

# **SPaT Challenge**

## **SPaT Infrastructure System**

### **Model Functional Requirements**

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# 1. Introduction

## 1.1 Background

The American Association of State Highway Transportation Officials (AASHTO), the Institute of Traffic Engineers (ITE), and ITS America (ITSA) working together through the Vehicle to Infrastructure Deployment Coalition (V2I DC) have challenged state and local public sector transportation infrastructure owners and operators (IOOs) to work together to achieve deployment of roadside Dedicated Short Range Communications (DSRC) 5.9 GHz broadcast radio infrastructure to broadcast signal phase and timing (SPaT) in real-time at signalized intersections on at least one road corridor or street network (approximately 20 signalized intersections) in each of the 50 states by January 2020. This is commonly called the SPaT Challenge. In 2017, the National Highway Traffic Safety Administration (NHTSA) released a notice of proposed rulemaking (NPRM) (inviting industry comments) that, if enacted, would require all new light vehicles sold in the US to be equipped with DSRC radios which can continuously and anonymously transmit basic information about the location, speed and critical operation of the vehicles. These radios may also be able to receive agency transmitted data, such as SPaT, with the intent to support safer, more efficient operations.

## 1.2 Purpose

While the primary goal of the SPaT Challenge is to deploy DSRC broadcasts of the SPaT messages, the long-term objective is sustained operation of connected vehicle applications that utilize the SPaT messages. For this reason, agencies accepting the SPaT Challenge are encouraged to consider a systems engineering approach towards planning and implementing the SPaT Challenge. The initial steps in the systems engineering approach include development of a Concept of Operations (ConOps) document and related system requirements.

This **Model Functional Requirements** document is intended for use by those agencies accepting the SPaT Challenge as they prepare for their deployments.

## 1.3 Document Overview

This document is the **SPaT Challenge Model Functional Requirements**, in which model requirements are defined and traced back to the operational concepts and ultimately to the user needs. The companion document to this is the **Model Concept of Operations** document, which provides a summary of stakeholder groups, system types, stakeholder needs, and operational concepts that describe the sequence of operational events and activities carried out by each stakeholder group.

The intent of these documents is to be utilized by state, city, and county Departments of Transportation (DOTs) as they begin to plan their SPaT Challenge deployment. ***This Model Functional Requirements document is written to be circulated as a working draft, with the intent that readers will benefit from the text in the document as they prepare their own individual Functional Requirements to address local specific needs.*** Further, this document contains industry input to define the minimal requirements that will be required to maintain compatibility between the SPaT messages being broadcast and the vehicle on-board units planned for deployment by the automobile industry. The accompanying Model Concept of Operations contains additional introductory and system information that will aid readers in understanding the system and functional requirements presented below.

### 1.4 Functional Requirements Organization

The SPaT Infrastructure Functional Requirements are organized within 12 functional groups, as illustrated in Figure 1. The diagram below is a Functional Diagram, not a Physical Diagram. Specifically, the requirements are presented in the tables below within the following groups:

- [Group 1: Manage Interface to SPaT Sources](#) requirements that describe the functions of the SPaT Infrastructure System to interface with sources of SPaT data.
- [Group 2: Manage SPaT](#) requirements that describe the functions of the SPaT Infrastructure to assemble the SPaT data into standard SPaT messages for broadcast.
- [Group 3: Manage User Interface](#) requirements that describe the functions of the SPaT Infrastructure System User Interface to manage functions of the SPaT Infrastructure System.
- [Group 4: Manage Maps](#) requirements that describe the functions of the SPaT Infrastructure to manage MAP data, use the correct MAP data for conditions and assemble standard MAP messages.
- [Group 5: Manage Position Correction](#) requirements that describe the functions of the SPaT Infrastructure to obtain GPS correction data, configure the source of correction data and assemble standard GPS correction messages.
- [Group 6: Manage SPaT Vehicle System Interface](#) requirements that describe the functions of the SPaT Infrastructure to broadcast and receive standard messages to/from SPaT Vehicle Systems.
- [Group 7: Manage Preemption / Priority](#) requirements that describe the functions of the SPaT Infrastructure to monitor requests for preemption and priority, manage conflicting requests, generate requests from and responses to SPaT Vehicle Systems.
- [Group 8: Manage Vehicle & PID Data](#) requirements that describe the functions of the SPaT Infrastructure to manage data received from vehicles and PIDs
- [Group 9: Manage Traffic Data System Interface](#) requirements that describe the functions of the SPaT Infrastructure System to exchange data with the Traffic Data System.
- [Group 10: Manage Security](#) requirements that describe the functions of the SPaT Infrastructure to obtain and send security credentials, verify the credentials received and use that information to manage network access.
- [Group 11: Manage Security Back End Interface](#) requirements that describe the functions of the SPaT Infrastructure to enable Traffic Engineering staff to configure the security interface.
- [Group 12: Provide Support](#) requirements that describe the functions of the SPaT Infrastructure to provide support to users to monitor status, activity and configure the system.

## Functional Requirements

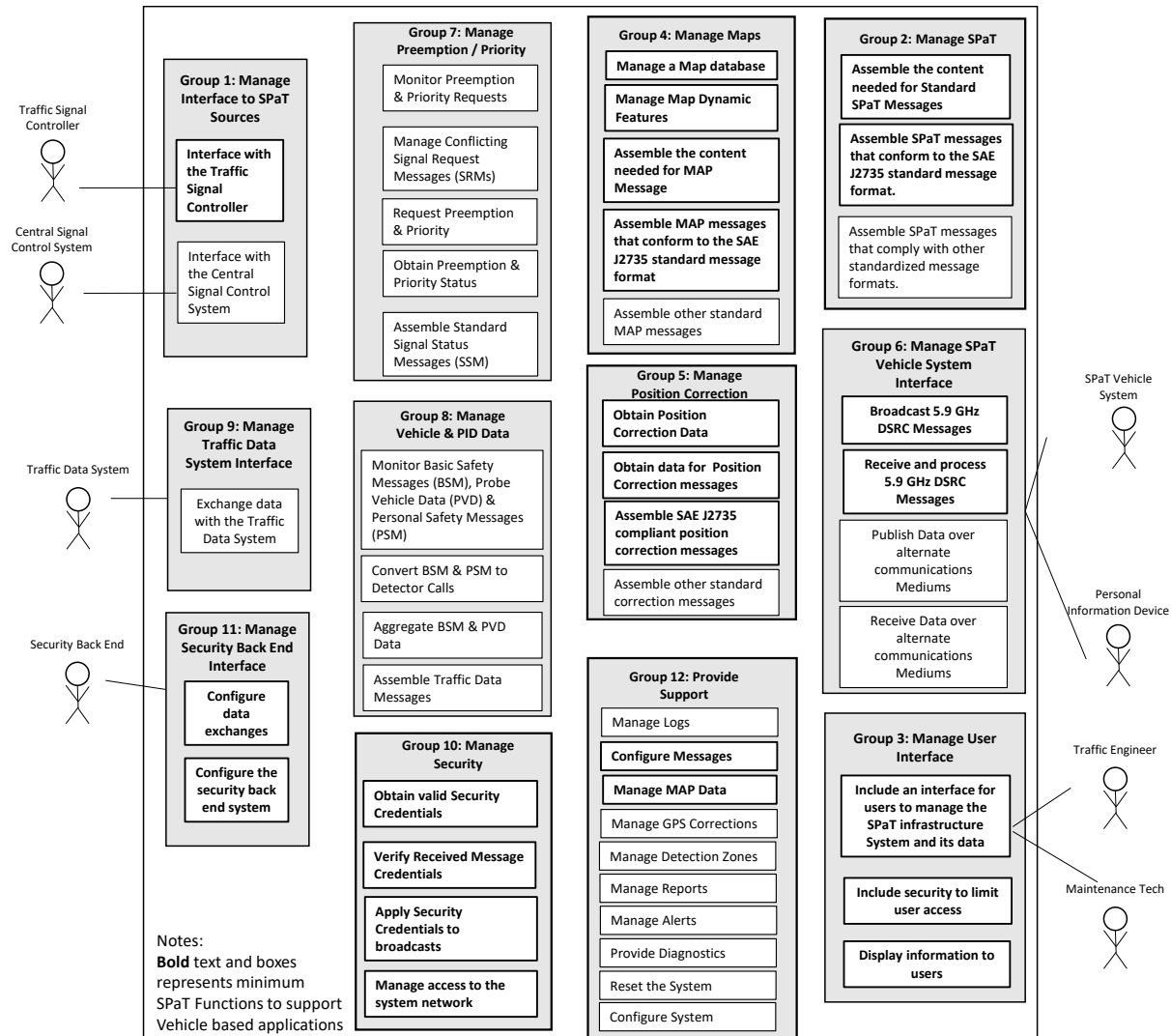


Figure 1 Functional Diagram presenting groupings of the SPaT Infrastructure Requirements

## 2. SPaT Infrastructure System Model Functional Requirements

Each SPaT Infrastructure System requirement is uniquely identified by a “REQ#” as noted in the first column according to the group it is associated. The second column provides the requirement text. Each requirement is designated in the “notes” column as follows:

- **Minimum:** The requirement is necessary to achieve the minimum functionality of a SPaT broadcast to support Red Light Violation Warning (RLVW) applications operating in vehicles.
- **Optional:** The requirement provides an alternate approach to achieve the minimum SPaT functionality, such as broadcasting SPaT data in a message format other than the SAE J2735 standard or using a communication mechanism other than DSRC.
- **Optional – minimum for application:** The requirement is not necessary to achieve the minimum SPaT functionality, but is necessary if additional functionality, such as signal priority/preemption and data collection from vehicles, is desired.

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- **Optional – recommended:** The requirement is not necessary to achieve the minimum functionality of SPaT, however, it is recommended because it improves the system manageability. Examples include reporting, log, and user management tools.

Finally, the fourth column provides a reference to the Model ConOps document for context and traceability purposes, where applicable.

REQ#	Requirements	Notes	ConOps Reference
<b>Group 1: Manage Interface to SPaT Sources</b> <i>Requirements describing the functions of the SPaT Infrastructure System to interface with sources of SPaT data.</i>			
<b>1.1</b>	<b>The SPaT Infrastructure System shall interface with the Traffic Signal Controller.</b>		<b>3.4.1</b>
1.1.1	The SPaT Infrastructure System shall receive traffic signal data from the Traffic Signal Controller that is compliant with the standard NTCIP 1202 v3 as defined in Exhibit A, the applicable Protocol Requirement List. (Note Appendix A is intended to be the NTCIP 1202 v3 Protocol Requirement List (PRL), pending approval to attach).	<i>Minimum; In locations where the Traffic Signal System is not NTCIP 1202 v3 compliant, a software upgrade may be used to replicate the data included in NTCIP 1202 v3 compliant controllers.</i>	<b>3.4.1.1, 3.4.1.5, 3.4.4, CAMP SPaT Verification document</b>
1.1.2	In locations where the SPaT Infrastructure System supports signal priority applications, the System shall receive Signal Control and Priority data compliant with the standard NTCIP 1211 v2.	<i>Optional - minimum; Only in locations where the System will receive priority requests.</i>	
1.1.3	In locations supporting Connected Vehicle enabled Pedestrian in Signalized Crosswalk Warning and/or Mobile Accessible Pedestrian Signal Systems (PED-SIG) applications, the SPaT Infrastructure System shall send or provide detector calls to the Traffic Signal System Interface compliant with the standard NTCIP 1202 v3 as defined in Exhibit A, the applicable Protocol Requirement List.	<i>Optional - minimum per application; Inclusion of Appendix A pending permission.</i>	<b>3.4.2</b>

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REQ#	Requirements	Notes	ConOps Reference
1.1.4	In locations where the SPaT Infrastructure System supports Signal Preemption, the SPaT Infrastructure System shall receive preemption status from the Traffic Signal System compliant with the standard NTCIP 1202 v3 as defined in Exhibit A, the applicable Protocol Requirement List.	<i>Optional - minimum; Only in locations where the System will receive preemption; Inclusion of Appendix A pending permission.</i>	
1.1.5	The SPaT Infrastructure System shall receive an updated data set from the Traffic Signal Controller on a schedule to be defined by the NTCIP 1202 v3 standard. At a minimum, the entire set of NTCIP objects shall be received each time there is a state change, and may be received as frequently as 10 Hz, regardless of whether there is a state change.	<i>Minimum; RLVW</i>	3.4.1.4
1.1.6	In locations where the SPaT Infrastructure System supports Signal Priority or Preemption, the SPaT Infrastructure System shall send or provide priority/preemption requests to the Traffic Signal System.	<i>Optional – minimum for application</i>	3.4.3
1.1.7	In locations where the SPaT Infrastructure System aggregates BSM or PVD data, the SPaT Infrastructure System shall send detection reports to the Traffic Signal System compliant with the standard NTCIP 1202 v3 as defined in Exhibit A, the applicable Protocol Requirement List.	<i>Optional - minimum, based on applications</i>	3.4.2.4
1.2	<b>The SPaT Infrastructure System shall interface with Central Signal Control System (CSCS)</b>	<i>Optional; Note: 1.2 Requirement is a placeholder for systems that interface to a CSCS and not to a roadside Traffic Signal System.</i>	<i>Not described in the SPaT Challenge ConOps</i>

REQ#	Requirements	Notes	ConOps Reference
<b>Group 2: Manage SPaT</b> <i>Requirements describing the functions of the SPaT Infrastructure to assemble the SPaT data into standard SPaT messages for broadcast.</i>			
<b>2.1</b>	<b>The SPaT Infrastructure System shall assemble the content needed for standard SPaT messages.</b>		
2.1.1	The SPaT Infrastructure System shall process the message containing SPaT data obtained from the Traffic Signal System and generate a SPaT message.	<i>Minimum; RLVW</i>	3.3.1.3
2.1.2	The SPaT Infrastructure System shall combine the data received from the SPaT Data Source with additional data to complete the SPaT messages.	<i>Minimum; RLVW</i>	4.2.1.1
2.1.3	The SPaT Infrastructure System shall synchronize an internal system clock with Coordinated Universal Time (UTC) and be accurate within 10 milliseconds (ms) of UTC at all times.	<i>Minimum; RLVW</i>	4.3.3.3.1, CAMP SPaT Verification document
2.1.4	The SPaT Infrastructure System shall convert all times obtained from the Traffic Signal Systems to UTC time and be accurate within 10 milliseconds in SPaT messages.	<i>Minimum; RLVW</i>	4.3.3.3.1
2.1.5	The SPaT Infrastructure System shall generate SPaT messages each time Traffic Signal System Data is received from the SPaT source.	<i>Minimum; RLVW</i>	3.4.1.4
2.1.6	The SPaT Infrastructure System shall have a maximum latency of 100 ms in generating SPaT messages from the time the System obtains Traffic Signal System data.	<i>Minimum; RLVW</i>	3.3.1.3
2.1.7	The SPaT Infrastructure System shall increment the Message Count whenever any data element in the message except the time stamp changes.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
2.1.8	The SPaT Infrastructure System shall use a point in time – also referred to as time marks (i.e. minutes and seconds of the year) as opposed to countdowns (e.g. “for the next 12 seconds”) to define start and end times.	<i>Minimum; RLVW</i>	4.3.3.1
2.1.9	Each SPaT message shall contain a current time stamp that is accurate to within 100 ms of UTC time (represented as minute of the year and milliseconds within the minute).	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
2.1.10	Each SPaT message shall contain the Intersection Status.	<i>Minimum; RLVW</i>	4.3.1.1
2.1.10.1	Each SPaT message shall uniquely identify the intersection for which it applies.	<i>Minimum; RLVW</i>	

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REQ#	Requirements	Notes	ConOps Reference
2.1.10.2	Intersection status shall include whether the intersection is operated as fixed time or actuated control.	<i>Minimum; RLVW</i>	4.3.1.1
2.1.10.3	Intersection status shall include whether the intersection is currently operating in preemption or priority.	<i>Minimum; RLVW</i>	4.3.1.1
2.1.10.4	Intersection status shall include whether the intersection is operating in failure flash.	<i>Minimum; RLVW</i>	4.3.1.1
2.1.10.5	Intersection status shall include which revocable lanes are currently enabled (if the MAP message has revocable lanes).	<i>Minimum; RLVW</i>	4.3.1.1
2.1.11	Each SPaT message shall contain Movement States. The number of Movement States shall correspond to the number of controller traffic and pedestrian phases that are currently in use at the intersection.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
2.1.11.1	The Movement State shall describe the current interval for each movement.	<i>Minimum; RLVW</i>	4.3.2.3
2.1.11.2	The Movement State shall indicate when the current interval will end for each movement.	<i>Minimum; RLVW</i>	4.3.3.1
2.1.11.3	The Movement State shall indicate when that movement is estimated to next be green if it is not currently green.	<i>Minimum; RLVW</i>	4.3.3.1
2.1.12	Each SPaT message shall include a minimum end time defined to be the earliest time mark when the current phase will end (assuming no preemption or priority calls).	<i>Minimum; RLVW</i>	4.3.3.1
2.1.13	Each SPaT message shall contain a maximum end time defined to be the latest time mark when the current phase will end (assuming no preemption or priority calls).	<i>Minimum; RLVW</i>	4.3.3.2
2.1.14	Each SPaT message shall contain a likely end time that is the most likely end time of the current phase.	<i>Minimum; RLVW</i>	4.3.3.2
2.1.15	When the maximum end time and likely end time are included in the data obtained from the Traffic Signal System, The SPaT Infrastructure System shall include these in the SPaT Message.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
2.1.16	For fixed signal time, The SPaT Infrastructure System shall make the maximum end time equal to the minimum end time when maximum end time is included in the SPaT message.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
2.1.17	Each SPaT message shall contain enabled lane data.	<i>Minimum; RLVW</i>	3.4.1.1
2.1.18	For locations where the ECO Departure application is implemented, each SPaT message shall include maneuver assist data.	<i>Optional - minimum for ECO Departure.</i>	3.4.1.3

REQ#	Requirements	Notes	ConOps Reference
2.2	<b>The SPaT Infrastructure System shall assemble SPaT messages that conform to the SAE J2735 standard format.</b>		
2.2.1	<p>The SPaT Infrastructure System shall use the SPaT data to create SPaT messages that conform to the SAE J2735 March 2016 standard format, including the following data frames (DF) and data elements (DE):</p> <ul style="list-style-type: none"> <li>• timeStamp MinuteOfTheYear (DE)</li> <li>• intersections IntersectionStateList (Sequence of IntersectionState) (DF) <ul style="list-style-type: none"> <li>○ IntersectionState (DF) <ul style="list-style-type: none"> <li>▪ id IntersectionReferenceID (DF) <ul style="list-style-type: none"> <li>• region RoadRegulatorID (DE)</li> <li>• id IntersectionID (DE)</li> </ul> </li> <li>▪ revision MsgCount (DE)</li> <li>▪ status IntersectionStatusObject (DE)</li> <li>▪ timeStamp DSecond (DE)</li> <li>▪ enabledLanes EnabledLaneList (DF) <ul style="list-style-type: none"> <li>• LaneID (DE)</li> </ul> </li> <li>▪ states MovementList (Sequence of MovementState) (DF) <ul style="list-style-type: none"> <li>• MovementState (DF) <ul style="list-style-type: none"> <li>▪ signalGroup SignalGroupID (DE)</li> <li>▪ state-time-speed MovementEventList (DF) <ul style="list-style-type: none"> <li>▪ MovementEvent (DF) <ul style="list-style-type: none"> <li>• eventState MovementPhaseState (DE)</li> <li>• timing TimeChangeDetails (DF) <ul style="list-style-type: none"> <li>• minEndTime TimeMark (DE)</li> <li>• maxEndTime Time Mark (DE)</li> <li>• likelyTime TimeMark (DE)</li> </ul> </li> </ul> </li> </ul> </li> <li>▪ maneuverAssistList ManeuverAssistList (DF) <ul style="list-style-type: none"> <li>• ConnectionManeuverAssist (DF) <ul style="list-style-type: none"> <li>▪ connectionID LaneConnectionID (DE)</li> <li>▪ queueLength ZoneLength (DE)</li> <li>▪ PedestrianBicycleDetect (DE)</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul>	<p><i>Minimum; RLVW; Note that some data is only needed by optional functions (e.g. DF_ManeuverAssist data frame is only needed for ECO Departure)</i></p>	4.3
2.3	<p><b>The SPaT Infrastructure System shall assemble SPaT messages that comply with other message formats in addition to SAE J2735.</b></p> <p><i>&lt;Placeholder for other formats beyond SAE J2735&gt;</i></p>	<i>Optional</i>	

REQ#	Requirements	Notes	ConOps Reference
<b>Group 3: Manage User Interface</b> <i>Requirements describing the functions of the SPaT Infrastructure System User Interface to manage functions of the SPaT Infrastructure System.</i>			
<b>3.1</b>	<b>The SPaT Infrastructure System shall include an interface for users to manage the SPaT Infrastructure System and its data.</b>		
3.1.1	The SPaT Infrastructure System User Interface shall be browser-based and provide access to authorized users for all management, configuration and support functionality as described in Groups 3 and 12.	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6
3.1.1.1	The SPaT Infrastructure System User Interface shall be accessible via workstations on the agency network.	<i>Minimum; RLVW; For example, a workstation at the Traffic Operations Center</i>	3.6.2
3.1.1.2	The SPaT Infrastructure System User Interface shall be accessible via remote portable devices through the Internet.	<i>Minimum; RLVW; For example, a field technician using a laptop at a SPaT intersection</i>	3.6.2
3.1.2	The SPaT Infrastructure System shall comply with the agency's security policy for remote access.	<i>Minimum; RLVW</i>	
<b>3.2</b>	<b>The SPaT Infrastructure System User Interface shall include security compliant with agency policy to limit user access.</b>	<i>Minimum; RLVW; Will require citing specific agency policy</i>	
3.2.1	The SPaT Infrastructure System User Interface shall only be accessible to authorized users.	<i>Minimum; RLVW</i>	
3.2.2	The SPaT Infrastructure System shall have a mechanism for an administrator to configure user roles such that different users are limited to different subsets of functionalities.	<i>Optional; For example, a manager role may have access to reports while a technician role may have access to device configuration</i>	

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REQ#	Requirements	Notes	ConOps Reference
<b>3.3</b>	<b>The SPaT Infrastructure System User Interface shall display information to users.</b>	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6
3.3.1	<b>The SPaT Infrastructure System User Interface shall display information to users on the operation, configuration and diagnostics of the System.</b>	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6
3.3.2	The SPaT Infrastructure System User Interface shall provide information to users in text and graphical formats as appropriate.	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6
3.3.3	The SPaT Infrastructure System shall provide a GIS-based digital map to geographically view the System and manage data.	<i>Optional</i>	3.6.1, 3.6.2, 3.6.3, 3.6.4, 3.6.5, 3.6.6
3.3.4	The SPaT Infrastructure System User Interface shall notify users of system alerts as defined in Group 12.	<i>Minimum; RLVW</i>	

REQ#	Requirements	Notes	ConOps Reference
<b>Group 4: Manage Maps</b> <i>Requirements describing the functions of the SPaT Infrastructure to manage MAP data, use the correct MAP data for conditions and assemble standard MAP messages.</i>			
<b>4.1</b>	<b>The SPaT Infrastructure System shall manage a MAP database.</b>		
4.1.1	The SPaT Infrastructure System shall include a database to store MAP data.	<i>Minimum; RLVW</i>	3.6.1
4.1.2	The SPaT Infrastructure System shall have a mechanism to configure the MAP data to be applied to the intersection associated with the SPaT Infrastructure System.	<i>Minimum; RLVW</i>	3.6.1
4.1.3	The SPaT Infrastructure System shall store a unique MAP message for each SPaT intersection.	<i>Minimum; RLVW</i>	4.2.1.1
<b>4.2</b>	<b>The SPaT Infrastructure System shall manage MAP dynamic features.</b>		

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REQ#	Requirements	Notes	ConOps Reference
4.2.1	At intersections with reversible lanes, or movements restricted during selected periods (e.g. left turn not allowed during peak periods), the MAP messages shall designate these lanes as revocable.	<i>Minimum; RLVW; The MAP message will not change during periods when revocable lanes transition from “not allowed” to “allowed”, instead the SPaT Message will identify each revocable lane as being “enabled” or “disabled” and the SPaT Vehicle System will process the SPaT message to determine the state of revocable lanes in the MAP message</i>	4.2.4.2, 4.2.4.2.1
4.2.1.1	In situations of reversible lanes, MAP messages shall define two lanes in the same location, one an ingress lane, and one an egress lane. Each lane shall be revocable.	<i>Minimum; RLVW</i>	4.2.4.2
4.2.1.2	In situations of turn restrictions (e.g. not permitting right turn on red or left turn allowed/not allowed), the MAP message shall define two lanes in the same location – one allowing the movement, the other not allowing the movement. Each lane shall be revocable.	<i>Minimum; RLVW</i>	4.2.4.2.1
<b>4.3</b>	<b>The SPaT Infrastructure System shall assemble the content for standard MAP messages.</b>		
4.3.1	The Intersection Geometry shall be changed if and only if the map information is updated.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
4.3.2	Each MAP message shall uniquely identify the intersection for which it applies.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document

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REQ#	Requirements	Notes	ConOps Reference
4.3.3	The SPaT Infrastructure System shall increment the MAP message count whenever any data element in the message except the time stamp changes.	<i>Minimum; RLVW</i>	4.2.4.1
4.3.4	Each Map message shall identify each lane approaching and departing from the intersection and shall provide an intersection unique ID for the lane.	<i>Minimum; RLVW; The lane departing from the intersection could/should utilize an approach lane that is part of the next successive intersection.</i>	CAMP SPaT Verification document
4.3.5	Each MAP message shall provide the directionality of each lane.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
4.3.6	Each MAP messages shall identify all ingress and egress lanes.	<i>Minimum; RLVW</i>	4.2.2.2
4.3.6.1	Each ingress and egress lane shall be described by at least two node points that depict the center of the lane.	<i>Minimum; RLVW</i>	4.2.1.2.1
4.3.6.2	Each ingress and egress lane shall be depicted by enough nodes such that the distance between the actual curved lane center line and the straight line connecting nodes shall not be more than half of the lane width.	<i>Minimum; RLVW; For example, a straight lane may require only the minimum two nodes, while a curved lane may require many nodes to represent its geometry</i>	4.2.1.2.2
4.3.6.3	Each MAP message shall separately identify each possible connection between ingress and egress lanes and provide an intersection unique ID for the connection.	<i>Minimum; RLVW; The connection could/should be to an approach lane that is part of the next successive intersection.</i>	4.2.3.1.1

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REQ#	Requirements	Notes	ConOps Reference
4.3.6.4	Each MAP message shall include, for each connection, the lane, maneuver and signal group associated with the connection.	<i>Minimum; RLVW</i>	4.2.3.2
4.3.6.5	When a single connection between an ingress lane and an egress lane is controlled by more than one signal group, such as a protected/permissive left turn movement, the MAP message shall separately identify each signal group that controls the movement on that connection.	<i>Minimum; RLVW</i>	4.2.3.1
4.3.7	In locations where PED-SIG or Pedestrian Warning applications are deployed, MAP messages shall include crosswalk lane types.	<i>Optional - minimum based on applications</i>	4.2.2.1
4.3.8	The accuracy of nodes represented in MAP messages shall be accurate to within 0.5 meters of the actual location being represented by the node.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
4.3.9	MAP message shall define ingress lanes from the stop bar to a minimum of 300 meters before the stop bar.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
4.3.10	When connecting to another intersection, each MAP message shall identify the remote intersection to be connected to.	<i>Minimum; RLVW</i>	4.2.3.1
<b>4.4</b>	<b>The SPaT Infrastructure System shall assemble MAP messages that conform to the SAE J2735 standard message format.</b>		
4.4.1	<p>The SPaT Infrastructure System shall assemble the MAP messages that adhere to the SAE J2735 March 2016 standard including the following data frames (DF) and data elements (DE):</p> <ul style="list-style-type: none"> <li>• msgIssueRevision MsgCount (DE)</li> <li>• intersections IntersectionGeometryList (Sequence of IntersectionGeometry) (DF) <ul style="list-style-type: none"> <li>○ IntersectionGeometry (DF) <ul style="list-style-type: none"> <li>▪ id IntersectionReferenceID (DF) <ul style="list-style-type: none"> <li>• region RoadRegulatorID (DE)</li> <li>• id IntersectionID (DE)</li> </ul> </li> <li>▪ revision MsgCount (DE)</li> <li>▪ refPoint Position3D (DF) <ul style="list-style-type: none"> <li>• lat Latitude (DE)</li> <li>• long Longitude (DE)</li> </ul> </li> <li>▪ laneWidth LaneWidth (DE)</li> <li>▪ laneSet LaneList (Sequence of GenericLane) (DF) <ul style="list-style-type: none"> <li>• GenericLane (DF) <ul style="list-style-type: none"> <li>○ laneID LaneID (DE)</li> </ul> </li> </ul> </li> </ul> </li> </ul> </li> </ul>	<i>Minimum; RLVW;</i>	CAMP SPaT Verification document

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
	<ul style="list-style-type: none"> <li>○ laneAttributes LaneAttributes (DF) <ul style="list-style-type: none"> <li>▪ directionalUse LaneDirection (DE)</li> <li>▪ sharedWith LaneSharing (DE)</li> <li>▪ laneType LaneTypeAttributes (DF)</li> </ul> </li> <li>○ maneuvers AllowedManeuvers (DE)</li> <li>○ nodeList NodeListXY (DF) <ul style="list-style-type: none"> <li>▪ nodes NodeSetXY (Sequence of NodeXY) (DF) <ul style="list-style-type: none"> <li>• Node (DF) <ul style="list-style-type: none"> <li>○ delta NodeOffsetPointXY (DF) [Any representation Node-XY-20b through Node-XY-32b]</li> </ul> </li> </ul> </li> </ul> </li> <li>○ connectsTo ConnectsToList (Sequence of Connection) (DF) <ul style="list-style-type: none"> <li>▪ Connection (DF) <ul style="list-style-type: none"> <li>• connectingLane ConnectingLane (DF) <ul style="list-style-type: none"> <li>○ lane LaneID (DE)</li> <li>○ maneuver AllowedManeuvers (DE)</li> </ul> </li> <li>• remoteIntersection IntersectionReferenceID (DF) <ul style="list-style-type: none"> <li>○ region RoadRegulatorID (DE)</li> <li>○ id IntersectionID (DE)</li> </ul> </li> <li>• signalGroup SignalGroupID (DE)</li> <li>• connectionID LaneConnectionID (DE)</li> </ul> </li> </ul> </li> </ul>	<p><i>For successive intersections it is beneficial to show the connection being to an approach lane of the succeeding intersection using the remoteIntersection field.</i></p>	
4.5	<b>The SPaT Infrastructure System shall assemble other standardized MAP messages, as needed.</b>	<i>Optional; Placeholder for other communications mediums.</i>	

REQ#	Requirements	Notes	ConOps Reference
<b>Group 5: Manage Position Correction</b> <i>Requirements describing the functions of the SPaT Infrastructure to obtain GPS correction data, configure the source of correction data and assemble standard GPS correction messages.</i>			

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
5.1	<b>The SPaT Infrastructure System shall obtain position correction data.</b>	<i>Minimum; Per intersection needs</i>	3.3.3, 3.3.3.1
5.1.1	The SPaT Infrastructure System shall either calculate or obtain GPS position correction data in the RTCM 10403 Message Type 1001 format that corrects for the current atmospheric conditions in the area surrounding the intersection.	<i>Minimum; If correction is needed at specific intersections</i>	CAMP SPaT Verification document
5.1.2	The SPaT Infrastructure System shall either generate or obtain the coordinates of the antenna reference point in the RTCM 10403 Message Type 1005 format.	<i>Minimum; If correction is needed at specific intersections</i>	CAMP SPaT Verification document
5.2	<b>The SPaT Infrastructure System shall assemble standard RTCM correction messages.</b>	<i>Minimum; Per intersection needs</i>	3.3.1.2
5.2.1	The SPaT Infrastructure System shall assemble standard RTCM correction messages for the following RTCM version 3.0 message types: <ul style="list-style-type: none"> <li>- Message Type 1001 – GPS L1 observations</li> <li>- Message Type 1005 – Antenna Reference Point coordinates</li> </ul>	<i>Minimum; Per intersection needs</i>	CAMP Verification document
5.2.2	The SPaT Infrastructure System shall generate new RTCM Correction messages with the most current correction data at a minimum frequency of 5 Hz.	<i>Minimum; Per intersection needs</i>	CAMP Verification document
5.3	<b>The SPaT Infrastructure System shall assemble RTCM correction messages that conform to the SAE J2735 standard message format.</b>	<i>Minimum</i>	3.3.1.2
5.4	<b>The SPaT Infrastructure System shall assemble position correction messages that comply with additional standards, as needed.</b>	<i>Optional</i>	

REQ#	Requirements	Notes	ConOps Reference
<b>Group 6: Manage SPaT Vehicle System Interface</b> <i>Requirements describing the functions of the SPaT Infrastructure to broadcast and receive standard messages to/from SPaT Vehicle Systems.</i>			
6.1	<b>The SPaT Infrastructure System shall broadcast standard 5.9 GHz DSRC messages.</b>	<i>Minimum; RLVW</i>	
6.1.1	The SPaT Infrastructure System broadcast of data shall be compliant with the USDOT's RSU Specification "DSRC Roadside Unit (RSU) Specification Document v4.1."	<i>Minimum; RLVW</i>	3.3.1, 3.3.1.1

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
6.1.2	The SPaT Infrastructure System shall broadcast SPaT, MAP, and RTCM messages using Dedicated Short Range Communications (DSRC) on channel 172.	<i>Minimum; RLVW</i>	3.3.1.3
6.1.3	The SPaT Infrastructure shall broadcast the SPaT messages with a minimum frequency of 10 Hz.	<i>Minimum; RLVW</i>	3.3.1.5
6.1.4	The SPaT Infrastructure system shall broadcast MAP messages with a minimum frequency of 1 Hz.	<i>Minimum; RLVW</i>	3.3.1.1
6.1.5	The SPaT Infrastructure System shall broadcast RTCM Correction messages containing the most recent RTCM 10403 Message Type 1001 data with a minimum frequency of 5 Hz.	<i>Minimum; RLVW</i>	3.3.1.1
6.1.6	The SPaT Infrastructure System shall broadcast RTCM Correction messages containing the most recent RTCM 10403 Message Type 1005 data with a minimum frequency of 2 Hz.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
6.1.7	In locations supporting preemption/priority applications, when there are active priority requests, the SPaT Infrastructure System shall broadcast Signal Status Messages (SSM) on Channel 182 with a minimum frequency of 10 Hz.	<i>Optional - minimum</i>	
6.1.8	The SPaT Infrastructure System shall broadcast messages such that they can be received by DSRC on-board units in each lane approaching the intersection.	<i>Minimum; RLVW</i>	3.3.1.1, 3.3.1.2
6.1.9	The SPaT Infrastructure System shall broadcast messages such that the data incurs no loss in fidelity to a distance of at least 300 meters upstream of the stop bar for each approaching lane.	<i>Minimum; RLVW</i>	3.3.1.1
6.1.10	The SPaT Infrastructure System shall sign outgoing broadcast messages with a valid security key.	<i>Minimum; RLVW</i>	3.8.1.2
<b>6.2</b>	<b>The SPaT Infrastructure System shall validate received messages based on signed certificate associated with the messages.</b>	<i>Optional - minimum</i>	
6.2.1	In locations where BSM data is collected, the SPaT Infrastructure System shall receive and process all valid DSRC broadcasts of the Basic Safety Message (BSM) received by the DSRC radio on Channel 172 at the SPaT Infrastructure System.	<i>Optional – minimum based on applications</i>	3.3.5.1
6.2.2	In locations support signal priority and preemption, the SPaT Infrastructure System shall receive valid DSRC Signal Request Messages (SRM) received by the DSRC radio on Channel 182 at the SPaT Infrastructure System.	<i>Optional – minimum based on applications</i>	3.3.4.1

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REQ#	Requirements	Notes	ConOps Reference
6.2.3	In locations where vehicle data is received, the SPaT Infrastructure System shall receive and process security credentials and digital signatures to be used to validate message received.	<i>Optional – minimum based on applications</i>	3.8.1.1
6.2.4	In locations where probe data is being collected by the SPaT Infrastructure System, the SPaT Infrastructure System shall receive and process valid Probe Vehicle Data (PVD) data broadcast received by the DSRC radio at the SPaT Infrastructure System.	<i>Optional – minimum based on applications</i>	3.3.5.2
6.2.5	In locations supporting PED-SIG applications, the SPaT Infrastructure System shall receive valid Personal Safety Message (PSM) data broadcast by the Personal Information Device Systems within range of the SPaT Infrastructure System.	<i>Optional - minimum based on applications</i>	3.9.2.1
6.3	<b>The SPaT Infrastructure System shall publish data over alternate communication mediums.</b>	<b><i>Optional; Placeholder for additional mediums</i></b>	
6.4	<b>The SPaT Infrastructure System shall receive data over alternate communication mediums.</b>	<b><i>Optional; Placeholder for additional mediums</i></b>	

REQ#	Requirements	Notes	ConOps Reference
<b>Group 7: Manage Preemption / Priority</b> <i>Requirements describing the functions of the SPaT Infrastructure to monitor requests for preemption and priority, manage conflicting requests, generate requests from and responses to SPaT Vehicle Systems.</i>			
7.1	<b>The SPaT Infrastructure System shall monitor for signal preemption and priority requests.</b>	<b><i>Optional - minimum</i></b>	
7.1.1	The SPaT Infrastructure System shall process Signal Request Messages (SRM) that adhere to the SAE J2735 March 2016 standard from SPaT Vehicle Systems as soon as they are received.	<i>Optional – minimum based on applications</i>	3.3.4.1
7.1.2	The SPaT Infrastructure System shall process preemption/priority request cancellations received from SPaT Vehicle Systems.	<i>Optional – minimum based on applications</i>	3.3.4.2
7.2	<b>The SPaT Infrastructure System shall manage conflicting SRMs.</b>	<b><i>Optional - minimum</i></b>	

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
7.2.1	In locations where the local approach is for the SPaT Infrastructure System to manage conflicting SRMs, the SPaT Infrastructure System shall have a mechanism to prioritize SRMs received from multiple vehicles, and multiple vehicle classifications.	<i>Optional – minimum based on applications</i>	3.3.4.1
7.2.2	In locations where the local approach is for the Traffic Signal System to manage conflicting SRMs, the SPaT Infrastructure System shall not perform any prioritization of SRMs received from multiple vehicles.	<i>Optional – minimum based on applications</i>	
<b>7.3</b>	<b>The SPaT Infrastructure System shall request preemption and priority.</b>	<i>Optional - minimum</i>	
7.3.1	The SPaT Infrastructure System shall generate and send SRMs to the Traffic Signal System via the Traffic Signal System Interface that complies with NTCIP 1202v3 for preemption requests and NTCIP 1211 for priority requests, in accordance with the local approach for managing conflicting SRMs.	<i>Optional – minimum based on applications</i>	3.4.3.1
7.3.2	The SPaT Infrastructure System shall send requests with a maximum latency of 100 ms from receiving the preemption or priority request.	<i>Optional – minimum based on applications</i>	3.4.3.1
<b>7.4</b>	<b>The SPaT Infrastructure System shall obtain preemption and priority status from the Traffic Signal System via the Traffic Signal System Interface with a maximum latency of 100 ms.</b>	<i>Optional – minimum based on applications</i>	3.4.3.3
<b>7.5</b>	<b>The SPaT Infrastructure System shall assemble signal status messages that conform to the SAE J2735 March 2016 standard.</b>	<i>Optional – minimum based on applications</i>	3.3.4.4
7.5.1	The SPaT Infrastructure System shall assemble Signal Status Messages (SSM) with a maximum latency of 100 ms from the time the System receives information from the Traffic Signal System.	<i>Optional – minimum based on applications</i>	3.3.4.4
<b>7.6</b>	<b>The SPaT Infrastructure System shall assemble signal status messages that comply with additional standards, as needed.</b>	<i>Optional</i>	
7.6.1	The SPaT Infrastructure System shall assemble Signal Status Messages in other standard formats with a maximum latency of 100 ms from the time the System receives information from the Traffic Signal System.	<i>Optional</i>	3.3.4.4

REQ#	Requirements	Notes	ConOps Reference
<b>Group 8: Manage Vehicle &amp; PID Data</b>			

<i>Requirements describing the functions of the SPaT Infrastructure to manage data received from vehicles and PIDs</i>			
<b>8.1</b>	<b>The SPaT Infrastructure System shall monitor BSM, PVD, and PSM.</b>	<b>Optional - minimum</b>	
8.1.1	The SPaT Infrastructure System shall receive BSM from vehicles.	Optional – minimum based on applications	3.3.5.1
8.1.2	The SPaT Infrastructure System shall receive PVD from vehicles.	Optional – minimum based on applications	3.3.5.2
8.1.3	The SPaT Infrastructure System shall receive PSM from Personal Information Devices (PIDs).	Optional – minimum based on applications	3.9.2.1
<b>8.2</b>	<b>The SPaT Infrastructure System shall convert BSM and PSM to detector calls.</b>	<b>Optional - minimum; Link to Group 1: Manage Interface to SPaT Sources</b>	
8.2.1	In locations where the intent is to convert BSMs to detector calls, the SPaT Infrastructure System shall have defined BSM geographic detection zones that define the geographic area assigned to each signal phase at each intersection detecting BSM.	Optional – minimum based on applications	
8.2.2	In locations where the intent is to convert PSMs into detector calls, the SPaT Infrastructure System shall have defined PSM geographic detection zones that define the geographic area assigned to each signal pedestrian phase at each intersection detecting PSM.	Optional – minimum based on applications	
8.2.3	The SPaT Infrastructure System shall convert the BSM and PSM messages received into detector calls for their corresponding detection zones.	Optional – minimum based on applications	3.4.2.2
8.2.3.1	When the SPaT Infrastructure System receives a BSM located within the respective detection zone, the SPaT Infrastructure System shall generate detector calls for the appropriate signal phase.	Optional – minimum based on applications	3.4.2.3
8.2.3.2	The SPaT Infrastructure System shall continue to generate detector calls whenever it receives BSM from one or more vehicles in a detection zone for BSM.	Optional – minimum based on applications	3.4.2.3
8.2.4	When the SPaT Infrastructure System receives a PSM located within the respective detection zone, the SPaT Infrastructure System shall convert each PSM that is requesting a WALK signal into a pedestrian crossing detector call for the signal pedestrian phase assigned to the PSM detection zone.	Optional - minimum based on applications	3.4.2.1

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8.2.4.1	The SPaT Infrastructure System shall assemble pedestrian crossing detector calls to include the relevant crosswalk the pedestrian is requesting to access.	<i>Optional – minimum based on applications</i>	3.4.2.1
8.2.4.2	When multiple PSM messages are received from more than one PID for a single WALK, the SPaT Infrastructure System shall generate no more than one detector call for a given phase within each cycle.	<i>Optional – minimum based on applications</i>	3.4.2.1
8.2.5	The SPaT Infrastructure System shall prepare actuation reports to be sent to the Traffic Signal System in compliance with NTCIP 1202 v3, at a minimum.	<i>Optional – minimum based on applications</i>	3.4.2.4
<b>8.3</b>	<b>In locations where BSM and PVD data is collected, the SPaT Infrastructure System shall aggregate BSM and PVD data.</b>	<b><i>Optional – minimum</i></b>	
8.3.1	The SPaT Infrastructure System shall aggregate BSM and PVD data over specified intervals.	<i>Optional – minimum based on applications</i>	3.5.1.3
8.3.2	The SPaT Infrastructure System shall process aggregate data from BSM and PVD messages sufficient for the Traffic Signal System to generate detector calls in compliance with NTCIP 1202v3, including: <ul style="list-style-type: none"> <li>- Volume</li> <li>- Average speed</li> <li>- Average travel time</li> <li>- Queue length</li> <li>- Average gap</li> </ul> Platoon length.	<i>Optional – minimum based on applications</i>	3.5.1.3
8.3.3	The SPaT Infrastructure System shall have sufficient data storage to collect aggregated BSM and PVD data for a configurable period of time.	<i>Optional - recommended; Based on applications</i>	3.5.1.3
8.3.4	The SPaT Infrastructure System shall delete aggregated BSM and PVD data at a configurable frequency.	<i>Optional - recommended; Based on applications</i>	3.5.1.3
<b>8.4</b>	<b>The SPaT Infrastructure System shall assemble traffic data messages from processed and unprocessed aggregated BSM and PVD data at a specified frequency to support local applications.</b>	<b><i>Optional; Based on applications</i></b>	<b>3.5.1.1</b>

REQ#	Requirements	Notes	ConOps Reference
<b>Group 9: Manage Traffic Data System Interface</b>			

<i>Requirements describing the functions of the SPaT Infrastructure System to exchange data with the Traffic Data System.</i>			
<b>9.1</b>	<b>The SPaT Infrastructure System shall exchange data with the Traffic Data System.</b>	<b>Optional - minimum</b>	
9.1.1	In locations where the Traffic Data System utilizes data from the SPaT Infrastructure System, the SPaT Infrastructure System shall send traffic data messages to the Traffic Data System.	Optional – minimum based on applications	3.5.1.3
9.1.1.1	The SPaT Infrastructure System shall exchange aggregated BSM data.	Optional – minimum based on applications	3.5.1.3
9.1.1.2	The SPaT Infrastructure System shall exchange aggregated PVD data.	Optional – minimum based on applications	3.5.1.3

REQ#	Requirements	Notes	ConOps Reference
<b>Group 10: Manage Security</b>			
<i>Requirements describing the functions of the SPaT Infrastructure to obtain and send security credentials, verify the credentials received and use that information to manage network access.</i>			
<b>10.1</b>	<b>The SPaT Infrastructure System shall obtain valid security credentials.</b>	<b>Minimum</b>	
10.1.1	The SPaT Infrastructure System shall comply with all security credentials, certification, and processes defined by the National Security Credentials Management System (SCMS), or another credential management system used by the SPaT Infrastructure System.	Minimum; RLVW	3.8.1
10.1.1.1	The SPaT Infrastructure System shall be enrolled in and maintain current security credential certification.	Minimum; RLVW	3.8.1.3
10.1.1.2	The SPaT Infrastructure System certification shall include all of the security credentials necessary to support each application.	Minimum; RLVW	3.8.1.3
10.1.2	The SPaT Infrastructure System shall have a mechanism for receiving updated security credential certification from the Security Back End System.	Minimum; RLVW	3.8.1.2, 3.3.6
10.1.3	The SPaT Infrastructure System shall store security credential certifications for use in broadcasting messages to SPaT Vehicle Systems for their validation purposes.	Minimum; RLVW	3.8.1.2
10.1.4	The SPaT Infrastructure System shall request updated security credentials from the Security Back End System a configurable period of time in advance of when the current security credential expires.	Minimum; RLVW	3.8.1

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10.1.5	The SPaT Infrastructure System shall receive updates from the Security Back End System regarding revoked security credentials.	<i>Optional – minimum based on applications</i>	3.8.1.1, 3.3.6
10.1.6	The SPaT Infrastructure System shall store data regarding revoked security credentials.	<i>Optional – minimum based on applications</i>	3.8.1.1
10.1.6.1	The SPaT Infrastructure System shall ignore data received from SPaT Vehicle Systems whose security credentials have been revoked.	<i>Optional – minimum based on applications</i>	3.8.1.1
10.1.6.2	The SPaT Infrastructure System shall send data to the Security Back End System regarding invalid security credentials received from SPaT Vehicle Systems.	<i>Optional – minimum based on applications</i>	3.8.1.1
<b>10.2</b>	<b>The SPaT Infrastructure System shall verify the credentials it receives.</b>	<b><i>Optional – minimum</i></b>	
10.2.1	The SPaT Infrastructure System shall have a mechanism for validating the security credentials received from SPaT Vehicle Systems.	<i>Optional – minimum based on applications</i>	3.3.6
10.2.1.1	The SPaT Infrastructure System shall check the security credentials of messages that include security credential data received from SPaT Vehicle Systems.	<i>Optional – minimum based on applications</i>	3.3.6
10.2.1.2	The SPaT Infrastructure System shall validate the security credentials of messages received from SPaT Vehicle Systems with valid credentials.	<i>Optional – minimum based on applications</i>	3.3.6, 3.8.1.1
10.2.1.3	The SPaT Infrastructure System shall identify as revoked the security credentials of messages received from SPaT Vehicle Systems that match a revoked security credential.	<i>Optional – minimum based on applications</i>	3.8.1.1, 3.3.6
10.2.1.4	The SPaT Infrastructure System shall ignore messages received from SPaT Vehicle Systems without a valid security credential.	<i>Optional – minimum based on applications</i>	3.8.1.1.1
<b>10.3</b>	<b>The SPaT Infrastructure System shall apply security credentials to broadcasts.</b>	<b><i>Minimum</i></b>	
10.3.1	The SPaT Infrastructure System shall broadcast valid security credentials in the form of digital certificates signed by a trusted certificate authority for those messages broadcast with security credential information.	<i>Minimum; RLVW</i>	3.3.7
10.3.2	The SPaT Infrastructure System shall sign and validate DSRC messages using the IEEE 1609.2 security standard.	<i>Minimum; RLVW</i>	CAMP SPaT Verification document
<b>10.4</b>	<b>The SPaT Infrastructure System shall manage access to the system network.</b>	<b><i>Optional – minimum</i></b>	
10.4.1	The SPaT Infrastructure System shall comply with agency security policy to block malicious attempts, such as Distributed Denial of Service (DDOS) attacks, malware distribution, or other hacking efforts, to infiltrate the agency networks and systems.	<i>Optional – minimum based on applications; Requires a reference to the</i>	3.3.6

## Functional Requirements

		<i>deploying agency's security policies</i>	
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REQ#	Requirements	Notes	ConOps Reference
<b>Group 11: Manage Security Back End Interface</b> <i>Requirements describing the functions of the SPaT Infrastructure to enable Traffic Engineering staff to configure the security interface</i>			
11.1	The SPaT Infrastructure System shall provide a mechanism for users to configure data exchanges between the SPaT Infrastructure System and the Security Back-End System that are compliant with agency security and network policies.	<i>Minimum; RLVW; Requires a reference to the deploying agency's security policies.</i>	3.6.5
11.2	The SPaT Infrastructure System shall provide a mechanism for users to configure the Security Back-end System that are compliant with agency security and network policies.	<i>Minimum; RLVW; Requires a reference to the deploying agency's security policies.</i>	3.6.6

REQ#	Requirements	Notes	ConOps Reference
<b>Group 12: Provide Support</b> <i>Requirements describing the functions of the SPaT Infrastructure to provide support to users to monitor status, activity and configure the system.</i>			
12.1	The SPaT Infrastructure System shall have a mechanism for managing logs of system activity.	<i>Optional - recommended</i>	
12.1.1	The SPaT Infrastructure System shall log and store records of data obtained by the System, including: <ul style="list-style-type: none"> <li>- Traffic Signal System data.</li> <li>- GPS correction data.</li> <li>- MAP data.</li> <li>- Messages from SPaT Vehicle Systems and PIDs, including BSM, PVD, PSM and SRM.</li> </ul>	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.2	The SPaT Infrastructure System shall log and store the messages assembled by the System, including the content, time of generation and time of broadcast.	<i>Optional - recommended; Based on applications</i>	3.7.1.2

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REQ#	Requirements	Notes	ConOps Reference
12.1.2.1	The SPaT Infrastructure System shall log and store the SPaT messages assembled by the System.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.2.2	The SPaT Infrastructure System shall log and store the MAP messages assembled by the System.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.2.3	The SPaT Infrastructure System shall log and store the RCTM messages assembled by the System.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.2.4	The SPaT Infrastructure System shall log and store the SSM messages assembled by the System.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.3	The SPaT Infrastructure System shall log and store the location of origin for all stored data, such as the location/intersection for each message broadcast and received.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.4	The SPaT Infrastructure shall log and store user-initiated changes in System configuration, including the user, date and time, and configuration change.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.5	The SPaT Infrastructure System shall log and store system errors and alerts, such as for loss of power, loss of connection to other systems, failure to process data and generate messages.	<i>Optional, based on applications</i>	3.7.1.2
12.1.6	The SPaT Infrastructure System shall log and store user activity, including, at a minimum, the user and time of log in and log out for each session, and the time and location of failed login attempts.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.7	The SPaT Infrastructure System shall have a mechanism for selecting stored data for deletion and then deleting that data.	<i>Optional - recommended; Based on applications</i>	3.7.1.2
12.1.8	The SPaT Infrastructure System shall have a mechanism for configuring multiple logs to reflect: <ul style="list-style-type: none"> <li>- log start and end times.</li> <li>- Data types and activities to be included in log.</li> <li>- Locations and/or devices to be included in log.</li> </ul>	<i>Optional - recommended; Based on applications</i>	

REQ#	Requirements	Notes	ConOps Reference
12.2	<b>The SPaT Infrastructure System shall provide a mechanism for users to configure the messages broadcast by the System.</b>	<b>Minimum; RLVW</b>	
12.2.1	The SPaT Infrastructure System shall provide a mechanism for users to select the appropriate standardized format(s) for messages to be broadcast.	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3
12.2.2	The SPaT Infrastructure System shall have a mechanism for users to configure the data elements to include in: <ul style="list-style-type: none"> <li>- SPaT Messages</li> <li>- MAP Messages</li> <li>- RTCM Messages</li> <li>- SSM</li> <li>- PSM</li> </ul>	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3
12.2.3	The SPaT Infrastructure System shall have a mechanism for users to configure the frequency of broadcast for: <ul style="list-style-type: none"> <li>- SPaT Messages</li> <li>- MAP Messages</li> <li>- RTCM Messages</li> <li>- SSM</li> <li>- PSM</li> </ul>	<i>Minimum; RLVW</i>	3.6.1, 3.6.2, 3.6.3
12.3	<b>The SPaT Infrastructure System shall have a mechanism for managing MAP data.</b>	<b>Optional - recommended</b>	
12.3.1	The SPaT Infrastructure System shall have a mechanism for the user to select the format of MAP data to be imported from the SPaT Infrastructure System's usable formats, including: <ul style="list-style-type: none"> <li>- XML</li> <li>- <b>&lt;to be defined&gt;</b></li> </ul>	<i>Optional - recommended; Based on the MAP management tool used</i>	3.6.2, 3.6.3
12.3.2	The SPaT Infrastructure System shall have a mechanism for the user to submit MAP data.	<i>Optional - recommended</i>	3.6.1
12.3.2.1	The SPaT Infrastructure System shall notify the user of successful MAP data submissions.	<i>Optional - recommended</i>	3.6.1
12.3.2.2	The SPaT Infrastructure System shall provide a mechanism for graphically displaying the location and layout of submitted MAP data.	<i>Optional - recommended</i>	3.6.1
12.3.2.3	The SPaT Infrastructure System shall notify the user of errors in the structure of the submitted data, such as missing required data in the wrong format, or data outside the range of allowable values.	<i>Optional - recommended</i>	3.6.1
12.3.3	The SPaT Infrastructure System shall have a mechanism for the user to create MAP data within the interface.	<i>Optional - recommended</i>	3.6.1

REQ#	Requirements	Notes	ConOps Reference
12.3.3.1	The SPaT Infrastructure System shall include a “wizard” environment for data entry that describes the type of data expected in each field. For example, the User Interface may inform the user of the number of digits of precision required for latitudes and longitudes.	<i>Optional - recommended</i>	3.6.1
12.3.3.2	The SPaT Infrastructure System shall have a mechanism for graphically displaying the location and layout of entered MAP data.	<i>Optional - recommended</i>	3.6.1
12.3.3.3	The SPaT Infrastructure System shall allow the user to name, copy, modify and delete MAP data of one or more configurations for each intersection.	<i>Optional - recommended</i>	3.6.1
<b>12.4</b>	<b>The SPaT Infrastructure System shall have a mechanism for users to configure GPS correction.</b>	<b>Minimum; RVLW</b>	
12.4.1	The SPaT Infrastructure System shall have a mechanism for users to configure the source of GPS position correction data (e.g. define the source, define the polling mechanism and approach).	<i>Minimum; RLVW</i>	
12.4.2	In locations where the source of position correction data is a regional or national source of data (e.g. Internet accessible data), the configuration shall include the location of the intersection to enable the acquisition of GPS correction data to obtain the correct values.	<i>Minimum; RLVW</i>	
<b>12.5</b>	<b>At locations where messages are received from SPaT Vehicle Systems and PIDS, the SPaT Infrastructure System shall have a mechanism for the user to manage the detection zones defined for receiving data from SPaT Vehicle Systems and PIDS.</b>	<i>Optional - recommended; Based on applications</i>	
12.5.1	The SPaT Infrastructure System shall have a mechanism for the user to create and modify detection zones and associate the detection zones to received message types and to vehicle and pedestrian movements at each intersection.	<i>Optional - recommended; Based on applications</i>	
12.5.2	The SPaT Infrastructure System shall have a mechanism for the user to graphically define detection zones within a digital map environment.	<i>Optional - recommended; Based on applications</i>	
12.5.3	The SPaT Infrastructure System will have a mechanism to automatically identify when a vehicle or pedestrian movement does not have an associated detection zone and notify the user.	<i>Optional - recommended; Based on applications</i>	
<b>12.6</b>	<b>The SPaT Infrastructure shall have a mechanism for managing reports.</b>	<i>Optional - recommended; RLVW</i>	

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
12.6.1	The SPaT Infrastructure System shall have a mechanism for users to define the timeframe for which each report will provide data.	<i>Optional - recommended; Based on applications</i>	
12.6.2	The SPaT Infrastructure System shall have a mechanism for users to define the location(s) for which each report will provide data.	<i>Optional - recommended; Based on applications</i>	
12.6.3	The SPaT Infrastructure System shall have predefined reports for, at a minimum, the following: <ul style="list-style-type: none"> <li>- System errors.</li> <li>- System diagnostics and health.</li> <li>- Volume of messages sent and/or received.</li> <li>- Messages sent and/or received by type.</li> <li>- Volume of vehicles messages received from.</li> <li>- Bad or unreadable data lists.</li> <li>- Revoked credential list.</li> </ul>	<i>Optional - recommended; Based on applications</i>	
12.6.4	The SPaT Infrastructure System shall have a mechanism for generating reports on a schedule configured by the user.	<i>Optional - recommended; Based on applications</i>	
12.6.5	The SPaT Infrastructure System shall have a mechanism to generate ad-hoc reports based on user-entered criteria.	<i>Optional - recommended; Based on applications</i>	
12.6.6	The SPaT Infrastructure shall generate report in a standard data file format, such as comma-delimited flat file, PDF, or Microsoft Excel.	<i>Optional - recommended; Based on applications</i>	
<b>12.7</b>	<b>The SPaT Infrastructure System shall have a mechanism to manage System alerts.</b>	<b><i>Optional - recommended</i></b>	
12.7.1	The SPaT Infrastructure System shall alert users for different types of conditions, including at a minimum: <ul style="list-style-type: none"> <li>- The system or any component of the system loses power.</li> <li>- The system loses communication with any component or other system required for operation.</li> <li>- Failure of any hardware component.</li> <li>- Failure to broadcast.</li> <li>- Failure to receive messages.</li> <li>- Data storage nearing capacity.</li> <li>- Reception of bad data.</li> </ul>	<i>Optional - recommended; Based on applications</i>	

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
12.7.2	The SPaT Infrastructure System shall have a mechanism for configuring the threshold values for alerts. For example, the System may alert users if the system loses connectivity with the Traffic Data System for longer than five seconds.	<i>Optional - recommended; Based on applications</i>	
12.7.3	The SPaT Infrastructure System shall have a mechanism for alerting users when a condition exceeds the configurable threshold by e-mail or SMS (text message) at a minimum.	<i>Optional - recommended; Based on applications</i>	
12.7.4	The SPaT Infrastructure System shall have a mechanism for configuring the users to be alerted for each alert type and how each user will receive each alert (e.g. e-mail or SMS).	<i>Optional - recommended; Based on applications</i>	
<b>12.8</b>	<b>The SPaT Infrastructure System shall have a mechanism for providing system diagnostic information.</b>	<i>Optional - recommended</i>	
12.8.1	The SPaT Infrastructure System shall have a mechanism for users to monitor the performance and health of all system devices and identify changes in performance.	<i>Optional - recommended; Based on applications</i>	
12.8.2	The SPaT Infrastructure System shall detect loss of connectivity or power at any devices.	<i>Optional - recommended; Based on applications</i>	
12.8.3	The SPaT Infrastructure System shall detect the failure of any components.	<i>Optional - recommended; Based on applications</i>	
12.8.4	The SPaT Infrastructure System shall have a mechanism to receive, decode, and display for users the messages exactly how they are broadcast and received by SPaT Vehicle Systems.	<i>Optional - recommended; Based on applications</i>	
<b>12.9</b>	<b>The SPaT Infrastructure System shall have a mechanism for resetting the system.</b>	<b><i>Optional - recommended</i></b>	
12.9.1	The SPaT Infrastructure System shall have a mechanism restarting any field device, both remotely and locally at the device location.	<i>Optional - recommended; Based on applications</i>	3.7.1.3
12.9.2	The SPaT Infrastructure System shall store default settings for each device.	<i>Optional - recommended; Based on applications</i>	3.7.1.3

## Functional Requirements

REQ#	Requirements	Notes	ConOps Reference
12.9.3	The SPaT Infrastructure System shall have a mechanism for restoring any field device to its default settings.	<i>Optional - recommended; Based on applications</i>	3.7.1.3
12.9.4	The SPaT Infrastructure System shall have a mechanism to report when devices fail to respond to commands to restart or be restored to default settings.	<i>Optional - recommended; Based on applications</i>	3.7.1.3