) Communication Profile**	
Interface Requirements Traceability • CVE-IX1615-V01 • CVE-IF3247-V01 • CVE-IF1249-V01 • CVE-IF1363-V01 • CVE-IF1361-V01 • CVE-IX1616-V01 • CVE-IF1230-V01 • CVE-IF1234-V01 • CVE-IF1226-V01 • CVE-IF1237-V01 • CVE-IF1359-V01	

Source: City of Columbus

Figure 53: Interface 15 Sequence Diagram – Vehicle Data for Traffic Operations



RSU-Related Sequence Diagrams

- Interface 7 → **Figure 17**
- Interface 11a → **Figure 31**
- Interface 12 → **Figure 37**
- Interface 13 → **Figure 43**
- Interface 14 → **Figure 48**

HDV OBU-Related Sequence Diagrams

- Interface 24 → **Figure 78**
- Interface 29 → **Figure 95**

Data Flow Communications Profiles

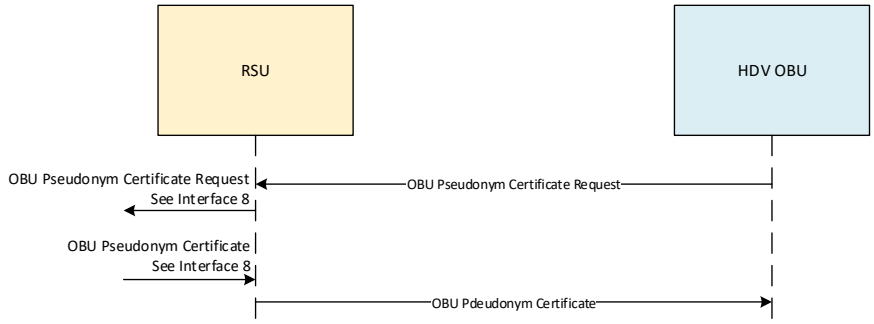
- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile**
- **Table 43: Signal Request Message (SAE J2735) Communication Profile**

Interface Requirements Traceability

- CVE-IX1615-V01
- CVE-IF3247-V01
- CVE-IF1249-V01
- CVE-IF1363-V01
- CVE-IF1361-V01

Source: City of Columbus

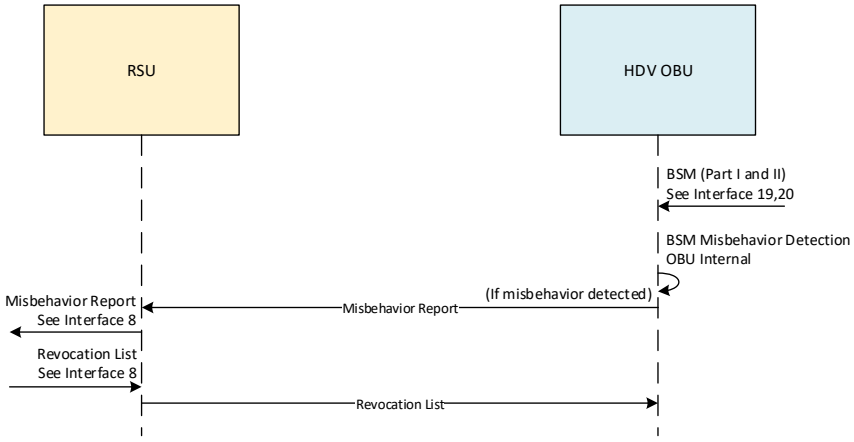
Figure 54: Interface 15 Sequence Diagram – Wireless Communications Security: Onboard Unit Pseudonym Certificates (via Roadside Unit)



RSU-Related Sequence Diagrams	HDV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 24**	• *None*
Data Flow Communications Profiles • **Table 19: OBU Pseudonym Certificate Communication Profile** • **Table 20: OBU Pseudonym Certificate Request Communication Profile**	
Interface Requirements Traceability • CVE-IX1615-V01 • CVE-IF3247-V01 • CVE-IF1361-V01 • CVE-IX1616-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	

Source: City of Columbus

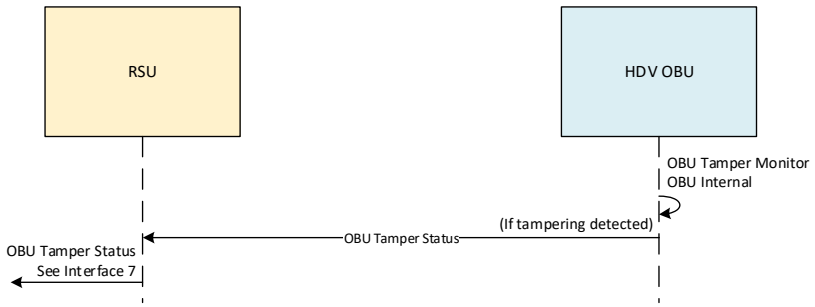
Figure 55: Interface 15 Sequence Diagram – Wireless Communications Security: Onboard Unit Misbehavior Detection, Misbehavior Reporting, and Revocation List (via Roadside Unit)



RSU-Related Sequence Diagrams	HDV OBU-Related Sequence Diagrams
• Interface 8 → **Figure 25**	• Interface 19 → **Figure 62** • Interface 20 → **Figure 63**
Data Flow Communications Profiles • **Table 16: Misbehavior Report Communication Profile** • **Table 29: Revocation List Communication Profile**	
Interface Requirements Traceability • CVE-IX1615-V01 • CVE-IF3247-V01 • CVE-IF1361-V01 • CVE-IX1616-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	

Source: City of Columbus

Figure 56: Interface 15 Sequence Diagram – System Status: Onboard Unit Status



RSU-Related Sequence Diagrams	HDV OBU-Related Sequence Diagrams
• Interface 7 → **Figure 22**	• *None*
Data Flow Communications Profiles • **Table 23: OBU Tamper Status Communication Profile**	
Interface Requirements Traceability • CVE-IX1615-V01 • CVE-IF3247-V01 • CVE-IF1361-V01 • CVE-IX1616-V01 • CVE-IF3247-V01 • CVE-IF3210-V01	

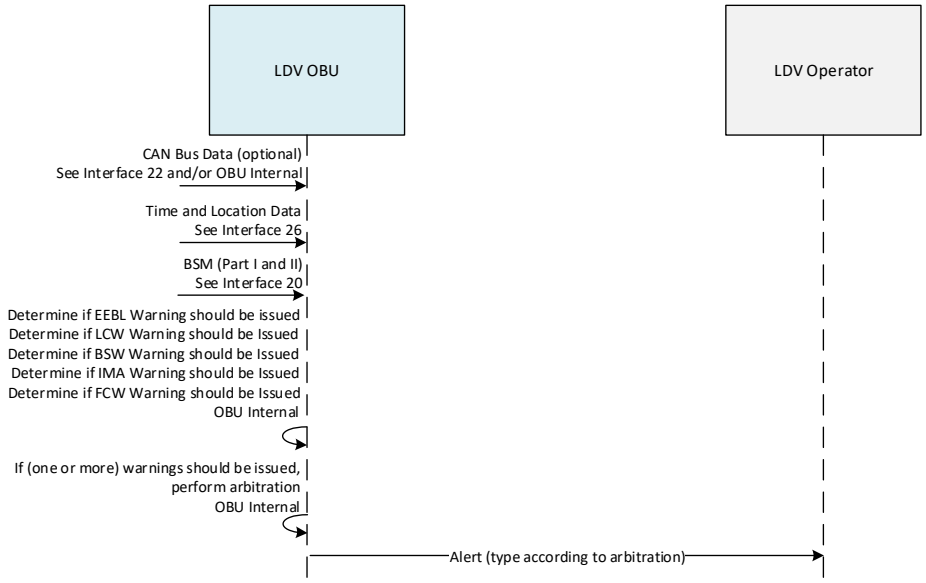
Source: City of Columbus

3.17. INTERFACE 17: LIGHT-DUTY VEHICLE ONBOARD UNIT – LIGHT-DUTY VEHICLE OPERATOR

Notes:

- Due to the discontinuation of the Data Assisted Truck Platooning project, Interface, 16 – between the HDV OBU and the Platooning Provider Central Management System – has been removed. To keep continuity between various systems engineering documents associated with the
- CVE Interface 16 is intentionally omitted, and the remaining interface numbering remains the same.

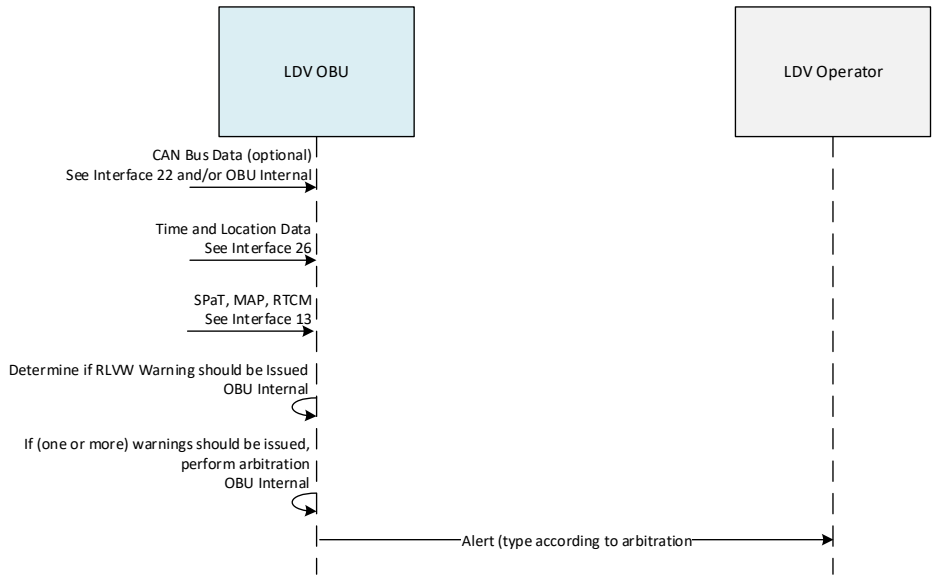
Figure 57: Interface 17 Sequence Diagram – V2V Safety



Related Sequence Diagrams	LDV Operator-Related Sequence Diagrams
• Interface 20 → **Figure 63** • Interface 22 → **Figure 71** • Interface 26 → **Figure 87**	• *None*
Data Flow Communications Profiles • **Table 4: Alert Communication Profile**	
Interface Requirements Traceability • CVE-IX1618-V01 • CVE-IF3197-V01 • CVE-IF3019-V01 • CVE-IF1222-V01 • CVE-IF1246-V01	

Source: City of Columbus

Figure 58: Interface 17 Sequence Diagram – Red Light Violation Warning



Related Sequence Diagrams

- Interface 13 → **Figure 41**
- Interface 22 → **Figure 72**
- Interface 26 → **Figure 88**

LDV Operator-Related Sequence Diagrams

- *None*

Data Flow Communications Profiles

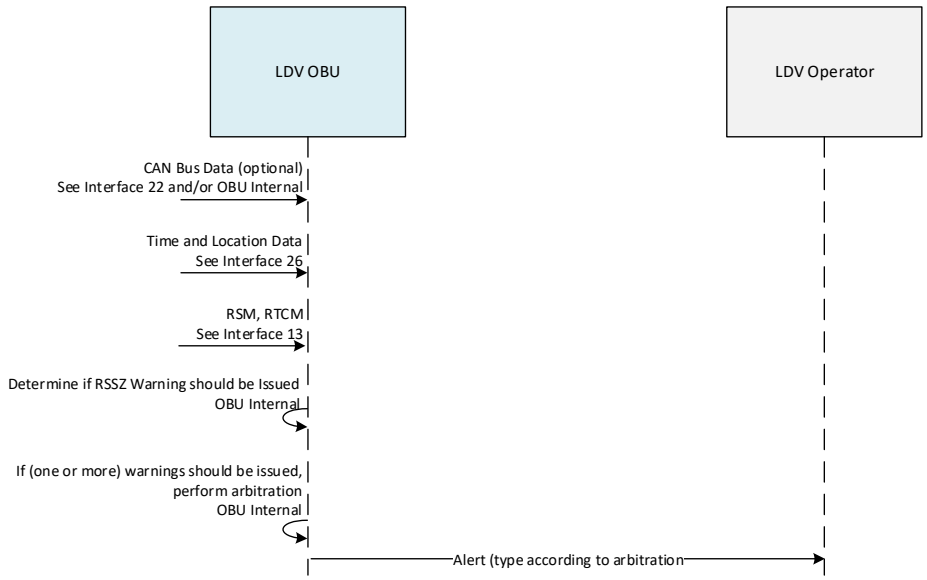
- **Table 4: Alert Communication Profile**

Interface Requirements Traceability

- CVE-IX1618-V01
- CVE-IF3197-V01
- CVE-IF3019-V01
- CVE-IF1222-V01
- CVE-IF1246-V01

Source: City of Columbus

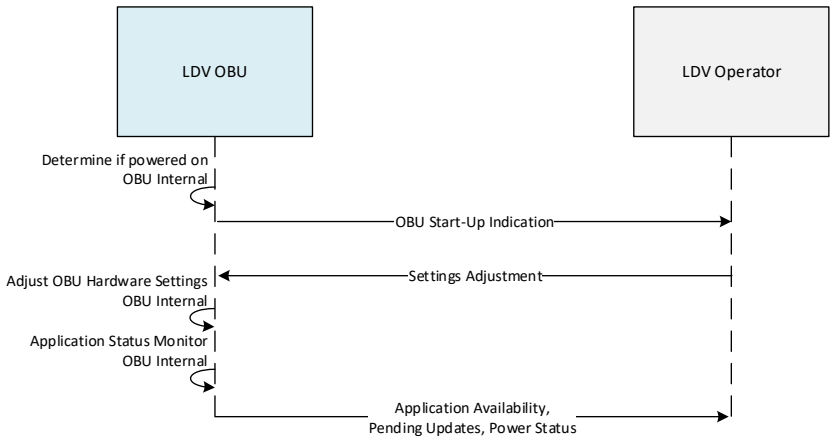
Figure 59: Interface 17 Sequence Diagram – Reduced Speed School Zone



Related Sequence Diagrams	LDV Operator-Related Sequence Diagrams
• Interface 13 → **Figure 42** • Interface 22 → **Figure 73** • Interface 26 → **Figure 89**	• *None*
Data Flow Communications Profiles • **Table 4: Alert Communication Profile**	
Interface Requirements Traceability • CVE-IX1618-V01 • CVE-IF3197-V01 • CVE-IF3019-V01 • CVE-IF1222-V01 • CVE-IF1246-V01	

Source: City of Columbus

Figure 60: Interface 17 Sequence Diagram – System Status: Onboard Unit Status



Related Sequence Diagrams	LDV Operator-Related Sequence Diagrams
• *None*	• *None*

Data Flow Communications Profiles

- **Table 5: Application Availability Communication Profile**
- **Table 21: OBU Start-Up Indication Communication Profile**
- **Table 39: Setting Adjustment Communication Profile**

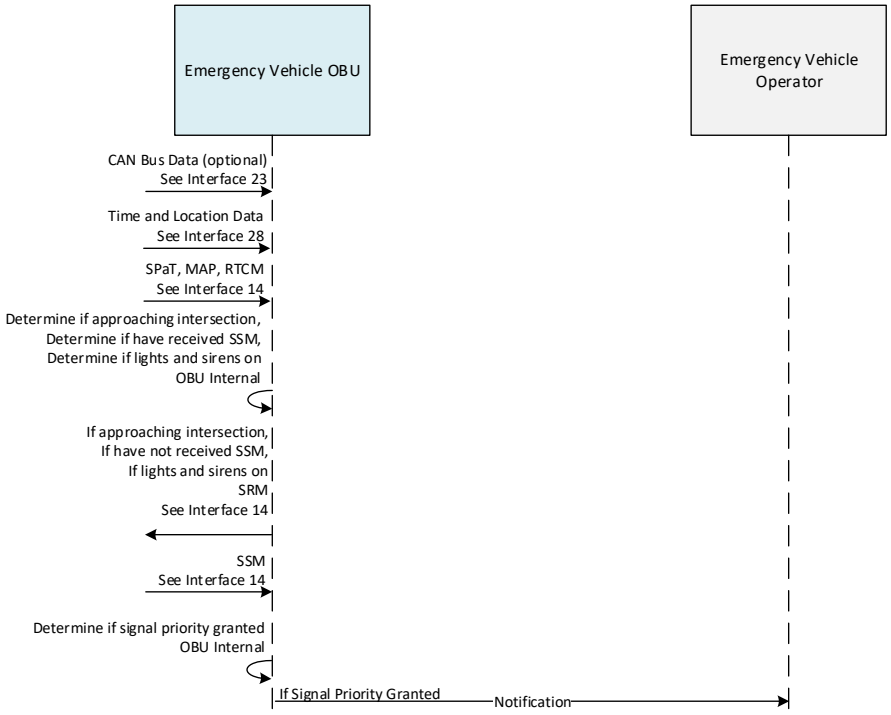
Interface Requirements Traceability

- CVE-IX3263-V01
- CVE-IF3019-V01

Source: City of Columbus

3.18. INTERFACE 18: EMERGENCY VEHICLE ONBOARD UNIT – EMERGENCY VEHICLE OPERATOR

Figure 61: Interface 18 Sequence Diagram – Emergency Vehicle Preemption

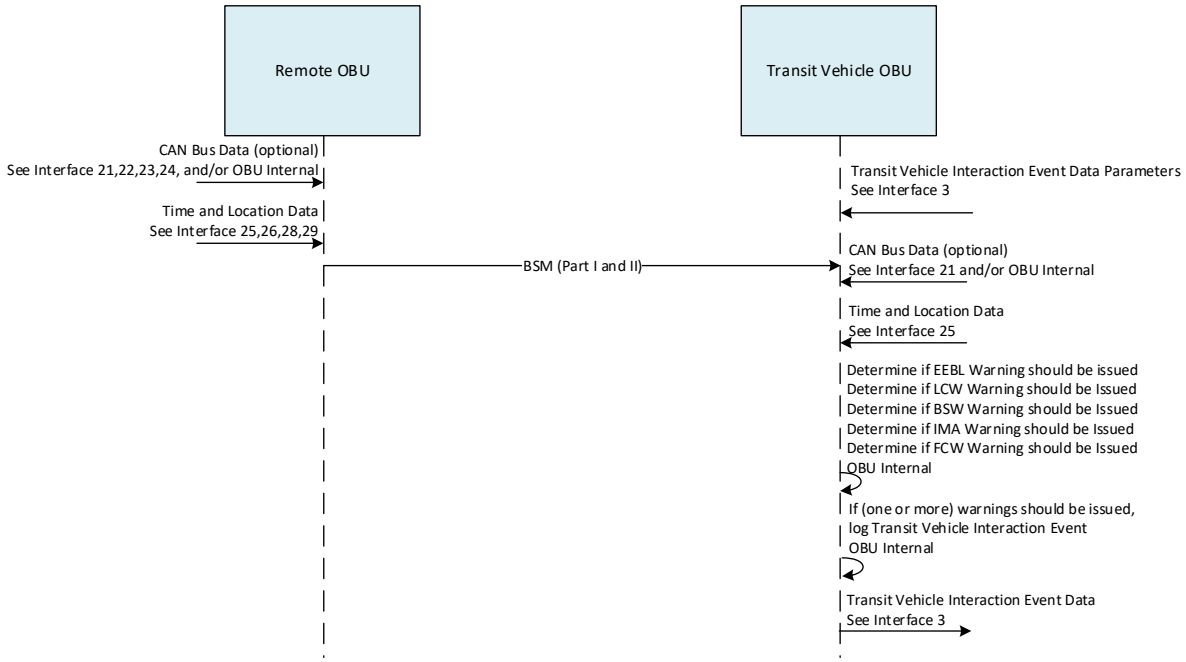


Related Sequence Diagrams	EV Operator-Related Sequence Diagrams
• Interface 14 → **Figure 47** • Interface 23 → **Figure 76** • Interface 28 → **Figure 93**	• *None*
Data Flow Communications Profiles	
• **Table 18: Notification Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1644-V01 • CVE-IF1247-V01	

Source: City of Columbus

3.19. INTERFACE 19: TRANSIT VEHICLE ONBOARD UNIT – REMOTE ONBOARD UNIT

Figure 62: Interface 19 Sequence Diagram – V2V Safety for Transit Vehicle Interaction Event Recording



Remote OBU-Related Sequence Diagrams

- Interface 21 → **Figure 64**
- Interface 22 → **Figure 70**
- Interface 23 → **Figure 74**
- Interface 24 → **Figure 77**
- Interface 25 → **Figure 80**
- Interface 26 → **Figure 86**
- Interface 28 → **Figure 91**
- Interface 29 → **Figure 94**

Transit Veh OBU-Related Sequence Diagrams

- Interface 3 → **Figure 12**
- Interface 21 → **Figure 66**
- Interface 25 → **Figure 82**

Data Flow Communications Profiles

- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile**

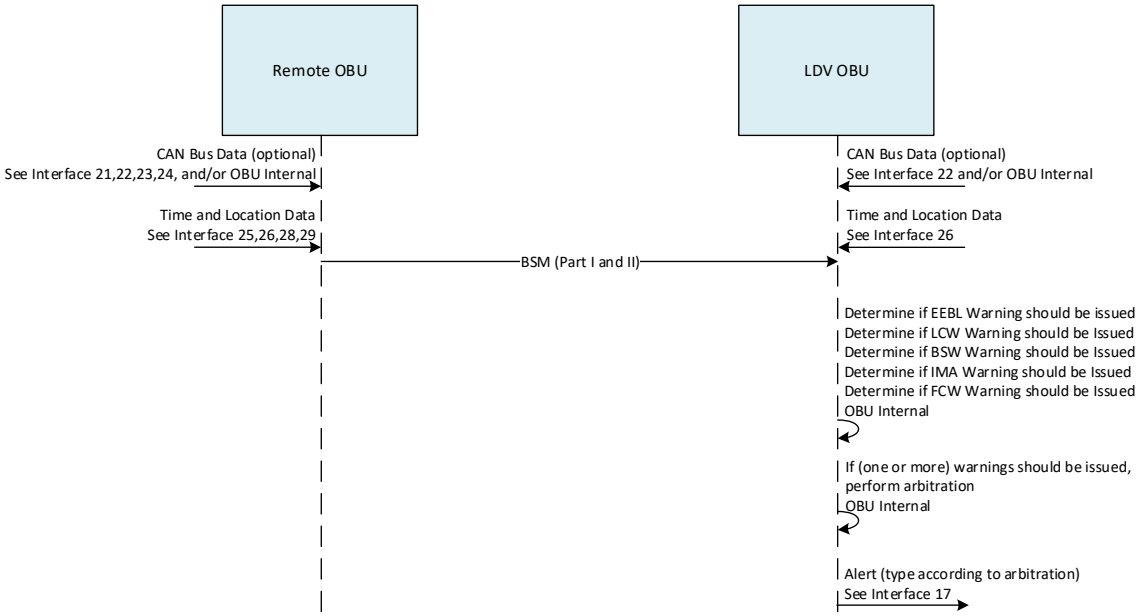
Interface Requirements Traceability

- CVE-IX3264-V01
- CVE-IX1630-V01
- CVE-IF1224-V01

Source: City of Columbus

3.20. INTERFACE 20: LIGHT-DUTY VEHICLE ONBOARD UNIT – REMOTE ONBOARD UNIT

Figure 63: Interface 20 Sequence Diagram – V2V Safety



Remote Veh OBU-Related Sequence Diagrams

- Interface 21 → **Figure 64**
- Interface 22 → **Figure 70**
- Interface 23 → **Figure 74**
- Interface 24 → **Figure 77**
- Interface 25 → **Figure 80**
- Interface 26 → **Figure 86**
- Interface 28 → **Figure 91**
- Interface 29 → **Figure 94**

LDV OBU-Related Sequence Diagrams

- Interface 17 → **Figure 57**
- Interface 22 → **Figure 71**
- Interface 26 → **Figure 87**

Data Flow Communications Profiles

- **Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile**
- **Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile**

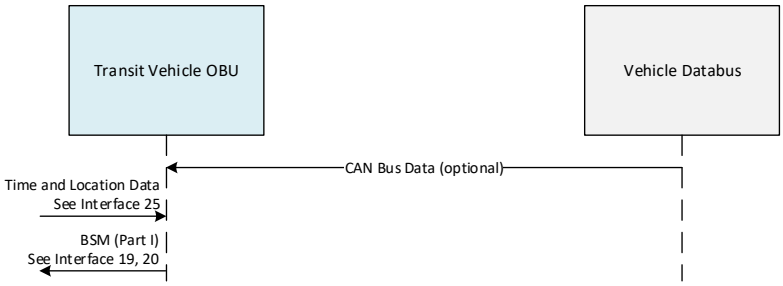
Interface Requirements Traceability

- CVE-IX3265-V01
- CVE-IF1218-V01
- CVE-IX1629-V01
- CVE-IF1220-V01
- CVE-IF1221-V01
- CVE-IF1219-V01
- CVE-IF1223-V01

Source: City of Columbus

3.21. INTERFACE 21: TRANSIT VEHICLE ONBOARD UNIT – TRANSIT VEHICLE DATABUS

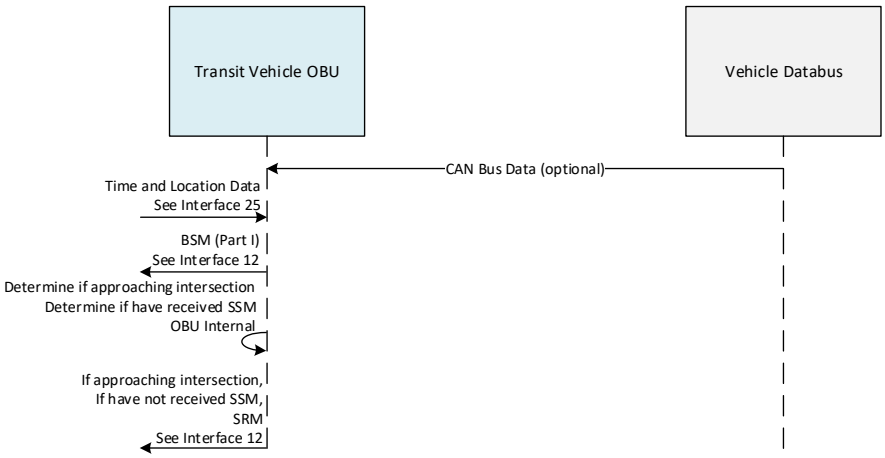
Figure 64: Interface 21 Sequence Diagram – V2V Safety (Remote Vehicle)



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 25 → **Figure 80**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1641-V01 • CVE-IF1244-V01 • CVE-IF1245-V01	

Source: City of Columbus

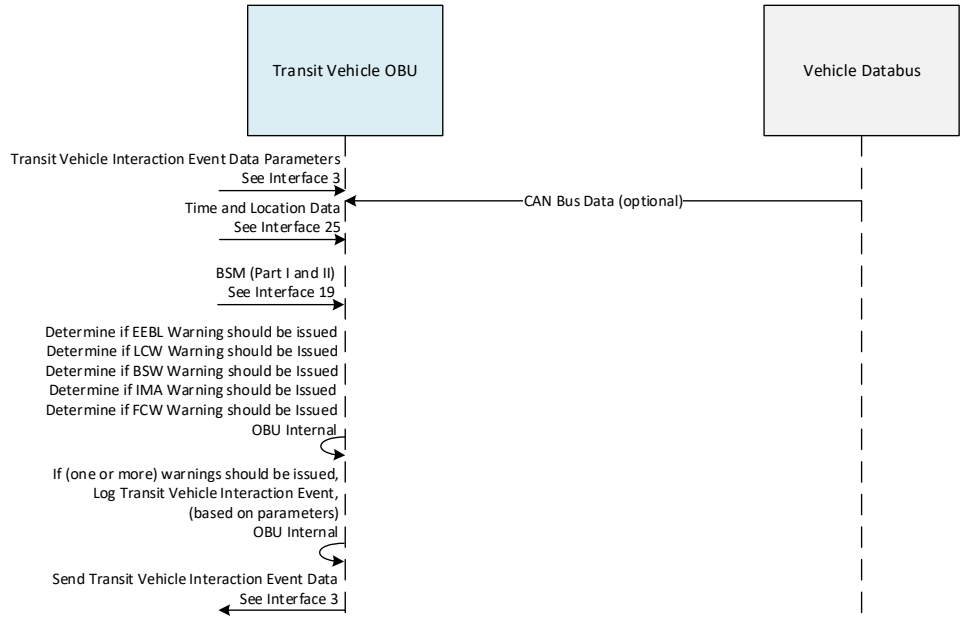
Figure 65: Interface 21 Sequence Diagram – Vehicle Data for Traffic Operations



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 12 → **Figure 37** • Interface 25 → **Figure 81**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1641-V01 • CVE-IF1244-V01 • CVE-IF1245-V01	

Source: City of Columbus

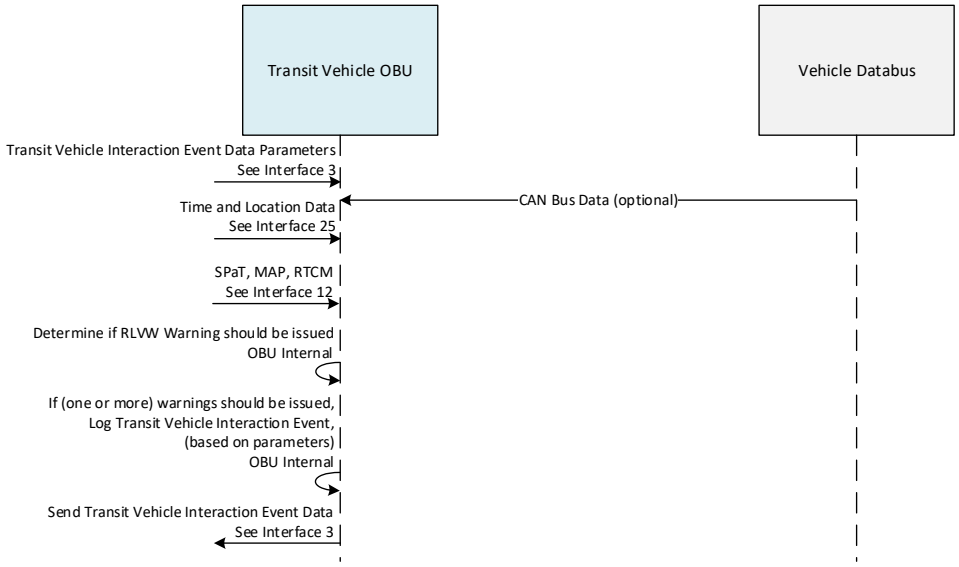
Figure 66: Interface 21 Sequence Diagram – V2V Safety for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 19 → **Figure 62** • Interface 25 → **Figure 82**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1641-V01 • CVE-IF1244-V01 • CVE-IF1245-V01	

Source: City of Columbus

Figure 67: Interface 21 Sequence Diagram – Red Light Violation Warning for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 12 → **Figure 35** • Interface 25 → **Figure 83**	• *None*

Data Flow Communications Profiles

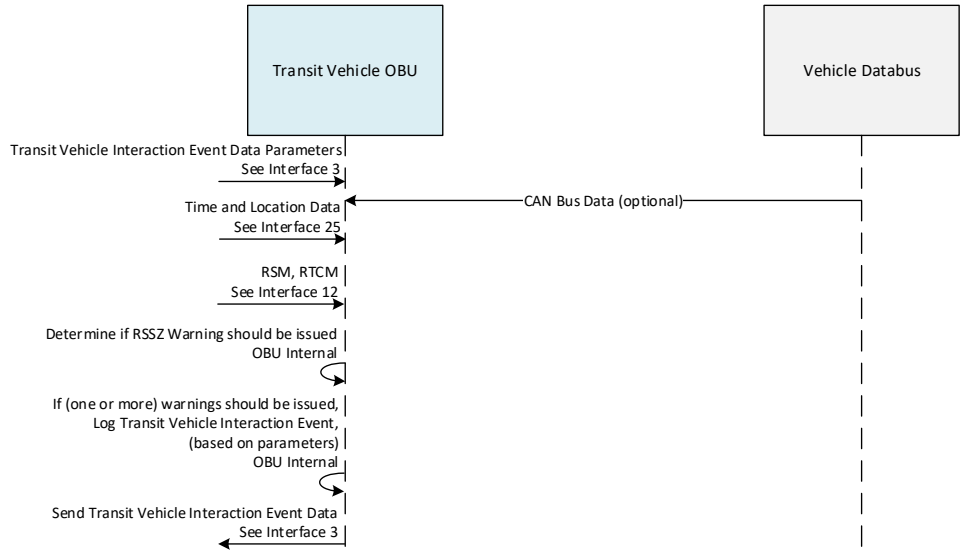
- **Table 13: CAN Bus Data Communication Profile**

Interface Requirements Traceability

- CVE-IX1641-V01
- CVE-IF1244-V01
- CVE-IF1245-V01

Source: City of Columbus

Figure 68: Interface 21 Sequence Diagram – Reduced Speed School Zone for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 12 → **Figure 36** • Interface 25 → **Figure 84**	• *None*

Data Flow Communications Profiles

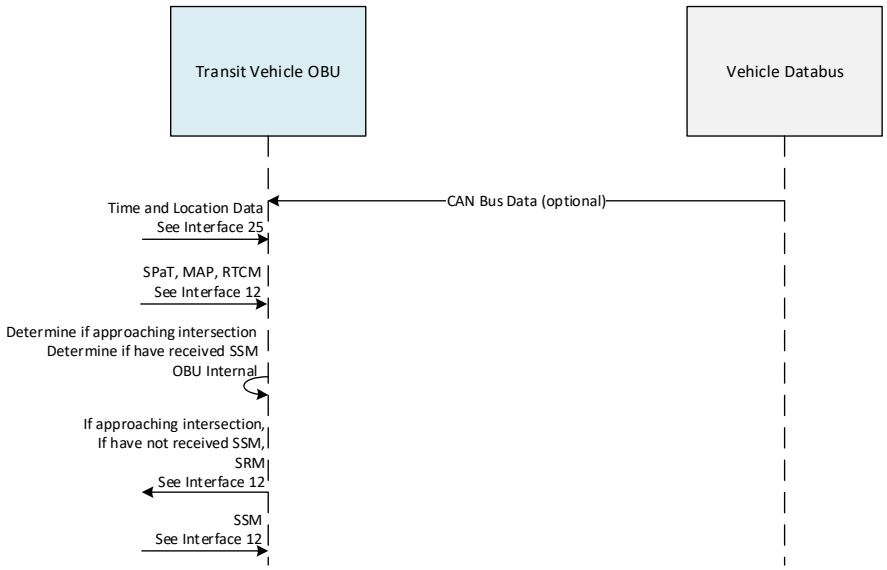
- **Table 13: CAN Bus Data Communication Profile**

Interface Requirements Traceability

- CVE-IX1641-V01
- CVE-IF1244-V01
- CVE-IF1245-V01

Source: City of Columbus

Figure 69: Interface 21 Sequence Diagram – Transit Signal Priority



Transit Veh OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 12 → **Figure 34** • Interface 25 → **Figure 85**	• *None*

Data Flow Communications Profiles

- **Table 13: CAN Bus Data Communication Profile**

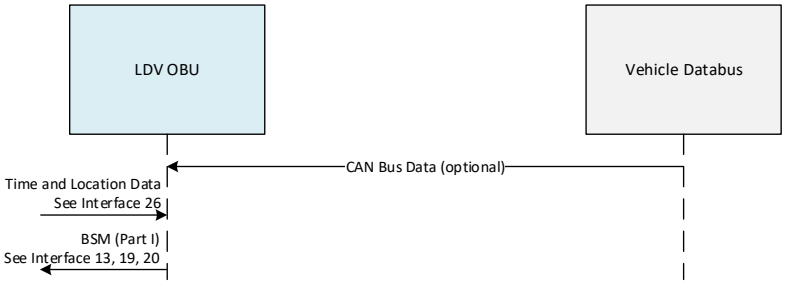
Interface Requirements Traceability

- CVE-IX1641-V01
- CVE-IF1244-V01
- CVE-IF1245-V01

Source: City of Columbus

3.22. INTERFACE 22: LIGHT-DUTY VEHICLE ONBOARD UNIT – LIGHT-DUTY VEHICLE DATABUS

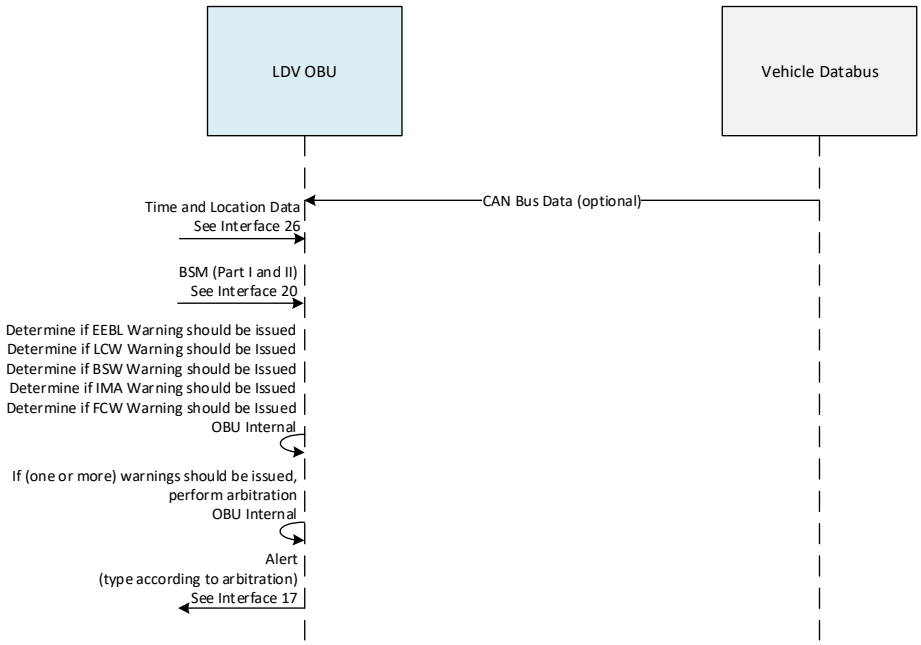
Figure 70: Interface 22 Sequence Diagram – Vehicle Data for Traffic Operations and V2V Safety (Remote)



LDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 13 → **Figure 43** • Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 26 → **Figure 86**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1617-V01	

Source: City of Columbus

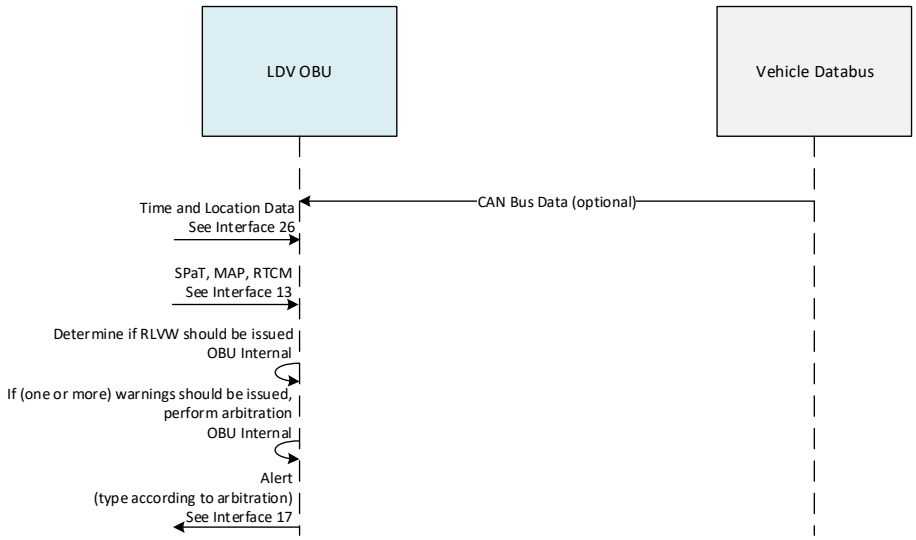
Figure 71: Interface 22 Sequence Diagram – V2V Safety



LDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 17 → **Figure 57** • Interface 20 → **Figure 63** • Interface 26 → **Figure 87**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1617-V01	

Source: City of Columbus

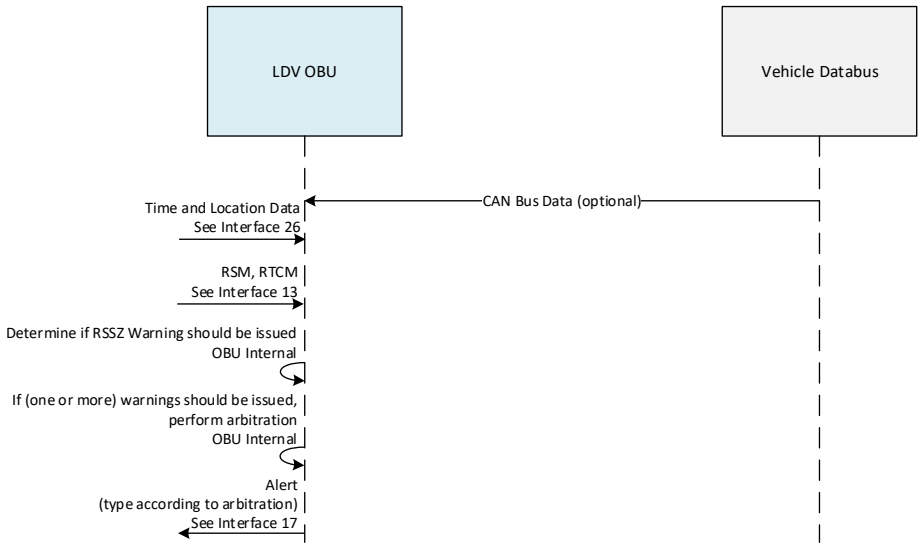
Figure 72: Interface 22 Sequence Diagram – Support Red Light Violation Warning



LDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 13 → **Figure 41** • Interface 17 → **Figure 58** • Interface 26 → **Figure 88**	• *None*
Data Flow Communications Profiles	
• **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1617-V01	

Source: City of Columbus

Figure 73: Interface 22 Sequence Diagram – Reduced Speed School Zone

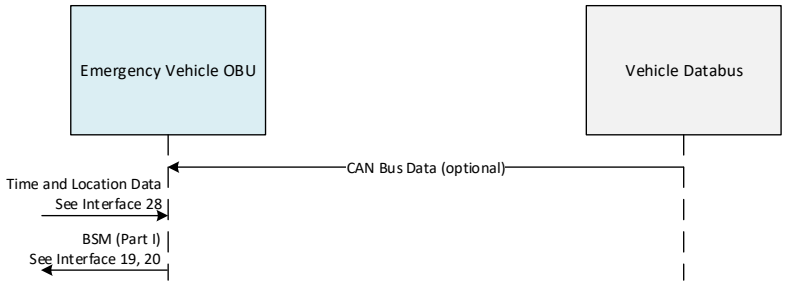


LDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 13 → **Figure 42** • Interface 17 → **Figure 59** • Interface 26 → **Figure 89**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1617-V01	

Source: City of Columbus

3.23. INTERFACE 23: EMERGENCY VEHICLE ONBOARD UNIT – EMERGENCY VEHICLE DATABUS

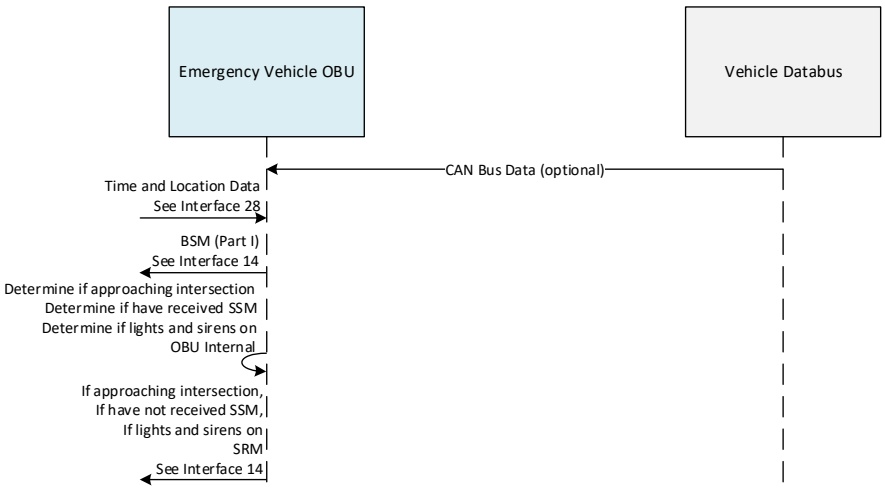
Figure 74: Interface 23 Sequence Diagram – V2V Safety (remote)



EV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 28 → **Figure 91**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1608-V01	

Source: City of Columbus

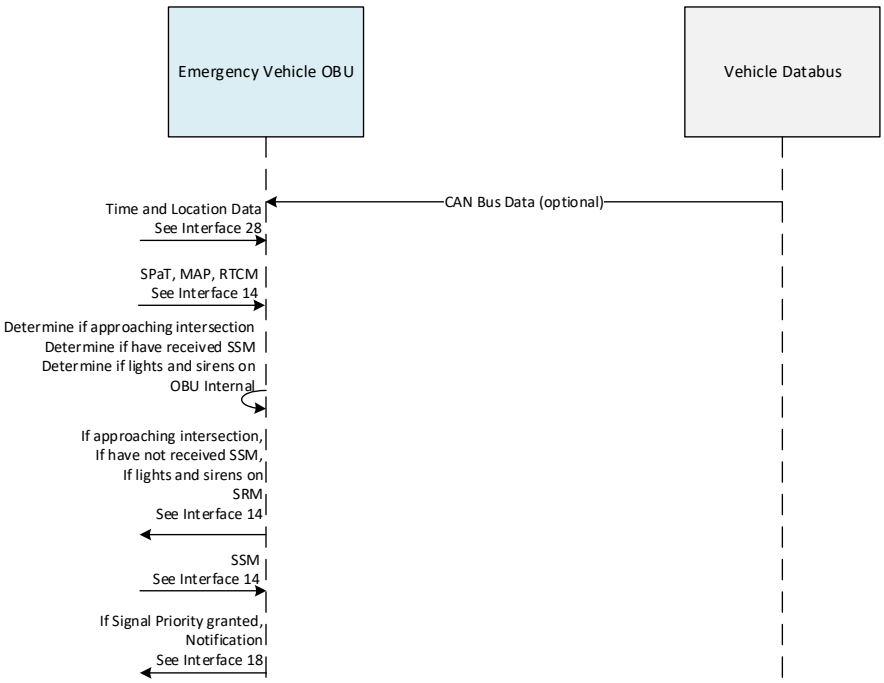
Figure 75: Interface 23 Sequence Diagram – Vehicle Data for Traffic Operations



EV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 14 → **Figure 48** • Interface 28 → **Figure 92**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1608-V01	

Source: City of Columbus

Figure 76: Interface 23 Sequence Diagram – Emergency Vehicle Preemption

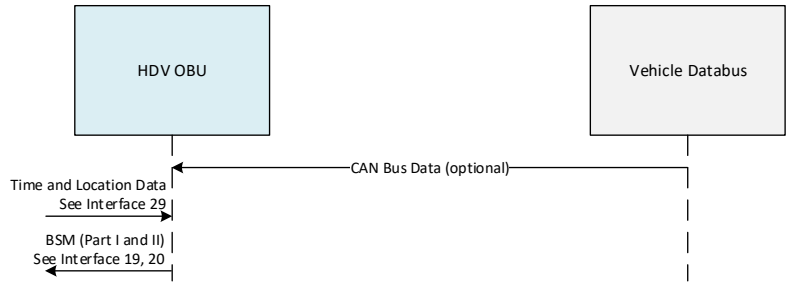


EV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 14 → **Figure 47** • Interface 18 → **Figure 61** • Interface 28 → **Figure 93**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1608-V01	

Source: City of Columbus

3.24. INTERFACE 24: HEAVY DUTY VEHICLE ONBOARD UNIT – HEAVY DUTY VEHICLE DATABUS

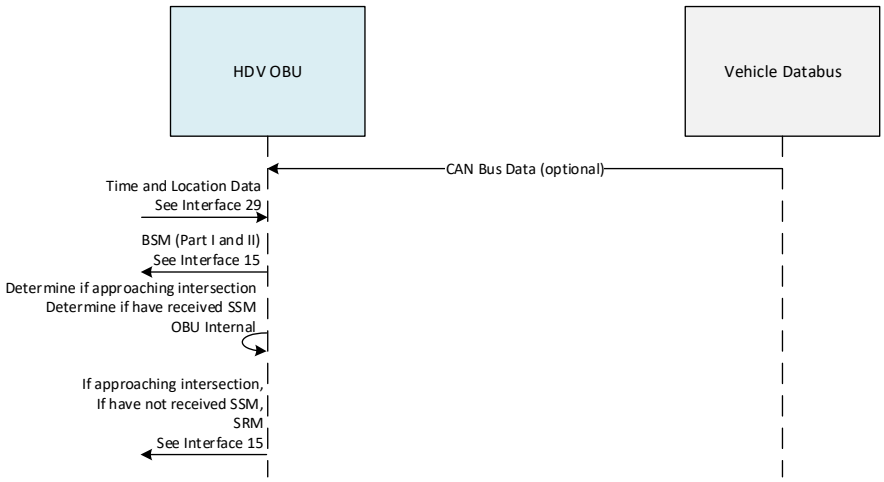
Figure 77: Interface 24 Sequence Diagram – V2V Safety (Remote)



HDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 29 → **Figure 94**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1612-V01	

Source: City of Columbus

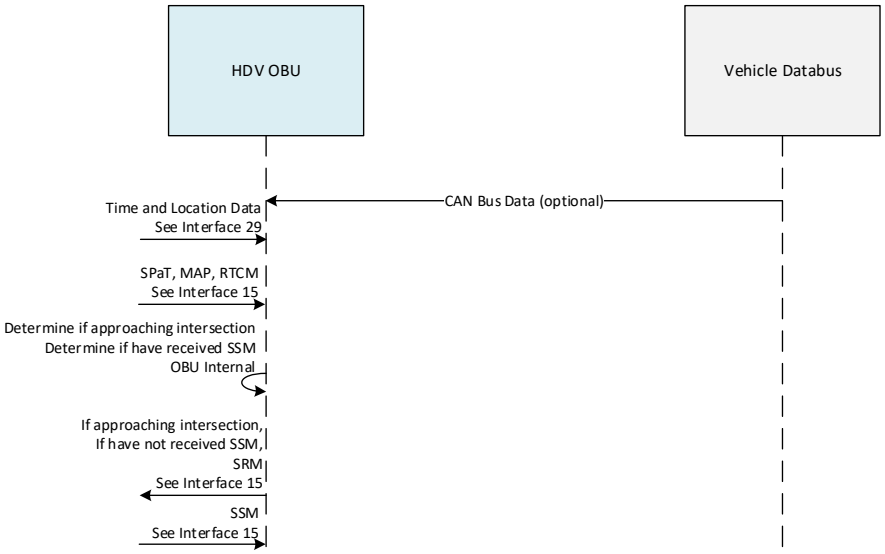
Figure 78: Interface 24 Sequence Diagram – Vehicle Data for Traffic Operations



HDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 15 → **Figure 53** • Interface 29 → **Figure 95**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
• Interface Requirements Traceability **CVE-IX1612-V01**	

Source: City of Columbus

Figure 79: Interface 24 Sequence Diagram – Freight Signal Priority

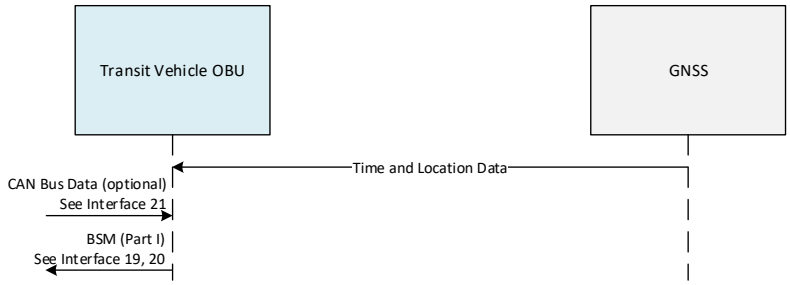


HDV OBU-Related Sequence Diagrams	Vehicle Databus-Related Sequence Diagrams
• Interface 15 → **Figure 52** • Interface 29 → **Figure 96**	• *None*
Data Flow Communications Profiles • **Table 13: CAN Bus Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1612-V01	

Source: City of Columbus

3.25. INTERFACE 25: TRANSIT VEHICLE ONBOARD UNIT – GLOBAL NAVIGATION SATELLITE SYSTEM

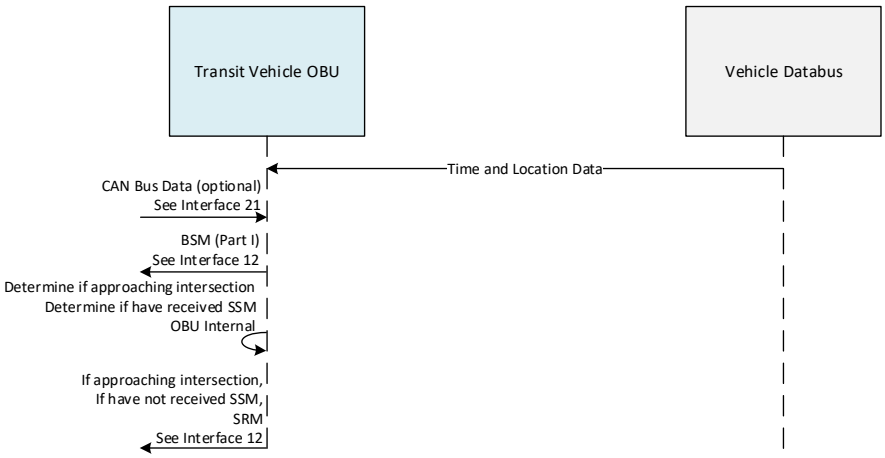
Figure 80: Interface 25 Sequence Diagram – V2V Safety (Remote)



Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 21 → **Figure 64**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1624-V01	

Source: City of Columbus

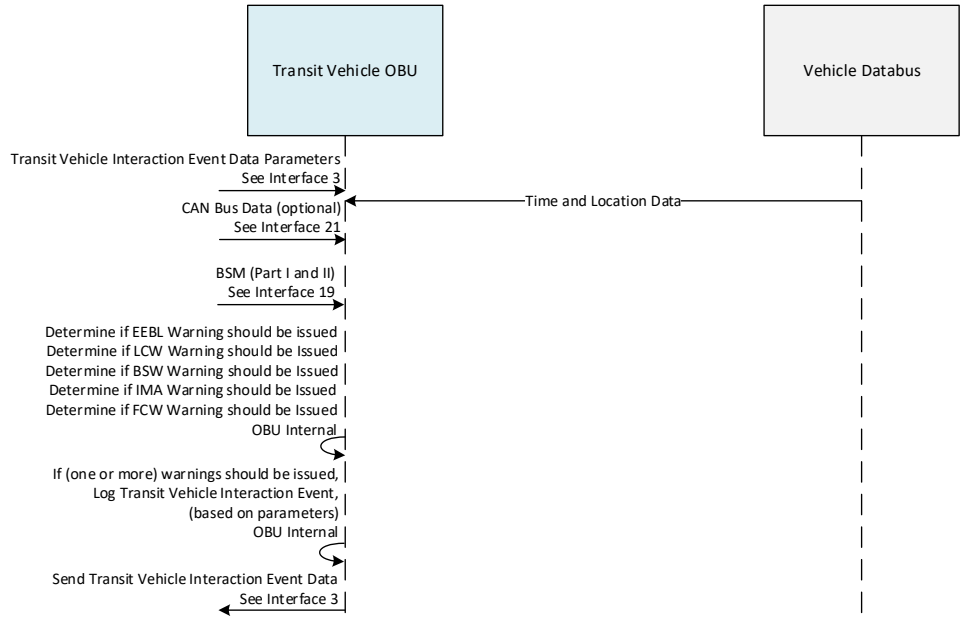
Figure 81: Interface 25 Sequence Diagram – Vehicle Data for Traffic Operations



Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 12 → **Figure 37** • Interface 21 → **Figure 65**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1624-V01	

Source: City of Columbus

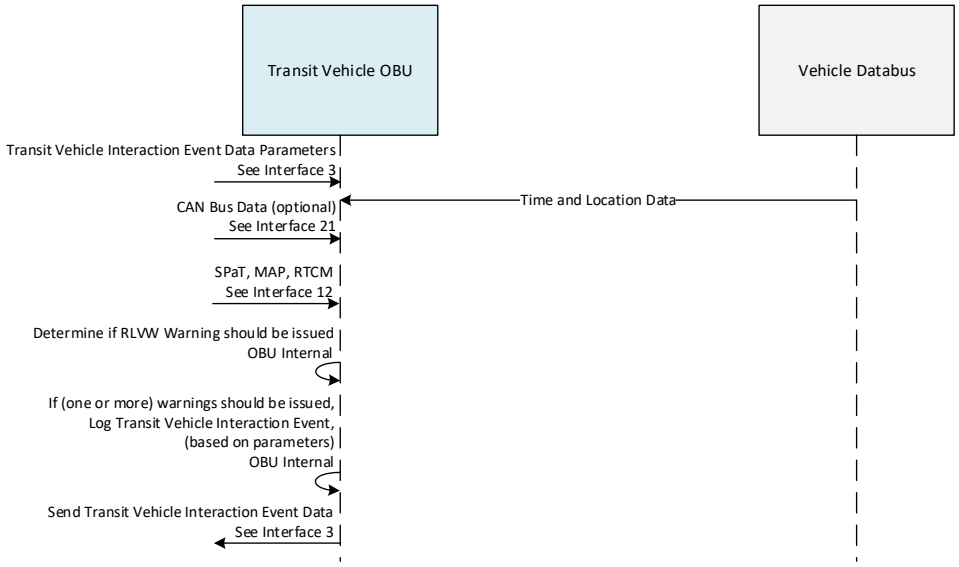
Figure 82: Interface 25 Sequence Diagram – V2V Safety for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 19 → **Figure 62** • Interface 21 → **Figure 66**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1624-V01	

Source: City of Columbus

Figure 83: Interface 25 Sequence Diagram – Red Light Violation Warning for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 12 → **Figure 35** • Interface 21 → **Figure 67**	• *None*

Data Flow Communications Profiles

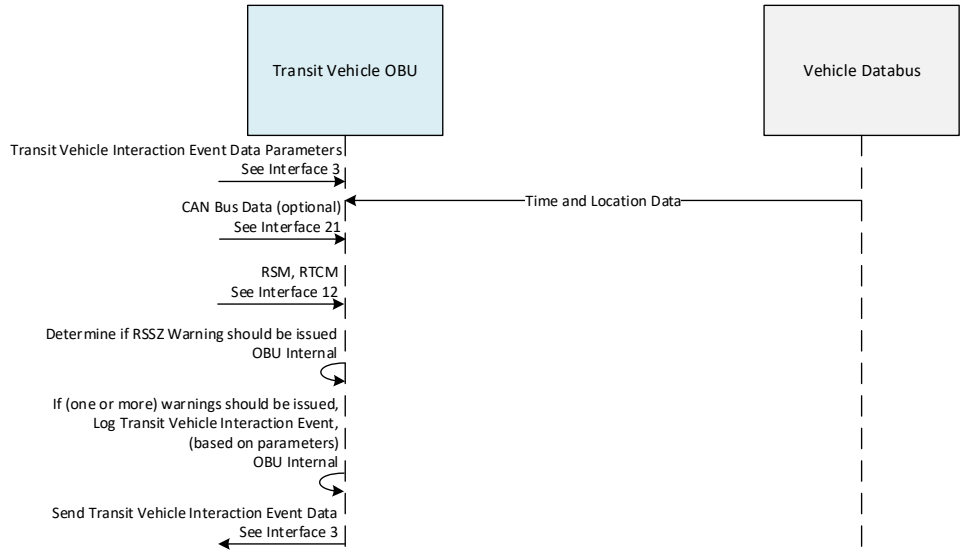
- **Table 47: Time and Location Data Communication Profile**

Interface Requirements Traceability

- CVE-IX1624-V01

Source: City of Columbus

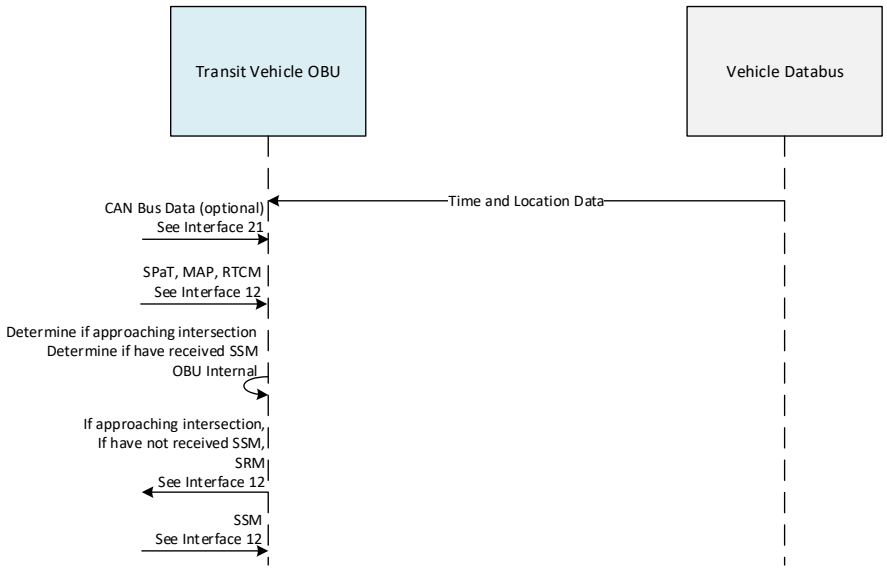
Figure 84: Interface 25 Sequence Diagram – Reduced Speed School Zone for Transit Vehicle Interaction Event Recording



Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 3 → **Figure 12** • Interface 12 → **Figure 36** • Interface 21 → **Figure 68**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1624-V01	

Source: City of Columbus

Figure 85: Interface 25 Sequence Diagram – Transit Signal Priority

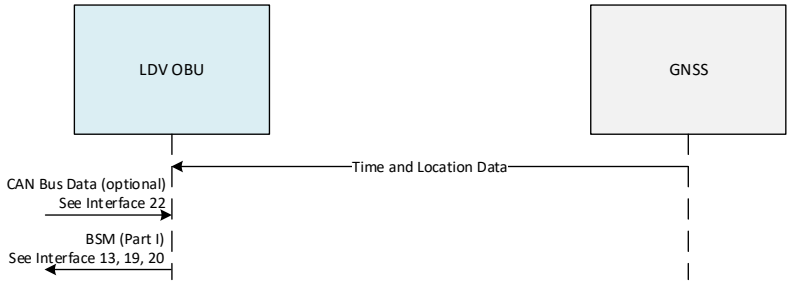


Transit Veh OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 12 → **Figure 34** • Interface 21 → **Figure 69**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1624-V01	

Source: City of Columbus

3.26. INTERFACE 26: LIGHT-DUTY VEHICLE ONBOARD UNIT – GLOBAL NAVIGATION SATELLITE SYSTEM

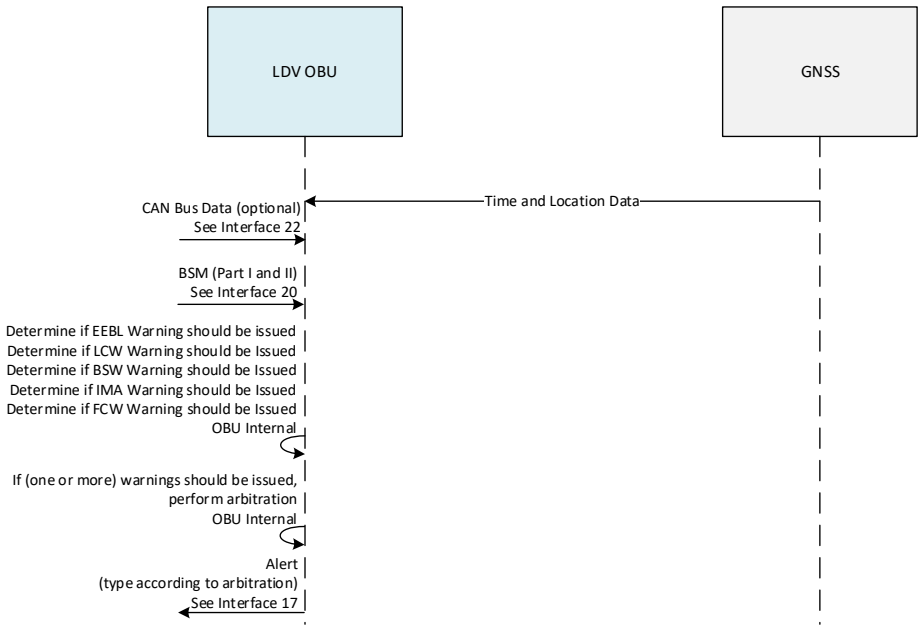
Figure 86: Interface 26 Sequence Diagram – Vehicle Data for Traffic Operations and V2V Safety (Remote)



LDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 13 → **Figure 43** • Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 22 → **Figure 70**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1623-V01 • CVE-IF1242-V01	

Source: City of Columbus

Figure 87: Interface 26 Sequence Diagram – V2V Safety



LDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 17 → **Figure 57** • Interface 20 → **Figure 63** • Interface 22 → **Figure 71**	• *None*

Data Flow Communications Profiles

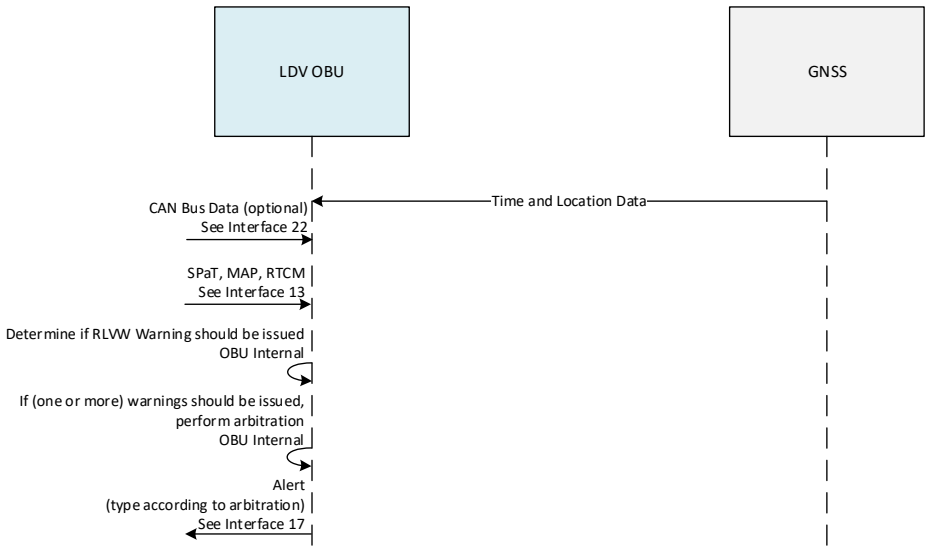
- **Table 47: Time and Location Data Communication Profile**

Interface Requirements Traceability

- CVE-IX1623-V01
- CVE-IF1242-V01

Source: City of Columbus

Figure 88: Interface 26 Sequence Diagram – Red Light Violation Warning



LDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 13 → **Figure 41** • Interface 17 → **Figure 58** • Interface 22 → **Figure 72**	• *None*

Data Flow Communications Profiles

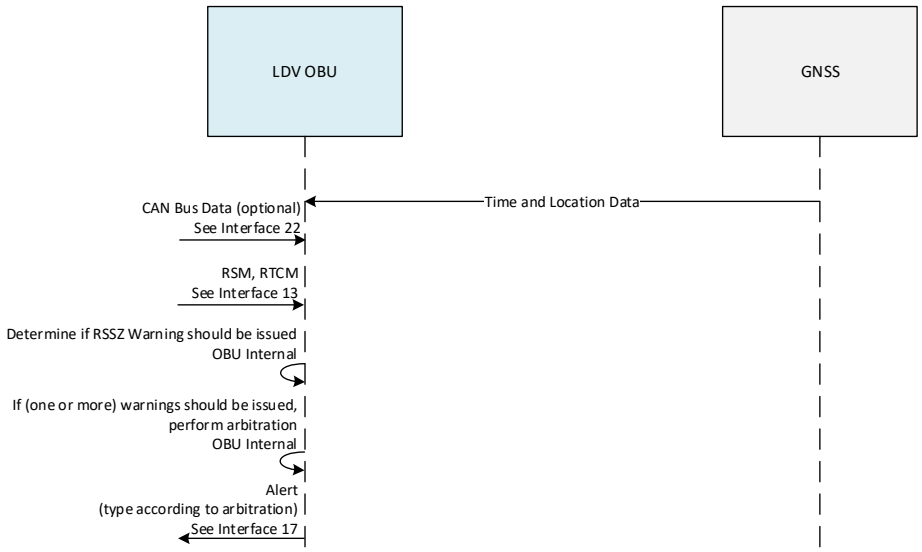
- **Table 47: Time and Location Data Communication Profile**

Interface Requirements Traceability

- CVE-IX1623-V01
- CVE-IF1242-V01

Source: City of Columbus

Figure 89: Interface 26 Sequence Diagram – Reduced Speed School Zone

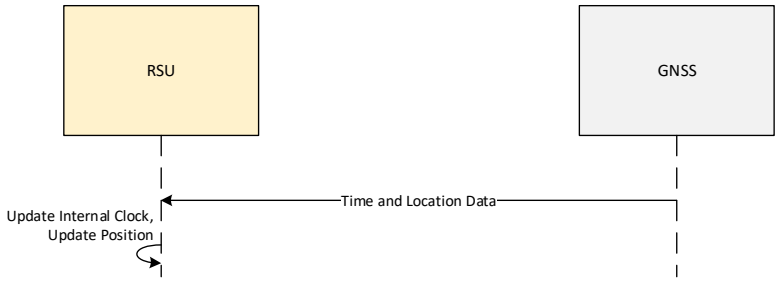


LDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 13 → **Figure 42** • Interface 17 → **Figure 59** • Interface 22 → **Figure 73**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1623-V01 • CVE-IF1242-V01	

Source: City of Columbus

3.27. INTERFACE 27: ROADSIDE UNIT – GLOBAL NAVIGATION SATELLITE SYSTEM

Figure 90: Interface 27 Sequence Diagram – RSU Time Synchronization

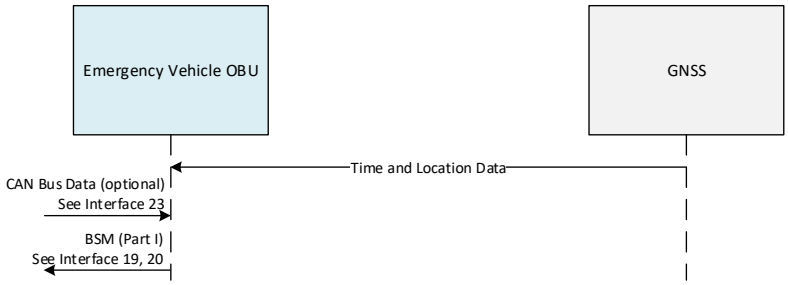


RSU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• *None*	• *None*
Data Flow Communications Profiles	
• **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability	
• CVE-IX1625-V01 CVE-IF1343-V01	

Source: City of Columbus

3.28. INTERFACE 28: EMERGENCY VEHICLE ONBOARD UNIT – GLOBAL NAVIGATION SATELLITE SYSTEM

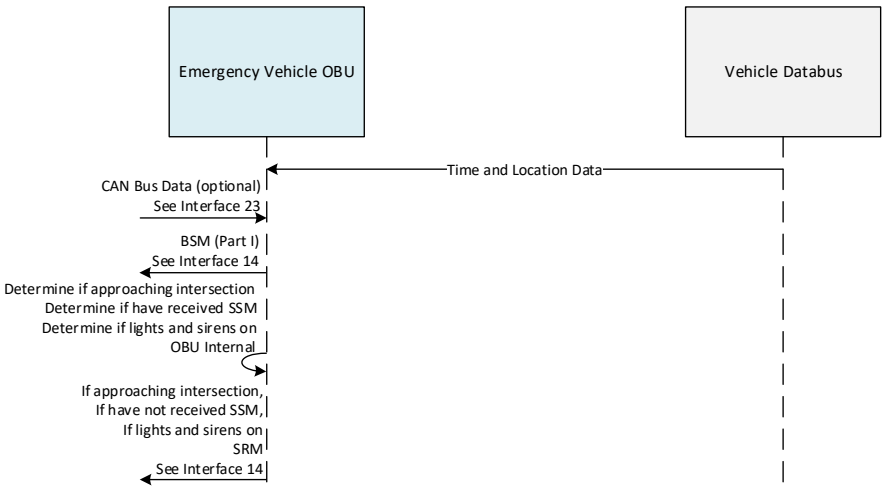
Figure 91: Interface 28 Sequence Diagram – V2V Safety (Remote)



EV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 23 → **Figure 74**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1621-V01	

Source: City of Columbus

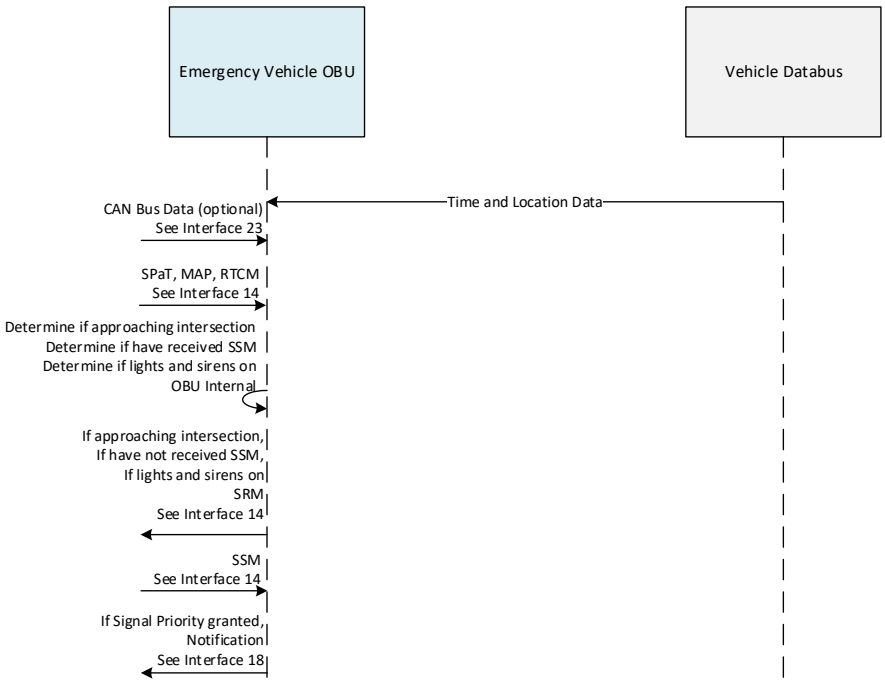
Figure 92: Interface 28 Sequence Diagram: Vehicle Data for Traffic Operations



EV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 14 → **Figure 48** • Interface 23 → **Figure 75**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1621-V01	

Source: City of Columbus

Figure 93: Interface 28 Sequence Diagram – Emergency Vehicle Preemption

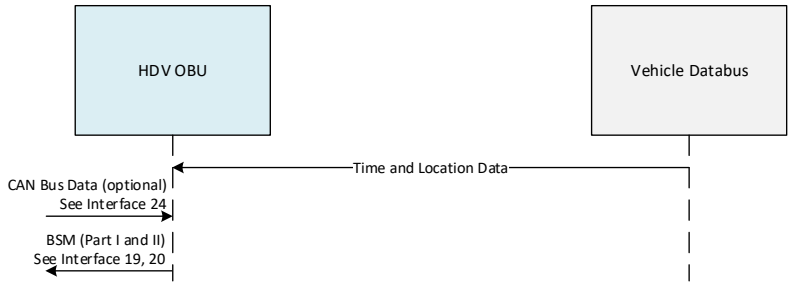


EV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 14 → **Figure 47** • Interface 18 → **Figure 61** • Interface 23 → **Figure 76**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1621-V01	

Source: City of Columbus

3.29. INTERFACE 29: HEAVY-DUTY VEHICLE ONBOARD UNIT – GLOBAL NAVIGATION SATELLITE SYSTEM

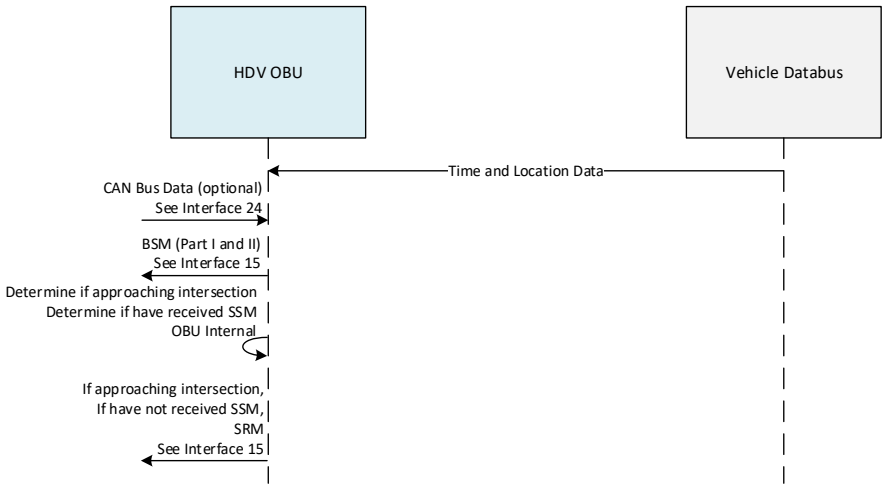
Figure 94: Interface 29 Sequence Diagram – V2V Safety (remote)



HDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 19 → **Figure 62** • Interface 20 → **Figure 63** • Interface 24 → **Figure 77**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1622-V01	

Source: City of Columbus

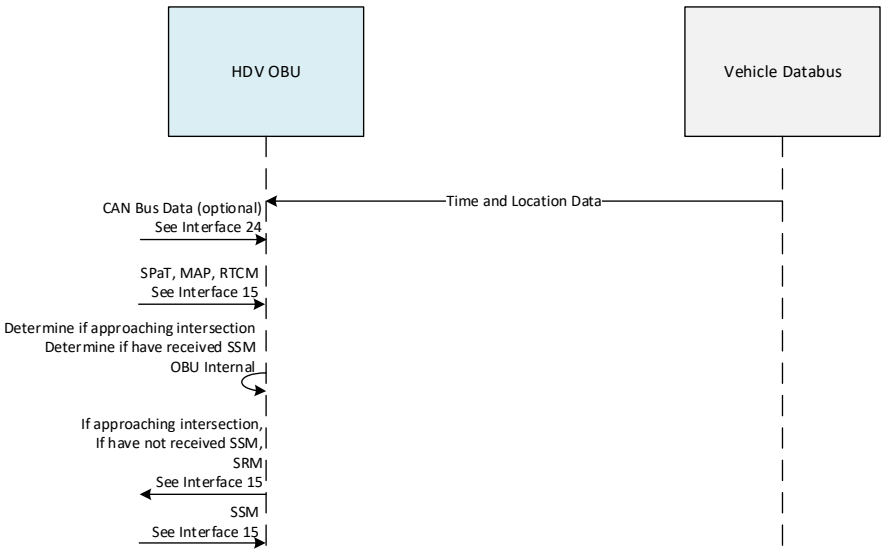
Figure 95: Interface 29 Sequence Diagram: Vehicle Data for Traffic Operations



HDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
• Interface 15 → **Figure 53** • Interface 24 → **Figure 78**	• *None*
Data Flow Communications Profiles • **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability • CVE-IX1622-V01	

Source: City of Columbus

Figure 96: Interface 29 Sequence Diagram – Freight Signal Priority



HDV OBU-Related Sequence Diagrams	GNSS-Related Sequence Diagrams
Interface 15 → **Figure 52** Interface 24 → **Figure 79**	• *None*
Data Flow Communications Profiles **Table 47: Time and Location Data Communication Profile**	
Interface Requirements Traceability CVE-IX1622-V01	

Source: City of Columbus

Chapter 4. Message Content

This section defines the message content for each message type that are indicated in the summary in the list of interfaces in **Chapter 2.2** and that are used in the sequence diagrams presented in **Chapter 3**. Certain data frames/elements are defined in existing standards which are referenced as needed. These standards specify whether data frames/elements are required or optional for certain interfaces. The "Required Data" row in each communication profile contains all data frame/elements required by the standard(s) that are referenced – it may also contain some data frames/elements that the reference specifies as optional. However, **all data frames/elements that are specified are required for the CVE**. This this does not preclude other (optional or non-listed) data frames/elements from being used. Communications Profiles for interfaces considered optional (e.g. CAN Bus data) do not specify required data. In these instances, it is up to the integrator to determine which data from this interface will be used. It is important to note that data flows across interfaces between the OBU Integrator and RSU Integrator system boundaries (Interface 12, Interface 13, Interface 14, Interface 15) are extensively defined to ensure interoperability and that each system has the data it needs to operate as intended. For ease of use, message types are listed in alphabetical order.

Each communications profile details the interface over which the message is sent, communications standards that are associated with that interface (these correspond to the communications standards specified for interfaces in **Chapter 2.2**), a description of the message, and details data items that are required to be contained in the message. When possible, data descriptions and possible values are taken from existing standards and referenced.

4.1. ALERT

Table 4: Alert Communication Profile

Message	Alert
Applicable Interface(s)	Interface 17
Applicable Standards	N/A (Human-Machine Interface)
Description	An audio/visual alert provided to the LDV Operator that supports V2V Safety and V2I Safety Applications.

Required Data

Name	Type	Description	Values	Reference
Emergency Electronic Brake Light Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when an Emergency Electronic Brake Light Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Forward Collision Warning Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when a Forward Collision Warning Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Lane Change Warning Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when a Lane Change Warning Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Blind Spot Warning Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when a Blind Spot Warning Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Intersection Movement Assist Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when an Intersection Movement Assist has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Red Light Violation Warning Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when a Red Light Violation Warning Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-
Reduced Speed School Zone Warning Alert	Audio/Visual	The type of alert that is issued to an LDV Operator when a Reduced Speed School Zone Event has occurred and arbitration on the LDV OBU indicates that it is the highest priority event.	-	-

Source: City of Columbus, ARC-IT

4.2. APPLICATION AVAILABILITY

Table 5: Application Availability Communication Profile

Message	Application Availability				
Applicable Interface(s)	Interface 17				
Applicable Standards	N/A (Human-Machine Interface)				
Description	An indicator on the OBU that provides the status of each application and the OBU system version to the LDV Operator.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Emergency Electronic Brake Light Warning Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of EEBL	(e.g.) Operational, Failed, Disabled	-
	Lane Change Warning Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of LCW	(e.g.) Operational, Failed, Disabled	-
	Blind Spot Warning Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of BSW	(e.g.) Operational, Failed, Disabled	-
	Intersection Movement Assist Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of IMA	(e.g.) Operational, Failed, Disabled	-
	Forward Collision Warning Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of FCW	(e.g.) Operational, Failed, Disabled	-
	Red Light Violation Warning Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of RLVW	(e.g.) Operational, Failed, Disabled	-
	Reduced Speed School Zone Availability	Audio/Visual	An indicator that tells the LDV Operator the availability of RSSZ	(e.g.) Operational, Failed, Disabled	-
	System Version	Audio/Visual	The version number of software/firmware on the OBU	-	-

Source: City of Columbus, ARC-IT

4.3. ARCHIVED DATA QUERY

Table 6: Archived Data Query Communication Profile

Message	Archived Data Query				
Applicable Interface(s)	Interface 1, Interface 2				
Applicable Standards	N/A (User Interface)				
Description	Allows management staff to query a database of stored data (BSM, SPaT, MAP, SRM, SSM, RSM) with basic time parameters to obtain the stored data.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Type of Data	Audio/Visual	An indicator of the type of data to query a local database for	BSM, SPaT, MAP, SRM, SSM, RSM	-
	From Date	Audio/Visual	A lower bound time for filtering the data that is returned	Time (MM/DD/YYYY HH:MM)	-
	To Date	Audio/Visual	An upper bound time for filtering the data that is returned	Time (MM/DD/YYYY HH:MM)	

Source: City of Columbus, ARC-IT

4.4. ARCHIVED DATA RETURN

Table 7: Archived Data Return Communication Profile

Message	Archived Data Return				
Applicable Interface(s)	Interface 1, Interface 2				
Applicable Standards	N/A (User Interface)				
Description	The data that is returned to management staff based on a query that was made				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Data (BSM, SPaT, MAP, SRM, SSM, RSM)	-	Data returned based on an archive data query	-	-

Source: City of Columbus, ARC-IT

4.5. BASIC SAFETY MESSAGE (PART I)

Table 8: Basic Safety Message (Part I) (SAE J2735) Communication Profile

<table>
<tr><th>Message</th><th colspan="2">Basic Safety Message (BSM) Part I</th></tr>
<tr><td>Applicable Interface(s)</td><td>Interface 7</td><td>Interface 12, Interface 13, Interface 14, Interface 15, Interface 19, Interface 20</td></tr>
<tr><td>Applicable Standards</td><td>• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer:IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3 (fiber-optic backhaul)
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td><td>• ITS Application Information Layer: SAE J2735_201603, Section 5.2
• Presentation Layer: ISO ASN.1 UPER
• Transport Layer: IEEE 1609.3 WSMP
• Network Layer: IEEE 1609.3 WSMP
• Data Link Layer: IEEE 1609.4, IEEE 802.11
• Physical Layer: IEEE 802.11
• Security Plane: IEEE 1609.2
See Table 3 in Chapter 2 for the proposed DSRC channel map.</td></tr>
<tr><td>Description</td><td colspan="2">The basic safety message (BSM) is used in a variety of applications to exchange safety data regarding vehicle state. This message is broadcast frequently to surrounding vehicles with data content as required by safety and other applications. Part I data shall be included in every BSM.
BSMs are received and logged by the RSU and are periodically sent to the Traffic CV Management System</td></tr>
<tr><td>Required Data</td><td colspan="2">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>coreData</td><td>BSMcoreData</td><td>Contains the critical core data elements deemed to be needed with every BSM issued</td><td>N/A (Data Frame)</td><td>SAE J2735_201603, Section 6.8</td></tr>
<tr><td>msgCnt</td><td>MsgCount</td><td>A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.</td><td>INTEGER (0…127)</td><td>SAE J2735_201603, Section 7.104</td></tr>
<tr><td>id</td><td>TemporaryID</td><td>4 octet random device identifier. Changes periodically to ensure the overall anonymity of the vehicle</td><td>OCTET STRING (SIZE(4))</td><td>SAE J2735_201603, Section 7.187</td></tr>
<tr><td>secMark</td><td>DSecond</td><td>Represents the milliseconds within a minute – units of milliseconds</td><td>INTEGER (0…65535)</td><td>SAE J2735_201603, Section 7.39</td></tr>
</table>
</td></tr>
</table>

Message	Basic Safety Message (BSM) Part I				
	lat	Latitude	The geographic latitude of an object, expressed in 1/10th integer microdegrees	INTEGER (-900000000... 900000001)	SAE J2735_201603, Section 7.91
	lon	Longitude	The geographic longitude of an object, expressed in 1/10th integer microdegrees	INTEGER (-1799999999.... 1800000001)	SAE J2735_201603, Section 7.95
	elev	Elevation	Geographic position above or below the reference ellipsoid (typically WGS-84). The number has a resolution of 1 decimeter	INTEGER (-4096...61439)	SAE J2735_201603, Section 7.44
	accuracy	PositionalAccuracy	various parameters of quality used to model the accuracy of the positional determination with respect to each given axis		SAE J2735_201603, Section 6.88
	semiMajor	SemiMajorAxisAccuracy	radius (length) of the semi-major axis of an ellipsoid representing the accuracy which can be expected from a GNSS system in 5 cm steps, typically at a one sigma level of confidence. range 0-12.7 meter, LSB = 0.05m	INTEGER (0...255)	SAE J2735_201603, Section 7.168
	semiMinor	SemiMinorAxisAccuracy	radius of the semi-minor axis of an ellipsoid representing the accuracy which can be expected from a GNSS system in 5 cm steps, typically at a one sigma level of confidence. range 0-12.7 meter, LSB = 0.05m	INTEGER (0...255)	SAE J2735_201603, Section 7.170
	orientation	SemiMajorAxisOrientation	orientate the angle of the semi-major axis of an ellipsoid. relative to true north (0~359.9945078786 degrees) LSB units of 360/65535 deg	INTEGER (0...65535)	SAE J2735_201603, Section 7.169
	transmission	TransmissionState	current state of the vehicle transmission	ENUMERATED{ neutral (0), park (1), forwardGears (2), reverseGears (3), unavailable (7)}	SAE J2735_201603, Section 7.201
	speed	Speed	vehicle speed expressed in unsigned units of 0.02 meters per second	INTEGER (0...8191)	SAE J2735_201603, Section 7.179

Message	Basic Safety Message (BSM) Part I				
	heading	Heading	current heading of the sending device, expressed in unsigned units of 0.0125 degrees from North	INTEGER (0...28800)	SAE J2735_201603, Section 7.53
	angle	SteeringWheelAngle	The angle of the driver's steering wheel, with LSB units of 1.5 degrees +127 to be used for unavailable	INTEGER (-126...127)	SAE J2735_201603, Section 7.185
	accelSet	AccelerationSet4Way	Set of acceleration values in 3 orthogonal directions of the vehicle and with yaw rotation rates	N/A (Data Frame)	SAE J2735_201603, Section 6.1
	long	Acceleration	Signed acceleration of the vehicle along some known axis in units of 0.01 meters per second squared along the Vehicle Longitudinal axis	INTEGER (-2000...2001)	SAE J2735_201603, Section 7.1
	lat	Acceleration	Signed acceleration of the vehicle along some known axis in units of 0.01 meters per second squared along the Vehicle Lateral axis	INTEGER (-2000...2001)	SAE J2735_201603, Section 7.1
	vert	VerticalAcceleration	Signed vertical acceleration of the vehicle along the vertical axis in units of 0.02 G	INTEGER (-127...127)	SAE J2735_201603, Section 7.217
	yaw	YawRate	Yaw Rate of the vehicle, a signed value (to the right being positive) expressed in 0.01 degrees per second	INTEGER (-32767...32767)	SAE J2735_201603, Section 7.229
	brakes	BrakeSystemStatus	Information about the current brake and system control activity of the vehicle		SAE J2735_201603, Section 6.7
	wheelBrakes	BrakeAppliedStatus	Independently for each of four wheels whether braking is currently active. Set to 1 if brakes are active on that wheel, or to 0 if brakes are inactive on that wheel	BIT STRING { unavailable (0), leftFront (1), leftRear (2), rightFront (3), rightRear (4) }	SAE J2735_201603, Section 7.18
	traction	TractionControlStatus	Status of the vehicle traction control system	ENUMERATED { unavailable (0), off (1), on (2), engaged (3)}	SAE J2735_201603, Section 7.196

Message	Basic Safety Message (BSM) Part I				
	abs	AntiLockBrakeStatus	Status of the vehicle ABS	ENUMERATED { unavailable (0), off (1), on (2), engaged (3)}	SAE J2735_201603, Section 7.10
	scs	StabilityControlStatus	Current state of the stability control system	ENUMERATED { unavailable (0), off (1), on (2), engaged (3)}	SAE J2735_201603, Section 7.181
	brakeBoost	BrakeBoostApplied	When set to the "on" state, indicates emergency braking	ENUMERATED { unavailable (0), off (1), on (2)}	SAE J2735_201603, Section 7.19
	auxBrakes	AuxilliaryBrakeStatus	status of the auxiliary brakes (sometimes referred to as the parking brake) of the vehicle	ENUMERATED { unavailable (0), off (1), on (2), reserved (3)}	SAE J2735_201603, Section 7.14
	size	VehicleSize	vehicle length and vehicle width	N/A (Data Frame)	SAE J2735_201603, Section 6.149
	width	VehicleWidth	Width of the vehicle expressed in centimeters	INTEGER (0...1023)	SAE J2735_201603, Section 7.214
	length	VehicleLength	Length of the vehicle measured from the edge of the front bumper to the edge of the rear bumper expressed in centimeters, unsigned.	INTEGER (0... 4095)	SAE J2735_201603, Section 7.210

Source: City of Columbus, ARC-IT

4.6. BASIC SAFETY MESSAGE (PART II)

Table 9: Basic Safety Message (Part II) (SAE J2735) Communication Profile

Message	Basic Safety Message (BSM) Part II	
Applicable Interface(s)	Interface 7	Interface 15, Interface 19, Interface 20
Applicable Standards	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS	• ITS Application Information Layer: SAE J2735_201603, Section 5.2 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2 *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	BSM Part II data items are optional for a given BSM and are included as needed, as specified in the System Requirements BSMs are received and logged by the RSU and are periodically sent to the Traffic CV Management System.	

Required Data	Name	Type	Description	Values	Reference
	specialVehicleExt	SpecialVehicleExtensions	various additional optional information elements for special vehicles. For example, a heavy truck sending content about the trailer it was hauling	N/A (Data Frame)	SAE J2735_201603, Section 6.128
	trailers	TrailerData	describe trailers pulled by a motor vehicle and/or other equipped devices	N/A (Data Frame)	SAE J2735_201603, Section 6.135

Message	Basic Safety Message (BSM) Part II				
	sspRights	SSPindex	Used to control the data elements that follow the occurrence of the index. In the absence of a matching index in the message sender's CERT, the message contents are not valid	INTEGER (0...31)	SAE J2735_201603, Section 7.180
	connection	PivotPointDescription	describes the geometric relationship between a vehicle and a trailer	N/A (Data Frame)	SAE J2735_201603, Section 6.86
	pivotOffset	Offset-B11	Offset is with respect to the length and tangential to the width of the object in question and is the distance from the edge of the outline measured from the edge of the length of this unit. An 11-bit delta offset in X or Y direction from some known point. a range of ±10.23 meters	INTEGER (-1024...1023)	SAE J2735_201603, Section 7.119
	pivotAngle	Angle	The current angle between the two objects. This is the only dynamic value when the vehicle is underway. Heading and reported positions of the trailers are given with respect to the object in front of them. The current heading of the sending device is expressed in unsigned units of 0.0125 degrees.	INTEGER (0...28800)	SAE J2735_201603, Section 7.7
	pivots	PivotingAllowed	Flag set to true when the described connection point allows pivoting to occur	BOOLEAN	SAE J2735_201603, Section 7.138
	units	TrailerUnitDescriptionList	Sequence of trailer descriptions	SEQUENCE (SIZE(1...8)) OF TrailerUnitDescription	SAE J2735_201603, Section 6.138
		TrailerUnitDescritption	Provides a physical description for one trailer	N/A (Data Frame)	SAE J2735_201603, Section 6.139
	isDolley	IsDolley	Set to False when false indicates a trailer unit	BOOLEAN	SAE J2735_201603, Section 7.58
	width	VehicleWidth	Trailer Width expressed in centimeters, unsigned. Units are 1 cm	INTEGER (0...1023)	SAE J2735_201603, Section 7.215
	length	VehicleLength	Trailer Width expressed in centimeters, unsigned. Units are 1 cm	INTEGER (0...1023)	SAE J2735_201603, Section 7.210

Message	Basic Safety Message (BSM) Part II				
	frontPivot	PivotPointDescription	describes the geometric relationship between a vehicle and a trailer	N/A (Data Frame)	SAE J2735_201603, Section 6.86
	pivotOffset	Offset-B11	Offset is with respect to the length and tangential to the width of the object in question and is the distance from the edge of the outline measured from the edge of the length of this unit. An 11-bit delta offset in X or Y direction from some known point, a range of ± 10.23 meters	INTEGER (-1024...1023)	SAE J2735_201603, Section 7.119
	pivotAngle	Angle	The current angle between the two objects. This is the only dynamic value when the vehicle is underway. Heading and reported positions of the trailers are given with respect to the object in front of them. The current heading of the sending device is expressed in unsigned units of 0.0125 degrees.	INTEGER (0...28800)	SAE J2735_201603, Section 7.7
	pivots	PivotingAllowed	Flag set to true when the described connection point allows pivoting to occur	BOOLEAN	SAE J2735_201603, Section 7.138
	positionOffset	Node-XY-24b	Current Position relative to the hauling Vehicle. A 24-bit node type with offset values from the last point in X and Y.	N/A (Data Frame)	SAE J2735_201603, Section 6.63
	x	Offset-B12	A 12-bit delta offset in X, Y or Z direction from some known point. A range of ± 20.47 meters	INTEGER (-2048...2047)	SAE J2735_201603, Section 7.120
	y	Offset-B12	A 12-bit delta offset in X, Y or Z direction from some known point. a range of ± 20.47 meters	INTEGER (-2048...2047)	SAE J2735_201603, Section 7.120

Source: City of Columbus, ARC-IT

4.7. CABINET STATUS QUERY

Table 10: Cabinet Status Query Communication Profile

Message	Cabinet Status Query				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	Allows Traffic CV Management Staff to query a particular cabinet to get its tamper alert status				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Cabinet Identifier	-	An identifier related to a specific cabinet on the roadside	Integer	-

Source: City of Columbus, ARC-IT

4.8. CABINET TAMPER ALERT

Table 11: Cabinet Tamper Alert Communication Profile

Message	Cabinet Tamper Alert				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	Audio/Visual alert provided at the TCVMS when a cabinet has been tampered with. This alert indicates the location of the cabinet				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Cabinet Tamper Alert	Audio/Visual	Alert provided at the TCVMS when a cabinet has been tampered with. This alert indicates the location of the cabinet	-	

Source: City of Columbus, ARC-IT

4.9. CABINET TAMPER STATUS

Table 12: Cabinet Tamper Status Communication Profile

<table>
<tr><th>Message</th><th colspan="5">Cabinet Tamper Status</th></tr>
<tr><td>Applicable Interface(s)</td><td>Interface 2</td><td colspan="4">Interface 7</td></tr>
<tr><td>Applicable Standards</td><td>N/A (User Interface)</td><td colspan="4">• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv4
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3 (fiber-optic backhaul)
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td></tr>
<tr><td>Description</td><td colspan="5">Contains a value that indicates if a cabinet has been tampered with.</td></tr>
<tr><td>Required Data</td><td colspan="5"><table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>Cabinet Tamper Status</td><td>-</td><td>Status of the cabinet</td><td>Integer
0: No tampering
1: Tampering (less than one minute since tampering detected)
2: Tampering (more than 1 min since tampering detected)
3: Tampering detection offline</td><td>-</td></tr>
</table></td></tr>
</table>

Source: City of Columbus, ARC-IT

4.10. CAN BUS DATA

Table 13: CAN Bus Data Communication Profile

Message	CAN Bus Data
Applicable Interface(s)	Interface 21, Interface 22, Interface 23, Interface 24
Applicable Standards	Controller Area Network (CAN) – ISO 11898 SAE J1939
Description	Data that is available from the Vehicle System via the CAN Bus (e.g. speed, RPMs, etc.)
Required Data	*All data from the CAN Bus is optional. Data regarding vehicle motion/state can be derived through alternative means.*

Source: City of Columbus, ARC-IT

4.11. CHANNEL CONGESTION PARAMETER

Table 14: Channel Congestion Parameter Communication Profile

Message	Channel Congestion Parameter				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	A parameter, converted to a percentage, that channel utilization is compared against to determine if an alert should be issued.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Channel Congestion Parameter	-	A parameter, converted to a percentage, that channel utilization is compared against to determine if an alert should be issued.	Integer (0…100)	-

Source: City of Columbus, ARC-IT

4.12. MAPDATA

Table 15: MapData Message (SAE J2735) Communication Profile

Message	MapData (MAP)			
Applicable Interface(s)	Interface 2	Interface 5	Interface 7	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	N/A (User Interface)	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 • Security Plane: IEEE 1609.2	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*	• ITS Application Information Layer: SAE J2735_201603, Section 5.6 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2
Description	The MapData message is used to convey many types of geographic road information. At the current time its primary use is to convey one or more intersection lane geometry maps within a single message. The map message content includes such items as complex intersection descriptions, road segment descriptions, high speed curve outlines (used in curve safety messages), and segments of roadway (used in some safety applications). A given single MapData message may convey descriptions of one or more geographic areas or intersections. The contents of this message involve defining the details of indexing systems that are in turn used by other messages to relate additional information (for example, the signal phase and timing via the SPaT message) to events at specific geographic locations on the roadway.			

Required Data

Name	Type	Description	Values	Reference
msgIssueRevision	MsgCount	A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.	INTEGER (0...127)	SAE J2735_201603, Section 7.104
intersections	IntersectionGeometryList	All intersection definitions. Consists of a list of IntersectionGeometry entries	SEQUENCE (SIZE(1...32)) OF IntersectionGeometry	SAE J2735_201603, Section 6.35
-	IntersectionGeometry	Description of an intersection's roadway geometry and its allowed navigational paths	N/A (Data Frame)	SAE J2735_201603, Section 6.34
id	IntersectionReferenceID	conveys the combination of an optional RoadRegulatorID and of an IntersectionID that is unique within that region	N/A (Data Frame)	SAE J2735_201603, Section 6.36
id	IntersectionID	A unique mapping to the intersection in question within the above region of use	INTEGER (0...65535)	SAE J2735_201603, Section 7.56
revision	MsgCount	A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.	INTEGER (0...127)	SAE J2735_201603, Section 7.104
refPoint	Position3D	The reference from which subsequent data points are offset until a new point is used	N/A (Data Frame)	SAE J2735_201603, Section 6.87
lat	Latitude	The geographic latitude of an object, expressed in 1/10th integer microdegrees	INTEGER (-900000000... 900000001)	SAE J2735_201603, Section 7.91

long	Longitude	The geographic longitude of an object, expressed in 1/10th integer microdegrees	INTEGER (-1799999999... 1800000001)	SAE J2735_201603, Section 7.95
laneWidth	LaneWidth	Reference width used by all subsequent lanes unless a new width is given. Units of 1 cm	INTEGER (0...32767)	SAE J2735_201603, Section 7.90
laneSet	LaneList	Data about one or more lanes. Consists of a list of GenericLane entries	SEQUENCE (SIZE(1...255)) OF GenericLane	SAE J2735_201603, Section 6.47
-	GenericLane	Describes the basic attribute information of the lane	N/A (Data Frame)	SAE J2735_201603, Section 6.29
laneID	LaneID	The unique ID number assigned to this lane object	INTEGER (0...255)	SAE J2735_201603, Section 7.88

maneuvers	AllowedManeuvers	the permitted maneuvers for this lane	BIT STRING {
			maneuverStraightAllowed (0),
			maneuverLeftAllowed (1),
			maneuverRightAllowed (2),
			maneuverUTurnAllowed (3),
			maneuverLeftTurnOnRedAllowed (4),
			maneuverRightTurnOnRedAllowed (5),
			maneuverLaneChangeAllowed (6),
			maneuverNoStoppingAllowed (7),
			yieldAllwaysRequired (8),
			goWithHalt (9),
			caution (10),
			reserved1 (11)
			}
				SAE J2735_201603, Section 7.4

	xy	NodeListXY	Lane spatial path information as well as various Attribute information along the node path. Provides the sequence of signed offset node point values for determining the Xs and Ys, using the then current Position3D object to build a path for the centerline of the subject lane type.	N/A (Data Frame)	SAE J2735_201603, Section 6.72
	nodes	NodeSetXY	a lane made up of two or more XY node points and any attributes defined in those nodes	SEQUENCE (SIZE(2...63)) OF NodeXY	SAE J2735_201603, Section 6.77
	-	NodeXY	data for a single node point in a path	N/A (Data Frame)	SAE J2735_201603, Section 6.78
	Delta	NodeOffsetPointXY	Nodes are described in terms of X and Y offsets in units of 1 cm	N/A (Data Frame)	SAE J2735_201603, Section 6.75
	Node-XY1 Node-XY2 Node-XY3 Node-XY4 Node-XY5 Node-XY6 (choice)	Node-XY-20b Node-XY-22b Node-XY-24b Node-XY-26b Node-XY-28b Node-XY-32b	node is within 5.11 m of last node node is within 10.23 m of last node node is within 20.47 m of last node node is within 40.96 m of last node node is within 81.91 m of last node node is within 327.67 m of last node	N/A (Data Frame)	SAE J2735_201603, Section 6.61, 6.62, 6.63, 6.64, 6.65, 6.66
	x	Offset-B10 Offset-B11	(10,11,12,13,14,16)-bit delta offset in X, Y or Z	INTEGER (-512...511) INTEGER (-1024...1023)	SAE J2735_201603, Section 7.118,

(corresponding to above choice)	Offset-B12 Offset-B13 Offset-B14 Offset-B16	direction from some known point.	INTEGER (-2048...2047) INTEGER (-4096...4095) INTEGER (-8192...8191) INTEGER (-32768...32767)	7.119, 7.120, 7.121, 7.122, 7.123
y (corresponding to above choice)	Offset-B10 Offset-B11 Offset-B12 Offset-B13 Offset-B14 Offset-B16	(10,11,12,13,14,16)-bit delta offset in X, Y or Z direction from some known point.	INTEGER (-512...511) INTEGER (-1024...1023) INTEGER (-2048...2047) INTEGER (-4096...4095) INTEGER (-8192...8191) INTEGER (-32768...32767)	SAE J2735_201603, Section 7.118, 7.119, 7.120, 7.121, 7.122, 7.123
connectsTo	ConnectsToList	A sequence of other defined lanes to which each lane connects beyond its stop point	SEQUENCE (SIZE(1...16)) OF Connection	SAE J2735_201603, Section 6.16
-	Connection	Data about how the stop line at the end of a single lane connects to another lane beyond its stop point	N/A (Data Frame)	SAE J2735_201603, Section 6.14
connectingLane	ConnectingLane	The index of the connecting lane and also the maneuver from the current lane to it	N/A (Data Frame)	SAE J2735_201603, Section 6.13
lane	LaneID	Index of the connecting lane. The unique ID number assigned to this lane object	INTEGER (0...255)	SAE J2735_201603, Section 7.88
maneuver	AllowedManeuvers	The Maneuver between the enclosing lane and this lane at the stop line to connect them	BIT STRING { maneuverStraightAllowed (0), maneuverLeftAllowed (1), maneuverRightAllowed (2), maneuverUTurnAllowed (3),	SAE J2735_201603, Section 7.4

Message	MapData (MAP)				
				maneuverLeftTurnOnRedAllowed (4), maneuverRightTurnOnRedAllowed (5), maneuverLaneChangeAllowed (6), maneuverNoStoppingAllowed (7), yieldAllwaysRequired (8), goWithHalt (9), caution (10), reserved1 (11) }	
	signalGroup	SignalGroupID	The matching signal group send by the SPaT message for this lane/maneuver.	INTEGER (0...255)	SAE J2735_201603, Section 7.171

Source: City of Columbus, ARC-IT

4.13. MISBEHAVIOR REPORT

Table 16: Misbehavior Report Communication Profile

Message	Misbehavior Report	
Applicable Interface(s)	Interface 8	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS	• Application Layer: IETF HTTP • Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	A misbehavior report contains identifying information about an OBU or RSU that may be compromised – whether intentionally or erroneously. This report is expected to be used by the SCMS to generate the Revocation List.	
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*	

Source: City of Columbus, ARC-IT

4.14. NETWORK COMMUNICATIONS METADATA

Table 17: Network Communications Metadata Communication Profile

Message	Network Communication Metadata
Applicable Interface(s)	Interface 7
Applicable Standards	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
Description	This message contains information that are expected when monitoring activity in a network. It includes information about devices accessing the network (wired and wireless) and message routing information that is used to determine if the device is permitted to be using the network and accessing other systems that may be connected to the network.
Required Data	*TBD*

Source: City of Columbus, ARC-IT

4.15. NOTIFICATION

Table 18: Notification Communication Profile

Message	Notification				
Applicable Interface(s)	Interface 18				
Applicable Standards	N/A (Human-Machine Interface)				
Description	A visual notification provided to the Emergency Vehicle Operator that supports the Emergency Vehicle Preemption Application.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Signal Priority Granted Notification	Visual	A notification issued to an Emergency Vehicle Operator when preemption has been granted at an intersection that priority has been requested for. Based on receipt of the SSM.	Not defined	N/A

Source: City of Columbus, ARC-IT

4.16. OBU PSEUDONYM CERTIFICATE

Table 19: OBU Pseudonym Certificate Communication Profile

Message	OBU Pseudonym Certificate	
Applicable Interface(s)	Interface 8	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS	• Application Layer: IETF HTTP • Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	Pseudonym Certificates are short-term and used primarily for BSM authentication and misbehavior reporting. For privacy reasons, a device is given multiple certificates that are valid simultaneously, so that it can change them frequently.	
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*	

Source: City of Columbus, ARC-IT

4.17. OBU PSEUDONYM CERTIFICATE REQUEST

Table 20: OBU Pseudonym Certificate Request Communication Profile

Message	OBU Pseudonym Certificate Request	
Applicable Interface(s)	Interface 8	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS	• Application Layer: IETF HTTP • Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF Ipv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	Allows the OBU to request a Pseudonym Certificate	
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*	

Source: City of Columbus, ARC-IT

4.18. OBU START-UP INDICATION

Table 21: OBU Start-Up Indication Communication Profile

Message	OBU Start-Up Indication				
Applicable Interface(s)	Interface 17				
Applicable Standards	N/A (Human-Machine Interface)				
Description	Provides an indication that tells the LDV Operator the OBU status upon startup				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	OBU Start Up Indication	-	An indicator that tells the LDV Operator the OBU status upon startup	Boot Successful, Boot Unsuccessful	-

Source: City of Columbus, ARC-IT

4.19. OBU TAMPER ALERT

Table 22: OBU Tamper Alert Communication Profile

Message	OBU Tamper Alert				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	Provides an audio/visual alert provided at the TCVMS when it has been detected that an OBU has been tampered with				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	OBU Tamper Alert	-	Audio/Visual alert provided at the TCVMS when it has been detected that an OBU has been tampered with	-	-

Source: City of Columbus, ARC-IT

4.20. OBU TAMPER STATUS

Table 23: OBU Tamper Status Communication Profile

<table>
<tr><th>Message</th><th colspan="2">OBU Tamper Status</th></tr>
<tr><td>Applicable Interface(s)</td><td>Interface 7</td><td>Interface 12</td></tr>
<tr><td>Applicable Standards</td><td>• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF Ipv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3 (fiber-optic backhaul)
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td><td>• Application Layer: IETF HTTP
• Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER
• Session Layer: IETF TLS
• Transport Layer: IETF TCP
• Network Layer: IETF Ipv6
• Data Link Layer: LLC and MAC Compatible with Physical and Network
• Physical Layer: IEEE 802.11p
• Security Plane: IEEE 1609.2, IETF TLS
See Table 3 in Chapter 2 for the proposed DSRC channel map.</td></tr>
<tr><td>Description</td><td colspan="2">Because this message is only sent when the OBU has been tampered with, the fact that tampering has occurred is inherent to this message.</td></tr>
<tr><td>Required Data</td><td colspan="2"><table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>OBU Identifier</td><td>-</td><td>Identifier that indicates the OBU that has been tampered with.</td><td>-</td><td>-</td></tr>
</table></td></tr>
</table>

Source: City of Columbus, ARC-IT

4.21. PENDING UPDATES

Table 24: Pending Updates Communication Profile

Message	Pending Updates				
Applicable Interface(s)	Interface 17				
Applicable Standards	N/A (Human-Machine Interface)				
Description	Provides an indication that tells the LDV Operator the percentage of an update that is has completed while it is being installed				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Update Status Indication	Audio/Visual	An indicator that tells the LDV Operator the percentage of an update that is has completed while it is being installed.	-	-

Source: City of Columbus, ARC-IT

4.22. PERFORMANCE MEASURE

Table 25: Performance Measure Communication Profile

Message	Performance Measures
Applicable Interface(s)	Interface 2
Applicable Standards	N/A (User Interface)
Description	*Performance Measure based on parameters specified in Performance Measure Parameters*
Required Data	*TBD*

Source: City of Columbus, ARC-IT

4.23. PERFORMANCE MEASURE PARAMETERS

Table 26: Performance Measure Parameters Communication Profile

Message	Performance Measure Parameters
Applicable Interface(s)	Interface 2
Applicable Standards	N/A (User Interface)
Description	*Code that allows Traffic CV Management Staff to query and process archived data to generate automated Performance Measures.*
Required Data	*TBD*

Source: City of Columbus, ARC-IT

4.24. POWER STATUS

Table 27: Power Status Communication Profile

Message	Power Status				
Applicable Interface(s)	Interface 17				
Applicable Standards	N/A (Human-Machine Interface)				
Description	An indicator that tells the LDV Operator the power status of the OBU				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Power Status	Audio/Visual	An indicator that tells the LDV Operator the power status of the OBU	Powering up Online Powering down	-

Source: City of Columbus, ARC-IT

4.25. RADIO TECHNICAL COMMISSION FOR MARITIME SERVICES CORRECTIONS MESSAGE

Table 28: Radio Technical Communication for Maritime Services Corrections Message (SAE J2735) Communication Profile

<table>
<tr><th>Message</th><th colspan="5">Radio Technical Commission for Maritime Services Corrections (RTCM) Message</th></tr>
<tr><td>Applicable Interface(s)</td><td colspan="5">Interface 12, Interface 13, Interface 14, Interface 15</td></tr>
<tr><td>Applicable Standards</td><td colspan="5">• ITS Application Information Layer: SAE J2735_201603, Section 5.12
• Presentation Layer: ISO ASN.1 UPER
• Transport Layer: IEEE 1609.3 WSMP
• Network Layer: IEEE 1609.3 WSMP
• Data Link Layer: IEEE 1609.4, IEEE 802.11
• Physical Layer: IEEE 802.11
• Security Plane: IEEE 1609.2
See Table 3 in Chapter 2 for the proposed DSRC channel map.</td></tr>
<tr><td>Description</td><td colspan="5">Encapsulates RTCM differential corrections for GPS and other radio navigation signals as defined by the RTCM (Radio Technical Commission For Maritime Services) special committee. RTCM messages are "wrapped" for transport on the DSRC media, and then can be re-constructed back into the final expected formats defined by the RTCM standard and used directly by various positioning systems to increase the absolute and relative accuracy estimates produced.</td></tr>
<tr><td>Required Data</td><td colspan="5">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>msgCnt</td><td>MsgCount</td><td>A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.</td><td>INTEGER (0...127)</td><td>SAE J2735_201603, Section 7.104</td></tr>
<tr><td>rev</td><td>RTCM-Revision</td><td>Specific revision of the RTCM standard which is being used</td><td>unknown (0),
rtcmRev2 (1),
rtcmRev3 (2),
reserved (3),</td><td>SAE J2735_201603, Section 7.162</td></tr>
<tr><td>msgs</td><td>RTCMmessageList</td><td>A list of RTCMmessage entries</td><td>SEQUENCE (SIZE(1...5)) OF RTCMmessage</td><td>SAE J2735_201603, Section 6.111</td></tr>
</table>
</td></tr>
</table>

Message	Radio Technical Commission for Maritime Services Corrections (RTCM) Message				
		RTCMmessage	Stream of octets of the actual RTCM message: 1001 GPS L1 observations at 5 Hz 1005 Antenna Reference Point (ARP) coordinates at 2 Hz	OCTET STRING (SIZE(1...1023))	SAE J2735_201603, Section 7.163

Source: City of Columbus, ARC-IT

4.26. REVOCATION LIST

Table 29: Revocation List Communication Profile

Message	Revocation List	
Applicable Interface(s)	Interface 8	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS	• Application Layer: IETF HTTP • Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER • Session Layer: IETF TLS • Transport Layer: IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.11p • Security Plane: IEEE 1609.2, IETF TLS *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	Contains information about certificates issued to devices that have been determined to be compromised. Such devices are no longer considered a trusted source for sending and receiving messages.	
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*	

Source: City of Columbus, ARC-IT

4.27. ROADSIDE SAFETY MESSAGE

Table 30: Roadside Safety Message (SAE J2945/4, draft, 2018-09-05) Communication Profile

Message	Roadside Safety Message (RSM)			
Applicable Interface(s)	Interface 2	Interface 5	Interface 7	Interface 12, Interface 13
Applicable Standards	N/A (User Interface)	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 • Security Plane: IEEE 1609.2	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS	• ITS Application Information Layer: SAE J2945/4 (draft, 2018-09-05) • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2 *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	An RSM contains information that may be important for a driver to receive regarding weather conditions, road closures, accidents, and local disasters (explosions, chemical leaks, bomb threats, etc.). RSM Data is the data input by Traffic CV Management Center Staff that is used to populate the RSM defined by SAE J2735 and subsequently broadcast from the RSU via DSRC. The RSM is used in the CVE to provide details regarding the geometry of a school zones, the speed limits in the school zone, and the time periods for which those school zone speed limits are effective.			

Message	Roadside Safety Message (RSM)				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	School Zone Speed Limit	-	The RSM shall contain the speed limit for the reduced speed (school) zone	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.2.2.3
	Speed Zone Geometry	-	The RSM shall contain the reduced speed zone geometry.	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.2.2.4
	Event Identification Number	-	The RSM shall contain the event identification number	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.1.1
	Event Type	-	The RSM shall contain the event type	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.1.2
	Event Start Time	-	The RSM shall contain the event start time	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.1.3.1
	Event Duration	-	The RSM shall contain the event duration	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.1.3.1
	Geographic Information	-	The RSM shall contain all data elements in the Geographic Information data frame	-	SAE J2945/4 (draft, 2018-09-05), Section 2.5.2.1.5

Source: City of Columbus, ARC-IT

4.28. RSU APPLICATION CERTIFICATE

Table 31: RSU Application Certificate Communication Profile

Message	RSU Application Certificate
Applicable Interface(s)	Interface 8
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS
Description	An application certificate is used by an RSU to sign any over-the-air messages transmitted. An RSU has only one application certificate valid at a time for a given application.
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*

Source: City of Columbus, ARC-IT

4.29. RSU APPLICATION CERTIFICATE REQUEST

Table 32: RSU Application Certificate Request Communication Profile

Message	RSU Application Certificate Request
Applicable Interface(s)	Interface 8
Applicable Standards	• Application Layer: IETF SNMP • Presentation Layer: ISO ASN.1 BER • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS
Description	Allows the RSU to request an Application Certificate
Required Data	*TBD. See **Chapter 1.1.3 – Risks**.*

Source: City of Columbus, ARC-IT

4.30. RSU CHANNEL CONGESTION ALERT

Table 33: RSU Channel Congestion Alert Communication Profile

Message	RSU Channel Congestion Alert				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	Audio/Visual alert provided at the TCVMS when an RSU detects that channel congestion has exceeded an indicated threshold. This alert indicates the location of the cabinet.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Channel Congestion Alert	-	Audio/Visual alert provided at the TCVMS when an RSU detects that channel congestion has exceeded an indicated threshold. This alert indicates the location of the cabinet.	-	-

Source: City of Columbus, ARC-IT

4.31. RSU LIMITED CONNECTIVITY ALERT

Table 34: RSU Limited Connectivity Alert Communication Profile

Message	RSU Limited Connectivity Alert				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	An indicator that alerts the Traffic CV Manager when the connection between the TCVMS and a particular RSU is limited or offline.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	RSU Connectivity Alert	-	An indicator that alerts the Traffic CV Manager when the connection between the TCVMS and a particular RSU is limited or offline.	Limited Connectivity, No Connectivity (offline)	-

Source: City of Columbus, ARC-IT

4.32. RSU STATUS

Table 35: RSU Status Communication Profile

Message	RSU Status		
Applicable Interface(s)	Interface 2	Interface 7	
Applicable Standards	N/A (Human-Machine Interface)	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP	• Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
Description	The UI will utilize different colored icons to represent each required data item, and will reveal detailed information when selected by Traffic CV Management Staff.		

Required Data

Name	Type	Description	Values	Reference
DSRC Channel Traffic/Utilization	-	An indicator provided to the Traffic CV Manager that indicates the current level of channel utilization detected by the RSU	0.00-100.00	-
Connectivity Uptime	-	An indicator provided to the Traffic CV Manager that indicates uptime of connectivity between the RSU and the TCVMS	0.00-100.00	-
Cabinet Tamper Status	-	An indicator provided to the Traffic CV Manager that indicates the status of the cabinet	Integer 0: No tampering 1: Tampering (less than one minute since tampering detected) 2: Tampering (more than 1 min since tampering detected) 3: Tampering detection offline	-
Transmit Power		Measure of transmit power of the RSU. Units of dB	-	-

Source: City of Columbus, ARC-IT

4.33. RSU STATUS QUERY

Table 36: RSU Status Query Communication Profile

Message	RSU Status Query				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	The Traffic CV Management System will allow Traffic Management Staff to select an RSU using the UI to reveal RSU information described in the RSU Status.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	RSU Identifier	-	An identifier related to a specific RSU on the roadside	Integer	-

Source: City of Columbus, ARC-IT

4.34. RTCM DATA

Table 37: RTCM Data (RTCM 10410.1) Communication Profile

Message	RTCM Data
Applicable Interface(s)	Interface 9
Applicable Standards	• ITS Application Information Layer: RTCM 10410.1 • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS
Description	RTCM Data is the data sent from the Ohio CORS to the RSU that is used to populate the RTCM defined by SAE J2735 and subsequently broadcast from the RSU via DSRC.
Required Data	See nested table below

Name	Type	Description	Values	Reference
1001	-	GPS L1 observations	-	RTCM 10410.1
1005	-	Antenna Reference Point (ARP) coordinates	-	RTCM 10410.1

Source: City of Columbus, ARC-IT

4.35. SCHOOL ZONE INDICATOR

Table 38: School Zone Indicator Communication Profile

Message	School Zone Indicator				
Applicable Interface(s)	Interface 11b				
Applicable Standards	N/A				
Description	Low-Voltage signal that provides an indication regarding the state of a school zone flashing signal				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	School Zone Indicator	Low-Voltage Signal	A low-voltage signal that indicates if the school zone flashing signal is active or not active.	0V – Flashing Lights not Active 24V – Flashing Lights Active	-

Source: City of Columbus, ARC-IT

4.36. SETTING ADJUSTMENT

Table 39: Setting Adjustment Communication Profile

Message	Setting Adjustment
Applicable Interface(s)	Interface 17
Applicable Standards	N/A (Human-Machine Interface)
Description	Allows the LDV Operator to change the following LDV OBU settings indicated in the required data.
Required Data	

Name	Type	Description	Values	Reference
Brightness (if screen is used),	-	Indicates a brightness level	-	-
Volume	-	Indicates volume level	-	-
Text Size (if screen is used)	-	Indicates text size	-	-
Contrast (if screen is used)	-	Indicates contrast level	-	-

Source: City of Columbus, ARC-IT

4.37. SIGNAL PHASE AND TIMING

Table 40: Signal Phase and Timing Message (SAE J2735) Communication Profile

Message	Signal Phase and Timing (SPaT)		
Applicable Interface(s)	Interface 5	Interface 7	Interface 12, Interface 13, Interface 14, Interface 15
Applicable Standards	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 • Security Plane: IEEE 1609.2	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS	• ITS Application Information Layer: SAE J2735_201603, Section • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2 *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	The Signal Phase and Timing (SPaT) message is used to convey the current status of one or more signalized intersections. Along with the MSG_MapData message (which describes a full geometric layout of an intersection) the receiver of this message can determine the state of the signal phasing and when the next expected phase will occur. The SPaT message sends the current movement state of each active phase in the system as needed (such as values of what states are active and values at what time a state has begun/does begin earliest, is expected to begin most likely and will end latest). The state of inactive movements is not normally transmitted. Movements are mapped to specific approaches and connections of ingress to egress lanes and by use of the SignalGroupID in the MapData message. The current signal preemption and priority status values (when present or active) are also sent. A more complete summary of any pending priority or preemption events can be found in the Signal Status message. SPaT is received and Logged by the RSU and is periodically sent to the Traffic CV Management System		

Required Data

Name	Type	Description	Values	Reference
timeStamp	MinuteOfTheYear	Number of elapsed minutes of the current year in the time system being used (typically UTC time)	INTEGER (0...527040)	SAE J2735_201603, Section 7.100
intersections	IntersectionStateList	The IntersectionStateList data frame consists of a list of IntersectionState entries	SEQUENCE (SIZE(1...32)) OF IntersectionState	SAE J2735_201603, Section 6.38
	IntersectionState	Convey all the SPaT information for a single intersection	N/A (Data Frame)	SAE J2735_201603, Section 6.37
id	IntersectionReferenceID	globally unique value set, consisting of a regionID and intersection ID assignment provides a unique mapping to the intersection MAP in question which provides complete location and approach/move/lane data	N/A (Data Frame)	SAE J2735_201603, Section 6.36
id	IntersectionID	The IntersectionID is used within a region to uniquely define an intersection within that country or region	INTEGER (0...65535)	SAE J2735_201603, Section 7.56
revision	MsgCount	A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.	INTEGER (0...127)	SAE J2735_201603, Section 7.104
status	IntersectionStatusObject	Contains Advanced Traffic Controller (ATC) status information that	BIT STRING {manualControlIsEnabled (0), stopTimeIsActivated (1), failureFlash (2), preemptIsActive (3), signalPriorityIsActive (4),	SAE J2735_201603, Section 7.57

			may be sent to local OBUs as part of the SPaT process	fixedTimeOperation (5), trafficDependentOperation (6), standbyOperation (7), failureMode (8), off (9), recentMAPmessageUpdate (10), recentChangeInMAPassignedLanesIDsUsed (11), noValidMAPisAvailableAtThisTime (12), noValidSPATisAvailableAtThisTime (13)	
	timeStamp	Dsecond	The mSec point in the current UTC minute that this message was constructed. Represents the milliseconds within a minute. Units of milliseconds	INTEGER (0...65535)	SAE J2735_201603, Section 7.39
	states	MovementList	Each Movement is given in turn and contains its signal phase state, mapping to the lanes it applies to, and point in time it will end, and it may contain both active and future states. The MovementList data frame consists of a list of MovementState entries.	SEQUENCE (SIZE(1...255)) OF MovementState	SAE J2735_201603, Section 6.52
	-	MovementState	convey various information about the current or future movement state of a designated collection of one or more lanes of a common type	N/A (Data Frame)	SAE J2735_201603, Section 6.53
	signalGroup	SignalGroupID	Map to lists of lanes (and their descriptions) which this MovementState data applies to.	INTEGER (0...255)	SAE J2735_201603, Section 7.171

	state-time-speed	MovementEventList	Consists of a list of MovementEvent entries – sets of movement data with: a) SignalPhaseState, b) TimeChangeDetails, and c) AdvisorySpeeds.	SEQUENCE (SIZE(1...16)) OF MovementEvent	SAE J2735_201603, Section 6.5
	-	MovementEvent	Details about a single movement	N/A (Data Frame)	SAE J2735_201603, Section 6.51
	eventState	MovementPhaseState	Overall current state of the movement (in many cases a signal state), including its core phase state and an indication of whether this state is permissive or protected.	unavailable (0), dark (1), stop-Then-Proceed (2), stop-And-Remain (3), permissive-Movement-Allowed (5), protected-Movement-Allowed (6), permissive-clearance (7), protected-clearance (8), caution-Conflicting-Traffic (9)	SAE J2735_201603, Section 7.103
	timing	TimeChangeDetails	Start and min/max end times of phase confidence and estimated next occurrence	N/A (Data Frame)	SAE J2735_201603, Section 6.134
	minEndTime	TimeMark	Expected shortest end time. Relates a moment in UTC (Coordinated Universal Time)-based time when a signal phase is predicted to change, with a precision of 1/10 of a second.	INTEGER (0...36001)	SAE J2735_201603, Section 7.194
	maxEndTime	TimeMark	Expected longest end time. Relates a moment in UTC (Coordinated Universal Time)-based time when a signal phase is predicted to change, with a precision of 1/10 of a second.	INTEGER (0...36001)	SAE J2735_201603, Section 7.194

	likelyTime	TimeMark	Best predicted value based on other data. Relates a moment in UTC (Coordinated Universal Time)-based time when a signal phase is predicted to change, with a precision of 1/10 of a second.	INTEGER (0...36001)	SAE J2735_201603, Section 7.194

Source: City of Columbus, ARC-IT

4.38. SIGNAL PHASE AND TIMING DATA

Table 41: Signal Phase and Timing Data (NTCIP 1202) Communication Profile

Message	SPaT Data
Applicable Interface(s)	Interface 11a
Applicable Standards	• ITS Application Information Layer: NTCIP 1202-ASC • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (local Ethernet) • Security Plane: IEEE 1609.2
Description	SPaT Data is the data sent from the Traffic Signal Controller to the RSU that is used to populate the SPaT Message defined by SAE J2735 and subsequently broadcast from the RSU via DSRC.
Required Data	*See SPaT*

Source: City of Columbus, ARC-IT

4.39. SIGNAL PRIORITY AUTHORIZATION LIST

Table 42: Signal Priority Authorization List Communication Profile

<table>
<tr><th>Message</th><th colspan="3">Signal Priority Authorization List</th></tr>
<tr><td>Applicable Interface(s)</td><td colspan="2">Interface 2</td><td>Interface 7</td></tr>
<tr><td>Applicable Standards</td><td colspan="2">N/A (User Interface)</td><td>• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3 (fiber-optic backhaul)
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td></tr>
<tr><td>Description</td><td colspan="3">A list of priority authorizations which indicate which vehicles are authorized to receive priority, at which intersection, for which movements, at which times.</td></tr>
<tr><td>Required Data</td><td colspan="3">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>Priority Authorization</td><td>List</td><td>An entry in the Signal Priority Authorization List that contains a vehicle identifier, priority type identifier, intersection identifier, approach identifier, connection identifier, and time of day.</td><td>-</td><td>-</td></tr>
<tr><td>Vehicle Identifier</td><td>-</td><td>A unique identifier associated with a vehicle that is authorized to receive priority. This identifier must correspond to a unique identifying vehicle characteristic (found in the SRM or in SRM metadata, such as the security information) sent by an OBU in the SRM.</td><td>INTEGER/ STRING</td><td>-</td></tr>
<tr><td>Priority Type Identifier</td><td>-</td><td>Indicates the type of priority (e.g. priority, preemption) that the identified vehicle is eligible to receive. This identifier must correspond to the SignalReqScheme sent by an OBU in the SRM.</td><td>Priority,
Preemption
…</td><td>-</td></tr>
</table>
</td></tr>
</table>

	Intersection Identifier	-	Indicates the intersection for which the identified vehicle is eligible to receive priority. This identifier must correspond to the (id) IntersectionID sent by an OBU in the SRM.	INTEGER	-
	Approach Identifier	-	Indicates the approach for which the identified vehicle is eligible to receive priority. This identifier must correspond to the (approach) ApproachID sent by an OBU in the SRM.	INTEGER	-
	Connection Identifier	-	Indicates the connection for which the identified vehicle is eligible to receive priority. This identifier must correspond to the (connection) LaneConnectionID sent by an OBU in the SRM.	INTEGER	-
	Time of Day Identifier	-	Indicates the time of day the identified vehicle is authorized to receive priority.	-	-

Source: City of Columbus, ARC-IT

4.40. SIGNAL REQUEST MESSAGE

Table 43: Signal Request Message (SAE J2735) Communication Profile

Message	Signal Request Message (SRM)		
Applicable Interface(s)	Interface 5	Interface 7	Interface 12, Interface 14, Interface 15
Applicable Standards	• Application Layer: HTTPS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 • Security Plane: IEEE 1609.2	• ITS Application Information Layer: Undefined • Application Layer: HTTPS • Session Layer: IETF TLS, IETF DTLS • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (fiber-optic backhaul) • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS	• ITS Application Information Layer: SAE J2735_201603 • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IEEE 1609.3 WSMP • Network Layer: IEEE 1609.3 WSMP • Data Link Layer: IEEE 1609.4, IEEE 802.11 • Physical Layer: IEEE 802.11 • Security Plane: IEEE 1609.2 *See **Table 3** in **Chapter 2** for the proposed DSRC channel map.*
Description	The Signal Request Message is a message sent by a DSRC equipped entity (such as a vehicle) to the RSU in a signalized intersection. It is used for either a priority signal request or a preemption signal request depending on the way each request is set. Each request defines a path through the intersection which is desired in terms of lanes and approaches to be used. Each request can also contain the time of arrival and the expected duration of the service. Multiple requests to multiple intersections are supported. The requestor identifies itself in various ways (using methods supported by the RequestorDescription data frame), and its current speed, heading and location can be placed in this structure as well. The specific request for service is typically based on previously decoding and examining the list of lanes and approaches for that intersection (sent in MAP messages). The outcome of all of the pending requests to a signal can be found in the Signal Status Message (SSM), and may be reflected in the SPaT message contents if successful. SRMs are received and Logged by the RSU and are periodically sent to the Traffic CV Management System		

Required Data

Name	Type	Description	Values	Reference
-	SignalReqScheme	Used in a priority or preempt request frame to select which preempt or priority controller sequence is to be activated. The data element has either a priority value or a preemption value, depending on the setting of the most significant bit and what data frame it is used in.	OCTET STRING (SIZE(1)) upper nibble: Preempt #: -- Bit 7 (MSB) 1 = Preempt and 0 = Priority	SAE J2735_201603, Section 7.172
second	DSecond	The mSec point in the current UTC minute that this message was constructed. Represents the milliseconds within a minute. units of milliseconds	INTEGER (0...65535)	SAE J2735_201603, Section 7.39
requests	SignalRequestList	Request Data for one or more signalized intersections that support SRM dialogs. Consists of a list of SignalRequest entries	SEQUENCE (SIZE(1...32)) OF SignalRequestPackage	SAE J2735_201603, Section 6.118
	SignalRequestPackage	Contains both the service request itself (the preemption and priority details and the inbound-outbound path details for an intersection) and the time period (start and end time) over which this service is sought from one single intersection.	N/A (Data Frame)	SAE J2735_201603, Section 6.123
request	SignalRequest	Used (as part of a request message) to request either a priority or a preemption service from a signalized intersection.	N/A (Data Frame)	SAE J2735_201603, Section 6.120
id	IntersectionReferenceID	globally unique value set, consisting of a regionID and intersection ID assignment provides a unique mapping to the intersection MAP in question which provides complete location and approach/move/lane data	N/A (Data Frame)	SAE J2735_201603, Section 6.36
id	IntersectionID	A unique mapping to the intersection in question within the above region of use	INTEGER (0...65535)	SAE J2735_201603, Section 7.56
requestID	RequestID	The unique requestID used by the requestor. The RequestID data element is used to provide a unique ID between two parties for various dialog exchanges	INTEGER (0...255)	SAE J2735_201603, Section 7.153

Message	Signal Request Message (SRM)				
	requestType	PriorityRequestType	Provides a means to indicate if a request (found in the Signal Request Message) represents a new service request, a request update, or a request cancellation	ENUMERATED { priorityRequestTypeReserved (0), priorityRequest (1), priorityRequestUpdate (2), priorityCancellation (3), }	SAE J2735_201603, Section 7.142
	inBoundLane	IntersectionAccessPoint	Desired entry approach or lane	N/A (Data Frame)	SAE J2735_201603, Section 6.33
	lane	LaneID	The unique ID number assigned to this lane object	INTEGER (0...255)	SAE J2735_201603, Section 7.88
	approach	ApproachID	Used to relate the index of an approach, either ingress or egress within the subject lane	INTEGER (0...15)	SAE J2735_201603, Section 7.11
	connection	LaneConnectionID	A connection index for a lane to lane connection	INTEGER (0...255)	SAE J2735_201603, Section 7.86
	requestor	RequestorDescription	contains vehicle ID (if from a vehicle) as well as type data and current position and may contain additional transit data.	N/A (Data Frame)	SAE J2735_201603, Section 6.98
	id	VehicleID	The ID used in the BSM or CAM of the requestor. This ID is presumed not to change during the exchange	N/A (Data Frame)	SAE J2735_201603, Section 6.147
	entityID	TemporaryID	Used as a means to identify the local vehicles that are interacting during an encounter	OCTET STRING (SIZE(4))	SAE J2735_201603, Section 7.187

Source: City of Columbus, ARC-IT

4.41. SIGNAL REQUEST MESSAGE DATA

Table 44: Signal Request Message Data (NTCIP 1202) Communication Profile

Message	SRM Data
Applicable Interface(s)	Interface 11a
Applicable Standards	• ITS Application Information Layer: NTCIP 1202-ASC • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (local Ethernet) • Security Plane: IEEE 1609.2
Description	SRM Data is the data required to place a priority or preemption request sent from the RSU to the Traffic Signal Controller that is extracted from the SRM defined by SAE J2735 received from the RSU via DSRC.
Required Data	*See SRM.*

Source: City of Columbus, ARC-IT

4.42. SIGNAL STATUS MESSAGE

Table 45: Signal Status Message (SAE J2735) Communication Profile

<table>
<tr><th>Message</th><th colspan="3">Signal Status Message (SSM)</th></tr>
<tr><td>Applicable Interface(s)</td><td>Interface 5</td><td>Interface 7</td><td>Interface 12, Interface 14, Interface 15</td></tr>
<tr><td>Applicable Standards</td><td>• Application Layer: HTTPS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3
• Security Plane: IEEE 1609.2</td><td>• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3 (fiber-optic backhaul)
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td><td>• ITS Application Information Layer: SAE J2735_201603
• Presentation Layer: ISO ASN.1 UPER
• Transport Layer: IEEE 1609.3 WSMP
• Network Layer: IEEE 1609.3 WSMP
• Data Link Layer: IEEE 1609.4, IEEE 802.11
• Physical Layer: IEEE 802.11
• Security Plane: IEEE 1609.2
See Table 3 in Chapter 2 for the proposed DSRC channel map.</td></tr>
<tr><td>Description</td><td colspan="3">The Signal Status Message is a message sent by an RSU in a signalized intersection. It is used to relate the current status of the signal and the collection of pending or active preemption or priority requests acknowledged by the controller. It is also used to send information about preemption or priority requests which were denied. This in turn allows a dialog acknowledgment mechanism between any requestor and the signal controller. The data contained in this message allows other users to determine their "ranking" for any request they have made as well as to see the currently active events. When there have been no recently received requests for service messages, this message may not be sent. While the outcome of all pending requests to a signal can be found in the Signal Status Message, the current active event (if any) will be reflected in the SPaT message contents.
SSMs are logged by the RSU and are periodically sent to the Traffic CV Management System</td></tr>
<tr><td>Required Data</td><td colspan="3">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>second</td><td>DSecond</td><td>The mSec point in the current UTC minute that this message was constructed. Represents the milliseconds within a minute. Units of milliseconds</td><td>INTEGER (0...65535)</td><td>SAE J2735_201603, Section 7.39</td></tr>
<tr><td>status</td><td>SignalStatusList</td><td>consists of a list of SignalStatus entries</td><td>SEQUENCE (SIZE(1...32)) OF SignalStatus</td><td>SAE J2735_201603, Section 6.121</td></tr>
</table>
</td></tr>
</table>

Message	Signal Status Message (SSM)				
	-	SignalStatus	Provide the status of a single intersection to others, including any active preemption or priority state in effect.	N/A (Data Frame)	SAE J2735_201603, Section 6.124
	sequenceNumber	MsgCount	A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.	INTEGER (0...127)	SAE J2735_201603, Section 7.104
	id	IntersectionReferenceID	globally unique value set, consisting of a regionID and intersection ID assignment provides a unique mapping to the intersection MAP in question which provides complete location and approach/move/lane data	N/A (Data Frame)	SAE J2735_201603, Section 6.36
	sigStatus	SignalStatusPackageList	list of detailed status containing all priority or preemption state data, both active and pending, and who requested it requests which are denied are also listed here for a short period of time. Consists of a list of SignalStatusPackage entries	SEQUENCE (SIZE(1...32)) OF SignalStatusPackage	SAE J2735_201603, Section 6.122
	-	SignalStatusPackage	Contains all the data needed to describe the preemption or priority state of the signal controller with respect to a given request and to uniquely identify the party who requested that state to occur.	N/A (Data Frame)	SAE J2735_201603, Section 6.119
	requestor	SignalRequestorInfo	information regarding the entity that requested a given signal behavior	N/A (Data Frame)	SAE J2735_201603, Section 6.117
	id	VehicleID	The ID used in the BSM or CAM of the requestor. This ID is presumed not to change during the exchange	N/A (Data Frame)	SAE J2735_201603, Section 6.147
	entityID	TemporaryID	Used as a means to identify the local vehicles that are interacting during an encounter	OCTET STRING (SIZE(4))	SAE J2735_201603, Section 7.187
	request	RequestID	The unique RequestID used by the requestor. The RequestID data element is used to provide a unique ID between two parties for various dialog exchanges	INTEGER (0...255)	SAE J2735_201603, Section 7.153

Message	Signal Status Message (SSM)				
	sequenceNumber	MsgCount	A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.	INTEGER (0...127)	SAE J2735_201603, Section 7.104
	inboundOn	IntersectionAccessPoint	Estimated lane / approach of vehicle. Specifies the index of either a single approach or a single lane at which a service is needed.	N/A (Data Frame)	SAE J2735_201603, Section 6.33
	lane	LaneID	The unique ID number assigned to this lane object	INTEGER (0...255)	SAE J2735_201603, Section 7.88
	approach	ApproachID	Used to relate the index of an approach, either ingress or egress within the subject lane	INTEGER (0...15)	SAE J2735_201603, Section 7.11
	connection	LaneConnectionID	A connection index for a lane to lane connection	INTEGER (0...255)	SAE J2735_201603, Section 7.86
	status	PrioritizationResponseStatus	Status of request, this may include rejection	ENUMERATED { unknown (0), requested (1), processing (2), watchOtherTraffic (3), granted (4), rejected (5), maxPresence (6), reserviceLocked (7)}	SAE J2735_201603, Section 7.140

Source: City of Columbus, ARC-IT

4.43. SIGNAL STATUS MESSAGE DATA

Table 46: Signal Status Message (NTCIP 1202) Communication Profile

Message	SSM Data
Applicable Interface(s)	Interface 11a
Applicable Standards	• ITS Application Information Layer: NTCIP 1202-ASC • Presentation Layer: ISO ASN.1 UPER • Transport Layer: IETF UDP, IETF TCP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC compatible with Physical and Network • Physical Layer: IEEE 802.3 (local Ethernet) • Security Plane: IEEE 1609.2
Description	SSM Data is the data sent from the Traffic Signal Controller to the RSU that is used to populate the SSM defined by SAE J2735 and subsequently broadcast from the RSU via DSRC.
Required Data	*See SSM.*

Source: City of Columbus, ARC-IT

4.44. TIME AND LOCATION DATA

Table 47: Time and Location Data Communication Profile

Message	Time and Location Data				
Applicable Interface(s)	Interface 25, Interface 26, Interface 27, Interface 28, Interface 29				
Applicable Standards	NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)				
Description	Contains data that are available via GPS for determining position, position accuracy, speed, and for time synchronization.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	$GPGGA, Field 1	-	UTC of position fix	-	-
	$GPGGA, Field 2	-	Latitude	-	-
	$GPGGA, Field 3	-	Direction of latitude:	N: North S: South	-
	$GPGGA, Field 4	-	Longitude	-	-
	$GPGGA, Field 5	-	Direction of longitude:	E: East W: West	-
	$GPGGA, Field 6	-	GPS Quality indicator:	0: Fix not valid 1: GPS fix 2: Differential GPS fix, OmniSTAR VBS 4: Real-Time Kinematic, fixed integers 5: Real-Time Kinematic, float integers, OmniSTAR XP/HP or Location RTK	-
	$GPGGA, Field 7	-	Number of SVs in use, range from 00 through to 24+	-	-
	$GPGGA, Field 8	-	HDOP	-	-

Message	Time and Location Data				
	$GPGGA, Field 9	-	Orthometric height (MSL reference)	-	-
	$GPGGA, Field 10	-	Antenna height unit	unit of measure for orthometric height is meters	-
	$GPGGA, Field 11	-	Geoidal separation	-	-
	$GPGGA, Field 12	-	Units of geoidal separation	geoid separation measured in meters	-
	$GPGGA, Field 13	-	Age of differential GPS data record,	Type 1 or Type 9. Null field when DGPS is not used.	-
	$GPGGA, Field 14	-	Reference station ID	range 0000-4095. A null field when any reference station ID is selected and no corrections are received	-
	$GPRMC, Field 1	-	UTC of position fix	-	
	$GPRMC, Field 2	-	Status	A=active or V=void	
	$GPRMC, Field 3	-	Latitude	-	
	$GPRMC, Field 4	-	Longitude	-	
	$GPRMC, Field 5	-	Speed over the ground in knots	-	
	$GPRMC, Field 6	-	Track angle in degrees (True)	-	
	$GPRMC, Field 7	-	Date	-	
	$GPRMC, Field 8	-	Magnetic variation in degrees	-	

Source: City of Columbus, ARC-IT

4.45. TIME DATA

Table 48: Time Data Communication Profile

Message	Time Data
Applicable Interface(s)	Interface 6, Interface 10
Applicable Standards	• Application Layer: IETF NTP • Transport Layer: IETF UDP • Network Layer: IETF IPv6 • Data Link Layer: LLC and MAC Compatible with Physical and Network • Physical Layer: IEEE 802.3
Description	Time data that is used to synchronize multiple devices.
Required Data	**Name** | **Type** | **Description** | **Values** | **Reference** Time | - | Current time expressed in Universal Time Coordinated (UTC) format from a Stratum-2 time server | - | -

Source: City of Columbus, ARC-IT

4.46. TRANSIT VEHICLE INTERACTION EVENT DATA

Table 49: Transit Vehicle Interaction Event Data Communication Profile

<table>
<tr><th>Message</th><th colspan="2">Transit Vehicle Interaction Event Data</th></tr>
<tr><td>Applicable Interface(s)</td><td>Interface 3</td><td>Interface 4</td></tr>
<tr><td>Applicable Standards</td><td>• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3, IEEE 802.11
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td><td>• Application Layer: HTTPS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3
• Security Plane: IEEE 1609.2</td></tr>
<tr><td>Description</td><td colspan="2">Transit Vehicle Interaction Event consists of the start and end time of an event (emergency braking ahead, forward collision imminent, intersection movement, blind spot, lane change, red light violation, school zone speed limit, priority request) and all locally stored messages (SPaT, MAP, received BSMs, broadcast BSMs) from a configurable amount of time before the start time of the event. The amount of time and the types of events are configured in the Transit Vehicle Event Data Parameters message.</td></tr>
<tr><td>Required Data</td><td colspan="2">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>Start Time</td><td>-</td><td>The time the event occurred</td><td>Time UTC (ms)</td><td>-</td></tr>
<tr><td>End Time</td><td>-</td><td>The time the event ended (in the case where multiple events of the same warning are issued based on messages received from the same vehicle or intersection within a configurable amount of time)</td><td>Time UTC (ms)</td><td>-</td></tr>
</table>
</td></tr>
</table>

Message	Transit Vehicle Interaction Event Data				
	BSMs (received)	-	A log of BSMs received from other vehicles	-	-
	BSMs (issued)	-	A log of BSMs sent from the Transit Vehicle OBU	-	-
	SPaT (received)	-	A log of SPaT Messages received	-	-
	MAP (received)	-	A log of MAP Messages received	-	-
	SRM (received)	-	A log of SRMs received	-	-
	SSM (received)	-	A log of SSMs received	-	-
	RSM (received)	-	A log of RSMs received	-	-

Source: City of Columbus, ARC-IT

4.47. TRANSIT VEHICLE INTERACTION EVENT DATA PARAMETERS

Table 50: Transit Vehicle Interaction Event Data Parameters Communication Profile

<table>
<tr><th>Message</th><th colspan="5">Transit Vehicle Interaction Event Data Parameters</th></tr>
<tr><td>Applicable Interface(s)</td><td colspan="2">Interface 1</td><td colspan="3">Interface 3</td></tr>
<tr><td>Applicable Standards</td><td colspan="2">N/A (User Interface)</td><td colspan="3">• ITS Application Information Layer: Undefined
• Application Layer: HTTPS
• Session Layer: IETF TLS, IETF DTLS
• Transport Layer: IETF UDP, IETF TCP
• Network Layer: IETF IPv6
• Data Link Layer: LLC and MAC compatible with Physical and Network
• Physical Layer: IEEE 802.3, IEEE 802.11
• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td></tr>
<tr><td>Description</td><td colspan="5">A list of parameters that governs the events that trigger a Transit Vehicle Interaction Event and the amount of data that is recorded before and after the event.</td></tr>
<tr><td>Required Data</td><td colspan="5">
<table>
<tr><th>Name</th><th>Type</th><th>Description</th><th>Values</th><th>Reference</th></tr>
<tr><td>Time prior to start of event</td><td>-</td><td>The amount of time before an event has occurred when log messages</td><td>Time (ms)</td><td>-</td></tr>
<tr><td>Time after event has ended</td><td>-</td><td>The amount of time after an event has ended to log messages</td><td>Time (ms)</td><td>-</td></tr>
<tr><td>Event Types</td><td>-</td><td>Specifies the types of events that trigger a Transit Vehicle Interaction Event</td><td>emergency braking ahead, forward collision imminent, intersection movement, blind spot, lane change, red light violation, school zone speed limit, priority request</td><td>-</td></tr>
</table>
</td></tr>
</table>

Source: City of Columbus, ARC-IT

4.48. UNAUTHORIZED ACCESS ALERT

Table 51: Unauthorized Access Alert Communication Profile

Message	Unauthorized Access Alert				
Applicable Interface(s)	Interface 2				
Applicable Standards	N/A (User Interface)				
Description	An indicator that alerts the Traffic CV Manager when an unauthorized device attempts to access the network.				
Required Data	**Name**	**Type**	**Description**	**Values**	**Reference**
	Unauthorized Access Alert	Audio/Visual	An indicator that alerts the Traffic CV Manager when an unauthorized device attempts to access the network.	Alert	-

Source: City of Columbus, ARC-IT

Appendix A. Acronyms and Definitions

Table 52: Acronym List

Abbreviation/Acronym	Definition
APPS	CV Applications
BSM	Basic Safety Message
BSW	Blind Spot Warning Application
CCTN	Columbus Connected Transportation Network
CEAV	Connected Electric Automated Vehicle (Smart Columbus Project #8)
CFR	Code of Federal Regulations
ConOps	Concept of Operations
CORS	Continuously Operating Reference Station
COTA	Central Ohio Transit Authority
CTSS	Columbus Traffic Signal System
CV	Connected Vehicle
CVE	Connected Vehicle Environment (Smart Columbus Project #2)
CVRIA	Connected Vehicle Reference Implementation Architecture
DOT	(City of Columbus) Department of Technology
DPS	Columbus Department of Public Service
DSRC	Dedicated Short Range Communications
EEBL	Emergency Electronic Brake Light Application
EVP	Emergency Vehicle Preemption Application
FCW	Forward Collision Warning Application
FSP	Freight Signal Priority
GNSS	Global Navigation Satellite System
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IMA	Intersection Movement Assist Application
IP	Internet Protocol address
ISO	International Organization for Standardization
ITS	Intelligent Transportation Systems
LCW	Lane Change Warning Application
LED	Light-Emitting Diode

Abbreviation/Acronym	Definition
LTE	Long-Term Evolution
LTS	Location and Time Service
MAP	MapData Message
MMITSS	Multimodal Intelligent Traffic Signal System
NEMA	National Electrical Manufacturers Association
NIST	National Institute of Standards and Technology
OBE	Onboard Equipment (many or all onboard devices)
OBU	Onboard Unit (one onboard device)
ODOT	Ohio Department of Transportation
Operating System	Operating System (Smart Columbus Project #1)
PII	Personally Identifiable Information
RLVW	Red Light Violation Warning Application
RSE	Roadside Equipment
RSM	Roadside Safety Message
RSSZ	Reduced Speed School Zone Application
RSU	Roadside Unit
RTCM	Radio Technical Commission for Maritime Services Corrections Message
SAE	Society of Automotive Engineers
SC	Smart Columbus
SCC	Smart City Challenge
SCMS	Security Credential Management System
SDD	System Design Document
SE	Systems Engineering
SET-IT	Systems Engineering Tool for Intelligent Transportation
SNMP	Simple Network Management Protocol
SPaT	Signal Phase and Timing
SRM	Signal Request Message
SSM	Signal Status Message
SyRS	System Requirements Specification
TCVMS	Traffic CV Management System
TMC	Traffic Management Center
TrCVMS	Transit CV Management System
TrMC	Transit Management Center
TSC	Traffic Signal Controller

Abbreviation/Acronym	Definition
TSP	Traffic Signal Priority Applications
TVIER	Transit Vehicle Interaction Event Recording
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VDTO	Vehicle Data for Traffic Operations

Source: City of Columbus

Appendix B. Glossary

Table 53: Glossary

Term	Definition
APPS	Represents the functional group of CV Apps to be deployed
GNSS	Global Navigation Satellite System used for OBU positioning. GPS is an example of a GNSS
BSW/LCW	Blind Spot Warning/Lane Change Warning CV App
CORS	Continuously Operating Reference System serves as a source of GNSS positioning correction information
CV Pilot	USDOT-sponsored CV deployments in Wyoming, Tampa, and New York City.
EVP	Emergency Vehicle Preempt CV App
EEBL	Emergency Electronic Brake Light CV App
FCW	Forward Collision Warning CV App
FSP	Freight Signal Priority CV App
IMA	Intersection Movement Assist CV App
ITP	Intent to Platoon Signal Priority CV App
MAP	J2735 Message used to convey roadway geometry and movements to OBU
MHP	Message Handler/Processor serves to route messages between RSU and other infrastructure devices. Optional
MSG	Represents the J2735 and J2945 messages that used as part of the CVE
RLVW	Red Light Violation Warning CV App
RSM	Roadside Safety Message – CAMP–driven message expected to be part of J2945
RSSZ	Reduced Speed School Zone CV App
TMC	Traffic Management Center is location that house system to monitor operations of network of signal controllers and will include RSUs
TrMC	Transit Management Center is location where transit fleet is managed, including data capture form onboard systems, to include CVE
TSC	Traffic Signal Controller – source of SPaT data
TSP	Transit Signal Priority CV App
TVIER	Monitor Transit Vehicle Interactions CV App
VDTO	Vehicle Data for Traffic Operations CV App

Source: City of Columbus

Appendix C. Version History

Table 54: Version History

Version Number	Date	Author(s), Agency	Summary of Changes
0.1	2/6/19	WSP	Initial Version for CoC Review
1.0	2/21/19	WSP, HNTB, CoC	Draft, submitted to USDOT
1.1	4/8/19	WSP, HNTB, CoC	Final, submitter to USDOT

THE CITY OF
COLUMBUS
ANDREW J. GINTHER, MAYOR