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Minimum Requirements to Support Traffic Signal Priority and Preemption

RATIONALE

There is a strong interest in both the automotive and infrastructure owner operator communities to have support for traffic signal priority and preemption capability at connected signalized intersection locations nationwide in the early phases of deployment. To support nationwide deployment, common messages, message content, and requirements are needed to support interoperability between connected vehicles and connected intersections.

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1. SCOPE

When identifying the content of this report, one of the goals was that it supports a nationally interoperable method for connected vehicles (CVs) to make traffic signal priority and/or preemption (TSPP) requests of connected intersections (CIs) that support priority and/or preemption services. Given that, this report specifies the over-the-air (OTA) interface between CVs and CIs to support TSPP applications using updated revisions of the SAE J2735 Signal Request Message (SRM) and Signal Status Message (SSM) and the use of a Wireless Access in Vehicular Environments (WAVE) Service Advertisement (WSA) to advertise support for TSPP at a CI. Included are a concept of operations, requirements, design, and message structure definitions developed using a detailed systems engineering process.

NOTE 1: During the report development, the concept of the intelligence regarding the need for TSPP residing in the CV or the CI was discussed, e.g., a CV that can determine what it needs to support its current and/or future actions and can provide that information to the CI versus a CV that only provides information about its current actions and the CI determines what the CV needs. In general, the approach taken in this version of the report is of the latter where the CV just provides information to the CI about its current state and the CI makes all the preferential treatment decisions. When more information is available regarding a CV's ability to know what it needs regarding TSPP and what the data requirements are to provide that information to the CI, future revisions of this report may be made available to provide this functionality.

NOTE 2: Given that this is the initial version of this report, the possibility exists that items will be uncovered by early adopters that necessitate changes. Should those changes require a break in backward compatibility with this version of the report, a versioning mechanism has been put in place whereby an application will know which version of this report a message is associated with. See 8.1 for the details on how this versioning mechanism is intended to work.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of the publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 1-877-606-7323 (U.S. and Canada only) or 1-724-776-4970 (outside U.S. and Canada), www.sae.org.

SAE J2735	V2X Communications Message Set Dictionary
SAE J2945	Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts™
SAE J2945/1	On-Board System Requirements for V2V Safety Communications
SAE J2945/5	Service Specific Permissions and Security Guidelines for Connected Vehicle Applications
SAE J3161	LTE Vehicle-to-Everything (LTE-V2X) Deployment Profiles and Radio Parameters for Single Radio Channel Multi-Service Coexistence
SAE J3268	Listing of Provider Service Identifiers and Associated Application Technical Reports
SAE J3289	SAE V2X ASN.1 Modules - Organization and Management Rules

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

Please note that this report incorporates certain IEEE specifications by reference. ESSENTIAL IPRs (Intellectual Property Rights) have been declared to IEEE. All information statements and licensing declarations of ESSENTIAL IPRs received by IEEE are publicly available via the IEEE IPR Online Database found at <https://standards.ieee.org/about/sasb/patcom/patents/>.

IEEE Std 1609.2 IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Applications and Management Messages

IEEE Std 1609.3 IEEE Standard for Wireless Access in Vehicular Environments (WAVE) - Networking Services

2.1.3 Other Publications

ARC-IT Architecture Reference for Cooperative and Intelligent Transportation, United States Department of Transportation, Version 9.2

NTCIP 1202 National Transportation Communications for ITS Protocol Object Definitions for Actuated Signal Controllers (ASC) Interface; American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, National Electrical Manufacturers Association, Version v03B, 2023

NTCIP 1211 National Transportation Communications for ITS Protocol Object Definitions for Signal Control and Prioritization (SCP); American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, National Electrical Manufacturers Association, Version v02A, 2017

NTCIP 8002 Annex B1 National Transportation Communications for ITS Protocol Content Outline for NTCIP 1200-Series Documents (for Standards Engineering Process (SEP) Content); American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, National Electrical Manufacturers Association

3. DEFINITIONS

Cited below are the definitions that apply to this report.

ABSOLUTE LANE LEVEL POSITIONING: The ability/need for a CV to calculate its position such that it places itself in the lane it is driving.

ACTIVE: The status of a TSPP request that has been accepted by the CI and the CI is taking actions to accommodate, either within the current timing for the requested lane, or by the CI altering its traffic signal phase timings for the requested lane.

NOTE: This term refers to the status of the TSPP request rather than the state for a traffic signal indication. That is, an indication of Active does not ensure that the CV will get a green indication simultaneous with the response. Rather, accommodating the request may be done by providing a longer green or an early green. An early green would mean that the CV may need to stop but not for as long as it otherwise would have.

CONNECTED INTERSECTION: An intersection component or set of components that communicates with external entities using a wireless interface. Examples of wireless interfaces include cellular networks, Wi-Fi networks, and V2X communications.

CONNECTED VEHICLE: A vehicle that communicates with external entities using a wireless interface. Examples of wireless interfaces include cellular networks, Wi-Fi networks, and V2X communications.

CONNECTED VEHICLE TRAFFIC SIGNAL PRIORITY AND PREEMPTION TRANSACTION PERIOD: On a CV, for a given CI TSPP request, the period bounded by the initial TSPP request transmission to the CI system, to either (1) after transmitting a TSPP request cancel transmission to the CI system, the reception of a TSPP request status from the CI system with the request no longer present in the request status, (2) in lieu of number one, after transmitting the last TSPP request cancel to the CI system (for a given request, multiple request cancel transmissions may be sent), or (3) the reception of a TSPP request status from the CI system indicating that the CV TSPP request has been rejected.

EXTERNAL SYSTEM INTERFACE: An interface for the transmission and/or reception of information to and/or from outside the system.

NOTE: The primary systems addressed in this report are the CV and CI systems. See 5.3 for a description of these systems and their external interfaces.

MAPPED AREA: The full extent of the lane geometry defined by the MAP message.

ON-BOARD EQUIPMENT: Refer to the 'Glossary' in ARC-IT (see 2.1.3).

PREEMPTION: Refer to NTCIP 1202 (see 2.1.3).

PREFERENTIAL TREATMENT: A CV being provided with priority or preemption services at a CI.

NOTE: It is up to the CI implementation to determine whether to accept a TSPP request and, if accepted, whether priority or preemption service will be provided and what strategy will be used to implement in responding to the request. A TSPP request by a CV does not necessarily mean that a CI can or will grant the request.

PRIORITY: Refer to NTCIP 1211 (see 2.1.3).

QUEUED: The status of a TSPP request that cannot be immediately activated, given the current or planned traffic signal phase timings, but will be placed in a queue for future consideration within the request and/or system timing.

ROLE: The high-level categorization regarding the purpose a vehicle is assigned or serves. For example, a public safety vehicle, a transit vehicle, a road maintenance vehicle, a freight vehicle.

NOTE: The vehicle role for a CV is expected to be fixed and not change over time.

REJECTED: The status of a TSPP request that will not be or will no longer be considered for activation.

SUBROLE: Within a given role, the lower-level categorization regarding the purpose a vehicle is assigned or serves. For example, a police vehicle for a vehicle that has a role of public safety vehicle, or a local bus for a vehicle that has a role of transit vehicle.

NOTE: Depending on the role (e.g., transit vehicle), the subrole may need to be selected in consultation with the CI authority.

TSPP REQUEST: A request by a CV for preferential treatment at a CI.

VEHICLE AUTHORITY ID SUPPORT LIST: A list of one or more vehicle authority IDs that will be considered by the CI system when considering TSPP requests. This may be just a single ID consistent with the CI road authority ID.

4. ABBREVIATIONS

Cited below are the abbreviations that are used in this report.

AASHTO	American Association of State Highway and Transportation Officials
ARC-IT	Architecture Reference for Cooperative and Intelligent Transportation
APDU	Application Protocol Data Unit
BSM	Basic Safety Message
CHC	Choice
CI	Connected Intersection (see Section 3 for a definition)
CO	Coordinator
CRL	Certificate Revocation List
CV	Connected Vehicle (see Section 3 for a definition)
CV-TSPP-TP	Connected Vehicle Traffic Signal Priority and Preemption Transaction Period (see Section 3 for a definition)
DE	Data Element
EC	Elliptic Curve
ETA	Estimated Time of Arrival
EXT	Extension
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IOO	Infrastructure Owner Operator
IPR	Intellectual Property Right
ISO	International Organization for Standardization
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
LLE	Latitude, Longitude, and Elevation
LTE	Long Term Evolution
MA	Misbehavior Authority

NEMA	National Electrical Manufacturers Association
NTCIP	National Transportation Communications for ITS Protocol
NRTM	Needs to Requirements Traceability Matrix
1PPS	One Pulse per Second
OBE	On-Board Equipment (see Section 3 for a definition)
OID	Object Identifier
OTA	Over-the-Air
PDU	Protocol Data Unit
PRG	Priority Request Generator
PRS	Priority Request Server
PSID	Provider Service Identifier
RAID	Road Authority ID
RGA	Road Geometry and Attributes
RLVW	Red Light Violation Warning
RTM	Requirements Traceability Matrix
Rx	Receive
SCMS	Security Credential Management System
SEQ	Sequence
SPaT	Signal Phase and Timing
SPDU	Security Services Protocol Data Unit
SRM	Signal Request Message
SSM	Signal Status Message
SSP	Service Specific Permissions
TSPP	Traffic Signal Priority and/or Preemption
Tx	Transmit
UPER	Unaligned Packed Encoding Rules
UTC	Coordinated Universal Time

V2I	Vehicle-to-Infrastructure
V2X	Vehicle-to-Everything
VAID	Vehicle Authority ID
WAVE	Wireless Access in Vehicular Environments
WGS	World Geodetic System
WSA	WAVE Service Advertisement
WSM	WAVE Short Message

5. CONCEPT OF OPERATIONS

5.1 Tutorial [Informative]

A concept of operations describes a proposed system from the users' perspective. Typically, a concept of operations is used on a project to enable the system developers to understand the users' needs. Within application reports, the concept of operations documents the purpose of each feature for which an application report supports an application. The concept of operations also serves as the starting point for users to select those features that may be appropriate for a specific application.

The concept of operations starts with a discussion of the current situation and issues that have led to the need to deploy systems within the scope of a report and to the development of the report itself. This discussion permits both potential users and system developers to understand the situation.

The concept of operations then documents key aspects of the proposed system, including:

- a. Reference architecture: The reference architecture defines the overall context of the proposed system and defines which specific interfaces are addressed.
- b. Architectural needs: The architectural needs discuss issues and needs related to the system architecture.
- c. Features: The features identify and describe the various functions that users may want a system to perform. These features are derived from the high-level user needs identified in the problem statement but are refined and organized into a more manageable structure that forms the basis of the traceability tables contained in 6.1.3.3 and Appendix A.

Architectural needs and features are collectively called user needs. In Section 6, these user needs lead to the definition of the various functional requirements of a system. Basic systems engineering requires that:

- a. Each user need traces to one or more functional requirements.
- b. Each functional requirement derives from at least one user need.

This traceability is shown in the needs to requirements traceability matrix (NRTM) in 6.1.3.3. Within the NRTM, each user need and requirement is identified as mandatory, optional, or conditional, and users may complete the NRTM to clearly define unique aspects of their implementation. Items marked mandatory are those that relate to the most basic functionality for the application. For specific implementations, the user identifies those optional or conditional needs appropriate for a specific implementation.

Each requirement is presented in the requirements traceability matrix (RTM) in Appendix A, which defines how the requirement is fulfilled through the standardized dialogs and data element definitions provided in 7.3 and Section 8, respectively.

A conformant system may support other user needs, if they are conformant with the requirements of this report and the standards it references.

5.2 Current Situation and Problem Statement [Informative]

Many of the TSPP systems deployed today are either using sensor-based technology or a variety of communications-based technologies. Depending on the system implementation, the data needs and/or the assignment of application functionality across the system may differ from one implementation to the next. This diversity in system implementations limits the ability for these systems to be interoperable which is desired per the Rationale of this report.

To address this, the applications addressed in this report require the use of common messages. To support interoperability among independent implementations of these messages, minimum requirements regarding the message content are provided. In doing so, the ambiguity regarding data elements that need to be included, should not be included, or are optional, when considering the applications intended to be supported by the messages is removed.

5.3 Reference Functional Architecture

Given the diversity in the physical components used for TSPP and the partitioning of the TSPP functionality across those components, both within the CI and the CV, the architecture presented in this report (see Figure 1) should be considered a functional one rather than a physical one. Also, there may be mechanisms available for a CI to receive a TSPP request or a CV to receive an TSPP request status other than direct CV to CI or CI to CV (e.g., cellular); however, for the purposes of this report the communications link between the CI and the CV is shown as a direct one.

The functional architecture shown in Figure 1 is partitioned into a CI System and a CV System, with subsystems provided for each. Also shown is the Security Credential Management System (SCMS). The CI and CV subsystems shown in Figure 1 are selected to consolidate and compartmentalize the TSPP functionality. However, the subsystems, as well as the functions assigned to a subsystem within this report, may reside in a different subsystem or component in a deployed system implementation. The important thing is not so much the subsystem but the functionality that needs to be supported by an implementation.

NOTE: While the CI and the CV may have subsystems which have the same name (e.g., Traffic Signal Priority/Preemption Subsystem), the functionality represented by the subsystem may be different to support the needs of the CI or CV.

Within the architecture, there are aspects of subsystems and interfaces that are covered by and are in the scope of this report. Also, there are supporting entities, subsystems, and interfaces which support functionality covered within the scope of this report but are outside the scope of this report. At the bottom of Figure 1 is a legend which provides the nomenclature used in the figure for indicating this. Also shown is a purple highlighted box which shows that the primary focus of this report is the communications interface between the CI and CV Systems.

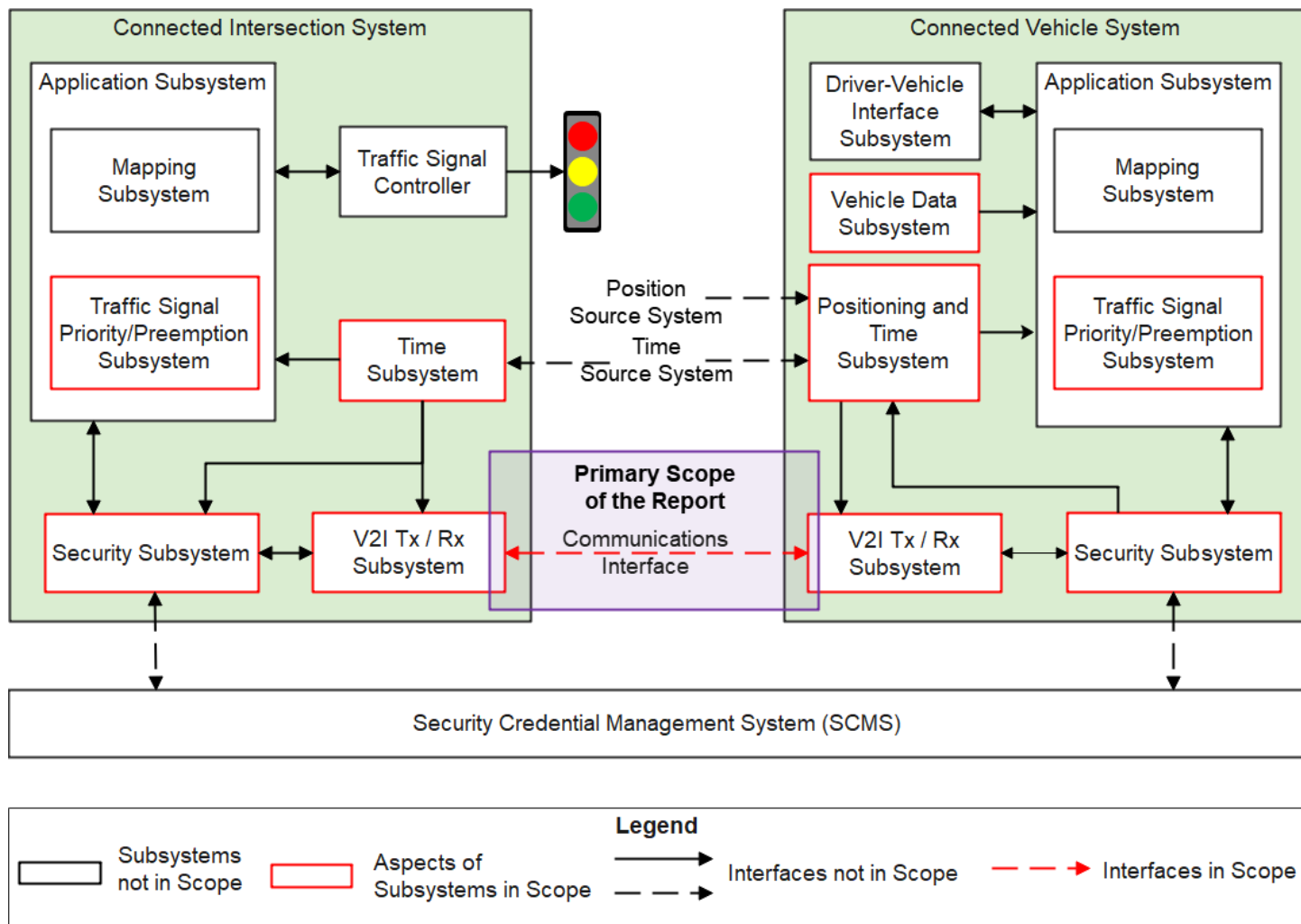


Figure 1 - Reference functional architecture

NOTE: Figure 1 does not contain a subsystem for the CI to provide or the CV to use positioning corrections even though at some CI, absolute lane level positioning may be required for a CV to provide the correct lane ID for the lane it is driving in. There are several ways this can be supported by a CV (e.g., position corrections provided by the CI, proprietary position correction solutions, dead-reckoning and other vehicle systems). However, whether the CI provides position corrections is expected to be determined by the application specification which addresses the MAP requirements for the MAP message broadcast by the CI. Given this, the method for a CV to support absolute lane level positioning and the conditions under which a CI provides position corrections information is outside the scope of this report.

5.3.1 Connected Intersection Functional Components

The CI System is comprised of the application subsystem in addition to subsystems required to support the applications. These include the traffic signal controller, time, security, and vehicle-to-infrastructure (V2I) transmit (Tx)/receive (Rx) subsystems. All of these are discussed in this section.

5.3.1.1 Application Subsystem

The Application Subsystem includes the following:

- Mapping Subsystem - Generates the mapped area message content which is used by CVs to determine the lane they are in and potentially attributes of the lane. This subsystem is outside the scope of this report; however, it is required to support the functionality of this report.
- Traffic Signal Priority/Preemption Subsystem - Processes the TSPP requests sent by CVs and, depending on several factors, determines and provides to the CVs the status of the TSPP requests. It also interfaces with the Traffic Signal Controller, should a change to the signal phase and timing be needed. The aspects of this subsystem necessary to support the communications interface requirements are in the scope of this report. However, the aspects of determining whether a TSPP request will be considered, prioritizing requests, interfacing with the signal controller, etc., are specific to the implementation and outside the scope of this report.

5.3.1.2 Traffic Signal Controller

The Traffic Signal Controller controls functions such as traffic signal phasing patterns, traffic coordination, pedestrian service, etc. It interfaces with the Traffic Signal Priority/Preemption Subsystem for processing TSPP requests and determining implementation specific actions and responses. The Traffic Signal Controller is outside the scope of this report; however, it is required to support the functionality of this report.

5.3.1.3 Time Subsystem

The Time Subsystem obtains system specific time information from a time data source system to be used by other subsystems. Aspects of this subsystem are in the scope of this report.

NOTE: While Figure 1 appears to show the same time source for the CI and CV, the CI time source system may be different than the CV one. What is important is that the system used enables the CV to meet the time requirements of the report.

5.3.1.4 Security Subsystem

The Security Subsystem performs the required security tasks including signing messages with the appropriate credentials obtained from the SCMS, verifying received messages, and ensuring that the security profiles are adhered to. This subsystem is required to support the functionality of this report, and aspects are in the scope of this report.

5.3.1.5 V2I Tx/Rx Subsystem

The V2I Tx/Rx Subsystem transmits the message content generated by the CI subsystems and receives the TSPP messages transmitted by the CVs to be used by the CI subsystems. This subsystem is required to support the formatting and delivery of the message and is in the scope of this report; however, the technology used to transmit and receive the data is outside the scope of this report.

5.3.2 Connected Vehicle Functional Components

The CV system is comprised of nearly the same subsystems as the CI as well as a couple of additional vehicle specific subsystems, all of which are discussed in this section.

5.3.2.1 Application Subsystem

The Application Subsystem includes the following:

- Mapping Subsystem - Processes the mapped area message content to determine select map-related information to include in the TSPP request. This subsystem is outside the scope of this report; however, the data that is to be provided by it is in scope.
- Traffic Signal Priority/Preemption Subsystem - Generates the TSPP requests to be sent to the CI and processes the CI TSPP status responses for these requests. The aspects of this subsystem necessary to support the communications interface requirements are in the scope of this report. However, the aspects of determining when to initiate a TSPP request, interfacing with the Driver-Vehicle Interface Subsystem, etc., are specific to the implementation and outside the scope of this report.

5.3.2.2 Positioning and Time Subsystem

The CV Positioning and Time Subsystem obtains system specific positioning and time information from a position/time data source system, respectively, both to be used by other subsystems. The position and time data may be from the same source but do not have to be. Aspects of this subsystem are in the scope of this report.

NOTE: While Figure 1 appears to show the same time source for the CI and CV, the CV time source system may be different than the CI one. What is important is that the system used enables the CV to meet the time requirements of the report.

5.3.2.3 Security Subsystem

The Security Subsystem provides the same functionality as in the CI. This subsystem is required to support the functionality of this report, and aspects are in the scope of this report.

5.3.2.4 V2I Tx/Rx Subsystem

The V2I Tx/Rx Subsystem provides the same functionality as in the CI. In general, where the CI is receiving or generating messages, the CV is generating or receiving them, respectively. Like the CI, the technology used to transmit and receive the data is outside the scope of this report.

5.3.2.5 Vehicle Data Subsystem

The Vehicle Data Subsystem provides some of the vehicle-specific data required to populate the TSPP request messages. The method for obtaining vehicle data from the internal vehicle systems is outside the scope of this report; however, the data that is to be provided by it is in scope.

5.3.2.6 Driver-Vehicle Interface

The Driver-Vehicle Interface Subsystem, if supported, provides information to the driver of the CV depending on the application set supported. This subsystem is outside the scope of this report.

5.3.3 Security Credential Management System (SCMS)

The SCMS provides certificates for signing the messages. The SCMS is outside the scope of this report; however, the security profiles and aspects regarding the use of the certificates are within scope.

5.4 Architectural Needs

The primary scope of this report is on the data exchange between the CI and CV to support the TSPP functionality. This section provides the external system interfaces that need to be supported by an architecture to support this data exchange.

5.4.1 Connected Intersection Connected Vehicle Interface

The CI and CV need to support an interface for the delivery and receipt of the message information.

5.4.2 Position Interface

The CV needs to support an interface to obtain system specific position information.

5.4.3 Time Interface

The CI and CV need to support an interface, which may be different, to obtain system specific time information.

5.4.4 SCMS Interface

The CI and CV need to support an interface, which may be different, to the SCMS to ensure that the required aspects of the security system, which rely on interactions with the SCMS, can be supported.

5.5 Features

This section provides the user needs for the TSPP feature which is the only feature supported by this report.

5.5.1 TSPP Feature User Needs

This section contains the user needs to support the TSPP feature to the extent it is addressed in the scope of this report (see Section 1).

NOTE: Some of the user needs apply to both the CV and the CI. For those user needs the CI and CV are both mentioned; however, they may have different requirements (called out in the requirements section) for fulfilling those user needs.

5.5.1.1 Request for TSPP

A CV needs to be able to request TSPP for a CI location, to, for example, maintain schedules, reduce stop times, improve traffic flow or, during special events, enable the CV to make a timely response to the event while reducing the potential for crashes and thus maintaining public safety during the event response. Examples include:

- A connected transit bus maintaining its schedule, resulting in decreased travel times, increasing the quality of service, and reducing fuel consumption and emissions from fewer stops.
- A connected freight vehicle not having to stop, thereby reducing the slow starts which can lead to backed up traffic conditions, increased fuel consumption, and increased emissions.
- A connected public safety vehicle responding to an emergency, thereby reducing the potential for accidents at a CI.
- A connected snowplow which has its blade down clearing snow, avoiding stops at traffic signals so that the plow can continue clearing snow effectively and reduce the total route time enabling clearing the roads of snow and ice sooner for improved safety.

5.5.1.2 Intersection TSPP Capability

The CV needs to know if a CI supports TSPP so it does not make requests to CI which will not be able to respond to the request thereby conserving bandwidth for services which are supported.

5.5.1.3 Vehicle Information

The CI needs information about the CV making a TSPP request to aid it in making an appropriate response to the request and to aid it in prioritizing one request versus another should that be supported by the CI. Examples include:

- Information about the role/subrole of CV to aid in determining what sort of preferential treatment may be supported and to prioritize one CV role/subrole versus another, should that be supported.
- Information about the equipment state (e.g., snowplow blade state, public safety lights or siren state, transit loading state) to determine what sort of preferential treatment may be needed.
- Information about the vehicle location, dynamics, time, etc., to determine what sort of signal timing may need to be accommodated.

5.5.1.4 Request Status

A CV needs to know the status of its TSPP request so it can react appropriately depending on whether the request will be activated or not. For example, a connected public safety vehicle responding to an emergency has not been granted a TSPP request, so it must take extra precautions to ensure all cross traffic has come to a stop before traversing a CI on a red light.

5.5.1.5 Request Need

The CI needs to know if a request is still needed or not so it can plan for other requests, should there be any, and manage the traffic signal timing appropriately.

5.5.1.6 Vehicle Differentiation

The CI needs to be able to differentiate between CVs making requests to support, for example, handling concurrent TSPP requests. For example, during an emergency event, multiple connected public safety vehicles may respond to the event. Depending on where the CVs are dispatched, some of the CVs could make requests of the same signalized location during the same period on their way to the location of the event.

5.5.1.7 Advanced Request Notice

A CI needs a CV to be able to provide a TSPP request with sufficient timing so that the CI has time to consider the request and select the best option for serving the request should it choose to do so.

NOTE 1: The timing needed may be different depending on the preferential treatment considered for the request. If so, assuming the request was received early enough, the CI could apply different time range filtering depending on if priority or preemption would be considered for the request.

NOTE 2: The timing of when a CV can make a TSPP request may be influenced by the lane distance provided in the mapped area (e.g., a MAP message). Some mapped areas may have lanes defined only to the distance needed to support the Red Light Violation Warning (RLVW) application. Those distances may be shorter than what is desired to support the timing needs of TSPP requests. During the development of this report, some methods were discussed for providing coarse mapped area data to extend the mapped area beyond the RLVW-only mapped distances. However, given that the mapped area data can be extended to support TSPP desired distances should they be different than the RLVW ones, this effort was not pursued. If it is determined that extending the mapped area data to ranges sufficient to support TSPP is problematic, a future revision of this report can address this.

5.5.1.8 Feature Authorization

The CI needs to know that CVs requesting TSPP and the CVs need to know that CI indicating TSPP request status are authorized to do so to maintain the integrity and usefulness of the feature.

NOTE: This user need is in addition to the security authorization user need (see 5.6.1) because there may be considerations beyond security authorization that need to be considered regarding whether a request should be made or a response will be accepted (e.g., have certain request/response criteria been met).

5.5.1.9 CV and CI Interoperability

The CI and CV need an interoperable system interface so that the CI and the CV systems can have confidence in what information will be provided and the meaning of that information, regardless of the device sourcing the information. Examples include providing a uniform representation of the minimum message elements used to convey the information, using common reference systems such as positioning and time, and providing timely notifications of changes to message information.

5.5.1.10 Other Message Interoperability

The CV and CI need a message design that supports compatibility with the mapped area data to avoid having to develop a new method for indicating mapped area related information. For example, lane identification.

5.6 Security Needs

The general security needs are described in this section. These security needs are necessary to protect the messages from attacks.

NOTE: Many of the security needs apply to both the CV and the CI. For those user needs the CI and CV are both mentioned; however, they may have different requirements (called out in the requirements section) for fulfilling those user needs.

5.6.1 Data Source Authenticity and Authorization

The CV and CI need a mechanism which enables them to authenticate sources of data and verify that those sources are authorized to send such data to enable them to trust the system sourcing the data.

NOTE: The term “authenticate(d) sources” encompasses not only the authorization of the transmitting device itself to participate in the vehicle-to-everything (V2X) ecosystem, but also its authority to transmit messages on behalf of its associated road authority or vehicle authority.

5.6.2 Data Integrity and Availability

The CV and CI need a mechanism which enables them to verify that data has not been changed or significantly delayed between the entity that produced the data and themselves, as consumers of the data, to enable them to trust the data they are receiving.

NOTE: A critical security assumption is that data inputs to or within the CI and CV from external elements are authentic and accurate.

5.6.3 User Privacy

While participation in the system is assumed to be optional, a CV making TSPP requests needs a mechanism which enables it to maintain its privacy should it need to do so, for example, to reduce the ability of other entities to track a CV (e.g., a public safety vehicle) via TSPP requests.

NOTE: There are no user needs to protect the privacy of a CI which supports TSPP.

5.6.4 Misbehavior Detection [Informative]

The SCMS needs the CV and CI to support the detection of misbehaving transmissions and, if any are identified, report them to a misbehavior authority (MA) for investigation and possible revocation so that misbehaving entities can be removed from the V2X ecosystem. Misbehavior, in the context of the messages considered for this report and the applications they are intended to support, is described further in Appendix D.

5.7 Operational Policies and Constraints

There is no standardized operational policy across the United States that defines the policy or process for defining, generating, distributing, and/or processing TSPP information. The policy for doing so is governed by regulatory guidelines or policies for the infrastructure owner operator (IOO) and state and local ordinances, policies, and procedures. These ordinances, policies, and procedures can vary from state to state and, within a state, IOO to IOO. This report attempts to employ industry standards, where they exist, in defining:

- The relevant information of the TSPP supporting messages.
- A common format for providing information.
- A common set of definitions and requirements regarding the information.

However, even in doing so, there may still be differences in how the content of this report is applied.

5.8 Relationship to the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) [Informative]

NOTE: The italicized text along with the ARC-IT service package, source object, flow, and destination object naming used throughout 5.8 are reprinted from the ARC-IT reference (see 2.1.3).

“The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) provides a common framework for planning, defining, and integrating Intelligent Transportation Systems.” It considers the Intelligent Transportation Systems (ITS) Architecture from four different views: Enterprise, Functional, Physical, and Communications. This report considers ARC-IT from the Physical View. The Physical View represents the major classes of the ITS Architecture, including the Support, Center, Field, Personal, and Vehicle classes. *“The information exchanges in the Physical View are identified by Triples that include the source and destination Physical Objects and the Information Flow that is exchanged.”*

In ARC-IT, *“Service Packages represent slices of the Physical View that address specific services.”* The ARC-IT service packages that are represented by this report for TSPP include the following along with a description taken directly from ARC-IT:

- PS03 - Emergency Vehicle Preemption
- CVO06 - Freight Signal Priority
- MC11 - Maintenance and Construction Signal Priority
- PT09 - Transit Signal Priority

Within these service packages there are many physical objects and flows (i.e., Triples). Table 1 provides those which are relevant to the scope of this report.

Table 1 - Signal control and prioritization feature group mapping to ARC-IT physical view components

J2945/B Feature Group	ARC-IT Service Packages	ARC-IT Triples		
		Source Object	Flow	Destination Object
Traffic Signal Priority and Preemption	PS03: Emergency Vehicle Preemption	Emergency Vehicle OBE NOTE: On-Board Equipment (OBE)	local signal preemption request	Connected Vehicle Roadside Equipment
			vehicle location and motion	
		Connected Vehicle Roadside Equipment	signal priority status	Emergency Vehicle OBE
			intersection status	
			intersection geometry	
	CVO06: Freight Signal Priority	Commercial Vehicle OBE	local signal priority request	Connected Vehicle Roadside Equipment
			vehicle location and motion	
		Connected Vehicle Roadside Equipment	signal priority status	Commercial Vehicle OBE
			intersection status	
			intersection geometry	
	MC11: Maintenance and Construction Signal Priority	Maint and Constr Vehicle OBE	local signal priority request	Connected Vehicle Roadside Equipment
			vehicle location and motion	
		Connected Vehicle Roadside Equipment	signal priority status	Maint and Constr Vehicle OBE
			intersection status	
			intersection geometry	
	PT09: Transit Signal Priority	Transit Vehicle OBE	local signal priority request	Connected Vehicle Roadside Equipment
			vehicle location and motion	
		Connected Vehicle Roadside Equipment	signal priority status	Transit Vehicle OBE
			intersection status	
			intersection geometry	

NOTE: While the ARC-IT has flows for a CV to request priority versus preemption, for the TSPP service defined by this report, the CV just provides a TSPP request, and the CI makes the determination if a priority or preemption preferential treatment will be considered for that CV.

NOTE: The italicized text along with the ARC-IT service package, source object, flow, and destination object naming used throughout 5.8 are reprinted from the ARC-IT reference (see 2.1.3).

Figure 2 provides an illustration of the ARC-IT service package physical objects, the functional objects within them, along with the information flows provided in Table 1. It also includes an additional physical object, 'ITS Roadway Equipment,' and the flows to and from it which are outside the scope of this report. These are included in the figure to provide additional context to the feature and to be consistent with the content of Figure 1.

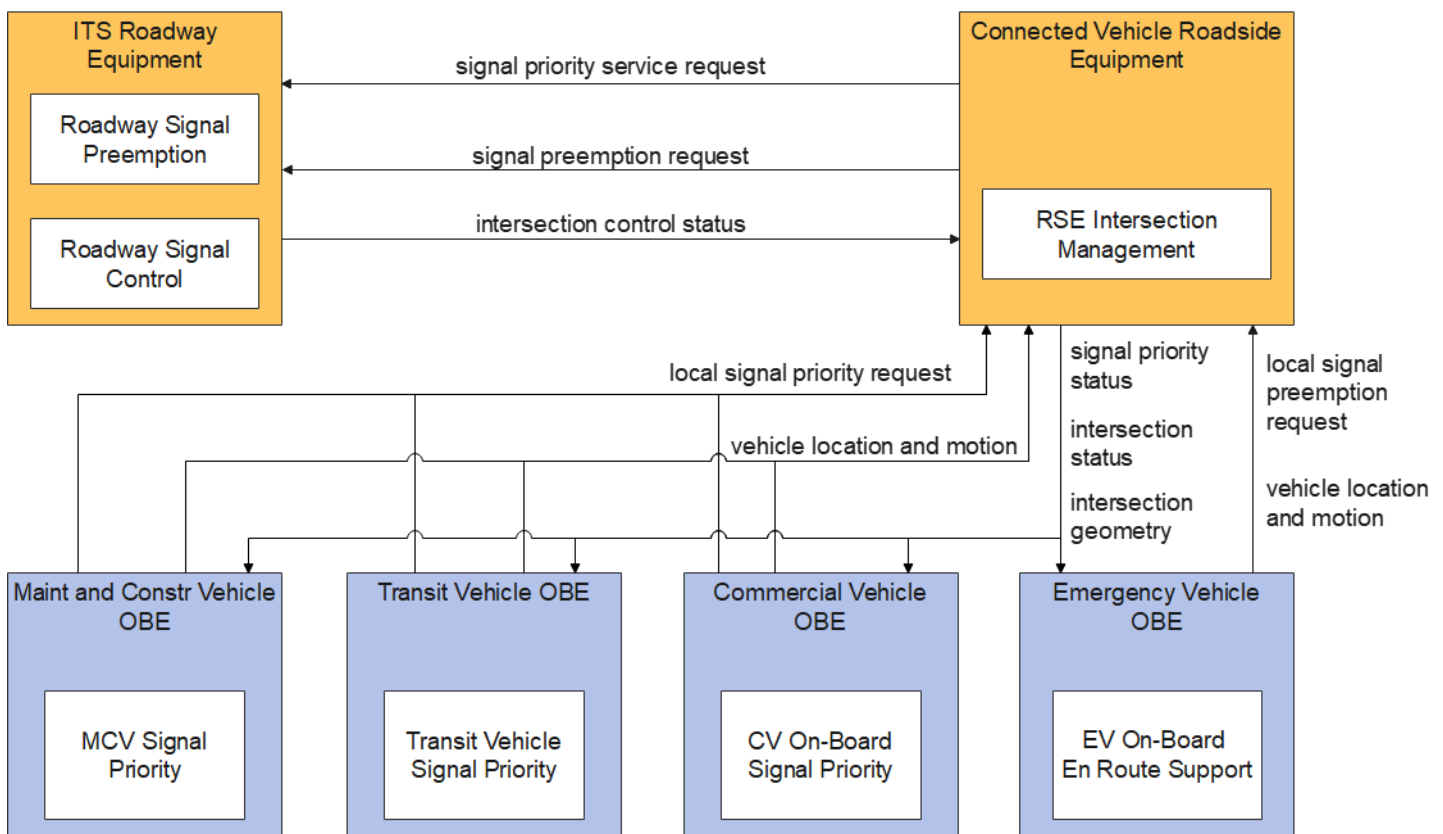


Figure 2 - Signal control and prioritization feature ARC-IT objects and data flows

5.9 Operational Scenarios [Informative]

The operational scenarios included in this section encapsulate some of the key aspects of the TSPP user needs provided in 5.5 that need to be supported. The operational scenarios do not imply any specific requirements or design. They are examples that consider some of the higher-level items, constraints, and preconditions that may need to be considered for a particular scenario but do not go into all the complexities of TSPP, such as making sure conflicting phases, pedestrian crossings, or queues are cleared, route planning needs, etc. Across the scenarios, the same base intersection geometry is used; however, it is expected the messages covered in this report will support all the relevant road geometries for CI that support TSPP.

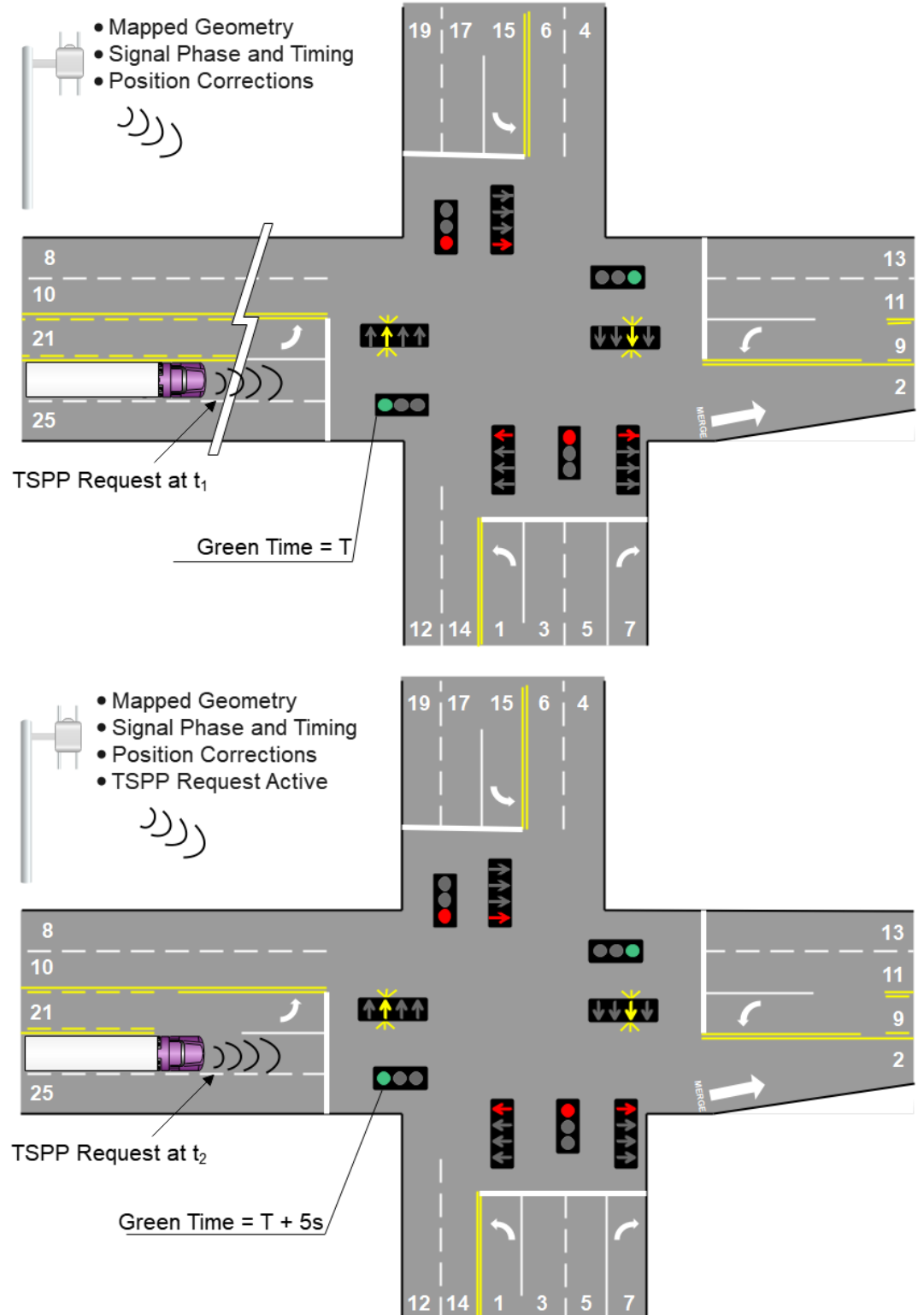
NOTE: The italicized text along with the ARC-IT service package, source object, flow, and destination object naming used throughout 5.8 are reprinted from the ARC-IT reference (see 2.1.3).

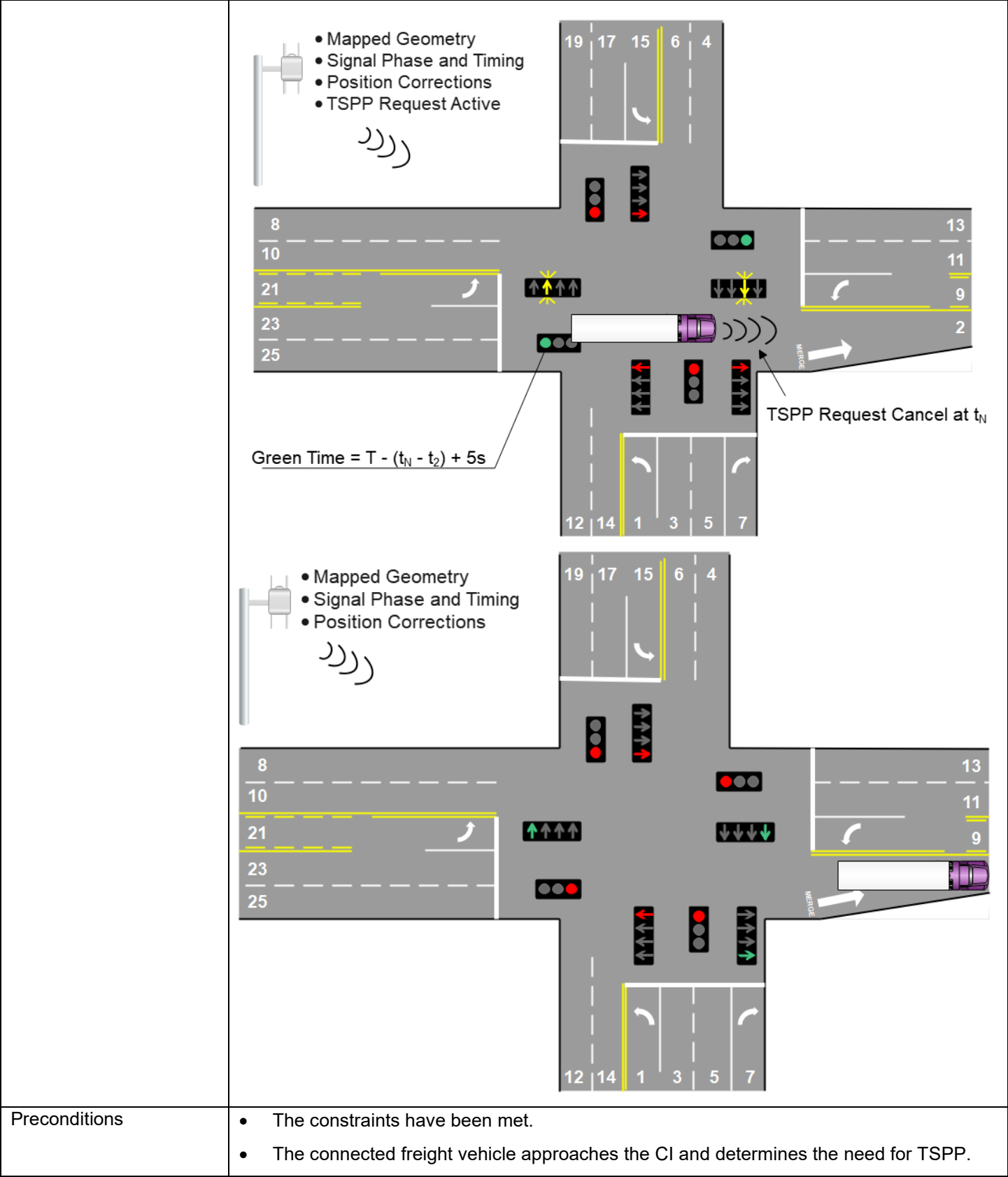
5.9.1 TSPP Request for Current Inbound Lane - Priority Preferential Treatment Granted

Table 2 - TSPP request for current inbound lane - priority preferential treatment granted

Use Case Name	TSPP Request for the Current Inbound Lane with Priority Preferential Treatment Granted
Category	Mobility, Environment
Infrastructure Role	Provides the required TSPP supporting information, accepts TSPP requests, provides TSPP response status information, and modifies traffic signal timing if necessary.
Vehicle Role	Interprets TSPP supporting information, makes TSPP requests, processes TSPP response status information, and takes appropriate actions based on the response status.
Short Description	A connected freight vehicle equipped with TSPP capability is approaching a CI which also supports TSPP. The connected freight vehicle communicates with the CI to request TSPP for its current lane of travel. The CI evaluates the information provided by the vehicle and determines that traffic signal priority should be provided to the connected freight vehicle by altering its traffic signal phase timings for the requested which for this scenario involves providing extra green time for the vehicle's current lane of travel.
Goal	Avoiding a connected freight vehicle having to stop, thereby reducing the slow starts which can lead to backed up traffic conditions, increased fuel consumption, and increased emissions.
Constraints	- The CI and the connected freight vehicle are equipped with an interoperable radio interface. - The CI supports TSPP requests and responses. - The connected freight vehicle is authorized to make TSPP requests. - The connected freight vehicle positioning system can localize its specific road and/or lane segment to that contained in mapped area while approaching the relevant CI location. - The mapped area, and, if necessary, position corrections information is being transmitted, or are available, and the connected freight vehicle supports processing them. - A security solution is in place to enable the authentication of data sources. NOTE: While the illustrations show signal phase and timing being transmitted by the CI, since it is generally considered to be paired with the mapped area data for a CI, it is not a constraint of the scenario.
Geographic Scope	Localized to a particular intersection represented by the mapped area data.
Actors	- CI - Connected Freight Vehicle

Illustration





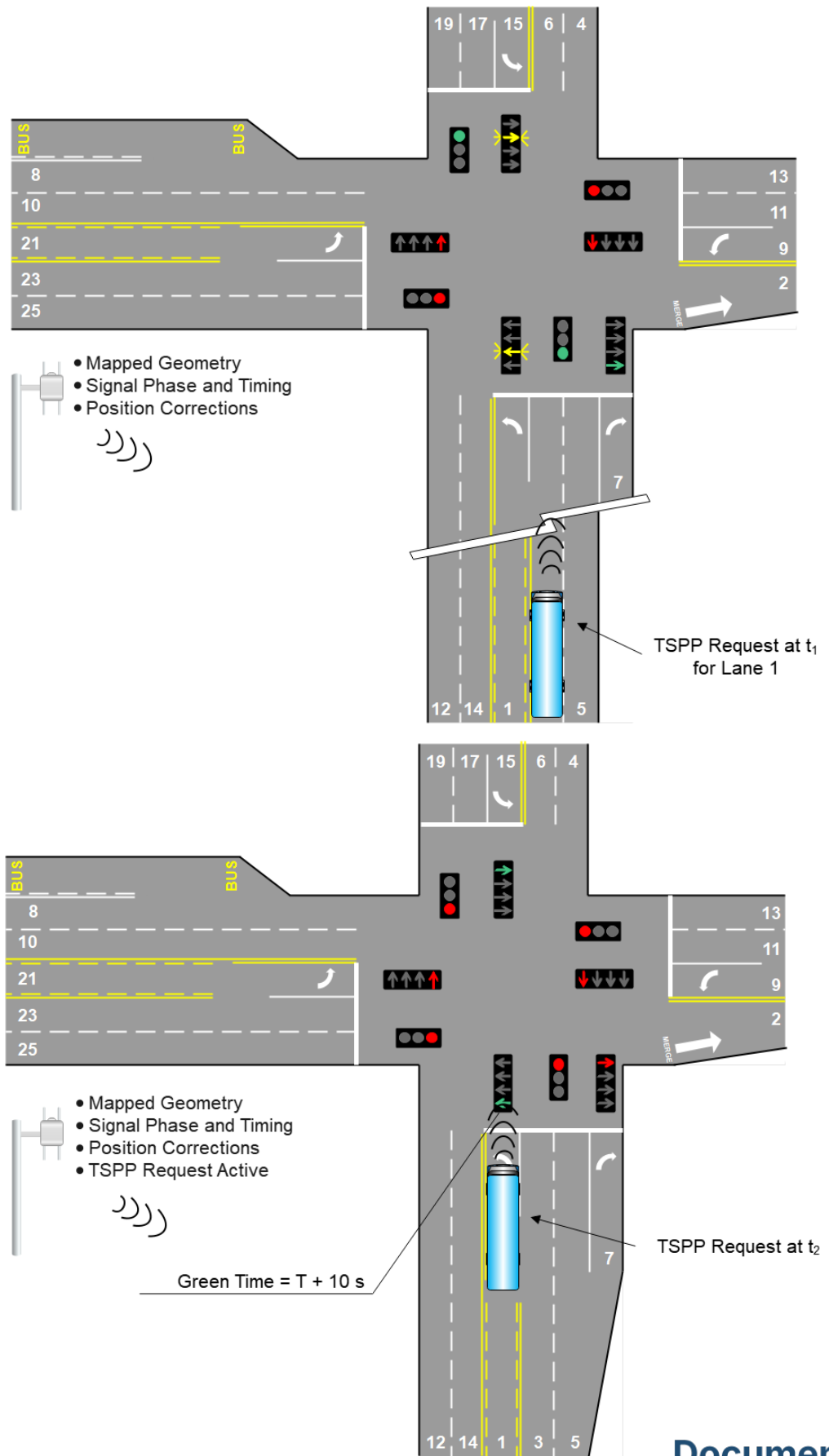
Main Flow	1. Based on vehicle localization and kinematics data, the connected freight vehicle makes a TSPP request (first figure of illustration). 2. The CI receives the TSPP request, determines that the freight vehicle should get priority preferential treatment, and responds indicating a TSPP response status of active (second figure of illustration). 3. The traffic signal controller extends the traffic signal green phase to allow the connected freight vehicle to pass through the intersection without stopping (second and third figure of illustration). 4. The connected freight vehicle continues to send in TSPP requests with updated information if necessary (second figure in the illustration). 5. The connected freight vehicle traverses the intersection and sends an indication to the CI that the TSPP request is no longer needed (third figure of the illustration). 6. The traffic signals resume normal timing operation (fourth figure of the illustration).
Alternate flow one	1. Step 1 of the Main Flow. 2. The CI receives the TSPP request and responds indicating the TSPP status as not being activated.
Alternate flow two	1. Steps 1 to 3 of the Main Flow. 2. The connected freight vehicle provides an update to its request and the CI provides the updated status.
Alternate flow three	1. Steps 1 to 2 of the Main Flow. 2. The CI terminates the green and then provides an early green for the next cycle. NOTE: This would support the situation where the green extension is not possible due to a maximum green time condition.
Alternate flow four	1. Steps 1 to 2 of the Main Flow. 2. The CI can meet the request without altering the scheduled green phase. NOTE: In this case the TSPP request is still activated.
Post-conditions	The traffic signals resume normal timing operation.
Information Requirements	• Mapped area and, if necessary, position corrections information. • Vehicle position, speed, and heading information. • Vehicle role/subrole information. • Vehicle lane or route information. • Request type. • Response status.
Source Documents/References	N/A

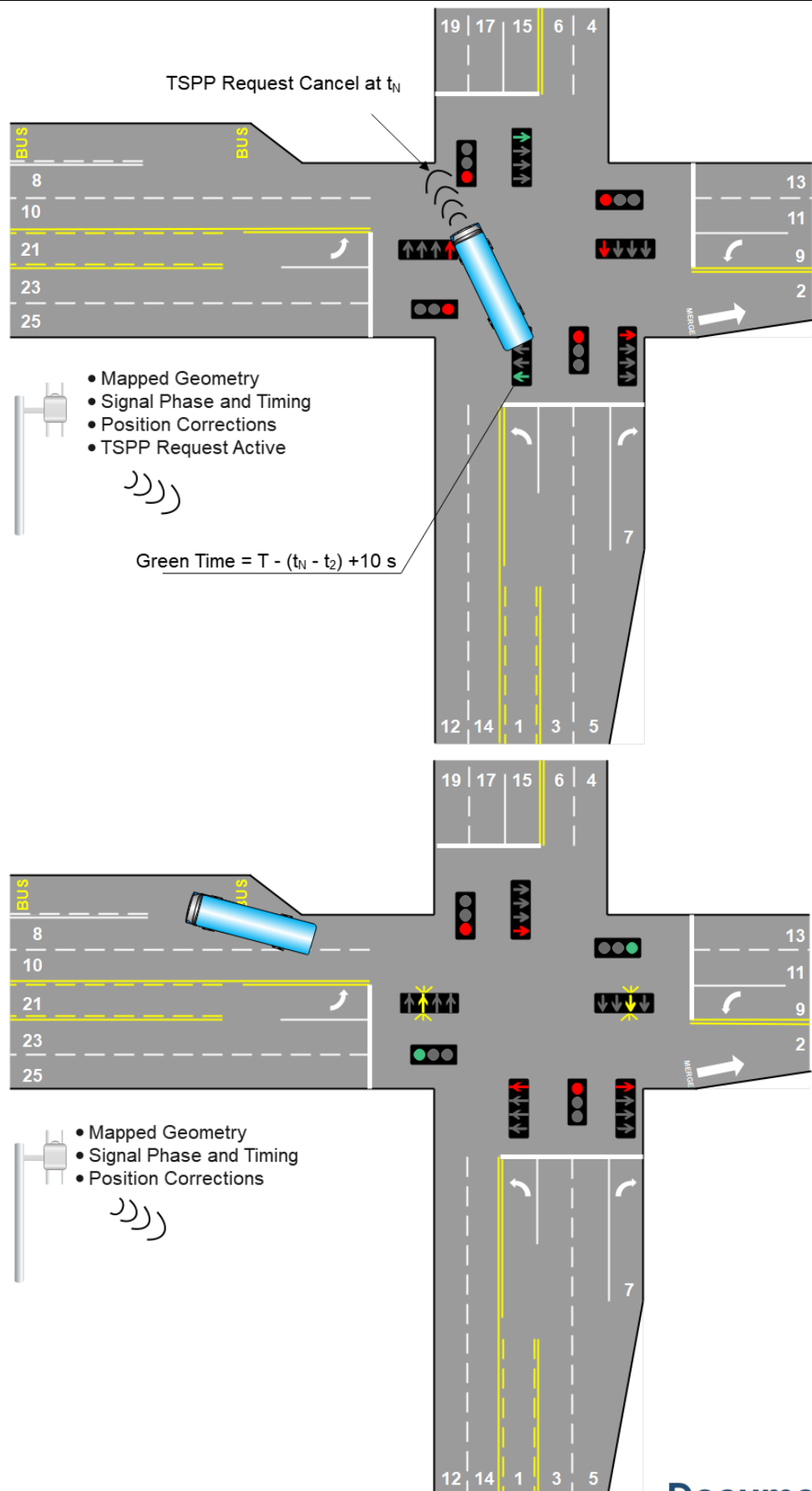
5.9.2 TSPP Request for Different Inbound Lane - Priority Preferential Treatment Granted

Table 3 - TSPP request for different inbound lane - priority preferential treatment granted

Use Case Name	TSPP Request for a Different Inbound Lane with Priority Preferential Treatment Granted
Category	Mobility
Infrastructure Role	Provides the required TSPP supporting information, accepts TSPP requests, provides TSPP response status information, and modifies traffic signal timing if necessary.
Vehicle Role	Interprets TSPP supporting information, makes TSPP requests, processes TSPP response status information, and takes appropriate actions based on the response status.
Short Description	A connected transit vehicle equipped with TSPP capability is approaching a CI which also supports TSPP. The connected transit vehicle communicates with the CI to request TSPP for an inbound/outbound lane combination that is different than what would be supported for its current lane of travel. The CI evaluates the information provided by the vehicle and determines that traffic signal priority should be provided to the connected transit vehicle by altering its traffic signal phase timings which for this scenario involves providing extra green time for the vehicle's future lane of travel.
Goal	Enabling a connected transit bus to maintain its schedule, resulting in decreased travel times, and increasing the quality of service.
Constraints	- The CI and the connected transit vehicle are equipped with an interoperable radio interface. - The CI supports TSPP requests and responses. - The connected transit vehicle is authorized to make TSPP requests. - The connected transit vehicle is aware of its route and where it is supposed to be within a certain period in the future and can provide the appropriate mapped area lane IDs consistent with that route. - The mapped area, and, if necessary, position corrections information is being transmitted, or are available, and the connected transit vehicle supports processing them. - A security solution is in place to enable the authentication of data sources. NOTE: While the illustrations show signal phase and timing being transmitted by the CI, since it is generally considered to be paired with the mapped area data for a CI, it is not a constraint of the scenario.
Geographic Scope	Localized to a particular intersection represented by the mapped area data.
Actors	- CI - Connected Transit Vehicle

Illustration





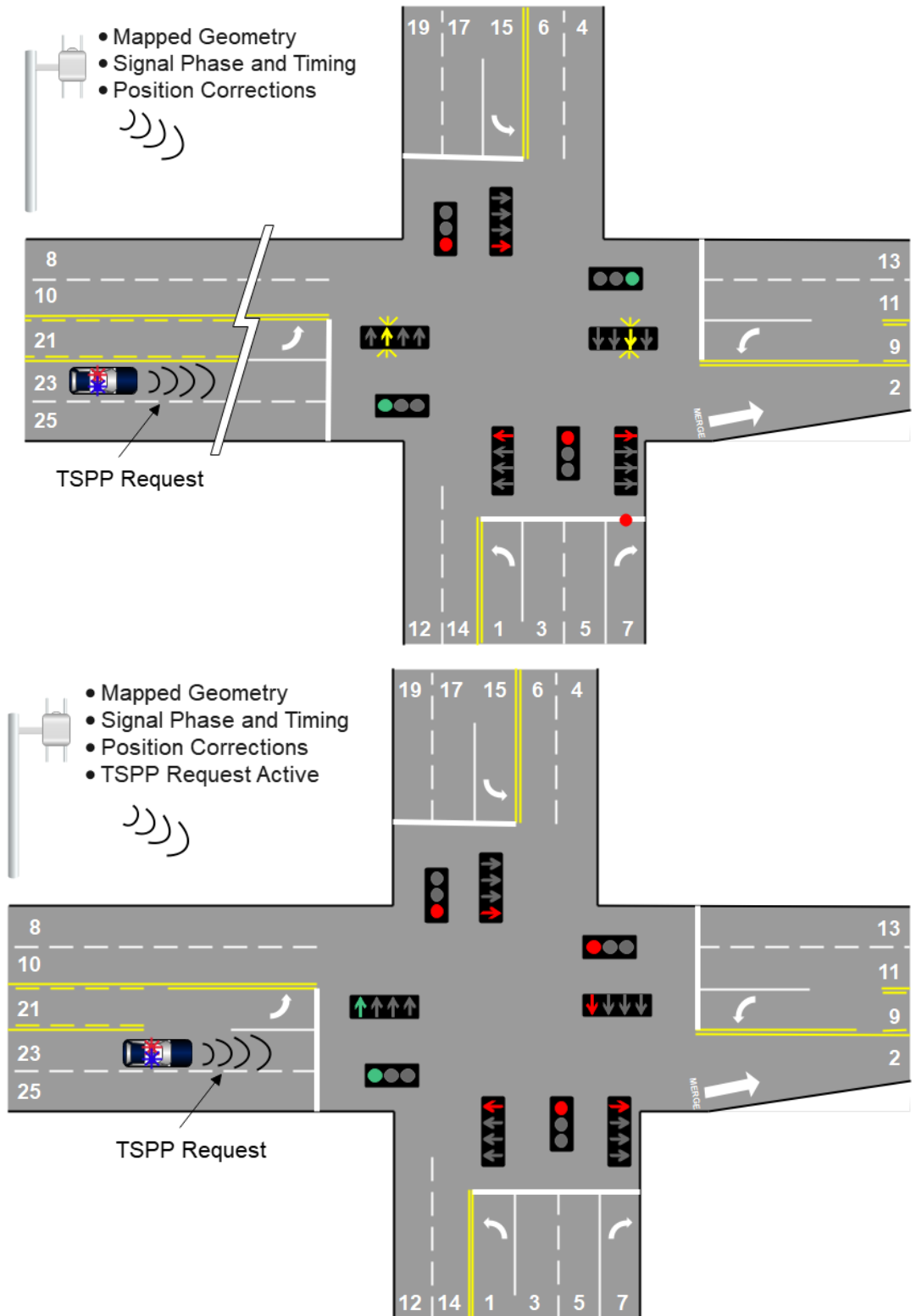
Preconditions	- The constraints have been met. - The connected transit vehicle approaches the CI and determines the need for TSPP.
Main Flow	- Based on vehicle localization and kinematics data as well as transit route information, the connected transit vehicle makes a TSPP request for a lane other than its current one (first figure of illustration). - The CI receives the TSPP request, determines that the transit vehicle should get priority preferential treatment, and responds indicating a TSPP response status of active (second figure of illustration). - The traffic signal controller extends the traffic signal green phase to allow the connected transit vehicle to turn left at the intersection without stopping (second and third figure of illustration). - The connected transit vehicle continues to send in TSPP requests with updated information if necessary (second figure in the illustration). - The connected transit vehicle traverses the intersection and sends an indication to the CI that the TSPP request is no longer needed (third figure of the illustration). - The traffic signals resume normal timing operation (fourth figure of the illustration).
Alternate flow one	- Step 1 of the Main Flow. - The CI receives the TSPP request and responds indicating the TSPP status as not being activated.
Alternate flow two	- Steps 1 to 3 of the Main Flow. - The connected transit vehicle provides an update to its request and the CI provides the updated status.
Alternate flow three	- Steps 1 to 2 of the Main Flow. - The CI can meet the request without altering the scheduled green phase. NOTE: In this case the request is still activated.
Post-conditions	The traffic signals resume normal timing operation.
Information Requirements	- Mapped area and, if necessary, position corrections information. - Vehicle position, speed, and heading information. - Vehicle role/subrole information. - Vehicle route information. - Request type. - Response status.
Source Documents/References	N/A

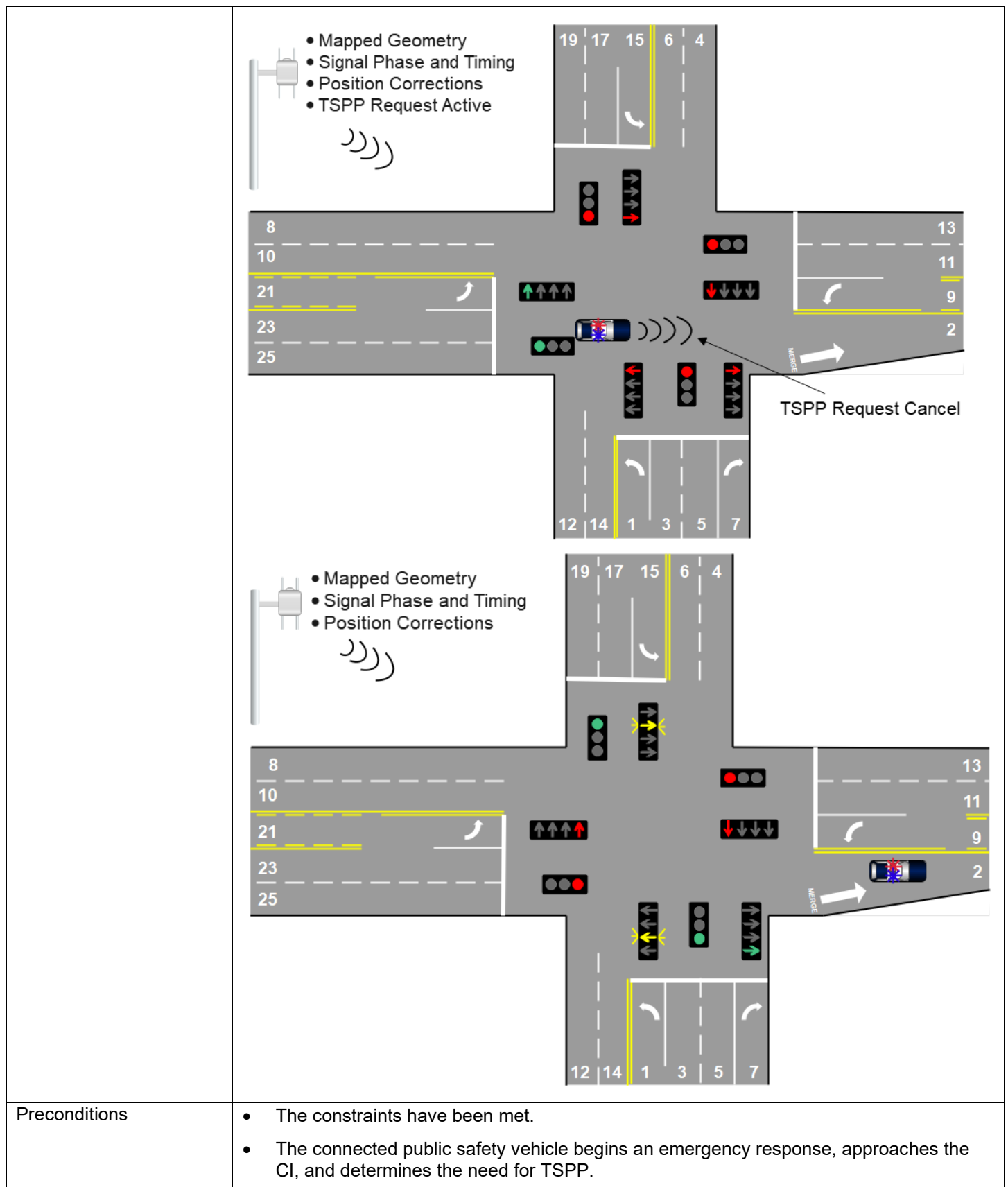
5.9.3 TSPP Request with Preemption Preferential Treatment Granted

Table 4 - TSPP request with preemption preferential treatment granted

Use Case Name	TSPP Request with Preemption Preferential Treatment Granted
Category	Safety, Mobility
Infrastructure Role	Provides the required TSPP supporting information, accepts TSPP requests, provides TSPP response status information, and modifies traffic signal timing if necessary.
Vehicle Role	Interprets TSPP supporting information, makes TSPP requests, processes TSPP response status information, and takes appropriate actions based on the response status.
Short Description	A connected public safety vehicle equipped with TSPP capability is approaching a CI which also supports TSPP. The connected public safety vehicle communicates with the CI to request TSPP for its current lane of travel. The CI evaluates the information provided by the vehicle and determines that traffic signal preemption should be provided to the connected public safety vehicle. The CI follows the programmed preemption sequence which, for this scenario, involves turning the traffic signal lights green on the emergency vehicle's direction of travel while turning the traffic signal lights red for the other directions as is depicted in this scenario.
Goal	Reduce the likelihood of collision at the intersection during an emergency response while improving overall response time to reach the destination.
Constraints	- The CI and the connected public safety vehicle are equipped with an interoperable radio interface. - The CI supports TSPP requests and responses. - The connected public safety vehicle is authorized to make TSPP requests. - The connected public safety vehicle positioning system can localize its specific road and/or lane segment to that contained in mapped area while approaching the relevant CI location. - The mapped area, and, if necessary, position corrections information is being transmitted, or are available, and the connected public safety vehicle supports processing them. - A security solution is in place to enable the authentication of data sources. NOTE: While the illustrations show signal phase and timing being transmitted by the CI, since it is generally considered to be paired with the mapped area data for a CI, it is not a constraint of the scenario.
Geographic Scope	Localized to a particular intersection represented by the mapped area data.
Actors	- CI - Connected Public Safety Vehicle

Illustration





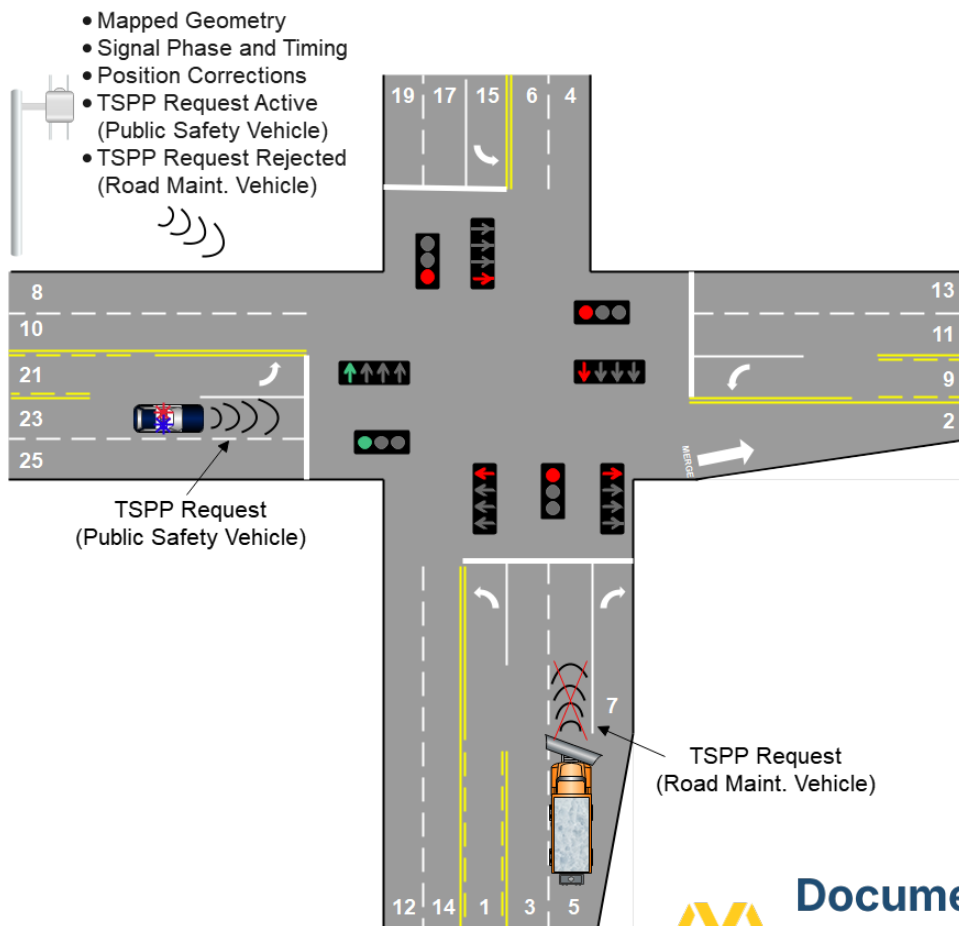
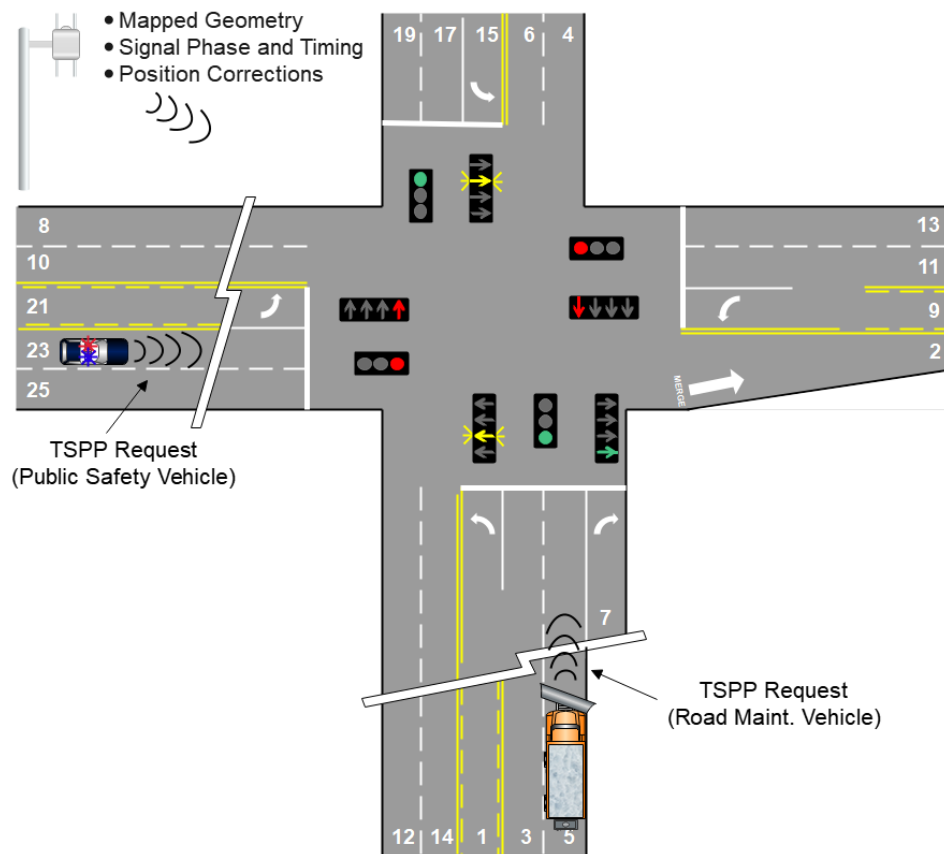
Main Flow	1. Based on vehicle localization and kinematics data, the connected public safety vehicle makes a TSPP request (first figure of illustration). 2. The CI receives the TSPP request, determines that the public safety vehicle should get preemption preferential treatment, and responds indicating a TSPP response status of active (second figure of illustration). 3. The traffic signal controller initiates the programmed preemption sequence which, in the case of this scenario, is to turn the traffic signals green in the public safety vehicle's direction of travel and turn all other direction of travel traffic signals to red (second figure in the Illustration). 4. The connected public safety vehicle continues to send in TSPP requests with updated information if necessary (second figure in the Illustration). 5. The connected public safety vehicle traverses the intersection and sends an indication to the CI that the TSPP request is no longer needed (third figure of the illustration). 6. The traffic signal controller initiates the appropriate sequence of events to have the traffic signals resume normal timing operation (fourth figure of the illustration).
Alternate flow one	1. Step 1 of the Main Flow. 2. The CI receives the TSPP request and responds indicating the TSPP status as not being activated.
Alternate flow two	1. Steps 1 to 3 of the Main Flow. 2. The connected public safety vehicle provides an update to its request and the CI provides the updated status.
Alternate flow three	1. Steps 1 to 2 of the Main Flow. 2. The signal controller initiates an alternate programmed preemption sequence than in step 3 of the Main Flow. NOTE: In this case the request is still activated.
Post-conditions	The traffic signals resume normal timing operation.
Information Requirements	• Mapped area and, if necessary, position corrections information. • Vehicle position, speed, and heading information. • Vehicle role/subrole information. • Vehicle lane information. • Request type. • Response status.
Source Documents/References	N/A

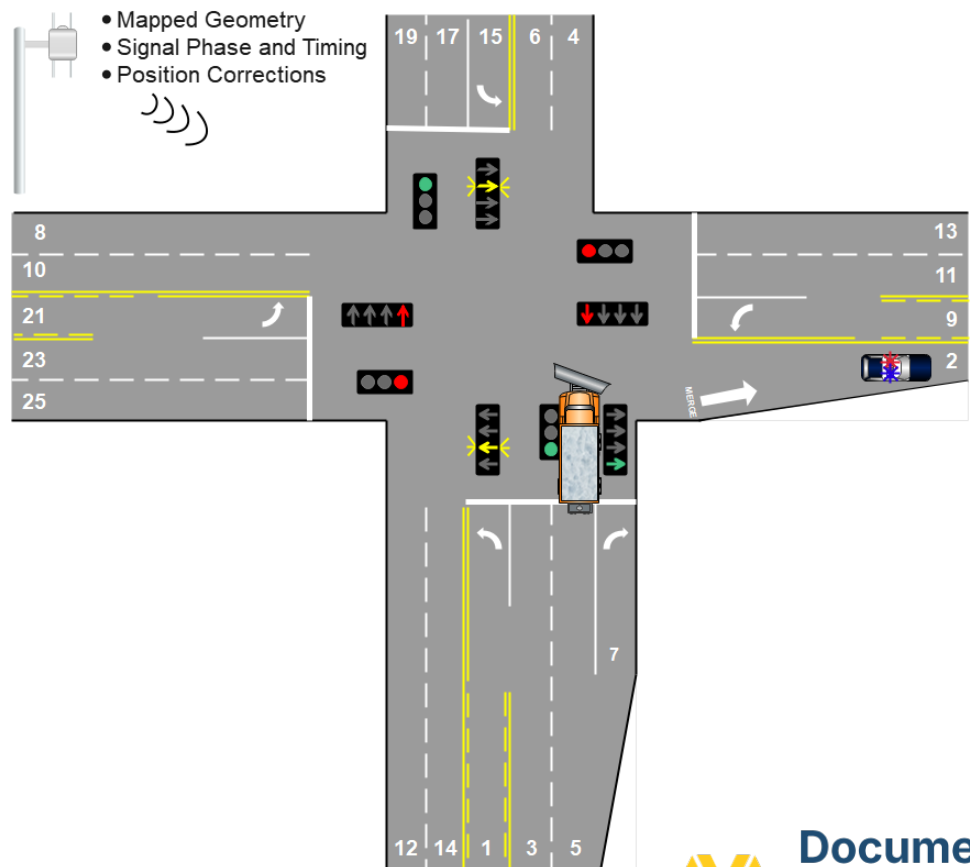
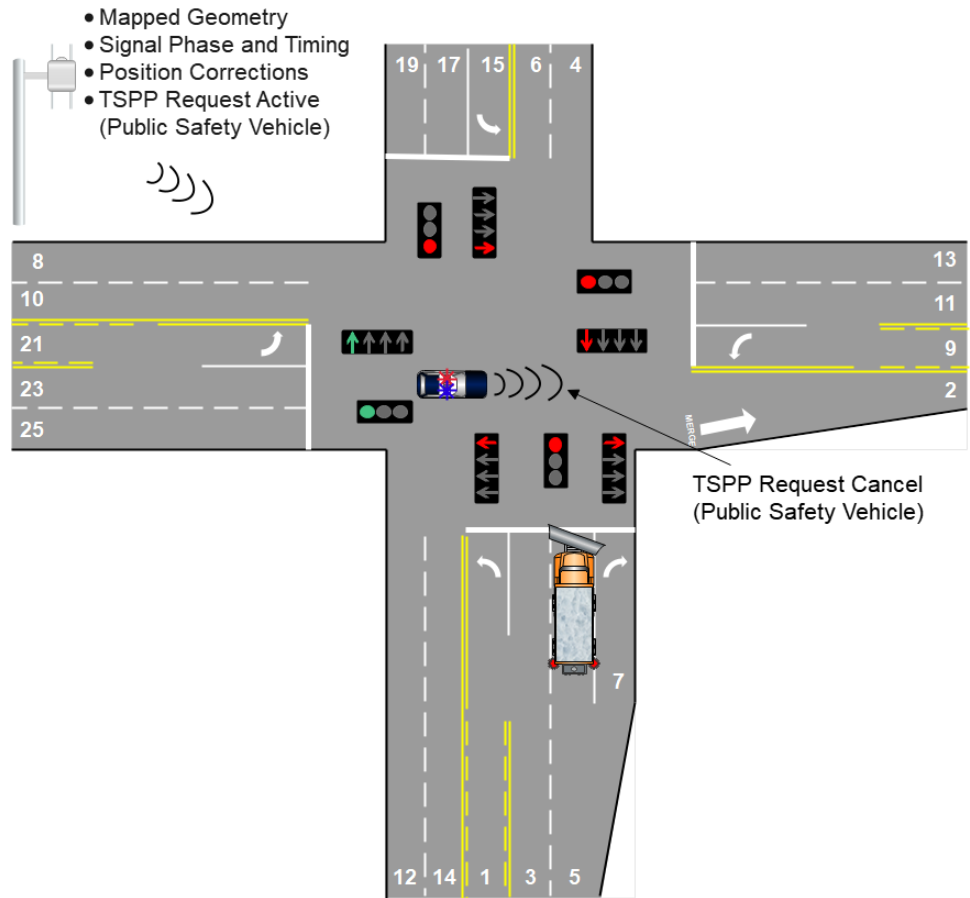
5.9.4 Concurrent TSPP Requests

Table 5 - Concurrent TSPP requests

Use Case Name	Concurrent TSPP Requests
Category	Safety, mobility
Infrastructure Role	Provides the required TSPP supporting information, accepts TSPP requests, prioritizes concurrent requests, provides TSPP response status information, and modifies traffic signal timing if necessary.
Vehicle Role	Interprets TSPP supporting information, makes TSPP requests, processes TSPP response status information, and takes appropriate actions based on the corresponding request status.
Short Description	A connected public safety vehicle and a connected road maintenance vehicle both equipped with TSPP capability are approaching a CI which also supports TSPP. The connected public safety vehicle and connected road maintenance vehicle communicate with the CI concurrently to request TSPP for their current lanes of travel. The CI prioritizes the concurrent requests, for example, based on provided vehicle/vehicle state information and determines that traffic signal preemption should be provided to the connected public safety vehicle and that the connected road maintenance vehicle should not be provided TSPP services and responds thus to the CVs.
Goal	In situations when concurrent TSPP requests are being made, prioritize the requests, to ensure the higher priority need is serviced.
Constraints	• The CI, the connected public safety vehicle, and the connected road maintenance vehicle are equipped with an interoperable radio interface. • The CI supports TSPP requests and responses. • The connected public safety vehicle and connected road maintenance vehicle are authorized to make TSPP requests. • The connected public safety vehicle's and connected road maintenance vehicle's positioning system can localize their specific road and/or lane segment to that contained in mapped area while approaching the relevant CI location. • The mapped area, and, if necessary, position corrections information is being transmitted, or are available, and the connected public safety vehicle and connected road maintenance vehicle support processing them. • A security solution is in place to enable the authentication of data sources. NOTE: While the illustrations show signal phase and timing being transmitted by the CI, since it is generally considered to be paired with the mapped area data for a CI, it is not a constraint of the scenario.
Geographic Scope	Localized to a particular intersection represented by the mapped area data.
Actors	• CI • Connected Public Safety Vehicle • Connected Road Maintenance Vehicle

Illustration





Preconditions	- The constraints have been met. - The connected public safety vehicle begins an emergency response, approaches the CI, and determines the need for TSPP. - The connected road maintenance vehicle is on its way to the location to begin plowing and treating the road, approaches the CI, and determines the need for TSPP.
Main Flow	- Based on vehicle localization and kinematics data, the connected public safety vehicle and connected road maintenance vehicle make concurrent requests for TSPP (first figure of illustration). - The CI receives the TSPP requests and, based on the various information available from the connected public safety vehicle and connected road maintenance vehicle, responds indicating the TSPP request status of active for the connected public safety vehicle and the TSPP request status of rejected for the connected road maintenance vehicle (second figure in the illustration). - The traffic signal controller initiates the programmed preemption sequence which, in the case of this scenario, is to turn the traffic signals green in the connected public safety vehicle's direction of travel and turn all other directions of travel traffic signals red (second figure in the illustration). - The connected public safety vehicle continues to send in TSPP requests while the connected road maintenance vehicle stops sending in TSPP requests (second figure in the illustration). - The connected road maintenance vehicle comes to a stop while the connected public safety vehicle traverses the intersection and sends an indication to the CI that the TSPP request is no longer needed (third figure of the illustration). - The traffic signal controller initiates the appropriate sequence of events to have the traffic signals resume normal timing operation, thereby enabling the connected road maintenance vehicle to proceed through the intersection upon its traffic signal turning green (fourth figure of the illustration).
Alternate flow one	- Step 1 of the Main Flow. - Based on various request information available from the connected public safety vehicle and the connected road maintenance vehicle, the CI determines that neither CV will be activated for TSPP. - The CI responds indicating a TSPP request status of rejected for both requests.
Alternate flow two	- Steps 1 to 3 of the Main Flow. - The connected public safety vehicle provides an update to its request and the CI provides the updated status.
Alternate flow three	- Step 1 of the Main Flow. - Based on the various vehicle information and traffic signal status and timing, the CI determines that both requests can be activated and responds indicating this.
Alternate flow four	- Step 1 of the Main Flow. - Based on the various vehicle information and traffic signal status and timing, the CI indicates active for the public safety vehicle TSPP request and queued for the road maintenance vehicle TSPP request. - After completing the public safety vehicle request, the CI indicates active for the road maintenance vehicle request. NOTE: For this case, it is possible that both requests could be supported without either vehicle needing to come to a stop. It is also possible that the road maintenance vehicle still needs to come to a stop but not for as long as it would have, due to it getting green earlier than it would have otherwise.

Alternate flow five	1. The road maintenance vehicle makes its TSPP request which is made active by the CI. 2. Then the public safety vehicle makes its TSPP request causing the CI to override the road maintenance vehicle request by queuing or rejecting the request and activating the public safety vehicle request.
Alternate flow six	1. The road maintenance vehicle has its blade down, actively plowing, and reports this information in its request. 2. The CI prioritizes the two requests , for example, based on the vehicle role or timing, and activates one of the requests while either queuing or rejecting the other.
Post-conditions	The traffic signals resume normal timing operation.
Information Requirements	• Mapped area and, if necessary, position corrections information. • Vehicle position, speed, and heading information. • Vehicle ID. • Vehicle role/type information. • Vehicle lane information (public safety vehicle). • Vehicle lane or route information (road maintenance vehicle). • Request type. • Response status.
Source Documents/References	N/A

6. FUNCTIONAL REQUIREMENTS

6.1 General

6.1.1 Tutorial [Informative]

Detailed information about requirements may be found in National Transportation Communications for ITS Protocol (NTCIP) 8002 Annex B1 Section 3. In addition, SAE J2945 contains information on the development of the requirements.

6.1.2 Scope of the Interface [Informative]

The scope of the interface is limited to the exchange of data from the CI to the CV via V2I Communications (see Section 3).

6.1.3 Needs to Requirements Traceability Matrix (NRTM)

The NRTM provides a mapping between the user needs and the functional requirements which have been developed to meet those needs.

Information about NRTM notation may be found in NTCIP 8002 Annex B1 Section 3.3.

The NRTM can be used by:

- a. A user or specification writer to indicate which requirements are to be implemented in a project-specific implementation.
- b. The protocol implementer, as a checklist to reduce the risk of failure to conform to the standard through oversight.
- c. The supplier and user, as a detailed indication of the capabilities of the implementation.
- d. The user, as a basis for initially checking the potential interoperability with another implementation.

6.1.3.1 Notation

This section provides notation that is used in the NRTM regarding requirement support.

6.1.3.1.1 Conformance Symbols

The symbols in Table 6 are used to indicate status in the conformance column of the NRTM table.

Table 6 - Conformance symbols

Symbol	Value
M	Mandatory: The system is required to implement this functionality.
M.#	Every item of the group labeled by the same numeral # is mandatory, but only one is active at a time.
O	Optional: The system does not need to implement the feature to be standards compliant.
O.# (range)	Part of an option group: At least the number of options indicated by the "(range)" is required from the options labeled with the same numeral #. ⁽¹⁾
C	Conditional: The system must implement the functionality corresponding to this requirement if another requirement is implemented.
N/A	Not applicable (i.e., logically impossible in the scope of the standard).
X	Excluded or prohibited.

⁽¹⁾ The O.# (range) notation is used to show a set of selectable options (e.g., O.2 (1..*)) would indicate that one or more of the option group two options must be implemented. Two-character combinations are used for dynamic requirements. In this case, the first character refers to the static (implementation) status, and the second refers to the dynamic (use); thus, .MO. means mandatory to be implemented, optional to be used.

6.1.3.1.2 Conditional Status Notation

The predicate notation provided in Table 7 may be used:

Table 7 - Predicate notations

Notation	Value
<predicate>:	This notation introduces a single item that is conditional on the <predicate>.
<predicate>::	This notation introduces a table or a group of tables, all of which are conditional on the <predicate>.
(predicate)	This notation introduces the first occurrence of the predicate either in the NRTM table or that specific user need. The feature associated with this notation is the base feature for all options that have this predicate in their conformance column.

The <predicate> notation means that the status following it applies only when the NRTM states that the feature or features identified by the predicate are supported. In the simplest case, <predicate> is the identifying tag of a single NRTM item. When the group predicate is true then the associated section shall be completed. The symbol <predicate> also may be a Boolean expression composed of several indices. .AND., .OR., and .NOT. shall be used to indicate the Boolean logical operations.

The predicates used in this report are as follows:

- Trnst: Indicates the conformance status corresponding to information regarding transit vehicle implementations.
- Snwplw: Indicates the conformance status corresponding to information regarding snowplow vehicle implementations.

6.1.3.1.3 Support Column Symbols

The support column can be used by a procurement specification to identify the required features for the given procurement or by an implementer to identify which features have been implemented. In either case, the user circles the appropriate answer (yes, no, or N/A as described in Table 8) in the support column.

Table 8 - Support symbols

Symbol	Value
Yes	To be supported (or supported) by the implementation.
No	Does not have to be supported (or not supported) by the implementation.
N/A	Not applicable.

6.1.3.2 Instructions for Completing the NRTM [Informative]

To claim conformance with this standard, an implementation must satisfy the mandatory and selected optional requirements as identified in the NRTM. Refer to SAE J2945 for additional information on the NRTM.

The columns in the NRTM table are the user need section number and user need title columns, Functional Requirement (FR) ID and FR section number and title (functional requirement title) columns, the conformance column, the support column, and the additional specifications column.

6.1.3.2.1 User Need Section Number and User Need Title Columns

The NRTM is based upon the user needs defined in each of the Feature's sections. The Features or User Needs section number and title are indicated within these columns.

6.1.3.2.2 FR ID and FR Section Number and Title Columns

The requirements are defined within 6.2 through 6.8. The NRTM traces from the user needs to these requirements. The requirements ID along with the section number and title containing the requirement are indicated within these columns.

6.1.3.2.3 Conformance Column

The notations and symbols used to indicate status and conditional status in the NRTM for this column are defined in 6.1.3.1.1 and 6.1.3.1.2. Not all these notations and symbols may be used in this report.

6.1.3.2.4 Support Column

In the “support” column, each response shall be selected either from the indicated set of symbols from 6.1.3.1.3 or it shall reference additional items that are to be attached.

If a conditional requirement is inapplicable, use the not applicable (N/A) symbol.

6.1.3.2.5 Additional Specifications Column

The additional specifications column may (and should) be used by a procurement specification to provide additional notes and requirements for the product to be procured or may be used by an implementer to provide any additional details about the implementation. In some cases, default text already exists in this field, which the user should complete to fully specify the implementation. However, additional text can be added to this field as needed to fully specify a feature. Performance requirements should also be specified in this column.

6.1.3.3 NRTM Table

Table 9 provides the NRTM table corresponding to the user needs and requirements provided within this report. To claim conformance with this standard, an implementation shall satisfy the mandatory and selected optional requirements as identified in the NRTM.

Table 9 - NRTM table

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
5.4	Architectural Needs			M	Yes	
5.4.1	Connected Intersection Connected Vehicle Interface			M	Yes	
		Arch-ExtSysIntf-MsgDeliv-1	6.2.1.1 - Message Delivery (MsgDeliv)	M	Yes	
		Arch-ExtSysIntf-MsgDeliv-2	6.2.1.1 - Message Delivery (MsgDeliv)	M	Yes	
5.4.2	Position Interface			M	Yes	
		Arch-ExtSysIntf-Pos-1	6.2.1.2 - Position Interface (Pos)	M	Yes	
5.4.3	Time Interface			M	Yes	
		Arch-ExtSysIntf-Tm-1	6.2.1.3 - Time Interface (Tm)	M	Yes	
5.4.4	SCMS Interface			M	Yes	
		Arch-ExtSysIntf-SCMS-1	6.2.1.4 - SCMS Interface (SCMS)	M	Yes	
5.5	Features			M	Yes	
5.5.1.1	Request for TSPP			M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-IntRefID-1	6.4.1.4.2.1 - Intersection Reference ID (IntRefID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-IntRefID-2	6.4.1.4.2.1 - Intersection Reference ID (IntRefID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-RqstID-1	6.4.1.4.2.2 - Request ID (RqstID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-RqstID-2	6.4.1.4.2.2 - Request ID (RqstID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-InbdOnID-1	6.4.1.4.2.4 - Inbound On ID (InbdOnID)	M	Yes	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		DatXchg-SRM-SgnlRqstPkg-Rqst-InbdOnID-2	6.4.1.4.2.4 - Inbound On ID (InbdOnID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-InbdOnID-3	6.4.1.4.2.4 - Inbound On ID (InbdOnID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-InbdOnID-4	6.4.1.4.2.4 - Inbound On ID (InbdOnID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-OutbdOnID-1	6.4.1.4.2.5 - Outbound On ID (OutbdOnID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-OutbdOnID-2	6.4.1.4.2.5 - Outbound On ID (OutbdOnID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-RdAuthID-1	6.4.1.4.2.6 - Road Authority ID (RdAuthID)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-RdAuthID-2	6.4.1.4.2.6 - Road Authority ID (RdAuthID)	M	Yes	
5.5.1.2	Intersection TSPP Capability			M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-IndvIntSuptInfo-1	6.4.3.3.4 - Individual Intersection Support Information (IndvIntSuptInfo)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-IndvIntSuptInfo-RdAuthID-1	6.4.3.3.5 - Road Authority ID (RdAuthID)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-IndvIntSuptInfo-IntID-1	6.4.3.3.6 - Intersection ID (IntID)	M	Yes	
		Tx-WSA-TxIntvl-1	6.6.3.2 - Transmit Interval (TxIntvl)	M	Yes	
5.5.1.3	Vehicle Information				Yes	
		DatXchg-SRM-SgnlRqstPkg-ETA-1	6.4.1.4.3 - Estimated Time of Arrival (ETA)	O	Yes/No	
		DatXchg-SRM-SgnlRqstPkg-ETA-2	6.4.1.4.3 - Estimated Time of Arrival (ETA)	C	Yes/NA	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		DatXchg-SRM-SgnlRqstPkg-ETA-3	6.4.1.4.3 - Estimated Time of Arrival (ETA)	C	Yes/NA	
		DatXchg-SRM-SgnlRqstPkg-ETA-4	6.4.1.4.3 - Estimated Time of Arrival (ETA)	C	Yes/NA	
		DatXchg-SRM-SgnlRqstPkg-ETA-5	6.4.1.4.3 - Estimated Time of Arrival (ETA)	C	Yes/NA	
		DatXchg-SRM-SgnlRqstPkg-ETA-6	6.4.1.4.3 - Estimated Time of Arrival (ETA)	C	Yes/NA	
		DatXchg-SRM-Rqstr-BSMID-1	6.4.1.5.2 - BSMID (BSMID)	M	Yes	
		DatXchg-SRM-Rqstr-PosVctr-Pos-1	6.4.1.5.3.1 - Position (Pos)	M	Yes	
		DatXchg-SRM-Rqstr-PosVctr-Hdg-1	6.4.1.5.3.2 - Heading (Hdg)	M	Yes	
		DatXchg-SRM-Rqstr-PosVctr-Trans-1	6.4.1.5.3.3 - Transmission (Trans)	O.1 (1)	Yes/No	
		DatXchg-SRM-Rqstr-PosVctr-Trans-2	6.4.1.5.3.3 - Transmission (Trans)	O.1 (1)	Yes/No	
		DatXchg-SRM-Rqstr-PosVctr-Spd-1	6.4.1.5.3.4 - Speed (Spd)	M	Yes	
		DatXchg-SRM-Rqstr-RdTrnst-LoadSt-1	6.4.1.5.5.3 - Road Transit - Loading State (RdTrnst-LoadSt)	Trnst: O.1 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-LoadSt-2	6.4.1.5.5.3 - Road Transit - Loading State (RdTrnst-LoadSt)	Trnst: O.1 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-SchedAdher-1	6.4.1.5.5.4 - Road Transit - Schedule Adherence (RdTrnst-SchedAdher)	Trnst: O.2 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-SchedAdher-2	6.4.1.5.5.4 - Road Transit - Schedule Adherence (RdTrnst-SchedAdher)	Trnst: O.2 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-SchedAdher-3	6.4.1.5.5.4 - Road Transit - Schedule Adherence (RdTrnst-SchedAdher)	Trnst: O.2 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-OccSts-1	6.4.1.5.5.5 - Road Transit - Occupancy Status (RdTrnst-OccSts)	Trnst: O.3 (1)	Yes/No	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		DatXchg-SRM-Rqstr-RdTrnst-OccSts-2	6.4.1.5.5.5 - Road Transit - Occupancy Status (RdTrnst-OccSts)	Trnst: O.3 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-OccSts-3	6.4.1.5.5.5 - Road Transit - Occupancy Status (RdTrnst-OccSts)	Trnst: O.4 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdTrnst-OccSts-4	6.4.1.5.5.5 - Road Transit - Occupancy Status (RdTrnst-OccSts)	Trnst: O.4 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdMaint-Snwplw-PlowSt-1	6.4.1.5.5.6 - Road Maintenance - Snowplow (RdMaint-Snwplw-PlowSt)	Snwplw: O.1 (1)	Yes/No	
		DatXchg-SRM-Rqstr-RdMaint-Snwplw-PlowSt-2	6.4.1.5.5.6 - Road Maintenance - Snowplow (RdMaint-Snwplw-PlowSt)	Snwplw: O.1 (1)	Yes/No	
5.5.1.4	Request Status			M	Yes	
		DatXchg-SSM-IntSgnlSts-IntRefID-1	6.4.2.4.3 - Intersection Reference ID (IntRefID)	M	Yes	
		DatXchg-SSM-IntSgnlSts-RdAuthID-1	6.4.2.4.5 - Road Authority ID (RdAuthID)	M	Yes	
		DatXchg-SSM-SgnlStsPkg-InbdOnID-1	6.4.2.5.3 - Inbound On ID (InbdOnID)	M	Yes	
		DatXchg-SSM-SgnlStsPkg-OutbdOnID-1	6.4.2.5.4 - Outbound On ID (OutbdOnID)	M	Yes	
		DatXchg-SSM-SgnlStsPkg-RespSts-1	6.4.2.5.5 - Response Status (RespSts)	M	Yes	
		DatXchg-SSM-SgnlStsPkg-RjctInfo-ReRqstTm-1	6.4.2.5.6.1 - Re-Request Time (ReRqstTm)	M	Yes	
		DatXchg-SSM-RqstrInfo-BSMID-1	6.4.2.6.2 - BSMID (BSMID)	M	Yes	
		DatXchg-SSM-RqstrInfo-RqstID-1	6.4.2.6.3 - Request ID (RqstID)	M	Yes	
		DatXchg-SSM-RqstrInfo-RqstContVer-1	6.4.2.6.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SSM-RqstrInfo-VehIdent-1	6.4.2.6.5 - Vehicle Identification (VehIdent)	M	Yes	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		DatXchg-SSM-RqstrInfo-VehIdent-2	6.4.2.6.5 - Vehicle Identification (VehIdent)	M	Yes	
		Tx-SRM-RjctReRqstCond-1	6.6.1.3 - Rejection Re-Request Conditions (RjctReRqstCond)	M	Yes	
		Tx-SRM-RjctReRqstCond-2	6.6.1.3 - Rejection Re-Request Conditions (RjctReRqstCond)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-1	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-2	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-3	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-4	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-5	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-6	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-7	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-8	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-9	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-10	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-11	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-12	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		Tx-SSM-StsPlusTxIntvl-13	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-14	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-15	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-StsPlusTxIntvl-16	6.6.2.3 - Status Plus Transmit Interval (StsPlusTxIntvl)	M	Yes	
		Tx-SSM-TxLtny-1	6.6.2.4 - Transmit Latencies (TxLtny)	M	Yes	
		Tx-SSM-TxLtny-2	6.6.2.4 - Transmit Latencies (TxLtny)	M	Yes	
5.5.1.5	Request Need			M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-1	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-2	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-3	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		Tx-SRM-CnclCondMet-1	6.6.1.2 - Cancel Conditions Met (CnclCondMet)	M	Yes	
		Tx-SRM-CnclCondMet-2	6.6.1.2 - Cancel Conditions Met (CnclCondMet)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-1	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-2	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-3	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-4	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-5	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		Tx-SRM-RqTypPlusTxIntvl-6	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-7	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-8	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-RqTypPlusTxIntvl-9	6.6.1.4 - Request Type Plus Transmit Interval (RqTypPlusTxIntvl)	M	Yes	
		Tx-SRM-TxLtncy-1	6.6.1.5 - Transmit Latencies (TxLtncy)	M	Yes	
		Tx-SRM-TxLtncy-2	6.6.1.5 - Transmit Latencies (TxLtncy)	M	Yes	
		Tx-SRM-TxLtncy-3	6.6.1.5 - Transmit Latencies (TxLtncy)	M	Yes	
		Tx-SRM-TxLtncy-4	6.6.1.5 - Transmit Latencies (TxLtncy)	M	Yes	
5.5.1.6	Vehicle Differentiation			M	Yes	
		DatXchg-SRM-Rqstr-VehIdent-1	6.4.1.5.4 - Vehicle Identification (VehIdent)	M	Yes	
		DatXchg-SRM-Rqstr-VehIdent-2	6.4.1.5.4 - Vehicle Identification (VehIdent)	M	Yes	
		DatXchg-SRM-Rqstr-VehIdent-3	6.4.1.5.4 - Vehicle Identification (VehIdent)	O.2 (1)	Yes/No	
		DatXchg-SRM-Rqstr-VehIdent-4	6.4.1.5.4 - Vehicle Identification (VehIdent)	O.2 (1)	Yes/No	
		DatXchg-SRM-Rqstr-VehRolSubrol-1	6.4.1.5.5.2 - Vehicle Role Subrole Data (VehRolSubrol)	M	Yes	
		DatXchg-SRM-Rqstr-VehRolSubrol-2	6.4.1.5.5.2 - Vehicle Role Subrole Data (VehRolSubrol)	M	Yes	
5.5.1.7	Advanced Request Notice			M	Yes	
		See NOTE 2 in 5.5.1.7.		M	Yes	MAP specification.
5.5.1.8	Feature Authorization			M	Yes	
		Rx-SRM-VldtyChk-1	6.7.1.1 - Validity Check (VldtyChk)	M	Yes	



User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		Rx-SRM-VldtyChk-2	6.7.1.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SRM-VldtyChk-3	6.7.1.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SSM-VldtyChk-1	6.7.2.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SSM-VldtyChk-2	6.7.2.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SSM-VldtyChk-3	6.7.2.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SSM-VldtyChk-4	6.7.2.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-SSM-VldtyChk-5	6.7.2.1 - Validity Check (VldtyChk)	M	Yes	
		Rx-WSA-VldtyChk-1	6.7.3.1 - Validity Check (VldtyChk)	M	Yes	
5.5.1.9	CV and CI Interoperability			M	Yes	
		Sys-Pos-LLERefSrc-1	6.3.1.1 - LLE Position Reference Source (LLERefSrc)	M	Yes	
		Sys-Pos-LLECoordSys-1	6.3.1.2 - LLE Coordinate System (LLECoordSys)	M	Yes	
		Sys-Tm-TmRef-1	6.3.2.1 - Time Reference (TmRef)	M	Yes	
		Sys-Tm-TmRef-2	6.3.2.1 - Time Reference (TmRef)	M	Yes	
		Sys-Tm-TmRef-3	6.3.2.1 - Time Reference (TmRef)	M	Yes	
		DatXchg-SRM-Gen-1	6.4.1.1 - General (Gen)	M	Yes	
		DatXchg-SRM-Gen-2	6.4.1.1 - General (Gen)	M	Yes	
		DatXchg-SRM-MsgFram-MinCont-1	6.4.1.2.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SRM-MsgFram-MsgID-1	6.4.1.2.2 - Message ID (MsgID)	M	Yes	
		DatXchg-SRM-MsgFram-MsgTyp-1	6.4.1.2.3 - Message Type (MsgTyp)	M	Yes	
		DatXchg-SRM-Msg-MinCont-1	6.4.1.3.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SRM-Msg-DtTm-1	6.4.1.3.2 - Date and Time (DtTm)	M	Yes	
		DatXchg-SRM-Msg-DtTm-2	6.4.1.3.2 - Date and Time (DtTm)	M	Yes	
		DatXchg-SRM-Msg-DtTm-3	6.4.1.3.2 - Date and Time (DtTm)	M	Yes	

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		DatXchg-SRM-Msg-SeqNum-1	6.4.1.3.3 - Sequence Number (SeqNum)	M	Yes	
		DatXchg-SRM-Msg-MsgFmtVer-1	6.4.1.3.5 - Message Format Version Information (MsgFmtVer)	M	Yes	
		DatXchg-SRM-Msg-MsgFmtVer-2	6.4.1.3.5 - Message Format Version Information (MsgFmtVer)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-MinCont-1	6.4.1.4.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-Rqst-MapdDatVerInfo-1	6.4.1.4.2.7 - Mapped Data Version Information (MapdDatVerInfo)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-1	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-2	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SRM-SgnlRqstPkg-RqstContVer-3	6.4.1.4.4 - Request Content Version (RqstContVer)	M	Yes	
		DatXchg-SRM-Rqstr-MinCont-1	6.4.1.5.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SRM-Rqstr-VehRolSubrol-MinCont-1	6.4.1.5.5.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SSM-Gen-1	6.4.2.1 - General (Gen)	M	Yes	
		DatXchg-SSM-Gen-2	6.4.2.1 - General (Gen)	M	Yes	
		DatXchg-SSM-MsgFram-MinCont-1	6.4.2.2.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SSM-MsgFram-MsgID-1	6.4.2.2.2 - Message ID (MsgID)	M	Yes	
		DatXchg-SSM-MsgFram-MsgTyp-1	6.4.2.2.3 - Message Type (MsgTyp)	M	Yes	
		DatXchg-SSM-Msg-MinCont-1	6.4.2.3.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SSM-Msg-DtTm-1	6.4.2.3.2 - Date and Time (DtTm)	M	Yes	
		DatXchg-SSM-Msg-DtTm-2	6.4.2.3.2 - Date and Time (DtTm)	M	Yes	

User Need Section Number	User Need Title	FR ID	FR Section Number and Title	Conformance	Support	Additional Specifications
		DatXchg-SSM-Msg-DtTm-3	6.4.2.3.2 - Date and Time (DtTm)	M	Yes	
		DatXchg-SSM-Msg-SeqNum-1	6.4.2.3.3 - Sequence Number (SeqNum)	M	Yes	
		DatXchg-SSM-Msg-MsgFmtVer-1	6.4.2.3.5 - Message Format Version Information (MsgFmtVer)	M	Yes	
		DatXchg-SSM-Msg-MsgFmtVer-2	6.4.2.3.5 - Message Format Version Information (MsgFmtVer)	M	Yes	
		DatXchg-SSM-IntSgnlSts-1	6.4.2.4 - Intersection Signal Status (IntSgnlSts)	M	Yes	
		DatXchg-SSM-IntSgnlSts-MinCont-1	6.4.2.4.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SSM-IntSgnlSts-SeqNum-1	6.4.2.4.2 - Sequence Number (SeqNum)	M	Yes	
		DatXchg-SSM-IntSgnlSts-SeqNum-2	6.4.2.4.2 - Sequence Number (SeqNum)	M	Yes	
		DatXchg-SSM-SgnlStsPkg-MinCont-1	6.4.2.5.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-SSM-RqstrInfo-MinCont-1	6.4.2.6.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-WSA-MinCont-1	6.4.3.1 - Minimum Content (MinCont)	M	Yes	
		DatXchg-WSA-SvcPSID-1	6.4.3.2 - Service PSID (SvcPSID)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-Gen-1	6.4.3.3.1 - General (Gen)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-MinCont-1	6.4.3.3.2 - Minimum Content (MinCont)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-AppDatFmtVer-1	6.4.3.3.3 - WSA Application Data Format Version Information (AppDatFmtVer)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-AppDatFmtVer-2	6.4.3.3.3 - WSA Application Data Format Version Information (AppDatFmtVer)	M	Yes	
		DatXchg-WSA-TSPPAppDatPyld-	6.4.3.3.7 - TSPP Message Format Versions (TSPPMsgFmtVers)	M	Yes	