



# SURFACE VEHICLE RECOMMENDED PRACTICE

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Minimum Requirements for Road Geometry and Attributes Definition

## RATIONALE

Earlier Vehicle-to-Infrastructure (V2I) road mapping information definitions provided in the SAE J2735 MAP message data set (DS) were tailored toward specific road geometry configurations (i.e., intersections and road segments) with the corresponding road attributes associated with them nested within each geometric definition. As such, it is not always possible to apply the available MAP definitions to other road geometries or to easily apply new attribute definitions that may be identified. In addition, size constraints were placed on the message DS, which makes it difficult to develop maps for complex or large distance road geometries. This report defines a new road geometry and attributes (RGA) data set to address these limitations.

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## 1. SCOPE

This report specifies the minimum requirements for the Road Geometry and Attributes (RGA) data set (DS) to support road geometry related motor vehicle safety applications. Contained in this report are a concept of operations, requirements, and design, developed using a detailed systems engineering process. Utilizing the requirements, the RGA DS is defined, which includes the DS Abstract Syntax Notation One (ASN.1) format, data frames, and data element definitions.

The requirements are intended to enable the exchange of the messages and their DS information to provide the desired interoperability and data integrity to support the applications considered within this report, as well as other applications which may be able to utilize the DS information. System requirements beyond this are outside the scope of this report.

NOTE: Unless otherwise marked as Informative, all material in this report is to be considered normative.

## 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 SAE publications shall apply.

#### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), [www.sae.org](http://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 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

|           |                                                                                                                                           |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------|
| ISO 21177 | Intelligent Transport Systems - ITS Station Security Services for Secure Session Establishment and Authentication Between Trusted Devices |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------|

#### 2.1.3 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, [www.ieee.org](http://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                                                                                                                                                                                                                            |
| 2.1.4 Other Publications                                                                                               |                                                                                                                                                                                                                                                                                                                     |
| ARC-IT                                                                                                                 | Architecture Reference for Cooperative and Intelligent Transportation, United States Department of Transportation                                                                                                                                                                                                   |
| CTI 4501                                                                                                               | Connected Intersections Implementation Guide; American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, National Electrical Manufacturers Association, SAE International, Version v01.01, June 2022                                                                |
| MAP Guidance Document                                                                                                  | Creation of a Guidance Document for MAP Preparation, Connected Vehicle Pool Fund Study - University of Virginia Center for Transportation Studies, Revision #1, May 2022                                                                                                                                            |
| End-entity Security Requirements, Design Guidance, and Validation Approach; SCMS Manager; Version 1.00, March 14, 2021 |                                                                                                                                                                                                                                                                                                                     |
| MUTCD                                                                                                                  | Manual on Uniform Traffic Control Devices for Streets and Highways; U.S. Department of Transportation, Federal Highway Administration; 2009 Edition Revision 1 dated May 2021 and Revision 2 dated May 2012                                                                                                         |
| 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 in this section are the definitions that apply to this report.

**APPROACH:** All lanes, from one lateral curb/boundary line to the other lateral curb/boundary line of a roadway, with the same direction of travel toward or away from an intersection or midblock location

**NOTE 1:** This definition is different from the definitions in the MUTCD and SAE J2735.

**NOTE 2:** Given this definition, this would not include crosswalks.

**ATTRIBUTE:** A characteristic of the mapped road features.

**BASE LAYER:** A special Data Layer intended to aid an application in processing the DS and/or determining the relevance of the DS.

**BICYCLE LANE:** Refer to 'Bicycle Lane' in the MUTCD.

**CONCISE NODES:** A subset of the measured nodes selected such that the reported way geometry meets the requirements of this report.

**CONNECTED INFRASTRUCTURE (CI):** An infrastructure 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.

**NOTE:** The CI may or may not be or include the roadside equipment (RSE) and, therefore, CI is used within this report does not necessarily indicate the RSE.

**CONNECTED VEHICLE (CV):** Uses a communications medium to exchange information between the vehicle and the infrastructure, which is required in the context of this report, as well as other vehicles and potentially other devices.

**CONTAINER:** A set of Data Layers that represent a common category of data. Depending on the supported application functionality some containers may be optional within a DS.

**CROSSWALK LANE:** Refer to 'Crosswalk' in the Manual on Uniform Traffic Control Devices (MUTCD).

**CURRENT LANE:** The physical lane that a connected vehicle is driving in.

**DATA ELEMENT:** Refer to SAE J2735.

**DATA FRAME:** Refer to SAE J2735.

**DATA LAYER:** A set of data elements and/or data frames that represent a common class of data. Depending on the supported application functionality some data layers may be optional within container.

**NOTE:** While there may be some similarities in the content, the data layers defined in this report are not intended to parallel the use of Geographic Information System (GIS) map layers which may include street data, building data, topographical information, etc. Rather, the data layers in this report are primarily used to add additional information specific to the geometry and use of the roadways.

**DATA SET:** A structured and complete set of data elements and/or data frames, made up by the base layer, data containers, and corresponding data layers, necessary to support an intended application or application set.

**INTERSECTION BOX:** The area defined by the prolongation or connection of the lateral curb lines, or if none, the lateral boundary lines of the roadways that contain motor vehicle lanes which intersect.

**LANE:** A section of road in the mapped road geometry typically marked off with painted lines and intended to separate single lines of traffic according to direction or use.

**LANE LEVEL POSITIONING:** Being able to determine the physical lane of a multi-lane road that is being occupied.

**LAYER:** See DATA LAYER.

**LINK/LINKAGE:** A connection between two sets of data.

**MAPPED WAY:** A Way which has its geometry provided via a set of Concise Nodes.

**MEASURED NODES:** The complete set of measured way geometry information which represents an oversampling of the way geometry.

**MOTOR VEHICLE LANE:** A portion of a roadway that has been designated for preferential or exclusive use by motor vehicles, either always or within certain periods, engaged in continuous movement, other than when under some form of stop or yield control.

**NOTE:** A motor vehicle lane may be designated for use by vehicles other than motor vehicles.

**NETWORK COMMUNICATIONS:** Communication between a vehicle and the infrastructure using a remote set of devices to relay the desired information.

**NODE:** A point in the road geometry defined by offsets from a known point.

**OPERATIONAL STATE:** The geometry of the mapped road and the attributes that apply to that geometry at a set point in time.

**POINT OF CONFLICT:** A point on the boundary of an area where two or more road users can potentially collide with each other.

**REFERENCE POINT (RP):** A unique latitude, longitude, and elevation combination, which is used as a reference position to identify the point location of the mapped road geometry. This point is also used as a reference position to determine the location of other points within the mapped road geometry via the use of offsets from this point.

**REFERENCE POSITION:** A position that is used as a reference for determining the relative location of other positions.

**RELATED POINTS OF CONFLICT:** One of more points of conflict which are generally associated with the same primary way-to-way geometry event. For example, at an intersection which has stop lines and crosswalks, the intersection is the primary way-to-way geometry event and the stop line locations, crosswalk areas, and intersection box area are related points of conflict. However, for the same intersection, if a mid-block crosswalk was also present, it and any traffic control points associated with it would not be related points of conflict with the intersection. Rather they would be their own related points of conflict where the mid-block crosswalk would be the primary way-to-way geometry event.

**ROAD LEVEL POSITIONING:** Being able to determine the physical road, but not necessarily the individual lane within the road, which is being occupied.

**ROAD SEGMENT:** A longitudinal section of the defined roadway.

**SYSTEM:** Collection of physical and functional components which work together to support a user need and/or requirement.

**NOTE:** To support the partitioning of the functionality within this report, two systems are considered, the CI and the CV.

**TRAFFIC CONTROL POINT:** Locations within a lane where traffic movements are controlled.

**V2I COMMUNICATIONS:** Direct communication between the CV and the CI using a common wireless communications channel.

**WAY:** An individual or collection of roads, lanes, paths, etc. used for travel from one location to another.

#### 4. ABBREVIATIONS

Cited in this section 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 |
| ASN.1  | Abstract Syntax Notation One                                          |
| CI     | Connected Infrastructure                                              |
| CV     | Connected Vehicle                                                     |
| DE     | Data Element                                                          |
| DF     | Data Frame                                                            |
| DOT    | Department of Transportation                                          |
| DS     | Data Set                                                              |
| ENU    | East, North, Up                                                       |
| ED     | Euclidian Distance                                                    |
| FR     | Functional Requirement                                                |
| GIS    | Geographic Information System                                         |

|       |                                                         |
|-------|---------------------------------------------------------|
| GNSS  | Global Navigation Satellite System                      |
| GPS   | Global Positioning System                               |
| ID    | Identifier                                              |
| IOO   | Infrastructure Owner Operator                           |
| IP    | Internet Protocol                                       |
| IPR   | Intellectual Property Rights                            |
| ISO   | International Organization for Standardization          |
| ITE   | Institute of Transportation Engineers                   |
| ITS   | Intelligent Transportation Systems                      |
| LLE   | Latitude, Longitude, and Elevation                      |
| MA    | Misbehavior Authority                                   |
| MUTCD | Manual on Uniform Traffic Control Devices               |
| NEMA  | National Electrical Manufacturers Association           |
| NRTM  | Needs to Requirements Traceability Matrix               |
| NTCIP | National Transportation Communications for ITS Protocol |
| 1PPS  | One Pulse per Second                                    |
| OBE   | On-Board Equipment                                      |
| PPOI  | Perpendicular Point of Intersection                     |
| PSID  | Provider Service Identifier                             |
| RAID  | Road Authority ID                                       |
| RFC   | Request for Comments                                    |
| RGA   | Road Geometry and Attributes                            |
| RP    | Reference Point                                         |
| RSE   | Roadside Equipment                                      |
| RTCM  | Radio Technical Commission for Maritime Services        |
| RTM   | Requirements Traceability Matrix                        |
| Rx    | Receive                                                 |
| SCMS  | Security Credential Management System                   |
| SPaT  | Signal Phase and Timing                                 |

|      |                                          |
|------|------------------------------------------|
| SSP  | Service Specific Permissions             |
| SYS  | System                                   |
| 2D   | Two-dimensional                          |
| TLS  | Transport Layer Security                 |
| Tx   | Transmit                                 |
| UPER | Unaligned Packed Encoding Rules          |
| U.S. | United States                            |
| UTC  | Coordinated Universal Time               |
| V2V  | Vehicle-to-Vehicle                       |
| V2X  | Vehicle-to-Everything                    |
| WAVE | Wireless Access in Vehicular Environment |
| WGS  | World Geodetic System                    |
| WRA  | WAVE Routing Advertisement               |
| WSA  | WAVE Service Advertisement               |

## 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 the 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 relative 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 needs 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. Within the NRTM, each of the user needs and requirements 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]

There are several similar maps related V2I safety applications deployed where, depending on the application, the provided data may differ from one implementation to the next. This can lead to ambiguity in the supported application set or expected behavior of the application.

To address this, all the applications addressed in this report require the use of a common RGA DS. To support interoperability among independent implementations of this DS, minimum requirements regarding the DS 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 RGA DS is removed.

The RGA DS defined in this report is new but is based on the MAP message from SAE J2735. The user needs for a new RGA DS definition are multifold, including:

- Providing a generalized mapping approach to support specifying the base geometric representations of roads and to associate attributes to those geometries.
- Allowing application specific geometries to be specified which can either be included in the RGA DS or another DS which links back to the RGA DS.
- Enabling the DS to support larger mapped area definitions regardless of the medium selected for providing the DS.

These needs are intended to enable a diverse set of V2I applications, each of which may have unique requirements regarding geometry and attributes, to be developed.

While there are similarities between the SAE J2735 MAP and the RGA, the RGA message does not replace the MAP message and the MAP message may continue to be used for applications that it was intended to support. The RGA DS can be considered like a database of road-related information linked to a particular mapped area that can continue to be expanded upon over time. Because of this design goal, the RGA message is not backward compatible with the MAP message.

## 5.3 Reference Architecture

Given the diversity in the physical equipment used and partitioning of the functionality, both within the connected infrastructure (CI) equipment and the connected vehicle (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, other than direct RSE infrastructure, available for a CV to receive an RGA DS (e.g., pre-loaded, cellular, internet), however, for the purposes of this report the link from the CI to the CV is shown as a direct one.

The architecture shown in Figure 1 is partitioned into a CI System and a CV System, with subsystems provided for each, in addition to the Security Credential Management System (SCMS). The CI and CV subsystems are selected to consolidate and compartmentalize the 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.

NOTE: While the CI and the CV may have subsystems which have the same name, 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 scope of this report. Also, there are supporting entities, subsystems, and interfaces which are outside the scope of this report, but support functionality covered within 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 from the CI System to the CV System.

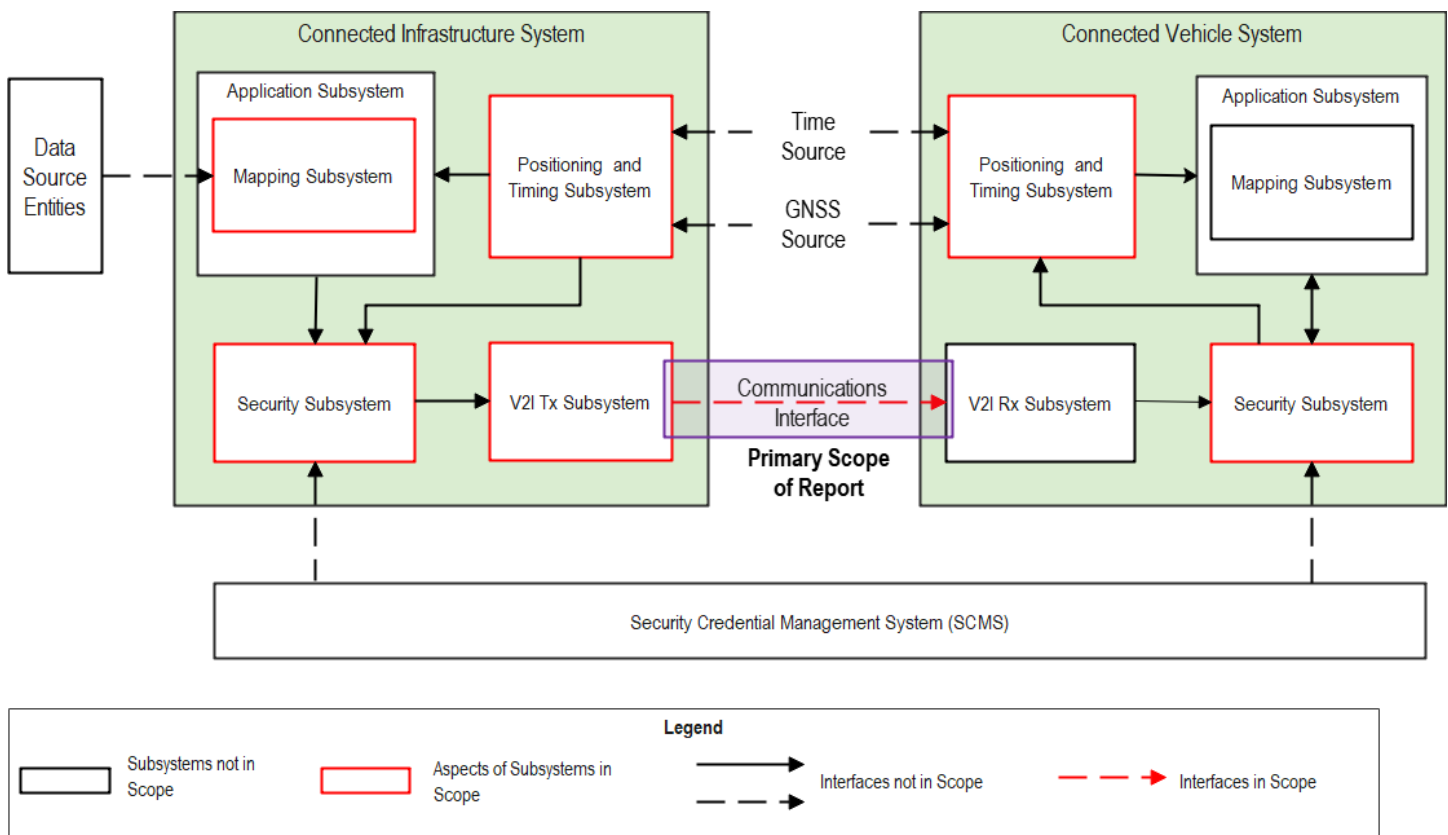


**Figure 1 - Reference functional architecture**

### 5.3.1 Connected Infrastructure Functional Components

The CI System is comprised of the application subsystem in addition to subsystems required to support the applications. These include the positioning and timing, security, and transmit (Tx) subsystems.

#### 5.3.1.1 Application Subsystem

The Application Subsystem includes the Mapping Subsystem which is in scope of this report and generates the mapped roadway geometry and attributes DS content. It assembles the data into a base layer and various geometry and attribute data layers which are compartmentalized into containers. Depending on the application set, different containers and/or data layers may be included in the DS. See 8.1.1 for more details on the DS structure and APPENDIX E for a set of layer illustrations for an example mapped intersection.

Most of the data used by the Mapping Subsystem comes from external data source entities including, but not limited to: Infrastructure Owner Operators (IOO), Map Data Providers (e.g., private map data provider, surveying company), Departments of Transportation (DOT), Road Operating Agencies/Authorities (e.g., toll authority), and Private Entities. Various architectures may be supported for providing the map and attributes DS content, therefore, the method by which the data is obtained is out of the scope of this report. Instead, aspects regarding the data (e.g., data precision), but not necessarily the data format, required from these entities is within scope.

#### 5.3.1.2 Positioning and Timing Subsystem

The Positioning and Timing Subsystem obtains position information from a GNSS data source and obtains timing information from a time source, both to be used by other subsystems. The GNSS and time data may be from the same source but do not have to be. Aspects of this subsystem are in scope of the scope of this report.

NOTE: The CI system time and GNSS sources may be different than the CVs.

#### 5.3.1.3 Security Subsystem

The Security Subsystem performs the required security tasks including signing the DS with the appropriate credentials obtained from the SCMS and seeing to it that the security profiles are adhered to. This subsystem is required to support the functionality of this report and is in scope of this report.

#### 5.3.1.4 V2I Tx Subsystem

The V2I Tx Subsystem transmits the DS content generated by the CI. This subsystem is required to support the formatting and delivery of the DS and is in scope of this report, however, the technology used to transmit the data is outside the scope of this report.

NOTE: While Figure 1 shows the interface from the CI to the CV as a direct one, other mechanisms may be employed by the infrastructure for providing and the CV for receiving the mapped DS content.

### 5.3.2 Connected Vehicle Functional Components

The CV system is comprised of nearly the same subsystems as the CI, i.e., application, positioning and timing, security, and V2I receive (Rx) (rather than Tx) subsystems. In general, where the infrastructure is generating DSs, the CV is handling them. While this report considers application requirements in the development of the DS, it does not provide a required application set which utilizes the DSs, therefore, the Application Subsystem is outside the scope of this report. Likewise, given that various mechanisms may be supported (e.g., cellular, internet) for receiving the DSs, the V2I Rx subsystem is out of the scope of this report. The following are the subsystems which have some aspects that are in scope.

#### 5.3.2.1 Positioning and Timing Subsystem

The Positioning and Timing Subsystem obtains position information from a GNSS data source and obtains timing information from a time source to be used by the other subsystems. The GNSS and time data may be from the same source but do not have to be.

It also processes the position corrections for mapped areas that require lane level positioning accuracy. The method by which the CV obtains positions corrections is outside the scope of this report.

NOTE: The CV system time and GNSS sources may be different than the CI.

#### 5.3.2.2 Security Subsystem

The Security Subsystem performs the required security tasks including verifying the DS with the appropriate credentials obtained from the SCMS, ensures profiles are adhered to, etc. While the report does not provide many receive-side security requirements, it does provide recommendations and does provide the security profiles which are to be adhered to.

### 5.3.3 Security Credential Management System (SCMS)

The SCMS provides certificates for signing the DSs. 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 for the CI to provide the mapped data to the CV. This section provides the external interfaces that need to be supported by the architecture to support this data exchange.

### 5.4.1 Connected Infrastructure Connected Vehicle Interface

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

### 5.4.2 GNSS Interface

Both the CI and CV need to support an interface, which may be different, to obtain GNSS position information.

### 5.4.3 Time Interface

Both the CI and CV need to support an interface, which may be different, to obtain timing information.

### 5.4.4 SCMS Interface

Both 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.

### 5.4.5 Data Content Acquisition

The CI needs to support an external interface(s) to data source entities to obtain the data for the geometry and attribute set to be supported and required to populate the mapped roadway and attributes DS.

## 5.5 Features

The features that are to be supported by the functional requirements, system design, and Abstract Syntax Notation One (ASN.1) are provided in the sections that follow.

### 5.5.1 Data Set

#### 5.5.1.1 Uniformity

A common understanding of the DS being exchanged needs to be supported. This is to provide interoperability between the infrastructure and CV to aid the applications that use the data.

#### 5.5.1.2 Conciseness and Completeness

The supported DS needs to be concise but complete. In addition to reducing unnecessary bandwidth consumption, this will aid in constraining data elements to primarily those that are necessary to support the features.

#### 5.5.1.3 Data Quality

The provided data needs to be reliable and valid. This is so that the data most accurately represents the current situation and/or conditions.

#### 5.5.1.4 Extensibility

The DS needs to be extensible in such a way to limit the impact on existing applications as new features and/or application support are identified for inclusion in later revisions of the report. This is to provide some level of processing determinism to the application implementation.

#### 5.5.1.5 Content Identification

Information regarding the current set of content needs to be provided. This is to enable a user of the data to determine if a newer set of data is available without having to undergo a potentially processing-intensive data comparison with a previous data set.

#### 5.5.2 Timing

##### 5.5.2.1 Common Understanding of Time

A common understanding of time among the devices needs to be supported. This allows the proper interpretation of time-based data.

##### 5.5.2.2 Time Resolution and Accuracy

Timing information needs to be provided with sufficient resolution and accuracy. This allows time-critical decisions to be supported.

##### 5.5.2.3 Timeliness

Changes to the data need to be provided in a timely manner such that it represents the current operational state of the data being reported. This allows the users of the data to make decisions based on the conditions they find themselves.

#### 5.5.3 Positioning

##### 5.5.3.1 Common Understanding of Position

A common understanding of position among the devices needs to be supported. This allows the proper interpretation of position-based data.

##### 5.5.3.2 Positions Resolution and Accuracy

Position information needs to be provided with sufficient resolution and accuracy. This allows position-critical decisions to be supported.

#### 5.5.4 Road Geometry and Attributes Features

##### 5.5.4.1 Identification

###### 5.5.4.1.1 Mapped Road Identification

Information enabling one mapped road area to be distinguished from another mapped road area needs to be provided. This is to enable other applications which leverage the mapped data to associate with the correct mapped road area.

###### 5.5.4.1.2 Mapped Way Identification

Information enabling one mapped way to be distinguished from another mapped way needs to be provided. This is to enable other data which relates to the mapped way to be associated with the correct mapped way.

#### 5.5.4.2 Road Geometry

##### 5.5.4.2.1 Types of Geometry

A broad range of road geometry types need to be supported. This is so that not only the currently envisioned uses of the data can be supported (e.g., see 5.9) but also future uses of the data.

##### 5.5.4.2.2 Lane Level Geometry

Support for defining the geometry at the lane level needs to be provided. This is so decisions can be based on the current and potentially future lane of travel which is necessary to support the current envisioned uses of the data provided in the operational scenarios of 5.9.

##### 5.5.4.2.3 Lane Location

The location of the lane needs to be provided. This is so a road user can relate their position to that of the lane to determine if the lane applies to their current or potentially future driving location.

##### 5.5.4.2.4 Geometry Partitioning

Support for partitioning a road geometry across multiple DS needs to be supported. This is to enable support for large road geometries that may exceed message size limitations, depending on the requirements of the selected communication stack, that otherwise would not be able to be supported.

#### 5.5.4.3 Movements

##### 5.5.4.3.1 Intra-Lane Movements

Information regarding movements that are allowed within a lane needs to be supported. This is to enable a user of the lane to determine if they are navigating the lane properly or, given their current direction of travel, to determine which lanes may or may not be available for navigation given the movements that are allowed within that lane.

##### 5.5.4.3.2 Inter-Lane Movements

Information regarding movements that are allowed from one lane to another lane needs to be supported. This is to aid a road user in determining route options and allowed actions at various junctures.

#### 5.5.4.4 Lane Use Attributes

Information regarding the allowed use of a lane needs to be supported. This is to let a road user know if their current use of the lane is allowed or not. As well, depending on the attribute, this can support applications for providing appropriate warnings, information, or guidance to the user. For example, the allowed speed could be used to inform a user of a pending intersection violation.

#### 5.5.4.5 Way Type

Different types of road user ways need to be supported. This will provide road users with an understanding of the other types of road traffic that may be encountered. Examples of ways include motor vehicle lanes, bicycle lanes, crosswalks.

#### 5.5.4.6 Time Restrictions

For any of the data item settings that are not fixed in time, a means of indicating when the setting applies needs to be supported. This is to enable a road user to know what settings apply given their time of travel.

#### 5.5.4.6.1 RGA DS Control

For any of the data items which are only applicable during fixed periods, a means of providing this information needs to be supported. This will enable a road user to determine, given, for example, the current time of day or day of the week, if the data item applies or not.

#### 5.5.4.6.2 Other DS Control

For any of the data items which have variable periods of applicability controlled by other DS, a means of indicating this needs to be supported. This will enable a road user to know this information is available but needs to be obtained from elsewhere.

#### 5.5.4.7 Other DS Support

The ability for other related DS to be supported by the RGA needs to be supported. This is so that the data items within the RGA that need to be leveraged do not need to be duplicated within other DS.

### 5.6 Security Needs

The road geometry system requires a data integrity mechanism at a centralized location (i.e., traffic/map management center) and in the field for applications/systems that are deployed remotely and may generate information without a central system being directly involved. The security needs for these use cases are described in this section. These security constraints reflect the sensitive nature of the mapped road data, which should be protected from attacks.

#### 5.6.1 Data Source Authenticity and Authorization

The system needs to provide a mechanism to authenticate sources of data and verify that they are authorized to send such data. 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.

#### 5.6.2 Data Integrity and Availability

The system needs to provide a mechanism to verify that data has not been changed or significantly delayed between the entity that produced the data and the entity that consumes the data. A critical security assumption is that data inputs to or within the CI from external elements are authentic and accurate.

#### 5.6.3 User Privacy

CI devices are not linked to individual people and RGA DSs do not contain personal data, therefore, there are no privacy needs for CIs sending an RGA DS.

#### 5.6.4 Misbehavior Detection [Informative]

The application should enable 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 DS 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 (U.S.) that defines the policy or process defining, generating, and distributing RGA information. The policy for doing so is governed by the regulatory guidelines or policies for the operating agency and state and local ordinances, policies, and procedures. These ordinances, policies, and procedures vary from state to state and, within a state, operating agency to operating agency. This report attempts to employ industry standards, where they exist, in defining relevant content of the RGA DS such that there is a common format for providing the information and 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: To enable the user of this report to better understand the ARC-IT, the italicized text throughout this section along with the ARC-IT service package, source object, flow, and destination object naming used throughout this section are reprinted from the ARC-IT reference (see 2.1.4).

*“The Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) provides a common framework for planning, defining, and integrating Intelligent Transportation Systems” (ITS). It considers the 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 Support, Center, Field, Personal, and Vehicle. “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.”*

NOTE: In the following, within the vehicle class only the vehicle on-board equipment (OBE) physical object is shown as it supports vehicle safety and driver information capabilities that apply to all vehicles (e.g., Commercial Vehicle OBE, Transit Vehicle OBE, Emergency Vehicle OBE).

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 include the following along with a partial or complete description taken directly from ARC-IT:

- SU04 - Map Management: *“This service package defines interfaces that can be used to download or update all types of map data used to support intelligent transportation systems. ...”*
- SU05 - Location and Time: *“This service package identifies the external systems and interfaces that provide accurate location and time to intelligent transportation system devices and systems.”*

Within each of 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 - Feature group mapping to ARC-IT physical view components**

| SAE J2945/A<br>Feature Group    | ARC-IT Service<br>Packages | ARC-IT Triples                          |                       |                                            |
|---------------------------------|----------------------------|-----------------------------------------|-----------------------|--------------------------------------------|
|                                 |                            | Source Object                           | Flow                  | Destination Object                         |
| Road Geometry and<br>Attributes | SU04: Map<br>Management    | Connected Vehicle<br>Roadside Equipment | intersection geometry | Vehicle OBE                                |
|                                 |                            |                                         | roadway geometry      |                                            |
|                                 |                            |                                         | map updates           |                                            |
|                                 |                            | Map Update System                       | intersection geometry | Vehicle OBE                                |
|                                 |                            |                                         | roadway geometry      |                                            |
|                                 |                            |                                         | map updates           |                                            |
| Position Corrections            | SU05: Location and<br>Time | Location and Time Data<br>Source        | location and time     | Vehicle OBE                                |
|                                 |                            | Positions Corrections<br>Source         | position corrections  | Connected Vehicle<br>Roadside<br>Equipment |
|                                 |                            | Connected Vehicle<br>Roadside Equipment | location correction   | Vehicle OBE                                |

While the source and destination objects are rather straight forward, from ARC-IT, following are descriptions of the flows:

- intersection geometry: *“The physical geometry of an intersection covering the location and width of each ingress lane, egress lane, and valid paths between these lanes. This flow also defines the location of stop lines, cross walks, specific traffic law restrictions for the intersection (e.g., turning movement restrictions), and other elements that support calculation of a safe and legal vehicle path through the intersection.”*
- roadway geometry: *“The physical geometry of a road segment that specifies the location and width of each lane, including normal lanes as well as special lanes for pedestrians and bicycles, transit vehicles, and trains. This flow also may include the curvature, grade, and superelevation or banking of the road segment.”*
- map updates: *“Map update that could include a new underlying static or real-time map or map layer(s) update. Map layers can include highways, major roads, streets, public transport routes, pedestrian routes, topography, points of interest, and regulatory information including turn restrictions and speed limits.”*
- location and time: *“The current geographic location in three dimensions (latitude, longitude, elevation) and the current time.”*
- position corrections: *“Ground based reference station positioning corrections.”*
- location correction: *“Information provided to improve positional accuracy. These corrections allow a mobile GPS receiver, such as a GPS system in a CV, to achieve a greater absolute positional accuracy, compensating for errors that exist in satellite positioning.”*

Figure 2 provides a combined illustration of the two ARC-IT service package physical objects and, where relevant, the functional objects within them along with these information flows.

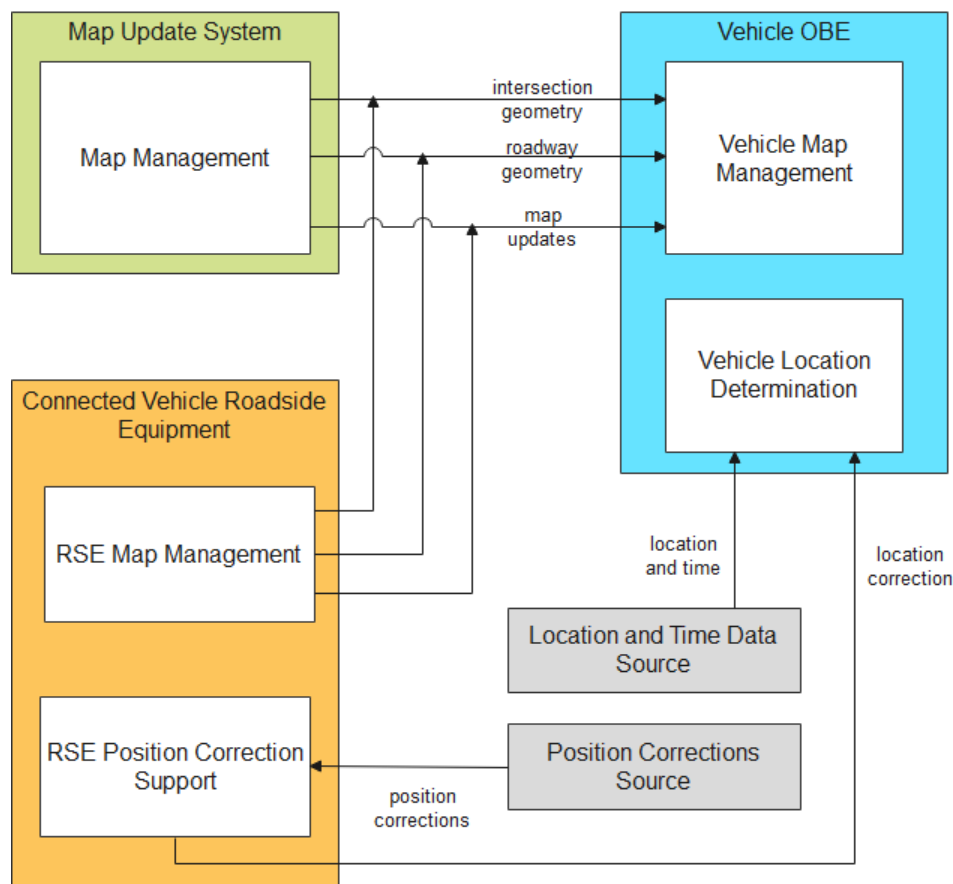
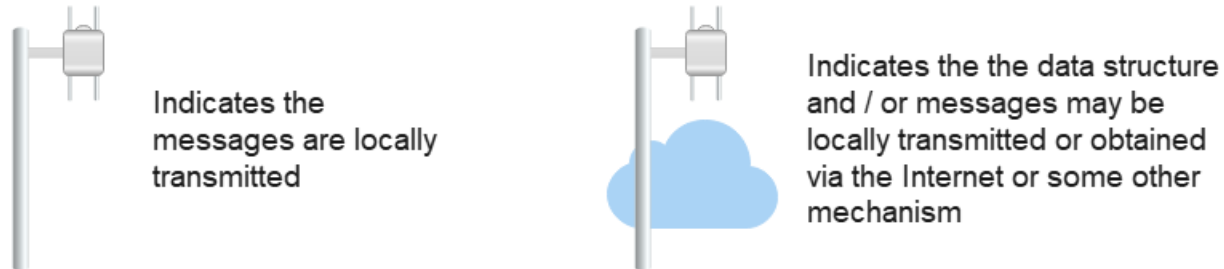


Figure 2 - ARC-IT objects and data flows

## 5.9 Operational Scenarios [Informative]

The operational scenarios included in this section encapsulate some of the key features described in 5.5. The operational scenarios do not imply any specific requirements or design. Also, consistent with other parts of this report, the scenarios do not state which communication mechanism is used for providing the information to the CV. However, regarding the communications mechanism, the 'Illustration' within each scenario provides one or both of the following symbols:



The scenarios are divided into two sections. The first contains scenarios that address more of the base operation of selecting relevant mapped geometry content and applying position corrections. These scenarios are preconditions for the remaining scenarios. The second section contains scenarios that detail how mapped geometry content may be used to support some potential V2I applications, in some cases, in combination with other V2I DSs (e.g., traffic signal information). Across the scenarios, a combination of road types and geometry is used to illustrate how the mapped geometry definition is intended to support a broad set of road geometries. However, the scenarios are not all encompassing and thus all the possible road geometries that are can be supported are not represented.

### 5.9.1 Base Operational Scenarios

#### 5.9.1.1 Mapped Geometry Availability and Selection

**Table 2 - Operational scenario 1: Mapped geometry availability and selection**

|                     |                                                                                                                                                                                                                                                                                                                                     |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Mapped Geometry Availability and Selection                                                                                                                                                                                                                                                                                          |
| Category            | Safety, Mobility                                                                                                                                                                                                                                                                                                                    |
| Infrastructure Role | Delivery of the mapped geometry DS                                                                                                                                                                                                                                                                                                  |
| Vehicle Role        | Reception and processing of the mapped geometry DS                                                                                                                                                                                                                                                                                  |
| Short Description   | Included in the mapped geometry DS is a reference point (RP) which indicates the location of the mapped road geometry. A CV uses this information to determine which mapped geometry DS contents, if any, may be relevant to its current area. If any are, the CV then determines if any are pertinent to its current location.     |
| Goal                | Identifying and selecting a relevant mapped geometry DS.                                                                                                                                                                                                                                                                            |
| Constraints         | <ul style="list-style-type: none"> <li>• Mapped geometry DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry DS via the supported interface.</li> <li>• Security solution is in place to enable secure data exchange and authentication of data sources.</li> </ul> |
| Geographic Scope    | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                             |
| Actors              | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                      |

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Illustration                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Preconditions               | <ul style="list-style-type: none"> <li>The CV can determine its current LLE position.</li> <li>The mapped geometry DSs are being transmitted or are available.</li> <li>The CV is or has previously received the mapped geometry DSs.</li> </ul>                                                                                                                                                                                                                                                  |
| Main Flow                   | <ol style="list-style-type: none"> <li>The CV evaluates the RP information contained in the set of mapped geometry data and determines that at least one mapped geometry DS is relevant.</li> <li>The CV decodes the relevant mapped geometry DSs and determines that a mapped geometry DS is pertinent to its current position.</li> <li>The CV decodes the data to determine the full extent of the mapped road area (yellow highlighted area in the 'Illustration') and attributes.</li> </ol> |
| Alternate Flow(s)           | <ol style="list-style-type: none"> <li>Steps 1 to 3 from the 'Main Flow'.</li> <li>No mapped geometry DSs are identified that are relevant to the current CV area or location.</li> <li>No further operations are performed by the CV regarding these mapped geometry DSs.</li> </ol>                                                                                                                                                                                                             |
| Post-Conditions             | <ol style="list-style-type: none"> <li>Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections.</li> <li>Further processing of the mapped geometry data per the CVs supported application set.</li> <li>Additionally, after departing the mapped road geometry provided by the relevant mapped geometry DS, if additional mapped geometry DSs are made available and received, the CV processes those as in the Main Flow.</li> </ol>                         |
| Information Requirements    | <ul style="list-style-type: none"> <li>Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>CV position.</li> </ul>                                                                                                                                                                                                                                                                                                                                       |
| Source Documents/References | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

#### 5.9.1.2 Mapped Geometry Lane Selection Using Position Corrections

**Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections**

|                     |                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Mapped Geometry Lane Selection Using Position Corrections                                                                                                                                                                                                                                                                                                               |
| Category            | Safety, Mobility                                                                                                                                                                                                                                                                                                                                                        |
| Infrastructure Role | <ul style="list-style-type: none"> <li>Delivery of the mapped geometry DS.</li> <li>Transmission of the Radio Technical Commission for Maritime Services (RTCM) corrections DS.</li> </ul>                                                                                                                                                                              |
| Vehicle Role        | <ul style="list-style-type: none"> <li>Reception and processing of the mapped geometry DS.</li> <li>Reception and processing of the RTCM corrections DS.</li> </ul>                                                                                                                                                                                                     |
| Short Description   | After identifying a mapped geometry DS pertinent to its current position, a CV applies the position corrections from the RTCM corrections DS, which corresponds to the mapped geometry DS, to correct its local position estimation. Using the corrected position, it determines which lane information contained in the mapped geometry DS it is currently driving in. |
| Goal                | Mapped geometry DS lane selection.                                                                                                                                                                                                                                                                                                                                      |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Constraints       | <ul style="list-style-type: none"> <li>• Mapped geometry and RTCM corrections DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry and RTCM corrections DSs via the supported interface(s).</li> <li>• Security solution is in place to enable secure data exchange and authentication of data sources.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Geographic Scope  | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Actors            | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Illustration      | <p>The diagram shows a top-down view of a road with two lanes, Lane 1 and Lane 3. A vehicle (CV) is shown in Lane 3. The road is divided into two sections by a yellow line. The top section is labeled 'Mapped Geometry RP' and shows a green dot representing the 'Mapped Geometry RP'. The bottom section shows the 'CV Local Position Estimation' (red transparent vehicle) and the 'CV Corrected Position Estimation' (purple transparent vehicle). The 'CV Actual Position' is shown as a white vehicle. The 'Mapped Geometry' is shown as a yellow line. The 'RTCM Corrections' are shown as a cloud icon. The diagram also shows 'Lane 1 - Node 1', 'Lane 3 - Node 1', 'Lane 1 - Node 2', and 'Lane 3 - Node 2'.</p>                                                                                                                                                                                                                                                                                                                                                                                              |
| Preconditions     | <ul style="list-style-type: none"> <li>• Table 2 - Operational scenario 1: Mapped geometry availability and selection.</li> <li>• The CV is receiving the RTCM corrections DSs corresponding to the mapped geometry DS it is processing.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Main Flow         | <p>After decoding the mapped geometry data, identified to be relevant to the current CV driving path, per the steps in Table 2:</p> <ol style="list-style-type: none"> <li>1. The CV decodes the RTCM corrections DS that corresponds to the mapped geometry DS.</li> <li>2. The CV applies the position corrections to its local position estimation (red transparent vehicle in the 'Illustration').</li> <li>3. This enables it to obtain a corrected position estimation (purple transparent vehicle in the 'Illustration').</li> <li>4. Applying the mapped geometry RP to the node offset points, for each of the lanes contained in the mapped geometry DS, the CV determines the absolute (within the required accuracy) lane level node point locations.</li> <li>5. The CV uses the node points, along with its corrected position estimation, to determine which mapped geometry lane is its current lane.</li> <li>6. Doing so, the CV determines it is in mapped geometry Lane 3, which is consistent with its actual lane position per the 'Illustration' (white vehicle in the 'Illustration').</li> </ol> |
| Alternate Flow(s) | <ol style="list-style-type: none"> <li>1. Steps 1 to 5 from the 'Main Flow'.</li> <li>2. The CV determines that no mapped geometry lanes apply to its current lane.</li> <li>3. No further operations are performed by the CV regarding the mapped geometry and RTCM corrections DSs.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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| Post-Conditions             | The CV further processes the mapped geometry data for attributes that may be relevant to its supported application set.                                                                                                                                            |
| Information Requirements    | <ul style="list-style-type: none"> <li>• Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>• RTCM corrections DS with corrections positions corresponding to the mapped geometry DS.</li> <li>• CV position.</li> </ul> |
| Source Documents/References | N/A                                                                                                                                                                                                                                                                |

### 5.9.1.3 Large Road Geometry

**Table 4 - Operational scenario 3: Large road geometry**

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Large Road Geometry                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Category            | Safety, Mobility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Infrastructure Role | <ul style="list-style-type: none"> <li>• Delivery of the mapped geometry DS partitions.</li> <li>• Transmission of the RTCM corrections DS.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Short Description   | <p>The geometry for a complex intersection is being provided in a mapped geometry DS. The message containing the DS is being transmitted locally. Given the constraints of the transmission medium, the mapped road geometry and associated attributes are too large to fit into a single mapped geometry message. To stay within size constraints, the mapped geometry DS is split into multiple partitions, each sent separately.</p> <p>Given the lane a CV is driving in, it may only need one of the mapped geometry partitions, however, to transverse the full mapped area, all partitions are required.</p> |
| Goal                | To enable large geometry mapped areas to be defined as a single set by enabling a partitioning of the data which can be reassembled upon reception of all the partitions.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Constraints         | <ul style="list-style-type: none"> <li>• Mapped geometry and RTCM corrections DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry and RTCM corrections DSs via the supported interface(s).</li> <li>• Security solution in place to enable secure data exchange and authentication of data sources.</li> </ul>                                                                                                                                                                                                                                      |
| Geographic Scope    | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Actors              | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Illustration        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

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| Preconditions               | <ul style="list-style-type: none"> <li>Table 2 - Operational scenario 1: Mapped geometry availability and selection</li> <li>Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Main Flow                   | <ol style="list-style-type: none"> <li>The red CV in the 'Illustration' receives all the mapped geometry partitions as separate messages (Mapped Geometry DS Partition 1 and Mapped Geometry DS Partition 2 per the illustration for this scenario).</li> <li>Per Table 2 - Operational scenario 1: Mapped geometry availability and selection, it determines the mapped area is pertinent to its current position, so it decodes the DS partitions fully.</li> <li>From information in the DS, the CV is aware that the two messages together comprise a single mapped area DS, so it combines the data into a single DS.</li> <li>Then, via the RP information and node offset information and per Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections, the CV determines which lane applies to its current lane.</li> <li>The CV processes the attributes contained in the combined mapped geometry DS and potentially other DSs (e.g., traffic signal information) depending on its application set.</li> </ol> |
| Alternate Flow(s)           | <p>Alternate Flow 1</p> <ol style="list-style-type: none"> <li>The CV only receives one of the mapped geometry partitions.</li> <li>It performs steps 1 - 5 of the 'Main Flow' pertaining to the partition it has received.</li> </ol> <p>Alternate Flow 2</p> <ol style="list-style-type: none"> <li>The mapped geometry DS partitions are determined to not be relevant to the current CV lane.</li> <li>No further operations are performed by the CV regarding the mapped geometry DS partitions.</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Post-Conditions             | The red CV in the 'Illustration' continues to process the mapped geometry DS partitions until it departs the mapped area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Information Requirements    | <ul style="list-style-type: none"> <li>All the mapped geometry partition messages, each which includes the RP data corresponding to the mapped geometry.</li> <li>RTCM corrections DS corresponding to the mapped geometry DS.</li> <li>CV position.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Source Documents/References | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## 5.9.2 Potential V2I Application Operational Scenarios

### 5.9.2.1 Intersection Geometry with Stop Line Identification

**Table 5 - Operational scenario 4: Intersection geometry with traffic signal phase and timing controlled lane maneuver information**

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Intersection Geometry with Traffic Signal Phase and Timing Controlled Lane Maneuver information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Category            | Safety                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Infrastructure Role | <ul style="list-style-type: none"> <li>Delivery of the mapped geometry DS.</li> <li>Transmission of the RTCM corrections DS.</li> <li>Transmission of the traffic signal phase and timing DS.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Short Description   | Included in the mapped geometry DS is a data layer which provides the lane maneuver information for the mapped geometry, which constitutes an intersection. Also provided in the mapped geometry is information indicating which signal control contained in the traffic signal phase and timing DS applies to the lanes. A CV, which supports an intersection violation application uses this information, in addition to the base mapped geometry information, RTCM corrections, and traffic signal phase and timing DS, to determine the location in their lane, where the maneuver applies, and the current state of the maneuver to determine if the driver should be informed to stop, assuming the CV supports that application functionality. |
| Goal                | To aid a CV in determining if the driver should be informed to stop at an intersection.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

|                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Constraints      | <ul style="list-style-type: none"> <li>• Mapped geometry, RTCM corrections, and traffic signal phase and timing DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry, RTCM corrections, and traffic signal phase and timing DSs via the supported interface(s).</li> <li>• The CV supports an intersection violation warning application.</li> <li>• Security solution in place to enable secure data exchange and authentication of data sources.</li> </ul>                                                                                                                                                                                                                                                                                 |
| Geographic Scope | Localized to the intersection represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Actors           | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Illustration     | <p>The diagram illustrates a four-way intersection with various lane configurations. Lane IDs are numbered: 19, 17, 15, 6, 4 (top); 8, 10, 21, 23, 25 (left); 13, 11, 9, 2 (right); and 12, 14, 1, 3, 5 (bottom). Signal group IDs are shown as circles with numbers: 2, 1, 5, 4, 1, 2, 3, 5. Maneuver information is indicated by yellow dots. A red car is shown in the bottom lane (lane 7). A legend box contains the following information:</p> <ul style="list-style-type: none"> <li># Lane ID</li> <li># Signal Group ID</li> <li>● Maneuver Information Provided</li> <li>○ Reference Point</li> </ul> <p>Additional labels include 'Mapped Geometry' with a cloud icon, 'RTCM Corrections', and 'Traffic Signal Phase and Timing'.</p>                                                             |
| Preconditions    | <ul style="list-style-type: none"> <li>• Table 2 - Operational scenario 1: Mapped geometry availability and selection.</li> <li>• Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections.</li> <li>• The CV is receiving the traffic signal phase and timing DSs corresponding to the mapped geometry and supports an intersection violation application.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                    |
| Main Flow        | <p>After decoding the mapped geometry data and applying the RTCM corrections:</p> <ol style="list-style-type: none"> <li>1. The CV determines which lane it is in.</li> <li>2. The CV decodes the appropriate data layers to determine that it is in a lane which has allowed maneuver information provided.</li> <li>3. The CV decodes the appropriate data layers to determine the signal group identifier (ID) linkage to the traffic signal phase and timing for identifying the current state of the maneuver control.</li> <li>4. It decodes the traffic signal phase and timing DS to obtain the control and timing information for the signal group ID corresponding to its lane.</li> <li>5. If necessary, the CV notifies the driver to stop depending on the CV application specifics.</li> </ol> |

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|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alternate Flow(s)           | The intersection may be one that is controlled by a stop sign. In this case no traffic signal phase and timing and possibly no RTCM corrections DSs may be required. However, the RTCM corrections DSs would enable the CV to determine the precise stop line location and apply its application specific information to determine if to notify the driver or not.                                                                                                                                                                                                     |
| Post-Conditions             | The CV continues to process mapped intersection geometry attributes relevant to its application set until it departs the mapped area.                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Information Requirements    | <ul style="list-style-type: none"> <li>• Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>• RTCM corrections DS corresponding to the mapped geometry DS.</li> <li>• Traffic signal phase and timing DSs corresponding to the mapped geometry DS.</li> <li>• CV position.</li> <li>• Stop line location for the lane.</li> <li>• Allowed lane connection maneuvers for the lane.</li> <li>• Signal group ID corresponding to the lane connection.</li> <li>• Signal control and timing information for the lane.</li> </ul> |
| Source Documents/References | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

#### 5.9.2.2 Curve Geometry with Speed Indication

**Table 6 - Operational scenario 5: Mapped geometry with curve advisory speed indication**

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Mapped Geometry with Curve Advisory Speed Indication                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Category            | Safety                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Infrastructure Role | <ul style="list-style-type: none"> <li>• Delivery of the mapped geometry DS.</li> <li>• Transmission of the RTCM corrections DS.</li> </ul>                                                                                                                                                                                                                                                                                                                                              |
| Short Description   | Included in the mapped geometry DS is a data layer with the speed for the mapped geometry. Included in this data layer is the location of an advisory speed which applies to a curved portion of the mapped roadway. A CV, which supports a curve speed warning application uses this information, in addition to the base mapped geometry information and RTCM corrections, to determine if the lane applies to them and if the driver should be informed of a reduced speed condition. |
| Goal                | To aid a CV in determining if the driver should be informed to slow down for an approaching curve.                                                                                                                                                                                                                                                                                                                                                                                       |
| Constraints         | <ul style="list-style-type: none"> <li>• Mapped geometry and RTCM corrections DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry and RTCM corrections DSs via the supported interface(s).</li> <li>• The CV supports a speed warning application.</li> <li>• Security solution in place to enable secure data exchange and authentication of data sources.</li> </ul>                                                   |
| Geographic Scope    | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Actors              | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                           |

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Illustration                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Preconditions               | <ul style="list-style-type: none"> <li>Table 2 - Operational scenario 1: Mapped geometry availability and selection.</li> <li>Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections.</li> <li>The CV supports a speed information application.</li> </ul>                                                                                                                                                                                  |
| Main Flow                   | <p>After decoding the mapped geometry data and applying the RTCM corrections:</p> <ol style="list-style-type: none"> <li>The CV determines it is in the curved lane represented by the mapped geometry DS.</li> <li>The CV evaluates its speed versus the advisory speed indicated in the mapped geometry data for the curve.</li> <li>If necessary, the CV notifies the driver of a reduced speed condition for the curve depending on the CV application specifics.</li> </ol> |
| Alternate Flow(s)           | <ol style="list-style-type: none"> <li>The CV determines it is not in the curved lane represented by the mapped geometry DS.</li> <li>No further operations are performed by the CV regarding the mapped geometry DS.</li> </ol>                                                                                                                                                                                                                                                 |
| Post-Conditions             | The CV continues to process mapped curve geometry attributes relevant to its application set until it departs the mapped area.                                                                                                                                                                                                                                                                                                                                                   |
| Information Requirements    | <ul style="list-style-type: none"> <li>Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>RTCM corrections DS corresponding to the mapped geometry DS.</li> <li>CV position.</li> <li>Speed information for the lane.</li> </ul>                                                                                                                                                                                                       |
| Source Documents/References | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

### 5.9.2.3 Fixed-Time Restricted Right Turn on Red

**Table 7 - Operational scenario 6: Fixed-time restricted right turn on red**

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Fixed-time Restricted Right Turn on Red                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Category            | Safety, Mobility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Infrastructure Role | <ul style="list-style-type: none"> <li>Delivery of the mapped geometry DS.</li> <li>Transmission of the traffic signal phase and timing DS.</li> <li>Transmission of the RTCM corrections DS.</li> </ul>                                                                                                                                                                                                                                                                                                                             |
| Short Description   | Included in the mapped geometry DS is a data layer which provides the lane maneuver information for the mapped geometry, which constitutes an intersection. For one of the lanes, information is provided which indicates that a right turn on red is not allowed within a certain timeframe. A CV in this lane uses this information, in addition to the base mapped geometry information, the traffic signal phase and timing, and RTCM corrections, to determine if a right turn on red is allowed given the current time of day. |
| Goal                | To aid a CV in determining if a right turn on red is allowed given the current time of day.                                                                                                                                                                                                                                                                                                                                                                                                                                          |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
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| Constraints              | <ul style="list-style-type: none"> <li>• Mapped geometry, traffic signal phase and timing, and RTCM corrections related DSs are available at the location the CV is driving.</li> <li>• The CV supports and can receive the mapped geometry, traffic signal phase and timing, and RTCM corrections related DSs via the supported interface(s).</li> <li>• Security solution in place to enable secure data exchange and authentication of data sources.</li> </ul>                                                                                                                                                                                             |
| Geographic Scope         | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Actors                   | <ul style="list-style-type: none"> <li>• Infrastructure-based communications system.</li> <li>• CV.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Illustration             | <p># Lane ID<br/>     ● Maneuver Information Provided<br/>     ● Time Restricted Maneuver Information<br/>     # Signal Group ID<br/>     ● Reference Point</p> <p>NO TURN ON RED<br/>     3PM - 6PM</p> <p>Mapped Geometry<br/>     • RTCM Corrections<br/>     • Traffic Signal Phase and Timing</p>                                                                                                                                                                                                                                                                                                                                                         |
| Preconditions            | <ul style="list-style-type: none"> <li>• Table 2 - Operational scenario 1: Mapped geometry availability and selection.</li> <li>• Table 3 - Operational scenario 2: Mapped geometry lane selection using position corrections.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Main Flow                | <p>After decoding the mapped geometry data and applying the RTCM corrections:</p> <ol style="list-style-type: none"> <li>1. The CV determines which lane it is in.</li> <li>2. The CV decodes the appropriate data layers to determine that it is in a lane which has time restricted right turn on red maneuver information.</li> <li>3. The CV determines the current time of day falls within the time restriction.</li> <li>4. The CV decodes the traffic signal phase and timing DS and determines that the current signal status for its lane is red.</li> <li>5. The CV informs the driver that no right turn on red is currently active.</li> </ol>    |
| Alternate Flow(s)        | <ul style="list-style-type: none"> <li>• The current time of day does not fall within the time restriction.</li> <li>• The CV completes a right turn when cross-traffic is such that it is safe to do so.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Post-Conditions          | The CV processes continues to process the traffic signal phase and timing data and makes the right turn when the light turns green.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Information Requirements | <ul style="list-style-type: none"> <li>• Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>• RTCM corrections DS corresponding to the mapped geometry DS.</li> <li>• Traffic signal phase and timing DSs corresponding to the mapped geometry DS.</li> <li>• CV position.</li> <li>• Stop line location for the lane.</li> <li>• Allowed lane connection maneuvers for the lane.</li> <li>• Maneuver time restriction data for the lane.</li> <li>• Signal group ID corresponding to the lane connection.</li> <li>• Signal control and timing information for the lane.</li> <li>• Current time of day.</li> </ul> |

|                             |     |
|-----------------------------|-----|
| Source Documents/References | N/A |
|-----------------------------|-----|

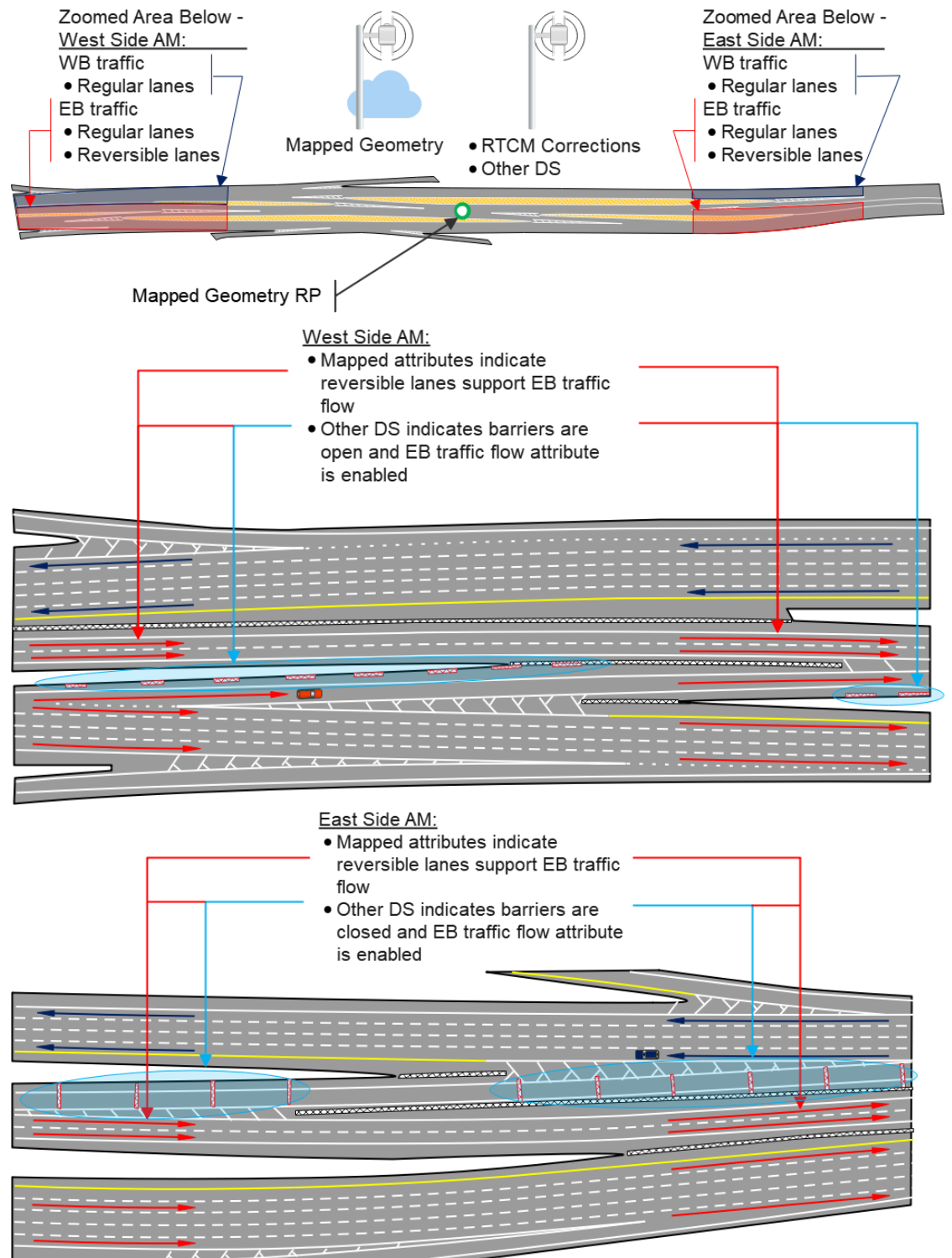
## 5.9.2.4 Variable Time Restricted Reversible Lanes

**Table 8 - Operational scenario 7: Variable time restricted reversible lanes**

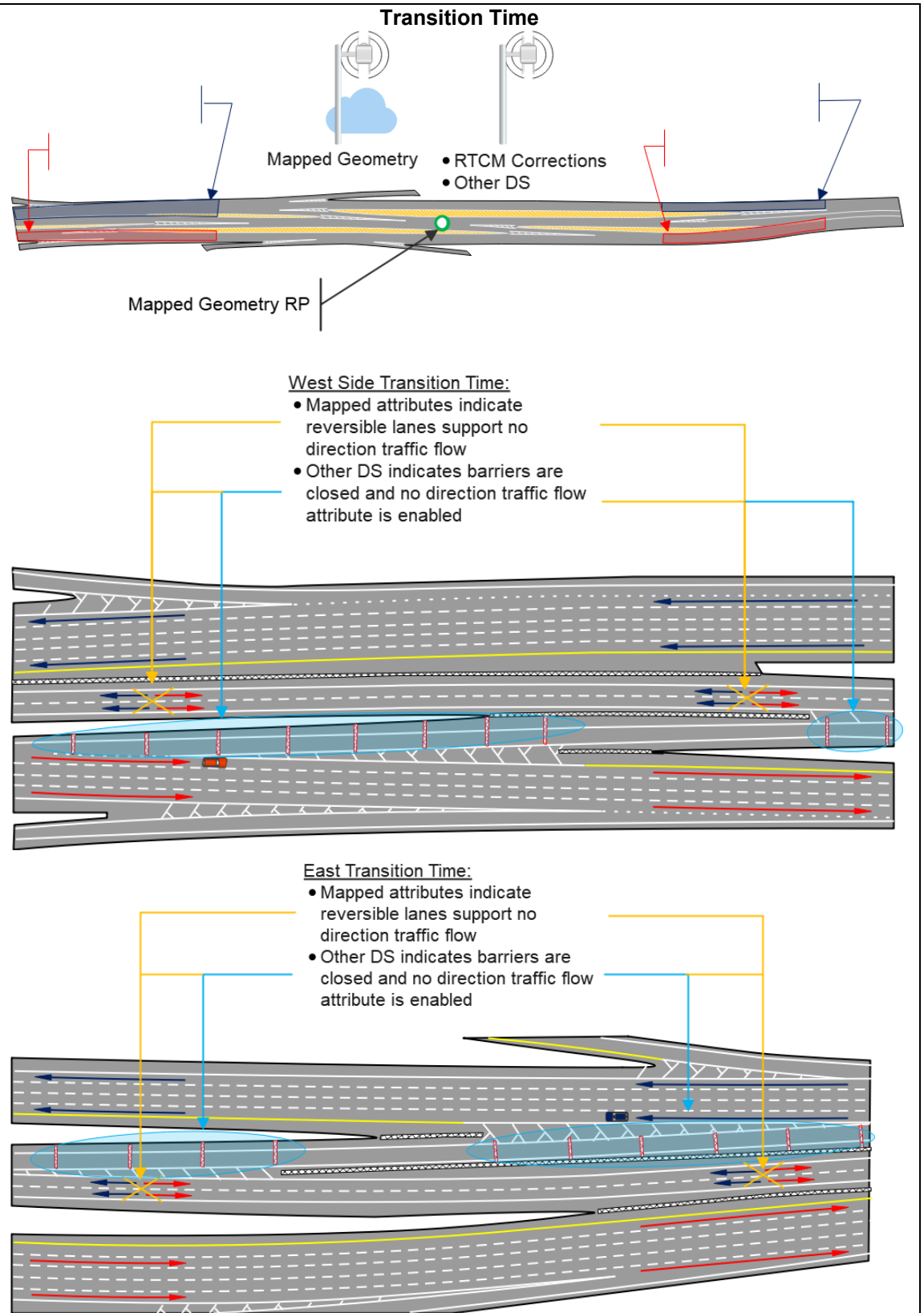
|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use Case Name       | Variable Time Restricted Reversible Lanes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Category            | Mobility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Infrastructure Role | <ul style="list-style-type: none"><li>• Delivery of the mapped geometry DS.</li><li>• Transmission of the other DS.</li><li>• Transmission of the RTCM corrections DS.</li></ul>                                                                                                                                                                                                                                                                                                                                                           |
| Short Description   | Included in the mapped geometry DS are data layers indicating multiple directions of travel attributes for the reversible lanes contained in the mapped geometry DS which are time restricted. Also included is an indication that the time restrictions are controlled by another DS. A CV uses this information, in addition to the base mapped geometry information, the other DS, and RTCM corrections, to determine which lane direction applies and if the driver should be informed given the vehicle's current driving conditions. |
| Goal                | To aid a CV in determining which lanes are available given its current driving direction and supported lane direction of travel.                                                                                                                                                                                                                                                                                                                                                                                                           |
| Constraints         | <ul style="list-style-type: none"><li>• Mapped geometry, Other, and RTCM corrections related DSs are available at the location the CV is driving.</li><li>• The CV supports and can receive the mapped geometry, Other, and RTCM corrections related DSs via the supported interface(s).</li><li>• Security solution in place to enable secure data exchange and authentication of data sources.</li></ul>                                                                                                                                 |
| Geographic Scope    | Localized to the geographic area represented by the mapped geometry DS.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Actors              | <ul style="list-style-type: none"><li>• Infrastructure-based communications system.</li><li>• CV.</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                |

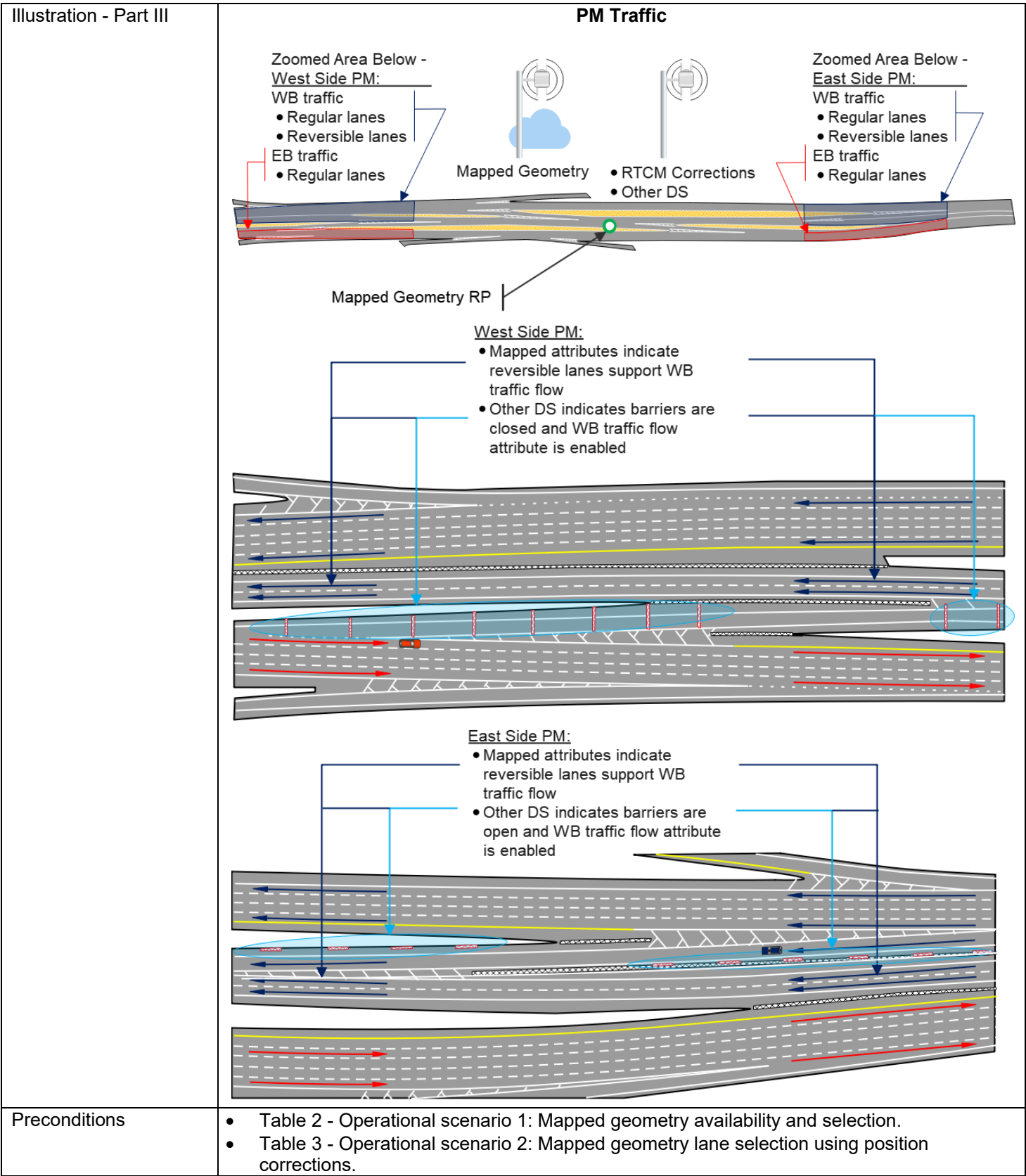
## Illustration - Part I

## AM Traffic



## Illustration - Part II





|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Main Flow                   | <p>After decoding the mapped geometry data and applying the RTCM corrections:<br/>For 'Illustration - Part I' - AM Traffic:</p> <ol style="list-style-type: none"> <li>1. An east-bound CV (middle illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are open and support EB direction traffic.</li> <li>• Informs the driver which leads to the driver maneuvering to the reversible lane entrance.</li> </ul> </li> <li>2. A west-bound CV (bottom illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are closed and do not support WB direction traffic.</li> <li>• Informs the driver which leads to the driver remaining in the regular lanes.</li> </ul> </li> </ol> <p>For 'Illustration - Part II' - Transition Time:</p> <ol style="list-style-type: none"> <li>1. An east-bound CV (middle illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are closed and do not support EB direction traffic.</li> <li>• Informs the driver which leads to the driver remaining in the regular lanes.</li> </ul> </li> <li>2. A west-bound CV (bottom illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are closed and do not support WB direction traffic.</li> <li>• Informs the driver which leads to the driver remaining in the regular lanes.</li> </ul> </li> </ol> <p>For 'Illustration - Part III' - PM Traffic:</p> <ol style="list-style-type: none"> <li>1. An east-bound CV (middle illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are closed and do not support EB direction traffic.</li> <li>• Informs the driver which leads to the driver remaining in the regular lanes.</li> </ul> </li> <li>2. A west-bound CV (bottom illustration) wishing to use the reversible lanes: <ul style="list-style-type: none"> <li>• Determines that the lanes are open and support WB direction traffic.</li> <li>• Informs the driver which leads to the driver maneuvering to the reversible lane entrance.</li> </ul> </li> </ol> |
| Alternate Flow(s)           | <ul style="list-style-type: none"> <li>• The CV's do not wish to use the reversible lanes and always remain in the regular lanes.</li> <li>• The time restrictions are static and are controlled by the time restriction ranges contained in the mapped geometry DS.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Post-Conditions             | The red CVs in 'Illustration - Part I' and 'Illustration - Part II' continue to process mapped geometry DS partitions until they depart the mapped area.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Information Requirements    | <ul style="list-style-type: none"> <li>• Mapped geometry DS which includes the RP data corresponding to the mapped geometry.</li> <li>• RTCM corrections DS corresponding to the mapped geometry DS.</li> <li>• CV positions.</li> <li>• Direction of travel time restriction data layer(s) for the mapped area.</li> <li>• Indication of the allowed direction of travel and lane open/closed status.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 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 Intelligent Transportation Systems (Intelligent Transportation Systems) Protocol (NTCIP) 8002 Annex B1 Section 3. In addition, SAE J2945 contains information on the development of the requirements used in this report.

#### 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. Text appearing in 6.1.3.1.1 through 6.1.3.1.3 implements NTCIP 8002 Annex B1 Section 3.3 and is reprinted with permission © 2016 American Association of State Highway and Transportation Officials (AASHTO)/Institute of Transportation Engineers (ITE)/National Electrical Manufacturers Association (NEMA) from NTCIP 8002 Annex B1.

The NRTM can be used by:

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

#### 6.1.3.1 Notation

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

##### 6.1.3.1.1 Conformance Symbols

The symbols in Table 9 are used to indicate status in the conformance column of the NRTM table.

**Table 9 - 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 #. <sup>(1)</sup> |
| 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.                                                                                                                                         |

<sup>(1)</sup> 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 following predicate notation may be used:

**Table 10 - 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 document are as follows:

- **RGA:** Indicates the conformance status corresponding to information regarding implementations which support the RGA.
- **TffcSgnlInfo:** Indicates the conformance status corresponding to information regarding implementations for which the RGA is intended to support DSs that provide traffic signal information.
- **Aprch:** Indicates the conformance status corresponding to information regarding implementations for which the RGA supports other DS or messages which require approach information to be included in the RGA.
- **CmptdLn:** Indicates the conformance status corresponding to information regarding implementation for which the RGA supports using computed lanes to represent lane geometry.
- **DupLn:** Indicates the conformance status corresponding to information regarding implementation for which the RGA supports using duplicate lanes to represent lane geometry.
- **TmRestFxd:** Indicates the conformance status corresponding to information regarding implementations for which the RGA supports attributes which have fixed time restrictions.
- **TmRestOthDS:** Indicates the conformance status corresponding to information regarding implementations for which the RGA supports attributes which have time restrictions which are controlled by other DS.
- **LclDistrib:** Indicates the conformance status corresponding to information regarding implementations for which the system supports local distribution of the RGA DS.
- **RGABdcst:** Indicates the conformance status corresponding to information regarding implementations for which the system supports a local broadcast distribution of the RGA DS.
- **WSA:** Indicates the conformance status corresponding to information regarding implementations for which the system supports a local connection-based distribution of the RGA via a WSA advertisement.

#### 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) in the support column:

**Table 11 - Support column 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.

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 responses 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) choice.

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

**Table 12 - 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 Infrastructure Connected Vehicle Interface |                                               |                             | M           | Yes     |                           |
|                          | Arch-ExtIntf-DSDeliv-1                               | 6.2.1.1 - Data Set Delivery (DSDeliv)         |                             | M           | Yes     |                           |
| 5.4.2                    | GNSS Interface                                       |                                               |                             | M           | Yes     |                           |
|                          | Arch-ExtIntf-GNSS-1                                  | 6.2.1.2 - GNSS Interface (GNSS)               |                             | M           | Yes     |                           |
| 5.4.3                    | Time Interface                                       |                                               |                             | M           | Yes     |                           |
|                          | Arch-ExtIntf-Tm-1                                    | 6.2.1.3 - Time Interface (Tm)                 |                             | M           | Yes     |                           |
| 5.4.4                    | SCMS Interface                                       |                                               |                             | M           | Yes     |                           |
|                          | Arch-ExtIntf-SCMS-1                                  | 6.2.1.4 - SCMS Interface (SCMS)               |                             | M           | Yes     |                           |
| 5.4.4                    | Data Content Acquisition                             |                                               |                             | RGA:M       | Yes     |                           |
|                          | Arch-ExtIntf-DatAqstn-1                              | 6.2.1.5 - Data Content Acquisition (DatAqstn) |                             | M           | Yes     |                           |

| User Need Section Number | User Need Title | FR ID                                                           | FR Section Number and Title                                | Conformance                  | Support | Additional Specifications |
|--------------------------|-----------------|-----------------------------------------------------------------|------------------------------------------------------------|------------------------------|---------|---------------------------|
| 5.5                      | Features        |                                                                 |                                                            | M                            | Yes     |                           |
| 5.5.1                    | Data Set        |                                                                 |                                                            | M                            | Yes     |                           |
| 5.5.1.1                  | Uniformity      |                                                                 |                                                            | M                            | Yes     |                           |
|                          |                 | DatXchg-RGA-Gen-1                                               | 6.4.1.1 - General (Gen)                                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-Gen-2                                               | 6.4.1.1 - General (Gen)                                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MsgFram-MinCont-1                                   | 6.4.1.2.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MsgFram-MsgID-1                                     | 6.4.1.2.2 - Message ID (MsgID)                             | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MsgFram-MsgTyp-1                                    | 6.4.1.2.3 - Message Type (MsgTyp)                          | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-Msg-MinCont-1                                       | 6.4.1.3.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-DS-MinCont-1                                        | 6.4.1.4.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-MinCont-1                                    | 6.4.1.5.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-DSFmtVer-1                                   | 6.4.1.5.2 - Data Set Format Version Information (DSFmtVer) | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-DSFmtVer-2                                   | 6.4.1.5.2 - Data Set Format Version Information (DSFmtVer) | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MinCont-1                                  | 6.4.1.6.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-MinCont-1                 | 6.4.1.6.2.1 - Minimum Content (MinCont)                    | Aprch:M                      | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-MinCont-1                      | 6.4.1.6.3.1 - Minimum Content (MinCont)                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-MinCont-1   | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                     | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-MinCont-1 | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                    | Cmptd:M                      | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-TmRest-MinCont-1               | 6.4.1.6.3.20 - Time Restrictions (TmRest)                  | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-MinCont-1                        | 6.4.1.6.4.1 - Minimum Content (MinCont)                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-MinCont-1     | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                     | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-TmRest-MinCont-1                 | 6.4.1.6.4.15 - Time Restrictions (TmRest)                  | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-MinCont-1                        | 6.4.1.6.5.1 - Minimum Content (MinCont)                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-MinCont-1     | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                     | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-TmRest-MinCont-1                 | 6.4.1.6.5.15 - Time Restrictions (TmRest)                  | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MinCont-1                                  | 6.4.1.7.1 - Minimum Content (MinCont)                      | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-MinCont-1               | 6.4.1.7.2.1 - Minimum Content (MinCont)                    | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-TmRest-MinCont-1        | 6.4.1.7.2.6 - Time Restrictions (TmRest)                   | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |

| User Need Section Number | User Need Title | FR ID                                                                        | FR Section Number and Title                                   | Conformance                  | Support | Additional Specifications |
|--------------------------|-----------------|------------------------------------------------------------------------------|---------------------------------------------------------------|------------------------------|---------|---------------------------|
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-MinCont-2                               | 6.4.1.7.3.1 - Minimum Content (MinCont)                       | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-TmRest-MinCont-1                        | 6.4.1.7.3.8 - Time Restrictions (TmRest)                      | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrslLyr-MinCont-2                        | 6.4.1.7.4.1 - Minimum Content (MinCont)                       | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrslLyr-TmRest-MinCont-1                 | 6.4.1.7.4.9 - Time Restrictions (TmRest)                      | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-MinCont-2                                 | 6.4.1.7.5.1 - Minimum Content (MinCont)                       | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-TmRest-MinCont-1                          | 6.4.1.7.5.8 - Time Restrictions (TmRest)                      | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MinCont-1                                             | 6.4.1.8.1 - Minimum Content (MinCont)                         | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-MinCont-1                           | 6.4.1.8.2.1 - Minimum Content (MinCont)                       | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-3                        | 6.4.1.8.2.4 - Location Speed Limits (LocSpdLmts)              | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdldxXYZOffset-MinCont-1 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdldxXYZOffset)          | RGA:M                        | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-MaxSpdTmRest-MinCont-1   | 6.4.1.8.2.8 - Maximum Speed Time Restrictions (MaxSpdTmRest)  | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-MinSpdTmRest-MinCont-1   | 6.4.1.8.2.10 - Minimum Speed Time Restrictions (MinSpdTmRest) | TmRestFxd:M<br>TmRestOthDS:M | Yes     |                           |
|                          |                 | Opr-RGA-CmnWay-Ndldx-1                                                       | 6.5.1.1.1 - Node Index (Ndldx)                                | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-CmnWay-Ndldx-2                                                       | 6.5.1.1.1 - Node Index (Ndldx)                                | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-CmnWay-LnWdth-1                                                      | 6.5.1.1.2 - Lane Width (LnWdth)                               | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-CmnWay-LnWdth-2                                                      | 6.5.1.1.2 - Lane Width (LnWdth)                               | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-CmnWay-LnCentr-1                                                     | 6.5.1.1.3 - Lane Center (LnCentr)                             | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-NdXYZPtSel-Gen-1                                            | 6.5.1.2.1.1 - General (Gen)                                   | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-NdXYZPtSel-Gen-2                                            | 6.5.1.2.1.1 - General (Gen)                                   | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-NdXYZPtSel-Gen-3                                            | 6.5.1.2.1.1 - General (Gen)                                   | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-LnSplit-4                                                   | 6.5.1.2.2 - Lane Splitting (LnSplit)                          | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-LnSplit-5                                                   | 6.5.1.2.2 - Lane Splitting (LnSplit)                          | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-MtrVehLn-LnSplit-6                                                   | 6.5.1.2.2 - Lane Splitting (LnSplit)                          | RGA:M                        | Yes     |                           |
|                          |                 | Opr-RGA-BikeLn-NdXYZPtSel-Gen-1                                              | 6.5.1.3.1.1 - General (Gen)                                   | RGA:M                        | Yes     |                           |

| User Need Section Number | User Need Title              | FR ID                                                             | FR Section Number and Title                                                | Conformance    | Support | Additional Specifications |
|--------------------------|------------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------|----------------|---------|---------------------------|
|                          |                              | Opr-RGA-BikeLn-NdXYZPtSel-Gen-2                                   | 6.5.1.3.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-BikeLn-NdXYZPtSel-Gen-3                                   | 6.5.1.3.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-BikeLn-LnSplit-4                                          | 6.5.1.3.2 - Lane Splitting (LnSplit)                                       | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-BikeLn-LnSplit-5                                          | 6.5.1.3.2 - Lane Splitting (LnSplit)                                       | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-BikeLn-LnSplit-6                                          | 6.5.1.3.2 - Lane Splitting (LnSplit)                                       | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-XwklLn-NdXYZPtSel-Gen-1                                   | 6.5.1.4.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-XwklLn-NdXYZPtSel-Gen-2                                   | 6.5.1.4.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-XwklLn-NdXYZPtSel-Gen-3                                   | 6.5.1.4.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | Opr-RGA-XwklLn-NdXYZPtSel-Gen-4                                   | 6.5.1.4.1.1 - General (Gen)                                                | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-WSA-MinCont-1                                             | 6.4.2.1 - Minimum Content (MinCont)                                        | WSA:M          | Yes     | SAE J3161                 |
|                          |                              | DatXchg-WSA-RGAAppDataPyld-MinCont-1                              | 6.4.2.4.1 - Minimum Content (MinCont)                                      | WSA:M          | Yes     |                           |
|                          |                              | DatXchg-WSA-RGAAppDataPyld-FmtVer-1                               | 6.4.2.4.2 - WSA Application Data Format Version Information (AppDatFmtVer) | WSA:M          | Yes     |                           |
|                          |                              | DatXchg-WSA-RGAAppDataPyld-FmtVer-2                               | 6.4.2.4.2 - WSA Application Data Format Version Information (AppDatFmtVer) | WSA:M          | Yes     |                           |
| 5.5.1.2                  | Conciseness and Completeness |                                                                   |                                                                            | M              | Yes     |                           |
|                          |                              | DatXchg-RGA-Msg-MultDS-1                                          | 6.4.1.3.2 - Multiple Data Sets (MultDS)                                    | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-AprchGeomInfo-2             | 6.4.1.6.2.2 - Approach Geometry Information (AprchGeomInfo)                | Aprch:M        | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-AprchGeomInfo-WayTypIDSet-1 | 6.4.1.6.2.4 - Way Type ID Set (WayTypIDSet)                                | Aprch:M        | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-AprchGeomInfo-WayTypIDSet-3 | 6.4.1.6.2.4 - Way Type ID Set (WayTypIDSet)                                | Aprch:M        | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-2                                | 6.4.1.6.3 - Motor Vehicle Lane Geometry Layer (MtrVehLnLyr)                | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnGeomInfo-1                     | 6.4.1.6.3.2 - Lane Geometry Information (LnGeomInfo)                       | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnGeomInfo-2                     | 6.4.1.6.3.2 - Lane Geometry Information (LnGeomInfo)                       | TffcSgnlInfo:M | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnGeomInfo-3                     | 6.4.1.6.3.2 - Lane Geometry Information (LnGeomInfo)                       | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnGeomInfo-4                     | 6.4.1.6.3.2 - Lane Geometry Information (LnGeomInfo)                       | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-9             | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                                     | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-2           | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)                      | RGA:M          | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-8           | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                                    | Cmptd:M        | Yes     |                           |



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|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-2                                               | 6.4.1.6.4 - Bicycle Lane Geometry Layer (BikeLnLyr)   | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-LnGeomInfo-1                                    | 6.4.1.6.4.2 - Lane Geometry Information (LnGeomInfo)  | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-LnGeomInfo-2                                    | 6.4.1.6.4.2 - Lane Geometry Information (LnGeomInfo)  | TffcSgnlInfo:M | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-LnGeomInfo-3                                    | 6.4.1.6.4.2 - Lane Geometry Information (LnGeomInfo)  | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-LnGeomInfo-4                                    | 6.4.1.6.4.2 - Lane Geometry Information (LnGeomInfo)  | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-9                            | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-2                          | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth) | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-2                                               | 6.4.1.6.5 - Crosswalk Lane Geometry Layer (XwklLnLyr) | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-LnGeomInfo-1                                    | 6.4.1.6.5.2 - Lane Geometry Information (LnGeomInfo)  | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-LnGeomInfo-2                                    | 6.4.1.6.5.2 - Lane Geometry Information (LnGeomInfo)  | TffcSgnlInfo:M | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-LnGeomInfo-3                                    | 6.4.1.6.5.2 - Lane Geometry Information (LnGeomInfo)  | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-9                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-2                          | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth) | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-8 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)  | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-MtrVehLn-NdXYZPtSel-Gen-4                                              | 6.5.1.2.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-MtrVehLn-NdXYZPtSel-Gen-5                                              | 6.5.1.2.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-MtrVehLn-LnSplit-3                                                     | 6.5.1.2.2 - Lane Splitting (LnSplit)                  | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-BikeLn-NdXYZPtSel-Gen-4                                                | 6.5.1.3.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-BikeLn-NdXYZPtSel-Gen-5                                                | 6.5.1.3.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-BikeLn-LnSplit-3                                                       | 6.5.1.3.2 - Lane Splitting (LnSplit)                  | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-XwklLn-NdXYZPtSel-Gen-5                                                | 6.5.1.4.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
|                          |                        | Opr-RGA-XwklLn-NdXYZPtSel-Gen-6                                                | 6.5.1.4.1.1 - General (Gen)                           | RGA:M          | Yes     |                           |
| 5.5.1.3                  | Data Quality           |                                                                                |                                                       | M              | Yes     |                           |
|                          |                        | Tx-Cmn-MinCnd-1                                                                | 6.6.1.1 - Minimum Conditions (MinCnd)                 | RGA:M          | Yes     |                           |
| 5.5.1.4                  | Extensibility          |                                                                                |                                                       | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-DS-Extsbl-1                                                        | 6.4.1.4.2 - Extensibility (Extsbl)                    | M              | Yes     |                           |
| 5.5.1.5                  | Content Identification |                                                                                |                                                       | RGA:M          | Yes     |                           |
|                          |                        | DatXchg-RGA-BasLyr-ContVer-1                                                   | 6.4.1.5.5.1 - Content Version (ContVer)               | RGA:M          | Yes     |                           |

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|                          |                              | DatXchg-RGA-BasLyr-ContVer-2                               | 6.4.1.5.5.1 - Content Version (ContVer)                                      | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-SvcPSID-1                                      | 6.4.2.2 - Service PSID (SvcPSID)                                             | WSA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-HostIPAddr-1                                   | 6.4.2.3 - Host IP Address (HostIPAddr)                                       | WSA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-RGAAppDataPyld-RGABasLyr-1                     | 6.4.2.4.3 - RGA Base Layer (RGABasLyr)                                       | WSA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-HTTPSGet-1                                     | 6.4.2.5 - HTTPS Get (HTTPSGet)                                               | WSA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-HTTPSGet-2                                     | 6.4.2.5 - HTTPS Get (HTTPSGet)                                               | WSA:M       | Yes     |                           |
|                          |                              | DatXchg-WSA-HTTPSGet-3                                     | 6.4.2.5 - HTTPS Get (HTTPSGet)                                               | WSA:M       | Yes     |                           |
| 5.5.2                    | Timing                       |                                                            |                                                                              | M           | Yes     |                           |
| 5.5.2.1                  | Common Understanding of Time |                                                            |                                                                              | M           | Yes     |                           |
|                          |                              | Sys-Tmg-TmRef-1                                            | 6.3.2.1 - Time Reference (TmRef)                                             | M           | Yes     |                           |
|                          |                              | Sys-Tmg-TmRef-2                                            | 6.3.2.1 - Time Reference (TmRef)                                             | M           | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-RefPt-TmCalc-1                          | 6.4.1.5.3.2 - Time of Calculation (TmCalc)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-ContDtTm-1                              | 6.4.1.5.5.2 - Content Date Time (ContDtTm)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtTmCalc-1 | 6.4.1.6.3.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtTmCalc-1   | 6.4.1.6.4.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-XwlkLnLyr-PhyXYZNd-AltRefPtTmCalc-1   | 6.4.1.6.5.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
| 5.5.2.2                  | Time Resolution and Accuracy |                                                            |                                                                              | M           | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-RefPt-TmCalc-2                          | 6.4.1.5.3.2 - Time of Calculation (TmCalc)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-RefPt-TmCalc-3                          | 6.4.1.5.3.2 - Time of Calculation (TmCalc)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-ContDtTm-2                              | 6.4.1.5.5.2 - Content Date Time (ContDtTm)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-BasLyr-ContDtTm-3                              | 6.4.1.5.5.2 - Content Date Time (ContDtTm)                                   | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtTmCalc-2 | 6.4.1.6.3.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtTmCalc-3 | 6.4.1.6.3.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtTmCalc-2   | 6.4.1.6.4.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtTmCalc-3   | 6.4.1.6.4.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-XwlkLnLyr-PhyXYZNd-AltRefPtTmCalc-2   | 6.4.1.6.5.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
|                          |                              | DatXchg-RGA-GeomCtnr-XwlkLnLyr-PhyXYZNd-AltRefPtTmCalc-3   | 6.4.1.6.5.7 - Alternate Reference Point Time of Calculation (AltRefPtTmCalc) | RGA:M       | Yes     |                           |
| 5.5.2.3                  | Timeliness                   |                                                            |                                                                              | M           | Yes     |                           |
|                          |                              | Tx-LclBdcst-Tmg-1                                          | 6.6.2.1 - Timing (Tmg)                                                       | RGABdcst:M  | Yes     |                           |

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|                          |                                  | Tx-CnxnBasd-WSA-1                                       | 6.6.3.1 - WAVE Service Advertisement (WSA)                     | WSA:M       | Yes     | SAE J3161                 |
| 5.5.3                    | Positioning                      |                                                         |                                                                | M           | Yes     |                           |
| 5.5.3.1                  | Common Understanding of Position |                                                         |                                                                | M           | Yes     |                           |
|                          |                                  | Sys-Pos-RefSrc-1                                        | 6.3.1.1 - LLE Position Reference Source (RefSrc)               | RGA:M       | Yes     |                           |
|                          |                                  | Sys-Pos-CoordSys-LLE-1                                  | 6.3.1.2.1 - Latitude, Longitude, Elevation (LLE)               | RGA:M       | Yes     |                           |
|                          |                                  | Sys-Pos-CoordSys-XYZ-1                                  | 6.3.1.2.2 - X, Y, Z (XYZ)                                      | RGA:M       | Yes     |                           |
|                          |                                  | Sys-Pos-GndRefPos-LLE-1                                 | 6.3.1.3.1 - Latitude, Longitude, Elevation (LLE)               | RGA:M       | Yes     |                           |
|                          |                                  | Sys-Pos-GndRefPos-XYZ-1                                 | 6.3.1.3.2 - X, Y, Z (XYZ)                                      | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-BasLyr-RefPt-Loc-2                          | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-BasLyr-RefPt-Loc-5                          | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-BasLyr-RefPt-Loc-8                          | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-BasLyr-RefPt-Loc-9                          | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-1 | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-4 | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-7 | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-8 | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-2   | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-3   | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-4   | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-2 | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-3 | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-1   | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-4   | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-7   | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-8   | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-2     | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                  | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-3     | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |



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|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-4                            | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-1                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-4                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-7                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-8                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-2                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-3                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-4                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-2 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-3 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
| 5.5.3.2                  | Positions       | Resolution and Accuracy                                                        |                                                                | M           | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-3                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-4                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-6                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-7                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-8                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-9                                                 | 6.4.1.5.3.1 - Location (Loc)                                   | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-2                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-3                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-5                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-6                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-7                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPtLoc-8                        | 6.4.1.6.3.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-5                          | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |



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|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-6           | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-7           | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-8           | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-4         | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-5         | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-4         | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-5         | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-6         | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-7         | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                        | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnPlnrGeom-CmptdXYZNd-LnWdth-2 | 6.4.1.6.3.17 - Lane Width (LnWdth)                             | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnPlnrGeom-CmptdXYZNd-LnWdth-3 | 6.4.1.6.3.17 - Lane Width (LnWdth)                             | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-2           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-3           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-5           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-6           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-7           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPtLoc-8           | 6.4.1.6.4.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-5             | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-6             | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-7             | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-8             | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |

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|                          |                                       | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-4                          | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-5                          | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-2                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-3                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-5                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-6                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-7                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPtLoc-8                          | 6.4.1.6.5.6 - Alternate Reference Point Location (AltRefPtLoc) | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-5                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-6                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-7                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-8                            | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                         | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-4                          | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-5                          | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth)          | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-4 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-5 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-6 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
|                          |                                       | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-NdIdxXYZOffset-NdOffsets-7 | 6.4.1.8.2.6 - Node Index XYZ Offset (NdIdxXYZOffset)           | RGA:M       | Yes     |                           |
| 5.5.4                    | Road Geometry and Attributes Features |                                                                                |                                                                | M           | Yes     |                           |



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| 5.5.4.1                  | Identification             |                                                                   |                                                        | M           | Yes     |                           |
| 5.5.4.1.1                | Mapped Road Identification |                                                                   |                                                        | RGA:M       | Yes     |                           |
|                          |                            | DatXchg-RGA-BasLyr-RdGeomID-2                                     | 6.4.1.5.4 - Road Geometry Reference ID (RdGeomID)      | M           | Yes     |                           |
|                          |                            | DatXchg-RGA-BasLyr-RdGeomID-3                                     | 6.4.1.5.4 - Road Geometry Reference ID (RdGeomID)      | M           | Yes     |                           |
| 5.5.4.1.2                | Mapped Way Identification  |                                                                   |                                                        | M           | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-AprchGeomInfo-AppchID-1     | 6.4.1.6.2.3 - Approach ID (AprchID)                    | Aprch:M     | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnAprchLyr-AprchGeomInfo-WayTypIDSet-2 | 6.4.1.6.2.4 - Way Type ID Set (WayTypIDSet)            | Aprch:M     | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnID-1                           | 6.4.1.6.3.3 - Lane ID (LnID)                           | RGA:M       | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-BikeLnLyr-LnID-1                             | 6.4.1.6.4.3 - Lane ID (LnID)                           | RGA:M       | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-XwklLnLyr-LnID-1                             | 6.4.1.6.5.3 - Lane ID (LnID)                           | RGA:M       | Yes     |                           |
| 5.5.4.2                  | Road Geometry              |                                                                   |                                                        | M           | Yes     |                           |
| 5.5.4.2.1                | Types of Geometry          |                                                                   |                                                        | RGA:M       | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-NdXYZPtSel-LnGeo-1                               | 6.5.1.2.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-NdXYZPtSel-LnGeo-2                               | 6.5.1.2.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-NdXYZPtSel-LnGeo-3                               | 6.5.1.2.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-NdXYZPtSel-LnGeo-4                               | 6.5.1.2.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-LnSplit-1                                        | 6.5.1.2.2 - Lane Splitting (LnSplit)                   | M           | Yes     |                           |
|                          |                            | Opr-RGA-MtrVehLn-LnSplit-2                                        | 6.5.1.2.2 - Lane Splitting (LnSplit)                   | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-NdXYZPtSel-LnGeo-1                                 | 6.5.1.3.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-NdXYZPtSel-LnGeo-2                                 | 6.5.1.3.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-NdXYZPtSel-LnGeo-3                                 | 6.5.1.3.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-NdXYZPtSel-LnGeo-4                                 | 6.5.1.3.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-LnSplit-1                                          | 6.5.1.3.2 - Lane Splitting (LnSplit)                   | M           | Yes     |                           |
|                          |                            | Opr-RGA-BikeLn-LnSplit-2                                          | 6.5.1.3.2 - Lane Splitting (LnSplit)                   | M           | Yes     |                           |
|                          |                            | Opr-RGA-XwklLn-NdXYZPtSel-LnGeo-1                                 | 6.5.1.4.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-XwklLn-NdXYZPtSel-LnGeo-2                                 | 6.5.1.4.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-XwklLn-NdXYZPtSel-LnGeo-3                                 | 6.5.1.4.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
|                          |                            | Opr-RGA-XwklLn-NdXYZPtSel-LnGeo-4                                 | 6.5.1.4.1.2 - Lane Geometry (LnGeo)                    | M           | Yes     |                           |
| 5.5.4.2.2                | Lane Level Geometry        |                                                                   |                                                        | M           | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-1                       | 6.4.1.6.3.4 - Physical XYZ Node Information (PhyXYZNd) | RGA:M       | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdGeom-1                | 6.4.1.6.3.8 - Node Geometry (NdGeom)                   | RGA:M       | Yes     |                           |
|                          |                            | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdGeom-2                | 6.4.1.6.3.8 - Node Geometry (NdGeom)                   | RGA:M       | Yes     |                           |

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|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdOffsets-1           | 6.4.1.6.3.9 - Node Offsets (NdOffsets)                       | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocPlnrGeom-1       | 6.4.1.6.3.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocPlnrGeom-2       | 6.4.1.6.3.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-1         | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-2         | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-NdLocLnWdth-3         | 6.4.1.6.3.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-1                   | 6.4.1.6.3.12 - Computed XYZ Nodes (CmptdXYZNd)               | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-RefLnID-1           | 6.4.1.6.3.13 - Reference Lane ID (RefLnID)                   | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NodeGeom-1          | 6.4.1.6.3.14 - Node Geometry (NdGeom)                        | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-NdOffsets-1         | 6.4.1.6.3.15 - Node Offsets (NdOffsets)                      | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-CmptdXYZNd-LnPlnrGeom-1        | 6.4.1.6.3.16 - Lane Planar Geometry Information (LnPlnrGeom) | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-LnPlnrGeom-CmptdXYZNd-LnWdth-1 | 6.4.1.6.3.17 - Lane Width (LnWdth)                           | Cmptd:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-DupXYZNd-1                     | 6.4.1.6.3.18 - Duplicate XYZ Nodes (DupXYZNd)                | DupLn:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-DupXYZNd-RefLnID-1             | 6.4.1.6.3.19 - Reference Lane ID (RefLnID)                   | DupLn:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-1                       | 6.4.1.6.4.4 - Physical XYZ Node Information (PhyXYZNd)       | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdGeom-1                | 6.4.1.6.4.8 - Node Geometry (NdGeom)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdGeom-2                | 6.4.1.6.4.8 - Node Geometry (NdGeom)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdOffsets-1             | 6.4.1.6.4.9 - Node Offsets (NdOffsets)                       | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocPlnrGeom-1         | 6.4.1.6.4.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocPlnrGeom-2         | 6.4.1.6.4.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |



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|--------------------------|-----------------|---------------------------------------------------------|--------------------------------------------------------------|-------------|---------|---------------------------|
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-1   | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-2   | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-NdLocLnWdth-3   | 6.4.1.6.4.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-DupXYZNd-1               | 6.4.1.6.4.13 - Duplicate XYZ Nodes (DupXYZNd)                | DupLn:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-BikeLnLyr-DupXYZNd-RefLnID-1       | 6.4.1.6.4.14 - Reference Lane ID (RefLnID)                   | DupLn:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-1               | 6.4.1.6.5.4 - Physical XYZ Node Information (PhyXYZNd)       | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdGeom-1        | 6.4.1.6.5.8 - Node Geometry (NdGeom)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdGeom-2        | 6.4.1.6.5.8 - Node Geometry (NdGeom)                         | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdOffsets-1     | 6.4.1.6.5.9 - Node Offsets (NdOffsets)                       | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocPlnrGeom-1 | 6.4.1.6.5.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocPlnrGeom-2 | 6.4.1.6.5.10 - Node Location Planar Geometry (NdLocPlnrGeom) | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-1   | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-2   | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-NdLocLnWdth-3   | 6.4.1.6.5.11 - Node Location Lane Width (NdLocLnWdth)        | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-DupXYZNd-1               | 6.4.1.6.5.13 - Duplicate XYZ Nodes (DupXYZNd)                | DupLn:M     | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-XwklLnLyr-DupXYZNd-RefLnID-1       | 6.4.1.6.5.14 - Reference Lane ID (RefLnID)                   | DupLn:M     | Yes     |                           |
|                          |                 | Opr-RGA-XwklLn-NdXYZPtSel-Gen-2                         | 6.5.1.4.1.1 - General (Gen)                                  | RGA:M       | Yes     |                           |
|                          |                 | Opr-RGA-XwklLn-NdXYZPtSel-Gen-4                         | 6.5.1.4.1.1 - General (Gen)                                  | RGA:M       | Yes     |                           |
| 5.5.4.2.3                | Lane Location   |                                                         |                                                              | RGA:M       | Yes     |                           |
|                          |                 | DatXchg-RGA-BasLyr-RefPt-Loc-1                          | 6.4.1.5.3.1 - Location (Loc)                                 | M           | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPt-1    | 6.4.1.6.3.5 - Alternate Reference Point (AltRefPt)           | M           | Yes     |                           |
|                          |                 | DatXchg-RGA-GeomCtnr-MtrVehLnLyr-PhyXYZNd-AltRefPt-2    | 6.4.1.6.3.5 - Alternate Reference Point (AltRefPt)           | M           | Yes     |                           |

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|                          |                       | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPt-1    | 6.4.1.6.4.5 - Alternate Reference Point (AltRefPt)          | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-GeomCtnr-BikeLnLyr-PhyXYZNd-AltRefPt-2    | 6.4.1.6.4.5 - Alternate Reference Point (AltRefPt)          | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPt-1    | 6.4.1.6.5.5 - Alternate Reference Point (AltRefPt)          | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-GeomCtnr-XwklLnLyr-PhyXYZNd-AltRefPt-2    | 6.4.1.6.5.5 - Alternate Reference Point (AltRefPt)          | M           | Yes     |                           |
| 5.5.4.2.4                | Geometry Partitioning |                                                       |                                                             | RGA:M       | Yes     |                           |
|                          |                       | DatXchg-RGA-DS-Prtn-1                                 | 6.4.1.4.3 - Data Set Partitioning (Prtn)                    | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-DS-Prtn-2                                 | 6.4.1.4.3 - Data Set Partitioning (Prtn)                    | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-BasLyr-PrtnInfo-1                         | 6.4.1.5.6 - Partition Information (PrtnInfo)                | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-BasLyr-PrtnInfo-2                         | 6.4.1.5.6 - Partition Information (PrtnInfo)                | M           | Yes     |                           |
| 5.5.4.3                  | Movements             |                                                       |                                                             | RGA:M       | Yes     |                           |
| 5.5.4.3.1                | Intra-Lane Movements  |                                                       |                                                             | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-LnDirTrvl-1   | 6.4.1.7.2.2 - Lane Directions of Travel (LnDirTrvl)         | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-LnID-1        | 6.4.1.7.2.3 - Lane ID (LnID)                                | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-DirTrvlInfo-1 | 6.4.1.7.2.4 - Direction of Travel Information (DirTrvlInfo) | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnDirTrvlLyr-NdTrvsl-1     | 6.4.1.7.2.5 - Node Traversal (NdTrvsl)                      | M           | Yes     |                           |
| 5.5.4.3.2                | Inter-Lane Movements  |                                                       |                                                             | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-MinCont-1        | 6.4.1.7.3.1 - Minimum Content (MinCont)                     | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-LnCnxns-1        | 6.4.1.7.3.2 - Lane Connections (LnCnxns)                    | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-LnID-1           | 6.4.1.7.3.3 - Lane ID (LnID)                                | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnInfo-1       | 6.4.1.7.3.4 - Connection Information (CnxnInfo)             | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnID-1         | 6.4.1.7.3.5 - Road Geometry Connection ID (CnxnID)          | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnFrm-1        | 6.4.1.7.3.6 - Connection From Information (CnxnFrm)         | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnTo-1         | 6.4.1.7.3.7 - Connection To Information (CnxnTo)            | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnTo-2         | 6.4.1.7.3.7 - Connection To Information (CnxnTo)            | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnTo-3         | 6.4.1.7.3.7 - Connection To Information (CnxnTo)            | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnTo-4         | 6.4.1.7.3.7 - Connection To Information (CnxnTo)            | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnLyr-CnxnTo-5         | 6.4.1.7.3.7 - Connection To Information (CnxnTo)            | M           | Yes     |                           |
|                          |                       | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvsLyr-MinCont-1   | 6.4.1.7.4.1 - Minimum Content (MinCont)                     | M           | Yes     |                           |

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|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-LnCnxnsMnvr-1    | 6.4.1.7.4.2 - Lanes Connections Maneuvers (LnCnxnsMnvr)             | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-LnID-1           | 6.4.1.7.4.3 - Lane ID (LnID)                                        | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-LnCnxnMnvrInfo-1 | 6.4.1.7.4.4 - Lane Connection Maneuver Information (LnCnxnMnvrInfo) | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-CnxnID-1         | 6.4.1.7.4.5 - Connection ID (CnxnID)                                | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-CnxnID-2         | 6.4.1.7.4.5 - Connection ID (CnxnID)                                | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-CnxnMnvrInfo-1   | 6.4.1.7.4.6 - Connection Maneuver Information (CnxnMnvrInfo)        | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-AllwdMnvr-1      | 6.4.1.7.4.7 - Allowed Maneuver (AllwdMnvr)                          | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-MtrVehLnCnxnsMnvrLyr-MnvrCtrlTyp-1    | 6.4.1.7.4.8 - (MnvrCtrlTyp)                                         | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-MinCont-1               | 6.4.1.7.5.1 - Minimum Content (MinCont)                             | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-LnCnxns-1               | 6.4.1.7.5.2 - Lane Connections (LnCnxns)                            | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-LnID-1                  | 6.4.1.7.5.3 - Lane ID (LnID)                                        | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnInfo-1              | 6.4.1.7.5.4 - Connection Information (CnxnInfo)                     | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnID-1                | 6.4.1.7.5.5 - Road Geometry Connection ID (CnxnID)                  | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnFrm-1               | 6.4.1.7.5.6 - Connection From Information (CnxnFrm)                 | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnTo-1                | 6.4.1.7.5.7 - Connection To Information (CnxnTo)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnTo-2                | 6.4.1.7.5.7 - Connection To Information (CnxnTo)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnTo-3                | 6.4.1.7.5.7 - Connection To Information (CnxnTo)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnTo-4                | 6.4.1.7.5.7 - Connection To Information (CnxnTo)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-MvmtCtnr-BikeLnCnxnLyr-CnxnTo-5                | 6.4.1.7.5.7 - Connection To Information (CnxnTo)                    | M           | Yes     |                           |
| 5.5.4.4                  | Lane Use Attributes |                                                            |                                                                     | RGA:M       | Yes     |                           |
|                          |                     | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LnSpdLmts-1       | 6.4.1.8.2.2 - Lane Speed Limits (LnSpdLmts)                         | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LnID-1            | 6.4.1.8.2.3 - Lane ID (LnID)                                        | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-1      | 6.4.1.8.2.4 - Location Speed Limits (LocSpdLmts)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-WayUseCtnr-MtrVehLnSpdLmtLyr-LocSpdLmts-2      | 6.4.1.8.2.4 - Location Speed Limits (LocSpdLmts)                    | M           | Yes     |                           |
|                          |                     | DatXchg-RGA-WayUseCtnr-                                    | 6.4.1.8.2.5 - Node Index (NdIdx)                                    | M           | Yes     |                           |