Connected Vehicle Environment (CVE) Interface Control Document

for the Smart Columbus Demonstration Program

FINAL | April 8, 2019
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Acknowledgement of Support
This material is based upon work supported by the U.S. Department of Transportation under Agreement No. DTFH6116H00013.

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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

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

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¹ [https://local.iteris.com/arc-it/](https://local.iteris.com/arc-it/)
² [https://local.iteris.com/cvria/](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, SPAI, 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. Active transit signal priority can reduce transit delay significantly. In some cases, bus travel times have been

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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.

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Chapter 1. Introduction

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)

- 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/psnntx55r2jl/?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 Connected 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

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

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

<table>
<thead>
<tr>
<th>Related Interface Requirements</th>
<th>Reference</th>
<th>Source Element</th>
<th>Destination Element</th>
<th>Data Flow</th>
<th>Communications Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CVE-IX1643-V01</td>
<td>Interface 1.1</td>
<td>TrCVMS</td>
<td>TrCVMS Staff</td>
<td>CV transit operational administrative coordination: o Archive data and query responses</td>
<td>N/A (user interface)</td>
</tr>
<tr>
<td>• CVE-IF1277-V01</td>
<td></td>
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<tr>
<td>• CVE-IF1473-V01</td>
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<td></td>
</tr>
<tr>
<td>• CVE-IX3259-V01</td>
<td>Interface 1.2</td>
<td>TrCVMS Staff</td>
<td>TrCVMS</td>
<td>CV transit operational administrative coordination: o Transit vehicle interaction event data parameters o Archived data query</td>
<td>N/A (user interface)</td>
</tr>
<tr>
<td>• CVE-IF1277-V01</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>• CVE-IX3260-V01</td>
<td>Interface 2.1</td>
<td>TCVMS</td>
<td>TCVMS Staff</td>
<td>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</td>
<td>N/A (user interface)</td>
</tr>
<tr>
<td>• CVE-IF3044-V01</td>
<td></td>
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<td></td>
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<tr>
<td>• CVE-IX1611-V01</td>
<td>Interface 2.2</td>
<td>TCVMS Staff</td>
<td>TCVMS</td>
<td>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</td>
<td>N/A (user interface)</td>
</tr>
<tr>
<td>• CVE-IF3044-V01</td>
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</table>
## Chapter 2. System Description

### Related Interface Requirements

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<tr>
<th>Related Interface Requirements</th>
<th>Reference</th>
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<th>Destination Element</th>
<th>Data Flow</th>
<th>Communications Media</th>
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<tr>
<td>• CVE-IX3261-V01</td>
<td>Interface 3.1</td>
<td>TrCVMS</td>
<td>Transit Vehicle OBU (COTA Garage Communications)</td>
<td>• Transit Vehicle Interaction Event Data Parameters</td>
<td>• ITS Application Information Layer: Undefined</td>
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<td>• CVE-IF3214-V01</td>
<td>Interface 3.1</td>
<td>TrCVMS</td>
<td>Transit Vehicle OBU (COTA Garage Communications)</td>
<td>• Transit Vehicle Interaction Data</td>
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<td>• CVE-IX1642-V01</td>
<td>Interface 3.2</td>
<td>Transit Vehicle OBU (COTA Garage Communications)</td>
<td>TrCVMS</td>
<td>• Transit Vehicle Interaction Data</td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
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<td>• CVE-IF3214-V01</td>
<td>Interface 3.2</td>
<td>Transit Vehicle OBU (COTA Garage Communications)</td>
<td>TrCVMS</td>
<td>• Transit Vehicle Interaction Data</td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
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<td>• CVE-IX1640-V01</td>
<td>Interface 4</td>
<td>TrCVMS</td>
<td>Smart Columbus Operating System</td>
<td>• Performance measures, (processed and PII-removed Transit Vehicle Interaction Events)</td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td>• CVE-IF1472-V01</td>
<td>Interface 4</td>
<td>TrCVMS</td>
<td>Smart Columbus Operating System</td>
<td>• Performance measures, (processed and PII-removed Transit Vehicle Interaction Events)</td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Physical Layer: IEEE 802.3, IEEE 802.11</td>
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<td></td>
<td>• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td>
</tr>
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**Notes:**
- COTA: COTelligent Transportation Applications
- OBU: On-Board Unit
- PII: Personal Identifiable Information
- IETF: Internet Engineering Task Force
- HTTPS: Hypertext Transfer Protocol Secure
- TLS: Transport Layer Security
- DTLS: Datagram Transport Layer Security
- UDP: User Datagram Protocol
- TCP: Transmission Control Protocol
- IPv6: Internet Protocol Version 6
- LLC: Logical Link Control
- MAC: Medium Access Control
- IEEE: Institute of Electrical and Electronics Engineers
- 802.x: IEEE 802 standards
- 1609.2: IEEE 1609.2 standards
## Chapter 2. System Description

<table>
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<tr>
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<th>Source Element</th>
<th>Destination Element</th>
<th>Data Flow</th>
<th>Communications Media</th>
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</table>
| • 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

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<td>Interface 7.2</td>
<td>TCVMS</td>
<td>RSU</td>
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<td>CVE-IF1342-V01</td>
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<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
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<td>CVE-IF1341-V01</td>
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<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul)</td>
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<td>CVE-IX1633-V01</td>
<td>Interface 8.1</td>
<td>RSU</td>
<td>SCMS</td>
<td>• Application Layer: IETF SNMP</td>
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<td>CVE-IF1354-V01</td>
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<td>• Presentation Layer: ISO ASN.1 BER</td>
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<td>• Session Layer: IETF TLS, IETF DTLS</td>
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<td>• Network Layer: IETF IPv6</td>
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<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
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<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet)</td>
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<td>SCMS</td>
<td>RSU</td>
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<th>Data Flow</th>
<th>Communications Media</th>
</tr>
</thead>
</table>
| CVE-IX1626-V01                   | Interface 10 Network Time Source | RSU                 | • Network Time Data                             | • 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-IX1637-V01                   | Interface 11.1 RSU Traffic Signal Controller | • SRM data (signal preemption request data) | • ITS Application Information Layer: NTCIP 1202-ASC |                                                                                                                                                             |
| CVE-IF1347-V01                   | Interface 11.2 Traffic Signal Controller | RSU                 | • SPaT data  
• SSM Data | • Presentation Layer: ISO ASN.1 UPER  
• Transport Layer: IETF UDP, IETF TCP |
| CVE-IX1638-V01                   |                              |                     |                                               |                                                                                                                                                             |
| CVE-IF1340-V01                   |                              |                     |                                               |                                                                                                                                                             |
| CVE-IF1345-V01                   |                              |                     |                                               |                                                                                                                                                             |
| CVE-IF1346-V01                   |                              |                     |                                               |                                                                                                                                                             |
## Chapter 2. System Description

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<td>School Zone Indicator (0/24V)</td>
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<td>RSU</td>
<td>BSM (Part I)</td>
<td>Network Layer: IEEE 1609.3 WSMP</td>
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<td>Application Layer: IETF HTTP</td>
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<td>Transit Vehicle OBU</td>
<td>RSU</td>
<td>OBU Tamper Status</td>
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<td>CVE-IF3247-V01</td>
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<td>OBU Enrollment Request</td>
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<td>• CVE-IX1620-V01</td>
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<td>RSU</td>
<td>LDV OBU</td>
<td>SPaT, MAP, RTCM, RSM</td>
<td>Application Layer: IETF HTTP</td>
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<td>• CVE-IF1361-V01</td>
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<td>LDV OBU</td>
<td>RSU</td>
<td>OBU Tamper Status, OBU Enrollment Request, OBU Pseudonym Certificate Request, Misbehavior Report</td>
<td>Application Layer: IETF HTTP</td>
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<tr>
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<th>Source Element</th>
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</thead>
</table>
| • CVE-IX1620-V01 | 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-IF3247-V01 | RSU | OBU Enrollment Certificate  
OBU Pseudonym Certificate  
Revocation List |  |
| • CVE-IF1243-V01 | RSU | OBU Enrollment Certificate  
OBU Pseudonym Certificate  
Revocation List |  |
| • CVE-IF3210-V01 | RSU | OBU Enrollment Certificate  
OBU Pseudonym Certificate  
Revocation List |  |

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<th>Data Flow</th>
<th>Communications Media</th>
</tr>
</thead>
</table>
| • CVE-IX1609-V01 | 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-IF3247-V01 | EV OBU | RSU | OBU Tamper Status  
OBU Enrollment Request | Application Layer:  
IETF HTTP |
| • CVE-IF1248-V01 | EV OBU | RSU | OBU Tamper Status  
OBU Enrollment Request | Application Layer:  
IETF HTTP |
| • CVE-IF1251-V01 | EV OBU | RSU | OBU Tamper Status  
OBU Enrollment Request | Application Layer:  
IETF HTTP |
| • CVE-IF1361-V01 | EV OBU | RSU | OBU Tamper Status  
OBU Enrollment Request | Application Layer:  
IETF HTTP |

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</table>
| • CVE-IX1610-V01 | RSU | EV OBU | • SPaT  
• MAP  
• RTCM  
• SSM |  |
| • CVE-IF3247-V01 | RSU | EV OBU |  |
| • CVE-IF1232-V01 | RSU | EV OBU |  |
| • CVE-IF1236-V01 | RSU | EV OBU |  |
| • CVE-IF1228-V01 | RSU | EV OBU |  |
| • CVE-IF1239-V01 | RSU | EV OBU |  |
| • CVE-IF2986-V01 | RSU | EV OBU |  |

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</table>
| • CVE-IX1609-V01 | EV OBU | RSU | • OBU Tamper Status  
• OBU Enrollment Request |  |
| • CVE-IF3247-V01 | EV OBU | RSU |  |
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</table>
| • CVE-IF1248-V01 | RSU | EV OBU | • OBU Pseudonym Certificate Request  
• Misbehavior Report | Presentation Layer:  
W3C XML, IETF GZIP,  
ISO ASN.1 DER |
| • CVE-IF1361-V01 | Interface 14.2 | HDV OBU | RSU |  
• BSM (Parts I and II)  
• SRM |
| • CVE-IX1610-V01 | Interface 15.1 | HDV OBU | RSU |  
• ITS Application Information Layer:  
SAE J2735_201603, SAE J2945  
• Presentation Layer:  
ISO ASN.1 UPER |
| • CVE-IX1615-V01 | Interface 15.2 | RSU | HDV OBU |  
• SPaT  
• MAP  
• SSM  
• RTCM |
| • CVE-IX1616-V01 | Interface 15.1 | HDV OBU | RSU |  
• OBU Tamper Status  
• OBU Enrollment Request |

### Communications Media

- 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
- 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
- Application Layer: IETF HTTP
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<tr>
<th>Related Interface Requirements</th>
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</table>
| • Interface 15.2              | RSU       | HDV OBU        |                     | • OBU Pseudonym Certificate Request  
• Misbehavior Report         |           |                |                     |           |                       |
| • 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               |           |                |                     |           |                       |
| • Interface 17.2              | LDV Operator | LDV OBU        |                     | • OBU Start-Up Indication  
• Setting Adjustment         |           |                |                     |           |                       |
| • CVE-IX3263-V01              |           |                |                     |           |                       |
| • CVE-IF3019-V01              |           |                |                     |           |                       |
| • Interface 18                | EV OBU    | EV Operator     |                     | • Signal Preempt Notification     | N/A (human machine interface) |
| • CVE-IX1644-V01              |           |                |                     |           |                       |
| • CVE-IF1247-V01              |           |                |                     |           |                       |
| • Interface 19.1              | Transit Vehicle OBU | Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU) | • BSM (Part I) |                       |
| • CVE-IX3264-V01              |           |                |                     |           |                       |
| • 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) |                       |
| • 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 | | | | | |
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<td>• BSM (Part I)</td>
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<td><strong>CVE-IF1218-V01</strong></td>
<td>Interface 20.1</td>
<td>LDV OBU</td>
<td>Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)</td>
<td>• BSM (Parts I and II)</td>
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<td><strong>CVE-IX1629-V01</strong></td>
<td>Interface 20.2</td>
<td>Remote OBU (LDV, HDV, EV, and Transit Vehicle OBU)</td>
<td>LDV OBU</td>
<td>• ITS Application Information Layer: SAE J2735_201603</td>
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<td><strong>CVE-IF1245-V01</strong></td>
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<td>HDV OBU</td>
<td>• CAN Bus Data (optional)</td>
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<td>Vehicle Databus</td>
<td>HDV OBU</td>
<td>• CAN Bus Data (optional)</td>
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- **Data Link Layer:** IEEE 1609.4, IEEE 802.11
- **Physical Layer:** IEEE 802.11
- **Security Plane:** IEEE 1609.2
- **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

- **Controller Area Network (CAN) – ISO 11898**
- **SAE J1939**
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<td>GNSS</td>
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<td>• Location and Time Data</td>
<td>• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
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<td>• CVE-IX1623-V01</td>
<td>Interface 26</td>
<td>GNSS</td>
<td>LDV OBU</td>
<td>• Location and Time Data</td>
<td>• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
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<td>• CVE-IX1625-V01</td>
<td>Interface 27</td>
<td>GNSS</td>
<td>RSU</td>
<td>• Location and Time Data</td>
<td>• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
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<td>GNSS</td>
<td>EV OBU</td>
<td>• Location and Time Data</td>
<td>• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
</tr>
<tr>
<td>• CVE-IX1622-V01</td>
<td>Interface 29</td>
<td>GNSS</td>
<td>HDV OBU</td>
<td>• Location and Time Data</td>
<td>• NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
</tr>
</tbody>
</table>

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

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<th>TrCVMS-Related Sequence Diagrams</th>
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<td>• Interface 3 (\rightarrow) Figure 12</td>
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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
- Interface 7 → Figure 19

TCVMS Staff-Related Sequence Diagrams
- 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
- Interface 7 → Figure 20

TCVMS Staff-Related Sequence Diagrams
- 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
• Interface 7 → Figure 18

TCVMS Staff-Related Sequence Diagrams
• 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

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<tr>
<th>TCVMS-Related Sequence Diagrams</th>
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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
- Interface 5 → Figure 15

TCVMS Staff-Related Sequence Diagrams
- 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
- Interface 7 → Figure 21

TCVMS Staff-Related Sequence Diagrams
- 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

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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
• Interface 7 → Figure 23

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 Vehicle OBU**
  - CAN Bus Data (optional)
  - Time and Location Data
  - BSM (Part I and Part II)
  - Logged received BSM
  - SPaT
  - Logged received SPaT
  - MAP
  - Logged received MAP
  - RTCM
  - Logged received RTCM
  - RSM
  - Logged received SSM
  - Delete Logged Data

- **TrCVMS**
  - Transit Vehicle Interaction Event Data Parameters
  - Archive Event Data
  - Backup Archived Data
  - Archived Data Query
  - Access Archived Data
  - Archived Data Return

- If (one or more) warnings should be issued, generate Transit Vehicle Interaction Event, based on parameters.

See Interface 1

See Interface 21 and/or OBU Internal

See Interface 25

See Interface 19

See Interface 12

See Interface 2

See Interface 4

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1

See Interface 1
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

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<th>TrCVMS-Related Sequence Diagrams</th>
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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
- Interface 2 → Figure 7
- Interface 7 → Figure 17

Operating System-Related Sequence Diagrams
- 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

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<th>TCVMS-Related Sequence Diagrams</th>
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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

<table>
<thead>
<tr>
<th>TCVMS-Related Sequence Diagrams</th>
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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
- Interface 11a → Figure 31
- Interface 12 → Figure 37
- Interface 13 → Figure 43
- Interface 14 → Figure 48
- Interface 15 → Figure 53

## TCVMS-Related Sequence Diagrams
- 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
Interface 9 → Figure 28
Interface 11a → Figure 32
Interface 12 → Figure 34
Interface 14 → Figure 47
Interface 15 → Figure 52

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

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

TCVMS-Related Sequence Diagrams
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
- None

TCVMS-Related Sequence Diagrams
- 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
• None

TCVMS-Related Sequence Diagrams
• Interface 2 \(\rightarrow\) 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
- Interface 12 → Figure 38
- Interface 13 → Figure 44
- Interface 14 → Figure 49
- Interface 15 → Figure 54

SCMS-Related Sequence Diagrams
- 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
- Interface 12 → Figure 39
- Interface 13 → Figure 45
- Interface 14 → Figure 50
- Interface 15 → Figure 55

SCMS-Related Sequence Diagrams
- 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
• Interface 7 → Figure 19
• Interface 11a → Figure 30
• Interface 12 → Figure 35
• Interface 13 → Figure 41

CORS-Related Sequence Diagrams
• 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
- Interface 7 → Figure 20
- Interface 11b → Figure 33
- Interface 12 → Figure 36
- Interface 13 → Figure 42

CORS-Related Sequence Diagrams
- 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
- Interface 7 ➔ Figure 18
- Interface 11a ➔ Figure 32
- Interface 12 ➔ Figure 34
- Interface 14 ➔ Figure 47
- Interface 15 ➔ Figure 52

CORS-Related Sequence Diagrams
- 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

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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
- Interface 7 → Figure 19
- Interface 9 → Figure 26
- Interface 12 → Figure 35
- Interface 13 → Figure 41

TSC-Related Sequence Diagrams
- 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

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<td>Interface 9 → Figure 27</td>
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<td>Interface 12 → Figure 36</td>
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<td>Interface 13 → Figure 42</td>
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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
• Interface 7 → Figure 18
• Interface 9 → Figure 28
• Interface 11a → Figure 32

Transit Veh OBU-Related Sequence Diagrams
• 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
- Interface 8 → Figure 24

Transit Veh OBU-Related Sequence Diagrams
- 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
- Interface 8 → Figure 25

Transit Veh OBU-Related Sequence Diagrams
- 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
- Interface 7 → Figure 22

Transit Veh OBU-Related Sequence Diagrams
- 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

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

LDV OBU-Related Sequence Diagrams
- 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
- Interface 7 → Figure 20
- Interface 9 → Figure 27
- Interface 11b → Figure 33

LDV OBU-Related Sequence Diagrams
- 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
• Interface 8 → Figure 24

LDV OBU-Related Sequence Diagrams
• 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
• Interface 8 → Figure 25

LDV OBU-Related Sequence Diagrams
• 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
- Interface 7 → Figure 22

LDV OBU-Related Sequence Diagrams
- 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
- Interface 7 → Figure 18
- Interface 9 → Figure 28
- Interface 11a → Figure 32

### EV OBU-Related Sequence Diagrams
- 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)

<table>
<thead>
<tr>
<th>RSU-Related Sequence Diagrams</th>
<th>EV OBU-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 8 → Figure 24</td>
<td>• None</td>
</tr>
</tbody>
</table>

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
- Interface 8 → Figure 25

EV OBU-Related Sequence Diagrams
- 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
- Interface 7 ➔ Figure 22

EV OBU-Related Sequence Diagrams
- 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
- HDV OBU

- SPAI Data
  - See Interface 11a

- MAP
  - See Interface 7

- RTCM Data
  - See Interface 9

- Signal Priority Authorization List
  - See Interface 7

- Check Query Against Authorization List
  - RSU Internal

- If authorized, SRM Data
  - See Interface 11a

- SSM Data
  - See Interface 11a

- CAN Bus Data (optional)
  - See Interface 24 and/or OBU Internal

- Time and Location Data
  - See Interface 29

- Determine if approaching intersection
  - Determine if have received SSM
  - OBU Internal

- If approaching intersection
  - If have not received SSM

- RTCM

- MAP

- MAP

- RTM
### RSU-Related Sequence Diagrams
- Interface 7 → **Figure 18**
- Interface 9 → **Figure 28**
- Interface 11a → **Figure 32**

### HDV OBU-Related Sequence Diagrams
- 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
- Interface 8 → Figure 24

HDV OBU-Related Sequence Diagrams
- 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
Chapter 3. System Interfaces

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
• Interface 8 → Figure 25

HDV OBU-Related Sequence Diagrams
• 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
- Interface 7 → Figure 22

HDV OBU-Related Sequence Diagrams
- 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

<table>
<thead>
<tr>
<th>Related Sequence Diagrams</th>
<th>LDV Operator-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 20 → Figure 63</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 22 → Figure 71</td>
<td></td>
</tr>
<tr>
<td>• Interface 26 → Figure 87</td>
<td></td>
</tr>
</tbody>
</table>

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

CAN Bus Data (optional)
See Interface 22 and/or OBU Internal

Time and Location Data
See Interface 26

SPaT, MAP, RTCM
See Interface 13

LDV Operator

Alert (type according to arbitration)

If (one or more) warnings should be issued, perform arbitration
OBU Internal

Determine if RLVW Warning should be issued
OBU Internal

Related Sequence Diagrams
• Interface 13 → Figure 41
• Interface 22 → Figure 72
• Interface 26 → Figure 88

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

LDV OBU

LDV Operator

CAN Bus Data (optional)

See Interface 22 and/or OBU Internal

Time and Location Data

See Interface 26

RSM, RTCM

See Interface 13

Determine if RSSZ Warning should be Issued

OBU Internal

If (one or more) warnings should be issued, perform arbitration

OBU Internal

Alert (type according to arbitration)

Related Sequence Diagrams
- Interface 13 → Figure 42
- Interface 22 → Figure 73
- Interface 26 → Figure 89

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

Related Sequence Diagrams
- None

LDV Operator-Related Sequence Diagrams
- 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
• Interface 14 → Figure 47
• Interface 23 → Figure 76
• Interface 28 → Figure 93

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)

<table>
<thead>
<tr>
<th>Transit Veh OBU-Related Sequence Diagrams</th>
<th>Vehicle Databus-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 20 → Figure 63</td>
<td></td>
</tr>
<tr>
<td>• Interface 25 → Figure 80</td>
<td></td>
</tr>
</tbody>
</table>

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 Vehicle OBU → Vehicle Databus

- Time and Location Data
  See Interface 25
- BSM (Part I)
  See Interface 12
- Determine if approaching intersection
  - Determine if have received SSM
  - OBU Internal
  - If approaching intersection,
    If have not received SSM,
    SRM
  See Interface 12

**Transit Veh OBU-Related Sequence Diagrams**
- Interface 12 → Figure 37
- Interface 25 → Figure 81

**Vehicle Databus-Related Sequence Diagrams**
- 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
- Interface 3 → Figure 12
- Interface 19 → Figure 62
- Interface 25 → Figure 82

Vehicle Databus-Related Sequence Diagrams
- 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
- Interface 3 → Figure 12
- Interface 12 → Figure 35
- Interface 25 → Figure 83

Vehicle Databus-Related Sequence Diagrams
- 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 Vehicle OBU

Vehicle Databus

Transit Vehicle Interaction Event Data Parameters
See Interface 3

Time and Location Data
See Interface 25

RSM, RTCM
See Interface 12

Determine if RSSZ Warning should be issued
OBU Internal

If (one or more) warnings should be issued,
Log Transit Vehicle Interaction Event,
(based on parameters)
OBU Internal

Send Transit Vehicle Interaction Event Data
See Interface 3

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

<table>
<thead>
<tr>
<th>Transit Veh OBU-Related Sequence Diagrams</th>
<th>Vehicle Databus-Related Sequence Diagrams</th>
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</thead>
<tbody>
<tr>
<td>• Interface 12  →  Figure 34</td>
<td>• None</td>
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<tr>
<td>• Interface 25  →  Figure 85</td>
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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)

<table>
<thead>
<tr>
<th>LDV OBU-Related Sequence Diagrams</th>
<th>Vehicle Databus-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 13 → Figure 43</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 19 → Figure 62</td>
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<tr>
<td>• Interface 20 → Figure 63</td>
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<td>• Interface 26 → Figure 86</td>
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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
- Interface 17 → Figure 57
- Interface 20 → Figure 63
- Interface 26 → Figure 87

Vehicle Databus-Related Sequence Diagrams
- 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
- Interface 13 → Figure 41
- Interface 17 → Figure 58
- Interface 26 → Figure 88

Vehicle Databus-Related Sequence Diagrams
- 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
- Interface 13 → Figure 42
- Interface 17 → Figure 59
- Interface 26 → Figure 89

Vehicle Databus-Related Sequence Diagrams
- 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)

<table>
<thead>
<tr>
<th>EV OBU-Related Sequence Diagrams</th>
<th>Vehicle Databus-Related Sequence Diagrams</th>
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</thead>
<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
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<tr>
<td>• Interface 20 → Figure 63</td>
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</tr>
<tr>
<td>• Interface 28 → Figure 91</td>
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</table>

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

- **Emergency Vehicle OBU**
- **Vehicle Databus**

**EV OBU-Related Sequence Diagrams**
- Interface 14 → Figure 48
- Interface 28 → Figure 92

**Vehicle Databus-Related Sequence Diagrams**
- 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
- Interface 14 → Figure 47
- Interface 18 → Figure 61
- Interface 28 → Figure 93

Vehicle Databus-Related Sequence Diagrams
- 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)

<table>
<thead>
<tr>
<th>HDV OBU-Related Sequence Diagrams</th>
<th>Vehicle Databus-Related Sequence Diagrams</th>
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<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
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<tr>
<td>• Interface 20 → Figure 63</td>
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</tr>
<tr>
<td>• Interface 29 → Figure 94</td>
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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
- Interface 15 → Figure 53
- Interface 29 → Figure 95

Vehicle Databus-Related Sequence Diagrams
- None

Data Flow Communications Profiles
- Table 13: CAN Bus Data Communication Profile

CVE-IX1612-V01

Source: City of Columbus
Figure 79: Interface 24 Sequence Diagram – Freight Signal Priority

HDV OBU-Related Sequence Diagrams

- Interface 15 → Figure 52
- Interface 29 → Figure 96

Vehicle Databus-Related Sequence Diagrams

- 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)

<table>
<thead>
<tr>
<th>Transit Veh OBU-Related Sequence Diagrams</th>
<th>GNSS-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 20 → Figure 63</td>
<td></td>
</tr>
<tr>
<td>• Interface 21 → Figure 64</td>
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</tr>
</tbody>
</table>

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 Vehicle OBU

Vehicle Databus

CAN Bus Data (optional)
See Interface 21

BSM (Part I)
See Interface 12

Determine if approaching intersection
Determine if have received SSM
OBU Internal

If approaching intersection,
If have not received SSM,
SRM

See Interface 12

Time and Location Data

Transit Veh OBU-Related Sequence Diagrams
- Interface 12 → Figure 37
- Interface 21 → Figure 65

GNSS-Related Sequence Diagrams
- 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

![Sequence Diagram]

Transit Veh OBU-Related Sequence Diagrams
- Interface 3 → Figure 12
- Interface 19 → Figure 62
- Interface 21 → Figure 66

GNSS-Related Sequence Diagrams
- 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
- Interface 3 → Figure 12
- Interface 12 → Figure 35
- Interface 21 → Figure 67

GNSS-Related Sequence Diagrams
- 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
- Interface 3 → Figure 12
- Interface 12 → Figure 36
- Interface 21 → Figure 68

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 Vehicle OBU

Vehicle Databus

- CAN Bus Data (optional)
- SPaT, MAP, RTCM
- See Interface 12
- Determine if approaching intersection
- Determine if have received SSM
- OBU Internal
- If approaching intersection,
- If have not received SSM,
- SRM
- See Interface 12
- SSM
- See Interface 12
- Time and Location Data

Transit Veh OBU-Related Sequence Diagrams
- Interface 12 → Figure 34
- Interface 21 → Figure 69

GNSS-Related Sequence Diagrams
- 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
• Interface 13 → Figure 43
• Interface 19 → Figure 62
• Interface 20 → Figure 63
• Interface 22 → Figure 70

GNSS-Related Sequence Diagrams
• 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
• Interface 17 → Figure 57
• Interface 20 → Figure 63
• Interface 22 → Figure 71

GNSS-Related Sequence Diagrams
• 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
• Interface 13 → Figure 41
• Interface 17 → Figure 58
• Interface 22 → Figure 72

GNSS-Related Sequence Diagrams
• 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

GNSS

CAN Bus Data (optional)
See Interface 22
RSM, RTCM
See Interface 13

Determine if RSSZ Warning should be issued
OBU Internal

If (one or more) warnings should be issued, perform arbitration
OBU Internal

Alert
(type according to arbitration)
See Interface 17

Time and Location Data

LDV OBU-Related Sequence Diagrams
- Interface 13 → Figure 42
- Interface 17 → Figure 59
- Interface 22 → Figure 73

GNSS-Related Sequence Diagrams
- 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
• None

GNSS-Related Sequence Diagrams
• 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)

<table>
<thead>
<tr>
<th>EV OBU-Related Sequence Diagrams</th>
<th>GNSS-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 20 → Figure 63</td>
<td></td>
</tr>
<tr>
<td>• Interface 23 → Figure 74</td>
<td></td>
</tr>
</tbody>
</table>

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
- Interface 14 → Figure 48
- Interface 23 → Figure 75

GNSS-Related Sequence Diagrams
- 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
- Interface 14 → Figure 47
- Interface 18 → Figure 61
- Interface 23 → Figure 76

GNSS-Related Sequence Diagrams
- 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)

<table>
<thead>
<tr>
<th>HDV OBU-Related Sequence Diagrams</th>
<th>GNSS-Related Sequence Diagrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interface 19 → Figure 62</td>
<td>• None</td>
</tr>
<tr>
<td>• Interface 20 → Figure 63</td>
<td></td>
</tr>
<tr>
<td>• Interface 24 → Figure 77</td>
<td></td>
</tr>
</tbody>
</table>

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
- Interface 15 → Figure 53
- Interface 24 → Figure 78

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
Interface 15 → Figure 52
Interface 24 → Figure 79

GNSS-Related Sequence Diagrams
• 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 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**

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

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emergency Electronic Brake Light Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Forward Collision Warning Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Lane Change Warning Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Blind Spot Warning Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Intersection Movement Assist Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Red Light Violation Warning Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduced Speed School Zone Warning Alert</td>
<td>Audio/Visual</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
4.2. APPLICATION AVAILABILITY

Table 5: Application Availability Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Application Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 17</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>An indicator on the OBU that provides the status of each application and the OBU system version to the LDV Operator.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Emergency Electronic Brake Light Warning Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of EEBL</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Lane Change Warning Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of LCW</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Blind Spot Warning Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of BSW</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Intersection Movement Assist Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of IMA</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Forward Collision Warning Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of FCW</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Red Light Violation Warning Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of RLVW</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reduced Speed School Zone Availability</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the availability of RSSZ</td>
<td>(e.g.) Operational, Failed, Disabled</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>System Version</td>
<td>Audio/Visual</td>
<td>The version number of software/firmware on the OBU</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.3. ARCHIVED DATA QUERY

Table 6: Archived Data Query Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Archived Data Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 1, Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>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.</td>
</tr>
<tr>
<td>Required Data</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
</tr>
<tr>
<td>Type of Data</td>
<td>Audio/Visual</td>
</tr>
<tr>
<td>From Date</td>
<td>Audio/Visual</td>
</tr>
<tr>
<td>To Date</td>
<td>Audio/Visual</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.4. ARCHIVED DATA RETURN

Table 7: Archived Data Return Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Archived Data Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 1, Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>The data that is returned to management staff based on a query that was made</td>
</tr>
<tr>
<td>Required Data</td>
<td>Name</td>
</tr>
<tr>
<td>Data (BSM, SPaT, MAP, SRM, SSM, RSM)</td>
<td>-</td>
</tr>
</tbody>
</table>

*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>
<thead>
<tr>
<th>Message</th>
<th>Basic Safety Message (BSM) Part I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 7</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>• ITS Application Information Layer: Undefined</td>
</tr>
<tr>
<td></td>
<td>• Application Layer: HTTPS</td>
</tr>
<tr>
<td></td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul)</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td>
</tr>
<tr>
<td>Description</td>
<td>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.</td>
</tr>
<tr>
<td>Required Data</td>
<td>BSMs are received and logged by the RSU and are periodically sent to the Traffic CV Management System</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

See Table 3 in Chapter 2 for the proposed DSRC channel map.
<table>
<thead>
<tr>
<th>Message</th>
<th>Basic Safety Message (BSM) Part I</th>
</tr>
</thead>
<tbody>
<tr>
<td>lat</td>
<td>Latitude</td>
</tr>
<tr>
<td>lon</td>
<td>Longitude</td>
</tr>
<tr>
<td>elev</td>
<td>Elevation</td>
</tr>
<tr>
<td>accuracy</td>
<td>PositionalAccuracy</td>
</tr>
<tr>
<td>semiMajor</td>
<td>SemiMajorAxisAccuracy</td>
</tr>
<tr>
<td>semiMinor</td>
<td>SemiMinorAxisAccuracy</td>
</tr>
<tr>
<td>orientation</td>
<td>SemiMajorAxisOrientation</td>
</tr>
<tr>
<td>transmission</td>
<td>TransmissionState</td>
</tr>
<tr>
<td>speed</td>
<td>Speed</td>
</tr>
</tbody>
</table>

**lat**
The geographic latitude of an object, expressed in 1/10th integer microdegrees

**lon**
The geographic longitude of an object, expressed in 1/10th integer microdegrees

**elev**
Geographic position above or below the reference ellipsoid (typically WGS-84). The number has a resolution of 1 decimeter

**accuracy**
Various parameters of quality used to model the accuracy of the positional determination with respect to each given axis

**semiMajor**
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.

**semiMinor**
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.

**orientation**
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

**transmission**
Current state of the vehicle transmission

**speed**
Vehicle speed expressed in unsigned units of 0.02 meters per second
### Basic Safety Message (BSM) Part I

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
<th>Data Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>heading</td>
<td>current heading of the sending device, expressed in unsigned units of 0.0125 degrees from North</td>
<td>INTEGER (0...28800)</td>
<td>SAE J2735_201603, Section 7.53</td>
</tr>
<tr>
<td>angle</td>
<td>The angle of the driver’s steering wheel, with LSB units of 1.5 degrees +127 to be used for unavailable</td>
<td>INTEGER (-126...127)</td>
<td>SAE J2735_201603, Section 7.185</td>
</tr>
<tr>
<td>accelSet</td>
<td>Set of acceleration values in 3 orthogonal directions of the vehicle and with yaw rotation rates</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.1</td>
</tr>
<tr>
<td>long</td>
<td>Signed acceleration of the vehicle along some known axis in units of 0.01 meters per second squared along the Vehicle Longitudinal axis</td>
<td>INTEGER (-2000...2001)</td>
<td>SAE J2735_201603, Section 7.1</td>
</tr>
<tr>
<td>lat</td>
<td>Signed acceleration of the vehicle along some known axis in units of 0.01 meters per second squared along the Vehicle Lateral axis</td>
<td>INTEGER (-2000...2001)</td>
<td>SAE J2735_201603, Section 7.1</td>
</tr>
<tr>
<td>vert</td>
<td>Signed vertical acceleration of the vehicle along the vertical axis in units of 0.02 G</td>
<td>INTEGER (-127...127)</td>
<td>SAE J2735_201603, Section 7.217</td>
</tr>
<tr>
<td>yaw</td>
<td>Yaw Rate of the vehicle, a signed value (to the right being positive) expressed in 0.01 degrees per second</td>
<td>INTEGER (-32767...32767)</td>
<td>SAE J2735_201603, Section 7.229</td>
</tr>
<tr>
<td>brakes</td>
<td>Information about the current brake and system control activity of the vehicle</td>
<td></td>
<td>SAE J2735_201603, Section 6.7</td>
</tr>
<tr>
<td>wheelBrakes</td>
<td>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</td>
<td>BIT STRING { unavailable (0), leftFront (1), leftRear (2), rightFront (3), rightRear (4) }</td>
<td>SAE J2735_201603, Section 7.18</td>
</tr>
<tr>
<td>traction</td>
<td>Status of the vehicle traction control system</td>
<td>ENUMERATED { unavailable (0), off (1), on (2), engaged (3) }</td>
<td>SAE J2735_201603, Section 7.196</td>
</tr>
<tr>
<td>Message</td>
<td>Basic Safety Message (BSM) Part I</td>
<td>Status</td>
<td>ENUMERATED { unavailable (0), off (1), on (2), engaged (3)}</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------</td>
<td>--------</td>
<td>------------------------------------------------</td>
</tr>
<tr>
<td>abs</td>
<td>AntiLockBrakeStatus</td>
<td>Status of the vehicle ABS</td>
<td>SAE J2735_201603, Section 7.10</td>
</tr>
<tr>
<td>scs</td>
<td>StabilityControlStatus</td>
<td>Current state of the stability control system</td>
<td>SAE J2735_201603, Section 7.181</td>
</tr>
<tr>
<td>brakeBoost</td>
<td>BrakeBoostApplied</td>
<td>When set to the &quot;on&quot; state, indicates emergency braking</td>
<td>SAE J2735_201603, Section 7.19</td>
</tr>
<tr>
<td>auxBrakes</td>
<td>AuxilliaryBrakeStatus</td>
<td>status of the auxiliary brakes (sometimes referred to as the parking brake) of the vehicle</td>
<td>SAE J2735_201603, Section 7.14</td>
</tr>
<tr>
<td>size</td>
<td>VehicleSize</td>
<td>vehicle length and vehicle width</td>
<td>N/A (Data Frame)</td>
</tr>
<tr>
<td>width</td>
<td>VehicleWidth</td>
<td>Width of the vehicle expressed in centimeters</td>
<td>INTEGER (0...1023)</td>
</tr>
<tr>
<td>length</td>
<td>VehicleLength</td>
<td>Length of the vehicle measured from the edge of the front bumper to the edge of the rear bumper expressed in centimeters, unsigned.</td>
<td>INTEGER (0... 4095)</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
## 4.6. BASIC SAFETY MESSAGE (PART II)

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

<table>
<thead>
<tr>
<th>Message</th>
<th>Basic Safety Message (BSM) Part II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 7</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>• ITS Application Information Layer: Undefined</td>
</tr>
<tr>
<td></td>
<td>• Application Layer: HTTPS</td>
</tr>
<tr>
<td></td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul)</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>specialVehicleExt</td>
<td>SpecialVehicleExtensions</td>
<td>various additional optional information elements for special vehicles. For example, a heavy truck sending content about the trailer it was hauling</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.128</td>
<td></td>
</tr>
<tr>
<td>trailers</td>
<td>TrailerData</td>
<td>describe trailers pulled by a motor vehicle and/or other equipped devices</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.135</td>
<td></td>
</tr>
<tr>
<td>Message</td>
<td>Basic Safety Message (BSM) Part II</td>
<td>Value Type</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------------</td>
<td>------------</td>
<td>-----------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sspRights</td>
<td>SSPIndex</td>
<td>INTEGER (0...31)</td>
<td>SAE J2735_201603, Section 7.180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>connection</td>
<td>PivotPointDescription</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pivotOffset</td>
<td>Offset-B11</td>
<td>INTEGER (-1024...1023)</td>
<td>SAE J2735_201603, Section 7.119</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pivotAngle</td>
<td>Angle</td>
<td>INTEGER (0...28800)</td>
<td>SAE J2735_201603, Section 7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pivots</td>
<td>PivotingAllowed</td>
<td>BOOLEAN</td>
<td>SAE J2735_201603, Section 7.138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>units</td>
<td>TrailerUnitDescriptionList</td>
<td>SEQUENCE (SIZE(1...8)) OF TrailerUnitDescription</td>
<td>SAE J2735_201603, Section 6.138</td>
<td></td>
<td></td>
</tr>
<tr>
<td>units</td>
<td>TrailerUnitDescription</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.139</td>
<td></td>
<td></td>
</tr>
<tr>
<td>isDolley</td>
<td>IsDolley</td>
<td>BOOLEAN</td>
<td>SAE J2735_201603, Section 7.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>width</td>
<td>VehicleWidth</td>
<td>INTEGER (0...1023)</td>
<td>SAE J2735_201603, Section 7.215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>length</td>
<td>VehicleLength</td>
<td>INTEGER (0...1023)</td>
<td>SAE J2735_201603, Section 7.210</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Basic Safety Message (BSM) Part II

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
<th>Data Type/Range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>frontPivot</td>
<td>PivotPointDescription</td>
<td>describes the geometric relationship between a vehicle and a trailer</td>
<td>N/A (Data Frame) SAE J2735_201603, Section 6.86</td>
</tr>
<tr>
<td>pivotOffset</td>
<td>Offset-B11</td>
<td>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</td>
<td>INTEGER (-1024...1023) SAE J2735_201603, Section 7.119</td>
</tr>
<tr>
<td>pivotAngle</td>
<td>Angle</td>
<td>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.</td>
<td>INTEGER (0...28800) SAE J2735_201603, Section 7.7</td>
</tr>
<tr>
<td>pivots</td>
<td>PivotingAllowed</td>
<td>Flag set to true when the described connection point allows pivoting to occur</td>
<td>BOOLEAN SAE J2735_201603, Section 7.138</td>
</tr>
<tr>
<td>positionOffset</td>
<td>Node-XY-24b</td>
<td>Current Position relative to the hauling Vehicle. A 24-bit node type with offset values from the last point in X and Y.</td>
<td>N/A (Data Frame) SAE J2735_201603, Section 6.63</td>
</tr>
<tr>
<td>x</td>
<td>Offset-B12</td>
<td>A 12-bit delta offset in X, Y or Z direction from some known point. A range of ± 20.47 meters</td>
<td>INTEGER (-2048...2047) SAE J2735_201603, Section 7.120</td>
</tr>
<tr>
<td>y</td>
<td>Offset-B12</td>
<td>A 12-bit delta offset in X, Y or Z direction from some known point. A range of ± 20.47 meters</td>
<td>INTEGER (-2048...2047) SAE J2735_201603, Section 7.120</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
## 4.7. CABINET STATUS QUERY

Table 10: Cabinet Status Query Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Cabinet Status Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Allows Traffic CV Management Staff to query a particular cabinet to get its tamper alert status</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cabinet Identifier</td>
<td>-</td>
<td>An identifier related to a specific cabinet on the roadside</td>
<td>Integer</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
## 4.8. CABINET TAMPER ALERT

Table 11: Cabinet Tamper Alert Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Cabinet Tamper Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Audio/Visual alert provided at the TCVMS when a cabinet has been tampered with. This alert indicates the location of the cabinet</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cabinet Tamper Alert</td>
<td>Audio/Visual</td>
<td>Alert provided at the TCVMS when a cabinet has been tampered with. This alert indicates the location of the cabinet</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.9. CABINET TAMPER STATUS

Table 12: Cabinet Tamper Status Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Cabinet Tamper Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
</tbody>
</table>
| Applicable Standards | N/A (User Interface) | • 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  

**Description:** Contains a value that indicates if a cabinet has been tampered with.

**Required Data**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
</table>
| Cabinet Tamper Status | -    | 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  

*Source: City of Columbus, ARC-IT*
4.10. **CAN BUS DATA**

Table 13: CAN Bus Data Communication Profile

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

Source: City of Columbus, ARC-IT

4.11. **CHANNEL CONGESTION PARAMETER**

Table 14: Channel Congestion Parameter Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Channel Congestion Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>A parameter, converted to a percentage, that channel utilization is compared against to determine if an alert should be issued.</td>
</tr>
<tr>
<td>Required Data</td>
<td>Name</td>
</tr>
<tr>
<td></td>
<td>Channel Congestion Parameter</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
4.12. MAPDATA

Table 15: MapData Message (SAE J2735) Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>MapData (MAP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2, Interface 5, Interface 7, Interface 12, Interface 13, Interface 14, Interface 15</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
</tbody>
</table>

- **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

*See Table 3 in Chapter 2 for the proposed DSRC channel map.*

**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.
<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>msgIssueRevision</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></td>
<td>intersections</td>
<td>IntersectionGeometryList</td>
<td>All intersection definitions. Consists of a list of IntersectionGeometry entries</td>
<td>SEQUENCE (SIZE(1...32)) OF IntersectionGeometry</td>
<td>SAE J2735_201603, Section 6.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IntersectionGeometry</td>
<td>Description of an intersection's roadway geometry and its allowed navigational paths</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.34</td>
</tr>
<tr>
<td></td>
<td>id</td>
<td>IntersectionReferenceID</td>
<td>conveys the combination of an optional RoadRegulatorID and of an IntersectionID that is unique within that region</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.36</td>
</tr>
<tr>
<td></td>
<td>id</td>
<td>IntersectionID</td>
<td>A unique mapping to the intersection in question within the above region of use</td>
<td>INTEGER (0..65535)</td>
<td>SAE J2735_201603, Section 7.56</td>
</tr>
<tr>
<td></td>
<td>revision</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></td>
<td>refPoint</td>
<td>Position3D</td>
<td>The reference from which subsequent data points are offset until a new point is used</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.87</td>
</tr>
<tr>
<td></td>
<td>lat</td>
<td>Latitude</td>
<td>The geographic latitude of an object, expressed in 1/10th integer microdegrees</td>
<td>INTEGER (-900000000...900000001)</td>
<td>SAE J2735_201603, Section 7.91</td>
</tr>
<tr>
<td>Field</td>
<td>Description</td>
<td>Type</td>
<td>Reference</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------------------------------</td>
<td>------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>long</td>
<td>Longitude</td>
<td>INTEGER (-1799999999...1800000001)</td>
<td>SAE J2735_201603, Section 7.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>laneWidth</td>
<td>LaneWidth</td>
<td>INTEGER (0...32767)</td>
<td>SAE J2735_201603, Section 7.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>laneSet</td>
<td>LaneList</td>
<td>SEQUENCE (SIZE(1...255)) OF GenericLane</td>
<td>SAE J2735_201603, Section 6.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GenericLane</td>
<td>Describes the basic attribute information of the lane</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>laneID</td>
<td>LaneID</td>
<td>INTEGER (0...255)</td>
<td>SAE J2735_201603, Section 7.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>maneuvers</td>
<td>AllowedManeuvers</td>
<td>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) }</td>
<td>SAE J2735_201603, Section 7.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xy</td>
<td>NodeListXY</td>
<td>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.</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.72</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>nodes</td>
<td>NodeSetXY</td>
<td>a lane made up of two or more XY node points and any attributes defined in those nodes</td>
<td>SEQUENCE (SIZE(2...63)) OF NodeXY</td>
<td>SAE J2735_201603, Section 6.77</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>NodeXY</td>
<td>data for a single node point in a path</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.78</td>
<td></td>
</tr>
<tr>
<td>Delta</td>
<td>NodeOffsetPointXY</td>
<td>Nodes are described in terms of X and Y offsets in units of 1 cm</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.75</td>
<td></td>
</tr>
<tr>
<td>Node-XY1</td>
<td></td>
<td>node is within 5.11 m of last node</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.61, 6.62, 6.63, 6.64, 6.65, 6.66</td>
<td></td>
</tr>
<tr>
<td>Node-XY2</td>
<td></td>
<td>node is within 10.23 m of last node</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Node-XY3</td>
<td></td>
<td>node is within 20.47 m of last node</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Node-XY4</td>
<td></td>
<td>node is within 40.96 m of last node</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Node-XY5</td>
<td></td>
<td>node is within 81.91 m of last node</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Node-XY6</td>
<td></td>
<td>node is within 327.67 m of last node</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(choice)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td>Offset-B10</td>
<td>(10,11,12,13,14,16)-bit delta offset in X, Y or Z</td>
<td>INTEGER (-512...511)</td>
<td>SAE J2735_201603, Section 7.118</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Offset-B11</td>
<td></td>
<td>INTEGER (-1024...1023)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Chapter 4. Message Content

<table>
<thead>
<tr>
<th>Description</th>
<th>Definition</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(corresponding to above choice)</td>
<td>Offset-B12, Offset-B13, Offset-B14, Offset-B16</td>
<td>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</td>
</tr>
<tr>
<td>y (corresponding to above choice)</td>
<td>Offset-B10, Offset-B11, Offset-B12, Offset-B13, Offset-B14, Offset-B16</td>
<td>(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</td>
</tr>
<tr>
<td>connectsTo</td>
<td>ConnectsToList</td>
<td>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</td>
</tr>
<tr>
<td>-</td>
<td>Connection</td>
<td>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</td>
</tr>
<tr>
<td>connectingLane</td>
<td>ConnectingLane</td>
<td>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</td>
</tr>
<tr>
<td>lane</td>
<td>LaneID</td>
<td>Index of the connecting lane. The unique ID number assigned to this lane object. INTEGER (0...255) SAE J2735_201603, Section 7.88</td>
</tr>
<tr>
<td>maneuver</td>
<td>AllowedManeuvers</td>
<td>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</td>
</tr>
<tr>
<td>Message</td>
<td>MapData (MAP)</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maneuverLeftTurnOnRedAllowed (4),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maneuverRightTurnOnRedAllowed (5),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maneuverLaneChangeAllowed (6),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>maneuverNoStoppingAllowed (7),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>yieldAlwaysRequired (8),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>goWithHalt (9),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>caution (10),</td>
<td></td>
</tr>
<tr>
<td></td>
<td>reserved1 (11)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>}</td>
<td></td>
</tr>
<tr>
<td>signalGroup</td>
<td>SignalGroupID</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The matching signal group send by the SPaT message for this lane/maneuver.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INTEGER (0...255)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAE J2735_201603, Section 7.171</td>
<td></td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.13. MISBEHAVIOR REPORT

#### Table 16: Misbehavior Report Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Misbehavior Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>Interface 12, Interface 13, Interface 14, Interface 15</td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th>Message</th>
<th>Network Communication Metadata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 7</td>
</tr>
</tbody>
</table>
| 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

<table>
<thead>
<tr>
<th>Message</th>
<th>Notification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 18</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>A visual notification provided to the Emergency Vehicle Operator that supports the Emergency Vehicle Preemption Application.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source: City of Columbus, ARC-IT</td>
<td>Signal Priority Granted Notification</td>
<td>Visual</td>
<td>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.</td>
<td>Not defined</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## 4.16. OBU PSEUDONYM CERTIFICATE

### Table 19: OBU Pseudonym Certificate Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>OBU Pseudonym Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
</tr>
</tbody>
</table>
| 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 |

### 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**

<table>
<thead>
<tr>
<th>Message</th>
<th>OBU Pseudonym Certificate Request</th>
<th>Interface 12, Interface 13, Interface 14, Interface 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
<td></td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>• Application Layer: IETF SNMP</td>
<td>• Application Layer: IETF HTTP</td>
</tr>
<tr>
<td></td>
<td>• Presentation Layer: ISO ASN.1 BER</td>
<td>• Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER</td>
</tr>
<tr>
<td></td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
<td>• Session Layer: IETF TLS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
<td>• Transport Layer: IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF Ip6</td>
<td>• Network Layer: IETF Ip6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
<td>• Data Link Layer: LLC and MAC Compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet)</td>
<td>• Physical Layer: IEEE 802.11p</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Message</th>
<th>OBU Start-Up Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 17</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
</tbody>
</table>

Description: Provides an indication that tells the LDV Operator the OBU status upon startup

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OBU Start Up Indication</td>
<td>-</td>
<td>An indicator that tells the LDV Operator the OBU status upon startup</td>
<td>Boot Successful, Boot Unsuccessful</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.19. OBU TAMPER ALERT

Table 22: OBU Tamper Alert Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>OBU Tamper Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Provides an audio/visual alert provided at the TCVMS when it has been detected that an OBU has been tampered with</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OBU Tamper Alert</td>
<td>-</td>
<td>Audio/visual alert provided at the TCVMS when it has been detected that an OBU has been tampered with</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
# 4.20. OBU TAMPER STATUS

## Table 23: OBU Tamper Status Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>OBU Tamper Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 7</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td></td>
</tr>
<tr>
<td>• ITS Application Information Layer: Undefined</td>
<td>• Application Layer: IETF HTTP</td>
</tr>
<tr>
<td>• Application Layer: HTTPS</td>
<td>• Presentation Layer: W3C XML, IETF GZIP, ISO ASN.1 DER</td>
</tr>
<tr>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
<td>• Session Layer: IETF TLS</td>
</tr>
<tr>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
<td>• Transport Layer: IETF TCP</td>
</tr>
<tr>
<td>• Network Layer: IETF IPv6</td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
<td>• Data Link Layer: LLC and MAC Compatible with Physical and Network</td>
</tr>
<tr>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul)</td>
<td>• Physical Layer: IEEE 802.11p</td>
</tr>
</tbody>
</table>

Description: Because this message is only sent when the OBU has been tampered with, the fact that tampering has occurred is inherent to this message.

### Required Data

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>OBU Identifier</td>
<td>-</td>
<td>Identifier that indicates the OBU that has been tampered with.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT

See Table 3 in Chapter 2 for the proposed DSRC channel map.
4.21. PENDING UPDATES

Table 24: Pending Updates Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Pending Updates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 17</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Provides an indication that tells the LDV Operator the percentage of an update that is has completed while it is being installed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Update Status Indication</td>
<td>Audio/Visual</td>
<td>An indicator that tells the LDV Operator the percentage of an update that is has completed while it is being installed.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT

4.22. PERFORMANCE MEASURE

Table 25: Performance Measure Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Performance Measure based on parameters specified in Performance Measure Parameters</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.23. PERFORMANCE MEASURE PARAMETERS

**Table 26: Performance Measure Parameters Communication Profile**

<table>
<thead>
<tr>
<th>Message</th>
<th>Performance Measure Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td><em>Code that allows Traffic CV Management Staff to query and process archived data to generate automated Performance Measures.</em></td>
</tr>
<tr>
<td>Required Data</td>
<td>TBD</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*

### 4.24. POWER STATUS

**Table 27: Power Status Communication Profile**

<table>
<thead>
<tr>
<th>Message</th>
<th>Power Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 17</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
<tr>
<td>Description</td>
<td><em>An indicator that tells the LDV Operator the power status of the OBU</em></td>
</tr>
<tr>
<td>Required Data</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
</tr>
<tr>
<td>Power Status</td>
<td>Audio/Visual</td>
</tr>
</tbody>
</table>

*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>
<thead>
<tr>
<th>Message</th>
<th>Radio Technical Commission for Maritime Services Corrections (RTCM) Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 12, Interface 13, Interface 14, Interface 15</td>
</tr>
</tbody>
</table>
| Applicable Standards | • 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  
| Description | 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. |
| Required Data |  |
| **Name** | **Type** | **Description** | **Values** | **Reference** |
| msgCnt | 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 |
| rev | RTCM-Revision | Specific revision of the RTCM standard which is being used | unknown (0), rtcmRev2 (1), rtcmRev3 (2), reserved (3) | SAE J2735_201603, Section 7.162 |
| msgs | RTCMmessageList | A list of RTCMmessage entries | SEQUENCE (SIZE(1..5)) OF RTCMmessage | SAE J2735_201603, Section 6.111 |
### Radio Technical Commission for Maritime Services Corrections (RTCM) Message

<table>
<thead>
<tr>
<th>Message</th>
<th>RTCMmessage</th>
<th>Stream of octets of the actual RTCM message: 1001 GPS L1 observations at 5 Hz 1005 Antenna Reference Point (ARP) coordinates at 2 Hz</th>
<th>OCTET STRING (SIZE(1...1023))</th>
<th>SAE J2735_201603, Section 7.163</th>
</tr>
</thead>
</table>

*Source: City of Columbus, ARC-IT*
### 4.26. REVOCATION LIST

Table 29: Revocation List Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Revocation List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
</tr>
</tbody>
</table>
| 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

<table>
<thead>
<tr>
<th>Message</th>
<th>Roadside Safety Message (RSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
</tbody>
</table>
| 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: IETF 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

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.
### Roadside Safety Message (RSM)

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

Source: City of Columbus, ARC-IT
### 4.28. RSU APPLICATION CERTIFICATE

Table 31: RSU Application Certificate Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Application Certificate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>• Application Layer: IETF SNMP</td>
</tr>
<tr>
<td></td>
<td>• Presentation Layer: ISO ASN.1 BER</td>
</tr>
<tr>
<td></td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet)</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2, IETF DTLS, IETF TLS</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Application Certificate Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 8</td>
</tr>
</tbody>
</table>
| 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

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Channel Congestion Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Channel Congestion Alert</td>
<td>-</td>
<td>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.</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
4.31. RSU LIMITED CONNECTIVITY ALERT

Table 34: RSU Limited Connectivity Alert Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Limited Connectivity Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>An indicator that alerts the Traffic CV Manager when the connection between the TCVMS and a particular RSU is limited or offline.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RSU Connectivity Alert</td>
<td>-</td>
<td>An indicator that alerts the Traffic CV Manager when the connection between the TCVMS and a particular RSU is limited or offline.</td>
<td>Limited Connectivity, No Connectivity (offline)</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
### 4.32. RSU STATUS

#### Table 35: RSU Status Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>Interface 7</td>
</tr>
<tr>
<td>N/A (Human-Machine Interface)</td>
<td>• ITS Application Information Layer: Undefined</td>
</tr>
<tr>
<td></td>
<td>• Application Layer: HTTPS</td>
</tr>
<tr>
<td></td>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul)</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td>
</tr>
</tbody>
</table>

#### 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSRC Channel Traffic/Utilization</td>
<td>-</td>
<td>An indicator provided to the Traffic CV Manager that indicates the current level of channel utilization detected by the RSU</td>
<td>0.00-100.00</td>
<td>-</td>
</tr>
<tr>
<td>Connectivity Uptime</td>
<td>-</td>
<td>An indicator provided to the Traffic CV Manager that indicates uptime of connectivity between the RSU and the TCVMS</td>
<td>0.00-100.00</td>
<td>-</td>
</tr>
<tr>
<td>Cabinet Tamper Status</td>
<td>-</td>
<td>An indicator provided to the Traffic CV Manager that indicates the 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: Tamper detection offline</td>
<td>-</td>
</tr>
<tr>
<td>Transmit Power</td>
<td></td>
<td>Measure of transmit power of the RSU. Units of dB</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.33. RSU STATUS QUERY

Table 36: RSU Status Query Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>RSU Status Query</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RSU Identifier</td>
<td>-</td>
<td>An identifier related to a specific RSU on the roadside</td>
<td>Integer</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.34. RTCM DATA

Table 37: RTCM Data (RTCM 10410.1) Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>RTCM Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applicable Standards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• ITS Application Information Layer: RTCM 10410.1</td>
<td></td>
</tr>
<tr>
<td>• Application Layer: HTTPS</td>
<td></td>
</tr>
<tr>
<td>• Session Layer: IETF TLS, IETF DTLS</td>
<td></td>
</tr>
<tr>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
<td></td>
</tr>
<tr>
<td>• Network Layer: IETF IPv6</td>
<td></td>
</tr>
<tr>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
<td></td>
</tr>
<tr>
<td>• Physical Layer: IEEE 802.3 (fiber-optic backhaul, Internet)</td>
<td></td>
</tr>
<tr>
<td>• Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1001</td>
<td>-</td>
<td>GPS L1 observations</td>
<td>-</td>
<td>RTCM 10410.1</td>
</tr>
<tr>
<td></td>
<td>1005</td>
<td>-</td>
<td>Antenna Reference Point (ARP) coordinates</td>
<td>-</td>
<td>RTCM 10410.1</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
4.35. **SCHOOL ZONE INDICATOR**

Table 38: School Zone Indicator Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>School Zone Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 11b</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A</td>
</tr>
<tr>
<td>Description</td>
<td>Low-Voltage signal that provides an indication regarding the state of a school zone flashing signal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>School Zone Indicator</td>
<td>Low-Voltage Signal</td>
<td>A low-voltage signal that indicates if the school zone flashing signal is active or not active.</td>
<td>0V – Flashing Lights not Active 24V – Flashing Lights Active</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: City of Columbus, ARC-IT
4.36. **SETTING ADJUSTMENT**

Table 39: Setting Adjustment Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Setting Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 17</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (Human-Machine Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>Allows the LDV Operator to change the following LDV OBU settings indicated in the required data.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brightness (if screen is used),</td>
<td>-</td>
<td>Indicates a brightness level</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Volume</td>
<td>-</td>
<td>Indicates volume level</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Text Size (if screen is used)</td>
<td>-</td>
<td>Indicates text size</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Contrast (if screen is used)</td>
<td>-</td>
<td>Indicates contrast level</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.37. SIGNAL PHASE AND TIMING

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

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Phase and Timing (SPaT)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applicable Interface(s)</strong></td>
<td>Interface 5</td>
</tr>
</tbody>
</table>
| **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)  
- 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 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>timeStamp</td>
<td>MinuteOfTheYear</td>
<td>Number of elapsed minutes of the current year in the time system being used (typically UTC time)</td>
<td>INTEGER (0...527040)</td>
<td>SAE J2735_201603, Section 7.100</td>
</tr>
<tr>
<td>intersections</td>
<td>IntersectionStateList</td>
<td>The IntersectionStateList data frame consists of a list of IntersectionState entries</td>
<td>SEQUENCE (SIZE(1...32)) OF</td>
<td>SAE J2735_201603, Section 6.38</td>
</tr>
<tr>
<td></td>
<td>IntersectionState</td>
<td>Convey all the SPaT information for a single intersection</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.37</td>
</tr>
<tr>
<td>id</td>
<td>IntersectionReferenceID</td>
<td>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</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.36</td>
</tr>
<tr>
<td></td>
<td>IntersectionID</td>
<td>The IntersectionID is used within a region to uniquely define an intersection within that country or region</td>
<td>INTEGER (0...65535)</td>
<td>SAE J2735_201603, Section 7.56</td>
</tr>
<tr>
<td>revision</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>status</td>
<td>IntersectionStatusObject</td>
<td>Contains Advanced Traffic Controller (ATC) status information that</td>
<td>BIT STRING {manualControlsEnabled (0), stopTimersActivated (1), failureFlash (2), preemptsActive (3), signalPriorityIs Active (4),</td>
<td>SAE J2735_201603, Section 7.57</td>
</tr>
</tbody>
</table>
### Chapter 4. Message Content

<table>
<thead>
<tr>
<th>timeStamp</th>
<th>Dsecond</th>
<th>The mSec point in the current UTC minute that this message was constructed. Represents the milliseconds within a minute. Units of milliseconds</th>
<th>INTEGER (0...65535)</th>
<th>SAE J2735_201603, Section 7.39</th>
</tr>
</thead>
<tbody>
<tr>
<td>states</td>
<td>MovementList</td>
<td>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.</td>
<td>SEQUENCE (SIZE(1...255)) OF MovementState</td>
<td>SAE J2735_201603, Section 6.52</td>
</tr>
<tr>
<td>signalGroup</td>
<td>SignalGroupID</td>
<td>Map to lists of lanes (and their descriptions) which this MovementState data applies to.</td>
<td>INTEGER (0...255)</td>
<td>SAE J2735_201603, Section 7.171</td>
</tr>
</tbody>
</table>

- 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), noValidMAPsAvailableAtThisTime (12), noValidSPATisAvailableAtThisTime (13)
## Chapter 4. Message Content

<table>
<thead>
<tr>
<th>state-time-speed</th>
<th>MovementEventList</th>
<th>Consists of a list of MovementEvent entries — sets of movement data with: a) SignalPhaseState, b) TimeChangeDetails, and c) AdvisorySpeeds.</th>
<th>SEQUENCE (SIZE(1...16)) OF MovementEvent</th>
<th>SAE J2735_201603, Section 6.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>MovementEvent</td>
<td>Details about a single movement</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.51</td>
</tr>
<tr>
<td>eventState</td>
<td>MovementPhaseState</td>
<td>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.</td>
<td>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)</td>
<td>SAE J2735_201603, Section 7.103</td>
</tr>
<tr>
<td>timing</td>
<td>TimeChangeDetails</td>
<td>Start and min/max end times of phase confidence and estimated next occurrence</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.134</td>
</tr>
<tr>
<td>minEndTime</td>
<td>TimeMark</td>
<td>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.</td>
<td>INTEGER (0...36001)</td>
<td>SAE J2735_201603, Section 7.194</td>
</tr>
<tr>
<td>maxEndTime</td>
<td>TimeMark</td>
<td>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.</td>
<td>INTEGER (0...36001)</td>
<td>SAE J2735_201603, Section 7.194</td>
</tr>
<tr>
<td>LikelyTime</td>
<td>TimeMark</td>
<td>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.</td>
<td>INTEGER (0…36001)</td>
<td>SAE J2735_201603, Section 7.194</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.38. SIGNAL PHASE AND TIMING DATA

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

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

Source: City of Columbus, ARC-IT
### 4.39. Signal Priority Authorization List

#### Table 42: Signal Priority Authorization List Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Priority Authorization List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
</tbody>
</table>
| Applicable Standards | N/A (User 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**: A list of priority authorizations which indicate which vehicles are authorized to receive priority, at which intersection, for which movements, at which times.

**Required Data**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</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.
- INTEGER

*Source: City of Columbus, ARC-IT*
4.40. SIGNAL REQUEST MESSAGE

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

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Request Message (SRM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 5</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>• Application Layer: HTTPS</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>SignalReqScheme</td>
<td>Name</td>
<td>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.</td>
<td>OCTET STRING (SIZE(1))&lt;br&gt;upper nibble: Preempt #:&lt;br&gt;– Bit 7 (MSB) 1 = Preempt and 0 = Priority</td>
<td>SAE J2735_201603, Section 7.172</td>
</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>requests</td>
<td>SignalRequestList</td>
<td>Request Data for one or more signalized intersections that support SRM dialogs. Consists of a list of SignalRequest entries.</td>
<td>SEQUENCE (SIZE(1...32)) OF SignalRequestPackage</td>
<td>SAE J2735_201603, Section 6.118</td>
</tr>
<tr>
<td>SignalRequestPackage</td>
<td></td>
<td>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.</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.123</td>
</tr>
<tr>
<td>request</td>
<td>SignalRequest</td>
<td>Used (as part of a request message) to request either a priority or a preemption service from a signalized intersection.</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.120</td>
</tr>
<tr>
<td>id</td>
<td>IntersectionReferenceID</td>
<td>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</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.36</td>
</tr>
<tr>
<td>id</td>
<td>IntersectionID</td>
<td>A unique mapping to the intersection in question within the above region of use</td>
<td>INTEGER (0...65535)</td>
<td>SAE J2735_201603, Section 7.56</td>
</tr>
<tr>
<td>requestID</td>
<td>RequestID</td>
<td>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</td>
<td>INTEGER (0..255)</td>
<td>SAE J2735_201603, Section 7.153</td>
</tr>
</tbody>
</table>
## Message Content

**CVE Interface Control Document – Final Report**

### Smart Columbus Program

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Request Message (SRM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>requestType</td>
<td>PriorityRequestType</td>
</tr>
<tr>
<td>inBoundLane</td>
<td>IntersectionAccessPoint</td>
</tr>
<tr>
<td>lane</td>
<td>LaneID</td>
</tr>
<tr>
<td>approach</td>
<td>ApproachID</td>
</tr>
<tr>
<td>connection</td>
<td>LaneConnectionID</td>
</tr>
<tr>
<td>requestor</td>
<td>RequestorDescription</td>
</tr>
<tr>
<td>id</td>
<td>VehicleID</td>
</tr>
<tr>
<td>entityID</td>
<td>TemporaryID</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.41. SIGNAL REQUEST MESSAGE DATA

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

<table>
<thead>
<tr>
<th>Message</th>
<th>SRM Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 11a</td>
</tr>
</tbody>
</table>
| 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>
<thead>
<tr>
<th>Message</th>
<th>Signal Status Message (SSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 5</td>
</tr>
</tbody>
</table>
| 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 |

Description

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.

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<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>
<td></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>
<td></td>
</tr>
</tbody>
</table>
## Message Content

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Status Message (SSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SignalStatus</strong></td>
<td>Provide the status of a single intersection to others, including any active preemption or priority state in effect.</td>
</tr>
<tr>
<td><strong>sequenceNumber</strong></td>
<td>A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.</td>
</tr>
<tr>
<td><strong>id</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>sigStatus</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>requestor</strong></td>
<td>Information regarding the entity that requested a given signal behavior.</td>
</tr>
<tr>
<td><strong>id</strong></td>
<td>The ID used in the BSM or CAM of the requestor. This ID is presumed not to change during the exchange.</td>
</tr>
<tr>
<td><strong>entityID</strong></td>
<td>Used as a means to identify the local vehicles that are interacting during an encounter.</td>
</tr>
<tr>
<td><strong>request</strong></td>
<td>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.</td>
</tr>
</tbody>
</table>

### SignalStatus

- **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.

### Sequence Number

- **MsgCount**: A sequence number within a stream of messages with the same DSRCmsgID and from the same sender.

### 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.

### 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.

### Requestor

- **SignalRequestorInfo**: Information regarding the entity that requested a given signal behavior.

### 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.
### Message Content

<table>
<thead>
<tr>
<th>Message</th>
<th>Signal Status Message (SSM)</th>
<th>Description</th>
<th>Data Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>sequenceNumber</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>inboundOn</td>
<td>IntersectionAccessPoint</td>
<td>Estimated lane / approach of vehicle. Specifies the index of either a single approach or a single lane at which a service is needed.</td>
<td>N/A (Data Frame)</td>
<td>SAE J2735_201603, Section 6.33</td>
</tr>
<tr>
<td>lane</td>
<td>LaneID</td>
<td>The unique ID number assigned to this lane object</td>
<td>INTEGER (0...255)</td>
<td>SAE J2735_201603, Section 7.88</td>
</tr>
<tr>
<td>approach</td>
<td>ApproachID</td>
<td>Used to relate the index of an approach, either ingress or egress within the subject lane</td>
<td>INTEGER (0...15)</td>
<td>SAE J2735_201603, Section 7.11</td>
</tr>
<tr>
<td>connection</td>
<td>LaneConnectionID</td>
<td>A connection index for a lane to lane connection</td>
<td>INTEGER (0...255)</td>
<td>SAE J2735_201603, Section 7.86</td>
</tr>
<tr>
<td>status</td>
<td>PrioritizationResponseStatus</td>
<td>Status of request, this may include rejection</td>
<td>ENUMERATED {unknown (0), requested (1), processing (2), watchOtherTraffic (3), granted (4), rejected (5), maxPresence (6), reserviceLocked (7)}</td>
<td>SAE J2735_201603, Section 7.140</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.43. SIGNAL STATUS MESSAGE DATA

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

<table>
<thead>
<tr>
<th>Message</th>
<th>SSM Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 11a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Applicable Standards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• ITS Application Information Layer: NTCIP 1202-ASC</td>
</tr>
<tr>
<td></td>
<td>• Presentation Layer: ISO ASN.1 UPER</td>
</tr>
<tr>
<td></td>
<td>• Transport Layer: IETF UDP, IETF TCP</td>
</tr>
<tr>
<td></td>
<td>• Network Layer: IETF IPv6</td>
</tr>
<tr>
<td></td>
<td>• Data Link Layer: LLC and MAC compatible with Physical and Network</td>
</tr>
<tr>
<td></td>
<td>• Physical Layer: IEEE 802.3 (local Ethernet)</td>
</tr>
<tr>
<td></td>
<td>• Security Plane: IEEE 1609.2</td>
</tr>
</tbody>
</table>

| 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

<table>
<thead>
<tr>
<th>Message</th>
<th>Time and Location Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 25, Interface 26, Interface 27, Interface 28, Interface 29</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>NMEA 0183 – serial interface for marine electronics devices including global positioning system (GPS)</td>
</tr>
<tr>
<td>Description</td>
<td>Contains data that are available via GPS for determining position, position accuracy, speed, and for time synchronization.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$GPGGA, Field 1</td>
<td>-</td>
<td>UTC of position fix</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 2</td>
<td>-</td>
<td>Latitude</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 3</td>
<td>-</td>
<td>Direction of latitude:</td>
<td>N: North, S: South</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 4</td>
<td>-</td>
<td>Longitude</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 5</td>
<td>-</td>
<td>Direction of longitude:</td>
<td>E: East, W: West</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 6</td>
<td>-</td>
<td>GPS Quality indicator:</td>
<td>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</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 7</td>
<td>-</td>
<td>Number of SVs in use, range from 00 through to 24+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$GPGGA, Field 8</td>
<td>-</td>
<td>HDOP</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### Time and Location Data

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

Source: City of Columbus, ARC-IT
### 4.45. TIME DATA

Table 48: Time Data Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Time Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 6, Interface 10</td>
</tr>
</tbody>
</table>

#### 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

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>-</td>
<td>Current time expressed in Universal Time Coordinated (UTC) format from a Stratum-2 time server</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### 4.46. TRANSIT VEHICLE INTERACTION EVENT DATA

Table 49: Transit Vehicle Interaction Event Data Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Transit Vehicle Interaction Event Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 3</td>
</tr>
</tbody>
</table>
| 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, IEEE 802.11  
  • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS | • 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 |

**Description**

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.

**Required Data**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<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>
<tr>
<td>Message</td>
<td>Transit Vehicle Interaction Event Data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSMs (received)</td>
<td>- A log of BSMs received from other vehicles -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BSMs (issued)</td>
<td>- A log of BSMs sent from the Transit Vehicle OBU -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPaT (received)</td>
<td>- A log of SPaT Messages received -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAP (received)</td>
<td>- A log of MAP Messages received -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRM (received)</td>
<td>- A log of SRMs received -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSM (received)</td>
<td>- A log of SSMs received -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSM (received)</td>
<td>- A log of RSMs received -</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Message</th>
<th>Transit Vehicle Interaction Event Data Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 1</td>
</tr>
</tbody>
</table>
| Applicable Standards | N/A (User 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, IEEE 802.11  
| | | • Security Plane: IEEE 1609.2, IETF TLS, IETF, DTLS |
| Description | 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. |
| Required Data | Name | Type | Description | Values | Reference |
| | Time prior to start of event | - | The amount of time before an event has occurred when log messages | Time (ms) | - |
| | Time after event has ended | - | The amount of time after an event has ended to log messages | Time (ms) | - |
| | Event Types | - | Specifies the types of events that trigger a Transit Vehicle Interaction Event | emergency braking ahead, forward collision imminent, intersection movement, blind spot, lane change, red light violation, school zone speed limit, priority request | - |

*Source: City of Columbus, ARC-IT*
4.48. **UNAUTHORIZED ACCESS ALERT**

Table 51: Unauthorized Access Alert Communication Profile

<table>
<thead>
<tr>
<th>Message</th>
<th>Unauthorized Access Alert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicable Interface(s)</td>
<td>Interface 2</td>
</tr>
<tr>
<td>Applicable Standards</td>
<td>N/A (User Interface)</td>
</tr>
<tr>
<td>Description</td>
<td>An indicator that alerts the Traffic CV Manager when an unauthorized device attempts to access the network.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required Data</th>
<th>Name</th>
<th>Type</th>
<th>Description</th>
<th>Values</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unauthorized Access Alert</td>
<td>Audio/Visual</td>
<td>An indicator that alerts the Traffic CV Manager when an unauthorized device attempts to access the network.</td>
<td>Alert</td>
<td>-</td>
</tr>
</tbody>
</table>

*Source: City of Columbus, ARC-IT*
### Table 52: Acronym List

<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPS</td>
<td>CV Applications</td>
</tr>
<tr>
<td>BSM</td>
<td>Basic Safety Message</td>
</tr>
<tr>
<td>BSW</td>
<td>Blind Spot Warning Application</td>
</tr>
<tr>
<td>CCTN</td>
<td>Columbus Connected Transportation Network</td>
</tr>
<tr>
<td>CEAV</td>
<td>Connected Electric Automated Vehicle (Smart Columbus Project #8)</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>ConOps</td>
<td>Concept of Operations</td>
</tr>
<tr>
<td>CORS</td>
<td>Continuously Operating Reference Station</td>
</tr>
<tr>
<td>COTA</td>
<td>Central Ohio Transit Authority</td>
</tr>
<tr>
<td>CTSS</td>
<td>Columbus Traffic Signal System</td>
</tr>
<tr>
<td>CV</td>
<td>Connected Vehicle</td>
</tr>
<tr>
<td>CVE</td>
<td>Connected Vehicle Environment (Smart Columbus Project #2)</td>
</tr>
<tr>
<td>CVRIA</td>
<td>Connected Vehicle Reference Implementation Architecture</td>
</tr>
<tr>
<td>DOT</td>
<td>(City of Columbus) Department of Technology</td>
</tr>
<tr>
<td>DPS</td>
<td>Columbus Department of Public Service</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communications</td>
</tr>
<tr>
<td>EEBL</td>
<td>Emergency Electronic Brake Light Application</td>
</tr>
<tr>
<td>EVP</td>
<td>Emergency Vehicle Preemption Application</td>
</tr>
<tr>
<td>FCW</td>
<td>Forward Collision Warning Application</td>
</tr>
<tr>
<td>FSP</td>
<td>Freight Signal Priority</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Navigation Satellite System</td>
</tr>
<tr>
<td>ICD</td>
<td>Interface Control Document</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>IMA</td>
<td>Intersection Movement Assist Application</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol address</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>LCW</td>
<td>Lane Change Warning Application</td>
</tr>
<tr>
<td>LED</td>
<td>Light-Emitting Diode</td>
</tr>
</tbody>
</table>
### 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
<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP</td>
<td>Traffic Signal Priority Applications</td>
</tr>
<tr>
<td>TVIER</td>
<td>Transit Vehicle Interaction Event Recording</td>
</tr>
<tr>
<td>USDOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>V2I</td>
<td>Vehicle-to-Infrastructure</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle-to-Vehicle</td>
</tr>
<tr>
<td>VDTO</td>
<td>Vehicle Data for Traffic Operations</td>
</tr>
</tbody>
</table>

Source: City of Columbus
## Appendix B. Glossary

Table 53: Glossary

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

*Source: City of Columbus*
## Appendix C. Version History

Table 54: Version History

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