CONNECTED INTERSECTIONS MESSAGE MONITORING SYSTEMS REQUIREMENTS & PROTOTYPE DEVELOPMENT (CIMMS)

System Requirements - DRAFT

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Prepared by

wsp

DRAFT

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1. Introduction

This Systems Requirements Specification (SyRS) is intended to document the requirements that drive the specification, design, development, implementation, integration and testing of the Connected Intersections Message Monitoring System (CIMMS). The SyRS is a "black-box" description of what the CIMMS must do, but not how it will do it. The document contains descriptions of inputs, outputs, and required relationships between inputs and outputs.

1.1. Document Purpose

This SyRS serves as the second in a series of systems engineering documents intended to describe the CIMMS, building upon the Concept of Operations (ConOps) document. The SyRS describes a set of requirements that, when realized, will satisfy the expressed needs of the CIMMS. This document includes the identification, organization and presentation of the requirements for the CIMMS project, which is a system made up of Connected Vehicle (CV) infrastructure and messages. These requirements are derived from the user needs, constraints, and interfaces that the CIMMS is expected to implement and leverages prior system requirements efforts for similar related projects and applications. This SyRS addresses conditions for incorporating operational concepts, design constraints and assumptions, and design configuration requirements as well as the necessary characteristics and qualities of individual requirements and the set of all requirements.

This document was developed based on IEEE 1233-1998 IEEE Guidance for Developing System Requirements Specifications and contains the following chapters:

- **Section 1 Introduction** provides an overview of the CIMMS project and key elements that guide the development of this SyRS document, including an overview of the project, the stakeholders, requirements development process, and referenced materials.
- **Section 2 References** contains a list of reference utilized in developing this document
- **Section 3 System Description** focuses on describing and extending the CIMMS concepts established in the Concept of Operations (ConOps), including system capabilities, conditions, constraints, and decomposing the system into its functional groups for establishing requirements.
- **Section 4 Needs to Requirements Traceability** contains the Needs to Requirements Traceability matrix
- **Section 5 System Requirements** contains the requirements for each functional group that make up the system.
- **Section 6 Engineering Principles** provides a description of engineering principles applied to the system and requirements definition process.

1.2. Project Scope

Since the inception of Connected Vehicle (CV) technology, researchers and deployers have sought new and innovative ways to use CV to improve transportation safety, mobility, and efficiency. Most of these efforts have focused on the ability of vehicles to react to the data they receive from other vehicles and from the infrastructure. Forward Collision Warning, Red-Light Violation Warning, Curve Speed Warning, etc., are all examples of critical CV safety applications that utilize CV data and as more data becomes available, these applications continue to mature. In parallel, numerous advances to ensure timely and

authenticated data is being provided to the CV environment continue. Robust fiber networks and the investment in the Security Credential Management Systems (SCMS) serve as proof of those investments. The assumption, however, has generally been that once a site had deployed and validated the broadcast messages, the data would remain correct. Two issues arise from this thinking:

- **Accuracy** – As has been the focus of the current CV PFS Connected Intersection project (CIP), and others before it, validation of message content goes beyond conformance to the SAE J2735 standard. To truly be considered conformant to the needs of OEMs, deployers need to ensure that broadcast messages truly match what is happening at the intersection. For instance, signal indications on the traffic signal must match those in the SPAT message.
- **Consistency and Changes** – The validation of message accuracy is not only needed at the time when CV equipment is deployed, but also throughout active operations of a CV system. Signal timing patterns change, road geometries change, and devices fail – it is important to confirm that these changes are properly accounted for in the CV system simultaneously after the changes are made. Presently, only limited capabilities exist to determine if a device is even operational, so it is not a simple matter to determine if the messages a CV system produces contain data that correctly reflect ground truth.

The CI project is focused on validating a site's ability to conform to the newly published ITE CI Design Guidance[1], guidance which the OEMs agree will uniformly support advanced safety applications, such as RLVW. CIP is a validation of the guidance itself, feedback which will be provided to the industry. It's important to note that in practice, use of the guidance would typically only occur at deployment however, and similarly validate a site's ability to conform to the guidance.

But what happens after a site validates in conformance to the guidance? Agencies don't have the bandwidth or budgets to subject every intersection to the same rigors as the CIP on a repetitive basis or over an extended period of time. Many agencies are also preparing to leverage increasingly larger amounts of Vehicle-to-Everything (V2X) data from intersections and from vehicles, especially as the number of V2X-equipped vehicles increases. The Concept of Operations proposes that this V2X data can be leveraged to continuously validate the correct operation of the infrastructure over a long-term time horizon. The broad goal of the Connected Intersection Message Monitoring System is to evaluate this potential.

Note that the scope for this project (initial implementation of the message monitor) is limited to receiving CV messages from an existing CV system, and using SPaT, MAP, and BSMs (driver behavior that provides a proxy for ground truth conditions) to assess the correctness of data within SPaT and MAP messages. The ability to use driver behavior to infer ground truth is predicated on the fact that a driver's response to traffic control devices and the roadway environment is generally predictable (though not perfect). Thus, it is reasonable to assume the data in SPaT and MAP messages should be consistent with general vehicular movement as evidenced in BSMs. The correctness of data in MAP and SPaT messages was initially cited as being a priority. Limiting the message monitor to SPaT, MAP, and BMS, simplifies the data and interfaces required between the existing system and the message monitor and minimizes the pre-requisites for the existing system. Any system for which CV data will be assessed should be able to produce and forward CV data to an external system such as the message monitor. Data from other (non-CV) sources, while useful for assessing SPaT and MAP accuracy, may not be available at

[1] *https://www.ite.org/ITEORG/assets/File/Standards/CTI%204501v0101-tracked.pdf*

every intersection. Thus, data from non-CV sources was not included for the initial implementation of the message monitor.

Other needs that have been identified during this process, such as the ability to assess message performance, generic message requirements, the correctness of position correction information in the RTCM message, and the impact of position correction data on the performance of message monitor algorithms that use BSM data are documented, but not considered in the initial implementation of the message monitor. However, the message monitor will be designed in a way that allows the modification/addition of interfaces and algorithms so that data from other sources can be utilized and so other needs can be addressed in future system development efforts.

The requirements established for this project will govern the CIMMS development cycle and are an essential factor in further defining and clarifying the scope and feasibility of development for the system. This document captures the System Requirements associated with the User Needs listed as "Ready" in the Priority column of **Table 6-User Needs Prioritization** in the Concept of Operations. The Requirements contained in this document will be implemented in the CIMMS Proof-of-Concept Prototype. This process will also provide the basis for the technical description of deliverables in the form of a system-level specification and defined interfaces at the system boundaries. **Figure 1** provides a high-level view of the project's stakeholder requirements definition process. Definitions for each box are as follows:

Activities: contains the core behaviors and actions of the system

Controls: contains the system parameters that can be adjusted to "tune" the operation of the system

Inputs: contains information or data to be transformed\processed by the system

Outputs: contains the resulting information based on the transformed\processed inputseh

Enablers: contain the standards, policies, and other factors that influence the operation of the system

Once the project's requirements are established, they will be formally placed under configuration control.

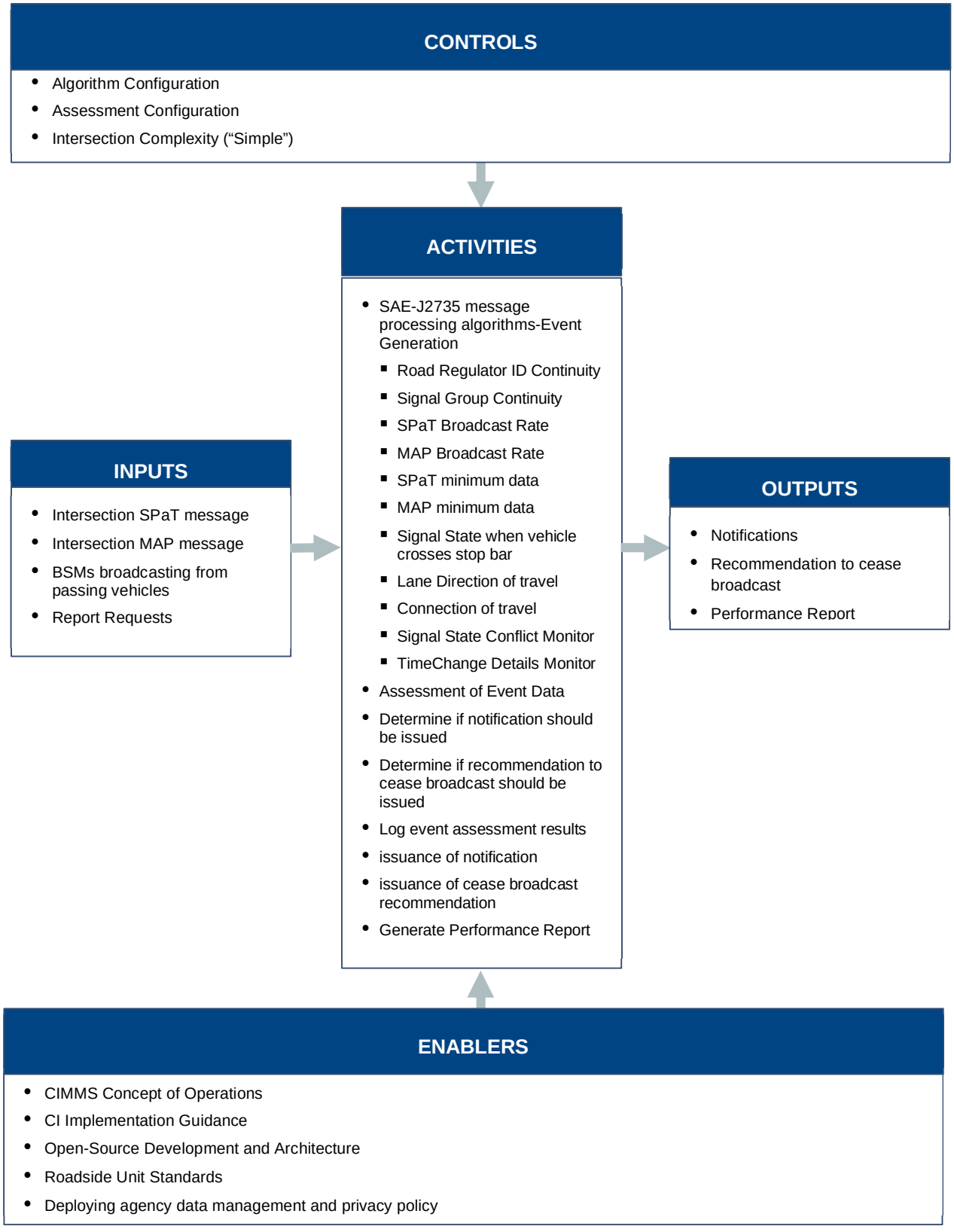

Figure 1: CIMMS Stakeholder Requirements Definition Process

2. References

This section contains documents and literature utilized to gather input for this document.

- Connected Intersection Message Monitoring System-Concept of Operations <TBD> — 06/2022 Draft
- CV PFS Map Guidance Document https://virginia.app.box.com/v/MAPGuidanceFinal — 2021
- SAE J2735 2016-03. V2X Communications Message Set Dictionary. https://www.sae.org/standards/content/j2735_201603/ — 2016
- SAE J2735 2020-07. V2X Communications Message Set Dictionary. https://www.sae.org/standards/content/j2735_202007 — 2020
- CTI 4501 v01 – Connected Intersections (CI) Implementation Guide http://www.ite.org/pub/76270782-B7E4-7F75-BC72-D5E318B14C9A — 2021
- CTI 4001 v01 - Roadside Unit (RSU) Standard http://www.ite.org/pub/764FB228-0F6C-BA02-6D7B-16A86B1F8108 — 2021
- SAE J2945/B Recommended Practices for Signalized Intersection Applications https://www.sae.org/standards/content/j2945/b/ — (Work in progress)
- Operational Data Environment open-source decoder for MAP/SPaT/BSM https://github.com/usdot-jpo-ode/jpo-ode — 2021 (latest version)
- CTI 4502 v01.00 – Connected Intersections Validation Report https://www.ite.org/pub/?id=59A8D354-F7B1-6A18-6FCC-1CECE6ACDE5B — 2022
- Connected Intersections Program, Connected Vehicle Pooled Fund Study https://engineering.virginia.edu/cv-pfs-projects-and-research#accordion620710

3. System Description

3.1. System Context

The CIMMS can be described as a watchdog system to assess the ability of SPaT and MAP messages to meet applicable requirements and, with a reasonable degree of certainty, reflect the actual signal status and geometry of the intersection . The Message Monitor is intended to be added to existing Connected Vehicle deployments to monitor the health of the SPaT and MAP messages, provide a summary of the status of the messages, generate periodic reports to inform traffic operations of the status and trend of the messages over time, and to notify the traffic operations if exceptions are detected.

To establish an organizational framework for CIMMS requirements, the proposed system described in Section 5 of the ConOps was further refined, decomposed, and classified according to its functionality (i.e., functional groups) and its major system components, as illustrated on the context diagrams in **Figure 2**.

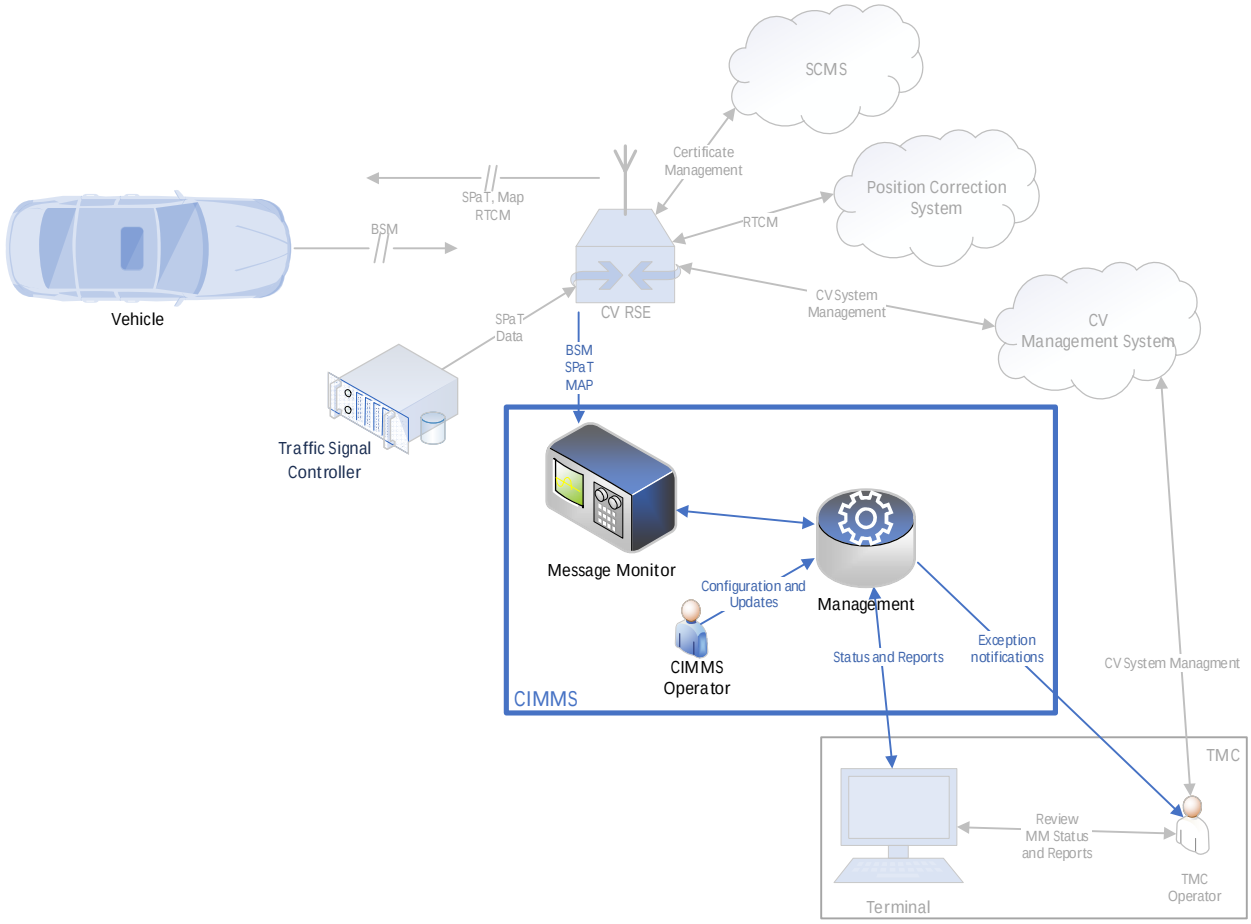

Figure 2: CIMMS System Context Diagram

Table 1 contains a high-level list of components, and their functionality, based on decomposing the CIMMS as describe in the Concept of Operations.

Table 1: CIMMS System Components

Ref	Component	Function	Description
SEC	CIMMS	Security	Protect CIMMS and existing system from unauthorized access and malicious attacks
V2XM	CIMMS	V2X Messages	SPaT, MAP, and BSMs required for CIMMS operation
COP	CIMMS Operator	Message Monitor Support	Personnel responsible for the operations and maintenance of the CIMMS, which includes resolving issues, adding features, etc. In the long-term, Message Monitor Support will likely become the responsibility of the IOO system owner.
CM	Management	CIMMS Management	Enables the operator to configure Message Monitor parameters, thresholds, etc.
EN	Management	Exception Notification	Provides Message Monitor exception notifications to the operator
MSR	Management	Message Status and Reports	Provides indications of real-time message compliance and compliance trends
MMA	Message Monitor	MAP Message Assessment	Verifies MAP message content complies with CTI 4501 guidance, publishes status reports, and notifies operator of exceptions (failures & faults)
SMBA	Message Monitor	SPaT and MAP Assessment using BSMs	Verifies SPaT and MAP messages align with vehicle movements based on BSM content
SMA	Message Monitor	SPaT Message Assessment	Verifies SPaT message content complies with CTI 4501 guidance, publishes status reports, and notifies operator of exceptions (failures & faults)

Table 2 contains a high-level list of the existing CV system components.

Table 2: Existing CV system components

Ref	Component	Description
CVMS	Connected Vehicle Management System	Provides overall CV system management, including but not limited to providing status of roadside equipment, enabling the operator to configure roadside equipment, generating and distributing MAP messages to applicable Intersections, etc.
CV RSE	Connected Vehicle Roadside Equipment	Devices or equipment deployed at the roadside to facilitate the exchange of Connected Vehicle messages between vehicles and infrastructure
PoS	Position Correction System	A position correction system provides global navigation satellite system (GNSS) data consisting of carrier phase and code range measurements in support of three-dimensional positioning. Correction data are used to improve the precision of GPS data. Enhanced post-processed coordinates approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically. The CIMMS Prototype will not assess RTCM.

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Ref	Component	Description
SCMS	Security Credential Management System	Manages Digital Certificates used to ensure authenticated message exchange
TOP	TMC Operator	Utilizes CIMMS status and notifications to address SPaT, MAP, and other related issues
TMC	Traffic Management Center	Centralized management for traffic operations
TSC	Traffic Signal Controller	Source of intersection signal phase and timing data

While the Proof-of-Concept prototype system is intended to be cloud-based, the requirements contained in this document will not preclude a roadside-based implementation in the future.

3.2. System Modes and States

Modes are composed of the overall status of a MM, its ability to receive CV messages and generate and send notifications and reports.

Devices have three modes:

- **Normal mode:** The MM is performing all required operations
- **Degradation mode:** Something unexpected occurred resulting in the MM not able to perform certain required functionality
- **Error mode:** a complete failure of the MM, including communication failures

The MM is considered to be in “normal” mode when it is operating as designed. The MM enters “degradation” mode if it stops performing one of the required functions. If the MM completely fails or loses the ability to communicate with the roadside equipment or traffic operations, it enters “error” mode.

3.3. Major System Characteristics

3.3.1. System Capabilities

The primary objective of the Message Monitor is two-fold; confirm SPaT and MAP messages broadcast at an intersection meet applicable portions of CTI 4501v001 guidance and confirm SPaT timing and MAP geometry align with traffic signal controller timing (and the signal heads) and roadway geometry, respectively.

The MM will provide Traffic Operations with current status of equipped intersections as well as weekly\monthly reports showing indicators of SPaT and MAP message correctness and operation and trends over time. Traffic Operations will receive notifications through e-mail and\or text messages when the system is not in compliance.

The MM provides IOOs with warnings that there are likely problems with SPaT and MAP messages being broadcast, enabling the IOO to rectify issues in a timely manor. MM Reports should ultimately provide OEMs a higher level of confidence that SPaT and MAP messages are correct and can reliably support in-vehicle applications.

3.3.2. System Conditions

The MM is generally expected to perform under most conditions, securely and timely processing SPaT, MAP, and BSM, as available, allowing for the stated objectives of the project to be met. Situations that may result in degraded or no performance include:

- **Loss of Power:** A power outage that impacts the infrastructure elements of the environment will prohibit the MM from performing as expected.
- **Loss of Communications:** Localized communications will be employed, where applicable, to minimize the impact a loss of communications will have on the overall operation of the MM, albeit there may be conditions whereby data cannot be collected and\or the MM cannot send status reports or notifications to traffic operations
- **Device Failure:** A device failure will render all MM functions inoperable.

The overall CV system should have a system monitor in place to ensure RSUs are operating as intended. Management provisions should be made to monitor the operation of the MM to identify and resolve failures as quickly as practical. A failure of the MM will not directly affect the overall operation of the CV system; however, it may lead to missing detection of non-complaint SPaT and MAP messages broadcast by the RSU. A failure of the CV system, specifically the RSU, will prevent the MM from operating.

3.4. User Characteristics

This section defines the stakeholders, user classes, and their roles and responsibilities for the CIMMS. Stakeholders refers to an individual or organization affected by the activities, inputs and outputs of the system being developed. They may have a direct or indirect interest in the system and their level of participation may vary. This primarily includes public agencies with a vested interest or "stake" in one or more aspects of the system as identified in **Table 3**. User Classes are classified based on their perception of the system and the needs identified. Note that some key personnel may serve in multiple roles based on the user needs and functions.

Table 3: CIMMS Stakeholders and User Classes

Target Stakeholders	User Classes		
	Traffic Operations	Message Monitor Support	Driver
Private Vehicle owners			X
Fleet Vehicle owners			X
Automotive OEMs			X
IOO system owner	X	X	
MM System Developer		X[2]	

[2] *The MM System Developer can act in the Message Monitor Support role for the duration of the Project. However, in*

3.4.1. Private Vehicle owners

The driver user class is represented by private vehicle owners. The driver does not directly interface with the MM and has the same role and responsibilities as described in Section 3.5 of the Concept of Operations. However, it is important to note that the driver indirectly benefits when the MM identifies an issue in a message that is corrected by the system owner. Improved message performance is expected to improve application performance on the driver's On-board Unit (OBU), thereby improving public confidence in the technology.

3.4.2. Fleet Vehicle owners

The driver user class is also represented by IOO (City, State, etc.) fleet vehicle owners. The driver does not directly interface with the MM and has the same role and responsibilities as described in Section 3.5 of the Concept of Operations. However, it is important to note that the driver indirectly benefits when the MM identifies an issue in a message that is corrected by the system owner. Improved message performance is expected to improve application performance on the driver's On-board Unit (OBU), thereby improving confidence in the technology.

3.4.3. Automotive OEMs

The driver user class is also represented by Automotive Original Equipment Manufacturers (OEM). The driver does not directly interface with the MM and has the same role and responsibilities as described in Section 3.5 of the Concept of Operations. However, it is important to note that the driver indirectly benefits when the MM identifies an issue in a message that is corrected by the system owner. Improved message performance is expected to improve application performance on the driver's On-board Unit (OBU), thereby improving public perception of the technology.

3.4.4. IOO system owner

Traffic Operations is represented by the IOO system owner, responsible for the management of the overall Connected Vehicle system. The IOO has likely selected staff (or consultants) that perform the CV-related roles performed by Traffic Operations Personnel. Traffic operations responsibilities will be expanded to include receiving, interpreting, and acting upon outputs from the MM – which indicates some aspects of the messages being broadcast are not compliant with CI guidance. Traffic operations will use MM outputs to locate an issue(s) in a SPaT or MAP message, exercise engineering judgement to determine if changes are needed (e.g., if/how a message needs to be modified), and subsequently make modifications to improve performance. Traffic Operations can also provide a list of desired system changes to Message Monitor Support to improve the usefulness of MM outputs.

3.4.5. Message Monitor Support

For the duration of the project, the Message Monitor Support user class will be represented by the CIMMS developer. Message Monitor Support is responsible for configuring and adjusting the functionality and operations of the CIMMS, within project scope, based on feedback from Traffic Operations. In the long-term, however, Message Monitor Support user class will likely become the responsibility of the IOO system owner.

the long term, this role will likely become part of the system owner

3.5. Assumptions and Dependencies

Table 4 contains a list of assumptions and dependencies that represent a risk to the CIMMS project that could affect the ability of the prototype system to meet the desired functionality, schedule, and performance goals.

Table 4: Assumptions and Dependencies

ID	Assumption	Corresponding Risk	Dependency	Degree
1	CV Roadside Units (RSU), installed at signalized intersections to be monitored, are broadcasting SPaT and MAP messages, compliant with applicable portions of CI 4501v01	CIMMS may not receive required SPaT and MAP messages	RSU hardware, firmware capability, and configuration	High
2	CV Roadside Equipment (RSE), installed at signalized intersections to be monitored, have a backhaul connection to exchange data with cloud based hosts and services	CIMMS may not receive required SPaT, MAP, and BSMs	General IOO IT\backhaul network	High
3	CV RSUs, installed at signalized intersections to be monitored, are, or can be configured to, forward SPaT, MAP, and BSMs to a remote host (CMMIS), as defined in ITE CTI 4001-v01	CIMMS may not receive required SPaT, MAP, and BSMs	RSU hardware, firmware capability, and configuration	High
4	Even if a V2X Hub, External Controls Local Application (ECLA), or similar type of device is utilized to generate SAE J2735 SPaT messages, it is expected the RSU, not the V2X Hub\ECLA, will send SPaT and MAP messages to the CIMMS	Timing issues between when the V2X Hub\ECLA sends SPaT and MAP messages to the RSU and when the RSU broadcast the SPaT and MAP messages could affect the performance of the Message Monitor	RSUs ability to forward messages to a remote host	High
5	Operation Center (TMC) has an external connection to exchange data with cloud based hosts and services	(TMC) Operator may not be able to request\review status and performance reports	General IOO IT network	Medium
6	Signalized intersections being monitored receive enough BSMs to assess the correctness of SPaT and MAP messages broadcast by the intersection	Potential issues resulting from the algorithms utilizing BSMs will take longer to identify	Quantity and frequency of vehicles traversing the intersection(s)	Medium
7	OBUs use the data in RTCM messages to apply corrections to vehicle position data. This is then reflected in position data in the BSM.	BSM position data may not correctly indicate the location of the OBU	The ability of OBUs correctly to utilize RTCM	Medium

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ID	Assumption	Corresponding Risk	Dependency	Degree
8	The deploying IOO does not have data storage polices that require special handling of BSM data	The system would need to be deployed without the BSM algorithm	IOO Data Policies	Low

3.6. System Constraints

Table 5 lists the constraints on the system as defined by the concept of operations and for developing and deploying an initial Message Monitor prototype. Requirements have been developed to support these constraints.

Table 5: System Constraints

Constraint ID	Reference	Constraint
CIMMS-CN001-v01	Concept of CIMMS Operations Section 5.2	There is a desire for the proposed system to use open-source software practices consistent with those currently in use by FHWA, such as the ITS Code Hub.
CIMMS-CN002-v01	Concept of CIMMS Operations Section 5.2	Only SPaT and MAP as defined in applicable portions of the ITE CTI 4501v01 Connected Intersection Guidance and SAE J2735 V2X Message Set Dictionary Standard will be supported.
CIMMS-CN003-v01	Concept of CIMMS Operations Section 5.2	Only BSMs as defined in the SAE J2735 V2X Message Set Dictionary Standard will be supported
CIMMS-CN004-v01	Concept of CIMMS Operations Section 5.2	Only RSUs compliant with message forwarding functionality as defined in CTI 4001 v01will be supported
CIMMS-CN005-v01	Concept of CIMMS Operations Section 5.2	SPaT and MAP will be assessed based on applicable requirements and design details contained in CTI 4501v01
CIMMS-CN006-v01	Concept of CIMMS Operations Section 5.2	Only common intersection types will be supported
CIMMS-CN007-v01	Concept of CIMMS Operations Section 5.2	For any type of temporal association of data, the message monitor will only use time data contained in messages, and not any timestamps associated with the capturing of the message
CIMMS-CN008-v01	Prototype	Only a cloud-based Message Monitor prototype will be supported, however, the System Requirements do not preclude deploying the message monitor at the roadside

3.7. Operational Scenarios

Chapter 6 of the CV PFS CIMMS *Concept of Operations* captures and documents the operational scenarios.

4. Needs to Requirements Traceability

Table 6 provides the Needs-to-Requirements Traceability Matrix (NRTM) relating the user needs provided in the CIMMS Concept of Operations and the requirements provided within the document. To claim conformance, an implementation shall satisfy the mandatory and selected optional requirements as identified in the NRTM.

The columns contained in the NRTM are defined as follows:

a. **User Need ID** - the number assigned to the user need statement. The NRTM is based on the user needs defined in the SR 710 Concept of Operations.
b. **User Need** – a short descriptive title identifying the user need.
c. **FR ID** – the number assigned to the functional requirement statement. The requirements are defined within Section **Error! Reference source not found.** and the NRTM references the traces from user needs to these requirements.
d. **Functional Requirement** – a short descriptive title identifying the requirement.
e. **Conformance** – notations used to indicate status and conditional status. Not all notations may be utilized within this implementation:
    - M: Mandatory
    - M.#: Support of every item of the group labeled by the same numeral # is required, but only one is active at a time
    - O: Optional
    - O.#: (range) Part of an option group. Support of the number of items indicated by the '(range)' is required from all options labeled with the same numeral #
    - C: Conditional
    - NA: Not-applicable (i.e., logically impossible in the scope of the
    - standard)
    - X: Excluded or prohibited
f. **Support** - notations 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:
    - Yes: Supported by the implementation
    - No: Not supported by the implementation
    - N/A: Not applicable
g. **Additional Specifications** - identifies other requirements to satisfy, including user selectable range values. 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 equipment. However, additional text can be added to this field as needed to fully specify a feature.

Table 6 provides the Needs-to-Requirements Traceability Matrix (NRTM) relating the user needs provided in the CIMMS Concept of Operations and the requirements provided within the document. To claim conformance, an implementation shall satisfy the mandatory and selected optional requirements as identified in the NRTM.

Note: since this document contains only the requirements for the CIMMS prototype, all requirements contained in this document are mandatory and expected to be implemented in the system.

Table 6: Needs-to-Requirements Traceability Matrix

Needs to Requirements Traceability Matrix					
User Need ID	User Need	Requirement ID	Conformance	Support	Additional Specifications
Primary Functions					
UN-001.1	Message Performance Requirements	CIMMS-FR-009-v01,CIMMS-FR-010-v01,CIMMS-FR-011-v01,CIMMS-FR-012-v01,CIMMS-FR-013-v01,CIMMS-FR-014-v01,CIMMS-FR-015-v01,CIMMS-FR-015.1-v01,CIMMS-FR-015.2-v01,CIMMS-FR-017-v01,CIMMS-FR-017.1-v01,CIMMS-FR-017.2-v01	M	Yes	
UN-001.3.1	Intersection Identification	CIMMS-FR-002-v01,CIMMS-FR-002.1-v01,CIMMS-FR-002.2-v01,CIMMS-FR-002.3-v01,CIMMS-FR-002.4-v01	M	Yes	
UN001.3.3	Current Movement State	CIMMS-FR-006-v01,CIMMS-FR-006.1-v01,CIMMS-FR-006.2-v01,CIMMS-FR-006.3-v01,CIMMS-FR-019-v01,CIMMS-FR-019.1-v01,CIMMS-FR-019.2-v01,CIMMS-FR-019.3-v01,CIMMS-FR-019.4-v01,CIMMS-FR-019.5-v01,CIMMS-FR-019.6-v01,CIMMS-FR-019.7-v01,CIMMS-FR-019.8-v01,CIMMS-FR-019.9-v01,CIMMS-FR-019.10-v01,CIMMS-FR-019.11-v01,CIMMS-FR-019.12-v01,CIMMS-FR-019.13-v01,CIMMS-FR-019.14-v01,CIMMS-FR-022-v01,CIMMS-FR-022.01-v01,CIMMS-FR-022.02-v01,CIMMS-FR-022.03-v01,CIMMS-FR-022.04-v01,CIMMS-FR-022.05-v01,CIMMS-FR-022.06-v01,CIMMS-FR-022.07-v01,CIMMS-FR-022.08-v01,CIMMS-FR-022.09-v01,CIMMS-FR-022.10-v01	M	Yes	
UN-001.3.5	Time Change Details	CIMMS-FR-023-v01,CIMMS-FR-023.01-v01,CIMMS-FR-023.02-v01,CIMMS-FR-023.03-v01,CIMMS-FR-023.04-v01	M	Yes	
UN-001.3.8	SPaT Accuracy	CIMMS-FR-019-v01,CIMMS-FR-019.1-v01,CIMMS-FR-019.2-v01,CIMMS-FR-019.3-v01,CIMMS-FR-019.4-v01,CIMMS-FR-019.5-v01,CIMMS-FR-019.6-v01,CIMMS-FR-019.7-v01,CIMMS-FR-019.8-v01,CIMMS-FR-019.9-v01,CIMMS-FR-019.10-v01,CIMMS-FR-019.11-v01,CIMMS-FR-019.12-v01,CIMMS-FR-019.13-v01,CIMMS-FR-019.14-v01	M	Yes	
UN-001.4.1	Intersection Geometry	CIMMS-FR-002-v01,CIMMS-FR-002.1-v01,CIMMS-FR-002.2-v01,CIMMS-FR-002.3-v01,CIMMS-FR-002.4-v01	M	Yes	

Needs to Requirements Traceability Matrix					
User Need ID	User Need	Requirement ID	Conformance	Support	Additional Specifications
UN-001.4.2	Lane Attributes	CIMMS-FR-020-v01,CIMMS-FR-020.01-v01,CIMMS-FR-020.02-v01,CIMMS-FR-020.03-v01,CIMMS-FR-020.04-v01,CIMMS-FR-020.05-v01,CIMMS-FR-020.06-v01,CIMMS-FR-020.07-v01,CIMMS-FR-020.08-v01,CIMMS-FR-020.09-v01,CIMMS-FR-020.10-v01,CIMMS-FR-020.11-v01	M	Yes	
UN-001.4.4	Connections Between Lanes	CIMMS-FR-021-v01,CIMMS-FR-021.01-v01,CIMMS-FR-021.02-v01,CIMMS-FR-021.03-v01,CIMMS-FR-021.04-v01,CIMMS-FR-021.05-v01,CIMMS-FR-021.06-v01,CIMMS-FR-021.07-v01,CIMMS-FR-021.08-v01,CIMMS-FR-021.09-v01	M	Yes	
UN-001.4.8	SPaT-MAP Synchronization	CIMMS-FR-019-v01,CIMMS-FR-019.1-v01,CIMMS-FR-019.2-v01,CIMMS-FR-019.3-v01,CIMMS-FR-019.4-v01,CIMMS-FR-019.5-v01,CIMMS-FR-019.6-v01,CIMMS-FR-019.7-v01,CIMMS-FR-019.8-v01,CIMMS-FR-019.9-v01,CIMMS-FR-019.10-v01,CIMMS-FR-019.11-v01,CIMMS-FR-019.12-v01,CIMMS-FR-019.13-v01,CIMMS-FR-019.14-v01	M	Yes	
UN-001.6	Security Requirements	CIMMS-SR-006-v01	M	Yes	
UN-002	Basic Validation	CIMMS-FR-001-v01,CIMMS-FR-001.1-v01,CIMMS-PR-002-v01,CIMMS-PR-003-v01,CIMMS-IR-001-v01,CIMMS-IR-002-v01,CIMMS-IR-003-v01,CIMMS-IR-001-v01,CIMMS-IR-002-v01,CIMMS-IR-003-v01,CIMMS-FR-006-v01,CIMMS-FR-006.1-v01,CIMMS-FR-006.2-v01,CIMMS-FR-006.3-v01,CIMMS-FR-009-v01,CIMMS-FR-010-v01,CIMMS-FR-011-v01,CIMMS-FR-012-v01,CIMMS-FR-013-v01,CIMMS-FR-014-v01,CIMMS-FR-015-v01,CIMMS-FR-015.1-v01,CIMMS-FR-015.2-v01,CIMMS-FR-017-v01,CIMMS-FR-017.1-v01,CIMMS-FR-017.2-v01,CIMMS-FR-022-v01,CIMMS-FR-022.01-v01,CIMMS-FR-022.02-v01,CIMMS-FR-022.03-v01,CIMMS-FR-022.04-v01,CIMMS-FR-022.05-v01,CIMMS-FR-022.06-v01,CIMMS-FR-022.07-v01,CIMMS-FR-022.08-v01,CIMMS-FR-022.09-v01,CIMMS-FR-022.10-v01,CIMMS-FR-023-v01,CIMMS-FR-023.01-v01,CIMMS-FR-023.02-v01,CIMMS-FR-023.03-v01,CIMMS-FR-023.04-v01,CIMMS-RG-002-v01,CIMMS-FR-002-v01,CIMMS-FR-002.1-v01,CIMMS-FR-002.2-v01,CIMMS-FR-002.3-v01,CIMMS-FR-002.4-v01	M	Yes	

Needs to Requirements Traceability Matrix					
User Need ID	User Need	Requirement ID	Conformance	Support	Additional Specifications
UN-003	Validation using BSMs	CIMMS-FR-001-v01,CIMMS-FR-001.1-v01,CIMMS-FR-020-v01,CIMMS-FR-020.01-v01,CIMMS-FR-020.02-v01,CIMMS-FR-020.03-v01,CIMMS-FR-020.04-v01,CIMMS-FR-020.05-v01,CIMMS-FR-020.06-v01,CIMMS-FR-020.07-v01,CIMMS-FR-020.08-v01,CIMMS-FR-020.09-v01,CIMMS-FR-020.10-v01,CIMMS-FR-020.11-v01,CIMMS-FR-021-v01,CIMMS-FR-021.01-v01,CIMMS-FR-021.02-v01,CIMMS-FR-021.03-v01,CIMMS-FR-021.04-v01,CIMMS-FR-021.05-v01,CIMMS-FR-021.06-v01,CIMMS-FR-021.07-v01,CIMMS-FR-021.08-v01,CIMMS-FR-021.09-v01,CIMMS-PR-002-v01,CIMMS-PR-003-v01,CIMMS-IR-003-v01,CIMMS-IR-003-v01,CIMMS-FR-019-v01,CIMMS-FR-019.1-v01,CIMMS-FR-019.2-v01,CIMMS-FR-019.3-v01,CIMMS-FR-019.4-v01,CIMMS-FR-019.5-v01,CIMMS-FR-019.6-v01,CIMMS-FR-019.7-v01,CIMMS-FR-019.8-v01,CIMMS-FR-019.9-v01,CIMMS-FR-019.10-v01,CIMMS-FR-019.11-v01,CIMMS-FR-019.12-v01,CIMMS-FR-019.13-v01,CIMMS-FR-019.14-v01	M	Yes	
UN-004	Event Generation	CIMMS-FR-006.2-v01,CIMMS-FR-006.3-v01,CIMMS-FR-010-v01,CIMMS-FR-011-v01,CIMMS-FR-013-v01,CIMMS-FR-014-v01,CIMMS-FR-015.2-v01,CIMMS-FR-017.2-v01,CIMMS-FR-021.09-v01,CIMMS-FR-022.07-v01,CIMMS-FR-022.10-v01,CIMMS-FR-023.01-v01,CIMMS-FR-023.02-v01,CIMMS-FR-023.03-v01,CIMMS-FR-023.04-v01,CIMMS-FR-002.4-v01,CIMMS-FR-019.14-v01	M	Yes	
UN-005	Logging	CIMMS-FR-027-v01,CIMMS-FR-027.05-v01,CIMMS-FR-032.03-v01,CIMMS-FR-054-v01,CIMMS-FR-001-v01,CIMMS-FR-001.1-v01,CIMMS-FR-006.2-v01,CIMMS-FR-006.3-v01,CIMMS-FR-010-v01,CIMMS-FR-011-v01,CIMMS-FR-013-v01,CIMMS-FR-014-v01,CIMMS-FR-015.2-v01,CIMMS-FR-017.2-v01,CIMMS-FR-021.09-v01,CIMMS-FR-022.07-v01,CIMMS-FR-022.10-v01,CIMMS-FR-023.01-v01,CIMMS-FR-023.02-v01,CIMMS-FR-023.03-v01,CIMMS-FR-023.04-v01,CIMMS-FR-002.4-v01	M	Yes	
UN-006	Assessment of Events	CIMMS-FR-024-v01,CIMMS-FR-024.01-v01,CIMMS-FR-024.02-v01,CIMMS-FR-027.01-v01,CIMMS-FR-027.02-v01,CIMMS-FR-027.03-v01,CIMMS-FR-027.04-v01,CIMMS-FR-032-v01,CIMMS-FR-032.01-v01,CIMMS-FR-032.02-v01,CIMMS-PR-004-v01,CIMMS-FR-027-v01,CIMMS-FR-027.05-v01,CIMMS-FR-032.03-v01	M	Yes	
UN-007	Continuous Assessment	CIMMS-PR-004-v01	M	Yes	
UN-008	Generate Notifications	CIMMS-FR-037-v01,CIMMS-FR-039-v01,CIMMS-FR-040-v01,CIMMS-FR-041-v01,CIMMS-FR-042-v01,CIMMS-FR-043-v01,CIMMS-FR-044-v01,CIMMS-FR-046-v01,CIMMS-FR-046.01-v01,CIMMS-FR-048-v01,CIMMS-FR-050-v01,CIMMS-FR-052-v01,CIMMS-FR-074-v01,CIMMS-FR-075-v01,CIMMS-FR-076-v01,CIMMS-PR-005-v01,CIMMS-IR-004-v01,CIMMS-IR-005-v01,CIMMS-IR-004-v01,CIMMS-IR-005-v01	M	Yes	

Needs to Requirements Traceability Matrix					
User Need ID	User Need	Requirement ID	Conformance	Support	Additional Specifications
UN-009	Suspend Message Broadcast	CIMMS-FR-045-v01,CIMMS-FR-047-v01,CIMMS-FR-047.01-v01,CIMMS-FR-049-v01,CIMMS-FR-051-v01,CIMMS-FR-053-v01,CIMMS-FR-071-v01,CIMMS-FR-081-v01,CIMMS-FR-082-v01,CIMMS-IR-006-v01,CIMMS-IR-007-v01,CIMMS-IR-006-v01,CIMMS-IR-007-v01,CIMMS-FR-074-v01,CIMMS-FR-075-v01,CIMMS-FR-076-v01	M	Yes	
UN-010	Performance Reports	CIMMS-FR-072-v01,CIMMS-FR-073-v01,CIMMS-IR-010-v01,CIMMS-IR-011-v01,CIMMS-IR-012-v01,CIMMS-IR-013-v01,CIMMS-IR-010-v01,CIMMS-IR-011-v01,CIMMS-IR-012-v01,CIMMS-IR-013-v01	M	Yes	
UN-011	Non-Interfering	CIMMS-IR-014-v01	M	Yes	
Operations					
UN-012	Automated Operations	CIMMS-PR-002-v01	M	Yes	
UN-013	Continuous Operations	CIMMS-AR-001-v01,CIMMS-MT-001-v01,CIMMS-PR-003-v01	M	Yes	
UN-014	Near Real-Time Operations	CIMMS-PR-005-v01, CIMMS-PR-004-v01, CIMMS-PR-006-v01	M	Yes	
UN-015	Scalability	CIMMS-PR-001-v01,CIMMS-PY-001-v01,CIMMS-PY-002-v01	M	Yes	
UN-016	Security	CIMMS-SR-001-v01,CIMMS-SR-002-v01,CIMMS-SR-003-v01,CIMMS-SR-004-v01,CIMMS-SR-005-v01,CIMMS-SR-007-v01,CIMMS-SR-008-v01	M	Yes	
Configuration					
UN-018	Algorithm Parameter Configuration	CIMMS-FR-056-v01,CIMMS-FR-057-v01,CIMMS-FR-058-v01,CIMMS-FR-059-v01,CIMMS-FR-060-v01,CIMMS-FR-061-v01,CIMMS-FR-070-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01	M	Yes	
UN-019	Notification Configuration	CIMMS-FR-062-v01,CIMMS-FR-063-v01,CIMMS-FR-064-v01,CIMMS-FR-065-v01,CIMMS-FR-066-v01,CIMMS-FR-067-v01,CIMMS-FR-068-v01,CIMMS-FR-069-v01,CIMMS-FR-077-v01,CIMMS-FR-078-v01,CIMMS-FR-079-v01,CIMMS-FR-080-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01	M	Yes	

Needs to Requirements Traceability Matrix					
User Need ID	User Need	Requirement ID	Conformance	Support	Additional Specifications
UN-020	Suspend Configuration	CIMMS-FR-062-v01,CIMMS-FR-063-v01,CIMMS-FR-064-v01,CIMMS-FR-065-v01,CIMMS-FR-066-v01,CIMMS-FR-067-v01,CIMMS-FR-068-v01,CIMMS-FR-069-v01,CIMMS-FR-077-v01,CIMMS-FR-078-v01,CIMMS-FR-079-v01,CIMMS-FR-080-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01,CIMMS-IR-008-v01,CIMMS-IR-009-v01	M	Yes	
Software / Application					
UN-022	Non-proprietary	CIMMS-RG-001-v01	M	Yes	
UN-023	Algorithm Modification	CIMMS-RG-001-v01	M	Yes	
UN-024	Interface Modification	CIMMS-RG-001-v01	M	Yes	

5. System Requirements

This section of the document lists the identified requirements for the CIMMS. The requirements are organized first by requirement type, then by system and services (i.e., functional requirements (FR) for functional group 1, then FR for functional group 2, etc.).

The requirements tables in this section include a column for the requirement identifier, functional group, sub-component, description, a reference, and verification method. Each requirement type has a requirement identifier - **Appendix A. Document Terminology and Conventions** provides an overview of the method that is used to build the requirement identifier. The next two columns provide the functional group and sub-component. These are intended to organize the requirements in a manner that allows similar requirements to be grouped together. The requirements in the tables in this section are grouped by functional group and sub-component. The next column provides the requirement description, which is intended to be well-formed as specified by the Systems Engineering Guide for Intelligent Transportation Systems[3]: necessary, clear, complete, correct, feasible, and verifiable. The reference number identifies traceability to user needs, user scenarios, other (parent) requirements, and/or policies and constraints. The final column provides the verification method – the four fundamental verification methods considered include: inspection, demonstration, test, and analysis. Definitions of these methods are provided in **Section 6.1**. **Table 7** describes the classifications of the requirements in this document.

Table 7: List of Requirement Types

Type	Description
Functional (FN)	The Functional requirements specify actionable and qualitative behaviors (e.g. functions, tasks) of the core system of interest, which in the case of CIMMS includes RSUs and the Message Monitor
Performance (PR)	The Performance requirements specify quantifiable characteristics of operations that define the extent, or how well, and under what conditions a function or task is to be performed (e.g., rates, velocities).
Interface (IF)	The Interface requirements define how the system will interact, communicate, or exchange data with external systems (external interface) and how core system elements interact with other parts of the system (internal interface).
Data (DR)	The Data requirements define the data collected, transformed, and stored from various sources as well as identifies new data that is expected to be generated.
Security (SR)	The Security requirements specify what is necessary to protect the integrity and operability of the system, its microservices, connections, and data. This includes physical security as well as cyber prevention, detection, identification, response and recovery requirements.
Policy and Regulation (RG)	The Policy and Regulation requirements specify relevant and applicable organizational policies or regulations that affect the development, operation or performance of the system (e.g. IT and labor policies, reports to regulatory agencies, health or safety criteria, etc.). This section also includes new policy and regulation imposed to realize the system.

[3] https://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf

Type	Description
Non-Functional (NF)	The Non-Functional requirements define the characteristics of the overall operation of the system, including the following: • Physical (PY) – specifies the construction, durability, adaptability and environmental characteristics of the system • Availability and Recovery (AR) – define the times of day, days of year, and overall percentage the system can be used and when it will not be available for use as well as recovery point and time objectives. • Maintainability (MT) – specify the level of effort required to locate and correct an error during operation. • Storage and Transport (ST) – specify the physical location and environment for the system, including designated storage facility, installation site, repair facility, requirements for transporting equipment, etc. • Disposal (DP) – specify the items related to the disposal of project/system components, due to either failure replacements, removal, end-of-life upgrade, or retirement.
Enabling (EN)	The Enabling requirements specify details concerning the management of information as well as the production of the system and its life cycle sustainment, including the following: • Information Management (IM) – specify the acquisition, management, and ownership of information from one or more sources, the custodianship and the distribution of that information to those who need it. • Life Cycle Sustainability (LC) – define what items the project or system will review, measure, and analyze as part of its commitment to quality during the life cycle of the system, including development, integration, verification, validation, and training.

5.1. Functional Requirements

This section provides the high-level requirements for the system of interest (i.e., what the system will do). The requirements in **Table 8** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 8: Functional Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-001-v01	*all Message Monitor functions*	Temporary V2X Message Storage	The Message Monitor Manager shall store V2X Messages received from the RSU for a configurable V2X message storage period.	UN-002, UN-003, UN-005	Demonstration
CIMMS-FR-001.1-v01	*all Message Monitor functions*	Temporary V2X Message Storage	Prior to processing any raw message data, the Message Monitor Manager should generate a list of unique MAP messages broadcast from each intersection (for a given period over which raw V2X messages are assessed) to improve processing efficiency.	UN-002, UN-003, UN-005	Inspection
CIMMS-FR-002-v01	SPaT/MAP Message Assessment	Intersection Reference Alignment	The Message Monitor shall determine if the data in the intersection reference ID data frame aligns between SPaT and MAP messages representing the same intersection	UN-001.3.1, UN-001.4.1, UN-002	Test
CIMMS-FR-002.1-v01	SPaT/MAP Message Assessment	Intersection Reference Alignment	The Message Monitor shall compare the RoadRegulatorID of SPaT Messages with the RoadRegulatorID of MAP messages representing the same intersection	UN-001.3.1, UN-001.4.1, UN-002	Inspection
CIMMS-FR-002.2-v01	SPaT/MAP Message Assessment	Intersection Reference Alignment	The Message Monitor shall compare the Intersection ID of SPaT Messages with the Intersection ID of MAP messages representing the same intersection	UN-001.3.1, UN-001.4.1, UN-002	Inspection
CIMMS-FR-002.3-v01	SPaT/MAP Message Assessment	Intersection Reference Alignment	The Message Monitor shall use a unique identifying feature of the RSU (e.g., IP address, MAC address) to determine the source of SPaT and MAP messages.	UN-001.3.1, UN-001.4.1, UN-002	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-002.4-v01	SPaT/MAP Message Assessment	Intersection Reference Alignment	The Message Monitor shall generate an event of type 'Intersection Reference Alignment' if the combination of RoadRegulatorID and Intersection ID in each SPaT message does not match the combination of RoadRegulatorID and IntersectionID of each MAP message originating from the same RSU.	UN-001.3.1, UN-001.4.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-006-v01	SPaT/MAP Message Assessment	Signal Group Alignment	The Message Monitor shall determine if the Signal Groups in the SPaT messages match Signal Groups in the MAP messages broadcast from the same intersection (if the RoadRegulatorID and IntersectionID from SPaT and MAP message match).	UN001.3.3, UN-002	Inspection
CIMMS-FR-006.1-v01	SPaT/MAP Message Assessment	Signal Group Alignment	The Message Monitor shall generate a list of unique signal groups in the SPaT Messages and a list of unique signal groups in the MAP messages.	UN001.3.3, UN-002	Inspection
CIMMS-FR-006.2-v01	SPaT/MAP Message Assessment	Signal Group Alignment	The Message Monitor shall generate an event of type 'Signal Group Alignment' if the list of unique signal group IDs from the SPaT Message are not contained in the list of unique signal groups ids from the MAP message.	UN001.3.3, UN-002, UN-004, UN-005	Test
CIMMS-FR-006.3-v01	SPaT/MAP Message Assessment	Signal Group Alignment	The Message Monitor shall generate an event of type 'Signal Group Alignment' if the list of unique signal group IDs from the MAP Message are not contained in the list of unique signal groups IDs from the SPaT message.	UN001.3.3, UN-002, UN-004, UN-005	Test

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-009-v01	SPaT Message Assessment	SPaT Broadcast Rate	The Message Monitor shall determine the 'SPaT Broadcast rate' for a rolling period of 10 seconds every 5 seconds.	UN-001.1, UN-002	Inspection
CIMMS-FR-010-v01	SPaT Message Assessment	SPaT Broadcast Rate	The Message Monitor shall generate an event of type 'SPaT Broadcast Rate' if the number of SPaT messages received is less than the 'SPaT Minimum 10-second Reception' configurable value .	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-011-v01	SPaT Message Assessment	SPaT Broadcast Rate	The Message Monitor shall generate an event of type 'SPaT Broadcast Rate' if the number of SPaT messages observed is greater than the 'SPaT Maximum 10-second Reception' configurable value.	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-012-v01	MAP Message Assessment	MAP Broadcast Rate	The Message Monitor shall determine the 'MAP Broadcast rate' for a rolling period of 10 seconds every 5 seconds.	UN-001.1, UN-002	Inspection
CIMMS-FR-013-v01	MAP Message Assessment	MAP Broadcast Rate	The Message Monitor shall generate an event of type 'MAP Broadcast Rate' if the number of MAP messages received is less than the 'MAP Minimum 10-second Reception' configurable value.	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-014-v01	MAP Message Assessment	MAP Broadcast Rate	The Message Monitor shall generate an event of type 'MAP Broadcast Rate' if the number of MAP messages observed is greater than the 'MAP Maximum 10-second Reception' configurable value.	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-015-v01	SPaT Message Assessment	SPaT Minimum Requirement	The Message Monitor shall determine if a SPaT Message meets the minimum CI 4501 data requirements (CTI 4501 Table 7).	UN-001.1, UN-002	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-015.1-v01	SPaT Message Assessment	SPaT minimum Requirement	The Message Monitor shall determine which data CTI 4501 required data elements are not contained in a SPaT message.	UN-001.1, UN-002	Inspection
CIMMS-FR-015.2-v01	SPaT Message Assessment	SPaT Minimum Requirement	The Message Monitor shall generate an event of type 'SPaT Minimum Data' if a SPaT message does not meet the CTI 4501 minimum requirement.	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-017-v01	MAP Message Assessment	MAP minimum Requirement	The Message Monitor shall determine if a MAP Message meets the CTI 4501 minimum data requirement (CTI 4501 Table 9).	UN-001.1, UN-002	Inspection
CIMMS-FR-017.1-v01	MAP Message Assessment	MAP minimum Requirement	The Message Monitor shall determine which data CTI 4501 required data elements are not contained in a MAP message.	UN-001.1, UN-002	Inspection
CIMMS-FR-017.2-v01	MAP Message Assessment	MAP minimum Requirement	The Message Monitor shall generate an event of type 'MAP minimum data' if a MAP message does not meet the CTI 4501 minimum requirement.	UN-001.1, UN-002, UN-004, UN-005	Test
CIMMS-FR-019-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall determine the signal state when the vehicle crosses the stop line (if the RoadRegulatorID and IntersectionID from SPaT and MAP messages match.)	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.1-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall use the MAP message to determine the location of all ingress lane stop lines (intersection reference latitude/longitude, first offset point for each ingress lane).	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.2-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall use the BSMs from the same vehicle to ascertain the time, latitude, longitude, speed, and heading while traversing the intersection.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-019.3-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall use the vehicle ID data element in the BSM to determine which latitude, longitude, speed, and heading data are produced from a single vehicle.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.4-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor may attempt to determine when a vehicle ID changes so that latitude, longitude, speed, and heading from a single vehicle can be traced through a vehicle ID change.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.5-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall determine which ingress lane stop line a single vehicle passes closest to.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.6-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall only consider the vehicle as crossing an ingress lane stop line if the vehicle is less than the 'maximum distance from stopbar' configurable value from the location of the stop line (i.e., roughly the minimum lateral distance from the center of the lane at the stopbar)	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.7-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall only consider the vehicle as crossing the ingress lane stop line if the vehicle heading is within the 'heading tolerance' configurable value of the ingress lane heading. Note: heading values wrap-around from 360 to 0.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.8-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall determine which signalGroup is associated with the ingress stop line.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-019.9-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	If more than one unique signalGroup is associated with the ingress stop line, then the connection the vehicle takes through the intersection is used to determine the correct signalGroup.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.10-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall determine the time at which a single vehicle crosses the ingress stop line from the BSM data – defined by the secMark (DSecond) data element.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.11-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall locate the SPaT message with the closest timestamp to the time at which a single vehicle crosses the ingress stop line.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.12-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall not generate an event of type 'signal state' if there is no SPaT message that has a timestamp within 200 ms of the time at which a single vehicle crosses the ingress stop line.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.13-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	The Message Monitor shall determine the event state of the identified signalGroup (FR-19.8, FR-19.9) from the identified SPaT Message (FR-19.11).	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-019.14-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Crosses Stop Line	If a vehicle is detected crossing a stop line and a SPaT Message is available (within 200 ms), the Message Monitor shall generate an event of type: 'Signal State'.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003, UN-004, UN-005	Test

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-020-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall compare the direction of movement for each vehicle to the direction within each lane segment geometry. *Note: lane segments correspond to the lane centerlines formed by the list of ordered nodes in the MAP message. The first lane segment is formed between the first and second specified nodes, etc.*	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.01-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall use the lane latitude/longitude coordinates (calculated using the intersection reference latitude/longitude and x-y offsets) and lane width (calculated using the reference lane width and lane width offsets) to create a polygon for each lane segment.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.02-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall use the MAP message x-y offsets (for each segment) and laneDirection data elements to determine the expected heading of travel for each lane segment.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.03-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall use the BSMs from the same vehicle to ascertain the time, latitude, longitude, speed, and heading while traversing a lane.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.04-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall use the vehicle ID data element in the BSM to determine which latitude, longitude, speed, and heading data are produced from a single vehicle.	UN-001.4.2, UN-003	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-020.05-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor may attempt to determine when a vehicle ID changes so that latitude, longitude, speed, and heading from a single vehicle can be traced through a vehicle ID change.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.06-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall compare the BSM latitude/longitude of the vehicle to each lane segment polygon to determine if the point falls in the polygon.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.07-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall determine the number of BSM latitude/longitude points from the same vehicle contained in each polygon with a speed above the configurable minimum speed threshold.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.08-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall generate an event of type 'Lane Direction of Travel' for each lane segment polygon that contains the number of lat/long points from the same vehicle that is equal or greater to the configurable minimum number of points.	UN-001.4.2, UN-003	Test
CIMMS-FR-020.09-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall aggregate the heading values associated with the lat/long points contained in the lane segment polygon from the same vehicle by taking the median value.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-020.10-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall determine the distance from each lat/long point contained in the lane segment polygon from the same vehicle to the centerline of the lane segment.	UN-001.4.2, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-020.11-v01	SPaT and MAP Assessment using BSMs	Lane Direction of Travel	The Message Monitor shall aggregate the distance values associated with the lat/long points contained in the lane segment polygon from the same vehicle by taking median of the absolute value of the distance to the lane centerline.	UN-001.4.2, UN-003	Inspection
CIMMS-FR-021-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall compare a vehicle's path of travel through an intersection to determine which ingress lane, egress lane, and connection it is using.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.01-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall use the MAP message to determine the location of all ingress lane stop lines (intersection reference latitude/longitude, first offset point for each ingress lane).	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.02-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall use the MAP message to determine the location of all egress lane initial points (intersection reference latitude/longitude, first offset point for each egress lane).	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.03-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall use the BSMs from the same vehicle to ascertain the time, latitude, longitude, speed, and heading while traversing the intersection.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.04-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall use the vehicle ID data element in the BSM to determine which latitude, longitude, speed, and heading data are produced from a single vehicle.	UN-001.4.4, UN-003	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-021.05-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor may attempt to determine when a vehicle ID changes so that latitude, longitude, speed, and heading from a single vehicle can be traced through a vehicle ID change.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.06-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall determine which ingress lane stop line a single vehicle passes closest to.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.07-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	The Message Monitor shall determine which egress lane (initial point) a single vehicle passes closest to.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.08-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	If both an ingress and egress lane are determined, the MAP message is used to determine if there is a connection associated with that ingress-egress pair.	UN-001.4.4, UN-003	Inspection
CIMMS-FR-021.09-v01	SPaT and MAP Assessment using BSMs	Connection of Travel	If the Message Monitor determines an ingress lane (21.6) and an egress lane (21.7), the Message Monitor shall generate an event of type: 'Connection of Travel'. Note, this is regardless of if a connection is found for the ingress/egress pair or not.	UN-001.4.4, UN-003, UN-004, UN-005	Test
CIMMS-FR-022-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall determine conflicts of signal state information.	UN-001.3.3, UN-002	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-022.01-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall spatially represent each connection in the MAP message as a line. The first point of a connection matches the location of an ingress lane stop line (intersection reference latitude/longitude, first offset point for the ingress lane), and the end point of a connection matches the location of its egress lane initial point (intersection reference latitude/longitude, first offset point for the egress lane).	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.02-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor may use a spline curve to define the line the spatially represents each connection. Spline control points should be chosen such that the line representing the connection better resembles an actual path of travel.	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.03-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall determine the centerline for each pedestrian lane.	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.04-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall determine which signal group is associated with each connection line and pedestrian lane centerline.	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.05-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall determine which of the connection lines and pedestrian lane geometries (from the MAP message) intersect each other. Note, connection lines that have the same egress point are considered to intersect; connection lines that have the same ingress point are not considered to intersect.	UN-001.3.3, UN-002	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-022.06-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message Monitor shall determine the event state of each signal group associated with each connection and pedestrian lane from the SPaT Message.	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.07-v01	SPaT Message Assessment	Signal State Conflict Monitor	For each SPaT message received, the Message Monitor shall generate an event of type Signal State Conflict Event for every intersecting connection line and pedestrian lane geometry where: the signal state of one connection is 'protected-Movement-Allowed' or 'protected-Clearance'; and the signal state of the other connection is anything other than 'stop-And-Remain'.	UN-001.3.3, UN-002, UN-004, UN-005	Inspection
CIMMS-FR-022.08-v01	SPaT Message Assessment	Signal State Conflict Monitor	The Message monitor shall determine which connections and pedestrian movements are allowed to be permissive at the same time.	UN-001.3.3, UN-002	Inspection
CIMMS-FR-022.09-v01	SPaT Message Assessment	Signal State Conflict Monitor	The determination of connections and pedestrian movements that are allowed to be permissive at the same time may be based on an allowed concurrent permissive movement setting.	UN-001.3.3, UN-002	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-022.10-v01	SPaT Message Assessment	Signal State Conflict Monitor	For each SPaT message received, the Message Monitor shall generate an event of type 'signal State Conflict' for every intersecting connection line and pedestrian lane geometry where: the signal state of one connection is 'permissive-Movement-Allowed' or 'permissive-Clearance'; and the signal state of the other connection is 'permissive-Movement-Allowed' or 'permissive-Clearance'; unless the pair of connections are allowed to be permissive at the same time.	UN-001.3.3, UN-002, UN-004, UN-005	Test
CIMMS-FR-023-v01	SPaT Message Assessment	Time Change Details Monitor	The Message Monitor shall determine issues with the progression of time change details.	UN-001.3.5, UN-002	Inspection
CIMMS-FR-023.01-v01	SPaT Message Assessment	Time Change Details Monitor	The Message Monitor shall generate an event of type Time Change Details Event when the minEndTime for the same signal group decreases between two consecutive SPaT Messages except when the event state for that signal group changes and except when the first minEndTime value is 'unknown'. Note that minEndTime values wrap around from 35999 to 0.	UN-001.3.5, UN-002, UN-004, UN-005	Test
CIMMS-FR-023.02-v01	SPaT Message Assessment	Time Change Details Monitor	The Message Monitor shall generate an event of type Time Change Details Event when the maxEndTime for the same signal group increases between two consecutive SPaT Messages except when the event state for that signal group changes and except when the first maxEndTime value is 'unknown'. Note that maxEndTime values wrap around from 35999 to 0.	UN-001.3.5, UN-002, UN-004, UN-005	Test

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-023.03-v01	SPaT Message Assessment	Time Change Details Monitor	The Message Monitor shall generate an event of type Time Change Details Event when the minEndTime does not equal the maxEndTime for a signal group when the event state is 'protected-Clearance' or 'permissive-clearance'.	UN-001.3.5, UN-002, UN-004, UN-005	Test
CIMMS-FR-023.04-v01	SPaT Message Assessment	Time Change Details Monitor	The Message Monitor shall generate an event of type 'Time Change Details Event' when the minEndTime or the maxEndTime for a signal group changes between two consecutive SPaT messages when the event state is 'protected-Clearance' or 'permissive-clearance'.	UN-001.3.5, UN-002, UN-004, UN-005	Test
CIMMS-FR-024-v01	SPaT and MAP Assessment using BSMs	Assessment of Signal State Events	The Message Monitor shall perform an assessment of Signal State event data every time a new signal state event(s) is available.	UN-006	Demonstration
CIMMS-FR-024.01-v01	SPaT and MAP Assessment using BSMs	Assessment of Signal State Events	The Message Monitor shall perform an assessment only using signal state event data that was generated during the configurable look-back period.	UN-006	Inspection
CIMMS-FR-024.02-v01	SPaT and MAP Assessment using BSMs	Assessment of Signal State Events	The Message Monitor shall determine for each signal group the percentage of signal state events that were associated with each state of the signal group. An event when the vehicle crosses the stop line during a 'stop-and-remain' event state is only counted if its speed is above a 'minimum speed' configurable value	UN-006	Inspection
CIMMS-FR-027-v01	SPaT and MAP Assessment using BSMs	Assessment of Signal State Events	The Message Monitor shall log the result of each assessment performed as an assessment result of type Signal State Event Assessment.	UN-005, UN-006	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-027.01-v01	SPaT and MAP Assessment using BSMs	Assessment of Lane Direction of Travel events	The Message Monitor shall perform an assessment of lane direction of travel event data every time a new lane direction of travel event(s) is available.	UN-006	Demonstration
CIMMS-FR-027.02-v01	SPaT and MAP Assessment using BSMs	Assessment of Lane Direction of Travel events	The Message Monitor shall perform an assessment only using lane direction of travel data that was generated during the configurable look-back period.	UN-006	Inspection
CIMMS-FR-027.03-v01	SPaT and MAP Assessment using BSMs	Assessment of Lane Direction of Travel events	The Message Monitor shall determine for each lane segment (unique lane id, offset number) the median heading value.	UN-006	Inspection
CIMMS-FR-027.04-v01	SPaT and MAP Assessment using BSMs	Assessment of Lane Direction of Travel events	The Message Monitor shall determine for each lane segment (unique lane id, offset number) the median distance from lane centerline value.	UN-006	Inspection
CIMMS-FR-027.05-v01	SPaT and MAP Assessment using BSMs	Assessment of Lane Direction of Travel events	The Message Monitor shall log the result of each assessment performed as an assessment result of type Lane Direction of Travel Assessment.	UN-005, UN-006	Demonstration
CIMMS-FR-032-v01	SPaT and MAP Assessment using BSMs	Assessment of Connection of Travel Events	The Message Monitor shall perform an assessment of connection of travel event data every time a new lane direction of travel event(s) is available.	UN-006	Demonstration
CIMMS-FR-032.01-v01	SPaT and MAP Assessment using BSMs	Assessment of Connection of Travel Events	The Message Monitor shall perform an assessment only using connection of travel data that was generated during the configurable look-back period.	UN-006	Inspection
CIMMS-FR-032.02-v01	SPaT and MAP Assessment using BSMs	Assessment of Connection of Travel Events	The Message Monitor shall determine for each unique ingress-egress pair the number of events associated.	UN-006	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-032.03-v01	SPaT and MAP Assessment using BSMs	Assessment of Connection of Travel Events	The Message Monitor shall log the result of each assessment performed as an assessment result of type Connection of Travel Assessment.	UN-005, UN-006	Demonstration
CIMMS-FR-037-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'Intersection Reference Alignment' event is generated.	UN-008	Test
CIMMS-FR-039-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'Signal Group Alignment' event is generated.	UN-008	Test
CIMMS-FR-040-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'SPaT Minimum Data' event is generated.	UN-008	Test
CIMMS-FR-041-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'MAP Minimum Data' event is generated.	UN-008	Test
CIMMS-FR-042-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'SPaT broadcast rate' event is generated.	UN-008	Test
CIMMS-FR-043-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'MAP broadcast rate' event is generated.	UN-008	Test
CIMMS-FR-044-v01	Exception Notification	Notification	The Message monitor Management shall issue a notification if an assessment of 'signal state' events indicates that the percentage of 'stop-And-Remain' events for a given signal group exceeds the minimum red light threshold and the number of events is greater than the configurable 'minimum number of events'.	UN-008	Test

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-045-v01	Exception Notification	Cease Broadcast Recommendation	The Message monitor Management shall issue a recommendation to cease broadcasting if an assessment of 'signal state' events indicates that the percentage of 'stop-And-Remain' events for a given signal group exceeds the 'minimum red light percentage' threshold.	UN-009	Test
CIMMS-FR-046-v01	Exception Notification	Notification	The Message monitor Management shall issue a notification if an assessment of 'lane direction of travel' events indicates that the median direction of travel is not within a configurable 'heading tolerance' of the actual heading and the number of events is greater than the configurable 'minimum number of events'.	UN-008	Test
CIMMS-FR-046.01-v01	Exception Notification	Notification	The Message monitor Management shall issue a notification if an assessment of 'lane direction of travel' events indicates that the median distance from lane centerline is not within a configurable ' distance from lane centerline tolerance' of the actual distance and the number of events is greater than the configurable 'minimum number of events'.	UN-008	Test
CIMMS-FR-047-v01	Exception Notification	Cease Broadcast Recommendation	The Message monitor Management shall issue a cease broadcast recommendation notification if an assessment of 'lane direction of travel' events indicates that the median direction of travel is not within a configurable 'heading tolerance' of the actual heading.	UN-009	Test

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-047.01-v01	Exception Notification	Cease Broadcast Recommendation	The Message monitor Management shall issue a cease broadcast recommendation notification if an assessment of 'lane direction of travel' events indicates that the median distance from lane centerline is not within a configurable ' distance from lane centerline tolerance' of the actual distance.	UN-009	Test
CIMMS-FR-048-v01	Exception Notification	Notification	The Message monitor Management shall issue a notification if an assessment of 'Connection of Travel' events indicates that there is a ingress-egress pair that has no connection and the number of events is greater than the configurable 'minimum number of events'.	UN-008	Test
CIMMS-FR-049-v01	Exception Notification	Cease Broadcast Recommendation	The Message monitor Management shall issue a cease broadcast recommendation if an assessment of 'Connection of Travel' events indicates that there is an ingress-egress pair that has no connection, and the number of events is greater than the configurable 'minimum number of events'.	UN-009	Test
CIMMS-FR-050-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'Signal State Conflict Event' data is generated from the signal state conflict monitor algorithm.	UN-008	Test
CIMMS-FR-051-v01	Exception Notification	Cease Broadcast Recommendation	The Message Monitor Management shall issue a cease broadcast recommendation if a 'Signal State Conflict Event' has not been cleared (see CIMMS-FR-074-v01) for a configurable 'signal state conflict notification duration'.	UN-009	Test

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-052-v01	Exception Notification	Notification	The Message Monitor Management shall issue a notification if a 'Time Change Details' event is generated from the time change details monitor algorithm.	UN-008	Test
CIMMS-FR-053-v01	Exception Notification	Cease Broadcast Recommendation	The Message Monitor Management shall issue a cease broadcast recommendation if a 'Time Change Details' event has not been cleared (see CIMMS-FR-074-v01) for a configurable 'time change details notification duration'.	UN-009	Test
CIMMS-FR-054-v01	Exception Notification	Notification Log	The Message Monitor Management shall log the issuance of a notification.	UN-005	Demonstration
CIMMS-FR-055-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for the '*V2X message processing frequency*' to be configurable.		Demonstration
CIMMS-FR-056-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'maximum distance from stopbar' to be configurable (Signal State algorithm).	UN-018	Demonstration
CIMMS-FR-057-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'heading tolerance' to be configurable (Signal State algorithm).	UN-018	Demonstration
CIMMS-FR-058-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum speed threshold' to be configurable (Lane Direction of Travel algorithm).	UN-018	Demonstration
CIMMS-FR-059-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum number of points' to be configurable (Lane Direction of Travel algorithm).	UN-018	Demonstration

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-060-v01	CIMMS Management	Configuration	If the Message Monitor is used to determine if connections and pedestrian movements that are allowed to be permissive at the same time, the Message Monitor Management shall allow the value for 'allowed concurrent permissive movements' to be configurable (Signal State Conflict Monitor).	UN-018	Demonstration
CIMMS-FR-061-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'look-back period' to be configurable (Assessment of Signal State Events).	UN-018	Demonstration
CIMMS-FR-062-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum red light percentage threshold' to be configurable (Assessment of Signal State Events).	UN-019, UN-020	Demonstration
CIMMS-FR-063-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum red light percentage threshold' to be configurable individually for each signal group (to determine if Notification needed based on Assessment of Signal State Events).	UN-019, UN-020	Demonstration
CIMMS-FR-064-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum number of events' to be configurable (to determine if Notification needed based on Assessment of Signal State Events).	UN-019, UN-020	Demonstration
CIMMS-FR-065-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'look-back period' to be configurable (Assessment of Lane Direction of Travel events).	UN-019, UN-020	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-066-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'heading tolerance' to be configurable (Assessment of Lane Direction of Travel events).	UN-019, UN-020	Demonstration
CIMMS-FR-067-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum number of events' to be configurable (to determine if Notification needed based on Assessment of Lane Direction of Travel events).	UN-019, UN-020	Demonstration
CIMMS-FR-068-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'look-back period' to be configurable (Assessment of Connection of Travel Events).	UN-019, UN-020	Demonstration
CIMMS-FR-069-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum number of events' to be configurable (to determine if Notification needed based on Connection of Travel Events).	UN-019, UN-020	Demonstration
CIMMS-FR-070-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'message storage period' to be configurable.	UN-018	Demonstration
CIMMS-FR-071-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'red light running minimum speed' to be configurable (to determine if Notification needed based on Assessment of Signal State Events)	UN-009	Demonstration
CIMMS-FR-072-v01	Message Status and Reports	Current Status	The Message Monitor Management shall provide the current status based on the most recent event and assessment data.	UN-010	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-073-v01	Message Status and Reports	Performance Report	The Message Monitor Management shall generate a performance report that provides a time-series table or time series visualization (e.g., graph) of all assessment results.	UN-010	Demonstration
CIMMS-FR-074-v01	CIMMS Management	Clear Notification	The Message Monitor Management shall clear a notification or a Cease Broadcast Recommendation when prompted by a system user.	UN-008, UN-009	Demonstration
CIMMS-FR-075-v01	CIMMS Management	Identify Event Data	The Message Monitor Management shall flag event data associated with the cleared notification to not be used in subsequent assessments.	UN-008, UN-009	Demonstration
CIMMS-FR-076-v01	*all Message Monitor functions*	Reset Assessment	The Message Monitor shall not use flagged event data (generated prior to the clearance of a notification) when performing subsequent assessments.	UN-008, UN-009	Demonstration
CIMMS-FR-077-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'SPaT Minimum 10-second Reception' to be configurable.	UN-019, UN-020	Demonstration
CIMMS-FR-078-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'SPaT Maximum 10-second Reception' to be configurable.	UN-019, UN-020	Demonstration
CIMMS-FR-079-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'MAP Minimum 10-second Reception' to be configurable.	UN-019, UN-020	Demonstration
CIMMS-FR-080-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'MAP Maximum 10-second Reception' to be configurable.	UN-019, UN-020	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-081-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'signal state conflict' to be configurable.	UN-009	Demonstration
CIMMS-FR-082-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'time change details notification duration' to be configurable.	UN-009	Demonstration
CIMMS-FR-083-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall determine the signal state when the vehicle stops at the stop line (if the RoadRegulatorID and IntersectionID from SPaT and MAP messages match.)	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.01-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall use the MAP message to determine the location of all ingress lane stop lines (intersection reference latitude/longitude, first offset point for each ingress lane).	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.02-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall use the BSMs from the same vehicle to ascertain the time, latitude, longitude, speed, and heading while traversing the intersection.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.03-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall use the vehicle ID data element in the BSM to determine which latitude, longitude, speed, and heading data are produced from a single vehicle.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-083.04-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor may attempt to determine when a vehicle ID changes so that latitude, longitude, speed, and heading from a single vehicle can be traced through a vehicle ID change.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.05-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall determine when a vehicle is stopped near the stopbar	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.06-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall only consider the vehicle as stopped near the stop line if the vehicle is less than the 'maximum distance from stopbar' configurable value from the location of the stop line (i.e., roughly the minimum lateral distance from the center of the lane at the stopbar)	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.06-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall only consider the vehicle as stopped near the stop line if the vehicle speed is less than the 'maximum speed threshold' configurable value	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.07-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall only consider the vehicle as stopped near the stop line if the vehicle heading is within the 'heading tolerance' configurable value of the ingress lane heading. Note: heading values wrap-around from 360 to 0.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-083.08-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall determine which signalGroup is associated with the ingress stop line the vehicle is stopped at.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.09-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	If more than one unique signalGroup is associated with the ingress stop line, then the connection the vehicle takes through the intersection is used to determine the correct signalGroup.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.10-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall determine all timestamps for which a single vehicle is stopped from BSM data – defined by the secMark (DSecond) data element.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.11-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall locate the SPaT message with the closest timestamp to each timestamp identified (FR-83.10), for when a single vehicle is stopped at the ingress stop line.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.12-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall determine the event state of the identified signalGroup from each identified SPaT Message.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-083.13-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	The Message Monitor shall not determine the event state of the identified signalGroup from each identified SPaT Message if the SPaT message timestamp is not within 200 ms of the vehicle timestamp.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-083.14-v01	SPaT and MAP Assessment using BSMs	Signal State when Vehicle Stops at Stop Line	If a vehicle is detected stopping, the Message Monitor shall generate an event of type: 'Vehicle Stop'.	UN001.3.3, UN-001.3.8, UN-001.4.8, UN-003	Inspection
CIMMS-FR-084-v01	SPaT and MAP Assessment using BSMs	Assessment of Vehicle Stop Events	The Message Monitor shall perform an assessment of Signal State event data every time a new signal state event(s) is available.	UN-006	Demonstration
CIMMS-FR-084.01-v01	SPaT and MAP Assessment using BSMs	Assessment of Vehicle Stop Events	The Message Monitor shall perform an assessment only using vehicle stop event data that was generated during the configurable look-back period.	UN-006	Inspection
CIMMS-FR-084.02-v01	SPaT and MAP Assessment using BSMs	Assessment of Vehicle Stop Events	The Message Monitor shall determine for each signal group the percentage of time vehicles were stopped on red (stop-and-remain), yellow (permissive-clearance, protected-clearance), and green (permissive-movement-allowed, protected-movement-allowed) event states. Consideration whether to include certain vehicle stop events may be given (based on the event state when the vehicle initially stopped) to remove any error due to vehicles stopping to yield to oncoming traffic/pedestrians.	UN-006	Inspection
CIMMS-FR-084.03-v01	SPaT and MAP Assessment using BSMs	Assessment of Vehicle Stop Events	The Message Monitor shall log the result of each assessment performed as an assessment result of type Signal State Event Assessment.	UN-005, UN-006	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-085-v01	Exception Notification	Notification	The Message monitor Management shall issue a notification if an assessment of 'vehicle stop' events indicates that the percentage of time vehicles in aggregate are stopped during a green (permissive-movement-allowed, protected-movement-allowed) event state for a given signal group exceeds the minimum stop-on-green threshold and the number of events is greater than the configurable 'minimum number of events'		
CIMMS-FR-085-v01	Exception Notification	Cease Broadcast Recommendation	The Message monitor Management shall issue a recommendation to cease broadcast if an assessment of 'vehicle stop' events indicates that the percentage of time vehicles in aggregate are stopped during a green (permissive-movement-allowed, protected-movement-allowed) event state for a given signal group exceeds the minimum stop-on-green threshold and the number of events is greater than the configurable 'minimum number of events'		
CIMMS-FR-086-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'maximum distance from stopbar' to be configurable (Vehicle Stop algorithm).	UN-018	Demonstration
CIMMS-FR-087-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'heading tolerance' to be configurable (Vehicle Stop algorithm).	UN-018	Demonstration

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-FR-088-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'look-back period' to be configurable (Assessment of Vehicle Stop Events).	UN-018	Demonstration
CIMMS-FR-089-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum stop-on-green threshold ' to be configurable (Assessment of Vehicle Stop Events).	UN-019, UN-020	Demonstration
CIMMS-FR-090-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum stop-on-green threshold' to be configurable individually for each signal group (to determine if Notification needed based on Assessment of Vehicle Stop Events).	UN-019, UN-020	Demonstration
CIMMS-FR-091-v01	CIMMS Management	Configuration	The Message Monitor Management shall allow the value for 'minimum number of events' to be configurable (to determine if Notification needed based on Assessment of Vehicle Stop Events).	UN-019, UN-020	Demonstration

5.2. Performance Requirements

This section provides the performance requirements (PR) for the system of interest (i.e., what the system will do). The requirements in **Table 9** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 9: Performance Requirements

ReqID	Functional Group	Sub-Component	Description	References	Assessment Method
CIMMS-PR-001-v01	*all Message Monitor functions*	Multiple Intersection V2X Message Ingestion	The Message Monitor shall support the ingestion of data from more than one intersection.	UN-015	Demonstration
CIMMS-PR-002-v01	*all Message Monitor functions*	Algorithm Execution	The Message Monitor shall initiate the processing (algorithms) of V2X messages without requiring user input.	UN-002, UN-003, UN-012	Demonstration
CIMMS-PR-003-v01	*all Message Monitor functions*	Algorithm Execution	The Message Monitor shall process ingested V2X messages at the configurable 'V2X message processing frequency'.	UN-002, UN-003, UN-013	Demonstration
CIMMS-PR-004-v01	*all Message Monitor functions*	Assessment Execution	The Message Monitor shall perform an assessment as soon as new event data (used in the assessment) are generated.	UN-006, UN-007, UN-014	Demonstration
CIMMS-PR-005-v01	Exception Notification	Notification Issuance	The Message Monitor Management shall determine if a notification should be issued as soon as event data or assessment results (used to determine if a notification is issued) are generated.	UN-008, UN-014	Demonstration
CIMMS-PR-006-v01	Exception Notification	Repeat Notification	The Message Monitor Management shall not issue a notification that has the same content as a notification that has been issued previously.	UN-014	Demonstration

5.3. Interface Requirements

The CIMMS interfaces allow dynamic and configurable functionality between internal and external components of the system that provide data or some other stated functionality as per the user needs. The IF requirements in **Table 10** have been categorized into these two groups, which will help further clarify system boundaries.

Table 10: Interface Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-IR-001-v01	MAP Message Assessment, SPaT and MAP Assessment using BSMs	Ingest V2X Message	The Message Monitor shall receive MAP messages from only the RSU	UN-002	Inspection
CIMMS-IR-002-v01	SPaT Message Assessment, SPaT and MAP Assessment using BSMs	Ingest V2X Message	The Message Monitor shall receive SPaT messages from only the RSU.	UN-002	Inspection
CIMMS-IR-003-v01	SPaT and MAP Assessment using BSMs	Ingest V2X Message	The Message Monitor shall receive BSMs from only the RSU.	UN-002, UN-003	Inspection
CIMMS-IR-004-v01	Exception Notification	User Interface	The Message Monitor shall provide a user interface to display notifications.	UN-008	Inspection
CIMMS-IR-005-v01	Exception Notification	User Interface	The Message Monitor Management may provide a user interface to issue notifications via email.	UN-008	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-IR-006-v01	Exception Notification	User Interface	The Message Monitor Management shall provide a user interface to display a Cease Broadcast Recommendation.	UN-009	Inspection
CIMMS-IR-007-v01	Exception Notification	User Interface	The Message Monitor Management may provide a user interface to issue Cease Broadcast Recommendation via email.	UN-009	Inspection
CIMMS-IR-008-v01	CIMMS Management	User Interface	The Message Monitor Management shall display the Configuration Settings via the Message Monitor User Interface.	UN-018, UN-019, UN-020	Inspection
CIMMS-IR-009-v01	CIMMS Management	User Interface	The Message Monitor Management shall accept a Configuration Setting via the Message Monitor User Interface.	UN-018, UN-019, UN-020	Inspection
CIMMS-IR-010-v01	Message Status and Reports	User Interface	The Message Monitor Management shall accept a Performance Report Request via the Message Monitor User Interface.	UN-010	Inspection
CIMMS-IR-011-v01	Message Status and Reports	User Interface	The Message Monitor Management shall issue a Performance Report via the Message Monitor User Interface.	UN-010	Inspection
CIMMS-IR-012-v01	Message Status and Reports	User Interface	The Message Monitor Management shall accept a Current Status Request via the Message Monitor User Interface.	UN-010	Inspection
CIMMS-IR-013-v01	Message Status and Reports	User Interface	The Message Monitor Management shall issue the current status via the Message Monitor User Interface.	UN-010	Inspection
CIMMS-IR-014-v01	Exception Notification	Output to RSE	The Message Monitor Management shall not provide an output to the existing system (initial implementation).	UN-011	Inspection

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5.4. Data Requirements

The data requirements (DR) for the core system of interest defines the data collected, transformed, and stored from various sources as well as identifies new data that is expected to be generated. The requirements in **Table 11** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 11: Data Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-001-v01	V2X Messages	MapData Message	The Message Monitor shall utilize MAP Messages that comply with SAE J2735_202007.	UN-002	Inspection
CIMMS-DR-002-v01	V2X Messages	Signal Phase and Timing Message	The Message Monitor shall utilize SPaT Messages that comply with SAE J2735_202007.	UN-002	Inspection
CIMMS-DR-003-v01	V2X Messages	Basic Safety Message	The Message Monitor shall utilize BSMs that comply with SAE J2735_202007.	UN-002, UN-003	Inspection
CIMMS-DR-004-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The Message Monitor shall have a data structure for the 'Intersection Reference Alignment' Event.	UN-004	Inspection
CIMMS-DR-004.01-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection
CIMMS-DR-004.02-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a timestamp that corresponds to the beginning of the period over which CV messages are processed.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-004.03-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a timestamp that corresponds to the end of the period over which CV messages are processed.	UN-004	Inspection
CIMMS-DR-004.04-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a list of unique Road Regulator IDs found in SPaT messages.	UN-004	Inspection
CIMMS-DR-004.05-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a list of unique Road Regulator IDs found in MAP messages.	UN-004	Inspection
CIMMS-DR-004.06-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a list of unique Intersection IDs found in SPaT messages.	UN-004	Inspection
CIMMS-DR-004.07-v01	SPaT / MAP Message Assessment	'Intersection Reference Alignment' Event	The 'Intersection Reference Alignment' Event shall contain a list of unique Intersection IDs found in MAP messages.	UN-004	Inspection
CIMMS-DR-006-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The Message Monitor shall have a data structure for the 'Signal Group Alignment' Event.	UN-004	Inspection
CIMMS-DR-006.01-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The 'Signal Group Alignment' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-006.02-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The 'Signal Group Alignment Event' shall contain a timestamp that corresponds to the beginning of the period over which CV messages are processed.	UN-004	Inspection
CIMMS-DR-006.03-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The 'Signal Group Alignment Event' shall contain a timestamp that corresponds to the end of the period over which CV messages are processed.	UN-004	Inspection
CIMMS-DR-006.04-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The 'Signal Group Alignment Event' shall contain a list of unique signal group IDs found in SPaT messages.	UN-004	Inspection
CIMMS-DR-006.05-v01	SPaT / MAP Message Assessment	'Signal Group Alignment' Event	The 'Signal Group Alignment Event' shall contain a list of unique signal group IDs found in MAP messages.	UN-004	Inspection
CIMMS-DR-007-v01	SPAT Message Assessment	'SPaT Broadcast Rate' Event	The Message Monitor shall have a data structure for the 'SPaT Broadcast Rate' Event.	UN-004	Inspection
CIMMS-DR-007.01-v01	SPAT Message Assessment	'SPaT Broadcast Rate' Event	The 'SPaT Broadcast Rate' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection
CIMMS-DR-007.02-v01	SPAT Message Assessment	'SPaT Broadcast Rate' Event	The 'SPaT Broadcast Rate' Event shall contain a timestamp that corresponds to the beginning of the period over which SPaT messages are processed.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-007.03-v01	SPAT Message Assessment	'SPaT Broadcast Rate' Event	The 'SPaT Broadcast Rate' Event shall contain a timestamp that corresponds to the end of the period over which SPaT messages are processed.	UN-004	Inspection
CIMMS-DR-007.04-v01	SPAT Message Assessment	'SPaT Broadcast Rate' Event	The 'SPaT Broadcast Rate' Event shall contain the number of observed SPaT messages.	UN-004	Inspection
CIMMS-DR-008-v01	MAP Message Assessment	'MAP Broadcast Rate' Event	The Message Monitor shall have a data structure for the 'MAP Broadcast Rate' Event.	UN-004	Inspection
CIMMS-DR-008.01-v01	MAP Message Assessment	'MAP Broadcast Rate' Event	The 'MAP Broadcast Rate' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection
CIMMS-DR-008.02-v01	MAP Message Assessment	'MAP Broadcast Rate' Event	The 'MAP Broadcast Rate' Event shall contain a timestamp that corresponds to the beginning of the period over which MAP messages are processed.	UN-004	Inspection
CIMMS-DR-008.03-v01	MAP Message Assessment	'MAP Broadcast Rate' Event	The 'MAP Broadcast Rate' Event shall contain a timestamp that corresponds to the end of the period over which MAP messages are processed.	UN-004	Inspection
CIMMS-DR-008.04-v01	MAP Message Assessment	'MAP Broadcast Rate' Event	The 'MAP Broadcast Rate' Event shall contain the number of observed MAP messages.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-009-v01	SPaT Message Assessment	'SPaT Minimum Data' Event	The Message Monitor shall have a data structure for the 'SPaT Minimum Data' Event.	UN-004	Inspection
CIMMS-DR-009.01-v01	SPaT Message Assessment	'SPaT Minimum Data' Event	The 'SPaT Minimum Data' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection
CIMMS-DR-009.02-v01	SPaT Message Assessment	'SPaT Minimum Data' Event	The 'SPaT Minimum Data Event' shall contain a timestamp that corresponds to the beginning of the period over which SPaT messages are processed.	UN-004	Inspection
CIMMS-DR-009.03-v01	SPaT Message Assessment	'SPaT Minimum Data' Event	The 'SPaT Minimum Data Event' shall contain a timestamp that corresponds to the end of the period over which SPaT messages are processed.	UN-004	Inspection
CIMMS-DR-009.04-v01	SPaT Message Assessment	'SPaT Minimum Data' Event	The 'SPaT Minimum data Event' shall contain a list of data elements in the SPaT Message that are required, but not included in the SPaT Message.	UN-004	Inspection
CIMMS-DR-010-v01	MAP Message Assessment	'MAP minimum Data' Event	The Message Monitor shall have a data structure for the 'MAP Minimum Data' Event.	UN-004	Inspection
CIMMS-DR-010.01-v01	MAP Message Assessment	'MAP minimum Data' Event	The 'MAP Minimum Data' Event shall contain a unique identifier for the source device (RSU) of the CV data used in the algorithm.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-010.02-v01	MAP Message Assessment	'MAP minimum Data' Event	The 'MAP Minimum Data' Event shall contain a timestamp that corresponds to the beginning of the period over which MAP messages are processed.	UN-004	Inspection
CIMMS-DR-010.03-v01	MAP Message Assessment	'MAP minimum Data' Event	The 'MAP Minimum Data' Event shall contain a timestamp that corresponds to the end of the period over which MAP messages are processed.	UN-004	Inspection
CIMMS-DR-010.04-v01	MAP Message Assessment	'MAP minimum Data' Event	The 'MAP Minimum Data' Event shall contain a list of data elements in the MAP Message that are required, but not included in the MAP Message.	UN-004	Inspection
CIMMS-DR-011-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The Message Monitor shall have a data structure for the 'Signal State' Event.	UN-004	Inspection
CIMMS-DR-011.01-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the timestamp.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-011.02-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-011.03-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the intersection ID.	UN-004	Inspection
CIMMS-DR-011.04-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the ingress lane.	UN-004	Inspection
CIMMS-DR-011.05-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the signal group.	UN-004	Inspection
CIMMS-DR-011.06-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the event state.	UN-004	Inspection
CIMMS-DR-011.07-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the vehicle ID.	UN-004	Inspection
CIMMS-DR-011.08-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the vehicle latitude.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-011.09-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the vehicle longitude.	UN-004	Inspection
CIMMS-DR-011.10-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the vehicle heading.	UN-004	Inspection
CIMMS-DR-011.11-v01	SPaT and MAP Assessment using BSMs	'Signal State' Event	The 'Signal State' Event shall contain the vehicle speed.	UN-004	Inspection
CIMMS-DR-012-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The Message Monitor shall have a data structure for the 'Lane Direction of Travel' Event.	UN-004	Inspection
CIMMS-DR-012.01-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the timestamp.	UN-004	Inspection
CIMMS-DR-012.02-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-012.03-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the intersection ID.	UN-004	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-012.04-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the lane id.	UN-004	Inspection
CIMMS-DR-012.05-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the lane segment number.	UN-004	Inspection
CIMMS-DR-012.06-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the lane segment initial latitude/longitude.	UN-004	Inspection
CIMMS-DR-012.07-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the lane segment final latitude/longitude.	UN-004	Inspection
CIMMS-DR-012.08-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the expected heading.	UN-004	Inspection
CIMMS-DR-012.09-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the (median) vehicle heading.	UN-004	Inspection
CIMMS-DR-012.10-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the number of points (BSM latitude/longitude that fall inside of the lane segment polygon used in the median aggregation).	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-012.11-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Event	The 'Lane Direction of Travel' Event shall contain the (median) distance from lane centerline.	UN-004	Inspection
CIMMS-DR-013-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The Message Monitor shall have a data structure for the 'Connection of Travel' Event.	UN-004	Inspection
CIMMS-DR-013.01-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' Event shall contain the timestamp.	UN-004	Inspection
CIMMS-DR-013.02-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-013.03-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' Event shall contain the intersection ID.	UN-004	Inspection
CIMMS-DR-013.04-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' shall contain the ingress lane ID.	UN-004	Inspection
CIMMS-DR-013.05-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' Event shall contain the egress lane ID.	UN-004	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-013.06-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Event	The 'Connection of Travel' Event shall contain a value that indicates if a connection was identified or not .	UN-004	Inspection
CIMMS-DR-014-v01	SPaT Message Assessment	'Signal State Conflict' Event	The Message Monitor shall have a data structure for the 'Signal State Conflict' Event.	UN-004	Inspection
CIMMS-DR-014.01-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the timestamp.	UN-004	Inspection
CIMMS-DR-014.02-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-014.03-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the intersection ID.	UN-004	Inspection
CIMMS-DR-014.04-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall indicate if the conflict is related to a protected movement or a permissive movement.	UN-004	Inspection
CIMMS-DR-014.05-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the signal group of the first conflicting signal group.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-014.06-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the signal state of the first conflicting signal group.	UN-004	Inspection
CIMMS-DR-014.07-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the signal group of the second conflicting signal group.	UN-004	Inspection
CIMMS-DR-014.08-v01	SPaT Message Assessment	'Signal State Conflict' Event	The 'Signal State Conflict' Event shall contain the signal state of the second conflicting signal group.	UN-004	Inspection
CIMMS-DR-015-v01	SPaT Message Assessment	'Time Change Details' Event	The Message Monitor shall have a data structure for the 'Time Change Details' Event.	UN-004	Inspection
CIMMS-DR-015.01-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Conflict Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-015.02-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the intersection ID.	UN-004	Inspection
CIMMS-DR-015.03-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the signal group.	UN-004	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS—015.04-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the first conflicting SPaT timestamp.	UN-004	Inspection
CIMMS—015.05-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the first conflicting timemark type (minEndTime, maxEndTime).	UN-004	Inspection
CIMMS-DR-015.06-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the first conflicting timemark.	UN-004	Inspection
CIMMS-DR-015.07-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the first conflicting event state.	UN-004	Inspection
CIMMS—015.08-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Conflict Event shall contain the second conflicting SPaT timestamp.	UN-004	Inspection
CIMMS—015.09-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Conflict Event shall contain the second conflicting timemark type (minEndTime, maxEndTime).	UN-004	Inspection
CIMMS—015.10-v01	SPaT Message Assessment	'Time Change Details' Event	The 'Time Change Details' Event shall contain the second conflicting timemark.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-016-v01	SPaT and MAP Assessment using BSMs	'Signal State' Assessment	The Message Monitor shall have a data structure for the 'Signal State' Assessment.	UN-006	Inspection
CIMMS-DR-016.01-v01	SPaT and MAP Assessment using BSMs	'Signal State' Assessment	The 'Signal State' Assessment shall contain the timestamp (when the assessment is performed).	UN-006	Inspection
CIMMS-DR-016.02-v01	SPaT and MAP Assessment using BSMs	'Signal State' Assessment	The 'Signal State' Assessment shall contain a data structure that relates: signalGroup, number of events (eventState red), number of events (eventState yellow), number of events (eventState green).	UN-006	Inspection
CIMMS-DR-017-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Assessment	The Message Monitor shall have a data structure for the 'Lane Direction of Travel' Assessment.	UN-006	Inspection
CIMMS-DR-017.01-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Assessment	The 'Lane Direction of Travel' Assessment shall contain the timestamp (when the assessment is performed).	UN-006	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-017.02-v01	SPaT and MAP Assessment using BSMs	'Lane Direction of Travel' Assessment	The 'Lane Direction of Travel' Assessment shall contain a data structure that relates: laneId, number of events (heading within tolerance), median heading (heading within tolerance), number of events (heading not within tolerance).	UN-006	Inspection
CIMMS-DR-018-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Assessment	The Message Monitor shall have a data structure for the 'Connection of Travel' Assessment.	UN-006	Inspection
CIMMS-DR-018.01-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Assessment	The 'Connection of Travel' Assessment shall contain the timestamp (when the assessment is performed).	UN-006	Inspection
CIMMS-DR-018.02-v01	SPaT and MAP Assessment using BSMs	'Connection of Travel' Assessment	The 'Connection of Travel' Assessment shall contain a data structure that relates: ingress lane ID, egress lane ID, connection (may be blank), number of events (with specified ingress / egress lane).	UN-006	Inspection
CIMMS-DR-019-v01	Exception Notification	Notification Message	The Message Monitor shall form a Notification Message contained in a Notification.	UN-008	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-019.01-v01	Exception Notification	Notification Message	The Notification Message shall contain the time the timestamp of the Assessment Result Data that resulted in the issuance of the notification.	UN-008	Inspection
CIMMS-DR-019.02-v01	Exception Notification	Notification Message	The Notification Message shall contain text that denotes the type of event data or assessment result data that resulted in the issuance of the notification.	UN-008	Inspection
CIMMS-DR-019.03-v01	Exception Notification	Notification Message	The Notification Message shall contain text that includes Assessment Result Data (that exceeds given threshold for issuing Notification).	UN-008	Inspection
CIMMS-DR-020-v01	Exception Notification	Cease Broadcast Recommendation Message	The Message Monitor shall form a Cease Broadcast Recommendation Message contained in a Cease Broadcast Recommendation.	UN-009	Inspection
CIMMS-DR-020.01-v01	Exception Notification	Cease Broadcast Recommendation Message	The Cease Broadcast Recommendation Message shall contain the time the timestamp of the Assessment Result Data that resulted in the issuance of the cease broadcast recommendation.	UN-009	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-020.02-v01	Exception Notification	Cease Broadcast Recommendation Message	The Cease Broadcast Recommendation Message shall contain text that denotes the type of event data or assessment result data that resulted in the issuance of the cease broadcast recommendation.	UN-009	Inspection
CIMMS-DR-020.03-v01	Exception Notification	Cease Broadcast Recommendation Message	The Cease Broadcast Recommendation Message shall contain text that includes Assessment Result Data (that exceeds given threshold for issuing Cease Broadcast Recommendation).	UN-009	Inspection
CIMMS-DR-021-v01	Message Status and Reports	Performance Report Information	The Message Monitor shall form Performance Report Information that is included in a Performance Report.	UN-010	Inspection
CIMMS-DR-021.01-v01	Message Status and Reports	Performance Report Information	The Performance Report Information should be provided separately for each individual intersection	UN-010	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-021.01-v01	Message Status and Reports	Performance Report Information	The Performance Report Information for a single intersection shall include one or more time series graphs of the number of events for each event type with the number of events on the vertical axis.	UN-010	Inspection
CIMMS-DR-021.02-v01	Message Status and Reports	Performance Report Information	The Performance Report Information for a single intersection shall include a single time series of assessment results for each type of Assessment.	UN-010	Inspection
CIMMS-DR-021.03-v01	Message Status and Reports	Performance Report Information	The Performance Report Information shall allow the user to aggregate the results using other data elements stored in the event or assessment result data.	UN-010	Inspection
CIMMS-DR-022-v01	CIMMS Management	C-V2X message processing frequency	The Configuration Data shall include the C-V2X message processing frequency in seconds (range >= 0, integer).	UN-018	Inspection
CIMMS-DR-023-v01	CIMMS Management	Minimum distance from stopbar (Signal State when Vehicle Crosses Stop Line algorithm)	The Configuration Data shall include the Minimum distance from stopbar (Signal State when Vehicle Crosses Stop Line algorithm) in feet (range >= 0.01, 2 decimal) or centimeters (range >=1, integer).	UN-018	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-024-v01	CIMMS Management	heading tolerance (Signal State when Vehicle Crosses Stop Line algorithm)	The Configuration Data shall include the heading tolerance (Signal State when Vehicle Crosses Stop Line algorithm) in degrees (range >= 1, integer).	UN-018	Inspection
CIMMS-DR-025-v01	CIMMS Management	minimum speed threshold (Lane Direction of Travel algorithm)	The Configuration Data shall include the minimum speed threshold (Lane Direction of Travel algorithm) in mph (range >= 0, integer) or mph (range >=0, integer).	UN-018	Inspection
CIMMS-DR-026-v01	CIMMS Management	minimum number of points (Lane Direction of Travel algorithm)	The Configuration Data shall include the minimum number of points (Lane Direction of Travel algorithm) (range >= 1, integer).	UN-018	Inspection
CIMMS-DR-027-v01	CIMMS Management	allowed concurrent permissive movements (Signal State Conflict Monitor)	The Configuration Data shall include the allowed concurrent permissive movements (Signal State Conflict Monitor) (variable size list/array of 2 integers).	UN-018	Inspection
CIMMS-DR-028-v01	CIMMS Management	look-back period (signal state assessment)	The Configuration Data shall include the look-back period (signal state assessment) in days (range >= 1, integer).	UN-019, UN-020	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-029-v01	CIMMS Management	minimum red light percentage threshold (Signal State assessment)	The Configuration Data shall include the minimum red light percentage threshold (Signal State assessment) (range 0-1, 2 decimal, may be expressed x100 as a %).	UN-019, UN-020	Inspection
CIMMS-DR-030-v01	CIMMS Management	minimum red light percentage threshold (Signal State assessment) may be specified individually for each signal group.	The Configuration Data shall include the minimum red light percentage threshold (Signal State assessment) may be specified individually for each signal group (range 0-1, 2 decimal, may be expressed x100 as a %).	UN-019, UN-020	Inspection
CIMMS-DR-031-v01	CIMMS Management	minimum number of events (Signal State assessment)	The Configuration Data shall include the minimum number of events (Signal State assessment) (range >=1, integer).	UN-019, UN-020	Inspection
CIMMS-DR-032-v01	CIMMS Management	look-back period (lane direction of travel event assessment)	The Configuration Data shall include the look-back period (lane direction of travel event assessment) in days (range >= 1, integer).	UN-019, UN-020	Inspection
CIMMS-DR-033-v01	CIMMS Management	heading tolerance (lane direction of travel event assessment)	The Configuration Data shall include the heading tolerance (Assessment of Lane Direction of Travel events) in degrees (range >= 1, integer).	UN-019, UN-020	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-034-v01	CIMMS Management	minimum number of events (lane direction of travel event assessment)	The Configuration Data shall include the minimum number of events (Assessment of Lane Direction of Travel events) (range >=1, integer).	UN-019, UN-020	Inspection
CIMMS-DR-035-v01	CIMMS Management	look-back period (connection of travel assessment)	The Configuration Data shall include the look-back period (Assessment of connection events) in days (range >= 1, integer).	UN-019, UN-020	Inspection
CIMMS-DR-036-v01	CIMMS Management	minimum number of events (connection of travel assessment)	The Configuration Data shall include the minimum number of events (Assessment of connection events) (range >=1, integer).	UN-019, UN-020	Inspection
CIMMS-DR-037-v01	CIMMS Management	V2X Message Storage Period	The Configuration Data shall include the V2X message storage period. (range 5 minutes – 24 hours)	UN-002, UN-003, UN-005	Inspection
CIMMS-DR-037-v01	CIMMS Management	minimum speed threshold (Signal State assessment)	The Configuration Data shall include the 'minimum speed' in mph (signal state assessment) (mph, range >= 0, integer)	UN-019, UN-020	Inspection
CIMMS-DR-038-v01	CIMMS Management	SPaT Minimum 10-second Reception (SPaT Broadcast Rate algorithm)	The Configuration Data shall include the 'SPaT Minimum 10-second Reception' (SPaT Broadcast Rate algorithm) in absolute number of messages (range >= 0, integer, default value 99).	UN-019, UN-020	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-039-v01	CIMMS Management	SPaT Maximum 10-second Reception (SPaT Broadcast Rate algorithm)	The Configuration Data shall include the 'SPaT Maximum 10-second Reception' (SPaT Broadcast Rate algorithm) in absolute number of messages (range >= 0, integer, default value 101).	UN-019, UN-020	Inspection
CIMMS-DR-040-v01	CIMMS Management	MAP Minimum 10-second Reception (MAP Broadcast Rate algorithm)	The Configuration Data shall include the 'MAP Minimum 10-second Reception' (MAPSPaT Broadcast Rate algorithm) in absolute number of messages (range >= 0, integer, default value 9).	UN-019, UN-020	Inspection
CIMMS-DR-041-v01	CIMMS Management	MAP Maximum 10-second Reception (MAP Broadcast Rate algorithm)	The Configuration Data shall include the 'MAP Maximum 10-second Reception' (MAP Broadcast Rate algorithm) in absolute number of messages (range >= 0, integer, default value 11).	UN-019, UN-020	Inspection
CIMMS-DR-042-v01	CIMMS Management	time change details notification duration	The Configuration Data shall include the 'signal state conflict notification duration' in hours (range >=0, double).	UN-009	Inspection
CIMMS-DR-043-v01	CIMMS Management	time change details notification duration	The Configuration Data shall include the 'time change details notification duration' in hours (range >=0, double).	UN-009	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-044-v01	CIMMS Management	Distance from centerline tolerance (lane direction of travel event assessment)	The Configuration Data shall include the 'maximum distance from lane centerline' in feet (range >=0, double).	UN-019, UN-020	Inspection
CIMMS-DR-045-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The Message Monitor shall have a data structure for the 'Vehicle Stop' Event.	UN-004	Inspection
CIMMS-DR-045.01-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the road regulator ID.	UN-004	Inspection
CIMMS-DR-045.02-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the intersection ID.	UN-004	Inspection
CIMMS-DR-045.03-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the ingress lane.	UN-004	Inspection
CIMMS-DR-045.04-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the signal group.	UN-004	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-045.05-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the vehicle ID.	UN-004	Inspection
CIMMS-DR-045.06-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the vehicle latitude.	UN-004	Inspection
CIMMS-DR-045.07-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the vehicle longitude.	UN-004	Inspection
CIMMS-DR-045.08-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the vehicle heading.	UN-004	Inspection
CIMMS-DR-045.09-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the event state when the vehicle initially comes to a stop.	UN-004	Inspection
CIMMS-DR-045.10-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the timestamp when the vehicle initially comes to a stop	UN-004	Inspection
CIMMS-DR-045.11-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the event state corresponding to the latest moment the vehicle remains at a stop.	UN-004	Inspection

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ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-045.12-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the timestamp corresponding to the latest moment the vehicle remains at a stop.	UN-004	Inspection
CIMMS-DR-045.13-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the time the vehicle was stopped during a red (stop-and-remain) event state	UN-004	Inspection
CIMMS-DR-045.14-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the time the vehicle was stopped during a yellow (permissive-clearance, protected-clearance) event state	UN-004	Inspection
CIMMS-DR-045.15-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Event	The 'Vehicle Stop' Event shall contain the time the vehicle was stopped during a green (permissive-movement-allowed, protected-movement-allowed) event state	UN-004	Inspection
CIMMS-DR-046-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Assessment	The Message Monitor shall have a data structure for the 'Vehicle Stop' Assessment.	UN-006	Inspection
CIMMS-DR-046.01-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Assessment	The 'Vehicle Stop' Assessment shall contain the timestamp (when the assessment is performed).	UN-006	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-046.02-v01	SPaT and MAP Assessment using BSMs	'Vehicle Stop' Assessment	The 'Vehicle Stop' Assessment shall contain a data structure that relates: signalGroup, aggregated percentage of time vehicles are stopped for (eventState red), aggregated percentage of time vehicles are stopped for (eventState yellow), aggregated percentage of time vehicles are stopped for (eventState green).	UN-006	Inspection
CIMMS-DR-047-v01	CIMMS Management	Minimum distance from stopbar (Signal State when Vehicle Stops at Stop Line algorithm)	The Configuration Data shall include the Minimum distance from stopbar (Signal State when Vehicle Crosses Stop Line algorithm) in feet (range >= 0.01, 2 decimal) or centimeters (range >=1, integer).	UN-018	Inspection
CIMMS-DR-048-v01	CIMMS Management	heading tolerance (Signal State when Vehicle Stops at Stop Line algorithm)	The Configuration Data shall include the heading tolerance (Signal State when Vehicle Crosses Stop Line algorithm) in degrees (range >= 1, integer).	UN-018	Inspection
CIMMS-DR-049-v01	CIMMS Management	look-back period (Vehicle Stop Event assessment)	The Configuration Data shall include the look-back period (Vehicle Stop assessment) in days (range >= 1, integer).	UN-019, UN-020	Inspection

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-DR-050-v01	CIMMS Management	minimum red light percentage threshold (Vehicle Stop Event assessment)	The Configuration Data shall include the minimum stop-on-green threshold (Vehicle Stop assessment) (range 0-1, 2 decimal, may be expressed x100 as a %).	UN-019, UN-020	Inspection
CIMMS-DR-051-v01	CIMMS Management	minimum red light percentage threshold (Vehicle Stop Event assessment) may be specified individually for each signal group.	The Configuration Data shall include the minimum stop-on-green threshold (Vehicle Stop assessment) may be specified individually for each signal group (range 0-1, 2 decimal, may be expressed x100 as a %).	UN-019, UN-020	Inspection
CIMMS-DR-052-v01	CIMMS Management	minimum number of events (Vehicle Stop Event assessment)	The Configuration Data shall include the minimum number of events (Vehicle Stop assessment) (range >=1, integer).	UN-019, UN-020	Inspection

5.5. Security Requirements

The security requirements (SR) for the core system of interest specifies what is necessary to protect the integrity and operability of the system, its microservices, connections, and data. This includes physical security as well as cyber prevention, detection, identification, response and recovery requirements. The requirements in **Table 12** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 12: Security Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-SR-001-v01	Security	Operating System	The Message Monitor shall disable, by default, any applications and services within its operating system that are not being utilized.	UN-016	Test
CIMMS-SR-002-v01	Security	Access Control list	The Message Monitor SHALL disable or allow by exception, by default, any ports and protocols not being utilized by any of the active applications running on the Message Monitor.	UN-016	Test
CIMMS-SR-003-v01	Security	Operating System	The Message Monitor shall prompt the first user to access the device to change the default password to a password that meets security industry standard password strengths.	UN-016	Test
CIMMS-SR-004-v01	Security	Network Security	The Message Monitor shall be able to gain assurance when it connects to another local device or backend device in its network, that it is being accessed by that device as intended by the administrator of the Message Monitor.	UN-016	Test
CIMMS-SR-005-v01	Security	Network Security	The Message Monitor shall be able to gain assurance that any ongoing network connection only allows access from the device it was originally connected to.	UN-016	Test
CIMMS-SR-006-v01	Security	Network Security	If supported by the RSU, the Message Monitor shall support TLS 1.3 or DTLS 1.3, as defined in IETF RFC 8446	UN-001.6	Test
CIMMS-SR-007-v01	Security	Network Security	IT best practices shall be utilized to secure the network connection between the Message Monitor and the RSE.	UN-016	Demonstration

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-SR-008-v01	Security	Network Security	IT best practices shall be utilized to secure the network connection between the Message Monitor and Message Monitor Support.	UN-016	Demonstration

5.6. Non-Functional Requirements

The non-functional requirements (NF) for the core system of interest specifies the characteristics of the overall operation of the system such as availability, maintainability, reliability, safety, environmental, human factors, and ergonomics.

5.6.1. Physical Requirements

The physical requirements specify the construction, durability, adaptability and environmental characteristics of the system, such as installation location, device weight limits, dimension and volume limitations, temperature regulations, layout, access for maintenance, growth and expansion characteristics, etc. The requirements in **Table 13** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 13: Physical Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-PY-001-v01	Message Monitor	Physical	The Message Monitor shall be capable of being installed on a physical device that can physically fit inside of a traffic signal controller cabinet.	UN-015	Inspection
CIMMS-PY-002-v01	Message Monitor	Physical	The Message Monitor shall be capable of being installed on a remote server.	UN-015	Inspection
CIMMS-PY-002-v01	Message Monitor	Physical	The hardware of the physical device that the message monitor is running on should be capable of producing event data in less than 2% of the time period of V2X data collection. e.g., if 5 minutes worth of V2X data are being processed, events should be generated in no greater than 6 seconds.	UN-015	Inspection

5.6.2. Availability and Recoverability Requirements

The availability requirements define the times of day, days of year, and overall percentage the system can be used and when it will not be available for use. It also specifies the recovery time objective (RTO) of the system, which describes the time frame permitted for a system to become operational, the recovery point objective (RPO), which specifies up to what point in time shall the data be restored, as well as how the system is expected to restore services (e.g., failover, backups, etc.) in an event of a failure. The ability to recover quickly from a system failure or disaster depends on a blend of technologies and having a predefined plan for recovering the data on new hardware, when appropriate. The requirements in **Table 14** are organized by the functional groups and are related to the user needs identified in the project ConOps.

Table 14: Availability and Recovery Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-AR-001-v01	Message Monitor		The Message Monitor shall be available to ingest and process data from an RSU a minimum of 99% of the time (not related to issues associated with the communications network)	UN-013	Test

5.6.3. Maintainability Requirements

The maintainability requirements for the system specify the level of effort required to locate and correct an error during operation, establishing a quantitative requirement for planned and unplanned support (e.g., mean and maximum times to repair or resolve issues, number of people and skill levels required, support equipment necessary, maintenance staff hours, time and frequency of preventative maintenance, etc.). The requirements in **Table 15** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 15: Maintainability Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-MT-001-v01	CIMMS Management		If the Message Monitor experiences non-normal operations or shuts down, the Message Monitor will automatically restart or provide a notification of non-normal operation.	UN-013	Test

5.7. Enabling Requirements

The enabling requirements specify details concerning the management of information as well as the production of the system and its lifecycle sustainment, including development, integration, verification, validation, and training.

5.8. Policy and Regulation Requirements

The policy and regulation requirements (RG) for the system of interest specifies relevant and applicable organizational policies and regulations that affect the development, operation or performance of the system (e.g., IT and labor policies, reports to regulatory agencies, health or safety criteria, etc.). This section also includes new policy and regulation imposed to realize the system. The requirements in **Table 16** are organized by the functional groups and are related to the user needs documented in the project ConOps.

Table 16: Policy and Regulation Requirements

ReqID	Functional Group	Sub-Component	Description	References	Verification Method
CIMMS-RG-001-v01	Message Monitor	software	The code base for the Message Monitor shall be open source.	UN-022, UN-023 ,UN-024	
CIMMS-RG-002-v01	Message Monitor	software	The Message Monitor software shall be modular to be forward compatible with additional or replacement modules for assessing the accuracy of SPaT and MAP messages identified in the ConOps as alternatives considered: A. Receive SPaT data and compare with actual signal indication (via circuit voltage/current) B. High Resolution Signal Controller Data provides an additional source of ground truth traffic operations data.	UN-001, UN-002	Documentation

6. Engineering Principles

This section describes engineering principles that guide composition of the CIMMS project.

6.1. Methods of Verification

The software and hardware components that make up the CIMMS will be individually verified, then integrated to produce top-level assemblies and microservices. These assemblies will also be individually verified before being integrated with others to produce larger, evolving assemblies until the complete system has been integrated and verified. Throughout this process, the CIMMS project team will utilize Microsoft Excel to capture, track and trace requirements starting with the user needs defined in the ConOps, through development, testing and deployment. This approach and software tool will be instrumental through the design and development phases of the project.

The requirements also contain a verification method, which details the plan for verifying the requirement based on its stated definition. One of the verification methods listed in **Table 17** is assigned for each requirement defined in the previous section.

Table 17: Methods of Verification

Type	Description
Inspection	Verification through a nondestructive examination of the device or system using one or more of the senses (visual, auditory, tactile). This may include simple physical handling and measurements.
Demonstration	Verification that exercises the system software or hardware as it is designed to be used, without external influence, to verify the results are specified by the requirement
Test	Verification using controlled and predefined inputs and other external elements (e.g. data, triggers, etc.) that influence or induce the system to produce the output specified by the requirement
Analyze	Verification through indirect and logical conclusion using mathematical analysis, models, calculations, testing equipment and derived outputs based on validated data sets
Documentation	Test Reports or other documentation detailing conformance

Appendix A. Document Terminology and Conventions

A.1 Reference Conventions

The following conventions are used through this document:

- Titles of externally referenced documents or sources are underlined.
- Titles of internally referenced exhibits, sections, etc. are *italicized*.

A.1.1 Requirement Numbering Convention

Each requirement contains a unique ID for traceability and configuration management. All requirements for the CIMMS project will follow the same convention. The identifier contains three elements partitioned into five octets, each representing an identifiable attribute of the requirement as shown in figure

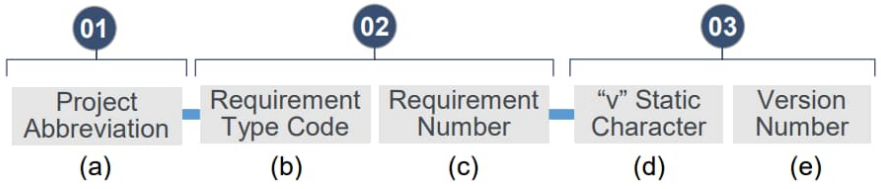

Figure 3: Requirement Naming elements

Table 18 lists the requirements naming convention.

Table 18: Requirements Numbering Convention

	Description	Data Type, Casing	# of Characters and/or Digits
a) Project Abbreviation	The Project Abbreviation is "CMMIS"	String, upper case	Variable

	Description	Data Type, Casing	# of Characters and/or Digits
b) Requirement Type Code	**Table 7: List of Requirement Types** • FN: Functional • PR: Performance • IF: Interface • DR: Data • SR: Security • RG: Policy and Regulation • PY: Physical • AR: Availability and Recovery • MT: Maintainability • ST: Storage and Transport • DP: Disposal • IM: Information Management • LC: Life Cycle Sustainability • CN: System Constraint	String, upper case	2
c) Requirement Number	An integer incrementing by one, indicating the number of requirements established	Integer	3
d) "v" Static Character	Static letter "v" represents the requirement version	Character	1
e) Version Number	An integer incrementing by one, indicating the number of revisions made to the requirement	Integer	2

As an example, version 1 of the first CIMMS Functional Requirement would be "CIMMS-FN001-v01", which is constructed as follows:

a) "CIMMS" = Project Abbreviation

b) "FN" = Functional Requirements

c) "001" = three-digit Requirement Number

d) "v" = version

e) "01" = the two-digit version number

D R A F T

A.1.2 Requirements Table Headings

The columns in the requirements tables throughout this document have the following definitions:

- **ReqID:** a unique identifier providing a reference to a specific requirement.
- **Functional Group** and **Sub-Component.** These are intended to organize the requirements in a manner that allows similar requirements to be grouped together. The requirements in the tables in this section are grouped by functional group and sub-component.
- **Description:** Statement of the business function or conditions the system must meet.
- **Reference:** Additional requirement(s), User Needs, Constraints or Interfaces that serve as the source (reason) a requirement exists.
- **Verification Method:** As detailed in **Chapter 6**, the method expected to verify that a requirement has been met is assigned to each requirement.

A.1.3 Conformance

Requirements listed in this document use the following terminology:

- SHALL indicates the definition is an absolute requirement of the specification.
- SHALL NOT indicates the definition is an absolute prohibition of the specification.
- SHOULD (RECOMMENDED) indicates there may exist valid reasons or circumstances to omit a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- SHOULD NOT (NOT RECOMMENDED) indicates there may exist valid reasons or circumstances when a particular function of condition is acceptable or even useful, but the full implications should be understood, and the case carefully weighed before implementing any function or condition described with this label.
- MAY (OPTIONAL) indicates an item is truly optional. Some vendors may choose to include or implement Optional Requirements to add value or enhance their overall product while other vendors may omit the same Optional Requirement to reduce cost, increase time to market, etc. An implementation which does not include an Optional Requirement SHALL be interoperable with implementations which does include the Optional Requirement, though perhaps with reduced functionality. In the same vein an implementation which does include an Optional Requirement SHALL be interoperable with an implementation which does not include the Optional Requirement (with the exception for the feature the option provides).

Appendix B. Acronyms and Definitions

Table 19 contains project specific acronyms used throughout this document.

Table 19: Acronym List

Acronym/Abbreviation	Definition
BSM	Basic Safety Message
ConOps	Concept of Operations
CV	Connected Vehicle
CVRIA	Connected Vehicle Reference Implementation Architecture
DSRC	Dedicated Short Range Communications
FHWA	Federal Highway Administration
GHz	Gigahertz
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IEEE	Institute of Electrical and Electronics Engineers
IT	Information Technology
ITS	Intelligent Transportation Systems
MAP	Map Message
NHTSA	National Highway Traffic Safety Administration
O&M	Operations and Maintenance
OBU	Onboard Unit (one onboard device)
OEM	Original Equipment Manufacturer
OSADP	Open-Source Application Data Portal
PII	Personally Identifiable Information
RFQ	Request for Quote
RSU	Roadside Unit
RTCM	Radio Technical Commission for Maritime
SAE	Society of Automotive Engineers
SCMS	Security and Credentials Management System
SPaT	Signal Phase and Timing
SRM	Signal Request Message

Acronym/Abbreviation	Definition
SSM	Signal Status Message
TIM	Traveler Information Message
TSC	Traffic Signal Controller
TSP	Transit Signal Priority
UI	User Interface
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VRU	Vulnerable Road User

Appendix C. Glossary

Table 20 contains project specific terms used throughout this document.

Table 20: Glossary

Term	Definition
App	Software application
Automated vehicle	A vehicle that can sense its environment and navigate without human input
Connected Vehicle	A vehicle capable of communicating with other vehicles, infrastructure, and smartphones
Data privacy	The reasonable expectation that data of a sensitive nature will be kept confidential, sanitized and/or encrypted, and respectfully and responsibly maintained by all users, managers, and collectors of the data
Data retention	The continued storage of data for compliance or business reasons
Data security	The tools, policies, practices, and procedures used to protect data from being accessed, manipulated, or destroyed or being leveraged by those with a malicious intent or without authorization, as well as the corrective actions taken when data breaches are suspected or have been identified.
Data sharing policies	Adopted plan around the practice of making data available to others
Dedicated Short Range Communications (DSRC)	A two-way short- to medium-range wireless communications capability that permits very high data transmission critical in communications-based active safety applications
Dependency	When one project, agency, or entity requires data or functionality provided by another project, agency, or entity to meet its objectives
Diminished operations	When pre-determined signal timing plans are not implemented at the proper time, or when traffic detection does not function properly
Enabling Technologies	An innovation that alone or paired with an existing solution produces a better end user solution at a rapid rate
Failure operations	When a complete failure of the intersection occurs, primarily due to loss of power or other malfunctions
Global Navigation Satellite System	Standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage. GPS, GLONASS, Galileo and Beidou are examples.
Global Positioning System	US Standard implementation of GNSS
Host vehicle	The vehicle that issues the alert or warning to the vehicle operator in a safety-critical situation

Term	Definition
Normal operations	When a signalized intersection is cycling through its pre-planned phases correctly, servicing all approaches, including pedestrian phases
Notification	General term used for message, alert, or warning issued to traffic operations
Onboard equipment	All equipment that is located in the vehicle, including any or all of the following items: GNSS receiver, vehicle data bus, a V2X radio, a processing unit, and a display
Open-data	Information that is freely available for anyone to use and republish as they wish
Open-source concepts	The notion of open collaboration and voluntary contribution for software development by writing and exchanging programming code
Performance metric	A measurement used to determine how a project is performing
Personally Identifiable Information (PII)	Information used in security and privacy laws that can be used to identify an individual, such as vehicle, driver, and payment information
Procurement	The act of obtaining or acquiring goods, services or works, from a competitive bidding process
Real-time data	Information that is delivered immediately after collection
Roadside equipment	All equipment located on the roadside, including any or all of the following items: traffic signal controllers, GNSS receiver, a DSRC radio, and a processing unit
System analytics or data analytics	The analysis of data, procedures, or business practices to locate information that can be used to create more efficient solutions
Third-party	Organizations not affiliated with the CIMMS Project
User Interface	Visual, audible, or haptic interface between a human and a machine, likely a computer of some form. Used to both convey and collect information.
V2X	Vehicle-to-Everything (vehicle-to-vehicle, -to-pedestrian, -to-infrastructure, etc.) communications in support of safety, mobility, and environmental applications
Vulnerable road users	Pedestrian, cyclist, or motorist who has a higher risk in traffic
Warning	Indication to traffic operations of an imminent situation for which they should take immediate action. Highest level of criticality.

Appendix D. Version History

Table 21: Version History

Version Number	Date	Author(s), Agency	Summary of Changes
0.1	07/15/2022	WSP	Initial Draft
1.0	08/22/2022	WSP	Updated Draft
2.0	08/31/22	WSP	Final Draft