Multi-Modal Intelligent Traffic Signal System

Final System Requirements Document

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RECORD OF CHANGES

Version Number	Date	Identification of Figure, Table, or Paragraph	Title or Brief Description	Change Request Number
1.0	10/26/12	N/A	Initial Draft submitted for review and feedback.	CDRL 120
2.0	12/21/12	Almost All	Interim submittal of MMITSS Requirements Document representing ~85% of completed requirements and PFS Panel feedback.	CDRL 122
3.0	1/21/13	6.2, 6.2, 6.3, 6.5, 6.6	Final submission to PFS Panel	CDRL 130
4.0	3/7/13	6.6.1, 6.6.2, 6.6.3	Integrated Feedback from USDOT	HP Email 3/4/13
		All	"…communication range of the intersection…" has been changed to "…communication control range of the intersection…"	12/4/12 Review
		6.5.1	Corrected A, C, and F nomenclature and minor corrections in performance requirements.	MMITSS Team
		A2013, A2014, A2015	Minor updates/corrections to requirements	MMITSS Team

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1 MMITSS Overview

The Multi-Modal Intelligent Traffic Signal System (MMITSS) project is part of the Cooperative Transportation System Pooled Fund Study (CTS PFS) entitled “Program to Support the Development and Deployment of Cooperative Transportation System Applications.” The CTS PFS was developed by a group of state and local transportation agencies and the Federal Highway Administration (FHWA). The Virginia Department of Transportation (VDOT) serves as the lead agency and is assisted by the University of Virginia’s Center for Transportation Studies, which serves as the technical and administrative lead for the PFS.

The United States Department of Transportation (US DOT) has identified ten high-priority mobility applications under the Dynamic Mobility Applications (DMA) program for the connected vehicle environment where high-fidelity data from vehicles, infrastructure, pedestrians, etc. can be shared through wireless communications. Three of the applications (Intelligent Traffic Signal System, Transit Signal Priority, and Mobile Accessible Pedestrian Signal System) are related to transformative traffic signal operations. Since a major focus of the CTS PFS members – who are the actual owners and operators of transportation infrastructure – lies in traffic signal related applications, the CTS PFS team is leading the project entitled “Multi-Modal Intelligent Traffic Signal System” in cooperation with US DOT’s Dynamic Mobility Applications Program.

The purpose of the Multi Modal Intelligent Traffic Signal System (MMITSS) is to integrate information from connected vehicles, nomadic devices, and existing information from infrastructure based detection systems into more effective and safer traffic signal control system for multiple modes of travelers (e.g., non-commercial vehicles, pedestrians, transit, freight, and emergency vehicles). This integrated information can be used to make improvements in traffic control algorithms and logic resulting in better performing and safer operating systems. In addition to enhancing traffic control algorithms and logic, information from connected vehicles (CV) can be used to directly measure system performance and for the assessment of safety.

During the MMITSS Requirements Walkthrough meeting on December 4, 2012 in Irvine, CA, the audience suggested that additional information about the MMITSS project be included in the introductory material of the MMITSS System Requirements Document. The rationale is that the collection of reviewers of the MMITSS program is both changing and expanding. As such, a reader who has not reviewed the MMITSS ConOps may not be familiar with some of the critical elements and assumptions of this research project. In response to this suggestion, the following subsections have been added to provide a brief overview of key elements of the MMITSS project.

1.1 MMITSS Conceptual Architecture

The basic architecture for the connected vehicle system is being defined across a variety of USDOT efforts and the MMITSS effort is coordinating through USDOT to ensure consistency. The basic architecture is illustrated in Figure 1 as a UML (Unified Modeling Language) Deployment Diagram. The nodes have been shaded such that the light colored nodes are part of the connected vehicle, Traffic Management and Fleet Management systems (or nodes that can be modified or assigned MMITSS responsibilities) and the gray colored nodes represent the vehicles and travelers.

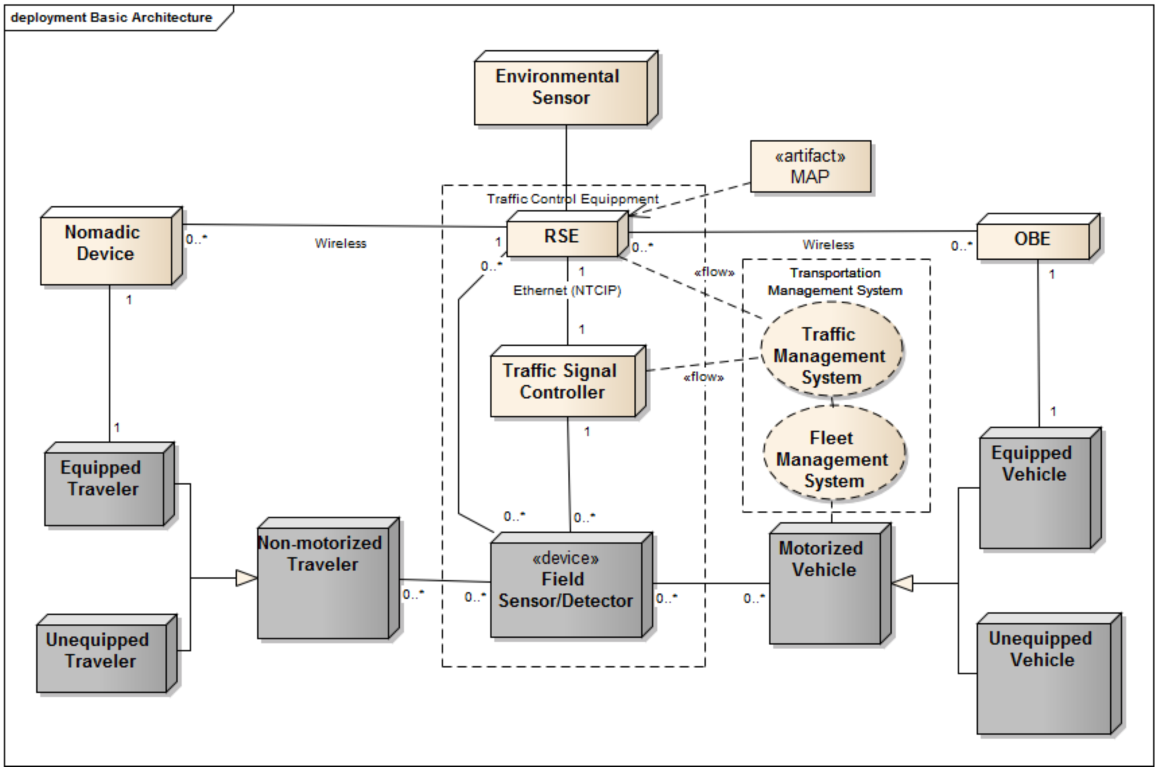

Figure 1 – MMITSS Conceptual Architecture (UML)

In this view of the system, there are two types of travelers – motorized vehicles and non-motorized travelers. Motorized vehicles consist of passenger vehicles, trucks, transit vehicles, emergency vehicles, and motorcycles. This type of traveler includes any vehicle that must be licensed to operate on the public roadway. Non-motorized travelers include pedestrians, bicyclists, and other modes such as equestrians that are not required to be licensed to operate on the public roadway. These travelers are either unequipped or equipped, meaning that they have some type of OBE (On-Board Equipment) or nomadic device that is CV (or MMITSS) aware and can operate as part of the traffic control system.

The anticipated system users, categorized as equipped or unequipped non-motorized travelers and/or motorized vehicles, are shown in Figure 3. The users are grouped into descriptive categories to convey the sharing of similar characteristics, traits, and needs. For example, a passenger vehicle and a non-commercial, light duty truck (e.g., Ford F-150 or Chevrolet Silverado) could be considered as one category of users. At this point in the MMITSS project, these have been defined these as two separate user categories to accommodate the difference in characteristics and traits for the case where the light duty truck could be loaded with a ton (2000 pounds) of cargo, which could impact the scenarios and use cases associated with Dilemma Zone (Use Case 11.1.4) and/or Congestion Control (Use Case 11.1.3). The requirement mapping for these use cases are included in the appendix of this document (See Section 7.2).

An equipped traveler can be a pedestrian with a nomadic device, a pedestrian with disabilities supported by an Authorized Nomadic Device (See ConOps Section 9.3.6), or any of the users shown in the upper left portion of this figure that possess a functioning nomadic device. In comparison, the user categories comprising the category of unequipped traveler are shown. Without a nomadic device (i.e., an unequipped traveler), the MMITSS cannot distinguish between a pedestrian, pedestrian with disabilities, or bicyclist. Hence, the possible user categories for an unequipped traveler are pedestrian and bicyclist (in cases where a dedicated bicycle lane push button or bicycle detector is present).

Motorized vehicles can be part of a fleet management system such as a transit management system, commercial freight management system, emergency vehicle dispatch system, and taxi dispatch, which is shown as a UML collaboration (oval in Figure 1) meaning that a collection of entities work together to perform the traffic management functions, but there may be many different systems involved in this collaboration.

The infrastructure based traffic signal control equipment consists of the traffic signal controller, and possibly roadside equipment (RSE). It is possible that an RSE will not be required at every intersection and that some of the RSE functionality could be supported remotely. The traffic signal controllers can be part of a larger traffic management system that controls and organizes groups (sections) of signals. The larger traffic management system is shown as a UML collaboration in Figure 1. The RSE is a general communications processing node that coordinates messages from the various modes of travelers into traffic signal controller inputs. The RSE contains (deploys) the MAP, which is the digital description of the intersection geometry and associated traffic control definitions. The MMITSS architecture has provisions for the inclusion of both local and networked weather sensors through the Environmental Sensor node. As a physical sensor, this can take the form of temperature, precipitation, ice, wind, or similar sensor interfaces. In a networked configuration, a data interface can provide weather and environmental information without actual hardware connection to the specific sensor. Regardless of the source of the environmental data, the MMITSS can make provisions during icy and inclement periods for pedestrians waiting to cross or the stopping distances of cars versus heavy trucks.

The traffic management systems (TMS) and the fleet management systems (FMS) together compose the greater transportation management system that is responsible for management of regional transportation capabilities. These systems may be distributed across government and agency boundaries, but work together to address the overall transportation needs. The actors comprising the transportation management system are shown in Figure 2.

Both motorized and non-motorized travelers can be detected by the Field Sensor/Detector node at the intersections using a variety of detection technologies, including inductive loop detectors, video detection, microwave, radar, pedestrian push button, etc. The detection system at an intersection provides information to the traffic signal controller that stimulates the control algorithms. For example, a vehicle that triggers a detector will call a signal control phase for service or extension. A pedestrian may activate a pedestrian push button to request the traffic signal pedestrian interval associated with a crosswalk movement.

Each of the systems that can be active participants in the MMITSS (e.g., connected vehicle, Traffic Management, and Fleet Management) can have different responsibilities, and in alternative system designs some of these responsibilities can be assigned to different components. In the discussion presented here, the basic operating functions will be reviewed and the alternative assignments will be explored in the detail design effort.

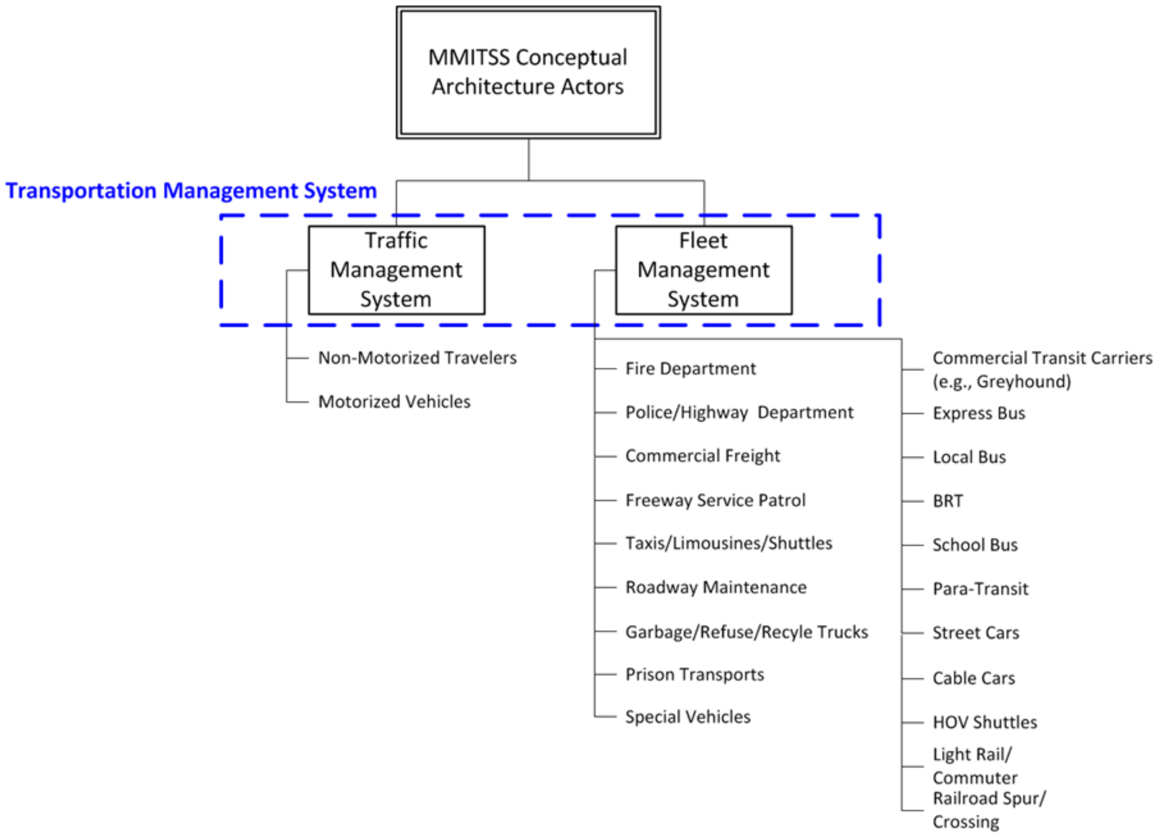

Figure 2 – MMITSS Transportation Management Actors

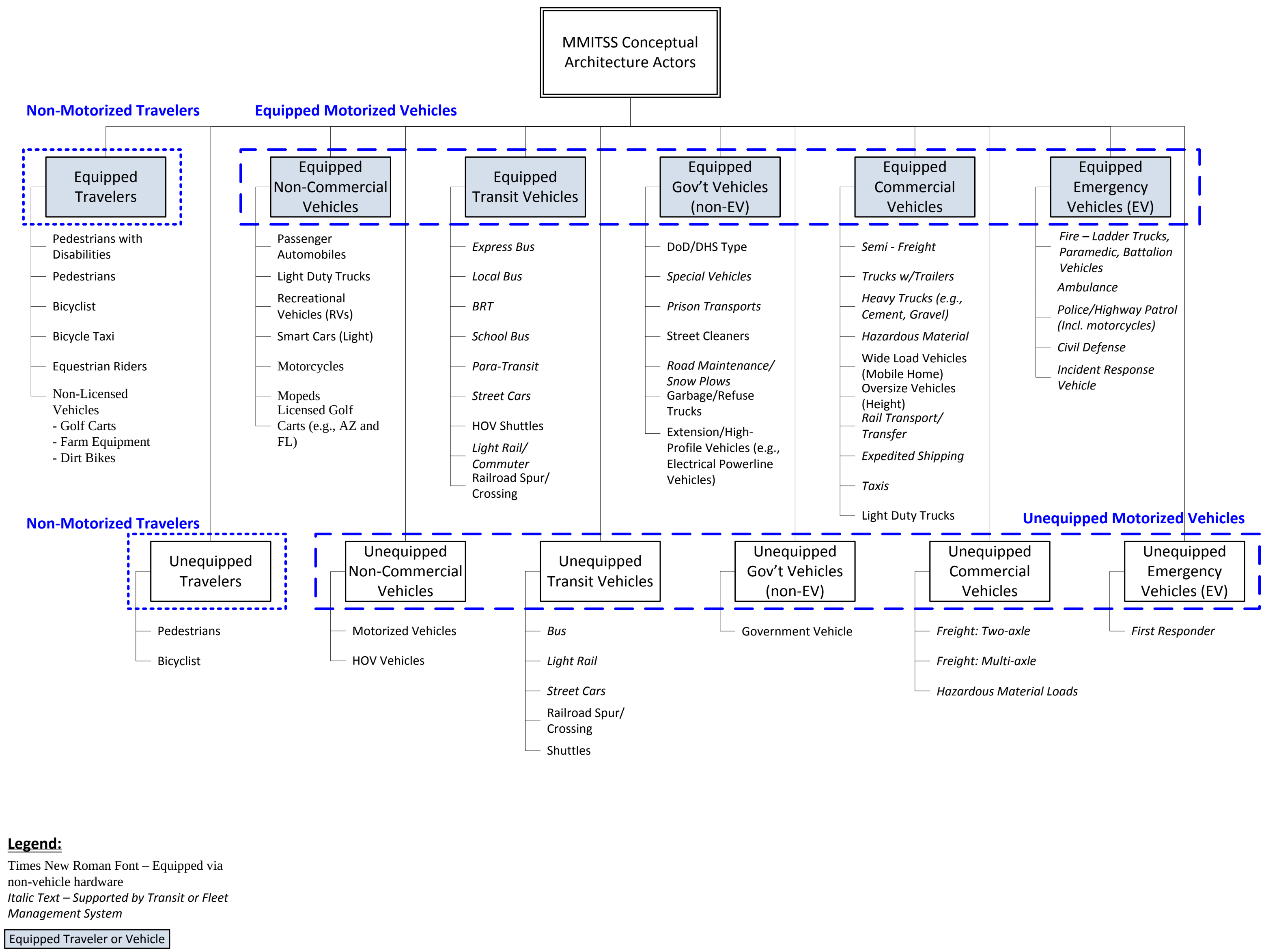

Figure 3 – MMITSS Equipped and Unequipped Actors

1.2 Concept for the Proposed System

The MMITSS is envisioned to be an intelligent traffic management system that will be deployed in the 5-year time horizon and reach a level of maturity within a 10-year time horizon. The MMITSS provides intelligent traffic signal control for both unequipped travelers and travelers that are "equipped" with wireless devices including smartphones, DSRC capable devices (direct short range communication), and potentially other nomadic devices. Some of the system users will be motorized (such as passenger cars, transit, trucks, and emergency vehicles) and others will be non-motorized (such as pedestrians and bicycles). The goal of MMITSS is to provide high quality traffic signal control to multiple modes of travelers by simultaneously optimizing operations for all of the modes.

The MMITSS supports two advanced control functions, including basic traffic control actuations and priority control. The basic traffic control actuation function assumes some vehicles and travelers are equipped and others are not equipped. The traffic signal system is aware of these travelers – either through sensors/detection or through assumed behaviors and controller programming (e.g., pedestrian recall). Basic traffic control provides actuation of phases and intervals in the traffic signal controller. Priority control considers specific requests from qualified classes of vehicles and travelers for traffic signal service based on vehicle mode, class, position, speed, and prevailing conditions, such as emergencies, disabilities, and weather conditions. Priority control enables a hierarchy of control considerations based on a policy that determines the importance of some vehicles over others, but can accommodate multiple requests for priority at any time. Coordination, or traffic signal synchronization, can be considered a form of priority control that provides progression through a series of traffic signals for a group (platoon) of vehicles.

The MMITSS design is partially driven by the traditional traffic signal control architecture and partially by the evolving connected vehicle architecture. The MMITSS will be designed and operated consistent with the architectures being developed in other dynamic mobility application (DMA) projects. The basic components of the connected vehicle system include the infrastructure based equipment (called Roadside Equipment – RSE) and the vehicle, or traveler, based equipment (called On-board Equipment OBE) or nomadic device. Each of these devices provides both communications and processing capabilities that support connectivity and intelligence for equipped travelers and vehicles.

All travelers, equipped and unequipped, can be served by the traffic control system either by being detected by field sensors (e.g., loop detectors or pedestrian push buttons) or by default programming of the traffic signal controller. In the event that there is a component failure in the connected vehicle system, the default mode of control would be to treat all vehicles as unequipped. Equipped travelers are actively sending information about their position and speed (plus significant additional data) that can augment and enhance the field sensor data. This new information is used to improve basic traffic signal operations as well as in the assessment of performance. Equipped travelers can be tracked by the MMITSS when they are within communications range of infrastructure-based equipment. Unequipped vehicles are monitored only at fixed detector locations. This additional information will allow intelligent traffic control logic to better serve the different modes of travelers.

MMITSS will operate the actuated and coordinated behavior of traffic signals, groups of traffic signals (referred to as sections), and systems of traffic signals to better adapt to prevailing conditions at the intersection level, section level, and system level. Traditional signal control is generally based on standard detector layouts that rely on agency standards and intersection design speeds. As traffic demands vary and vehicles travel and queue in a stochastic manner, these assumptions may not result in the best possible control. Equipped vehicle data, in conjunction with traditional detection, can be used to mitigate some of these assumptions. Examples include the call and extension of phases by different classes of vehicles (passenger vehicles, freight trucks, etc.). Another is in the protection of different modes of vehicles on high-speed approaches, called dilemma zones, especially when the environmental conditions could impact vehicle dynamics. Similarly, coordinated signal operations are dependent on selection of pattern parameters including cycle length, offset, and phase splits based on design volumes and speeds. These factors can vary on a daily basis and the performance can be measured and improved. Equipped vehicle data can be used to assess the performance of the coordinate pattern and to make adjustments in critical timing parameters.

Some equipped travelers, including emergency vehicles, transit, freight trucks, and pedestrians can actively participate in requesting special service considerations (e.g., priority) by the traffic signal controller. These equipped travelers will be capable of transmitting a request for service message to intersections as they travel their intended route. The request for service message contains information about the mode, vehicle class, priority level, and desired time of service. The signal control system will have the ability to send service status messages, or confirmations, about the future signal timing plan to allow requesting travelers to know their status in the priority request scenarios. This is a significant enhancement over priority systems used today.

An important and new capability of MMITSS is the management of multiple requests for priority that may be received from multiple vehicles, as well as multiple modes with different priority levels, at any time. These requests can come from emergency vehicles that are responding to an incident (or several incidents), transit vehicles, freight vehicles, bicyclists, and/or pedestrians. To manage these multiple requests, MMITSS will provide a hierarchical level of priority that can facilitate regional policies and preferences for priority control. For example, an agency may decide that emergency vehicles are given priority levels two (2) through four (4), where two (2) is assumed to have higher priority than four (4). Fire vehicles may be assigned to a level two (2), ambulances a level three (3), and police a level four (4), if there is a critical event that requires the police to respond as quickly as possible, such as a person with a weapon at a school or shopping center, they may be given a level two (2) priority. Similarly, transit may be assigned levels five (5) through nine (9) where the level of priority depends on the class of service (BRT, Express, or local) as well as other factors such as lateness and passenger occupancy. The fleet management system and the vehicle have the opportunity for determining the priority level for the vehicle before it communicates the request for service to the traffic control system (MMITSS). Freight and pedestrians might be assigned lower levels of priority. It is assumed that rail and cable cars are provided the highest level of priority (or preemption) due to the special characteristics associated with their operation (track clearance, gates down, dwell, free-running etc.). [Note: this structure and definition is consistent with NTCIP 1211 – Object Definitions for Signal Control and Prioritization].

The MMITSS design will support interfaces to the connected vehicle system (RSE), existing traffic control equipment and management system, new traffic control technology with evolving new sensors and detection technology, and other dynamic mobility applications. The interface between the traffic signal control equipment and the RSE is the fundamental channel for control coordination. Recently, FHWA has developed a MAP and SPaT interface for modern traffic signal controllers providing signal controller status in a format consistent with the NTCIP standards. The SPaT interface includes the ability for inputs to the controller as well, but it may be necessary to extend this interface to include priority requests and to utilize existing priority related objects (NTCIP 1211) and other ASC control objects (NTCIP 1202). In addition to the basic interface to the controller, MMITSS will collect performance data for use in intelligent control logic, which will be made available to the traffic management system. This interface will be designed to conform to the traffic management data dictionary (TMDD) as well as NTCIP standards. These two interfaces are critical to the integration of MMITSS with existing traffic control and management systems.

Advances in sensor and detection technology in the next 5 to 10 years are likely to result in information that will be valuable to MMITSS as well as other connected vehicle applications. For example, emerging developments in sensor and detector technology are producing sensors for tracking objects in the roadway[1]. This information could be used to enhance and validate the connected vehicle component (RSE) that is tracking BSMs from equipped vehicles. Hence, there needs to be an interface between the RSE and these new sensors. It is anticipated that this interface will be defined in a cooperative fashion with sensor developers and will conform to national communication standards (e.g., NTCIP).

A key future capability will be the interface between MMITSS and other dynamic mobility applications, such as speed harmonization and applications that monitor environmental (weather) conditions. Applications such as speed harmonization can provide significant benefits to MMITSS, resulting in effective coordination in a signalized section and in mixed mode operations, such as in a freight corridor. The ability to coordinate vehicle speeds will provide MMITSS the ability to better provide progression, smoother and safer traffic flow, and service to transit and freight vehicles. Information from applications that monitor environmental conditions can augment environmental data that could be collected locally (e.g., environmental sensor) for the purpose of decision making for dilemma zones and freight priority, as well as in choosing coordination plans. It is assumed that other dynamic mobility applications will be developed that can provide benefits to MMITSS as well and that their value to MMITSS can be determined as they are developed and integrated.

In summary, the key capabilities described in this section facilitate the goal of the MMITSS to provide high quality traffic signal control to various roadway users by simultaneously optimizing operations for all of the modes: private vehicles, pedestrians, transit, freight, and emergency vehicles.

2 Purpose of Document

The MMITSS System Requirements Document provides a listing of requirements and critical, supporting information (e.g., constraints) on the basis of which the MMITSS system can be designed. This is the MMITSS System Requirements Document and not the MMITSS Requirements Specification. The difference is fundamental. The MMITSS System Requirements Document is a listing of requirements and constraints on the basis of which a system can be designed. In contrast a system specification is a listing of requirements and constraints on the basis of which a system can be built or mass-produced. The latter document provides complete specification on each detail of the design, whereas the MMITSS requirements document allows further specification of implementation detail to support the differences between the systems and infrastructure deployed in the Arizona Testbed and the California Testbed.

The MMITSS System Requirements Document was developed using a customized version of the IEEE-1233 Requirements Development Process[2]. The customization incorporates the specific MMITSS tasking for a draft submittal, requirement workshop review, and final submittal. These elements, along with the corresponding deliverable (CDRL) and timeline, are shown in

Figure 4. As noted on the left side of the figure, the initial source of Customer/Stakeholder, Environment, Customer, and Technical Community requirement inputs are based on the MMITSS ConOps, which provides traceability to specific Stakeholder inputs in ConOps Section 13.4.

Using this requirements development process, an “Initial Set of Requirements” was defined during a meeting of University of Arizona and PATH team members in Phoenix, Arizona on October 8-10, 2012.

[1] MMITSS ConOps Workshop Meeting Minutes, July 18, 2012, (GD), p10.
[2] IEEE , IEEE Standard 1233, 1998, p21

After this initial definition, the “Refine Requirements Definition” was achieved by executing the requirement review process shown in Figure 5. The first step of this review process called for each MMITSS subject matter expert to swap requirements in an effort to ensure proper coverage. The review process employed an iterative approach with the MMITSS systems engineer to ensure compliance with the MMITSS Requirements Checklist and acceptable practices listed in the reference section (Section 7.3).

Figure 4 also conveys that the contents of the draft requirements document served as the basis of the MMITSS Requirements Walkthrough scheduled on December 4, 2012 in Irvine, CA. This working meeting provided details on the systems engineering methodology employed by MMITSS, the mapping of MMITSS use cases-to-requirements, data and interface requirements, functional requirements analysis, and traceability of requirements to the MMITSS ConOps and Stakeholder feedback in greater detail than draft requirements document. This Final MMITSS Requirements Document is intended to show the results of the requirements development processes, analyses, and integration of Sponsor feedback from the Requirements Walkthrough meeting on December 4, 2012.

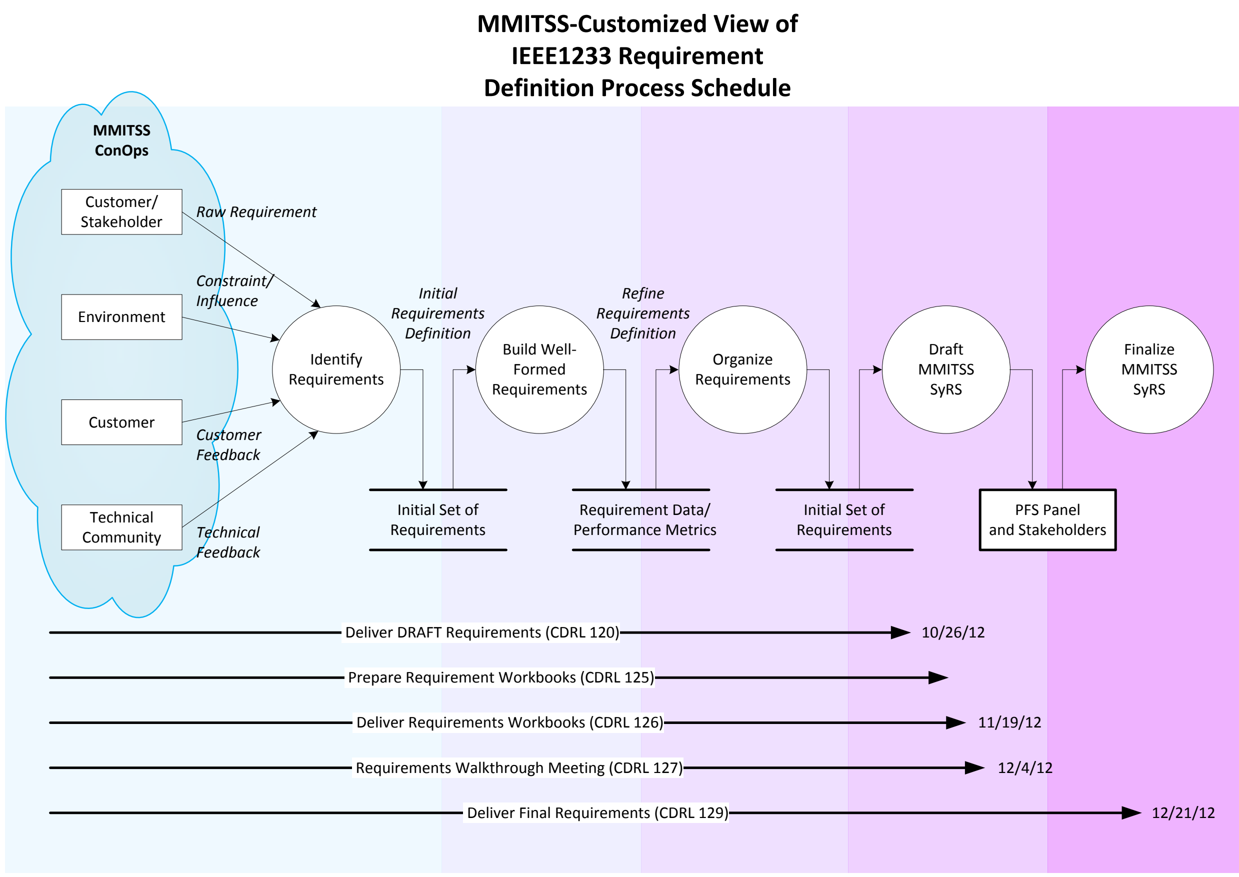

Figure 4 – MMITSS-Customized View of IEEE 1233 Requirement Definition Process

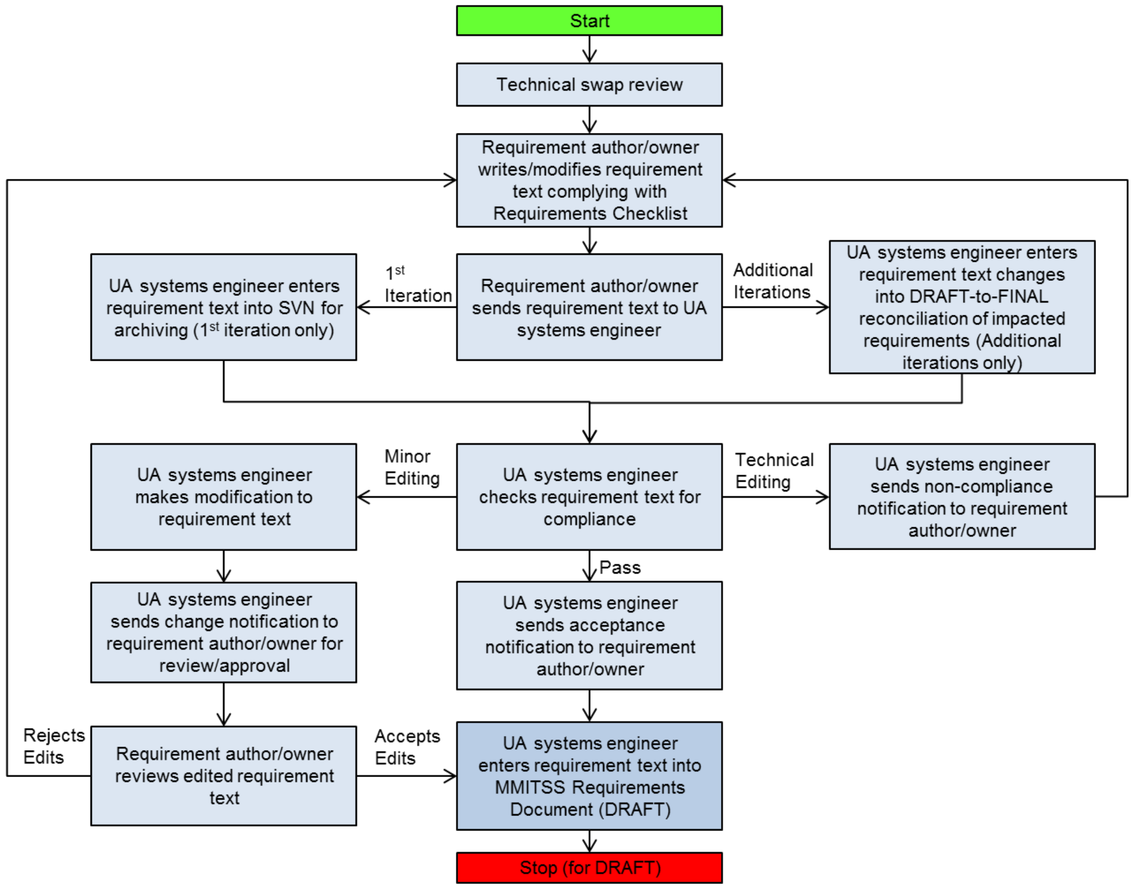

Figure 5 – MMITSS Requirement Review Process

3 Scope of Document

The scope of the MMITSS Systems Requirements Document includes information on requirements, constraints, and processes used to develop and formulate the requirements and constraints. This document relies on the contents of the Final MMITSS ConOps as its primary foundation. Since both the requirement documents and ConOps are living documents, the process of developing and formulating requirements and constraints will result in the identification of omissions, inaccuracies, or misunderstandings in one or both of the documents. Along these lines, a process has commenced to reconcile these types of findings on the MMITSS project. The record of these findings is updated continuously and posted in the MMITSS SVN repository. SVN, or Subversion, is a document version control system commonly used in software development. The MMITSS project has set up and maintained a SVN repository where the team members can share versioned documents in a structured manner.

Since this document relies on the Final MMITSS ConOps, a brief summary of assumptions is appropriate in this section. With respect to terminology, this document continues the use of specific language developed and used in the Final MMITSS ConOps such as traveler, nomadic device, and equipped vehicle. The concept of “priority level” has continued to evolve since the submission of the MMITSS ConOps to provide greater reliance on NTCIP guidance. As such, the data requirement for “level of priority” will appear modified from that presented in the ConOps.

Within this document, the use of the terminology “intersection” and “section” imply that they are contained within the MMITSS system boundaries. As such, “equipped intersection” or “connected intersection” are equivalent to the term “intersection” within the MMITSS. Some reviewers may be more familiar with the term corridor. The MMITSS “section” referenced in this document refers to a pre-defined collection of coordinated signals/intersections. As will be evident from the requirements, MMITSS provides the functionality for a transportation agency to define or redefine sections within their specific implementations. Definitions for specific terms used in this document are included in Section 5.1.

A listing of MMITSS internal reference documents is included in Section 4 and external references are included in Section 7.3. The structure, nomenclature, definitions, and other preliminaries used in the MMITSS Requirements Document are presented in Section 5. Using the previously defined requirements structure, Section 6 organizes each MMITSS requirement into the corresponding document section or subsection. Other useful mappings of MMITSS requirements are provided in the Verification Cross Reference Matrix (VCRM) and Requirements Traceability Matrix located in the appendices Section 7 and Section 8, respectively.

Version 1.0 of this document is a manual, standalone Word document. It is the intent of the MMITSS Team to incorporate the use and standardization of IBM DOORS, Dynamic Object Oriented Requirements System. Future versions of this document will be generated from the version-controlled database of requirements within the MMITSS DOORS implementation. As such, the MMITSS DOORS implementation is the version-controlled source of information on each and every MMITSS requirement. At any instance of time during the MMITSS project, the information in DOORS supersedes any written or electronic version of the MMITSS Requirements Document.

4 Referenced Documents

External and public released information used or referenced in this document is listed in the References Appendix in Section 7.3. The MMITSS project documentation used or referenced in this report is shown below:

- MMITSS Assessment of Prior and Ongoing Research (Submitted 6/29/12)
- Final MMITSS Stakeholder Input Report (Submitted 8/1/12)
- MMITSS ConOps Workshop Meeting Minutes on 7/18/12 (Submitted on 9/9/12)
- MMITSS Report of Responses from ConOps Workshop (CDRL 112 submitted on 9/12/12)
- MMITSS Final ConOps (CDRL 115 submitted on 10/21/12)

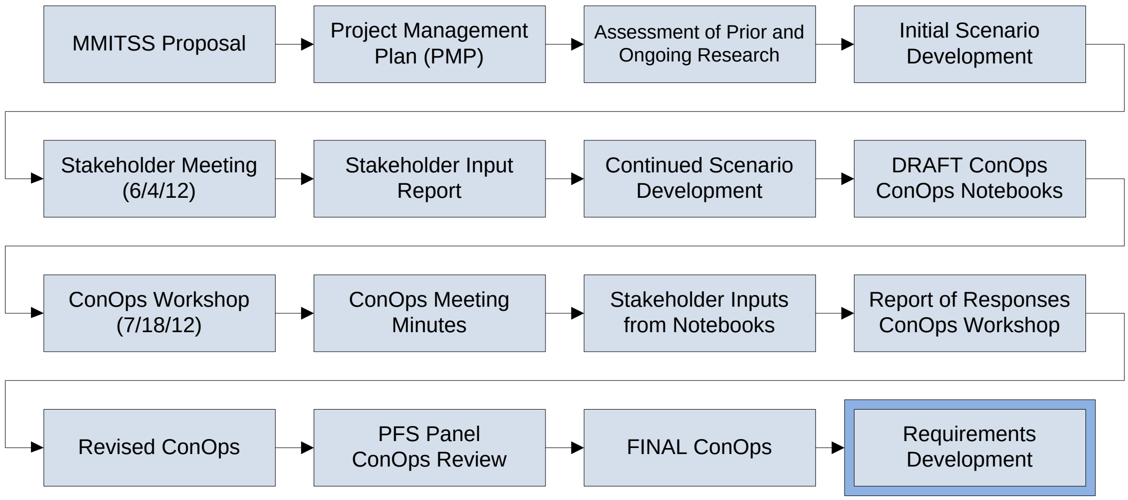

Figure 6 – MMITSS Reference Document Flow

5 Preliminaries and Nomenclature of Requirements

5.1 Important Definitions

As an introductory explanation of MMITSS requirements to follow, the following subsections provide definitions and clarifications of critical terms related to requirement definitions. The definitions supporting the verification methods reference INCOSE SE Handbook as appropriate.

Term	MMITSS Definition/Interpretation
Analysis (A)	The verification method referenced by analysis (A) describes the use of analytical data, analysis, or simulations under defined conditions to show theoretical compliance. This verification method is used where testing to realistic conditions cannot be achieved or is not cost-effective. Analysis (including simulation) may be used when such means establish that the appropriate requirement, specification, or derived requirement is met by the proposed solution.
Child Requirement	A child requirement is a partial, definitive allocation from a system or "parent' requirement enabling greater clarification and ease in verification testing.
Demonstration (D)	The verification method referenced by demonstration (D) describes a qualitative exhibition of functional performance, usually accomplished with no or minimal instrumentation. Demonstration (a set of test activities with system stimuli selected by the system developer) may be used to show that system or subsystem response to stimuli is suitable. Demonstration may be appropriate when requirements or specifications are given in statistical terms (e.g., mean time to repair, average power consumption, etc.).
Derived Requirement	A derived requirement is a requirement deduced or inferred from the collection and organization of requirements into a particular system configuration and solution.[3]
Inspection (I)	The verification method referenced by inspection (I) describes an examination of the item against applicable documentation to confirm compliance with requirements. Inspection is used to verify properties best determined by examination and observation (e.g., - paint color, weight, etc.).
MMITSS	MMITSS is used in a requirement to describe the *system* under design as part of the PFS Project.

[3] IEEE 1233-1998, page 8.

Nomadic Device	The term "nomadic device" is used to describe a technology device such as a smart phone or tablet carried by a pedestrian and/or bicyclist enabling the exchange of real-time information about their movements and traffic signal infrastructure within communication control range of the device.
Parent Requirement	A parent requirement is the hierarchical level of a localized flow down of requirement scope to "child requirements." If constructed properly, a parent requirement is verified through the verification of the child requirements and specific interoperability that is noted explicitly in the MMITSS Test Plan.
Shall	The term "shall" is used whenever a requirement or specification is binding within the current MMITSS project scope and instantiations that are likely to occur within a five-year time horizon. Shall is the preferred terminology for requirements and is used whenever possible and applicable. The "shall" requirement statements in this document correspond to the prototype development designs to be deployed at the Arizona and California Testbeds. These requirements provide the basis of the Verification Cross Reference Matrix (VCRM).
Should	The term "should" is used to distinguish a MMITSS requirement that will be imposed in future instantiations of the system on a 25-year time horizon. Requirements written with "should" express non-mandatory or non-binding provisions and are used only where necessary. As such, they are not included in the VCRM.
Similarity (S)	The verification method referenced by similarity (S) describes an examination that relies on comparative results with an acceptable standard or existing system (e.g., stop bar detector activation for an equipped vehicle can be verified in the same manner as stop bar detector activation for the existing intersection).
System	The term "System" is used in a requirement to describe the overall traffic entity (network).
Test (T)	The verification method referenced by test (T) describes an action by which the operability, supportability, or performance capability of an item is verified when subjected to controlled conditions that are real or simulated. These verifications often use special test equipment or instrumentation to obtain very accurate quantitative data for analysis.
Traveler	A traveler is the single entity that is monitored and supported by MMITSS. An equipped traveler is supported by either a nomadic device or an OBE, which corresponds to an equipped non-motorized traveler and equipped motorized traveler (passenger cars, transit, freight vehicles, and EV). An unequipped traveler, whether non-motorized or motorized, is the single entity supported by the current traffic signal infrastructure.
Validation	Validation is the process by which the system is assessed to determine if it meets or satisfies the user's needs. Using the classic systems engineering idiom, validation answers the question: "Was the right system built?"
Verification	Verification is the process by which the system, its elements, its interfaces, and work products are assessed to determine if they meet the corresponding requirements. Using the classic systems engineering idiom, verification answers the question: "Was the system built right?"
Will	The term "will" is used to distinguish a MMITSS requirement that will be imposed in future instantiations of the system that are expected to occur in a ten-year horizon. Requirements referencing the term "will' are not verified in the current scope of the MMITSS project. As such, they are not included in the VCRM.

Table 1 – Definitions of MMITSS-Specific Requirements Terminology

5.2 Requirements Structure and Indenture

From an overview perspective, the structure of the MMITSS requirements is presented in graphical form in Figure 7 and as an indentured tabular form in Table 3. The reader will note that the color scheme of this diagram is consistent the color schemes used in various requirement trees and supporting diagrams throughout this document. At the very core of the diagram are the multi-modal users and beneficiaries of MMITSS. As with all systems, a set of interfaces provides the physical and non-physical connections to the users and Stakeholders. The color-coding for the interface and data requirements are identical to convey the interdependency between these two requirement sets. The functional requirements comprise the majority of the MMITSS, as depicted in this diagram. The data requirements support nearly all the requirement categories; as such they are located in a separate section. This approach is similar to that employed with variable assignments, scope, and encapsulation in object oriented programming (OOP). The "Ilities" requirements are focused on the operational aspects and operational performance of MMITSS as an integrated, functioning system. The administrative and deployment requirements provide compliance with various standards, municipalities, governance, and related issues with MMITSS. In addition, it provides required compliance for the prototype designs that will be deployed at the Arizona Testbed and California Testbed. Finally and almost as important as the multi-modal users, the performance requirements surround and encompass all of the other requirement categories and the core. This is a visual and logical reminder of the purpose of MMITSS: enhance the performance of signalized traffic signal operations for multi-modal users.

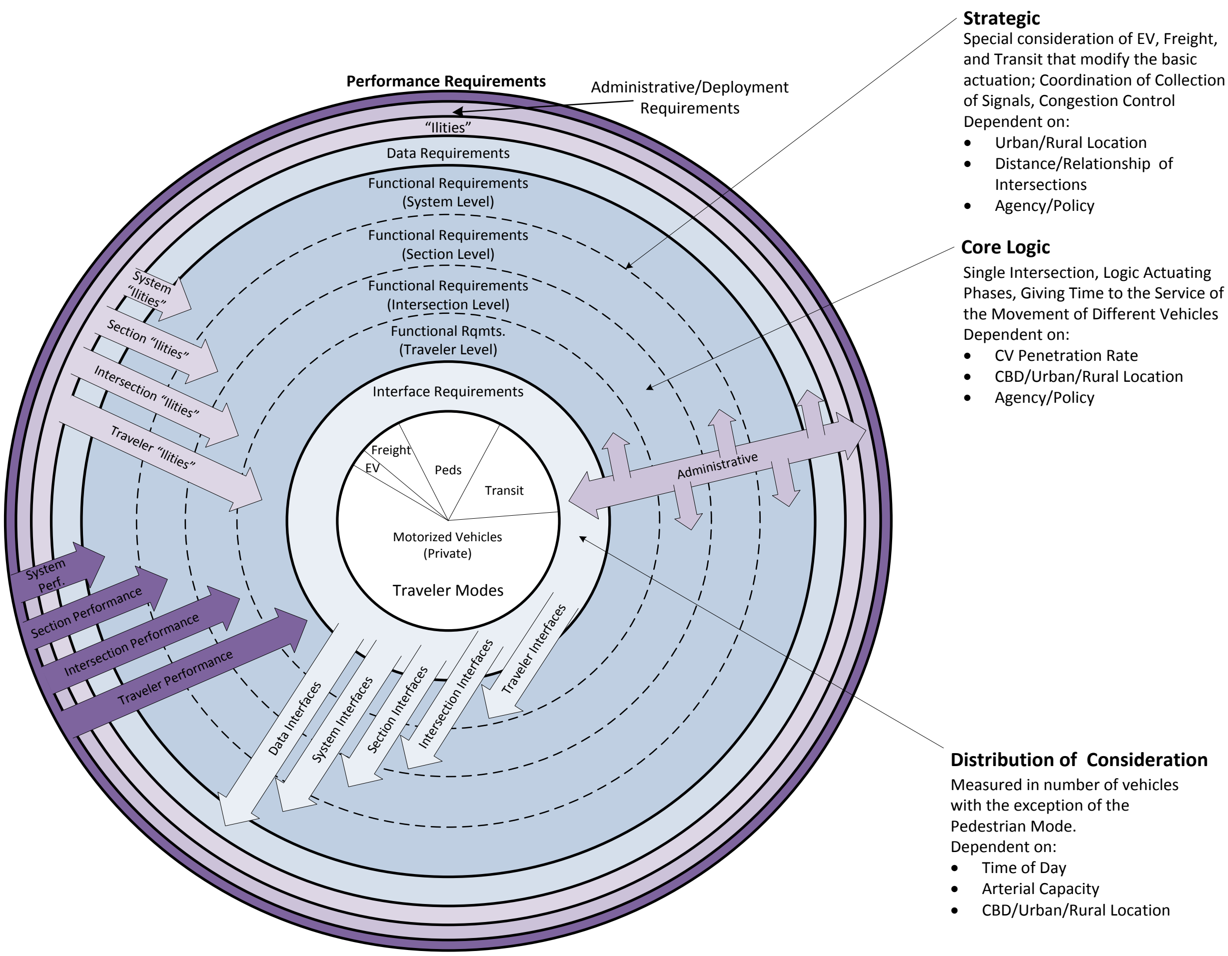

Figure 7 – MMITSS Requirements Structure

This *onion diagram* presentation of the MMITSS Requirements structure can be *peeled back* to reveal more definitive levels of the underlying structure. The underlying structure is depicted as a *requirements tree* in

Figure 8. Within the MMITSS Requirements Tree, the segmentations and color coding employed in annular regions of the MMITSS Requirements Structure shown in Figure 7 are maintained to provide clarity of the underlying structure of the particular annular region or *onion layer*. Each layer of the onion is identified through descriptive text and requirement identification or RQID, which is defined in greater detail in Section 5.3.1. Then, each layer of the onion is followed by sub-layers showing the categories of requirements within each layer.

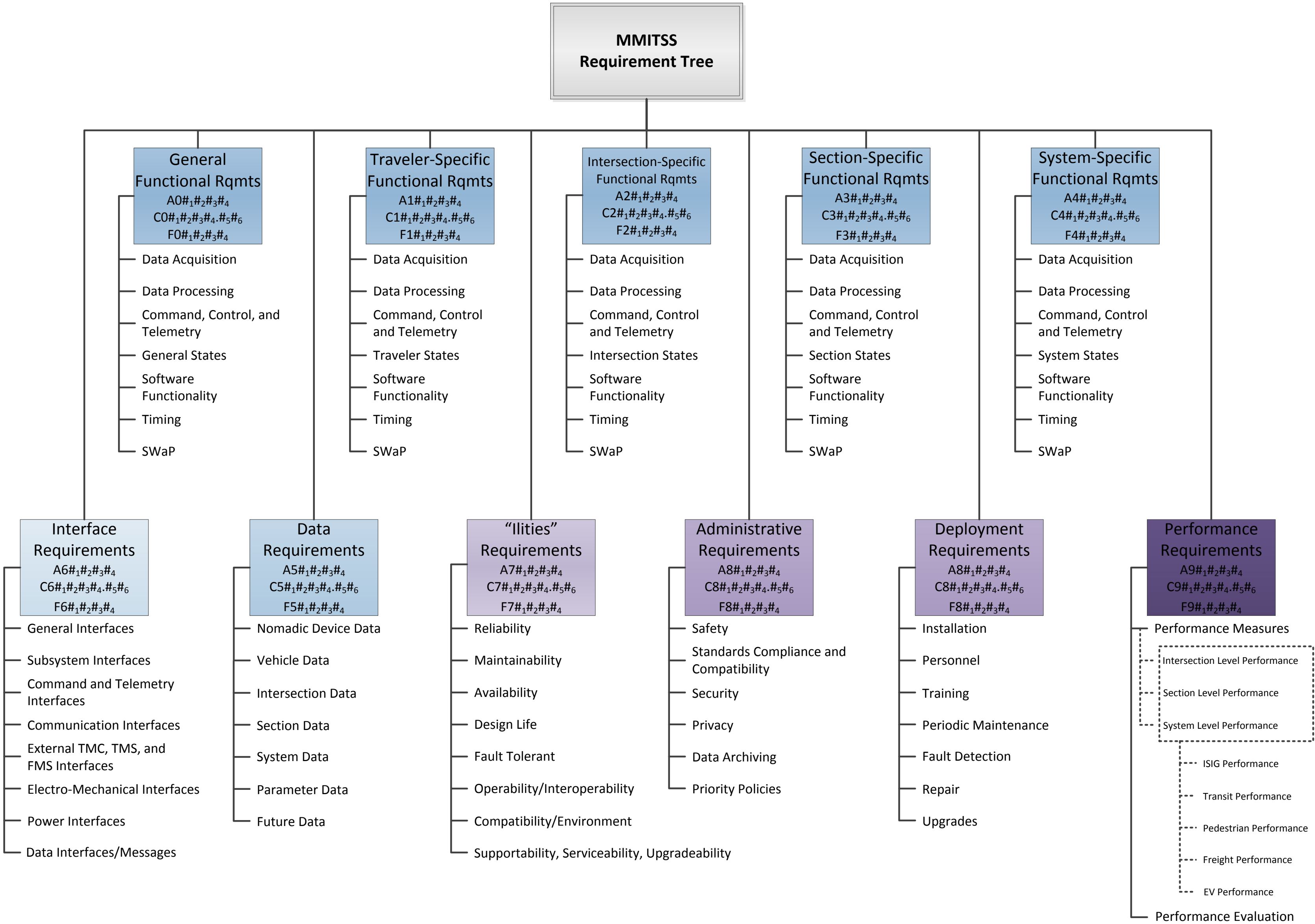

Figure 8 – MMITSS Requirements Tree

5.3 MMITSS Requirement Components

5.3.1 Requirement Number and Numbering Scheme

The structure, indenture, and flow-down of requirements are indicated by the numbering scheme incorporated in both the Word-version and DOORS-version of the MMITSS Requirements. As shown in Table 2, the requirement numbering scheme is used to define a unique requirement identification (RQID). Since this is not the final version of the MMITSS Requirement Document, there are a few remaining instances where the RQID has not been specified completely. This will be remedied in the final version of the document.

Requirement ID	Explanation / Description
A$\#_1\#_2\#_3\#_4$	System Level Requirement:
B$\#_1\#_2\#_3\#_4$	Research/Prototype
C$\#_1\#_2\#_3\#_4.\#_5\#_6\#_7$	Child/Derived Requirement, where $\#_1\#_2\#_3\#_4$ is identical to the parent requirement, $\#_5$ indicates the allocated area of the child, and $\#_6\#_7$ is the consecutive child numbering value
F$\#_1\#_2\#_3\#_4$ F$\#_1\#_2\#_3\#_4.\#_5\#_6\#_7$	Future ("should" and "will") Future Child Format
$\#_1$	Requirements Structure Diagram: 0=General, 1=Traveler, 2=Intersection, 3=Section; 4=System, 5=Data, 6=Interface, 7="Ilities", 8= Administrative/Deployment, 9=Performance
$\#_2$	0=Multiple, 1=ISIG, 2=Transit, 3=Pedestrian, 4=Freight, 5=EV
$\#_3\#_4$	Consecutive Requirement Number: 01, 02,…
$\#_5$	Child allocation to: 0=All Vehicles, 1=ISIG, 2=Transit, 3=Pedestrian, 4=Freight, 5=EV
$\#_6\#_7$	Consecutive *Child* Requirement Numbering: 01, 02,…

Table 2 – Summary of Requirement ID Nomenclature

In this document, the highest level of a requirement is designated by an RQID that starts with either an "A" or an "F." An RQID starting with an "A" is applicable to requirements that must be implemented of functional within five years of the development and deployment of MMITSS. An RQID that begin with an "F" implies that the requirement must be implemented in the time period associated with the use of "will" or "should" in the requirement text, which is 10 years and 25 years, respectively. Additional details on the use of "shall," "will," and "should" are included in the MMITSS requirement definition shown in Table 1. An RQID starting with "B" is at the same hierarchical level as "A" and "F" requirements. However, MMITSS will not utilize "B"-type requirement structure until the System Design process commences, since this RQID designation indicates a specific design implementation or design constraint.

An "A,", "B", or "F" requirement can be a single requirement or a parent requirement. As shown in Table 2, a child requirement can begin with a "C" for "F" depending on the implied implementation time frame corresponding with the use of "shall" or "will" within the requirement text, respectively. A child requirement will have the same numerical specification for the first four numbers ($\#_1\#_2\#_3\#_4$) as the parent. This is similar to the convention of parents and children having the same last name in many Western cultures. The number specification located to the right of the radix point indicates characteristics of the child.

At this point, a few examples may convey the utility of the numbering scheme better than additional narration. In the first example, A2006 is examined. With only the specification A2006 given, it is not known whether this is a single or parent requirement. However, it is known that the requirement pertains to the intersection level as indicated by the "2". The next digit, "0" indicates that the requirement pertains to more than one mode. The next two digits, "06" indicate that this is the sixth requirement (i.e., there are at least five more requirements) at the intersection level for multi-modal travelers.

In the second example, C2006.202 is examined. This is a child requirement whose parent is A2006. This child requirement has a timeframe of applicability of the first five years of MMITSS development and/or deployment. Most importantly, this is a transit-mode specific requirement (".2") in the requirement flow down of the parent. The last two digits "02" of the ".202" specification let us know that this is the second child in a family with at least two children.

A reader with little exposure to large-scale systems engineering programs might wonder why any of this information or specification is needed. These types of numbering schemes (RQIDs) are used throughout programs that will have (i) a large number of requirements to manage, (ii) a long systems development process, (iii) significant programmatic and Stakeholder impacts, (iv) significant costs or value, (v) integrate an automated requirements management tool such as DOORS, and (vi) any combination of these factors. It is speculated that all of these factors apply to the long-term perspective of MMITSS.

5.3.2 Requirement Text

Each RQID is followed by the requirement text. In compliance with acceptable standards, including IEEE 1233, the requirement is stated as a single, concise, standalone, unambiguous sentence. The exception to this approach applies to the data requirements listed in Section 6.26.1.5.7. In keeping with standards and industry practice, the data requirements are presented in tabular form.

5.3.3 Requirement Supporting Text

Until the MMITSS DOORS implementation is complete, versions of the MMITSS Requirements Document will include supporting text to describe the reason or rationale for inclusion and impact of each requirement. Integrated notes, comments, and change control are implemented and supported in DOORS. The "supporting text" shown in this document will be imported and preserved into MMITSS-DOORS implementation.

5.3.4 Requirement Traceability

As appropriate, each requirement statement is accompanied by traceability information linking the requirement to the Final MMITSS ConOps and/or specific Stakeholder inputs. A tabularized summary of requirement traceability is included in the appendix section of this document (Section 7.6).

5.3.5 Requirement Verification Method

As shown in the requirements development checklist in Section 7.4, a well-formed requirement must be testable from its inception. As such, information on the verification method is included for each requirement listed. In keeping with standard approaches, the verification method is displayed in summary notation by the letters A, I, D, T, and S representing analysis, inspection, demonstration, test, and similarity, respectively. These terms are included in the MMITSS definitions provided in Section 5.1.

As summarized in the definitions for parent and child requirements in Table 1, the use of the parent-child relationship in requirements definition is motivated by the efficiency, effectiveness, and costs of requirements verification. Requirements with vast or broad scope can be difficult and/or costly to verify. If the parent-child requirement structure is employed correctly, verification can follow the flow-down and flow-up of the parent-child requirement structure, which can reduce greatly the complexity, time, and cost of verification activities.

Consistent with this verification flow-down logic, the pedigree of a child requirement has to be the same as the parent. As shown in

Figure 8, the MMITSS functional requirement structure specifies sub-functions of data acquisition, data processing, CC&T (command, control, and telemetry), and others. A parent requirement that satisfies a data processing functional need cannot (or should not) have a child that provides a data acquisition functional need.

If a parent requirement has several children and one of the children is a "will" requirement (designate by $F\#_1\#_2\#_3\#_4.\#_5\#_6\#_7$), the parent remains unverified until such time that each of the children becomes a verified "shall" requirement.

5.3.6 Requirement Dependencies

Whereas requirements are presented in a stand-alone manner, dependencies between requirements exist. Using an apparent example, data acquisition requirements are included in the indentured subsections of the functional requirements. The action or activity of acquiring data is a functional requirement that has an explicit dependency on the data requirements. Where appropriate, data-dependent requirements will provide links to the specific data requirement tables for information on the data, data source, and data fidelity. The data tables provide a means of consolidating data information without the need for repetitive specification in each requirement utilizing the data.

The dependency between parent and child requirements was defined previously in the context of verification.

5.3.7 Order of Precedence

In the event of a conflict between the requirements listed in this document and the references cited herein, the text of this document takes precedence with the following exceptions: (1) an applicable safety standard is imposed on the prototype design developed based on this system requirements document; (2) A law, practice, or standard related to traffic signal systems presents a conflict with the MMITSS Requirements; and/or (3) a System Specification is written to supersede the design requirements of this system requirements document.

6 MMITSS Requirements

As stated previously, the MMITSS Requirements Document is a listing of requirements and constraints on the basis of which a multi-modal traffic signal system can be designed. In this section the requirements are segmented into the major categories shown in the dynamic-linked table below. Table 3 can be used to navigate through the requirements (in addition to the Table of Contents).

Section	Sub-Section	Requirement Category
6.1		Functional Requirements
	6.1.1	General Functional Requirements
	6.1.2	Traveler-Specific Functional Requirements
	6.1.3	Intersection-Specific Functional Requirements
	6.1.4	Section-Specific Functional Requirements
	6.1.5	System-Specific Functional Requirements
	6.2.1	Nomadic Device Data Requirements
	6.2.2	Vehicle Data Requirements
	6.2.3	Intersection Data Requirements
	6.2.4	Section Data Requirements
	6.2.5	System Data Requirements
	6.2.6	Parameter Requirements
6.3		Interface Requirements

6.4	"Ilities" Requirements
6.5	Performance Requirements
6.6	Administrative Requirements
6.7	Deployment Requirements

Table 3 – MMITSS Indentured Requirement Structure

6.1 Functional Requirements

6.1.1 General Functional Requirements

General functional requirements are those requirements that possess a scope throughout complete expanse of MMITSS and corresponding lifecycle. This is in contrast to a System-Specific Functional Requirement (Section 6.1.5) that possesses scope across system functionality. For example, if a requirement is imposed on every aspect, level, or component of MMITSS such as incorporate object-oriented programming, have UL-listed components, operate exclusively at 24VDC, or be pink in color, these would be listed as general functional requirements.

Since MMITSS is defined as a research project[4], many of the general functional requirements are not applicable at this time. However, this section is included for completeness and will be addressed in future context of the Arizona and California testbeds. During the research deployment and test phases, some of these requirements will rely on standardized approaches available in a particular testbed such as J2735, DSRC, and other integrated standards and protocols.

RQID: B0101	**Title:** Testbed Intersection Infrastructure Software Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype software shall be compatible with the processors, computers, or microcontrollers contained in the intersection infrastructure of the testbeds.	
Supporting Text: *This requirement addresses the need for MMITSS software to be compatible with the intersection infrastructure that will serve as the supporting platform. For instance, if a MMITSS prototype design required an algorithm to be operational at the intersection, the software supporting that algorithm would need to be compatible with the processing infrastructure supporting the intersection (e.g., RSE processor or microcontroller). The requirement does not specify a computer language, design methodology, or other design specificity. Similar to other parent requirements, this requirement is verified through the verification of the child-requirements. Verification of the parent requirement does not require that a single prototype be compatible with both the Arizona and California testbeds.*	

RQID: B0101.101	**Title:** Arizona Testbed Intersection Infrastructure Software Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype software shall be compatible with the processors, computers, or microcontrollers contained in the intersection infrastructure of the Arizona testbed.	
Supporting Text: *This requirement provides for software compatibility of a MMITSS prototype design with the Arizona testbed intersection infrastructure. For instance, if a MMITSS prototype design required an algorithm to be operational at the intersection, the software supporting that algorithm would need to be compatible with the processing infrastructure supporting the intersection (e.g., RSE processor or microcontroller). The requirement does not specify a computer language, design methodology, or other design specificity.*	

RQID: B0101.102	**Title:** California Testbed Intersection Infrastructure Software Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5

[4] MMITSS ConOps Workshop Meeting Minutes, 7/18/12, pp. 3, 8.

Requirement Text The MMITSS prototype software shall be compatible with the processors, computers, or microcontrollers contained in the intersection infrastructure of the California testbed.
Supporting Text: *This requirement provides for software compatibility of a MMITSS prototype design with the California testbed intersection infrastructure. The requirement does not specify a computer language, design methodology, or other design specificity. Instead, it requires that the prototype software supporting intersection functionality provide compatibility with the infrastructure provided at the intersection level of the testbed.*

1

RQID: B0102	**Title:** Testbed Intersection Infrastructure Electrical Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection electrical infrastructure of the testbeds.	
Supporting Text: *This requirement provides for electrical compatibility of the MMITSS prototype design with the testbed intersection infrastructure. The requirement does not specify a specific voltage type (AC or DC), voltage level, current draw, grounding scheme, or electrical isolation. Instead, it requires that the prototype electrical hardware supporting intersection functionality provide electrical compatibility with the infrastructure provided at the intersection level of the testbed. The hardware considered may include a separate MMITSS processor if this is determined in the design. Similar to other parent requirements, this requirement is verified through the verification of the child-requirements. Verification of the parent requirement does not require that a single prototype be compatible with both the Arizona and California testbeds.*	

2

RQID: B0102.101	**Title:** Arizona Testbed Intersection Infrastructure Electrical Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection electrical infrastructure of the Arizona testbed.	
Supporting Text: *This requirement provides for electrical compatibility of a MMITSS prototype design with the Arizona testbed intersection infrastructure. The requirement does not specify a specific voltage type (AC or DC), voltage level, current draw, grounding scheme, or electrical isolation. Instead, it requires that the prototype electrical hardware supporting intersection functionality provide electrical compatibility with the infrastructure provided at the intersection level of the testbed. The hardware considered may include a separate MMITSS processor if this is determined in the design.*	

3

RQID: B0102.102	**Title:** California Testbed Intersection Infrastructure Electrical Compatibility
Verification: T	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection electrical infrastructure of the California testbed.	
Supporting Text: *This requirement provides for electrical compatibility of a MMITSS prototype design with the California testbed intersection infrastructure. The requirement does not specify a specific voltage type (AC or DC), voltage level, current draw, grounding scheme, or electrical isolation. Instead, it requires that the prototype electrical hardware supporting intersection functionality provide electrical compatibility with the infrastructure provided at the intersection level of the testbed. The hardware considered may include a separate MMITSS processor if this is determined in the design.*	

4

RQID: B0103	**Title:** Testbed Intersection Infrastructure Mechanical Compatibility
Verification: D	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection mechanical infrastructure of the testbeds.	
Supporting Text: *This requirement provides for mechanical compatibility of the MMITSS prototype design with the testbed intersection infrastructure. The requirement does not specify a specific volume,*	

footprint, weight, or physical placement. Instead, it requires that the prototype mechanical hardware supporting intersection functionality provide mechanical compatibility with the infrastructure provided at the intersection level of the testbed. This may include installation of equipment is existing traffic signal controller cabinets or in other enclosures as determined in the design. Similar to other parent requirements, this requirement is verified through the verification of the child-requirements. Verification of the parent requirement does not require that a single prototype be compatible with both the Arizona and California testbeds.

RQID: B0103.101	**Title:** Arizona Testbed Intersection Infrastructure Mechanical Compatibility
Verification: D	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection mechanical infrastructure of the Arizona testbed.	
Supporting Text: *This requirement provides for mechanical compatibility of a MMITSS prototype design with the Arizona testbed intersection infrastructure. The requirement does not specify a specific volume, footprint, weight, or physical placement. Instead, it requires that the prototype mechanical hardware supporting intersection functionality provide mechanical compatibility with the infrastructure provided at the intersection level of the testbed. This may include installation of equipment is existing traffic signal controller cabinets or in other enclosures as determined in the design.*	

RQID: B0103.102	**Title:** California Testbed Intersection Infrastructure Mechanical Compatibility
Verification: D	**Traceability:** ConOps §5, §8, §11.3; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS prototype shall be compatible with the intersection mechanical infrastructure of the California testbed.	
Supporting Text: *This requirement provides for mechanical compatibility of a MMITSS prototype design with the California testbed intersection infrastructure. The requirement does not specify a specific volume, footprint, weight, or physical placement. Instead, it requires that the prototype mechanical hardware supporting intersection functionality provide mechanical compatibility with the infrastructure provided at the intersection level of the testbed. This may include installation of equipment is existing traffic signal controller cabinets or in other enclosures as determined in the design.*	

6.1.2 Traveler-Specific Functional Requirements

The scope of MMITSS requirements applies to software, firmware, and hardware elements that are designed, developed, and tested to integrate with intelligent traffic signal infrastructure (e.g., TSCs and RSEs). There is an assumed requirement that an equipped vehicle (e.g., freight vehicle) wanting to participate in the MMITSS must have an operational OBE that is configured properly, powered-on, and communicating with the infrastructure. Similarly, an equipped non-motorized traveler wanting to participate in the MMITSS must have an operational nomadic device that is configured properly, powered-on, and communicating with the infrastructure. The configuration, operation, and communication of OBEs and nomadic devices is outside the scope of MMITSS requirements except for instances where additional or modified functionality is required specifically for interoperability with MMITSS (e.g., a nomadic device application for pedestrians with disabilities). This section of the document provides definition of requirements necessary for providing device applications, software, and updates. Some of the requirements presented in this section may have related or corresponding requirements found in the Administrative, Deployment, or Performance Requirement sections of this document.

6.1.2.1 Traveler Data Acquisition

The functional requirements in this section are concerned with the acquisition of data by the OBEs and nomadic devices supporting equipped vehicles and travelers within the communication boundaries or neighborhood of the intersection. This includes the acquisition of signal status data elements (See

Section 6.2.3), basic status data elements, geometric intersection description (GID), and related data elements utilized by MMITSS in rendering service to nomadic devices. For equipped travelers, the “boundaries or neighborhood of an intersection” is defined, at least partially, by the communication range supported by both the intersection infrastructure, MMITSS, on-board equipment (equipped vehicle OBE), and nomadic devices (equipped travelers).

The traveler data acquisition requirements are concerned with the function and specificity of acquiring data (what, where, when, from whom, and sometimes how). The data being acquired is also a requirement, but is specified separately in the MMITSS Data Requirements (Section 6.2).

RQID: A1001	**Title:** Vehicle Configuration to Acquire Signal Status Data from Intersection
Verification: D	**Traceability:** ConOps §5, §8, §11.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: A participating OBE shall be configured to acquire signal status data defined in Section 6.2.3 when within communication control range of a MMITSS intersection.	
Supporting Text: *This requirement provides for the acquisition of signal request status data by an OBE from a MMITSS intersection (Intersection ID, Time Remaining, Phase Status, etc.) defined in Section 6.2.3 for equipped vehicles. This requirement provides a means of verifying the transmission of critical MMITSS data to the OBE of an equipped vehicle.*	

RQID: A1301	**Title:** Traveler Configuration to Acquire Basic Status Data from Intersection
Verification: D	**Traceability:** ConOps §5, §8, §11.1, §11.3; Use Case 13.3.3
Requirement Text: A participating nomadic device shall be configured to acquire basic status data defined in Section 6.2.3 when within communication control range of a MMITSS intersection.	
Supporting Text: *This requirement provides for the acquisition of basic status data from a MMITSS intersection (MMITSS Time, Intersection ID, Intersection Message Time Stamp, Intersection Status, etc.) defined in Section 6.2.3 for equipped non-motorized travelers. This requirement provides a means of verifying the transmission of critical MMITSS data to the nomadic device associated with an equipped non-motorized traveler.*	

RQID: A1302	**Title:** Traveler Configuration to Acquire Signal Status Data from Intersection
Verification: D	**Traceability:** ConOps §5, §8, §11.1, §11.3; Use Case 13.3.3
Requirement Text: A participating nomadic device shall be configured to acquire signal status data defined in Section 6.2.3 when within communication control range of a MMITSS intersection.	
Supporting Text: *This requirement provides for the acquisition of signal request status data from a MMITSS intersection (Intersection ID, Time Remaining, Phase Status, Pedestrian Phase Status, etc.) defined in Section 6.2.3 for equipped non-motorized travelers.*	

6.1.2.2 Traveler Data Processing

Traveler data processing is the terminology used to describe the handling, alteration, or manipulation of raw data from MMITSS into information by the individual OBE or nomadic device supporting an equipped vehicle or traveler, respectively. This includes the processing of signal status data elements (See Section 6.2.3), basic status data elements, geometric intersection description (GID), and related data elements transmitted by MMITSS in rendering service to an OBE or nomadic device.

In a typical MMITSS deployment, an application or “app” will be offered for download to owners of nomadic devices (e.g., smartphone). This application will provide the minimum necessary data processing required for an equipped traveler to initiate, cancel, or update a request for service as defined in Section 6.1.2.3. For nomadic devices, data processing can include the visualization or graphical user interface (GUI) functionality that resides on the nomadic device for the purpose of informing the equipped traveler of the state of the intersection, status of priority request, or other useful information provided by MMITSS.

6.1.2.3 Traveler Command, Control, and Telemetry

The requirements in this document section pertain to the command, control, and telemetry functions that exist solely between the equipped traveler (via nomadic device or OBE) and MMITSS. These requirements exclude any functional behavior, need, or capability that would be provided by intersection, section, or system infrastructure, since those requirements can be found in the respective document sections that follow.

RQID: A1002	**Title:** Vehicle Configuration to Acquire Basic Status Data from Intersection
Verification: D	**Traceability:** ConOps §5, §8, §11.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: A participating OBE shall be configured to acquire basic status data defined in Section 6.2.3 when within communication control range of a MMITSS intersection.	
Supporting Text: *This requirement provides for the acquisition of basic status data by an OBE from a MMITSS intersection (MMITSS Time, Intersection ID, Intersection Message Time Stamp, Intersection Status, etc.) defined in Section 6.2.3 for equipped vehicles. This requirement provides a means of verifying the transmission of critical MMITSS data to the OBE of an equipped vehicle.*	

RQID: A1003	**Title:** Determine Vehicle Eligibility
Verification: T	**Traceability:** ConOps §4, §4.1.2, §4.1.4, §4.1.5, §5, §9.3.4, §11.0, §11.0.1, §11.0.2, §11.2, §11.4, §11.5; Use Case 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS component onboard the equipped vehicle shall determine priority eligibility.	
Supporting Text: *Equipped vehicles requesting priority must first determine their priority eligibility before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the equipped vehicle's OBE.*	

RQID: C1003.201	**Title:** Determine Transit Vehicle Eligibility
Verification: T	**Traceability:** ConOps §4, §4.1.2, §5, §9.3.4, §11.0, §11.0.2, §11.2; Use Case 13.3.2
Requirement Text: The MMITSS component onboard the transit vehicle shall determine priority eligibility.	
Supporting Text: *Equipped transit vehicles requesting priority must first determine their priority eligibility before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the transit vehicle OBE.*	

RQID: F1003.402	**Title:** Determine Freight Vehicle Eligibility
Verification: T	**Traceability:** ConOps §4, §4.1.4, §5, §9.3.4, §11.0, §11.0.1, §11.4; Use Case 13.3.4
Requirement Text: The MMITSS component onboard the freight vehicle shall determine priority eligibility.	
Supporting Text: *Equipped freight vehicles requesting priority must first determine their priority eligibility before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the freight vehicle OBE.*	

RQID: C1003.503	**Title:** Determine Emergency Vehicle Eligibility
Verification: T	**Traceability:** ConOps §4, §4.1.5, §5, §9.3.4, §11.0, §11.0.1, §11.0.2, §11.5; Use Case 13.3.5
Requirement Text: The MMITSS component onboard the emergency vehicle shall determine priority eligibility.	
Supporting Text: *Equipped emergency vehicles requesting priority must first determine their priority eligibility before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the emergency vehicle OBE.*	

RQID: A1004	**Title:** Determine Vehicle Level of Priority
Verification: T	**Traceability:** ConOps §4, §4.1.2, §4.1.4, §4.1.5, §5, §9.3.4, §11.0, §11.0.1, §11.0.2, §11.2, §11.4, §11.5; Use Case 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS component onboard the equipped vehicle shall determine desired level of priority.	
Supporting Text: *Equipped vehicles requesting priority must first determine their desired level of priority before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the equipped vehicle's OBE.*	

RQID: C1004.201	**Title:** Determine Transit Vehicle Level of Priority
Verification: T	**Traceability:** ConOps §4, §4.1.2, §5, §9.3.4, §11.0, §11.0.2, §11.2; Use Case 13.3.2
Requirement Text: The MMITSS component onboard the transit vehicle shall determine desired level of priority.	
Supporting Text: *Equipped transit vehicles requesting priority must first determine their desired level of priority before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the transit vehicle OBE.*	

RQID: F1004.402	**Title:** Determine Freight Vehicle Level of Priority
Verification: T	**Traceability:** ConOps §4, §4.1.4, §5, §9.3.4, §11.0, §11.0.1, §11.4; Use Case 13.3.4
Requirement Text: The MMITSS component onboard the freight vehicle shall determine desired level of priority.	
Supporting Text: *Equipped freight vehicles requesting priority must first determine their desired level of priority before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the freight vehicle OBE.*	

RQID: C1004.503	**Title:** Determine Emergency Vehicle Level of Priority
Verification: T	**Traceability:** ConOps §4, §4.1.5, §5, §9.3.4, §11.0, §11.0.1, §11.0.2, §11.5; Use Case 13.3.5
Requirement Text: The MMITSS component onboard the emergency vehicle shall determine desired level of priority.	
Supporting Text: *Equipped emergency vehicles requesting priority must first determine their desired level of priority before communicating this data in the request message to the MMITSS. This is the MMITSS functionality that resides and occurs in the emergency vehicle OBE.*	

6.1.2.4 Traveler States

Consistent with the MMITSS Conceptual Architecture shown in Figure 1, this section provides pictorial overviews of the states and transitions associated with equipped non-motorized travelers, equipped passenger/private vehicles, and equipped vehicles that are eligible for priority (i.e., transit, freight, and emergency vehicles). These state diagrams are shown as UML state model diagrams where states that are marked by the "∞" symbol in the lower right corner of the drawings represent composite states. These composite states indicate that a component may be "on-line" and in this "on-line" state be in one of several sub-states. The traveler state information is both useful and critical when relying on simulation for requirement verification (designated by "A" in the verification method specified in each MMITSS requirement).

As shown in Figure 9, an equipped traveler with a nomadic device is characterized by states that include: off-line, on-line (seeking MAP, active MAP, preparing request, active request, completed request), and error states (position failure, communication failure, and other failure).

A pedestrian with disabilities supported by an authorized nomadic device would include a special on-line state (called authorized special on-line) that would provide additional capabilities including pedestrian requests with additional crossing time, active request monitoring that could request pedestrian clearance extension, and extended warning broadcast messages.

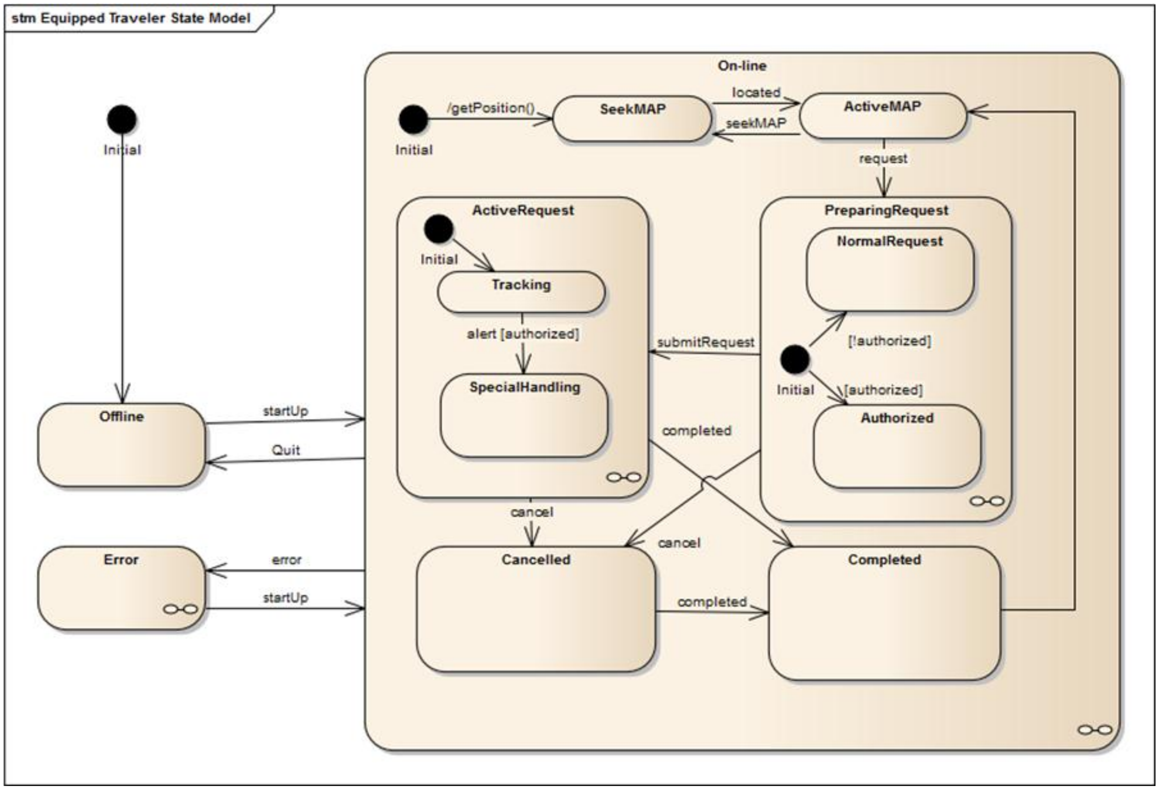

Figure 9 – MMITSS Equipped Traveler State Model

Equipped passenger or privately owned vehicles are essentially passive participants in MMITSS. They broadcast vehicle information (via a Basic Safety Message) and receive status data (via SPaT and SSM messages), but they do not request priority. Hence the states of an equipped vehicle are Offline, On-line, and error. The states associated with this class of traveler are shown in Figure 10.

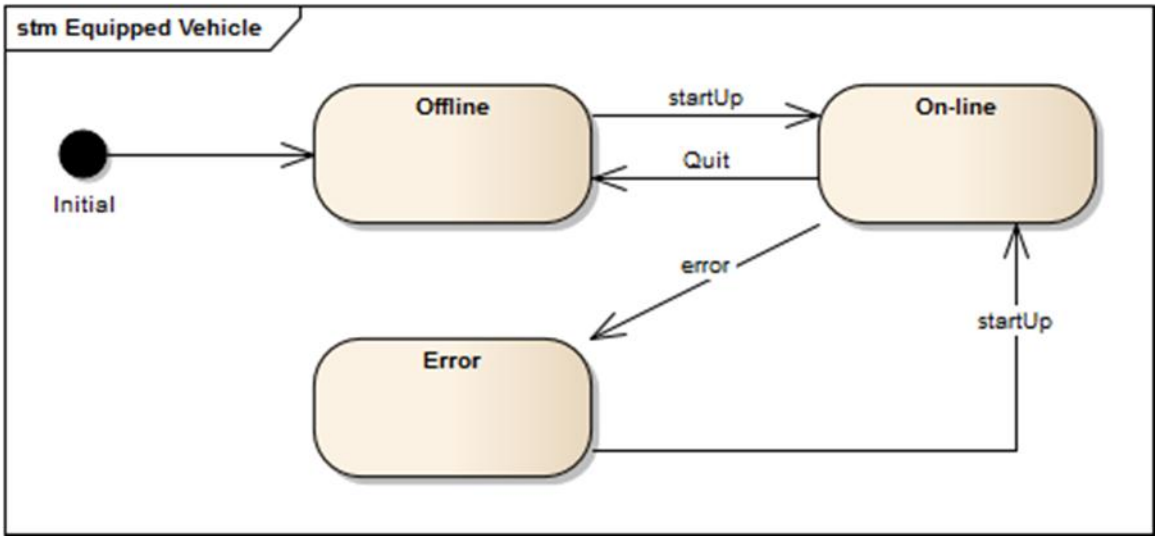

Figure 10 – MMITSS Equipped Passenger Vehicle State Model

Transit, freight, and emergency vehicles comprise the class of equipped vehicles with an OBE that has the states: off-line, on-line (Seeking MAP, Active MAP, preparing request, active request, completed request), and error states (position failure, communication failure, and other failure). These states and associated transitions are shown in Figure 11.

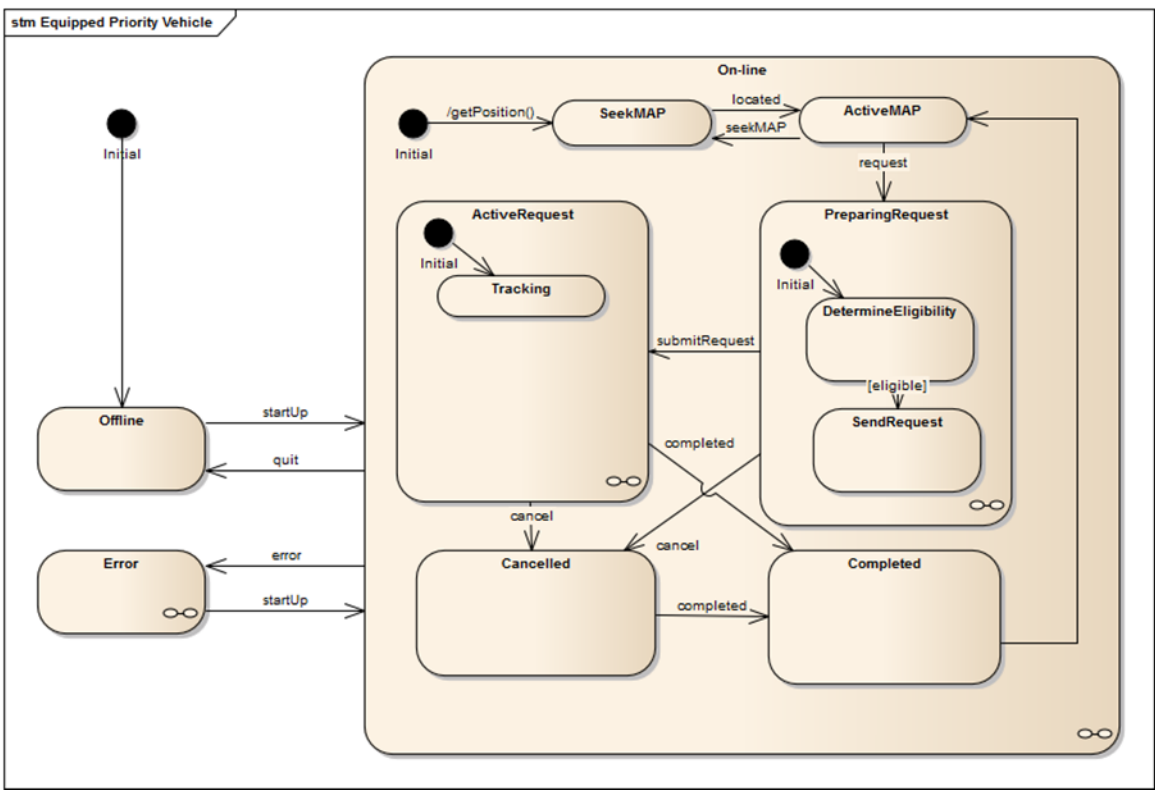

Figure 11 – MMITSS Equipped Priority Vehicle State Model

6.1.2.5 Traveler Software Functionality

Nomadic devices configured with MMITSS application software enable non-motorized travelers to access functionality associated with equipped travelers as shown in the MMITSS Conceptual Architecture in Figure 1. Since a nomadic device is not completely contained in the MMITSS system boundary (in a Venn diagram sense), both the owner of the nomadic device and MMITSS have collaborative responsibilities and corresponding requirements. This section addresses the software functionality requirements imposed on the MMITSS to support equipped non-motorized travelers. The nomadic device owner has the responsibility of installing and operating the device in the manner prescribed to receive consideration by MMITSS. Please note that requirements associated with software upgradeability are included in Section 6.7.1.

RQID: A1303	**Title:** Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.1, §11.0.2, §11.3; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to a downloadable, nomadic device application (embedded software) that enables equipped traveler functionality when installed and operated properly.	
Supporting Text: *MMITSS shall provide a downloadable software application to owners of compatible nomadic devices for the purpose of granting equipped traveler functionality when installed and operated in accordance with provided instructions, applicable laws, and the communication control range of a MMITSS intersection, section, or system.*	

RQID: C1303.301	**Title:** Certified Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.2, §11.3; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to a downloadable, certified nomadic device application (embedded software) that enables basic equipped traveler functionality when installed and operated properly.	
Supporting Text: *MMITSS shall provide a downloadable and certified software application to owners of compatible nomadic devices for the purpose of granting basic equipped traveler functionality when installed and operated in accordance with provided instructions, applicable laws, and the communication control range of a MMITSS intersection, section, or system. The application is certified in the sense that the local governing agency or neighboring agencies have certified and approved its use by general non-motorized travelers within the boundaries of the MMITSS being supported by the agency or agencies. As is common with mobile apps, the end-user may be required to stipulate or agree to the proper use to avoid gaming the traffic control system or gaining unintended consideration or priority.*	

RQID: C1303.302	**Title:** Authorized Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.2, §11.3; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to a downloadable, authorized nomadic device application (embedded software) that enables equipped traveler functionality for pedestrians with disabilities when installed and operated properly.	
Supporting Text: *MMITSS shall provide a downloadable and authorized software application to owners of compatible nomadic devices that have been identified by an agency as authorized to participate in the MMITSS with special consideration reserved for pedestrians with disabilities. The difference between a certified and authorized nomadic device has to do with the degree of consideration provided to address specific disabilities such as mobility, vision, and hearing loss. Since the physical control of a nomadic device is outside the scope of MMITSS, the user is responsible for installing and operating the application according to guidance provided. The application is authorized in the sense that the local governing agency or neighboring agencies have certified and approved its use by specific non-motorized travelers analogous to the process of issuing a handicapped parking placard or license plate.*	

6.1.2.6 Traveler Timing

For the MMITSS research prototype, it is assumed that each OBE or nomadic device has been time-synchronized to a credible reference (e.g., via the service provider in the case of a nomadic device hosted on a smart phone). If this is not the case, MMITSS shall provide a means for establishing a temporary synchronization while the tracked traveler device is within communication control range of the MMITSS. As the MMITSS development matures, specific requirements and provisions need to be established for determining if devices are synchronized and handling instances where synchronization has not been established.

6.1.2.7 Traveler SWaP

Size, weight, and power requirements should be established for full MMITSS deployments for both nomadic devices and OBEs. Although OBEs have a more robust power source, both devices have finite power resources that should be considered. Initial discussions called for the MMITSS nomadic device being allocated less than a small percentage (e.g., 5%) of the available power over an expected time interval while traversing the system. For the MMITSS research effort, the possibility of nomadic device loss of power is included in the error handling requirements (Section 6.4.5). Since nomadic devices are intended to serve pedestrians with disabilities, future requirements should consider the SWaP aspects of haptic or biometric attachments to address specific disabilities while enhance interoperability.

6.1.3 Intersection-Specific Functional Requirements

The requirements in this document section pertain to the functions and capabilities that reside at the intersection level of MMITSS. Examples of intersection level functions and capabilities include those concerned with intersection data acquisition, intersection data processing, intersection CC&T, and others listed and gathered in the following subsections. These requirements exclude any functional behavior, need, or capability that would be initiated or supported by section or system levels of MMITSS, since those requirements can be found in the respective document sections that follow.

6.1.3.1 Intersection Data Acquisition

The functional requirements in this section are concerned with the acquisition of data by the intersection from equipped and unequipped vehicles and travelers within the boundaries or neighborhood of the intersection. This includes the geometric intersection description (GID), the approach to the intersection, and the geographical area leaving the intersection that may have infrastructure sensors or supporting equipment that is utilized by MMITSS. For equipped vehicles and travelers, the “boundaries or neighborhood of an intersection” is defined, at least partially, by the communication range supported by both the intersection infrastructure, MMITSS, on-board equipment (equipped vehicle OBE), and nomadic devices (equipped travelers).

The intersection data acquisition requirements are concerned with the function and specificity of acquiring data (what, where, when, from whom, and sometimes how). The data being acquired is also a requirement, but is specified separately in the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A2001	**Title:** Acquire Basic Status Data from Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §5, §8, §11.1.1, §11.1.3, §11.2.1, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire basic status data from equipped vehicles and equipped non-motorized travelers within communication control range of an intersection.	
Supporting Text: *This is the parent requirement that provides the acquisition of basic vehicle and traveler status data for equipped vehicle characteristics and status (i.e., data elements described in Section 6.2.2 including type, location, speed, heading, etc.) for operational use by a MMITSS intersection.*	

1

RQID: C2001.001	**Title:** Acquire Equipped Vehicle Status Data
Verification: T	**Traceability:** ConOps §5, §8, §11.1.1, §11.1.3, §11.2.1, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire vehicle status data including time stamp, vehicle ID, vehicle type, vehicle size (vehicle width and vehicle length), vehicle mass, location (latitude, longitude, elevation), speed, and heading as specified in Section 6.2.2 from equipped vehicles within range of an intersection.	
Supporting Text: *This requirement provides the acquisition of equipped vehicle characteristics and status data (i.e., data elements described in Section 6.2.2) for operational use by MMITSS.*	

2

RQID: C2001.302	**Title:** Acquire Equipped Non-motorized Traveler Status Data
Verification: T	**Traceability:** ConOps§8, §11.0, §11.3.2, §11.3.3; Use Case 13.3.3
Requirement Text: The MMITSS shall acquire non-motorized traveler status data including time stamp, device ID, device type, location (latitude, longitude, elevation), speed, and heading as specified in Section 6.2.1 from nomadic devices within range of an intersection.	
Supporting Text: *This requirement provides the acquisition of nomadic device characteristics and status data (i.e., data elements described in Section 6.2.1) for operational use by MMITSS.*	

3

RQID: A2002	**Title:** Acquire Signal Request Data from Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps§8, §11.0, §11.3.2, §11.3.3; Use Case 13.3.3
Requirement Text: The MMITSS shall acquire signal request data from equipped vehicles and travelers within communication control range of an intersection.	
Supporting Text: *This is the parent requirement that provides the acquisition of signal request data for equipped vehicle (i.e., data elements described in Section 6.2.2) and nomadic devices (i.e., data elements described in Section 6.2.1) for operational use by a MMITSS intersection.*	

4

RQID: F2002.001	**Title:** Acquire Equipped Vehicles Signal Request Data
Verification: T	**Traceability:** ConOps§8, §11.1; Use Case 13.3.1
Requirement Text: The MMITSS will acquire signal request data including time stamp, vehicle ID, vehicle type, intersection ID, priority level of request, and expected time of arrival at the intersection from equipped passenger vehicles.	
Supporting Text: *This requirement provides the acquisition of equipped passenger vehicle priority-related characteristics and data (i.e., data elements described in Section 6.2.2) for operational use by MMITSS.*	

5

RQID: C2002.202	**Title:** Acquire Equipped Transit Vehicles Signal Request Data
Verification: T	**Traceability:** ConOps§8, §11.0, §11.2; Use Case 13.3.2
Requirement Text: The MMITSS shall acquire transit vehicle signal request data including time stamp, vehicle ID, vehicle type, intersection ID, priority level of request, and expected time of arrival at the intersection from equipped transit vehicles.	
Supporting Text: *This requirement provides the acquisition of transit vehicle priority-related characteristics and data (i.e., data elements described in Section 6.2.2) for operational use by MMITSS.*	

6

RQID: C2002.303	**Title:** Acquire Equipped Non-Motorized Travelers Signal Request Data
Verification: T	**Traceability:** ConOps§8, §11.0, §11.3; Use Case 13.3.3
Requirement Text: The MMITSS shall acquire signal request data including time stamp, device ID, device type, intersection ID, desired direction of travel (pedestrian or bicycle), priority level of request, and expected time of arrival at the intersection from nomadic devices within communication control range of an intersection.	
Supporting Text: *This requirement provides the acquisition of equipped non-motorized traveler priority-related characteristics and data (i.e., data elements described in Section6.2.1) for operational use by MMITSS.*	

7

RQID: C2002.404	**Title:** Acquire Equipped Freight Vehicles Signal Request Data
Verification: T	**Traceability:** ConOps§8, §11.0, §11.4; Use Case 13.3.4
Requirement Text: The MMITSS shall acquire freight vehicle signal request data including time stamp, vehicle ID, vehicle type, intersection ID, priority level of request, and expected time of arrival at the intersection from equipped freight vehicles.	
Supporting Text: *This requirement provides the acquisition of equipped freight vehicle priority-related characteristics and data (i.e., data elements described in Section 6.2.2) for operational use by MMITSS.*	

1

RQID: C2002.505	**Title:** Acquire Emergency Vehicles Signal Request Data
Verification: T	**Traceability:** ConOps§8, §11.0, §11.5; Use Case 13.3.5
Requirement Text: The MMITSS shall acquire emergency vehicle signal request data including time stamp, vehicle ID, vehicle type, intersection ID, priority level of request, and expected time of arrival at the intersection from equipped emergency vehicles.	
Supporting Text: *This requirement provides the acquisition of emergency vehicle priority-related characteristics and data (i.e., data elements described in Section 6.2.2) for operational use by MMITSS.*	

2

RQID: F2003	**Title:** Acquire Intended Travel Path from Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §11.0, §11.4.1, §11.5.1; Use Cases 13.3.4, 13.3.5; Stakeholder Input 4.3.8
Requirement Text: The MMITSS will acquire intended travel path through the intersection for equipped vehicles and travelers within communication control range of an intersection.	
Supporting Text: *This is the parent requirement that provides the acquisition of the intended travel path through an intersection for equipped vehicles. The path is currently described by the inbound (in-lane) land and the desired outbound lane (out-lane). This is a "will" requirement because non-transit vehicles do not have an intended path at this time.*	

3

RQID: C2003.201	**Title:** Acquire Intended Travel Path from Equipped Transit Vehicles
Verification: T	**Traceability:** ConOps §11.2; Use Case 13.3.2
Requirement Text: The MMITSS shall acquire the intended travel path through the intersection from equipped transit vehicles within communication control range of an intersection.	
Supporting Text: *This requirement provides for the acquisition of the intended travel path through an intersection for transit vehicles within communication control range of the intersection. The path is currently described by the inbound (in-lane) land and the desired outbound lane (out-lane). This route information can be used for MMITSS functionality such as those supporting coordinated signals.*	

4

RQID: C2003.302	**Title:** Acquire Intended Travel Path from Equipped Pedestrian
Verification: T	**Traceability:** ConOps §11.3.2, §11.3.3; Use Case 13.3.3
Requirement Text: The MMITSS shall acquire the intended travel path through the intersection from an equipped pedestrian (nomadic device) within range of an intersection.	
Supporting Text: *This requirement provides for the future acquisition of the intended travel path through an intersection for pedestrians that are within communication control range of the intersection. The path is currently described by the crosswalk orientation.*	

5

RQID: F2003.303	**Title:** Acquire Intended Travel Path from Equipped Bicyclists
Verification: T	**Traceability:** ConOps §11.3.2, §11.3.3; Use Case 13.3.3
Requirement Text: The MMITSS will acquire the intended travel path through the intersection from equipped bicyclists within range of an intersection.	
Supporting Text: *This requirement provides for the future acquisition of the intended travel path through an intersection for bicyclists that are within communication control range of the intersection. The path is currently described by the crosswalk orientation.*	

6

RQID: A2012	**Title:** Acquire Intersection Signal Timing Parameters
Verification: T	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5

Requirement Text: The MMITSS shall acquire signal timing parameters from the traffic signal controller supporting the intersection when needed.	
Supporting Text: *Intersection signal timing parameters from the intersection traffic controller are used by MMITSS decision algorithms. This requirement is written in a manner permitting the control of multiple intersections by a single RSE*	

1

RQID: C2012.001	**Title:** Acquire Intersection Signal Intervals
Verification: T	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire signal timing parameters including minimum and maximum green intervals, pedestrian intervals, passage interval, and yellow and all-red clearance intervals for each permitted phase of the intersection traffic signal controller (see Section 6.2 – Intersection Parameter Requirements).	
Supporting Text: *Intersection signal intervals are used by MMITSS decision algorithms.*	

2

RQID: C2012.002	**Title:** Acquire Intersection Active Interval Information
Verification: T	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire active interval information (e.g., Walk, Flash Don't Walk, Minimum Green, Passage, Gap out, Max out, Force-off, Red Clearance) from the intersection traffic signal controller (See Section 6.2).	
Supporting Text: *Intersection active interval is used by MMITSS decision algorithms.*	

3

RQID: A2016	**Title:** Acquire Extended Status Data from Equipped Vehicles
Verification: D	**Traceability:** ConOps§8, §11.0, §11.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire extended status data from equipped vehicles within communication control range of an intersection.	
Supporting Text: *This is the parent requirement that provides the acquisition of extended status data for equipped vehicles (i.e., data elements described in Section 6.2.2) for operational use by a MMITSS intersection.*	

4

RQID: C2016.001	**Title:** Acquire Extended Status Data – Vehicle Status
Verification: D	**Traceability:** ConOps§8, §11.0, §11.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire extended status data including time stamp, vehicle ID, vehicle type, windshield wiper status, brake applied status, and roadway friction as defined in Section 6.2.2 from equipped vehicles within communication control range of an intersection.	
Supporting Text: *This is the child requirement that provides the acquisition of extended status data for equipped vehicles (i.e., data elements described in Section 6.2.2) for operational use by a MMITSS intersection.*	

5

RQID: F2016.002	**Title:** Acquire Extended Status Data - Weather Data Elements
Verification: D	**Traceability:** ConOps §11.0, §11.1.3, §11.1.4, §11.3.4; Use Cases 13.3.3 SID 3.2.9, 6.1.1
Requirement Text: The MMITSS will acquire weather data including outside air temperature, average wind speed, and precipitation as defined in Section 6.2.x from equipped vehicles within communication control range of an intersection.	
Supporting Text: *Local weather information can be used to adjust intersection timing in response to current and recent conditions.*	

6

RQID: F2017	**Title:** Estimate Intersection Weather Data with Extended Status Data
Verification: D	**Traceability:** ConOps §6, §8, §11.1.3, §11.1.4, §11.3.4, §11.4; Use Cases 11.3.4, SID 1.1.3, 3.2.9, 6.1.1
Requirement Text: The MMITSS will estimate the weather conditions local to the intersection based on data provided by equipped vehicle extended status data such as windshield wiper status, outside air temperature, and roadway friction.	

Supporting Text: *Using the last known weather data and extended status data provided by equipped vehicles, the MMITSS will generate an estimate of the weather conditions local to the intersection.*

1

RQID: A2101	**Title:** Acquire Intersection Field Sensor Detection Data
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4; Use Cases 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire field detector data for each infrastructure vehicle detector.	
Supporting Text: *In addition to equipped vehicle information, field detector data, when available is used in the estimation of intersection performance and provide correspondence of equipped vehicle locations with controller actuations for ISIG. Quality of this data will affect the accuracy of estimation of intersection performance.*	

2

RQID: C2101.001	**Title:** Acquire Intersection Field Sensor Detection – Traffic Counts
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §12.7.1; Use Cases 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire available field detector data from the intersection traffic signal controller to support the calculation of Traffic Counts, which is described in Section 6.2.3.	
Supporting Text: *In addition to equipped vehicle information, field detector data is used for estimation of intersection performance, and to associate equipped vehicle locations with controller actuations for ISIG. Quality of this data will affect the accuracy of estimation of intersection performance.*	

3

RQID: C2101.002	**Title:** Acquire Intersection Field Sensor Detection – Vehicle Occupancy
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §12.7.1; Use Cases 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire available field detector data from the intersection traffic signal controller for Vehicle Detector Occupancy, and Vehicle Detector Status as described in Section 6.2.3.	
Supporting Text: *In addition to equipped vehicle information, field detector data is used for estimation of intersection performance, and to associate equipped vehicle locations with controller actuations for ISIG. Quality of this data will affect the accuracy of estimation of intersection performance.*	

4

RQID: C2101.003	**Title:** Acquire Intersection Field Sensor Detection – Vehicle Detector Status
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §12.7.1; Use Cases 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire available field detector data from the intersection traffic signal controller for Vehicle Detector Status as described in Section 6.2.3.	
Supporting Text: *In addition to equipped vehicle information, field detector data is used for estimation of intersection performance, and to associate equipped vehicle locations with controller actuations for ISIG. This requirement provides information on the status of the vehicle detector (on or off), which can be used in control decisions and estimation of performance measures Quality of this data will affect the accuracy of estimation of intersection performance.*	

5

RQID: C2101.004	**Title:** Acquire Intersection Field Sensor Detection – Vehicle Detector Alarms
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §12.7.1; Use Cases 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire available field detector alarm data from the intersection traffic signal controller as described in Section 6.2.3.	
Supporting Text: *In addition to equipped vehicle information, field detector data is used for estimation of intersection performance, and to associate equipped vehicle locations with controller actuations for ISIG. This requirement provides information on the alarm condition of the vehicle detector (e.g. operating normally or in a no activity or error state). This information will be used to determine if the data received should be used in the estimation of intersection performance and in operational decisions.*	

6

RQID: C2101.305	**Title:** Acquire Intersection Field Sensor Detection – Pedestrian Data Element
Verification: D	**Traceability:** ConOps §11.0.2, §11.3.1; Use Cases 13.3.3

Requirement Text: The MMITSS shall acquire available field detector data including Phase Pedestrian Calls as described in Section 6.2.3 from the intersection traffic signal controller.	
Supporting Text: *In addition to equipped vehicle and nomadic device information, field detector data is used for traffic control decisions, estimation of intersection performance, and to actuate pedestrian phase intervals.*	

6.1.3.2 Intersection Data Processing

The requirements in this document section pertain to the data processing functions that occur within the intersection, between the intersection and unequipped and equipped vehicles and travelers (via nomadic device), and between the intersection and MMITSS. These requirements exclude any data processing behavior, need, or capability that would be provided separately by the section or system level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.4 and Section 6.1.5).

The intersection data processing requirements are concerned with the functions and specificity related to calculating, estimating, updating, identifying, determining, and other processing of data pertaining to or at the intersection level. The data being processed is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A2006	**Title:** Track Equipped Vehicles and Equipped Travelers Near Intersection
Verification: A	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall track equipped vehicles and nomadic devices while they are within the communication control range of the intersection.	
Supporting Text: *Tracking equipped vehicles and nomadic devices enables estimates of useful intersection states for operational use by MMITSS. These estimates can be used for servicing priority, dilemma zone applications, and estimating performance measures.*	

RQID: C2006.001	**Title:** Track Equipped Vehicles Near Intersection
Verification: A	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall track equipped vehicles within communication control range of the intersection.	
Supporting Text: *Tracking equipped vehicles enables estimates of useful intersection states (such as vehicle location, vehicle counts, etc.) for operational use by MMITSS. These estimates can be used for servicing priority, dilemma zone applications, and estimating performance measures.*	

RQID: C2006.302	**Title:** Track Equipped Non-Motorized Traveler Near Intersection
Verification: A	**Traceability:** ConOps §11.0, §11.3.2, §11.2.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall track an equipped non-motorized traveler (nomadic device) that is requesting service within communication control range of the intersection.	
Supporting Text: *Tracking nomadic devices within communication control range of the intersection provides data and parameters useful in estimating the arrival time at the intersection, remaining time to clear the crosswalk, etc.*	

RQID: F2006.003	**Title:** Determine Possible Conflicts In Travel Path
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.2.3, §11.3.2, §11.3.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5

Requirement Text: The MMITSS will determine possible conflicts in path of travel between equipped vehicles, including transit vehicles, freight vehicles, and emergency vehicles, and equipped travelers (nomadic devices) for tracked vehicles and travelers.	
Supporting Text: *This requirement provides identification of possible conflicts in the path of travel at the intersection, between equipped vehicles, including transit vehicles, freight vehicles, and emergency vehicles, and equipped travelers.*	

1

RQID: A2007	**Title:** Estimate Intersection Expected Time of Arrival of Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §11.1, §11.2, §11.3, §11.4, §11.5; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate the expected time of arrival of an equipped vehicle and equipped non-motorized travelers at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an equipped traveler approaching the intersection will need service, such as dilemma zone accommodations, priority requests, etc.*	

2

RQID: C2007.001	**Title:** Estimate Intersection Expected Time of Arrival of Equipped Vehicles
Verification: T	**Traceability:** ConOps §11.1, §11.2, §11.4, §11.5; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate the expected time of arrival of an equipped vehicle at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an equipped vehicle approaching the intersection will need service, such as dilemma zone accommodations, priority requests, etc. This is an aggregated estimate for all equipped vehicles at the intersection.*	

3

RQID: C2007.202	**Title:** Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles
Verification: T	**Traceability:** ConOps §11.1, §11.2; Use Cases 13.3.2
Requirement Text: The MMITSS shall estimate the expected time of arrival of an equipped transit vehicle at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an equipped transit vehicle approaching the intersection will need service, such as dilemma zone accommodations, priority requests, etc. Including a child requirement specific for transit will permit consideration of near-side bus stops, far-side bus stops, left turns, etc.*	

4

RQID: C2007.303	**Title:** Estimate Intersection Expected Time of Arrival of Equipped Non-Motorized Traveler
Verification: T	**Traceability:** ConOps §11.0.2, §11.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall estimate the expected time of arrival of an equipped non-motorized traveler at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an equipped non-motorized traveler (i.e., nomadic device) approaching the intersection or in a cross walk will need service, such as a priority request, etc.*	

5

RQID: C2007.404	**Title:** Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
Verification: S	**Traceability:** ConOps §11.0.1, §11.1, §11.4; Use Cases 13.3.0, 13.3.4
Requirement Text: The MMITSS shall estimate the expected time of arrival of an equipped freight vehicle at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an equipped freight vehicle approaching the intersection will need service, such as dilemma zone accommodations, priority requests, etc. Including a child requirement specific for freight allows consideration of specially defined network sections for freight such as the one described in the MMITSS ConOps Section 11.0.1. [Verification note: This can be verified by comparison to transit and other modes.]*	

1

RQID: C2007.505	**Title:** Estimate Intersection Expected Time of Arrival of Emergency Vehicles
Verification: S	**Traceability:** ConOps §11.1, §11.5; Use Cases 13.3.5
Requirement Text: The MMITSS shall estimate the expected time of arrival of an emergency vehicle at specified locations within communication control range of the intersection.	
Supporting Text: *These estimates are used to assess when an emergency vehicle approaching the intersection will need preemption or priority assistance. Including a child requirement specific for EV enables MMITSS to clear intersections of pedestrians by flashing the Don't Walk and sending information to nomadic devices.*	

2

RQID: C2007.006	**Title:** Estimate Phase Failure Duration
Verification: T	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall estimate phase failure duration of the intersection.	
Supporting Text: *A phase failure in a CV system is defined as vehicles not being served in two or more phase cycles as opposed to traditional measure of occupancy at stop bar detectors throughout the entire service (green time). Phase Failure Status (A2104) provides the status indication of the phase. The Phase Failure Duration is the length of time the Phase Failure Status is in the fail-state. Duration of the phase failure is needed for analysis of MMITSS performance measures.*	

3

RQID: A2008	**Title:** Estimate Intersection Expected Time of Departure of Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §11.1, §11.2, §11.3, §11.4, §11.5; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall calculate the time of departure of an equipped vehicle and equipped non-motorized travelers within communication control range of the intersection.	
Supporting Text: *This estimate is used to assess when an equipped traveler departing the intersection no longer needs consideration (e.g. priority timing may be terminated) and may arrive at the next intersection of a section. Also, this estimate can be used in the computation of intersection performance measures (such as delay) for all modes of equipped travelers.*	

4

RQID: C2008.001	**Title:** Estimate Intersection Expected Time of Departure of Equipped Vehicles
Verification: T	**Traceability:** ConOps §11.1, §11.2, §11.4, §11.5; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall calculate the time of departure of an equipped vehicle within communication control range of the intersection.	
Supporting Text: *This estimate is used to assess when an equipped vehicle departing the intersection no longer needs consideration (e.g. phase extension (gap) timer may be terminated) and may arrive at the next intersection of a section. Also, this estimate can be used in the computation of intersection performance measures (such as delay) for equipped vehicles.*	

5

RQID: C2008.202	**Title:** Estimate Intersection Expected Time of Departure of Equipped Transit Vehicles
Verification: T	**Traceability:** ConOps §11.2; Use Cases 13.3.2
Requirement Text: The MMITSS shall calculate the time of departure of an equipped transit vehicle within communication control range of the intersection.	
Supporting Text: *The calculation of time of departure of an equipped transit vehicle is needed to estimate when the vehicle no longer needs consideration (e.g. priority timing may be terminated) and to estimate the time of arrival at its next stop or progress along its route/path, estimate intersection transit delay, estimate intersection transit throughput, and supporting transit performance measures.*	

6

RQID: C2008.303	**Title:** Estimate Intersection Expected Time of Departure of Equipped Non-Motorized Traveler
Verification: T	**Traceability:** ConOps §11.0.2, §11.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall calculate the time of departure of an equipped non-motorized traveler within communication control range of the intersection.	

Supporting Text: *The calculation of time of departure of an equipped traveler (nomadic device) is used to estimate when the traveler no longer needs priority treatment and to estimate the intersection-non-motorized traveler (e.g. pedestrian) performance measures.*

1

RQID: C2008.404	**Title:** Estimate Intersection Expected Time of Departure of Equipped Freight Vehicles
Verification: S	**Traceability:** ConOps §11.0.1, §11.4; Use Cases 13.3.0, 13.3.4
Requirement Text: The MMITSS shall calculate the time of departure of an equipped freight vehicle within communication control range of the intersection.	
Supporting Text: *This estimate is used to assess when an equipped freight vehicle departing the intersection no longer needs consideration (e.g. priority timing may be terminated) and may arrive at the next intersection of a section. Also, this estimate can be used in the computation of intersection performance measures (such as delay) for equipped freight vehicles.*	

2

RQID: C2008.505	**Title:** Estimate Intersection Expected Time of Departure of Emergency Vehicles
Verification: S	**Traceability:** ConOps §11.5; Use Cases 13.3.5
Requirement Text: The MMITSS shall calculate the time of departure of an emergency vehicle within communication control range of the intersection.	
Supporting Text: *The calculation of time of departure of an emergency vehicle is used to estimate when the emergency vehicle no longer needs priority treatment and to estimate the time of arrival at the next intersection or progress along its route/path (for use by EMS) and supporting emergency vehicle performance measures.*	

3

RQID: A2010	**Title:** Process Signal Request Message from Equipped Vehicle or Traveler
Verification: T	**Traceability:** ConOps §11.2.1, §11.2.2, §11.2.3, §11.3.2, §11.3.3, §11.4.1, §11.5.1; Use Cases 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall process a signal request message (SRM) as defined in Section 6.2.1 and 6.2.2 from an equipped vehicle or equipped non-motorized traveler to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement provides association of signal requests from equipped vehicles and equipped non-motorized travelers (nomadic devices) with a traffic signal phase and the desired time of service. The associated signal phase information can be used to determine which phase to provide priority in response to priority requests.*	

4

RQID: F2010.001	**Title:** Process Signal Request Message from Equipped Vehicle
Verification: T	**Traceability:** ConOps §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Cases 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will process signal request messages (SRMs) as defined in Section 6.2.2 from equipped vehicles to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement associates the signal requests from equipped vehicles with the traffic signal phase and desired time of service to support the movement of the equipped vehicle through the intersection. The signal phase information and desired time of service can be used to determine how the traffic signal controller should respond to priority requests.*	

5

RQID: C2010.202	**Title:** Process Signal Request Message from Equipped Transit Vehicle
Verification: T	**Traceability:** ConOps §11.0.2, §11.2.1, §11.2.2, §11.2.3; Use Cases 13.3.2
Requirement Text: The MMITSS shall process a signal request message (SRM) as defined in Section 6.2.2 from an equipped transit vehicle to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement associates the signal requests from equipped transit vehicles with the traffic signal phase and desired time of service to support the movement of the equipped transit vehicle through the intersection. The signal phase information and desired time of service can be used to determine how the traffic signal controller should respond to transit priority requests.*	

6

RQID: C2010.303	**Title:** Process Signal Request Message from Equipped Non-Motorized Traveler
Verification: T	**Traceability:** ConOps §11.3.2, §11.3.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall process a signal request message (SRM) as defined in Section 6.2.1 from nomadic devices to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement associates a signal request from a nomadic device with the traffic signal phase and desired time of service to support the movement of the equipped non-motorized traveler through the intersection. The signal phase information and desired time of service can be used to determine how the traffic signal controller should respond to priority requests.*	

1

RQID: C2010.404	**Title:** Process Signal Request Message from Equipped Freight Vehicle
Verification: T	**Traceability:** ConOps §11.0.1, §11.4.1; Use Cases 13.3.4
Requirement Text: The MMITSS shall process a signal request message (SRM) as defined in Section 6.2.2 from an equipped freight vehicle to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement associates the signal request from an equipped freight vehicle with the traffic signal phase and desired time of service to support the movement of the equipped freight vehicle through the intersection. The signal phase information and desired time of service can be used to determine how the traffic signal controller should respond to freight priority requests.*	

2

RQID: C2010.505	**Title:** Process Signal Request Message from Emergency Vehicle
Verification: T	**Traceability:** ConOps §11.0, §11.5; Use Cases 13.3.5
Requirement Text: The MMITSS shall process a signal request message (SRM) as defined in Section 6.2.2 from an emergency vehicle to determine the traffic signal phase and desired time of service associated with the request.	
Supporting Text: *This requirement associates the signal request from an emergency vehicle with the traffic signal phase and desired time of service to support the movement of the emergency vehicle through the intersection. The signal phase information and desired time of service can be used to determine how the traffic signal controller should respond to EV priority requests.*	

3

RQID: A2013	**Title:** Estimate Intersection Performance Measures
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection performance measures based on a combination of equipped vehicle and traveler data and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of intersection level performance measures using both equipped vehicle and traveler data and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C2013.001	**Title:** Estimate Intersection Traffic Counts
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4
Requirement Text: The MMITSS shall estimate intersection traffic counts based on a combination of equipped vehicle data and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of traffic counts using both equipped vehicle data and existing intersection sensor infrastructure. Traffic count is the measured number of vehicles that cross a specified location(s) at an intersection. Generally, traffic counts are measured on each intersection approach using infrastructure-based sensors. Connected vehicle data can be used to improve the accuracy and to estimate turning volumes (e.g. left and right turning vehicles). The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and combination of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates.*	

1

RQID: C2013.002	**Title:** Estimate Intersection Traffic Count Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4
Requirement Text: The MMITSS shall estimate intersection traffic count variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of traffic count variability using both equipped vehicle and existing intersection sensor infrastructure. Traffic counts are the measured volume of vehicles that cross a specified location(s) at an intersection. The variability of traffic count is defined as the variance of the traffic volume value over the same defined time period of interest (e.g. every day rush hour, every hour every day, etc.) The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C2013.003	**Title:** Estimate Intersection Queue Length
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection queue length based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of queue length using both equipped vehicle data and existing intersection sensor infrastructure. Queue length is the number of vehicles per lane that are stopped at an intersection. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C2013.004	**Title:** Estimate Intersection Queue Length Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection queue length variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of queue length variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C2013.005	**Title:** Estimate Intersection Delay
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection delay based on a combination of equipped vehicle data (as specified in Sections 6.2.2, and 6.5.1) and field sensor data using a user-selectable time interval.	

Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of delay using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*

1

RQID: C2013.006	**Title:** Estimate Intersection Delay Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection delay variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2, and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of delay variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C2013.007	**Title:** Estimate Intersection Throughput
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection throughput based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of throughput using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C2013.008	**Title:** Estimate Intersection Throughput Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall estimate intersection throughput variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the estimation of the intersection level performance measure of throughput variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and weighting of equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: A2014	**Title:** Process Basic Status Messages
Verification: D	**Traceability:** ConOps §5, §8, §11.1.1, §11.1.3, §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5

Requirement Text: The MMITSS shall process basic status messages from equipped vehicles and nomadic devices.
Supporting Text: *This requirement provides MMITSS the capability of processing basic status message information.*

1

RQID: C2014.001	**Title:** Match Tracked Vehicle Location With Field Sensor Location
Verification: D	**Traceability:** ConOps §5, §8, §11.1.1, §11.1.3, §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall process tracked vehicles to match their location with field sensor (detector) locations, within 10 meters.	
Supporting Text: *This requirement provides MMITSS association of tracked equipped vehicle movement with a field sensor location from existing infrastructure. The associated events of vehicle locations and controller actuations can be used by ISIG to control an appropriate passage time for the associated vehicle.*	

2

RQID: A2015	**Title:** Update Estimates of Intersection Performance Measures
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection performance measures based on a combination of equipped vehicle data (as specified in Sections 6.2.1, 6.2.2, 6.2.3, and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of throughput variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the estimation process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C2015.001	**Title:** Update Estimates of Intersection Traffic Counts
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4
Requirement Text: The MMITSS shall update estimates of intersection traffic counts based on a combination of equipped vehicle data (as specified in Sections 6.2.1, 6.2.2, 6.2.3, and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of traffic counts using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. Generally, traffic counts are measured on each intersection approach using infrastructure-based sensors. Connected vehicle data can be used to improve the accuracy and to estimate turning volumes (e.g. left and right turning vehicles). The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C2015.002	**Title:** Update Estimates of Intersection Traffic Count Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4
Requirement Text: The MMITSS shall update estimates of intersection traffic count variability based on a combination of equipped vehicle data (as specified in Sections 6.2.1, 6.2.2, 6.2.3, and 6.5.1) and field sensor data using a user-selectable time interval.	

Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of traffic count variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. Traffic counts are the measured volume of vehicles that cross a specified location(s) at an intersection. The variability of traffic count is defined as the variance of the traffic volume value over the same defined time period of interest (e.g. every day rush hour, every hour every day, etc.)The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*

1

RQID: C2015.003	**Title:** Update Estimates of Intersection Queue Length
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection queue length based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of queue length using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C2015.004	**Title:** Update Estimates of Intersection Queue Length Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection queue length variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of queue length variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C2015.005	**Title:** Update Estimates of Intersection Delay
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection delay based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of delay using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C2015.006	**Title:** Update Estimates of Intersection Delay Variability

Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection delay variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of delay variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

1

RQID: C2015.007	**Title:** Update Estimates of Intersection Throughput
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection throughput based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of throughput using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C2015.008	**Title:** Update Estimates of Intersection Throughput Variability
Verification: A	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall update estimates of intersection throughput variability based on a combination of equipped vehicle data (as specified in Sections 6.2.2 and 6.5.1) and field sensor data using a user-selectable time interval.	
Supporting Text: *This requirement provides for the data processing required to update estimates of the intersection level performance measure of throughput variability using both equipped vehicle data (extended wireless sensory information) and existing intersection sensor infrastructure. The data processing associated with the updating process is configurable in the time interval of interest (e.g., rush hour, hourly, daily, weekly, etc.) and considers equipped vehicle and sensor infrastructure to address the time-varying aspects of CV market penetration rates. Updating of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: A2019	**Title:** Estimate Required Stopping Distance for Equipped Vehicles
Verification: A	**Traceability:** ConOps §5, §8, §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS shall estimate required stopping distance for equipped vehicles at an intersection.	
Supporting Text: *MMITSS uses estimates of vehicle required stopping distance to determine efficient phase termination times at an intersection in support of dilemma zone protection.*	

4

RQID: F2019.001	**Title:** Estimate Required Stopping Distance for Passenger Vehicles
Verification: A	**Traceability:** ConOps §5, §8, §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS will estimate passenger vehicle required stopping distance at an intersection using vehicle characteristics including vehicle size, vehicle mass, speed, and roadway friction (specified in Section 6.2.2).	
Supporting Text: *MMITSS uses estimates of passenger vehicle required stopping distance to determine efficient phase termination times* at an intersection.	

RQID: F2019.202	**Title:** Estimate Required Stopping Distance for Transit Vehicles
Verification: A	**Traceability:** ConOps §5, §8, §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS will estimate transit vehicle required stopping distance at an intersection using vehicle characteristics including vehicle size, vehicle mass, speed, and roadway friction (specified in Section 6.2.2).	
Supporting Text: *MMITSS uses estimates of transit vehicle required stopping distance to determine efficient phase termination times* at an intersection.	

RQID: F2019.403	**Title:** Estimate Required Stopping Distance for Freight Vehicles
Verification: A	**Traceability:** ConOps §5, §8, §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS will estimate freight vehicle required stopping distance at an intersection using vehicle characteristics including vehicle size, vehicle mass, speed, and roadway friction (specified in Section 6.2.2).	
Supporting Text: *MMITSS uses estimates of freight vehicle required stopping distance to determine efficient phase termination times* at an intersection.	

RQID: A2021	**Title:** Process Multiple Requests for Priority
Verification: D	**Traceability:** Use Case 11.5.2
Requirement Text: The MMITSS shall process requests for priority from one or more vehicles at a single intersection.	
Supporting Text: *This requirement allows MMITSS to process multiple requests for priority from one or more vehicles traveling in all movements at a single intersection. This requirement does not imply simultaneity of the processing (i.e., advanced parallel processing is not inferred or necessary). This requirement does imply that multiple requests will be retained at the intersection for service consideration.*	

RQID: A2103	**Title:** Determine Traffic Signal Phase for Tracked Vehicle
Verification: T	**Traceability:** Use Case 13.3.1 (for 11.1.1.3)
Requirement Text: The MMITSS shall determine the appropriate traffic signal phase to serve a tracked vehicle while on approach to an intersection.	
Supporting Text: *Equipped vehicles are tracked using the basic safety messages (BSM) broadcast by the vehicles as they move about the intersection. Each tracked vehicle will be served by a traffic signal phase that serves the approach (movement) to the intersection. MMITSS will determine the appropriate phase that can be called to serve the tracked vehicle and should be able to make this determination while the vehicle is approaching the intersection (as opposed to leaving).*	

RQID: A2104	**Title:** Determine Phase Failure Status
Verification: T	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall determine phase failure status of an intersection.	
Supporting Text: *A phase failure in a connected vehicle system is defined as vehicles not being served in two or more phase cycles as opposed to traditional measure of occupancy at stop bar detectors throughout the entire service (green time). Phase Failure Status is the indication of whether the intersection has reached a phase failure state and is an intersection performance measure.*	

RQID: A2501	**Title:** Acquire Active Response Mode Status of Emergency Vehicle
Verification: D	**Traceability:** Use Case 11.5.1
Requirement Text: The MMITSS shall acquire the status of an emergency vehicle in active emergency mode while traversing the intersection.	
Supporting Text: *This requirement allows MMITSS to determine that an emergency vehicle is in active response mode while traversing the intersection and an appropriate preemption strategy is needed. Active Response mode is a vehicle determined status and is determined by the vehicle operator.*	

6.1.3.3 Command, Control, and Telemetry

The requirements in this document section pertain to the command, control, and telemetry (CC&T) functions that pertain solely within the intersection, between the intersection and unequipped and equipped vehicles and travelers (via nomadic device), and between the intersection and MMITSS. These requirements exclude any functional behavior, need, or capability that would be provided by the section or system level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.4 and Section 6.1.5).

The intersection CC&T requirements are concerned with the functions and specificity related to providing, controlling, commanding, evaluating, assessing, setting and resetting. The data being commanded or controlled is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A2004	**Title:** Provide Intersection Signal Phase and Timing Data to Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.0, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input 7.1.2, 7.1.10
Requirement Text: The MMITSS shall provide intersection signal phase and timing data to equipped vehicles and nomadic devices within communication control range of the intersection.	
Supporting Text: *Signal phase and timing messages describe the signal phase (green, yellow, or red) and the amount of time remaining until the change of the phase for each approach and lane at the intersection. This information can be used to alert equipped pedestrians with disabilities on when to start crosswalk, and the remaining time while the pedestrians are walking on the crosswalk. This information can also be used in vehicle-based applications to help increase fuel efficiency, safety, and mobility. This information is consistent with the Signal Phase and Timing data (SPaT) described in the Battelle MAP and SPaT specification.*	

RQID: C2004.001	**Title:** Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.0, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input 7.1.2, 7.1.10
Requirement Text: The MMITSS shall provide signal phase and timing data including time stamp, intersection ID, and intersection state as described in Section 6.2.3 to equipped vehicles within communication control range of an intersection.	
Supporting Text: *Signal phase and timing messages describe the signal phase (green, yellow, or red) and the amount of time remaining until the change of the phase for each approach and lane at the intersection. This information can also be used in vehicle-based applications to help increase fuel efficiency, safety, and mobility. This information is consistent with the Signal Phase and Timing data (SPaT) described in the Battelle MAP and SPaT specification.*	

RQID: C2004.302	**Title:** Provide Signal Phase and Timing Data to Equipped Non-Motorized Travelers
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.3; Use Cases 13.3.3; Stakeholder Input 7.1.2, 7.1.10
Requirement Text: The MMITSS shall provide signal phase and timing data including time stamp, intersection ID, and intersection state as described in Section 6.2.3 to nomadic devices within communication control range of an intersection.	
Supporting Text: *Signal phase and timing messages describe the signal phase (green, yellow, or red) and the amount of time remaining until the change of the phase for each approach and lane at the intersection. This information can be used to alert equipped pedestrians with disabilities on when to start crosswalk, and the remaining time while the pedestrians are walking on the crosswalk. This information is consistent with the Signal Phase and Timing data (SPaT) described in the Battelle MAP and SPaT specification.*	

RQID: A2005	**Title:** Provide Geometric Intersection Description Data to Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.0, §11.2.1, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall provide Geometric Intersection description data as described in Section 6.2.3 to equipped vehicles and travelers within communication control range of an intersection.	
Supporting Text: *Geometric Intersection description messages describe the physical geometry and roadway attributes at an intersection. This information may be used by vehicles and travelers to make decisions about sending signal (priority) requests to the intersection as well as in support of other functions that require knowledge of the intersection geometry. This information may be used to alert equipped pedestrians (including pedestrians with disabilities) that they are near an intersection such that the pedestrians can request signal service if needed. This information can also be used in other connected vehicles applications to help increase fuel efficiency, safety, and mobility. The geometric intersection description (GID) format is defined as part of the SAE J2735 specification.*	

RQID: C2005.001	**Title:** Provide Geometric Intersection Description (GID) Data to Equipped Vehicles
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.0, §11.2.1, §11.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall provide Geometric Intersection description data as described in Section 6.2.3 to equipped vehicles within communication control range of an intersection.	
Supporting Text: *Geometric Intersection description messages describe the physical geometry and roadway attributes at an intersection. This information is used by transit, freight, and emergency vehicles in the decision making about sending signal requests (priority). This information can also be used in other connected vehicles applications to help increase fuel efficiency, safety, and mobility.*	

RQID: C2005.302	**Title:** Provide Geometric Intersection Description (GID) Data to Equipped Travelers
Verification: T	**Traceability:** ConOps§4.1.3, §5, §8, §9.1, §11.0, §11.3, §11.4.1, §11.5.1; Use Case 13.3.3
Requirement Text: The MMITSS shall provide Geometric Intersection description data as described in Section 6.2.3 to nomadic devices within communication control range of an intersection.	
Supporting Text: *Geometric Intersection description messages describe the physical geometry and roadway attributes at an intersection. This information can be used to alert equipped pedestrians (including pedestrians with disabilities) that they are near an intersection such that the pedestrians can request signal service if needed.*	

RQID: A2009	**Title:** Provide Signal Status Data to Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §8, §11.0, §11.2.1 §11.2.3, §11.3, §11.4.1, §11.4.2, §11.5.1; Use Cases 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall provide signal status message (SSM) information as defined in Section 6.2.3 to equipped vehicles and equipped non-motorized travelers within communication control range of the intersection.	
Supporting Text: *Signal status information describes the active intersection state (e.g., Intersection Status, Active Priority, Active Priority Cause, Preempt Status, Preempt Cause, and Transit Status). This information can be used to alert equipped travelers that the requested priority is pending or that an active EV is in the vicinity.*	

RQID: C2009.001	**Title:** Provide Signal Status Data to Equipped Vehicles
Verification: T	**Traceability:** ConOps §8, §11.0, §11.2.1 §11.2.3 §11.4.1, §11.4.2, §11.5.1; Use Cases 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall provide signal status message (SSM) information as described in Section 6.2.3 to equipped vehicles within communication control range of the intersection.	

Supporting Text: *Signal status information describes the active intersection state (e.g., Intersection Status, Active Priority, Active Priority Cause, Preempt Status, Preempt Cause, and Transit Status). This information can be used to alert equipped vehicles that the requested priority is pending or that an active EV is in the vicinity.*

1

RQID: C2009.302	**Title:** Provide Signal Status Data to Equipped Non-Motorized Travelers
Verification: T	**Traceability:** ConOps §8, §11.0, §11.3.2, §; Use Cases 13.3.3
Requirement Text: The MMITSS shall provide signal status message (SSM) information to nomadic devices within communication control range of an intersection as described in Section 6.2.3.	
Supporting Text: *Signal status information describes the active intersection state (e.g., Intersection Status, Active Priority, Active Priority Cause, Preempt Status, Preempt Cause, and Transit Status). This information can be used to alert equipped non-motorized travelers (via nomadic device) that the requested priority is pending or that an active EV is in the vicinity.*	

2

RQID: A2011	**Title:** Control Signal Actuation for Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.3.2, §11.3.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall control the actuation of traffic signals at the intersection with data from equipped vehicles and nomadic devices in conjunction with the current practice of sensor-based signal actuation.	
Supporting Text: *This requirement provides control of signal actuation with equipped vehicle data and nomadic device data to enhance the current practice of sensor based signal actuation.*	

3

RQID: C2011.001	**Title:** Control Signal Actuation for Equipped Vehicles
Verification: T	**Traceability:** ConOps §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall control the actuation of traffic signals at the intersection with data from equipped vehicles in conjunction with the current practice of sensor based signal actuation.	
Supporting Text: *This requirement provides control of vehicular signal actuation with equipped vehicle data to enhance the current practice of sensor based signal actuation.*	

4

RQID: C2011.302	**Title:** Control Signal Actuation for Equipped Travelers
Verification: T	**Traceability:** ConOps §11.3.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall control the pedestrian actuation of traffic signals at the intersection with data from nomadic devices in conjunction with the current practice of pedestrian push button-based signal actuation.	
Supporting Text: *This requirement provides control of pedestrian signal actuation with nomadic device data to improve the current practice of pedestrian push button based signal actuation.*	

5

RQID: C2011.303	**Title:** Call Pedestrian Phase and Interval
Verification: T	**Traceability:** ConOps §11.3.2. §11.3.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall call the pedestrian phase and interval associated with the particular nomadic device request and desired direction of travel.	
Supporting Text: *This requirement provides a call for pedestrian service and associated pedestrian intervals with nomadic device data. It is written to include default nomadic device service requests and nomadic device service requests for pedestrians with disabilities using an Authorized Nomadic Device, which may specify additional crossing parameters.*	

6

RQID: C2011.304	**Title:** Provide Pedestrian Clearance Extension
Verification: T	**Traceability:** ConOps §11.3.3; Use Cases 13.3.3
Requirement Text: The MMITSS shall provide a dynamic pedestrian clearance extension to authorized nomadic devices when the pedestrian is still in the crosswalk at the end of the current pedestrian clearance interval.	

Supporting Text: *This requirement provides extension of an active pedestrian clearance interval for authorized equipped nomadic devices to improve intersection safety.*

1

RQID: C2011.005	**Title:** Call the Signal Phase Associated with a Tracked Equipped Vehicle
Verification: T	**Traceability:** ConOps §11.1.1.2, §11.1.1.3, §11.1.4; Use Cases 13.3.1
Requirement Text: The MMITSS shall call the signal phase associated the direction of travel of a tracked equipped vehicle.	
Supporting Text: *This requirement ensures that a call for phase service is placed for each tracked equipped vehicle.*	

2

RQID: C2011.006	**Title:** Provide Dynamic Passage Interval for Tracked Equipped Vehicles
Verification: T	**Traceability:** ConOps §11.1.1.2, §11.1.1.3, §11.1.4; Use Cases 13.3.1
Requirement Text: The MMITSS shall provide a dynamic passage interval to accommodate tracked equipped vehicles based on the vehicles estimated arrival and departure times.	
Supporting Text: *This requirement provides a dynamic passage interval for equipped vehicles to pass the intersection during a green signal. It is a “dynamic passage interval” because the length of the passage interval depends on the estimated arrival and departure times of the tracked vehicle and will include consideration of the phase status (maximum time) and coordination force off time.*	

3

RQID: F2018	**Title:** Provide Notification of Travel Path Conflict
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.2.3, §11.3.2, §11.3.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input ID# 3.4.12, 5.1.9
Requirement Text: The MMITSS will provide notification of supported travel path conflicts to tracked vehicles and travelers.	
Supporting Text: *This parent requirement provides notification of supported travel path conflicts to equipped vehicles and travelers that are being tracked at the intersection. This requirement is verified by the collective verification of the child requirements. It is structured this way to allow additions or removal to the “supported travel path conflicts.”*	

4

RQID: F2018.001	**Title:** Provide Notification on Emergency Vehicle-Vehicle Travel Path Conflict
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.2.1, §11.2.2, §11.2.3, §11.4.1, §11.5.1; Use Cases 13.3.1, 13.3.2, 13.3.4, 13.3.5; Stakeholder Input ID# 3.4.12, 5.1.9
Requirement Text: The MMITSS will provide a notification of a travel path conflict to tracked vehicles that have a conflicted path with a tracked equipped emergency vehicle.	
Supporting Text: *This requirement provides broadcast of possible conflicts in the path of travel with an emergency vehicle at an intersection for operational use by MMITSS. The notification will help equipped vehicles be aware of the active emergency vehicle, which could assist in the clearance of the emergency vehicle path through the intersection.*	

5

RQID: F2018.302	**Title:** Provide Notification on Active Emergency Vehicle-Pedestrian Travel Path Conflict
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.3.2, §11.3.3, §11.5.1; Use Cases 13.3.1, 13.3.3, 13.3.5; Stakeholder Input ID# 3.4.12, 5.1.9
Requirement Text: The MMITSS will provide notification to the nomadic device of an equipped traveler of a travel path conflict with a tracked equipped emergency vehicle.	
Supporting Text: *This requirement provides broadcast of possible conflicts in the path of travel with an emergency vehicle at an intersection. The notification will help equipped travelers be aware of the active emergency vehicle, which could assist in the clearance of the emergency vehicle path through the intersection.*	

6

RQID: F2018.303	**Title:** Provide Notification of Misaligned Traveler Movement

Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4, §11.3.2, §11.3.3; Use Cases 13.3.1, 13.3.3; Stakeholder Input ID# 3.4.12, 5.1.9
Requirement Text: The MMITSS will provide notification to tracked equipped travelers via qualified nomadic devices when their movement is misaligned with the selected crosswalk direction.	
Supporting Text: *This requirement is intended to support pedestrians with disabilities with information on alignment with the selected crosswalk direction. This requirement applies to tracked pedestrians supported by a qualified nomadic device.*	

RQID: A2020	**Title:** Provide Warning Notification to Equipped Vehicles
Verification: D	**Traceability:** ConOps §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS shall provide a warning notification to an equipped vehicle that the maximum time will occur before the vehicle reaches the stop bar and imminent stopping is advised.	
Supporting Text: *This requirement enables MMITSS to provide advance warning to the equipped vehicle indicating that the equipped vehicle will need to stop at the intersection it is approaching.*	

RQID: A2102	**Title:** Associate Intersection Field Sensor with Traffic Signal Controller Channel
Verification: D	**Traceability:** ConOps §11.0, §11.1.1, §11.1.4; Use Cases 13.3.1,13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall associate each infrastructure vehicle detector with the traffic signal controller detector channel number.	
Supporting Text: *Generally, detectors are associated with channels in a traffic signal controller and not associated with locations in the field. MMITSS will need to know which detector channel a physical detector will use for reporting data.*	

RQID: A2105	**Title:** Evaluate Alternative Strategies for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall evaluate alternative strategies for phase failure management at an intersection.	
Supporting Text: *A phase failure in a CV system is defined as vehicles not being served in two or more phase cycles as opposed to traditional measure of occupancy at stop bar detectors throughout the entire service (green time). Phase failure management can be achieved using strategies that include free operation, split adjustment, cycle length modifications, or queue management. MMITSS shall determine the best strategy to implement to address the cause of the phase failure. This may depend on the conditions on other phases (approaches).*	

RQID: C2105.101	**Title:** Evaluate Free Operation for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: MMITSS shall evaluate free operation for phase failure management of an intersection that has been identified as having phase failure.	
Supporting Text: *This requirement allows MMITSS to evaluate free operation as a possible solution to phase failure at a congested intersection.*	

RQID: C2105.102	**Title:** Evaluate Split Adjustment for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: MMITSS shall evaluate split adjustment for phase failure management at an intersection that has been identified as having phase failure.	
Supporting Text: *This requirement allows MMITSS to evaluate split adjustment as a possible solution to phase failure at a congested intersection. Split adjustment includes increasing the split of the phase that is failing and reducing the split of an associated phase so that cycle length does not need to be changed.*	

RQID: C2105.103	**Title:** Evaluate Cycle Length Modification for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall evaluate cycle length modification for phase failure management at an intersection that has been identified as having phase failure.	

Supporting Text: *This requirement allows MMITSS to evaluate cycle length modification as a possible solution to phase failure at a congested intersection. Changing the cycle length (increasing) is one method of increasing the phase split without having to reduce the associated phase splits.*	

RQID: C2105.104	**Title:** Evaluate Queue Management for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall evaluate queue management for phase failure management at an Intersection that MMITSS has identified as having phase failure.	
Supporting Text: *This requirement allows MMITSS to evaluate queue management as a possible solution to phase failure at a congested intersection. Queue management includes the change in phase splits if there is a queue blockage causing the phase failure. The queue could be from a left turn pocket overflow or downstream phase failure.*	

RQID: A2106	**Title:** Control Infrastructure Advance Warning Flashers
Verification: D	**Traceability:** ConOps §11.0.1, §11.1.4; Use Case 11.1.4
Requirement Text: The MMITSS shall control the actuation of infrastructure advance warning flashers when an equipped vehicle will not reach the stop bar before the maximum time occurs.	
Supporting Text: *The MMITSS uses control of advance warning flashers to warn equipped vehicles that imminent stopping is needed at the intersection it is approaching.*	

RQID: A2107	**Title:** Implement Strategy for Phase Failure Management
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall implement the selected strategy for phase failure management at an intersection that has been identified as having phase failure based on results of alternative strategy evaluations.	
Supporting Text: *The command and implementation parameters are determined by the corresponding section and the strategy is implemented at the intersection level by setting corresponding intersection parameters (e.g., offsets in A3103). Appropriate strategies include free operation, split adjustment, cycle length modifications, and queue management and are evaluated prior to selection. (Use Case 11.1.3 main step 3). Simulation will be used as the verification method by creating models that have high demand on some movements so that phase failure occurs.*	

6.1.3.4 Required Intersection States

The required states of an intersection are defined using the state transition diagram shown in Figure 12. The states shown in blue (Coordinated, Actuated-Free, and Priority) are the MMITSS states associated with active control. The remaining states (Dark, Flash, Startup, and Free) are states associated with startup operations, maintenance, and failure modes.

MMITSS assumes that the intersections (as well as sections and the system) are operating in a state where MMITSS capabilities can enhance operations using data from equipped vehicles and travelers. As such, considering the operational state of each intersection is critical in the determination of when MMITSS can be active. To understand the states of an intersection assume that the signal has just been installed and power is first applied. Initially, the signal will start in a state of flash. The signal indication is the flash state determined by the hardware configuration of the cabinet, but generally, this is flashing red indications in all directions. After a defined startup period of time (clear) the intersection will display a set of startup phases (e.g., red for all but one set of phases which may be green, then, after a programmed amount of time, begin serving all phases (in the ring specified order), including all pedestrian intervals). Once all phases and pedestrian intervals have timed, the intersection will transition to a coordinated or a free actuated mode. In coordination, the intersection will seek the desired cycle length and offset (call transition) until it is operating according to the coordinated plan.

At any time in the operation, a priority (preemption) input may override the intersections current logic. Priority will require the intersection to step through preprogrammed states of entry phases (e.g., track clearance for rail crossings), then dwell phases during the service of the priority event, and finally, either after the request has cancelled, or cleared, to an exit phase(s). Finally, the intersection will return to either actuated free or coordinated operation.

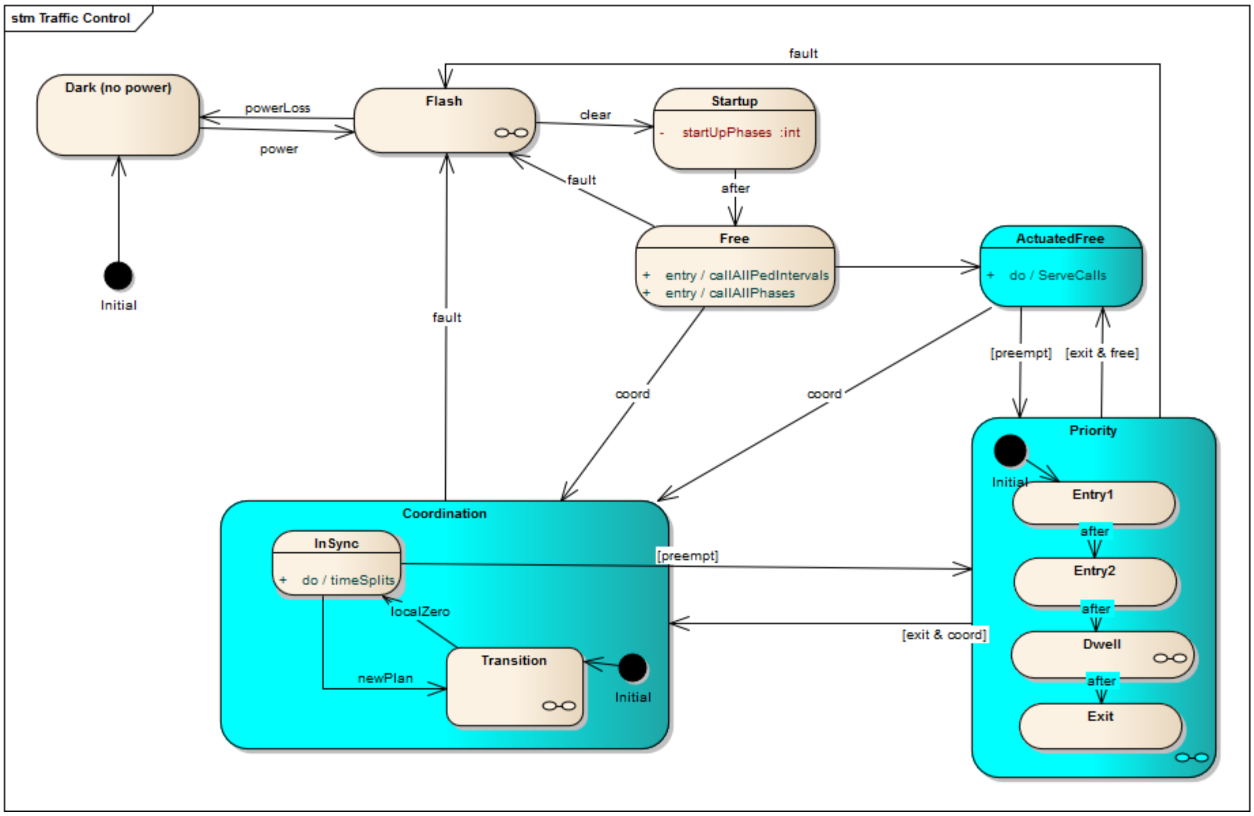

Figure 12 – MMITSS Intersection States

6.1.3.5 Intersection Software Functionality

As the development of the MMITSS progresses, requirements for software functionality should be considered closely. Such requirement could be as simple as requiring that MMITSS software be downloadable to the intersection infrastructure (e.g., RSE) or that the software be upgradeable in the field by a technician. Higher level software functionality requirements might impose design constraints such as those associated with object oriented programming, UML, or CMMI conformity.

6.1.3.6 Intersection Timing

The MMITSS intersection software shall be capable of synchronizing its time reference with the MMITSS Section or System time reference. In cases where synchronization has failed, the MMITSS intersection shall provide indication (e.g., error message) of the failure or inability to verify synchronization.

6.1.3.7 Intersection SWaP

Intersection size, weight, and power (SWaP) requirements would apply to a complete MMITSS development effort in contrast to the MMITSS research prototypes. Intersection SWaP requirements would also include provisions for the size, weight, power, and climate control of mechanical and electrical hardware needed in addition to the existing intersection infrastructure.

6.1.4 Section-Specific Functional Requirements

The requirements in this document section pertain to the functions and capabilities that reside at the section level of MMITSS. Examples of section level functions and capabilities include those concerned with section data acquisition, section data processing, section CC&T, and others listed and gathered in the following subsections. These requirements exclude any functional behavior, need, or capability that would be initiated or supported by intersection or system levels of MMITSS, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.5).

6.1.4.1 Section Data Acquisition

The functional requirements in this section are concerned with the acquisition of data by the section from the intersection and infrequently from equipped and unequipped vehicles and travelers within the boundaries or neighborhood of the section. This includes the geometric intersection description (GID) of the intersections comprising the section.

The section data acquisition requirements are concerned with the function and specificity of acquiring data (what, where, when, from whom, and sometimes how). The data being acquired is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A3001	**Title:** Acquire Active Priority Requests in a Section
Verification: T	**Traceability:** ConOps §11.2, §11.4, §11.5; Use Cases 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall acquire active priority requests received through signal request messages from equipped vehicles and travelers at intersections within a section.	
Supporting Text: *This requirement provides exchange of priority requests with a section and/or system for operational use by MMITSS. The shared priority requests can be used in determining section-based priority strategies to accommodate multiple requests for priority.*	

RQID: F3001.101	**Title:** Acquire Active Vehicle Priority Requests in a Section
Verification: T	**Traceability:** ConOps §11.1; Use Cases 13.3.1
Requirement Text: The MMITSS will acquire active priority requests received through signal request messages from equipped passenger vehicles at intersections within a section.	
Supporting Text: *This requirement provides future sharing of passenger vehicle priority requests from equipped vehicles that are not included in the classes: transit, freight, and/or emergency vehicles, with a section and/or system for operational use by MMITSS. The shared priority requests can be used in determining section-based priority strategies to accommodate multiple requests for priority.*	

RQID: C3001.202	**Title:** Acquire Active Transit Vehicle Priority Requests in a Section
Verification: T	**Traceability:** ConOps §11.0.2, §11.2; Use Cases 13.3.2
Requirement Text: The MMITSS shall acquire active transit priority requests received through signal request messages from equipped transit vehicles at intersections within a section.	
Supporting Text: *This requirement provides exchange of transit vehicle priority requests with a section and/or system for operational use by MMITSS. The shared priority requests can be used in determining section-based priority strategies to accommodate multiple requests for priority.*	

RQID: C3001.403	**Title:** Acquire Active Freight Vehicle Priority Requests in a Section
Verification: T	**Traceability:** ConOps §11.0.1, §11.2; Use Cases 13.3.4
Requirement Text: The MMITSS shall acquire active freight priority requests received through signal request messages from equipped freight vehicles at intersections within a section.	
Supporting Text: *This requirement provides exchange of freight vehicle priority requests with a section and/or system for operational use by MMITSS. The shared priority requests can be used in determining section-based priority strategies to accommodate multiple requests for priority.*	

RQID: C3001.504	**Title:** Acquire Active Emergency Vehicle Priority Requests in a Section
Verification: T	**Traceability:** ConOps §11.0.1, §11.2; Use Cases 13.3.4
Requirement Text: The MMITSS shall acquire active emergency vehicle priority requests received through signal request messages from equipped emergency vehicles at intersections within a section.	
Supporting Text: *This requirement provides exchange of emergency vehicle (EV) priority requests with a section and/or system for operational use by MMITSS. The shared priority requests can be used in determining section-based priority strategies to accommodate multiple requests for priority.*	

1

RQID: A3002	**Title:** Acquire Intersection Performance Measure Data
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire performance measures from intersections.	
Supporting Text: *Performance measures collected and estimated at each intersection (A2013) can be collected/acquired by the corresponding section. Performance measures at intersections will be used to determine the performance in sections. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C3002.001	**Title:** Acquire Intersection Performance Measure Data - Queue Length
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of estimated queue length for each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Estimated queue length will be used to determine the congestion level at intersections in a section. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C3002.002	**Title:** Acquire Intersection Performance Measure Data - Queue Length Variability
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of estimated queue length variability for each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Estimated queue length variability will be used to determine the congestion level at intersections in a section. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C3002.003	**Title:** Acquire Intersection Performance Measure Data - Delay
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of delay from each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Delay at intersections will be used in determining signal priority timing that balances impacts on traffic in a section. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

5

RQID: C300\02.004	**Title:** Acquire Intersection Performance Measure Data – Delay Variability
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of delay variability from each intersection.	

Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Delay variability at intersections will be used in determining signal priority timing that balances impacts on traffic in a section. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*

1

RQID: C3002.005	**Title:** Acquire Intersection Performance Measure Data - Throughput
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of throughput for each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Throughput will be used to determine demands for the section or system, which serves as input for adjusting section/system signal timing plan parameters in response to demand fluctuations. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

2

RQID: C3002.006	**Title:** Acquire Intersection Performance Measure Data – Throughput Variability
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the performance measure of throughput variability for each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Throughput variability will be used to determine demands for the section or system, which serves as input for adjusting section/system signal timing plan parameters in response to demand fluctuations. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process. Estimation of performance measures using equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

3

RQID: C3002.007	**Title:** Acquire Intersection Performance Measure Data – Traffic Counts
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the estimate of traffic counts from each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Traffic counts will be used to determine volume demands for the section or system, which serves as input for adjusting section/system signal timing plan parameters in response to demand fluctuations. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

4

RQID: C3002.008	**Title:** Acquire Intersection Performance Measure Data – Traffic Count Variability
Verification: A	**Traceability:** ConOps §11; Use Case 13.3.1
Requirement Text: A MMITSS Section shall acquire the estimate of traffic count variability for each intersection.	
Supporting Text: *Performance measures estimated and updated at each intersection (A2013) can be collected/acquired by the corresponding section. These measures will be used to estimate section level performance measures. Traffic count variability will be used to determine the varying volume demands for the section or system, which serves as input for adjusting section/system signal timing plan parameters in response to demand fluctuations. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

RQID: A3006	**Title:** Acquire Basic Vehicle Status Information
Verification: A	**Traceability:** ConOps §11.0, §4.1.1; Use Case 11.1.2
Requirement Text: The MMITSS section(s) shall acquire basic status information (specified in Section 6.2.2) from an equipped vehicle that is in an identified platoon.	
Supporting Text: *The system shall acquire basic vehicle status data from the intersections for the purpose of platoon identification and tracking. Simulation will be used to validate the platoon estimation and tracking capabilities and the section level acquisition of basic vehicle status data is part of that validation process.*	

6.1.4.2 Section Data Processing

The requirements in this document section pertain to the data processing functions that occur within the section (predefined collection of intersections), between the section and unequipped and equipped vehicles and travelers (via nomadic device), and between the section and MMITSS. These requirements exclude any functional behavior, need, or capability that would be provided separately by the intersection or system level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.5).

The section data processing requirements are concerned with the functions and specificity related to calculating, estimating, identifying, determining, and other processing of data pertaining to or at the section level. The data being processed is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A3003	**Title:** Characterize a Platoon
Verification: A, D	**Traceability:** ConOps §11.0, §5, §4.1.1; Use Case 11.1.2; Stakeholder ID # 1.1.11
Requirement Text: The MMITSS shall characterize a platoon of equipped and unequipped vehicles traversing a section of coordinated intersection.	
Supporting Text: *Characterization of a platoon of vehicles from a collection of tracked vehicles and detector data allows MMITSS to use coordination of intersection signals in a section to improve efficiency in traffic flow.*	

RQID: C3003.001	**Title:** Identify the Leading and Trailing Vehicles of a Platoon
Verification: A	**Traceability:** ConOps §11.0, §5, §4.1.1; Use Case 11.1.2; Stakeholder ID # 1.1.11
Requirement Text: The MMITSS shall identify the leading vehicle and trailing vehicle of a platoon traveling within a section of coordinated signals.	
Supporting Text: *This requirement is concerned with the data processing required to identify a platoon of vehicles traveling in some segment of a section. This requirement will be verified using microscopic traffic simulation.*	

RQID: C3003.002	**Title:** Estimate Platoon Size
Verification: A	**Traceability:** ConOps §4.1.1; Use Case 11.1.2; Stakeholder ID # 1.1.11
Requirement Text: The MMITSS shall estimate the size of a platoon in terms of number of equipped and unequipped vehicles.	
Supporting Text: *Section level data processing is used to estimate the size of the platoon in terms of the number of equipped and unequipped (C2013.001) vehicles allows MMITSS to make intelligent signal timing decisions and efficiently calculate performance requirements. This requirement will be verified using microscopic traffic simulation.*	

RQID: C3003.003	**Title:** Identify a Platoon of Vehicles
Verification: D	**Traceability:** ConOps §4.1.1; Use Case 11.1.2; Stakeholder ID # 1.1.11

Requirement Text: The MMITSS shall identify a platoon of vehicles using a unique platoon identification number (ID) for the purpose of tracking a platoon.
Supporting Text: *A platoon identifier is needed in order to identify, measure, track and associate a specific platoon during coordination activities.*

1

RQID: C3003.004	**Title:** Track a Platoon of Vehicles
Verification: A	**Traceability:** ConOps §4.1.1; Use Case 11.1.2; Stakeholder ID # 1.1.11
Requirement Text: The MMITSS shall track a platoon of vehicles as it moves through a section.	
Supporting Text: *In order to track a platoon of vehicles, MMITSS shall use the same tracking information provided by the leading and trailing vehicles. This requirement will be verified using microscopic traffic simulation. (Use Case 11.1.2 main step 2)*	

2

RQID: C3003.005	**Title:** Estimate Platoon Travel Time Between Intersections
Verification: A	**Traceability:** ConOps §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall estimate the platoon travel time between intersections in a section.	
Supporting Text: *Platoon travel time is an important section level performance measure that will be used to make intelligent signal timing decisions (e.g. offset and split adjustment). This requirement will be verified using microscopic traffic simulation.*	

3

RQID: C3003.006	**Title:** Estimate Number of Stops of a Platoon in a Section
Verification: A	**Traceability:** ConOps §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall estimate the number of times a platoon is stopped while traversing a section of coordinated intersections.	
Supporting Text: *The number of times a platoon is stopped is a section level performance measure that is used to make intelligent signal timing decisions and as a measure of performance (quality) of traffic signal timing. This requirement will be verified using microscopic traffic simulation.*	

4

RQID: A3005	**Title:** Calculate Appropriate Intersection Offset(s) for the Section
Verification: A	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall calculate appropriate intersection coordination pattern offset(s) for each intersection in a section based on current performance measures and considerations of priority for transit and freight vehicles in the section.	
Supporting Text: *The coordination pattern offset values determine the progression (direction of a green band or wave) for the movement of platoons in a section. Properly set offset values significantly affect performance and depend on current operating conditions including considerations for priority.*	

5

RQID: C3005.001	**Title:** Calculate Appropriate Intersection Offset(s) Based on Queue Discharging Time and Expected Travel Time
Verification: A	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall calculate appropriate intersection offset(s) using the queue discharging time at individual intersections and expected vehicle travel time between intersections.	
Supporting Text: *Platoons are released from a queue (stop) at an intersection when the traffic signal phase turns from red to green (called queue discharge time). This time maybe earlier than the programmed coordination pattern offset value due to gap out of other phases in the cycle. The offsets may need to be adjusted based on the actual queue discharge time due to the early return to green. This MMITSS requirement is needed to consider this event in the calculation of coordination pattern offset. This requirement will be verified using microscopic traffic simulation.*	

6

RQID: C3005.002	**Title:** Calculate Intersection Offsets for Multiple Directions of Travel
Verification: A	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall calculate appropriate intersection offset(s) using an appropriate trade-off calculation that balances traffic flow in more than one direction.	

Supporting Text: *MMITSS needs this calculation in order to improve efficiency of traffic flow through the section. This requirement will be verified using microscopic traffic simulation.*

1

RQID: A3102	**Title:** Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
Verification: A	**Traceability:** ConOps §4.2, §5, §11, §11.1.2, §11.4.2, §11.5.2; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input ID# 1.1.8, 1.1.9, 1.1.11, 1.1.38
Requirement Text: The MMITSS shall determine signal timing parameters to accommodate priority, coordination, and congestion control.	
Supporting Text: *This requirement provides the processing to determine the value of signal timing parameters based on the prevailing traffic conditions, multiple requests for priority, and coordination on a section of signals to improve the current practice of rule-based signal priority control. Congestion level is considered when making control decisions for priority requests to ensure that signal timing decisions do not negatively impact the level of congestion.*	

2

RQID: C3102.001	**Title:** Determine Section Signal Timing
Verification: A	**Traceability:** ConOps §4.2, §5, §11, §11.1.2, §11.4.2, §11.5.2; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input ID# 1.1.8, 1.1.9, 1.1.11, 1.1.38
Requirement Text: The MMITSS shall determine signal timing for intersections within a section based on individual priority requests, the prevailing traffic conditions, and the coordination request from the section.	
Supporting Text: *This requirement provides the processing required to determine the signal timing parameters needed to accommodate the prevailing traffic conditions, multiple requests for priority, and coordination on a section of signals to improve the current practice of rule-based signal priority control.*	

3

RQID: C3102.002	**Title:** Determine Section Signal Coordination Timing
Verification: A	**Traceability:** ConOps §4.2, §5, §11, §11.1.2, §11.4.2, §11.5.2; Use Cases 13.3.1, 13.3.4, 13.3.5; Stakeholder Input ID# 1.1.8, 1.1.9, 1.1.11, 1.1.38
Requirement Text: The MMITSS shall determine the signal coordination parameters including Coordination Pattern Cycle Time, Coordination Pattern Offset, and Coordination Pattern Phase Split for each signal in a section using individual priority requests, the prevailing traffic conditions, and congestion.	
Supporting Text: *This requirement provides the need for processing of CV data to support coordinated signal priority control for a section of signals to improve the current practice of rule-based signal priority control. The coordination parameters (cycle length, offset, and phase splits) can be adjusted using connected vehicle data including travel time (offset), queuing delay (offset), and congestion level (cycle length and phase splits).*	

4

RQID: A3106	**Title:** Determine Phase Failure Strategy
Verification: A	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall determine the appropriate strategy for phase failure management using alternative strategy evaluations for intersections within a section.	
Supporting Text: *The command and implementation parameters are determined by the corresponding section and the strategy is implemented at the intersection level by setting corresponding intersection parameters (e.g., offsets in A3103). Appropriate strategies include free operation, split adjustment, cycle length modifications, and queue management and are evaluated prior to selection. (Use Case 11.1.3 main step 3). Simulation will be used as the verification method by creating models that have high demand on some movements so that phase failure occurs.*	

5

RQID: A3107	**Title:** Determine if Queue Length Estimate is Greater Than Upstream Queue Capacity
Verification: A	**Traceability:** Use Case 11.1.3

Requirement Text: The MMITSS shall determine if the estimated intersection queue length is greater than the upstream queue capacity.
Supporting Text: *This requirement allows MMITSS to determine if the use of flow metering or another strategy for limiting traffic flow from an upstream intersection is needed to reduce congestion at the downstream intersection. (Use Case 11.1.3 main step 3)*

6.1.4.3 Section Command, Control, and Telemetry

The requirements in this document section pertain to the command, control, and telemetry (CC&T) functions that pertain within the section (predefined collection of intersections), between the section and unequipped and equipped vehicles and travelers (via nomadic device), and between the section and MMITSS. These requirements exclude any functional behavior, need, or capability that would be provided separately by the intersection or system level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.5).

The section CC&T requirements are concerned with the functions and specificity related to providing, controlling, commanding, evaluating, assessing, setting and resetting. The data being commanded or controlled is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: A3004	**Title:** Identify an Intersection with Inappropriate Offset
Verification: A	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall identify inappropriate coordination pattern offset at an intersection based on a combination of equipped vehicle data and field sensor data.	
Supporting Text: *This requirement provides the ability to analyze the performance of an intersection to identify if the coordination pattern offset needs to be adjusted. This analysis will use platoon travel time and number of stops to identify conditions when the current coordination pattern offset should be changed. This requirement will be verified using microscopic traffic simulation.*	

RQID: A3101	**Title:** Control Signal Timing Plans to Accommodate Priority, Coordination, and Congestion Control
Verification: T	**Traceability:** ConOps §11, §11.1.2, §11.4.2, §11.5.2; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; Stakeholder Input ID# 2.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7, 2.1.13, 2.1.16
Requirement Text: The MMITSS shall control signal timing plans to accommodate priority, coordination, and congestion control.	
Supporting Text: *This requirement provides enhanced intersection-based signal priority control that adapts to the prevailing traffic conditions, multiple requests for priority, and coordination on a section of signals to improve the current practice of rule-based signal priority control. Congestion level is considered when making control decisions for priority requests to ensure that signal timing decisions do not negatively impact the level of congestion.*	

RQID: C3101.001	**Title:** Command Signal Coordination
Verification: T	**Traceability:** ConOps §11.0, §11.1.2, §11.4.2, §11.5.2; Use Cases 13.3.1, 13.3.4, 13.3.5; Stakeholder Input ID#.1.2, 2.1.3, 2.1.4, 2.1.5, 2.1.6, 2.1.7, 2.1.13, 2.1.16
Requirement Text: The MMITSS shall command the signal coordination to the individual intersections along a section.	
Supporting Text: *This requirement provides sharing of signal coordination parameters for a section of intersection signals to improve the current practice of time-of-day based coordination plans.*	

RQID: A3103	**Title:** Set Intersection Offset(s) at Each Intersection in the Section
Verification: D	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2

Requirement Text: The MMITSS shall set intersection offset(s) for each intersection in the section using the MMITSS calculated appropriate offset(s).	
Supporting Text: *This requirement enables MMITSS to replace intersection offset(s) in a section with revised offset(s) that MMITSS has calculated using queue discharging time and intersection travel time.*	

RQID: A3104	**Title:** Implement Flow Metering at Upstream Intersections Neighboring the Congested Intersection
Verification: T	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall implement flow metering at an upstream intersection neighboring the congested downstream intersection when the downstream intersection queue length estimate is greater than the upstream queue capacity.	
Supporting Text: *This requirement allows MMITSS to implement the use of flow metering to limit traffic flow from an upstream intersection into the congested intersection. Flow metering can be achieved by reducing the phase splits of phases that feed vehicles to the congested intersection.*	

RQID: A3105	**Title:** Monitor Phase Failure Status
Verification: T	**Traceability:** Use Case 11.1.3
Requirement Text: The MMITSS shall monitor phase failure status to determine if the intersection phase is in failure mode or if the intersection phase is no longer in failure mode.	
Supporting Text: *This requirement allows MMITSS to determine when to start and stop the use of alternative strategies to improve traffic flow at a congested intersection.*	

6.1.4.4 Section States

The state of a section depends on two types of factors: the state of the MMITSS section control components (software) and the state of each MMITSS intersection that is in the collection of intersections composing the section. The section control components can be in states of offline (startup), online (ready and active), and in an error state that could occur if there are configuration, data, communications, or other critical errors. Although a section could be modeled to have a “coordinated” state, MMITSS has modeled the coordination at the intersection level of the corresponding section (See Figure 12 for MMITSS Intersection States). The states associated with a MMITSS section are depicted in Figure 13.

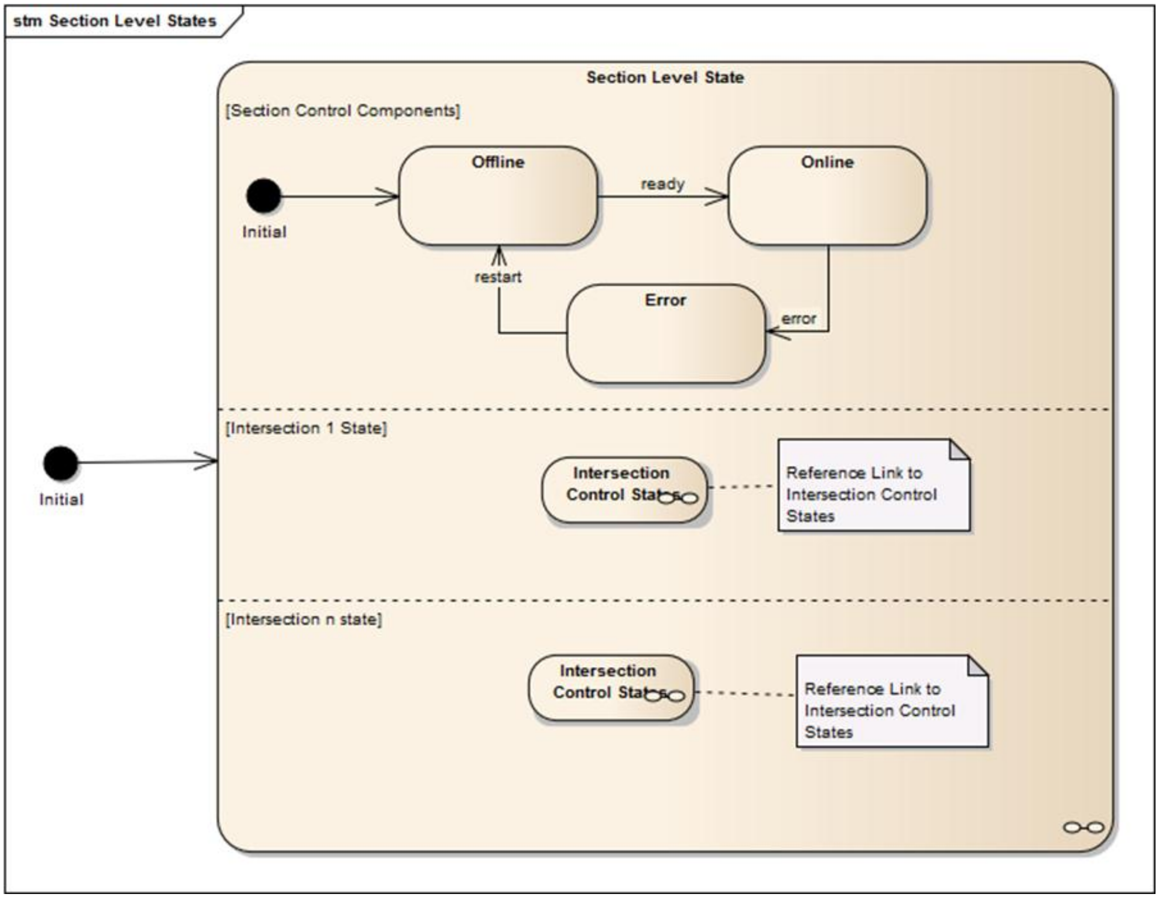

Figure 13 – MMITSS Section State Model

6.1.4.5 Section Software Functionality

The Section software may be deployed on a central (or cloud based) server or on a field device, such as a field master. Software designed and deployed on a field master must conform to the agency acceptable standards for field masters including processing power and memory limitations. The section software must be able to be started and stopped without impacting the intersection level functionality and new software must be able to be loaded remotely for the purposes of upgrades and maintenance.

6.1.4.6 Section Timing

The section timing must be synchronized with the system clock.

6.1.4.7 Section SWaP

The section software may be deployed on a central (or cloud based) server or on a field device. Server based solutions must allow section processing to be accomplished by normal rack mounted computer servers. Field master based deployment must conform to agency requirements for deployment of a field master controller.

6.1.5 System-Specific Functional Requirements

The requirements in this document section pertain to the functions and capabilities that reside at the system level of MMITSS. Examples of system level functions and capabilities include those concerned with system data acquisition, system data processing, system CC&T, and others listed and gathered in the following subsections. These requirements exclude any functional behavior, need, or capability that would be initiated or supported separately by intersection or section levels of MMITSS, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.4).

6.1.5.1 System Data Acquisition

The functional requirements in this section are concerned with the acquisition of data by the system from the sections and intersections comprising the system and infrequently from equipped and unequipped vehicles and travelers within the boundaries of the system.

The system data acquisition requirements are concerned with the function and specificity of acquiring data (what, where, when, from whom, and sometimes how). The data being acquired is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: F4001	**Title:** Acquire Current Signal Timing Plan Parameters
Verification: T	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; SID 6.1.5, 5.1.7
Requirement Text: The MMITSS will acquire the current signal timing plan parameters from each intersection in a section including the parameters cycle length, split, and offset defined in Section 6.2.3.	
Supporting Text: *Since the section can modify signal timing parameters based on coordinated control, priority, preemption, and other MMITSS functionality, the system needs to gather, monitor, and record the signal timing parameters in use at section-controlled intersections.*	

RQID: F4003	**Title:** Acquire Vehicle Route Data
Verification:	**Traceability:** ConOps §11.0, §11.2.3, §11.4.2; Use Case 13.3.1, 13.3.2, 13.3.4
Requirement Text: The MMITSS will acquire vehicle route data.	
Supporting Text: *This requirement provides the acquisition of vehicle route data at a section level to support route based priority and coordinated traffic signal timing.*	

RQID: C4003.201	**Title:** Acquire Transit Route Information
Verification: D	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.2
Requirement Text: The MMITSS shall acquire fixed route information for transit vehicles that is provided or made available by a transit management system.	
Supporting Text: *This requirement provides sharing of transit fixed route information for operational use by MMITSS. This information can be used for providing route-based signal priority to transit vehicles within a section of signals.*	

RQID: C4003.402	**Title:** Acquire Freight Route Information
Verification: D	**Traceability:** ConOps §11.0, §11.4.2; Use Case 13.3.4
Requirement Text: The MMITSS shall acquire fixed route information for freight vehicles that is provided or made available by a fleet management system (FMS).	
Supporting Text: *This requirement provides sharing of freight fixed route information for operational use by MMITSS. This information can be used for providing route-based signal priority to freight.*	

RQID: F4003.003	**Title:** Acquire Route Information Updates
Verification: D	**Traceability:** ConOps §11.0, §11.2.3, §11.4.2; Use Case 13.3.2, 13.3.4
Requirement Text: The MMITSS will acquire updates of fixed route information from fleet management systems to accommodate routine route adjustments and modifications.	
Supporting Text: *This requirement provides the ability to accept updates to fixed route information from a fleet management system to accommodate for changes in schedules, routes, and adjustment of service.*	

RQID: F4003.204	**Title:** Acquire Dynamic Transit Route Information Updates

Verification: D	**Traceability:** ConOps §11.0, §11.2.3, §11.4.2, §11.5.2; Use Case 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire dynamic updates of transit route information from a transit management system.	
Supporting Text: *This requirement provides dynamic sharing of transit vehicle fixed route information for operational use by MMITSS. This type of update is different than routine updates from the Fleet (Transit) Management System, which are issued when schedules, routes, or services are altered. Instead, these updates are planned deviations (near real-time) from the nominal transit route. This information can be used for providing route-based signal priority to transit vehicles and enhancing coordinated section of signals.*	

RQID: F4003.405	**Title:** Acquire Dynamic Freight Route Information Updates
Verification: D	**Traceability:** ConOps §11.0
Requirement Text: The MMITSS will acquire dynamic updates of freight routes from fleet management systems.	
Supporting Text: *This requirement provides dynamic sharing of freight vehicle fixed route information for operational use by MMITSS. This type of update is different than routine updates from the Fleet Management System, which are issued when schedules, routes, or services are altered. Instead, these updates are planned deviations (near real-time) from the nominal freight route. This information can be used for providing route-based signal priority to transit vehicles and enhancing coordinated section of signals.*	

RQID: A4103	**Title:** Acquire Section Level Performance Measures
Verification: T	**Traceability:** ConOps §11.0, §11.1.2; Use Case 11.1.2
Requirement Text: The MMITSS shall acquire section level performance measures.	
Supporting Text: *Performance measures collected and estimated at each section (A30##) can be collected/acquired by the system. Performance measures in sections will be used to determine the performance at the system level. Estimation of performance measures using information from equipped vehicles and travelers provides new opportunities for data collection and will require additional specification during the design process.*	

RQID: C4103.001	**Title:** Acquire Section Vehicle Delay
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire the vehicle delays that were calculated or estimated at a section (section average vehicle delay, section peak-period average vehicle delay, section average transit delay, section peak period average transit delay, section average truck delay, section peak period average truck delay, section average emergency vehicle delay, and section peak period average emergency vehicle delay).	
Supporting Text: *This requirement provides the acquisition of estimated vehicle delay for traffic aggregated at each section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as estimating system performance measures. Simulation will be used as the verification method by comparing estimated delay to the simulation computed delay.*	

RQID: C4103.002	**Title:** Acquire Section Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire the vehicle delay variability calculated or estimated at a section (section all day vehicle delay variability, section peak-period vehicle delay variability, section all day transit delay variability, section peak period transit delay variability, section all day emergency vehicle delay variability, and section peak period emergency vehicle delay variability).	

Supporting Text: *This requirement provides the acquisition of calculated or estimated vehicle delay variability for traffic aggregated at each section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as estimating system performance measures. Simulation will be used as the verification method by comparing estimated delay variability to the simulation computed delay variability.*

RQID: C4103.003	**Title:** Acquire Section Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire the vehicle total travel times calculated or estimated at a section (section all day vehicle total travel time, section peak-period vehicle total travel time, section all day emergency vehicle total response time, and section peak period emergency vehicle total response time).	
Supporting Text: *This requirement provides the acquisition of estimated total travel time for traffic aggregated at each section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as system performance measures. Simulation will be used as the verification method by comparing estimated [total] travel time to the simulation computed travel time variability.*	

RQID: C4103.004	**Title:** Acquire Section Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS will acquire the vehicle travel time variability calculated or estimated at a section (section all day vehicle total travel time variability and section peak-period vehicle total travel time variability).	
Supporting Text: *This requirement provides the acquisition of estimated travel time variability for general traffic on a section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as system performance measures. Simulation will be used as the verification method by comparing estimated [total] travel time variability to the simulation computed travel time variability.*	

RQID: F4103.405	**Title:** Acquire Section Freight Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.4
Requirement Text: The MMITSS will acquire the freight vehicle travel time variability calculated or estimated at a section (all day freight vehicle total travel time variability and section peak-period freight vehicle total travel time variability).	
Supporting Text: *This requirement provides the future acquisition of estimated travel time variability for freight vehicle traffic on a section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving freight traffic progression, as well as system performance measures. Simulation will be used as the verification method by comparing estimated freight travel time variability to the simulation computed freight vehicle type travel time variability.*	

RQID: C4103.006	**Title:** Acquire Section Vehicle Number of Stops
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1, 13.3.2, 13.3.4
Requirement Text: The MMITSS will acquire the vehicle number of stops calculated or estimated at a section (section all day vehicle number of stops, section peak-period vehicle number of stops, section all day freight vehicle number of stops, and section peak-period freight vehicle number of stops).	
Supporting Text: *This requirement provides the acquisition of calculated or estimated number of stops by vehicle traffic on a section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as system performance measures. Simulation will be used as the verification method by comparing estimated number of stops to the simulation computed number of stops.*	

RQID: C4103.007	**Title:** Acquire Section Vehicle Throughput
Verification: A	**Traceability:** ConOps §11.0, §11.2.3; Use Case 13.3.1

Requirement Text: The MMITSS will acquire the vehicle throughput calculated or estimated at a section (section all day vehicle throughput and section peak-period vehicle throughput).
Supporting Text: *This requirement provides the acquisition of calculated or estimated throughput for general traffic within a section for operational use by MMITSS. This data can be used for adjusting signal offsets for the purpose of improving traffic progression, as well as system performance measures. Simulation will be used as the verification method by comparing estimated section throughput to the simulation computed throughput.*

6.1.5.2 System Data Processing

The requirements in this document section pertain to the data processing functions that occur at the system level. These requirements exclude any functional behavior, need, or capability that would be provided separately by the intersection or section level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.4).

The system data processing requirements are concerned with the functions and specificity related to calculating, estimating, identifying, determining, and other processing of data pertaining to or at the system level. The data being processed is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

6.1.5.3 System Command, Control, and Telemetry

The requirements in this document section pertain to the command, control, and telemetry (CC&T) functions at the system level. These requirements exclude any functional behavior, need, or capability that would be provided separately by the intersection or section level or infrastructure, since those requirements can be found in the respective document sections (Section 6.1.3 and Section 6.1.4).

The system CC&T requirements are concerned with the functions and specificity related to assigning, providing, controlling, commanding, evaluating, assessing, setting and resetting. The data being commanded or controlled is also a requirement, but is specified separately in the corresponding sections of the MMITSS Data Requirements (Section 6.2) and Interface Requirements (Section 6.3).

RQID: F4002	**Title:** Communicate Desired Signal Timing Plan Parameters
Verification: T	**Traceability:** ConOps §11; Use Cases 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5; SID 6.1.5, 5.1.7
Requirement Text: The MMITSS will communicate the desired signal timing plan parameters to each intersection in a section including the parameters cycle length, split, and offset.	
Supporting Text: *Since the section can modify signal timing parameters based on coordinated control, priority, preemption, and other MMITSS functionality, the system needs to be able to command the intersection signal timing parameters in use at section-controlled intersections.*	

RQID: A4004	**Title:** Store Available Vehicle Route Data
Verification: I	**Traceability:** §11.0, §11.0.1, §11.0.2; Use Case 13.3.2, 13.3.4
Requirement Text: The MMITSS shall store available vehicle route, including planned vehicle stops, paths, routes, schedules, and related geometric intersection description (GID) data.	
Supporting Text: *The vehicle route data provided to MMITSS is stored and used for providing MMITSS functionality. This data can be used to determine intended travel path and schedule adherence.*	

RQID: C4004.201	**Title:** Store Available Transit Route Data
Verification: I	**Traceability:** §11.0, §11.0.2; Use Case 13.3.2
Requirement Text: The MMITSS shall store available transit vehicle route data, including planned transit vehicle stops, paths, routes, schedules, and related geometric intersection description (GID) data.	

Supporting Text: *The transit vehicle route data is provided to MMITSS by the Transit Management System (TMS, or related agency). The transit route data is stored and used for providing MMITSS functionality. This data can be used to determine intended travel path and schedule adherence.*

RQID: C4004.402	**Title:** Store Available Freight Route Data
Verification: I	**Traceability:** §11.0, §11.0.1; Use Case 13.3.4
Requirement Text: The MMITSS shall store available freight vehicle route data, including planned freight vehicle stops, paths, routes, schedules, and related geometric intersection description (GID) data.	
Supporting Text: *The freight vehicle route data is provided to MMITSS by the Fleet/Freight Management System (FMS, or related entity). The fleet route data is stored and used for providing MMITSS functionality. This data can be used to determine intended travel path and schedule adherence.*	

RQID: A4101	**Title:** Assign MMITSS Intersection ID
Verification: D	**Traceability:** ConOps §11.1.2, §11.1.3; Use Cases 13.3.1
Requirement Text: The MMITSS shall assign a unique ID to each intersection in the system as described in Section 6.2.3.	
Supporting Text: *This requirement provides the assignment of a unique ID for each intersection. This ID is used in the SRM, GID, SPaT, and SSM. The MMITSS Data Table states that this ID will comply with J2735.*	

RQID: A4102	**Title:** Assign MMITSS Section ID
Verification: D	**Traceability:** ConOps §11.1.2, §11.1.3; Use Cases 13.3.1 (for 11.1.2)
Requirement Text: The MMITSS shall assign a unique ID to each section in the system as described in Section 6.2.4.	
Supporting Text: *This requirement provides the assignment of a unique ID for each section. The Traffic Management Center can specify a collection of coordinated intersections within MMITSS. These sections are used to provide coordinated operation of a group of signals by commanding a signal timing plan and by aggregation of performance measures, such as throughput and delay. The Section ID is the unique identifier for this description and is specified in Section 6.2.4.*	

6.1.5.4 System States

The current state of the MMITSS system depends on two types of factors: the state of the MMITSS system control components (software) and the state of each MMITSS section that composes the system. The system states for MMITSS are shown in Figure 14.

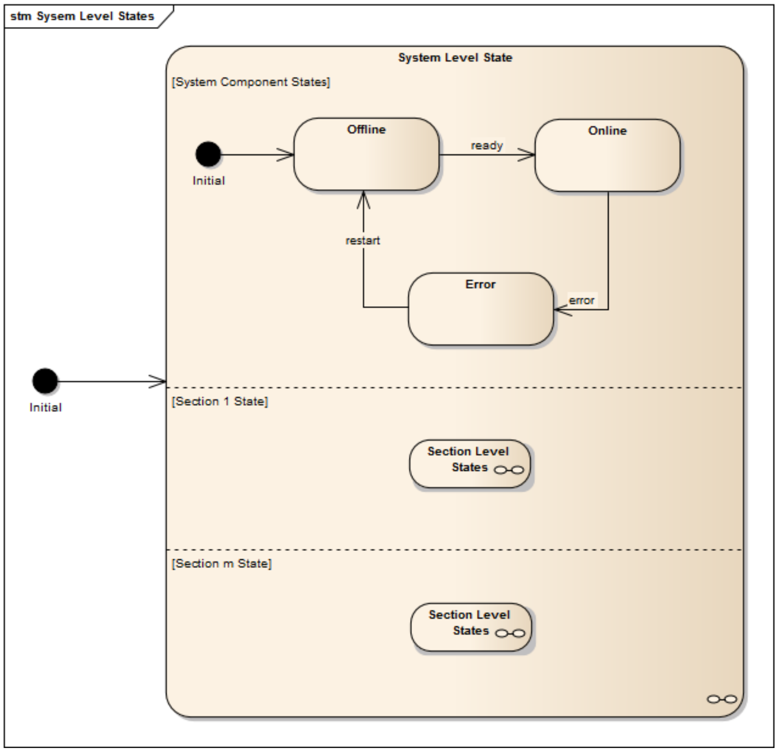

Figure 14 – MMITSS System State Model

6.1.5.5 System Software Functionality

As the development of the MMITSS progresses, requirements for software functionality should be considered closely. Such requirement could be as simple as requiring that MMITSS software be downloadable to the intersection infrastructure (e.g., RSE) or that the software be upgradeable in the field by a technician. Higher level software functionality requirements might impose design constraints such as those associated with object oriented programming, UML, or CMMI conformity. In the case of the MMITSS prototypes, requirements have been defined for software compatibility in Section 6.1.1.

6.1.5.6 System Timing

System timing shall be coordinated with the time reference of sections and intersections.

6.1.5.7 System SWaP

System SWaP requirements would apply to complete MMITSS development effort in contrast to the MMITSS research prototypes. System SWaP requirements would also include provisions for the size, weight, power, and climate control of the data archiving platform. System SWaP requirements include those pertaining to the System server that provides the platform for the Section logic, System user interface, visualization, error logs, system-level maintenance, and viewing archived data and statistics/performance measures.

6.2 Data Requirements

The data tables included in this section of the MMITSS Requirements Document provide a means of consolidating data information without the need for repetitive specification in each requirement utilizing the data. These data tables are divided into categories of nomadic device, vehicle, intersection, section, system, and parameter data. The future data elements support the “will” and “should” requirements, which infer future functionality or capability of MMITSS (See Section 5.1 for details).

6.2.1 Nomadic Device Data Requirements

The rows listed in the table below include the MMITSS data elements that are acquired, processed, shared, and used by a nomadic device that interacts with MMITSS.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5301	C2001.302	Nomadic Device Time	Nomadic Device	Nomadic Device Status Message	Year, Month, Day, Hour, Minutes, And Seconds	1 Hz	1 Second	D	The Nomadic Device must track current time in order to timestamp messages sent to the intersection.
A5101	C2001.302 C2002.303	Device ID	Nomadic Device	Nomadic Device Status Message Nomadic Device SRM	Unique Identifier For Each Nomadic Device	1 Hz	N/A	D	There may be privacy concerns with a static Device ID. It would not cause a problem for the MMITSS if the ID were periodically changed, but it would be desirable if the Device ID remained static while communicating with an intersection.
A5302	C2001.302 C2002.303 C2004.302	Nomadic Device Message Time Stamp	Nomadic Device	Nomadic Device Status Message Nomadic Device SRM	Year, Month, Day, Hour, Minutes, And Seconds	1 Hz	1 Second	D	
A5303	C2001.302 C2002.303	Device Type	Nomadic Device	Nomadic Device Status Message Nomadic Device SRM	Pedestrian, Pedestrian with Disabilities, Bicyclist	1 Hz	N/A	D	SAE J2735 defines a SRM (Signal Request Message) for vehicles, but there are no provisions for pedestrians or bicycles using a nomadic device.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5304	C2001.302	Nomadic Device Latitude	Nomadic Device	Nomadic Device Status Message	Degrees	1 Hz	Error < 5 m from the combined lat/long location. This equates to roughly 0.00005 deg of error. Note: The length of a degree of latitude or longitude is not constant.	D	MMITSS desires to place a pedestrian on a street corner which is roughly a 2x2 m box, but this may not be feasible with current technology. Since the minimum distance between street corner centers would be on the order of 10 m, MMITSS would need an accuracy of about 5 m to guess at which street corner the pedestrian was on. For verification, compare with ground truth of known Nomadic Device locations or travel path.
A5305	C2001.302	Nomadic Device Longitude	Nomadic Device	Nomadic Device Status Message	Degrees	1 Hz			
A5306	C2001.302	Nomadic Device Elevation	Nomadic Device	Nomadic Device Status Message	Meters (m)	1 Hz	Error < 5 m	D	Elevation may be important for grade-separated intersections or to minimize sending SRMs from nearby buildings. For verification, compare with Nomadic Device ground truth.
A5307	C2001.302	Nomadic Device Heading	Nomadic Device	Nomadic Device Status Message	Degrees	1 Hz	Error < 15 degrees	D	The Nomadic Device heading accuracy matters most for the pedestrian out of the crosswalk calculation. Assuming a 15 m wide intersection with a 2 m wide crosswalk, a heading error of 15 degrees would result in a position error of approximately 2 m upon reaching the far side of the intersection. For verification, compare with Nomadic Device ground truth.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5308	C2001.302	Nomadic Device Speed	Nomadic Device	Nomadic Device Status Message	Meters/Second (m/s)	1 Hz	Error < 0.3 m/s	T	MMITSS desires to detect and track slow moving Nomadic Devices (< 1.2 m/s typical walking speed) that will not clear the intersection within 3-4 seconds after the steady don't walk sign (at which time cross traffic is released). Across a 15 m wide intersection, this calculation results in a maximum speed estimation error of 0.3 m/s. For verification, compare with an independent speed measurement.
A5309	C2002.303	Nomadic Device SRM Intersection ID	Nomadic Device	Nomadic Device SRM	Unique identifier of the Intersection with which the SRM is associated	Once	N/A	D	Intersection ID will be read by the Nomadic Device through the SPaT and/or GID messages received by the device when in proximity of the equipped intersection. (SR) This data element is sent from Nomadic Device to MMITSS as part of SRM
A5310	C2002.303 C2003.302	Pedestrian Travel Path	Nomadic Device	Nomadic Device SRM	This path can be defined based on the GID message map objects indicating the desired crosswalk to cross.	Once	N/A	D	The SAE J2735 GID MAP message includes provisions for the definition of pedestrian lanes and crosswalks.
A5311	C2002.303 F2003.303	Bicyclist Travel Path	Nomadic Device	Nomadic Device SRM	This path can be defined based on the GID message map objects for the intended intersection approach and egress lanes.	Once	N/A	D	The SAE J2735 GID MAP message includes provisions for defining vehicle travel lanes and bicycle crossing lanes which may both be used by bicyclists.
A5312	C2002.303	Nomadic Device SRM Priority Level of Request	Nomadic Device	Nomadic Device SRM	Type (1-10) Level (1-10)	Once	N/A	D	This data element is defined in NTCIP 1211 and the established priority policy for the intersection. The SAE J2735 SRM includes this data element.
A5313	C2002.303 A2007 C2007.303	Nomadic Device Expected Time of Arrival	Nomadic Device	Nomadic Device SRM	Seconds	Once	Fidelity 1 second	D	This data element may exist in the SAE J2735 SRM in the form on the requested time of service element.

Table 4 – Nomadic Device Data Requirements

6.2.2 Vehicle Data Requirements

The rows listed in the table below include the data elements that are acquired, processed, shared, and used by a connected vehicle that interacts with MMITSS. These data elements permit MMITSS to identify, differentiate, and quantify vehicles and vehicle properties/characteristics whether the vehicle is at an intersection, section, or system level within MMITSS. As described in Section 5.3.1, the RQID is used to specify the data element when used or accessed by a functional requirement, which is indicated by the reference RQID in the second column of the table.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5001	C2001.001	Vehicle Time	Vehicle OBE	N/A	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	10 Hz	0.1 seconds	D	Equipped Vehicles must track current time in order to timestamp messages sent to the intersection and perform time-based calculations.
A5102	A2001 C2001.001 F2002.001 C2002.202 C2002.404 C2002.505 C2016.001	Vehicle ID	Vehicle OBE	BSM Part I BSM Part II SRM	Unique Alphanumeric Vehicle ID Not the VIN number of the vehicle.	10 Hz	N/A	D	This data element is already defined in the SAE J2735 standard for the BSM and SRM messages. There may be privacy concerns with a static Vehicle ID, and SAE J2735 does allow for the periodic randomization of the Vehicle ID. It would be desirable if the Vehicle ID remained static until a vehicle cleared the intersection.
A5002	C2001.001 F2002.001 C2002.202 C2002.404 C2002.505 C2016.001	Vehicle Message Time Stamp	Vehicle OBE	BSM Part I BSM Part II SRM	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	Up to 10 Hz	0.1 seconds	D	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5003	C2001.001 F2002.001 C2002.202 C2002.404 C2002.505 C2016.001	Vehicle Type	Vehicle OBE	BSM Part II	Passenger Car, Transit Vehicle, Freight Vehicle, or Emergency Vehicle	Once	N/A	D	This data element is already defined in SAE J2735 under BSM Part II. A total of 15 discrete vehicle classes including passenger cars, busses, and various classes of trucks are defined, but EVs are not specifically called out. It is possible that an EV may broadcast different vehicles types for the purpose of the SRM at different times, i.e., it may only flag itself as an EV if it is actively responding to an emergency.
A5004	C2001.001	Vehicle Latitude	Vehicle OBE GPS	BSM Part I	Degrees	10 Hz	Desired error < 1.8 m from combined lat/long location. This equates to roughly 0.000018 deg. of error. Note: The length of a degree of latitude or longitude is not constant.	D	This data element is already defined in the SAE J2735 standard. MMITSS desires to place a vehicle into a lane (3.6 m wide), so a desired accuracy would be about half of a lane width or 1.8 m. For verification, compare with ground truth.
A5005	C2001.001	Vehicle Longitude	Vehicle OBE GPS	BSM Part I	Degrees	10 Hz			
A5006	C2001.001	Vehicle Elevation	Vehicle OBE GPS	BSM Part I	Meters (m)	10 Hz	Error < 15 m	D	This data element is already defined in the SAE J2735 standard. For verification, compare with ground truth.
A5007	C2001.001	Vehicle Heading	Vehicle OBE Either GPS or Compass	BSM Part I	Degrees	10 Hz	Error < 10 degrees	D	This data element is already defined in the SAE J2735 standard. For verification, compare with ground truth.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5008	C2001.001	Vehicle Speed	Vehicle OBE Either GPS or Wheel Speed from the CAN bus	BSM Part I	Meters/Second (m/s)	10 Hz	Error < 1 m/s	T	This data element is already defined in the SAE J2735 standard. For verification, compare with independent speed measurement.
A5009	C2001.001	Vehicle Width	Vehicle OBE	BSM Part I	Centimeters	10 Hz	Fidelity 1 cm Error < 10 cm	D	This data element is already defined in the SAE J2735 standard up to a maximum of 1023 cm. However, it is unclear whether or not this includes trailers. The MMITSS requires the maximum vehicle width including trailers. Typical travel lanes range from 350 – 425 cm.
A5010	C2001.001	Vehicle Length	Vehicle OBE	BSM Part I	Centimeters	10 Hz	Fidelity 1 cm Error < 20 cm	D	This data element is already defined in the SAE J2735 standard up to a maximum length of 16,383 cm. However, it is unclear whether or not this includes trailers. The MMITSS requires the maximum vehicle length including trailers. Typical vehicles may range from 400 cm for a small car to 2300 cm for a tractor-trailer combination.
A5011	C2001.001	Vehicle Mass	Vehicle OBE from either stored data or from vehicle sensing and estimation	BSM Part II	Kilograms	Once	Fidelity in 50 kg increments Error < 150 kg	D	This data element is already defined in the SAE J2735 standard under the BSM Part II; however, the message defined maximum weight of 6350 kg might be too low given that single axel trucks up to 9000 kg are allowable in many states.
A5401	C2016.001 F2019.403	Trailer Mass	Vehicle OBE from either stored data or from vehicle sensing and estimation	BSM Part II	Kilograms	Once	Fidelity in 2 kg increments Accuracy within 150 kg	D	This data element is already defined in the SAE J2735 standard under the BSM Part II coded at 2 kg per bit up to a maximum weight of 128,510 kg.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5012	A2001 C2001.001	Brake Applied Status	Vehicle OBE CAN bus	BSM Part I	On/Off	10 Hz	N/A	D	This data element is already defined in the SAE J2735 standard. For verification, compare message with visible brake light status.
A5013	C2016.001	Turn Signal Status	Vehicle OBE CAN	BSM Part II	Off, Left, Right, or Both (Hazard Flashers)	1 Hz	N/A	D	This data element is already defined in the SAE J2735 standard under the BSM Part II. Turn Signal Status may be useful in predicting the vehicle travel path.
A5014	C2016.001 F2017	Windshield Wiper Status	Vehicle OBE Either from the windshield wiper status or rain sensor status on the CAN bus	BSM Part II	Wipers on high, low, intermittent, or off. Alternatively, rain sensor status is defined in terms of 7 levels of intensity in SAE J2735.	0.05 Hz	N/A	D	This data element is already defined in the SAE J2735 standard under the BSM Part II and may be used in aggregate across equipped vehicles to estimate precipitation. Thus, it should only be necessary to receive the information once per vehicle.
A5015	F2016.002 F2017	Outside Air Temperature	Vehicle OBE Thermometer	BSM Part II	Degrees Celsius coded from -40 to 150 C in 1 degree steps	0.05 Hz	Fidelity 1° C Error < 4° C	D	This data element is already defined in the SAE J2735 standard under the BSM Part II and may be used to estimate the weather conditions at the intersection.
A5016	C2016.001 F2017	Roadway Friction	Vehicle OBE CAN	BSM Part II	Coefficient of friction between 0 and 1 (dimensionless)	0.1 Hz	Fidelity 0.02 Error < 0.1	D	This data element is already defined in the SAE J2735 standard under the BSM Part II. Typical road surface friction can range from 0.1 (icy) to 0.7 (dry), and change of 0.1 near boundary conditions can result in dramatically increased stopping distances.
A5017	F2002.001 C2002.202 C2002.404 C2002.505	Vehicle SRM Intersection ID	Vehicle OBE	SRM	Unique identifier of Intersection for which the SRM is associated	Once	N/A	D	This data element is already defined in the SAE J2735 SRM. Intersection ID will be received by the vehicle from the GID and SPaT messages broadcast by the intersection.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5018	F2002.001 C2002.202 C2002.404 C2002.505	Vehicle SRM Priority Level of Request	Vehicle OBE	SRM	Type (1-10) Level (1-10)	Once	N/A	D	This data element is defined in NTCIP 1211 and the established priority policy for the intersection. The SAE J2735 SRM includes this data element.
A5103	F2002.001 C2002.202 C2002.404 C2002.505 A2007 C2007.001 C2007.202 C2007.404 C2007.505	Vehicle Expected Time of Arrival	Vehicle OBE	SRM	Seconds	Once	Fidelity 1 second	D	This data element may exist in the SAE J2735 SRM in the form on the requested time of service element. (SR) Does the vehicle calculate/send its own ETA? I thought MMITSS was calculating this ETA using speed, heading, location. If not, then this data element should be deleted and the Intersection ETA element should be used instead.
A5019	C2003.201	Vehicle Travel Path	Vehicle OBE	SRM	GID lane number for intended approach and egress at the intersection	Once		D	This data element exists as an optional element in the SAE J2735 SRM.

Table 5 – Vehicle Data Requirements

6.2.3 Intersection Data Requirements

The rows listed in the table below include the data elements that are acquired, processed, shared, and used by equipped and unequipped travelers interacting with MMITSS. An unequipped traveler will be associated by the data elements pulse, presence, signal phase, and other elements available through the infrastructure and intersection detectors. Equipped travelers will have the associate of data elements corresponding to connected vehicles as well as the infrastructure and detector elements. The data elements permit MMITSS to identify, differentiate, and quantify travelers and traveler properties/characteristics within the proximity of an intersection. As described in Section 5.3.1, the RQID is used to specify the data element when used or accessed by a functional requirement, which is indicated by the reference RQID in the second column of the table.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5104	A1301	Intersection Time	MMITSS Intersection	N/A	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	10 Hz	0.1 seconds	D	The MMITSS intersection must track current time in order to make time-based calculations and timestamp messages that are broadcast to equipped vehicles and nomadic devices.
A5105	C2004.001 C2004.302 A4101	Intersection ID	MMITSS Intersection Stored Data	SPaT GID SSM	Alphanumeric unique ID associated with an intersection	Up to 10 Hz	N/A	D	This data element is already defined in the SAE J2735 for the GID, SPaT, and SSM. Intersection ID is stored once, and broadcast at up to 10 Hz depending on the message. Unless otherwise noted for the SPaT, GID, and SSM message data elements, the verification is based on MMITSS acquiring the correct value from the data source, transmitting it to the equipped vehicles and nomadic devices, and those vehicles or devices receiving the correct values.
A5106	C2004.001 C2004.302	Intersection Message Time Stamp	MMITSS Intersection	SPaT SSM	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	Up to 10 Hz	0.1 seconds	D	
A5107	A2005 C2005.001 C2005.302	GID	MMITSS Intersection Stored Data	GID	Intersection feature descriptions (such as geometry, location, and attributes) for travel lanes, crosswalks, and bicycle crossings	1 Hz	Desired Location Error < 20 cm (or about 5% of a std. lane width)	D	The GID message and data elements are already defined in the SAE J2735. Describing the message elements in detail is beyond the scope of this project.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5108	A2009 C2009.001 C2009.302	Intersection Status	MMITSS Intersection TSC	SPaT	The bits of the Intersection Status object are as follows: 0: Manual Control is enabled. 1: Stop Time is activated 2: Conflict Flash State is active 3: Preempt is active 4: Priority is active 5: Reserved 6: Reserved 7: Reserved as zero A bit set to a logic one indicates that the described condition is present at the intersection while a bit set to zero indicates that it is not present.	10 Hz	N/A	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message and may not include this data element. (SR) Note: Redundant "Intersection Status" deleted from "SSM" data message section below.
A5109	C2004.001 C2004.302 A2009 C2009.001 C2009.302	Intersection State	MMITSS Intersection		Intersection States: Dark (No power) Flash Startup Free Actuated Free Coordinated Priority				(SR) States are from System Requirements Document Figure 9.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5110	A2004 C2004.001	Movement Lane Set	MMITSS Intersection Stored Data	SPaT	The Lane Set object is a sequence of one or more double-octets where each pair represents an available movement thorough the intersection. The lane numbers correspond with the lane numbers included in the GID. Movement Bit Field Coding: 0: (LSB) Straight. 1: Left Turn. 2: Right Turn. 3: U Turn. A bit set to a logic one indicates that the described movement is present while a bit set to zero indicates that it is not present.	10 Hz	N/A	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element as described. (SR) This data element describes possible travel paths associated with each inbound lane.
A5111	A2004 C2004.001 C2004.302	Current Movement State	MMITSS Intersection TSC	SPaT	The Current State object defines the current state of a particular known movement, and the content of this object is determined by the type of lane(s): vehicle, pedestrian, or special lane. Each of the following objects can be in a state of Green, Yellow, or Red: • Ball • Left Arrow • Right Arrow • Straight Arrow • Soft Left Arrow • Soft Right Arrow • U-Turn Arrow	10 Hz	N/A	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element as described.
A5112	A2004 C2004.001 C2004.302 C2012.002	Pedestrian Movement State	MMITSS Intersection TSC	SPaT	For pedestrian lanes, this object defines the current signal state of the crosswalk indicators for a particular known pedestrian movement. 0: Unavailable or not equipped 1: Do not walk 2: Flashing, do not walk 3: Walk	10 Hz	N/A	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element as described.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5113	A2004 C2004.001 C2004.302	Special Movement Lane State	MMITSS Intersection TSC	SPaT	For special lanes (such as trains), this object defines the current lane state. 1: Empty or not in use 2: About to be occupied 3: Occupied 4: About to be empty	10 Hz	N/A	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element as described.
A5114	A2004 C2004.001 C2004.302	Minimum Time Remaining	MMITSS Intersection TSC	SPaT	Seconds 0-1200: In tenths of seconds 1201: Indefinite time remaining (more than 2 minutes) 1202: Unknown amount of time remaining	10 Hz	Fidelity 0.1 s Error < 0.1 s	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element as described.
A5115	A2004 C2004.001 C2004.302	Maximum Time Remaining	MMITSS Intersection TSC	SPaT	Seconds 0-1200: In tenths of seconds 1201: Indefinite time remaining (more than 2 minutes) 1202: Unknown amount of time remaining	10 Hz	Fidelity 0.1 s Error < 0.1 s	D	This data element is based on the Battelle Signal Phase and Timing Data (Rev. C). SAE J2375 has an alternative definition of the SPaT message that does not include this data element.
A5116		Phase Status Red	MMITSS Intersection TSC	NTCIP	0: Not Red 1: Red	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding. Unless otherwise noted for NTCIP message data elements, the verification is based on MMITSS acquiring the correct value from the data source.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5117		Phase Status Yellow	MMITSS Intersection TSC	NTCIP	0: Not Yellow 1: Yellow	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5118		Phase Status Green	MMITSS Intersection TSC	NTCIP	0: Not Green 1: Green	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5119	C2012.002	Phase Status Pedestrian Don't Walk	MMITSS Intersection TSC	NTCIP	0: Not Don't Walk 1: Don't Walk Active	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5120		Phase Status Pedestrian Clearance	MMITSS Intersection TSC	NTCIP	0: Not Pedestrian Clear 1: Pedestrian Clear Active	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5121	C2012.002	Phase Status Pedestrian Walk	MMITSS Intersection TSC	NTCIP	0: Not Walk 1: Walk Active	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5122	C2012.002	Phase Control	MMITSS Intersection TSC	NTCIP	• Phase Control Group Number • Phase Omit Control (on/off) Pedestrian Omit Control (on/off) • Phase Hold Control (on/off) • Phase Force Off Control (on/off) • Vehicle Call Control (on/off) • Pedestrian Call Control (on/off)	10 Hz	N/A	D	Data and Interface definition and communication protocol (NTCIP 1202 2.2.5) The California AB3418E standard may not have similar data elements defined.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5123		Phase Status Vehicle Call	MMITSS Intersection TSC	NTCIP	0: No Phase Call 1: Phase Call	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5124	C2011.303	Phase Status Pedestrian Call	MMITSS Intersection TSC	NTCIP	0: No Pedestrian Call 1: Pedestrian Call	10 Hz	N/A	D	Indicates active phase interval (NTCIP 1202) The California AB3418E standard contains a similar data element with a different coding.
A5125		Phase Status Phase On	MMITSS Intersection TSC	NTCIP	0: Phase Active 1: Phase Not Active	10 Hz	N/A	D	Indicates active phase (NTCIP 1202) The California AB3418E standard may not have similar data elements defined.
A5126		Phase Status Phase Next	MMITSS Intersection TSC	NTCIP	0: Not Phase Next 1: Phase Next	10 Hz	N/A	D	Indicates next phase (NTCIP 1202) The California AB3418E standard may not have similar data elements defined.
A5127		Coordination Status	MMITSS Intersection TSC	NTCIP	0: Not used 1-253 Pattern Currently Running 254: Free 255: Flash	10 Hz	N/A	D	NTCIP 1202 The California AB3418E standard may have similar data elements defined.
A5128	C2101.004	Vehicle Detector Alarms	MMITSS Intersection TSC	NTCIP	Bit Function 0: No Activity 1: Max Presence 2: Erratic Output 3: Communications Error 4: Configuration Error 7: Other Fault	10 Hz	N/A	D	NTCIP 1202 The California AB3418E standard may not have a similar data element defined.
A5129	C2101.003	Vehicle Detector Status	MMITSS Intersection TSC	NTCIP	0: Off 1: On	10 Hz	N/A	D	NTCIP 1202 The California AB3418E standard contains a similar data element.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5130	C2101.002	Vehicle Detector Occupancy	MMITSS Intersection TSC	NTCIP	Percent Occupancy Per Period Coded as Integer 0-200: Coded at 0.5% 210: Max Presence Fault 211: No Activity Fault 212: Open loop Fault 213: Shorted loop Fault 214: Excessive Change Fault 215: Reserved 216: Watchdog Fault 217: Erratic Output Fault	Variable based on signal cycle length	Fidelity 0.5%	D	NTCIP 1202 The California AB3418E standard contains a similar data element with a different coding.
A5131	C2101.001 C2013.001 C2013.002 C2013.003 C2013.004 C2013.007 C2013.008	Vehicle Detector Volume	MMITSS Intersection TSC	NTCIP	Vehicle Count Per Period Coded as Integer 0-254: Period Count 255: Volume Overflow	Variable based on signal cycle length	Desired Error < 3 Vehicle Per Period	D	NTCIP 1202 The California AB3418E standard contains a similar data element with a different coding.
A5132		Pedestrian Detector Alarms	MMITSS Intersection TSC	NTCIP	Bit Definition 0: No Activity Fault 1: Max Presence Fault 2: Erratic Output Fault 3: Communications Fault 4: Configuration Fault 7: Other Fault	10 Hz	N/A	D	NTCIP 1202 The California AB3418E standard may not have a similar data element defined.
A5133	C2014.001	Vehicle Detector Locations	MMITSS Intersection Static Data	N/A	Detector location might be represented in a number of ways based upon the MMITSS design including GPS coordinates and detector size and shape or more simply approach lane number and distance to intersection.	On Change	Error < 1 m from actual detector location	D	Detector location is not currently stored in the TSC or defined in the SAE J2735 GID. Detector locations do not need to be broadcast to equipped vehicles or nomadic devices. They are internally by MMITSS as static data that only needs to change when detector locations change.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5134		ESS Latitude	MMITSS System or Other ESS	NTCIP	Degrees	15 min	Desired error < 10 m from combined lat/long location. This equates to roughly 0.0001 deg. of error. Note: The length of a degree of latitude or longitude is not constant.	D	ESS (Environmental Sensor Station) weather data element defined in NTCIP 1204.
A5135		ESS Longitude	MMITSS System or Other ESS	NTCIP	Degrees	15 min		D	ESS weather data element defined in NTCIP 1204.
A5136		ESS Elevation	MMITSS System or Other ESS	NTCIP	Meters (m)	15 min	Error < 5 m	D	ESS weather data element defined in NTCIP 1204.
A5137		ESS Outside Air Temperature	MMITSS System or Other ESS	NTCIP	Degree Celsius	15 min	Error < 5 Degrees Celsius	D	ESS weather data element defined in NTCIP 1204.
A5138	F2016.002	Wind Sensor Status	MMITSS System or Other ESS	NTCIP	on/off	15 min	N/A	D	ESS weather data element defined in NTCIP 1204.
A5139	F2016.002	Average Wind Speed	MMITSS System or Other ESS	NTCIP	Meters/Second (m/s)	15 min	Error < 2.5 m/s	D	ESS weather data element defined in NTCIP 1204.
A5140	F2016.002	Wind Gust Speed	MMITSS System or Other ESS	NTCIP	Meters/Second (m/s)	15 min	Error < 2.5 m/s	D	ESS weather data element defined in NTCIP 1204.
A5141	F2016.002	Wind Direction	MMITSS System or Other ESS	NTCIP	Degrees (0 to 360 Corresponding to Compass Direction)	15 min	Error < 20 Degrees	D	ESS weather data element defined in NTCIP 1204.
A5142	F2016.002	Humidity	MMITSS System or Other ESS	NTCIP	Relative humidity (percentage)	15 min	N/A	D	ESS weather data element defined in NTCIP 1204.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5143	F2016.002	Precipitation Situation	MMITSS System or Other ESS	NTCIP	Integer 1: Other 2: Unknown 3: No Precipitation 4: Unidentified Slight 5: Unidentified Moderate 6: Unidentified Heavy 7: Snow Slight 8: Snow Moderate 9: Snow Heavy 10: Rain Slight 11: Rain Moderate 12: Rain Heavy 13: Froze Slight 14: Frozen Moderate 15: Frozen Heavy	15 min	N/A	D	ESS weather data element defined in NTCIP 1204.
A5144	F2016.002	Visibility	MMITSS System or Other ESS	NTCIP	Distance (meters) or alternatively: 1: Other 2: Unknown 3: Clear 4: Fog Not Patchy 5: Patchy Fog 6: Blowing Snow 7: Smoke 8: Sea Spray 9: Vehicle Spray 10: Blowing Dust Or Sand 11: Sun Glare 12: Swarms Of Insects	15 min	N/A	D	ESS weather data element defined in NTCIP 1204. Several different codes for this element are available.
A5145	A2009 C2009.001 C2009.302	Active Priority	MMITSS Intersection	SSM	Integer detailing the active priority state of the intersection	1 Hz	N/A	D	This data element is defined in the SAE J2735 SSM.
A5146	A2009 C2009.001 C2009.302	Active Priority Cause	MMITSS Intersection	SSM	Vehicle Identification Responsible for Active Priority Cause	1 Hz	N/A	D	This data element is defined in the SAE J2735 SSM.
A5147	A2009 C2009.001 C2009.302	Preempt Status	MMITSS Intersection	SSM	Integer detailing the active preempt state of the intersection	1 Hz	N/A	D	This data element is defined in the SAE J2735 SSM.
A5148	A2009 C2009.001 C2009.302	Preempt Cause	MMITSS Intersection	SSM	Vehicle identification responsible for preempt	1 Hz	N/A	D	This data element is defined in the SAE J2735 SSM.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5201	A2009 C2009.001 C2009.302	Transit Status	MMITSS Intersection	SSM	Bit code providing additional transit information 0: Nothing Active 1: ADA Boarding Active 2: Bicycle Loading Active 3: Passenger Loading Active 4/5: Passenger Occupancy Coding (0, 25, 75, 100%)	1 Hz	N/A	D	This data element is defined in the SAE J2735 SSM.
A5149	F2006.003 F2018 F2018.001 F2018.302	Travel Path Conflict Notice	MMITSS Intersection	MMITSS Travel Path Conflict Message	Notice that pedestrian or vehicle travel path is in conflict with an approaching emergency vehicle.	10 Hz	N/A	A	The 10 Hz update rate refers to the calculation of the conflict state and the broadcast of the warning message when necessary.
A5150	F2018.303	Travel Path Not Aligned with Crosswalk Notice	MMITSS Intersection	MMITSS Travel Path Not Aligned with Crosswalk Message	Notice that pedestrian travel path is not aligned with crosswalk.	1 Hz	N/A	A	The 1 Hz update rate refers to the calculation of the state and the broadcast of the warning message when necessary.
A5151	C2006.001	Computed Intersection Approach	MMITSS Intersection (Derived from Equipped Vehicle BSM)	N/A	Inbound lane number calculated using vehicle tracks.	10 Hz	N/A	A	
A5152	A2104	Phase Failure Status	MMITSS Intersection	N/A	0: Normal Operation 1: Phase Failure Active	1 Hz	N/A	D	
A5153		Vehicle Intersection Arrival and Departure Data	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Parent of vehicle expected time of arrival and expected time of departure				Parent of vehicle expected time of arrival and expected time of departure
C5153.101	C2007.001	Passenger Vehicle Expected Time of Arrival	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.102	C2007.202	Transit Expected Time of Arrival	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.103	C2007.303	Nomadic Device Expected Time of Arrival	MMITSS Intersection Derived from Nomadic Device BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5153.104	C2007.404	Freight Expected Time of Arrival	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.105	C2007.505	Emergency Vehicle Expected Time of Arrival	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.106	C2008.001	Passenger Vehicle Expected Time of Departure	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.107	C2008.202	Transit Expected Time of Departure	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.108	C2008.303	Nomadic Device Expected Time of Departure	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.109	C2008.404	Freight Expected Time of Departure	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
C5153.110	C2008.505	Emergency Vehicle Expected Time of Departure	MMITSS Intersection Derived from Equipped Vehicle BSM	N/A	Seconds (from now)	10 Hz	Error < 10%	A	
A5154		Intersection Performance Measure Data	MMITSS Intersection	Intersection Performance Metrics	Parent of intersection performance measure data				Parent of intersection performance measure data
C5154.101		Passenger Vehicle Intersection Travel Time	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5154.102		Passenger Vehicle Intersection Travel Time Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.103	C2013.005 A2015 A2015.005 A3002 C3002.003 A9001 A9001.001 A9001.002	Passenger Vehicle Intersection Delay Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.104	C2013.006 A2015.006 A3002 C3002.004 A9004	Passenger Vehicle Intersection Delay Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Standard Deviation in Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.105		Transit Vehicle Intersection Travel Time	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.106		Transit Vehicle Intersection Travel Time Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.107	C2013.005 A2015.005 A3002 C3002.003 A9001 C9001.203 C9001.204	Transit Vehicle Intersection Delay	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.108	C2013.006 A2015.006 A3002 C3002.004 A9004	Transit Vehicle Intersection Delay Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Standard Deviation in Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5154.109		Freight Vehicle Intersection Travel Time	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.110		Freight Vehicle Intersection Travel Time Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.111	A2013 C2013.005 A2015 A2015.005 A3002 C3002.003 A9001 C9001.405 C9001.406	Freight Vehicle Intersection Delay	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.112	A2013 C2013.006 A2015 A2015.006 A3002 C3002.004 A9004	Freight Vehicle Intersection Delay Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Standard Deviation Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.113		Emergency Vehicle Intersection Travel Time	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.114		Emergency Vehicle Intersection Travel Time Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5154.115	A2013 C2013.005 A2015 C2015.005 A3002 C3002.003 A9001 A9001.507 A9001.508	Emergency Vehicle Intersection Delay	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.116	A2013 C2013.006 A2015 C2015.006 A3002 C3002.004 A9004	Emergency Vehicle Intersection Delay Variability	MMITSS Intersection Derived from Equipped Vehicle BSM	Intersection Performance Metrics	Standard Deviation in Seconds	Variable based on vehicle travel time	Error < 10%	A	This data element is calculated based on tracked equipped vehicles and communicated to the section or system level on demand.
C5154.117	A2013 C2013.001 A2015 C2015.001 A2101 C2101.001 A3002 C3002.007	Traffic Count	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Number of Vehicles Per Configurable Unit Time	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.118	A2013 C2013.002 A2015 C2015.002 A3002 C3002.008	Traffic Count Variability	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Standard Deviation of Number of Vehicles Per Configurable Unit Time	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.119	A2013 C2013.003 A2015 C2015.003 A3002 C3002.001	Queue Length	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Number of vehicles	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.120	A2013 C2013.004 A2015 C2015.004 A3002 C3002.002	Queue Length Variability	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Standard Deviation of Number of Vehicles in Queue	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5154.121	A2013 C2013.003 A2015 C2015.003 A3002 C3002.001	Average cyclic maximum queue length	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Meters	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.122	A2013 C2013.004 A2015 C2015.004 A3002 C3002.002	Average cyclic maximum queue length variability	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Standard Deviation in Meters	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.123	A2013 C2013.007 A2015 C2015.007 A3002 C3002.005	Intersection throughput	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Number of Vehicles Per Unit Time	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.124	A2013 C2013.008 A2015 C2015.008 A3002 C3002.006	Intersection throughput variability	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Standard Deviation of Number of Vehicles Per Unit Time	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.125		Number of Passenger Vehicle Stops at Intersection	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Count Per Signal Cycle	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.126		Number of Freight Vehicle Stops at Intersection	MMITSS Intersection estimated based on field sensors and equipped vehicle data	Intersection Performance Metrics	Count Per Signal Cycle	Variable based on signal cycle length	Error < 10%	A	This data element is calculated as vehicle arrives, and then reported over a configurable unit to the section or system level as requested.
C5154.127		Estimated Market Penetration of Equipped Vehicles	MMITSS Intersection	Intersection Performance Metrics	Percentage	Variable based on signal cycle length	Error < 10%	A	

Table 6 – Intersection Data Requirements

6.2.4 Section Data Requirements

The rows listed in the table below correspond to the data elements that are acquired, processed, shared, and/or used by MMITSS at the section level. These data elements permit MMITSS to identify, differentiate, and quantify platoon properties/characteristics within the section. When a particular data element is used or included in a functional requirement, the "Ref. RQID" column is populated to show the requirements accessing, using, populating, or modifying the particular data element. Performance measure data applicable to the section level are also included in this table.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5162	A1301	Section Time	MMITSS Section	N/A	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	10 Hz	0.1 seconds	D	The MMITSS section must track current time in order to make time-based calculations and timestamp messages sent to the intersection or system level.
A5163	A4102	Section ID	MMITSS Section Static Data	N/A	Alphanumeric unique ID associated with a section	Variable	N/A	D	Section ID is stored once, and then used in messages sent to the intersection or system level as needed.
A5164		Section Status	MMITSS Section	System Level Coordination of Sections	Section Level notification to the System Level 0: Normal Section operation 1: Heavy traffic 2: Inability to service traffic	When Needed	N/A	A	MMITSS Section/System Level coordination messages are not currently defined in the reviewed standards.
A5165	C3003.003	Platoon ID	MMITSS Section	N/A	Section level platoon ID used for data processing				
A5166	A3104	Upstream Queue Capacity	MMITSS Section						
A5167		Section Performance Measure Data	MMITSS Section		Parent of section performance measure data elements				Parent of section performance measure data elements
C5167.101		Section Travel Time for Passenger Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.102		Section Travel Time Variability for Passenger Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5167.103	A9002 A9002.001 A9002.002	Section Travel Delay for Passenger Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.104		Section Travel Time for Transit Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.105		Section Travel Time Variability for Transit Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.106	A9002 A9002.203 A9002.204	Section Travel Delay for Transit Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.107		Section Travel Time for Freight Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.108		Section Travel Time Variability for Freight Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.109	A9002 A9002.405 A9002.406	Section Travel Delay for Freight Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.110		Section Travel Time for Emergency Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.111		Section Travel Time Variability for Emergency Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	
C5167.112	A9002 A9002.507 A9002.508	Section Travel Delay for Emergency Vehicles	MMITSS Section	Section Performance Metrics	Seconds	Variable based on section size	Fidelity 1 s Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5167.113		Number of Vehicle Stops in a Section	MMITSS Section	Section Performance Metrics	Total number of vehicle stops in a defined section in a specified time period.	Variable based on section size	Error < 10%	A	
C5167.114		Number of Freight Vehicle Stops in a Section	MMITSS Section	Section Performance Metrics	Total number of freight vehicle stops in a defined section in a specified time period.	Variable based on section size	Error < 10%	A	.
C5167.115		Estimated Section Traveler Throughput	MMITSS Section	Section Performance Metrics	Count Per Unit Time	Variable based on section size	Error < 10%	A	

Table 7 – Section Data Requirements

6.2.5 System Data Requirements

The rows listed in the table below correspond to the data elements that are acquired, processed, shared, and used by MMITSS at the system level. When a particular data element is used or included in a functional requirement, the “Ref. RQID” column is populated to show the requirements accessing, using, populating, or modifying the particular data element. Performance measure data applicable to the system level are also included in this table.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5168	A1301	System Time	MMITSS System	N/A	Year, Month, Day, Hour, Minutes, Seconds, Milliseconds	10 Hz	Fidelity 0.1 seconds	D	The MMITSS section must track current time in order to make time-based calculations and timestamp messages sent to the intersection or system level.
A5202		Transit Fixed Route	Transit Management System	N/A	Fixed route information for transit vehicles.	On Request	N/A	D	This could be a list of intersections along each transit route.
A5402		Freight Fixed Route	Freight Management System	N/A	Fixed route information for freight vehicles	On Request	N/A	D	This could be a list of intersections along each freight corridor.
A5169		MMITSS Intersection Availability	MMITSS System	N/A	Availability of MMITSS Services at Intersection Level. Percentage.	Variable	Error < 0.1%	A	
A5170		MMITSS Section Availability	MMITSS System	N/A	Availability of MMITSS Services at Section Level. Percentage.	Variable	Error < 0.1%	A	
A5171		MMITSS System Availability	MMITSS System	N/A	Availability of MMITSS Services at System Level. Percentage.	Variable	Error < 0.1%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5172		System Performance Measure Data Intersection Level	MMITSS System		Parent of system performance measure data elements at Intersection Level				Parent of system performance measure data elements at Intersection Level
C5172.101	C9031.001	Intersection Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average vehicle delay is the broadest aggregate measure of intersection performance.
C5172.102	C9031.002	Intersection Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average vehicle delay is the broadest aggregate measure of intersection performance.
C5172.103	C9031.203	Intersection Transit All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	The average transit vehicle delay reduction is the best aggregate measure of effects on transit service.
C5172.104	C9031.204	Intersection Transit Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	The average transit vehicle delay reduction is the best aggregate measure of effects on transit service.
C5172.105	C9031.305	Intersection Pedestrian All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average Pedestrian delay is the broadest aggregate measure of intersection performance on Pedestrians.
C5172.106	C9031.306	Intersection Pedestrian Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average Pedestrian delay is the broadest aggregate measure of intersection performance on Pedestrians.
C5172.107	C9031.407	Intersection Freight Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average truck delay is the broadest aggregate measure of intersection performance on trucks.
C5172.108	C9031.408	Intersection Freight Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	Average truck delay is the broadest aggregate measure of intersection performance on trucks.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.109	C9031.509	Intersection Emergency Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.110	C9031.510	Intersection Emergency Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.111	C9034.001	Intersection Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.112	C9034.002	Intersection Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.113	C9034.203	Intersection Transit All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.114	C9034.204	Intersection Transit Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.115	C9034.405	Intersection Freight Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.116	C9034.406	Intersection Freight Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.117	C9034.507	Intersection Emergency Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.118	C9034.508	Intersection Emergency Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on signal cycle length	Fidelity 1 second Error < 10%	A	
C5172.119	C9037.001	Intersection Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.120	C9037.002	Intersection Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.121	C9037.203	Intersection Transit All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.122	C9037.204	Intersection Transit Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.123	C9037.305	Intersection Pedestrian All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.124	C9037.306	Intersection Pedestrian Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.125	C9037.407	Intersection Freight Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.126	C9037.408	Intersection Freight Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.127	C9037.509	Intersection Emergency Vehicle All Day Average Response Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.128	C9037.510	Intersection Emergency Vehicle User-Defined Average Response Time	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.129	C9040.001	Intersection Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.130	C9040.002	Intersection Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.131	C9040.203	Intersection Transit All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.132	C9040.204	Intersection Transit Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.133	C9040.405	Intersection Freight All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.134	C9040.406	Intersection Freight Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable	Error < 10%	A	
C5172.135	C9043.001	Intersection Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.136	C9043.002	Intersection Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.137	C9043.203	Intersection Transit All Day Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.138	C9043.204	Intersection Transit Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.139	C9043.405	Intersection Freight Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.140	C9043.406	Intersection Freight Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.141	C9043.507	Intersection Emergency Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.142	C9043.508	Intersection Emergency Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count of Stops Per Unit Time	Variable	Error < 10%	A	
C5172.143	C9046.001	Intersection Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.144	C9046.002	Intersection Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.145	C9046.203	Intersection Transit All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.146	C9046.204	Intersection Transit Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.147	C9046.405	Intersection Freight Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.148	C9046.406	Intersection Freight Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.149	C9046.507	Intersection Emergency Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.150	C9046.508	Intersection Emergency Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5172.151	C9049.001	Intersection Vehicle All Day Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.152	C9049.002	Intersection Vehicle Peak Period Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.153	C9049.203	Intersection Transit All Day Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.154	C9049.204	Intersection Transit Peak Period Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.155	C9049.405	Intersection Freight Vehicle All Day Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.156	C9049.406	Intersection Freight Vehicle Peak Period Max Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.157	C9501.501	Intersection EV All Day Approach Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.158	C9501.502	Intersection EV Peak Period Approach Queue Length	MMITSS System	System Performance Metrics	Count of Queued Vehicles	Variable	Error < 10%	A	
C5172.159	C9052.001	Intersection Vehicle All Day Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.160	C9052.002	Intersection Vehicle Peak Period Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.161	C9052.203	Intersection Transit All Day Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.162	C9052.204	Intersection Transit Peak Period Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.163	C9052.405	Intersection Freight Vehicle All Day Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.164	C9052.406	Intersection Freight Vehicle Peak Period Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.165	C9052.507	Intersection Emergency Vehicle All Day Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	
C5172.166	C9052.508	Intersection Emergency Vehicle Peak Period Extent of Congestion	MMITSS System	System Performance Metrics	Count of Congested Intersections	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.167	C9053.001	Intersection Vehicle All Day Temporal Duration of Congestion	MMITSS System	System Performance Metrics	Temporal Duration of Congestion	Variable	Error < 10%	A	
C5172.168	C9053.002	Intersection Vehicle Peak Period Temporal Duration of Congestion	MMITSS System	System Performance Metrics	Temporal Duration of Congestion	Variable	Error < 10%	A	
C5172.169	C9053.403	Intersection Freight Vehicle All Day Temporal Duration of Congestion	MMITSS System	System Performance Metrics	Temporal Duration of Congestion	Variable	Error < 10%	A	
C5172.170	C9053.404	Intersection Freight Vehicle Peak Period Temporal Duration of Congestion	MMITSS System	System Performance Metrics	Temporal Duration of Congestion	Variable	Error < 10%	A	
C5172.171	C9054.001	Intersection Vehicle Total Number of Accidents	MMITSS System	System Performance Metrics	Number of Accidents	Variable	Error < 10%	A	
C5172.172	C9054.002	Intersection Vehicle Accident Rate	MMITSS System	System Performance Metrics	Number of accidents per unit time	Variable	Error < 10%	A	
C5172.173	C9054.403	Intersection Freight Vehicle Number of Accidents	MMITSS System	System Performance Metrics	Number of freight accidents	Variable	Error < 10%	A	
C5172.174	C9054.404	Intersection Freight Vehicle Accident Rate	MMITSS System	System Performance Metrics	Number of freight accidents per unit time	Variable	Error < 10%	A	
C5172.175	C9054.505	Intersection EV Number of Accidents	MMITSS System	System Performance Metrics	Number of EV accidents	Variable	Error < 10%	A	
C5172.176	C9054.506	Intersection EV Accident Rate	MMITSS System	System Performance Metrics	Number of EV accidents per unit time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.177	C9057.001	Intersection Vehicle All Day Dilemma Zone Incursions	MMITSS System	System Performance Metrics	Number of dilemma zone incursions	Variable	Error < 10%	A	
C5172.178	C9057.002	Intersection Vehicle Peak Period Dilemma Zone Incursions	MMITSS System	System Performance Metrics	Number of dilemma zone incursions	Variable	Error < 10%	A	
C5172.179	C9057.403	Intersection Freight Vehicle All Day Dilemma Zone Incursions	MMITSS System	System Performance Metrics	Number of dilemma zone incursions	Variable	Error < 10%	A	
C5172.180	C9057.404	Intersection Freight Vehicle Peak Period Dilemma Zone Incursions	MMITSS System	System Performance Metrics	Number of dilemma zone incursions	Variable	Error < 10%	A	
C5172.181	C9058.001	Intersection Number of Equipped Vehicles Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5172.182	C9058.002	Intersection Number of Equipped Vehicles Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5172.183	C9058.203	Intersection Number of Equipped Transit Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5172.184	C9058.204	Intersection Number of Equipped Transit Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5172.185	C9058.305	Intersection Number of Equipped Peds Per Hour	MMITSS System	System Performance Metrics	Number of pedestrians per hour	Variable	Error < 10%	A	
C5172.186	C9058.306	Intersection Number of Equipped Peds Peak Period	MMITSS System	System Performance Metrics	Number of pedestrians per unit time	Variable	Error < 10%	A	
C5172.187	C9058.407	Intersection Number of Equipped Freight Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5172.188	C9058.408	Intersection Number of Equipped Freight Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5172.189	C9058.509	Intersection Number of Equipped EV All Day	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5172.190	C9058.510	Intersection Number of Equipped EV Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
A5173		System Performance Measure Data Section Level	MMITSS System		Parent of system performance measure data elements at Section Level				Parent of system performance measure data elements at Section Level
C5173.001	C9032.001	Section Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.002	C9032.002	Section Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.003	C9032.203	Section Transit All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.004	C9032.204	Section Transit Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.005	C9032.405	Section Freight Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.006	C9032.406	Section Freight Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.007	C9032.507	Section Emergency Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.008	C9032.508	Section Emergency Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.009	C9035.001	Section Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.110	C9035.002	Section Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.111	C9035.203	Section Transit All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.112	C9035.204	Section Transit Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.113	C9035.405	Section Freight Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.114	C9035.406	Section Freight Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.115	C9035.507	Section Emergency Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.116	C9035.508	Section Emergency Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.117	C9038.001	Section Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.118	C9038.002	Section Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.119	C9038.203	Section Transit All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.120	C9038.204	Section Transit Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.121	C9038.405	Section Freight Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.122	C9038.406	Section Freight Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.123	C9038.507	Section Emergency Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.124	C9038.508	Section Emergency Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.125	C9041.001	Section Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.126	C9041.002	Section Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.127	C9041.203	Section Transit All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.128	C9041.204	Section Transit Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.129	C9041.405	Section Freight Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.130	C9041.406	Section Freight Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.131	C9041.507	Section Emergency Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.132	C9041.508	Section Emergency Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.133	C9044.001	Section Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.134	C9044.002	Section Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.135	C9044.203	Section Transit All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.136	C9044.204	Section Transit Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.137	C9044.405	Section Freight Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.138	C9044.406	Section Freight Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.139	C9044.507	Section Emergency Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.140	C9044.508	Section Emergency Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.141	C9047.001	Section Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5173.142	C9047.002	Section Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.143	C9047.403	Section Freight Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5173.144	C9047.404	Section Freight Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5173.145	C9055.001	Section Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.146	C9055.002	Section Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.147	C9055.403	Section Freight Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.148	C9055.404	Section Freight Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.149	C9055.505	Section Emergency Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.150	C9055.506	Section Emergency Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Seconds	Variable based on section size	Fidelity 1 second Error < 10%	A	
C5173.151	C9059.001	Section Number of Equipped Vehicles Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5173.152	C9059.002	Section Number of Equipped Vehicles Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5173.153	C9059.203	Section Number of Equipped Transit Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5173.154	C9059.204	Section Number of Equipped Transit Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5173.155	C9059.305	Section Number of Equipped Peds Per Hour	MMITSS System	System Performance Metrics	Number of pedestrians per hour	Variable	Error < 10%	A	
C5173.156	C9059.306	Section Number of Equipped Peds Peak Period	MMITSS System	System Performance Metrics	Number of pedestrians per unit time	Variable	Error < 10%	A	
C5173.157	C9059.407	Section Number of Equipped Freight Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5173.158	C9059.408	Section Number of Equipped Freight Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5173.159	C9059.509	Section Number of Equipped EV All Day	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5173.160	C9059.510	Section Number of Equipped EV Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5174		System Performance Measure Data System Level	MMITSS System		Parent of system performance measure data elements at System Level				Parent of system performance measure data elements at System Level
A5174.001	C9033.001	System Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.002	C9033.002	System Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.003	C9033.203	System Transit All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.004	C9033.204	System Transit Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.005	C9033.405	System Freight Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.006	C9033.406	System Freight Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.007	C9033.507	System Emergency Vehicle All Day Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.008	C9033.508	System Emergency Vehicle Peak Period Average Delay	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
A5174.009	C9036.001	System Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.110	C9036.002	System Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.111	C9036.203	System Transit All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.112	C9036.204	System Transit Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.113	C9036.405	System Freight Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.114	C9036.406	System Freight Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.115	C9036.507	System Emergency Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.116	C9036.508	System Emergency Vehicle Peak Period Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.117	C9039.001	System Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.118	C9039.002	System Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.119	C9039.203	System Transit All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.120	C9039.204	System Transit Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.121	C9039.405	System Freight Vehicle All Day Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.122	C9039.406	System Freight Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.123	C9039.507	System Emergency Vehicle All Day Delay Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.124	C9039.508	System Emergency Vehicle Peak Period Total Travel Time	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.125	C9042.001	System Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.126	C9042.002	System Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.127	C9042.203	System Transit All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.128	C9042.204	System Transit Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.129	C9042.405	System Freight Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.130	C9042.406	System Freight Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.131	C9042.507	System Emergency Vehicle All Day Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.132	C9042.508	System Emergency Vehicle Peak Period Travel Time Variability	MMITSS System	System Performance Metrics	Seconds	Variable based on system size	Fidelity 1 second Error < 10%	A	
C5174.133	C9045.001	System Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Fidelity 1 second Error < 10%	A	
C5174.134	C9045.002	System Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Fidelity 1 second Error < 10%	A	
C5174.135	C9045.203	System Transit All Day Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	
C5174.136	C9045.204	System Transit Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	
C5174.137	C9045.405	System Freight All Day Number of Vehicle Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	
C5174.138	C9045.406	System Freight Peak Period Number of Vehicle Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.139	C9045.507	System Emergency Vehicle All Day Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	
C5174.140	C9045.508	System Emergency Vehicle Peak Period Number of Stops	MMITSS System	System Performance Metrics	Count	Variable	Error < 10%	A	
C5174.141	C9048.001	System Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5174.142	C9048.002	System Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5174.143	C9048.403	System Freight Vehicle All Day Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5174.144	C9048.404	System Freight Vehicle Peak Period Throughput	MMITSS System	System Performance Metrics	Count of Travelers Per Unit Time	Variable	Error < 10%	A	
C5174.145	C9056.001	System Vehicle Total Number of Accidents	MMITSS System	System Performance Metrics	Number of Accidents	Variable	Error < 10%	A	
C5174.146	C9056.002	System Vehicle Accident Rate	MMITSS System	System Performance Metrics	Number of accidents per unit time	Variable	Error < 10%	A	
C5174.147	C9056.403	System Freight Vehicle Number of Accidents	MMITSS System	System Performance Metrics	Number of freight accidents	Variable	Error < 10%	A	
C5174.148	C9056.404	System Freight Vehicle Accident Rate	MMITSS System	System Performance Metrics	Number of freight accidents per unit time	Variable	Error < 10%	A	
C5174.149	C9056.505	System EV Number of Accidents	MMITSS System	System Performance Metrics	Number of EV accidents	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.150	C9056.506	System EV Accident Rate	MMITSS System	System Performance Metrics	Number of EV accidents per unit time	Variable	Error < 10%	A	
C5174.151	C9060.001	System Number of Equipped Vehicles Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5174.152	C9060.002	System Number of Equipped Vehicles Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5174.153	C9060.203	System Number of Equipped Transit Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5174.154	C9060.204	System Number of Equipped Transit Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5174.155	C9060.305	System Number of Equipped Peds Per Hour	MMITSS System	System Performance Metrics	Number of pedestrians per hour	Variable	Error < 10%	A	
C5174.156	C9060.306	System Number of Equipped Peds Peak Period	MMITSS System	System Performance Metrics	Number of pedestrians per unit time	Variable	Error < 10%	A	
C5174.157	C9060.407	System Number of Equipped Freight Tracked Per Hour	MMITSS System	System Performance Metrics	Number of vehicles per hour	Variable	Error < 10%	A	
C5174.158	C9060.408	System Number of Equipped Freight Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5174.159	C9060.509	Section Number of Equipped EV All Day	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	
C5174.160	C9060.510	System Number of Equipped EV Peak Period	MMITSS System	System Performance Metrics	Number of vehicles per unit time	Variable	Error < 10%	A	

Table 8 – System Data Requirements

6.2.6 Parameter Requirements

The rows listed in the table below correspond to the TSC-related parameters that are set, acquired, processed, shared, or used by MMITSS at the intersection level. When a particular data element is used or included in a functional requirement, the “Ref. RQID” column is populated to show the requirements accessing, using, populating, or modifying the particular data element. As of the submission of this document, the update rates associated with these parameters was under review. The update rates listed in the following table can be interpreted as “not to exceed” the rate stated.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5155		Intersection TSC Parameter Data	TSC		Parent of intersection TSC parameter data elements				Parent of intersection TSC parameter data elements
C5155.101	A2012 C2012.001 C2012.002	Phase Number	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202. The 10 Hz update rate is based on the frequency at which the SAE J2735 SPaT message must be sent. Unless otherwise noted, for NTCIP messages, verification consists of comparing the value received by MMITSS with the value sent by the TSC.
C5155.102	A2012 C2012.001 C2012.002	Phase Walk	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5155.103	A2012 C2012.001 C2012.002	Phase Pedestrian Clear	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.104	C2012.002	Phase Minimum Green	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.105	A2012 C2012.001 C2012.002	Phase Passage	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.106	C2012.001	Phase Maximum Green 1	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.107	C2012.001	Phase Maximum Green 2	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.108	A2012 C2012.001 C2012.002	Phase Yellow Change	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.109	A2012 C2012.001 C2012.002	Phase Red Clearance	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.110	A2012 C2012.001 C2012.002	Phase Red Revert	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.111		Phase Added Initial	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.112		Phase Minimum Initial	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.113		Phase Red Reduction	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.114		Phase Minimum Initial	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.115		Phase Time Before Reduction	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.116		Phase Cars Before Reduction	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.117		Phase Time to Reduce	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.118		Phase Reduce By	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.119		Phase Minimum Gap	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5155.120	C2012.002	Phase Dynamic Maximum Limit	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.121		Phase Dynamic Max Step	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.122	C2012.002	Phase Start Up	TSC	NTCIP	Integer or bit function coding: 1: other 2: Phase Not On 3: Green Walk 4: Green No Walk 5: Yellow Change 6: Red Clear	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.123		Vehicle Detector Number	TSC	NTCIP	Integer (1-255)	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.124		Vehicle Detector Options	TSC	NTCIP	Integer or bit function coding: 7: Call 6: Queue 5: Added Initial 4: Passage 3: Red Lock Call 2: Yellow Lock Call 1: Occupancy Detector 0: Volume	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.125		Vehicle Detector Call Phase	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.126		Vehicle Detector Switch Phase	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.127		Vehicle Detector Delay	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.128		Vehicle Detector Extend	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.129		Vehicle Detector Queue Limit	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.130		Vehicle Detector No Activity	TSC	NTCIP	Minutes	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.131		Vehicle Detector Maximum Presence	TSC	NTCIP	Minutes	10 Hz	N/A	D	This data element is defined in NTCIP 1202.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5155.132		Vehicle Detector Erratic Counts	TSC	NTCIP	Integer (count/minutes)	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.133		Vehicle Detector Fail Time	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.134		Vehicle Detector Volume/Occupancy Period	TSC	NTCIP	Seconds	10 Hz	Fidelity 0.1 s	D	This data element is defined in NTCIP 1202.
C5155.135		Pedestrian Detector Number	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.136		Pedestrian Detector Call Phase	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.137		Pedestrian Detector No Activity	TSC	NTCIP	Minutes	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.138		Pedestrian Detector Maximum Presence	TSC	NTCIP	Minutes	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.139		Pedestrian Detector Erratic Count	TSC	NTCIP	Integer	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.140		Coordination Mode	TSC	NTCIP	Integer or bit function coding: 0: Automatic 1-253: Manual Pattern 254: Manual Free 255: Manual Flash	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.141		Coordination Correction Model	TSC	NTCIP	Integer or bit function coding: 1: other 2: dwell 3: short way 4: add only	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.142		Coordination Maximum Model	TSC	NTCIP	Integer or bit function coding: 1: other 2: maximum1 3: maximum2 4: maxInhibit	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.143		Coordination Force Mode	TSC	NTCIP	Integer or bit function coding: 1: other 2: floating 3: fixed	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.144		Coordination Pattern Number	TSC	NTCIP	Integer 0-255	10 Hz	N/A	D	This data element is defined in NTCIP 1202.

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
C5155.145		Coordination Pattern Cycle Time	TSC	NTCIP	Integer 0-255	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.146		Coordination Pattern Offset	TSC	NTCIP	Integer 0-255	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.147		Coordination Pattern Phase Split	TSC	NTCIP	Integer 0-255	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.148		Coordination Pattern Phase Split Mode	TSC	NTCIP	Integer or bit function coding: 1: other 2: none 3: minimum Vehicle Recall 4: maximum Vehicle Recall 5: pedestrian Recall 6: maximum Vehicle And Pedestrian Recall 7: phase Omitted	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.149		Coordinated Pattern	TSC	NTCIP	True (1) or False (0) by Phase	10 Hz	N/A	D	This data element is defined in NTCIP 1202.
C5155.150		Coordinated Phase	TSC	NTCIP	True (1) or False (0) by Phase	10 Hz	N/A	D	This data element is defined in NTCIP 1202.

Table 9 – Parameter Requirements

6.3 Interface Requirements

This section provides information and placeholders for requirements that will specify the interfaces between MMITSS and the infrastructure supporting signalized intersections. These interfaces can be visualized by consulting the MMITSS Conceptual Architecture shown in Figure 1. Specifically, this section addresses the interfaces between MMITSS and the dashed-boxes defined as the Traffic Control Equipment and Transportation Management System.

The MMITSS interface requirements are divided into the major categories of: (1) general interface requirements, (2) command and telemetry interface requirements, (3) communication interface requirements, (4) external TMC, TMS, and FMS interface requirements, (5) electro-mechanical interfaces, and (6) power interfaces. Specific interface information (e.g., Section 6.3.2) is defined as it applies to the MMITSS prototypes. Placeholder text is included for future MMITSS development and deployment activities.

As the MMITSS development matures, interface requirements will be defined in terms of Interface Control Documents and Interface Control Diagrams (ICDs) that provide a greater level of detail required for installation, maintenance, and repair.

6.3.1 General Interface Requirements

6.3.2 Command and Telemetry Interface Requirements

RQID	Ref. RQID	Data Element Name	Data Source	Data Message	Data Description & Units	Update Rate	Data Fidelity & Accuracy	Verify Method	Notes
A5156	A2011	Phase Omit	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	
A5157	A2011	Phase Pedestrian Omit	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	
A5158	A2011 C2011.304 C2011.006	Phase Hold	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	
A5159	C2012.002	Phase Force Off	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	
A5160	A2011 C2011.005	Phase Vehicle Call	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	
A5161	A2011 C2011.303	Phase Pedestrian Call	MMITSS Intersection	NTCIP	On (1) or Off (0) per phase number	10 Hz	N/A	D	

6.3.3 Communication Interface Requirements

Communications between MMITSS components and most modern transportation management system components (e.g. controllers, transit management systems, and fleet management systems) will be supported by IP based communications, such as Ethernet. Legacy components (e.g., older traffic signal controllers) may support only serial (RS-232) communications with either NTCIP (STMP - Simple Transportation Management Protocol) over PMPP (point to multi-point communications), the California AB3418 protocol, or vendor specific (proprietary) protocols. Support of vendor specific protocols will require software customization and may be limited by the capabilities of the protocol.

6.3.4 External TMC, TMS, EMS, and FMS Interface Requirements

Communications between system level components shall utilize the NTCIP Center to Center communications for peer-to-peer communications including: (a) TMDD—The TMDD Standard for Traffic Management Center-to-Center Communications covers the functional area of traffic management, and is a joint standard of ITE and AASHTO; (b) ATIS—The Message Sets for Advanced Traveler Information Systems, SAE J2354, is a standard of the Society of Automotive Engineers; (c) TCIP—The Transit Communications Interface Profile (TCIP) is an American Public Transit Association (APTA) standard to allow transit agencies and transit suppliers to create standardized tailored interfaces. TCIP is based on the earlier NTCIP 1400-series standards; (d) IM—The incident management (IM) standards of IEEE, IEEE 1512 series, have been developed to standardize communications between transportation and emergency management centers.

6.4 "Ilities" Requirements

The requirements associated with the "ilities" of a fully operational MMITSS exceed those imposed on the current research project. This section provides an overview of "ilities" and provides proposed requirements that are applicable to the prototypes being deployed in the Arizona and California testbeds.

6.4.1 Reliability

Reliability is often defined as the ability of a system to perform its intended function or mission when operating for a specified period of time and operational situation. As the MMITSS matures from research prototypes to operational deployments, the *mission* can be defined in terms of specific use cases such as those presented in Section 7.2.

Since traffic signal systems can be operated at intersection, section, and system levels, MMITSS system reliability shown in F7007 can be allocated mathematically to section and intersection levels and applied through the addition of child-requirements. This progression in specificity can be accompanied by the inclusion of figures of merit and measurement such as *mean time between failure (MTBF)* and *mean time to failure (MTTF).* The reader will note that the reliability requirement, F7007, is designated as a future requirement through the RQID. As discussed during the MMITSS ConOps Workshop, it is assumed that it could take five years before the penetration rate of equipped vehicles and equipped travelers is sufficient to reach nominal operation of MMITSS. Aside from performing simulations and reliability analyses, adequate verification of system-level reliability is unlikely to occur in the time period associated with an A-level RQID.

RQID: F7007	**Title:** MMITSS Reliability
Verification: A	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All
Requirement Text: The MMITSS will have a system-reliability greater than or equal to 95% of the operational reliability of the system it replaces.	
Supporting Text: *This requirement provides for a MMITSS system reliability that is ≥ 95% of the operational (preferably measured) reliability of the system it replaces. The rationale for specifying a value slightly less than the existing system is motivated by the fact that MMITSS provides greater functionality than the existing system. On a comparative basis, at* $0.95R_{Existing}$ *MMITSS will be providing greater*	

reliability on a comparative functional basis.

6.4.2 Maintainability

As the MMITSS development matures from a research prototype to a deployable system, it will be necessary to define requirements to address the maintainability aspects of the system. During preliminary discussions at the MMITSS ConOps Workshop, the idea of specifying these types of requirements in a comparative manner was reviewed. Specifically, the Stakeholders would prefer that a deployable MMITSS will have maintainability figures of merits (FOMs) that are better or no worse than the system being replaced. However, the added functionality provided by MMITSS needs to be incorporated into the FOMs.

During the requirements development phase of the research project, maintainability requirements were categorized in terms of (1) general maintenance, (2) traveler-specific maintenance, (3) intersection-specific maintenance, (4) section-specific maintenance, and (5) system-specific maintenance. Most of these categories include regular maintenance, installation, calibration, synchronization, check-out, and reset activities. Traveler-specific maintenance would include those tasks associated with nomadic device application maintenance, support, and upgrades. System-specific maintenance would include tasking to support data security and archiving.

6.4.3 Availability

System availability is typically described in terms of one or a combination of three measures: (1) inherent availability, (2) achieved availability, and (3) operational availability. In the anticipated life cycle of the overall MMITSS objectives, all three availability measures will be relevant and assessed. During the research aspects of MMITSS, inherent availability will be the measure of interest. As the development of MMITSS progresses with trial deployments, achieved availability will be the measure of interest. As the system matures and receives acceptance, operational availability will be the governing measure of interest. In brief summary, inherent availability assumes an ideal support environment and system operation within the bounds defined by the prototype system requirements. Achieved availability expands on the definition, estimation, and calculation by extending the applicable requirements, including the effects of preventative maintenance, and excluding logistics delay time and administrative delay time. Operational availability will factor in the full system requirements and actual operational conditions, in contrast to the limited operational conditions imposed by the Arizona and California testbeds (e.g., lack of sustained freezing temperatures and precipitation).

RQID: B7001	**Title:** Inherent Availability
Verification: A	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: The MMITSS shall have an inherent availability greater than or equal to 95% of the operational availability of the testbeds.	
Supporting Text: *This requirement provides for an inherent availability that is ≥ 95% of the operational availability of the two testbeds. As described in the Final MMITSS Requirements Document, the inherent availability factors in requirements imposed on the research prototypes without the effect of preventative maintenance and the need to operate in actual operational environments that a mature MMITSS system would experience throughout the USA (e.g., temperature ranges of Yuma, Arizona to Anchorage, Alaska). Verification of the parent requirement does not require that a single prototype meet the threshold of actual operational availability of both the Arizona and California testbeds.*	

RQID: B7001.101	**Title:** Inherent Availability – Arizona MMITSS Prototype
Verification: A	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: The Arizona MMITSS prototype shall have an inherent availability greater than or	

equal to 95% of the operational availability of the Arizona testbed.
Supporting Text: *This requirement provides for an inherent availability of the Arizona MMITSS prototype that is ≥ 95% of the operational availability of the Arizona testbed. As described in the Final MMITSS Requirements Document, the inherent availability factors in requirements imposed on the research prototypes without the effect of preventative maintenance and the need to operate in actual operational environments that a mature MMITSS system would experience throughout the USA (e.g., temperature ranges of Yuma, Arizona to Anchorage, Alaska). This requirement can be verified by analysis, simulation, or a combination of analysis and test data.*

RQID: B7001.102	**Title:** Inherent Availability – California MMITSS Prototype
Verification: A	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: The California MMITSS prototype shall have an inherent availability greater than or equal to 95% of the operational availability of the California testbed.	
Supporting Text: *This requirement provides for an inherent availability of the California MMITSS prototype that is ≥ 95% of the operational availability of the California testbed. As described in the Final MMITSS Requirements Document, the inherent availability factors in requirements imposed on the research prototypes without the effect of preventative maintenance and the need to operate in actual operational environments that a mature MMITSS system would experience throughout the USA (e.g., temperature ranges of Yuma, Arizona to Anchorage, Alaska). This requirement can be verified by analysis, simulation, or a combination of analysis and test data.*	

6.4.4 Design Life

Although the MMITSS is a new and transformational system, it needs to be designed with the lifecycle and design life imposed on the predecessor system, which can be in excess of 50 years. As the MMITSS development matures from a research prototype to a deployable system, design life requirements need to be developed, matured, and supported. The MMITSS research prototype(s) are designed with a five and 10 year time horizon consideration and are expected to support MMITSS functionality for up to five years.

6.4.5 Fault Tolerance and Error Handling

Fault tolerance and error handling requirements provide the guidance and constraints on how MMITSS will respond to expected, probabilistic, or catastrophic errors or events. Since MMITSS is currently a research project, the requirements presented in this section are a mere subset of those that would be imposed on a system integrated into America's greater roadway and traffic system. For a fully deployed system, this section would be integrated with the safety requirements to ensure that great care has been taken to address error handling that could prevent or minimize safety hazards.

In the MMITSS research system, the fault tolerance and error handling requirements are focused on errors or events that would require MMITSS to transfer control of the traffic system to the nominal operation of the underlying traffic signal controller (TSC). Such situations would exist if MMITSS suffered a loss of power, loss of communication with the TSC, or loss of communication with equipped vehicles and equipped travelers (total loss or sufficient periods of communication loss).

In addition to the more severe fault tolerance and error handling, there are specific instances where MMITSS can govern and correct fault and error conditions. These instances include transmitted data elements that are outside the acceptable ranges specified in the Data Element Tables shown in Sections 6.2.1 - 6.2.6.

RQID: A7002	**Title:** Loss of Power Error Handling
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5

Requirement Text: The MMITSS shall be integrated with the traffic signal controller (TSC) such that a MMITSS loss of power results in transfer of control to the TSC.
Supporting Text: *This requirement provides error handling associated with the loss of power to MMITSS regardless of the power status of the TSC. MMITSS needs to be designed and integrated into the TSC in a manner where if "the plug were pulled on MMITSS" the TSC assumes control of the intersection with respect to signal function, parameters, and traffic flow.*

1

RQID: A7003	**Title:** Loss of Communication Error Handling with TSC
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: The MMITSS shall be integrated with the traffic signal controller (TSC) such that a loss or sustained interruption of communication between the MMITSS and TSC would result in transfer of control to the TSC.	
Supporting Text: *This requirement provides error handling for lost or dropped communication between the MMITSS and TSC. A communication loss or drop is defined as unresponsiveness during attempts to communicate signal parameters listed in Section 6.2.6 or data elements listed in Section 6.2.3. In such cases of communication loss or sustained interruption, the TSC would command control of the intersection. Specifically, the TSC would behave as though the MMITSS was not present.*	

2

RQID: A7004	**Title:** Loss of Communication Error Handling of Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: In the event of communication loss or drop with an equipped vehicle or equipped traveler, MMITSS shall service the equipped vehicle or equipped traveler as though it were unequipped (i.e., current nominal behavior of intersection TSC).	
Supporting Text: *This requirement provides error handling for lost or dropped communication with an equipped vehicle or traveler that was being serviced by MMITSS. A communication loss or drop is defined as unresponsiveness during attempts to communicate basic status messages, signal status messages, and requests for priority/consideration. In such cases of communication loss, MMITSS will handle the vehicle or traveler as though it were unequipped. Specifically, the vehicle or traveler would be treated as though MMITSS were not present.*	

3

RQID: C7004.001	**Title:** Loss of Communication Error Handling of Equipped Vehicles
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: In the event of communication loss or drop with an equipped vehicle, MMITSS shall service the equipped vehicle as though it were unequipped (i.e., current nominal behavior of intersection TSC).	
Supporting Text: *This requirement provides error handling for lost or dropped communication with an equipped vehicle that was being serviced by MMITSS. A communication loss or drop is defined as unresponsiveness during attempts to communicate basic status messages, signal status messages, and requests for priority/consideration. In such cases of communication loss, MMITSS will handle the vehicle as though it were unequipped. Specifically, the vehicle would be treated as though MMITSS were not present.*	

4

RQID: C7004.302	**Title:** Loss of Communication Error Handling of Equipped Travelers
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: In the event of communication loss or drop with an equipped traveler, MMITSS shall service the equipped traveler as though it were unequipped (i.e., current nominal behavior of intersection TSC).	
Supporting Text: *This requirement provides error handling for lost or dropped communication with an equipped traveler that was being serviced by MMITSS. A communication loss or drop is defined as unresponsiveness during attempts to communicate basic status messages, signal status messages, and requests for priority/consideration. In such cases of communication loss, MMITSS will handle the traveler*	

as though it were unequipped. Specifically, the traveler would be treated as though MMITSS were not present.

1

RQID: A7005	**Title:** Data Range Error Handling of Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: The MMITSS shall integrate error handling to address and resolve received data elements that are outside of data ranges (specified in Sections 6.2.1-6.2.5) from equipped vehicles and equipped travelers.	
Supporting Text: *This requirement provides error handling for addressing and resolving the value of data elements that were received or interpreted as out-of-range as specified in the Data Element Tables (Section 6.2.1-6.2.5). Without specifying design implementations, there are numerous ways that a MMITSS prototype can implement error handling for out-of-range values that are received during transmissions with equipped vehicles and travelers. For instance, MMITSS could request that data messages be retransmitted, could wait for the next message receipt, or it could reassign the value to the smallest, largest, or nearest value to the one received.*	

2

RQID: A7005.001	**Title:** Priority Level Data Range Error Handling of Equipped Vehicles
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: In the event that an equipped vehicle priority level request exceeds the range of acceptable priority for the corresponding type of vehicle, the MMITSS shall integrate error handling to ensure adherence with the N-level priority scheme.	
Supporting Text: *This requirement provides error handling for addressing and resolving the possibility that a priority level request exceeds the acceptable range for the specific type/class vehicle requesting consideration. Without specifying design implementations, there are numerous ways that a MMITSS prototype can implement error handling to ensure compliance with the N-level priority scheme assigned to various classes of equipped vehicles. Error handling might be different for different classes of vehicles, for example emergency vehicles might by handled differently than transit or trucks.*	

3

RQID: A7005.002	**Title:** Vehicle Speed Data Range Error Handling of Equipped Vehicles
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All; Stakeholder Input 7.3.5
Requirement Text: In the event that an equipped vehicle speed exceeds the range of acceptable values, the MMITSS shall integrate error handling to ensure adherence with dilemma zone functionality.	
Supporting Text: *This requirement provides error handling for addressing and resolving the possibility that an equipped vehicle speed exceeds the acceptable range for the specific type/class vehicle approaching an intersection. Without specifying design implementations, there are numerous ways that a MMITSS design can implement error handling to ensure compatibility with the dilemma zone functionality.*	

4

RQID: A7006	**Title:** Error Handling of Equipped Vehicles and Travelers
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All
Requirement Text: In the event of a critical component failure in the connected vehicle capability, MMITSS shall enter a default mode of control where all equipped vehicles and equipped travelers are treated as unequipped.	
Supporting Text: *This requirement provides error handling and a fault tolerant approach when the connected vehicle capability has sustained a critical component failure. In such case, the operation of MMITSS will revert to the nominal, unequipped system operation. Specifically, the intersection, section, or system would operate as though MMITSS were not present.*	

5

RQID: C7006.001	**Title:** Error Handling of Equipped Vehicles
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All
Requirement Text: In the event of a critical equipped vehicle component failure, MMITSS shall treat the vehicle as unequipped.	
Supporting Text: *This requirement provides error handling and a fault tolerant approach when the*	

connected vehicle capability has sustained a critical component failure. In such case, MMITSS will treat the vehicle as unequipped. Specifically, an equipped vehicle with a failed critical component traversing the intersection, section, or system would be treated as an unequipped vehicle.

RQID: C7006.302	**Title:** Error Handling of Equipped Travelers
Verification: T	**Traceability:** ConOps §7, §11.1.3, §12.5.1, §12.7.6; Use Case All
Requirement Text: In the event of a critical component failure of an equipped traveler component, MMITSS shall treat the equipped traveler as an unequipped traveler.	
Supporting Text: *This requirement provides error handling and fault tolerant approach when the connected capability has sustained a critical component failure. In such case, the operation of MMITSS will revert to the nominal, unequipped system operation. Specifically, all pedestrians traversing the intersection, section, or system would be treated as unequipped travelers.*	

6.4.6 Operability and Interoperability

As the MMITSS development matures from a research prototype to a deployable system, requirements supporting interoperability with various transit management systems (TMS), fleet management systems (FMS) and emergency management systems (EMS) need to be developed, matured, and supported to obtain the operability and interoperability implied in the MMITSS Conceptual Architecture (Figure 1). For the two research prototype systems, only the operability and interoperability described in the specific use cases will be considered (See Section 7.2 for use cases 11.2.3, 11.4.2, 11.5.1, and 11.5.2).

MMITSS shall be designed to be operable and interoperable with other connected vehicle components that utilize the specified communication standards. The MMITSS prototype software shall be designed to operate on hardware that exists (or is being procured) in the Arizona and California testbeds, and designed such that it utilizes standard C or C++ programming languages and can be ported to other hardware platforms.

6.4.7 Environmental Compatibility

The definition and design of a deployable MMITSS must take into consideration the extreme and diverse environment that the system or its subsystems will experience. The environmental compatibility requirements imposed on the MMITSS are divided into two categories: operating environment and non-operating environment. Each of these environmental categories will impact the analysis and assessment of reliability, maintainability, and availability presented previously.

6.4.7.1 Operating Environment

The operating environment of MMITSS includes the expected outdoor and indoor (e.g., system data archiving, computer interfaces, etc.) environments that the system will experience during nominal operation, system initiation, system operation, and maintenance. Future requirements for MMITSS should specify operating temperature, humidity (condensing and non-condensing), precipitation, lightning, electro-static discharge (ESD), UV-exposure, duty cycles, and acoustics. For subsystems located near intersections, the inclusion of shock and vibration environmental factors should be included if the equipment is in close proximity to vehicle travel paths.

6.4.7.2 Non-Operating Environment

The non-operating environment of MMITSS includes the dynamic and static environments associated with equipment transportation, shipment, and storage. Again, the extreme and diverse conditions that traffic control systems experience will carryover in some instances and extent to non-operating environments. Future requirements for MMITSS should specify non-operating temperature, humidity, precipitation, ESD, UV-exposure, shock, and vibration.

6.5 Performance Requirements

The MMITSS Performance Requirements are divided into two categories: Performance Measures Requirements (Section 6.5.1) and Performance Evaluation Requirements (Section 6.5.2). Performance measures (or measurements) are specified quantities that MMITSS estimates, calculates, monitors, controls, uses, and archives in the process of functioning and operating the system. In contrast, performance evaluation requirements define specific measures and methods that will be used to evaluate the performance of one system design against another system design. These evaluation requirements define how well a design met the totality of system requirements in contrast to fulfilling individual requirements, which is the purpose of requirement verification.

6.5.1 Performance Measures Requirements

As initiated in the Stakeholder feedback (See Section 8.6) and furthered in the MMITSS ConOps Workshop (See Final MMITSS ConOps Section 12.7), the collection, measurement, and estimation of performance measures serve a variety of users and needs. For system development, this data is critical in monitoring and assessing system performance over varying time intervals (e.g., peak period, all day, short-term, mid-term, and long-term performance). Agencies fielding, operating, and maintaining MMITSS deployments will be interested in the operational and state-of-health (SOH) performance, especially at the MMITSS intersection level. Original equipment manufacturers (OEMs) will be interested in the data for assessing reliability, availability, maintainability, and lifecycle costs. The diversity and applicability of these performance measures are nearly as large as the number of MMITSS requirements supporting these useful measures. As such, the organization and presentation of these particular requirements are shown as requirement trees with parent-child associations. These requirement trees are organized based on applicability at the intersection, section, and system level.

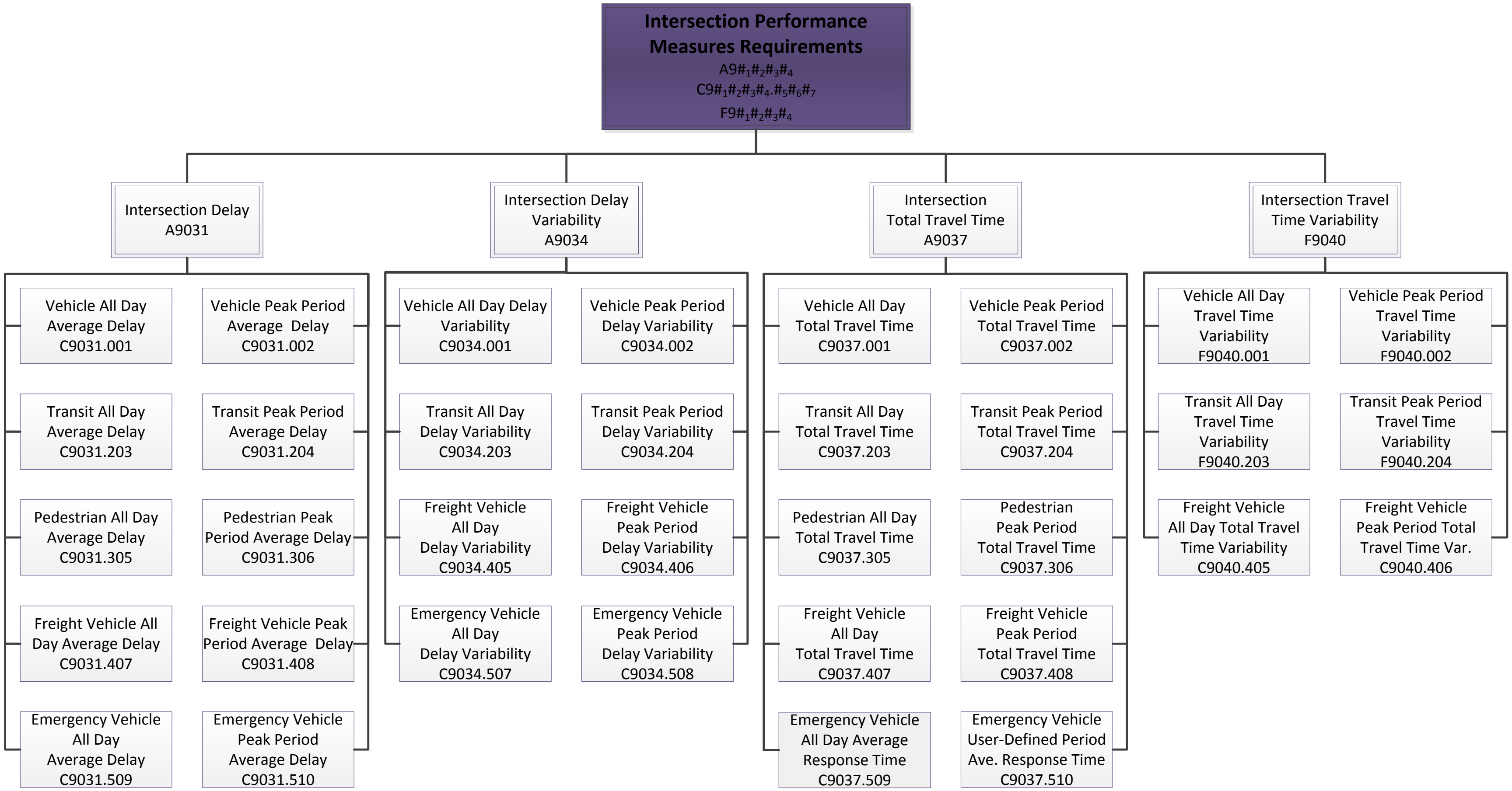

Figure 15 – MMITSS Intersection Performance Measures Requirements (Part 1)

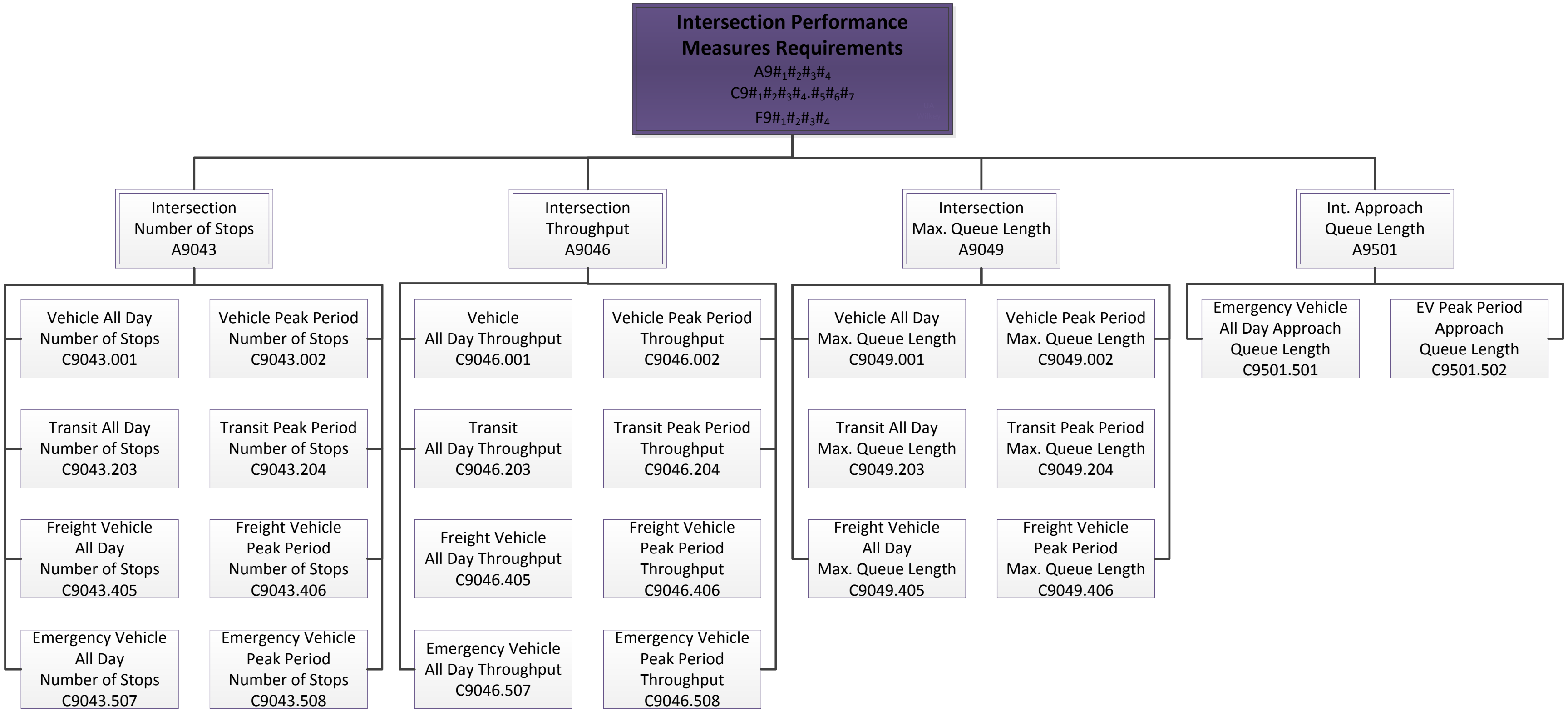

Figure 16 – MMITSS Intersection Performance Measures Requirements (Part 2)

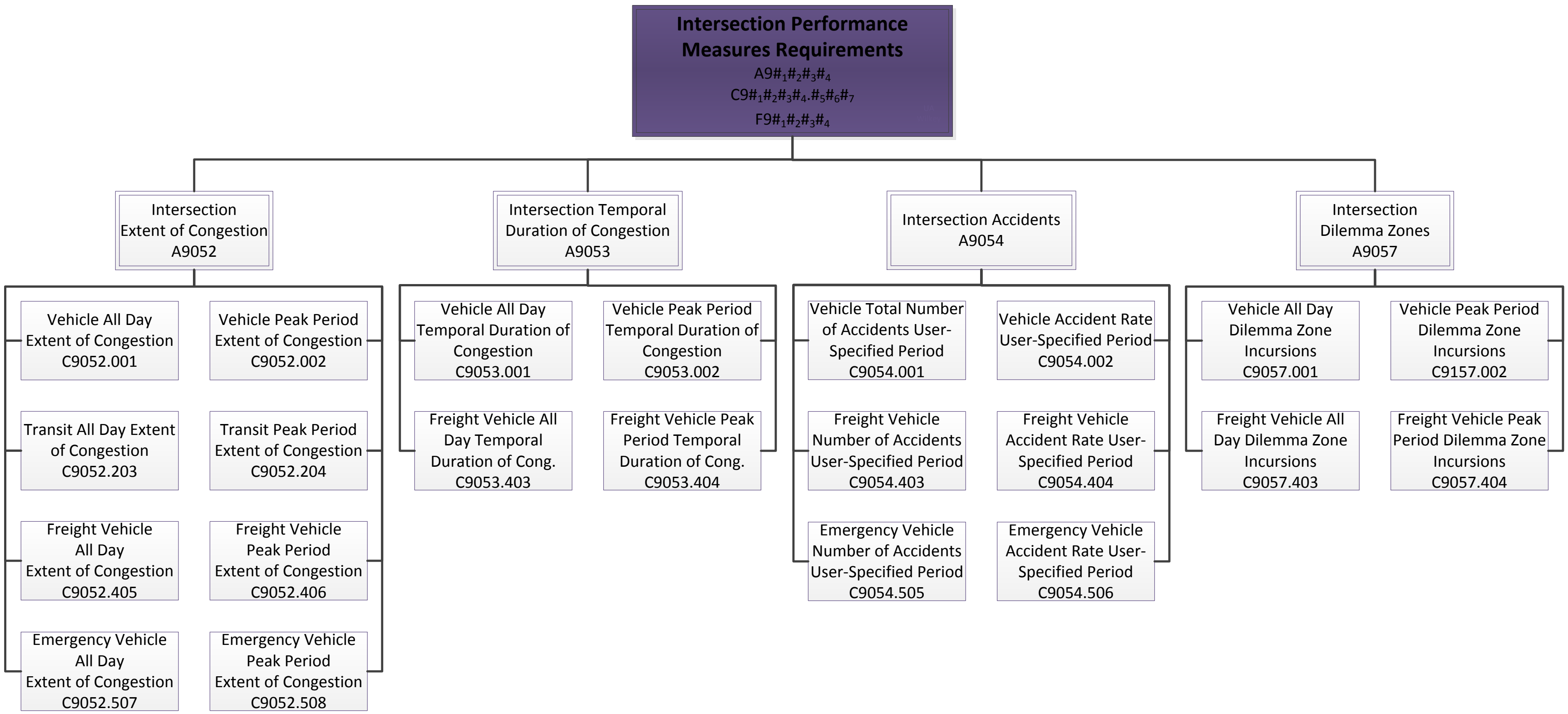

Figure 17 – MMITSS Intersection Performance Measures Requirements (Part 3)

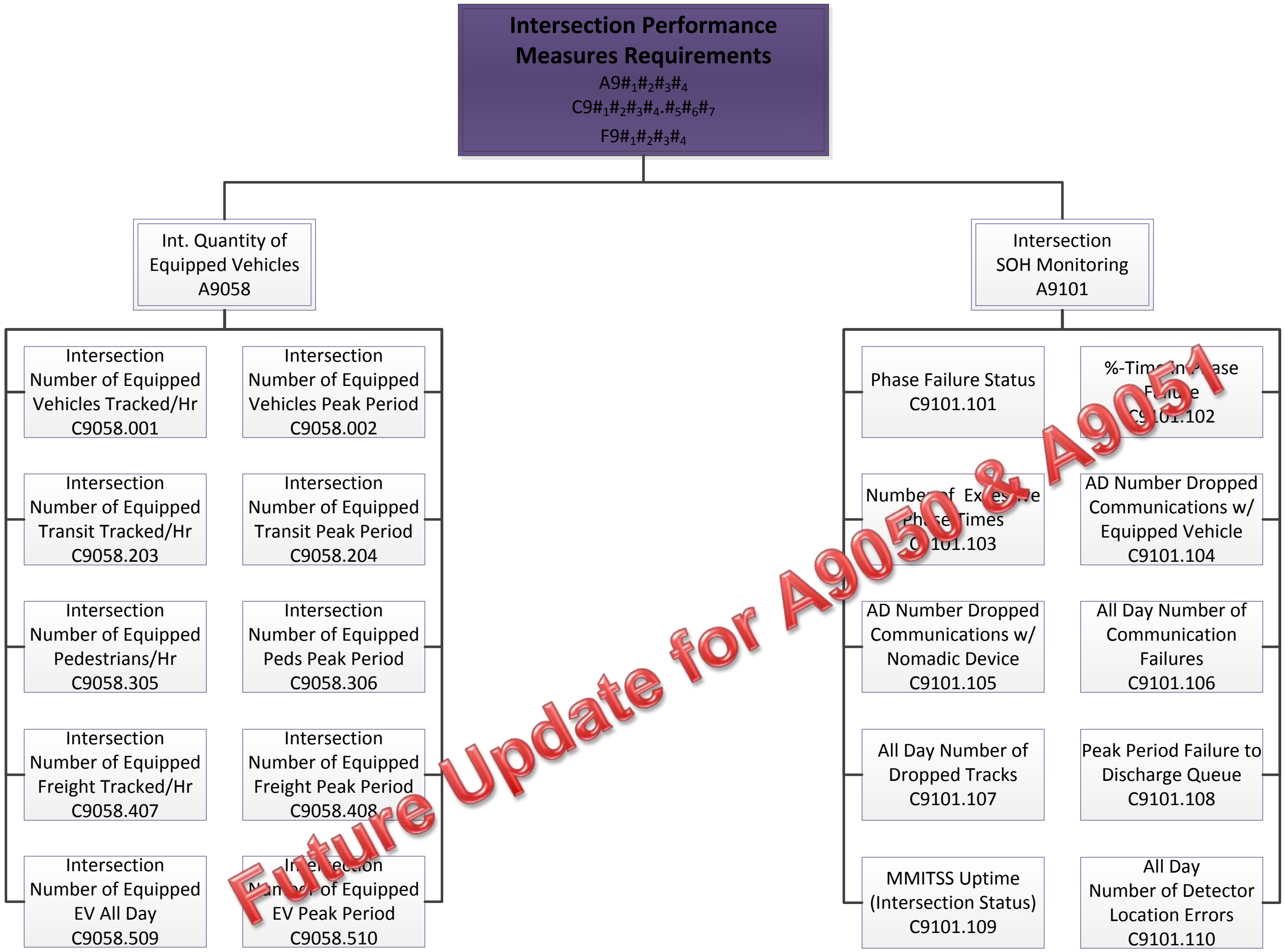

Figure 18 – MMITSS Intersection Performance Measures Requirements (Part 4)

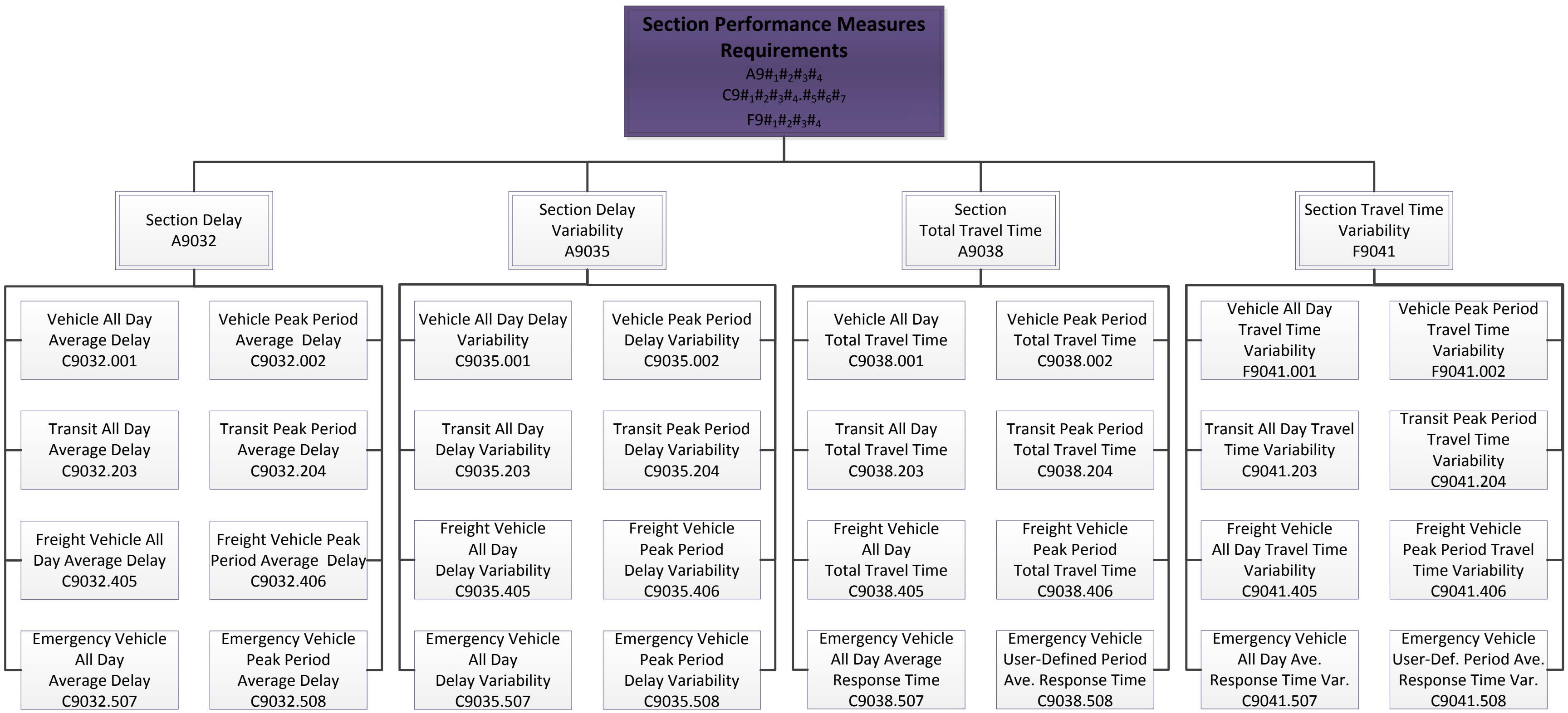

Figure 19 – MMITSS Section Performance Measures Requirements (Part 1)

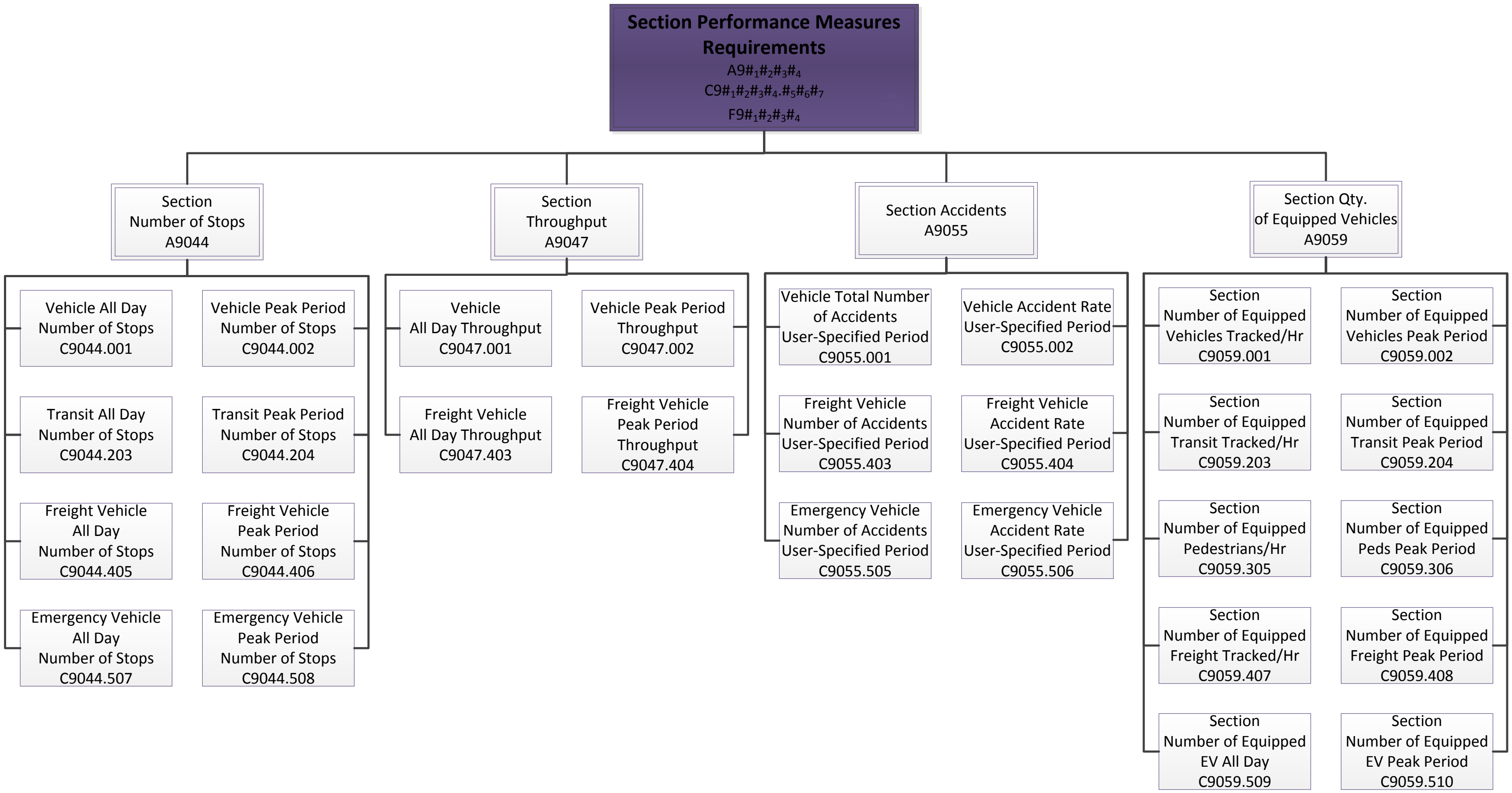

Figure 20 – MMITSS Section Performance Measures Requirements (Part 2)

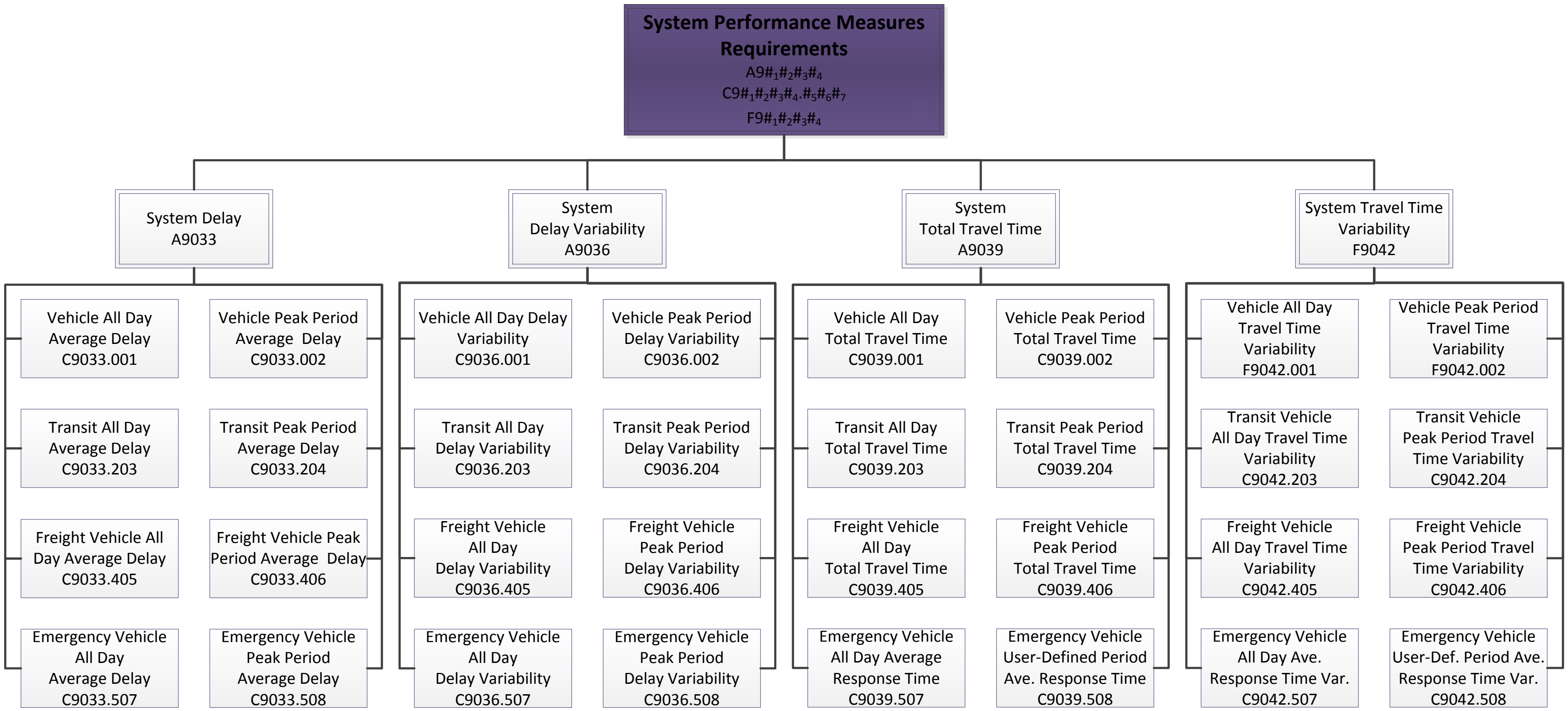
System Performance Measures Requirements
$A9\#_1\#_2\#_3\#_4$
$C9\#_1\#_2\#_3\#_4.\#_5\#_6\#_7$
$F9\#_1\#_2\#_3\#_4$
System Delay A9033
System Delay Variability A9036
System Total Travel Time A9039
System Travel Time Variability F9042
Vehicle All Day Average Delay C9033.001
Vehicle Peak Period Average Delay C9033.002
Transit All Day Average Delay C9033.203
Transit Peak Period Average Delay C9033.204
Freight Vehicle All Day Average Delay C9033.405
Freight Vehicle Peak Period Average Delay C9033.406
Emergency Vehicle All Day Average Delay C9033.507
Emergency Vehicle Peak Period Average Delay C9033.508
Vehicle All Day Delay Variability C9036.001
Vehicle Peak Period Delay Variability C9036.002
Transit All Day Delay Variability C9036.203
Transit Peak Period Delay Variability C9036.204
Freight Vehicle All Day Delay Variability C9036.405
Freight Vehicle Peak Period Delay Variability C9036.406
Emergency Vehicle All Day Delay Variability C9036.507
Emergency Vehicle Peak Period Delay Variability C9036.508
Vehicle All Day Total Travel Time C9039.001
Vehicle Peak Period Total Travel Time C9039.002
Transit All Day Total Travel Time C9039.203
Transit Peak Period Total Travel Time C9039.204
Freight Vehicle All Day Total Travel Time C9039.405
Freight Vehicle Peak Period Total Travel Time C9039.406
Emergency Vehicle All Day Average Response Time C9039.507
Emergency Vehicle User-Defined Period Ave. Response Time C9039.508
Vehicle All Day Travel Time Variability F9042.001
Vehicle Peak Period Travel Time Variability F9042.002
Transit Vehicle All Day Travel Time Variability C9042.203
Transit Vehicle Peak Period Travel Time Variability C9042.204
Freight Vehicle All Day Travel Time Variability C9042.405
Freight Vehicle Peak Period Travel Time Variability C9042.406
Emergency Vehicle All Day Ave. Response Time Var. C9042.507
Emergency Vehicle User-Def. Period Ave. Response Time Var. C9042.508

Figure 21 – MMITSS System Performance Measures Requirements (Part 1)

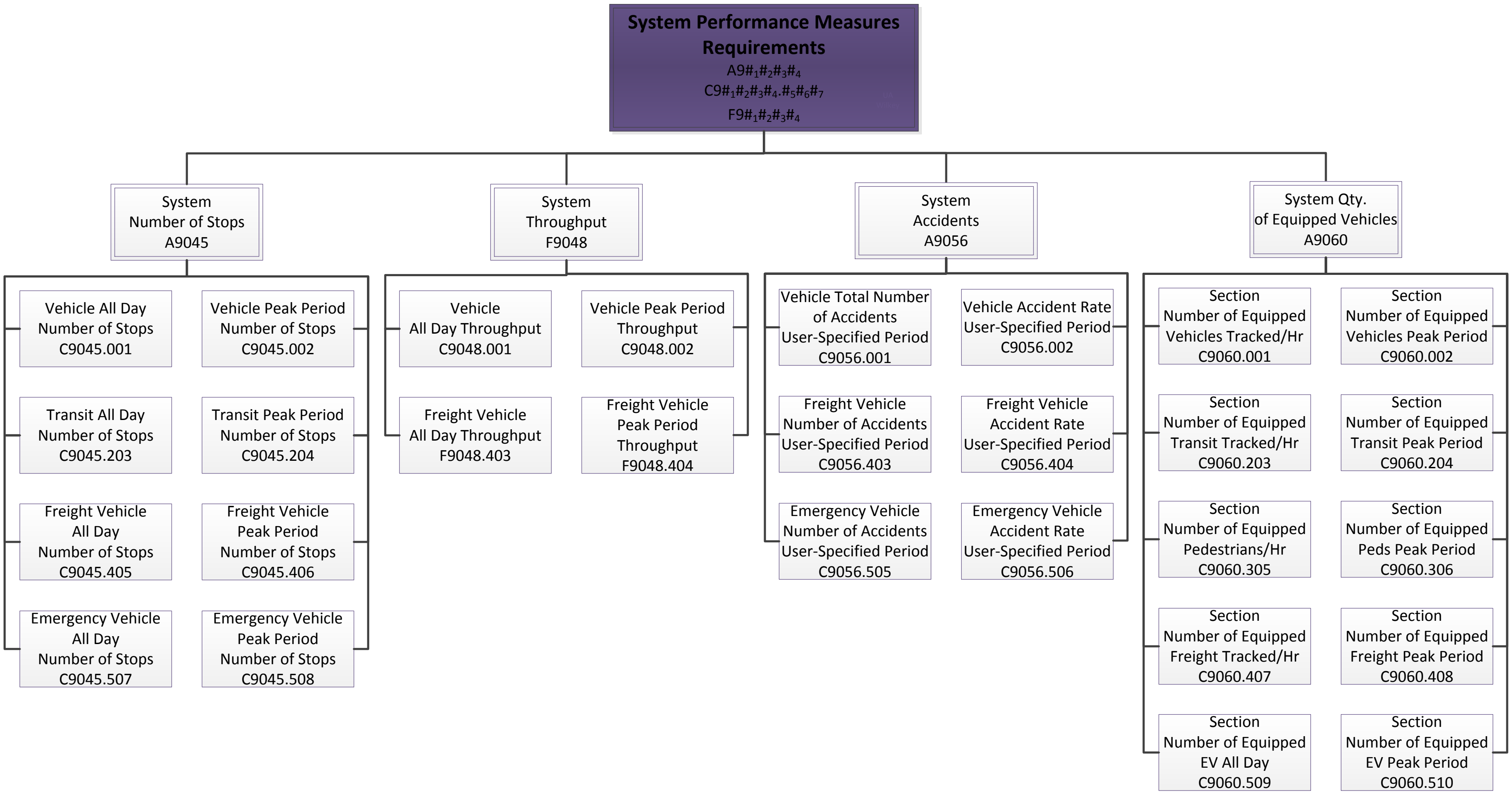

Figure 22 – MMITSS System Performance Measures Requirements (Part 2)

6.5.2 Performance Evaluation Requirements

As described previously, performance evaluation requirements define specific criteria and methods that will be used to evaluate the performance of one system design against another system design or multiple alternative designs. These evaluation requirements define how well a design met the totality of all requirements in terms of prescribed performance. This is in contrast to fulfilling individual requirements, which is the purpose of requirement verification.

Given the scope and complexity of MMITSS, a hierarchical structure is employed with the Performance Evaluation Requirements to aid in understanding and execution. At the highest level, these requirements are divided into intersection, section, and system level performance. The next level is defined by the criteria of interest (e.g., delay, travel time, etc.). The third level, where applicable, defines the timeframe or duration of the evaluation criteria (e.g., all-day criteria or peak period criteria). Where applicable, the final hierarchical level is defined on a modal basis (e.g., all vehicles, pedestrians, transit, freight, and EV). This structure is best viewed from the tree diagrams presented in the corresponding sections.

6.5.2.1 Intersection Performance Evaluation Requirements

Intersection performance evaluation requirements define specific criteria and methods that will be used to evaluate the performance at only an intersection level when one system design is compared or evaluated with another system design or multiple alternative designs. These evaluation requirements define how well a design met the totality of requirements in terms of prescribed performance as measured or observed at an intersection. This is in contrast to fulfilling individual intersection requirements, which is the purpose of requirement verification.

The number and structure of intersection performance evaluation requirements is substantial. As such, this material is introduced using a requirements tree structure. Following the requirements tree, each requirement is presented in the standard MMITSS requirement format. This approach is used to avoid losing the attention of the reader in this important material.

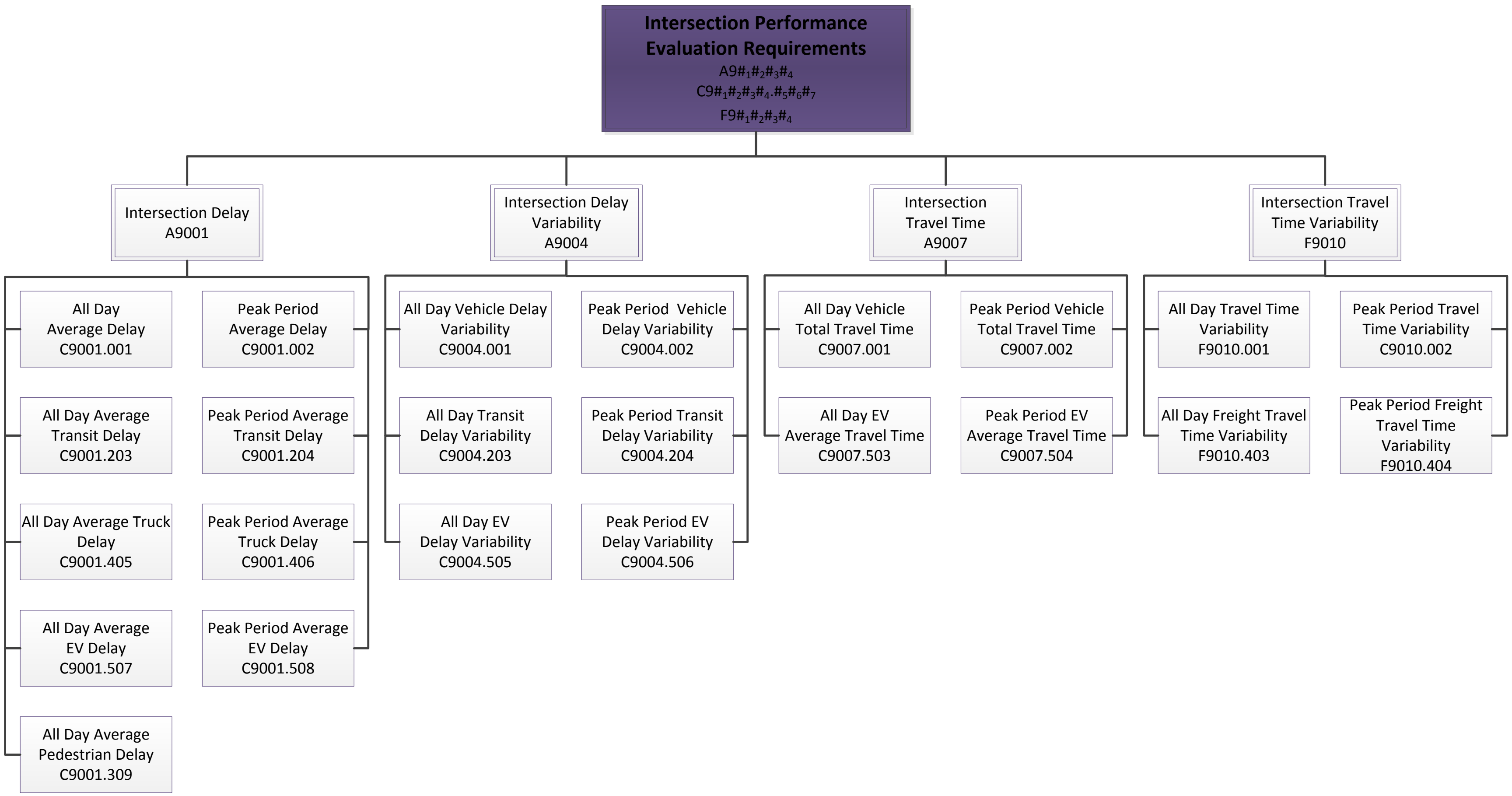

Figure 23 – MMITSS Intersection Performance Evaluation Requirements (Part 1)

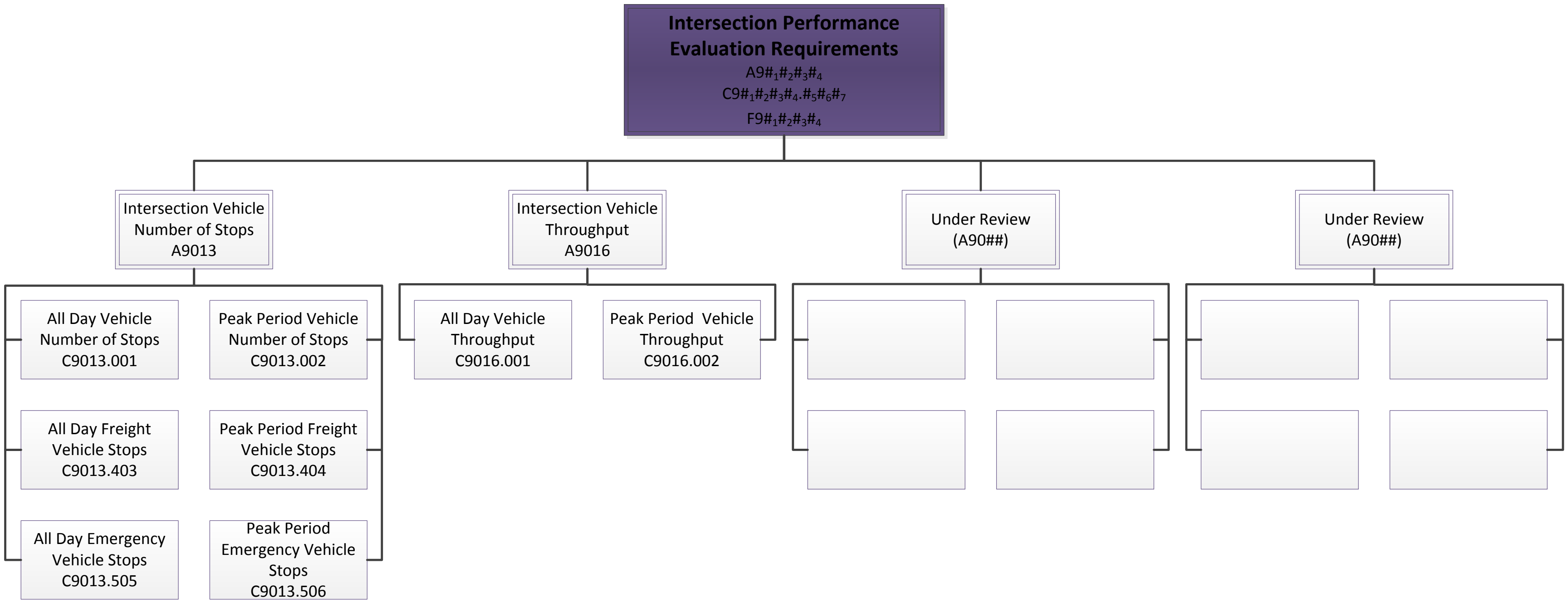

Figure 24 – MMITSS Intersection Performance Evaluation Requirements (Part 2)

RQID: A9001	**Title:** Evaluate Performance on Intersection Vehicle and Traveler Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on delay of vehicles and travelers traversing the intersection.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of intersection performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.001	**Title:** Evaluate Performance on Intersection Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on average delay throughout the day of vehicles traversing the intersection.	
Supporting Text: *Average vehicle delay is the broadest aggregate measure of intersection performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.002	**Title:** Evaluate Performance on Intersection Peak Period Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on average delay during the peak period of vehicles traversing the intersection.	
Supporting Text: *Average vehicle delay is the broadest aggregate measure of intersection performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.203	**Title:** Evaluate Performance on Intersection Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance shall be judged on the average delay throughout the day for transit vehicles traversing the intersection.	
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.204	**Title:** Evaluate Performance on Intersection Peak Period Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance shall be judged on the average delay during the peak period for transit vehicles traversing the intersection.	
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Peak period operations are particularly important for transit service and this is also the most difficult time to reduce bus delays. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.405	**Title:** Evaluate Performance on Intersection Average Truck Delay

Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance at individual intersections shall be judged on average delay throughout the day of trucks traversing the intersection.	
Supporting Text: *Average truck delay is the broadest aggregate measure of intersection performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.406	**Title:** Evaluate Performance on Intersection Peak Period Average Truck Delay
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on average delay during the peak period of trucks traversing the intersection.	
Supporting Text: *Average truck delay is the broadest aggregate measure of intersection performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.507	**Title:** Evaluate Performance on Intersection Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the average delay throughout the day experienced by emergency vehicles responding to emergencies while traversing the intersection.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.508	**Title:** Evaluate Performance on Intersection Peak Period Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the average delay during the peak period experienced by emergency vehicles responding to emergencies while traversing the intersection.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since emergency vehicle response is most challenging during peak period congestion, this measure is specifically focused on the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9001.309	**Title:** Evaluate Performance on Intersection Average Pedestrian Delay
Verification: A	**Traceability:** ConOps §12.7.3; Use Case 13.3.3
Requirement Text: MMITSS performance will be judged on the average delay throughout the day experienced by pedestrians while traversing the intersection.	
Supporting Text: *Pedestrian delay is an important measure of the quality of service experienced by pedestrians. If the delay is too large, pedestrians may ignore the traffic signals and cross the street increasing the risk of accidents. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9004	**Title:** Evaluate Performance on Intersection Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays for vehicles traversing the intersection.	

Supporting Text: *The variability of delay of vehicles traversing the intersection is the statistical variability, dispersion, or variation of delay of those vehicles over the time period of interest. This parent requirement is decomposed into child requirements for all day vehicle delay variability and peak period vehicle delay variability. It is further decomposed into transit delay variability for all day and peak period timeframes as defined in Section 12.7.1 of the Final MMITSS ConOps.*

1

RQID: C9004.001	**Title:** Evaluate Performance on Intersection All Day Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for vehicles traversing the intersection.	
Supporting Text: *The all day delay variability for all vehicles traversing the intersection is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: C9004.002	**Title:** Evaluate Performance on Intersection Peak Period Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for vehicles traversing the intersection.	
Supporting Text: *The peak period delay variability for all vehicles traversing the intersection is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: C9004.203	**Title:** Evaluate Performance on Intersection All Day Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for transit vehicles traversing the intersection.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

4

RQID: C9004.204	**Title:** Evaluate Performance on Intersection Peak Period Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for transit vehicles traversing the intersection.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

5

RQID: C9004.505	**Title:** Evaluate Performance on Intersection All Day Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for emergency vehicles responding to emergencies while traversing the intersection.	

Supporting Text: *The all day delay variability for emergency vehicles responding to emergencies while traversing the intersection is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9004.506	**Title:** Evaluate Performance on Intersection Peak Period Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for emergency vehicles responding to emergencies while traversing the intersection.	
Supporting Text: *The peak period delay variability for emergency vehicles responding to emergencies while traversing the intersection is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. A large variability indicates that the system is not adequately responding to the importance (high level of priority). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9007	**Title:** Evaluate Performance on Intersection Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the total travel time associated with traversing the intersection.	
Supporting Text: *Total intersection travel time is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the intersection. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9007.001	**Title:** Evaluate Performance on Intersection All Day Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the total travel time throughout the day for vehicles traversing the intersection.	
Supporting Text: *Total intersection travel time evaluated on an all-day basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the intersection. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9007.002	**Title:** Evaluate Performance on Intersection Peak Period Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the total travel time during the peak period for vehicles traversing the intersection.	
Supporting Text: *Total intersection travel time evaluated on a peak period basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the intersection. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9007.503	**Title:** Evaluate Performance on Intersection All Day Emergency Vehicle Average Travel Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the emergency vehicle average travel time throughout the day while responding to emergencies while traversing the intersection.	

Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for emergencies, which is best measured at the system level, but is impacted at the intersection and section levels by the travel time. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

1

RQID: C9007.504	**Title:** Evaluate Performance on Intersection Peak Period Emergency Vehicle Average Travel Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the emergency vehicle response time during the peak period while responding to emergencies while traversing the intersection.	
Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for emergencies, which is best measured at the system level, but is impacted at the intersection and section levels by the travel. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9010	**Title:** Evaluate Performance on Intersection Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time by vehicles traversing the intersection.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9010.001	**Title:** Evaluate Performance on Intersection All day Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time throughout the day by vehicles traversing the intersection.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9010.002	**Title:** Evaluate Performance on Intersection Peak Period Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time during the peak period by vehicles traversing the intersection.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9010.403	**Title:** Evaluate Performance on intersection All Day Freight Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times throughout the day of freight vehicles traversing the intersection.	

Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. Although this measure is most relevant for complete trips spanning the system-level, information gathered at the intersection and section can provide a level of granularity for identifying localized problems and performance contributions. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

1

RQID: F9010.404	**Title:** Evaluate Performance on Intersection Peak Period Freight Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times during the peak period of freight vehicles traversing the intersection.	
Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. Although this measure is most relevant for complete trips spanning the system-level, information gathered at the intersection and section can provide a level of granularity for identifying localized problems and performance contributions. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: A9013	**Title:** Evaluate Performance on Intersection Vehicle Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops incurred by vehicles at an intersection.	
Supporting Text: *The number of stops is an important measure of intersection level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: C9013.001	**Title:** Evaluate Performance on Intersection All Day Vehicle Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops throughout the day incurred by vehicles traversing the intersection.	
Supporting Text: *The number of stops is an important measure of intersection level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: C9013.002	**Title:** Evaluate Performance on Intersection Peak Period Vehicle Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops during the peak period incurred by vehicles traversing the intersection.	
Supporting Text: *The number of stops is an important measure of intersection level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: C9013.403	**Title:** Evaluate Performance on Intersection All Day Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on the number of stops throughout the day incurred by freight vehicles traversing the intersection.	

Supporting Text: *The number of freight vehicle stops is an important measure of intersection level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

RQID: C9013.404	**Title:** Evaluate Performance on Intersection Peak Period Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on the number of stops during the peak period incurred by freight vehicles traversing the intersection.	
Supporting Text: *The number of freight vehicle stops is an important measure of intersection level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9013.505	**Title:** Evaluate Performance on Intersection All Day Number of Emergency Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.5 (to be added); Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops throughout the day incurred by emergency vehicles traversing the intersection while responding to an emergency.	
Supporting Text: *The number of emergency vehicle stops is an important measure of intersection priority effectiveness. Whenever and where ever possible, MMITSS does not want to stop active emergency vehicles at an intersection. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9013.506	**Title:** Evaluate Performance on Intersection Peak Period Number of Emergency Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.5 (to be added); Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops during the peak period incurred by emergency vehicles traversing the intersection while responding to an emergency.	
Supporting Text: *The number of emergency vehicle stops is an important measure of intersection priority effectiveness. Whenever and where ever possible, MMITSS does not want to stop active emergency vehicles at an intersection. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9016	**Title:** Evaluate Performance on Intersection Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on total vehicle throughput traversing the intersection.	
Supporting Text: *Intersection throughput is an important measure of the productivity and capacity of the intersection when its performance is being pushed to its limits. This parent requirement is broken into two intersection measures: all-day throughput and peak period throughput. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

RQID: C9016.001	**Title:** Evaluate Performance on Intersection All Day Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on throughput throughout the day by vehicles traversing the intersection.	
Supporting Text: *All day throughput is an overall measure of the productivity and capacity of the intersection. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

RQID: C9016.002	**Title:** Evaluate Performance on Intersection Peak Period Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on throughput during the peak period by vehicles traversing the intersection.	
Supporting Text: *Peak period throughput is an important measure of the productivity and capacity of the intersection when its performance is being pushed to its limits. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

6.5.2.2 Section Performance Evaluation Requirements

RQID: A9002	**Title:** Evaluate Performance on Section Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the delay of vehicles traversing the section.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of section performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9002.001	**Title:** Evaluate Performance on Section Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on average delay throughout the day of vehicles traversing the section.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of section performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9002.002	**Title:** Evaluate Performance on Section Peak Period Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on average delay during the peak period of vehicles traversing the section.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of section performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9002.203	**Title:** Evaluate Performance on Section Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance shall be judged on the average delay throughout the day for transit vehicles traversing the section.	
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9002.204	**Title:** Evaluate Performance on Section Peak Period Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2

Requirement Text: MMITSS performance shall be judged on the average delay during the peak period for transit vehicles traversing the section.
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. This measure is concerned with the average transit vehicle delay during the defined peak period. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Peak period operations are particularly important for transit service and this is also the most difficult time to reduce bus delays.*

1

RQID: C9002.405	**Title:** Evaluate Performance on Section Average Truck Delay
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on the average delay throughout the day for trucks traversing the section.	
Supporting Text: *Average truck delay is the broadest aggregate measure of section performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: C9002.406	**Title:** Evaluate Performance on Section Peak Period Average Truck Delay
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on average delay during the peak period for trucks traversing the section.	
Supporting Text: *Average truck delay is the broadest aggregate measure of section performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: C9002.507	**Title:** Evaluate Performance on Section Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the average delay throughout the day experienced by emergency vehicles responding to emergencies while traversing the section.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since emergency vehicle response is most challenging during peak period congestion, consider an additional measure specifically focused on the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: C9002.508	**Title:** Evaluate Performance on Section Peak Period Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the average delay during the peak period experienced by emergency vehicles responding to emergencies while traversing the section.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since emergency vehicle response is most challenging during peak period congestion, this measure is specifically focused on the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: A9005	**Title:** Evaluate Performance on Section Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5

Requirement Text: MMITSS performance shall be judged on the variability of delays for vehicles traversing the section.	
Supporting Text: *The variability of delay of vehicles traversing the section is the statistical variability, dispersion, or variation of delay of those vehicles over the time period of interest. This parent requirement is decomposed into child requirements for all day vehicle delay variability and peak period vehicle delay variability. It is further decomposed into transit delay variability for all day and peak period timeframes as defined in Section 12.7.1 of the Final MMITSS ConOps.*	

1

RQID: C9005.001	**Title:** Evaluate Performance on Section All Day Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the variability of delays throughout the day for vehicles traversing the section.	
Supporting Text: *The all day delay variability for all vehicles traversing the section is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: C9005.002	**Title:** Evaluate Performance on Section Peak Period Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the variability of delays during the peak period for vehicles traversing the section.	
Supporting Text: *The peak period delay variability for all vehicles traversing the section is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: C9005.203	**Title:** Evaluate Performance on Section All Day Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance shall be judged on the variability of delays throughout the day for transit vehicles traversing the section.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

4

RQID: C9005.204	**Title:** Evaluate Performance on Section Peak Period Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance shall be judged on the variability of delays during the peak period for transit vehicles traversing the section.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

5

RQID: C9005.505	**Title:** Evaluate Performance on Section All Day Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the variability of delays throughout the day for emergency vehicles responding to emergencies while traversing the section.	

Supporting Text: *The all day delay variability for emergency vehicles responding to emergencies while traversing the section is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

1

RQID: C9005.506	**Title:** Evaluate Performance on Section Peak Period Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance shall be judged on the variability of delays during the peak period for emergency vehicles responding to emergencies while traversing the section.	
Supporting Text: *The peak period delay variability for emergency vehicles responding to emergencies while traversing the section is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. A large variability indicates that the system is not adequately responding to the importance (high level of priority).. At the Section a high level of variability could reflect the impact of section level priority performance of MMITSS. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9008	**Title:** Evaluate Performance on Section Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the total travel time associated vehicles with traversing the section.	
Supporting Text: *Section vehicle total travel time is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the section. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9008.001	**Title:** Evaluate Performance on Section All Day Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the total travel time throughout the day for vehicles traversing the section.	
Supporting Text: *Total section travel time evaluated on an all-day basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the section. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9008.002	**Title:** Evaluate Performance on Section Peak Period Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the total travel time during the peak period for vehicles traversing the section.	
Supporting Text: *Total travel time evaluated on an peak period basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the section. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9008.503	**Title:** Evaluate Performance on Section All Day Emergency Vehicle Response Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the emergency vehicle response time throughout the day while responding to emergencies while traversing the section.	

Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for handling emergencies, which is best measured at the system level, but is impacted at the intersection and section levels. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

1

RQID: F9008.504	**Title:** Evaluate Performance on Section Peak Period Emergency Vehicle Response Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the emergency vehicle response time during the peak period while responding to emergencies while traversing the section.	
Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for handling emergencies, which is best measured at the system level, but is impacted at the intersection and section levels. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9011	**Title:** Evaluate Performance on Section Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time by vehicles traversing the section.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9011.001	**Title:** Evaluate Performance on Section All day Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time throughout the day by vehicles traversing the section.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9011.002	**Title:** Evaluate Performance on Section Peak Period Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time during the peak period by vehicles traversing the section.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9011.403	**Title:** Evaluate Performance on Section All Day Freight Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times throughout the day of freight vehicles traversing the section.	

Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. Although this measure is most relevant for complete trips spanning the system-level, information gathered at the intersection and section can provide a level of granularity for identifying localized problems and performance contributions. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

RQID: F9011.404	**Title:** Evaluate Performance on Section Peak Period Freight Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times during the peak period of freight vehicles traversing the section.	
Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. Although this measure is most relevant for complete trips spanning the system-level, information gathered at the intersection and section can provide a level of granularity for identifying localized problems and performance contributions. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9014	**Title:** Evaluate Performance on Section Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops incurred at a section.	
Supporting Text: *The number of stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9014.001	**Title:** Evaluate Performance on Section All Day Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops throughout the day incurred by vehicles traversing the section.	
Supporting Text: *The number of stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9014.002	**Title:** Evaluate Performance on Section Peak Period Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on the number of stops during the peak period incurred by vehicles traversing the section.	
Supporting Text: *The number of stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9014.403	**Title:** Evaluate Performance on Section All Day Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on the number of stops throughout the day incurred by freight vehicles traversing the section.	

Supporting Text: *The number of freight vehicles stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: C9014.404	**Title:** Evaluate Performance on Section Peak Period Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance shall be judged on the number of stops during the peak period incurred by trucks traversing the section.	
Supporting Text: *The number of freight vehicle stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: A9017	**Title:** Evaluate Performance on Section Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on total vehicle throughput traversing the section.	
Supporting Text: *Section throughput is an important measure of the productivity and capacity of the intersection when its performance is being pushed to its limits. This parent requirement is broken into two section measures: all-day throughput and peak period throughput. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

RQID: C9017.001	**Title:** Evaluate Performance on Section All Day Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on throughput throughout the day by vehicles traversing the section.	
Supporting Text: *All day throughput is an overall measure of the productivity and capacity of the section. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

RQID: C9017.002	**Title:** Evaluate Performance on Section Peak Period Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance shall be judged on throughput during the peak period by vehicles traversing the section	
Supporting Text: *Peak period throughput is an important measure of the productivity and capacity of the section when its performance is being pushed to its limits. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit).*	

6.5.2.3 System Performance Evaluation Requirements

RQID: F9003	**Title:** Evaluate Performance on System Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on average delay of vehicles traversing the system.	
Supporting Text: *Average vehicle delay is the broadest aggregate measure of system performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

1

RQID: F9003.001	**Title:** Evaluate Performance on System All Day Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on average delay throughout the day of vehicles traversing the system.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of system performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9003.002	**Title:** Evaluate Performance on System Peak Period Average Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on average delay during the peak period of vehicles traversing the system.	
Supporting Text: *Vehicle delay is the broadest aggregate measure of system performance, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse (e.g., accommodation for pedestrians with disabilities). Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9003.203	**Title:** Evaluate Performance on System Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the average delay throughout the day for transit vehicles traversing the system.	
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9003.204	**Title:** Evaluate Performance on System Peak Period Average Transit Delay
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the average delay during the peak period for transit vehicles traversing the system.	
Supporting Text: *The average transit vehicle delay reduction is the best aggregate measure of effects on transit service, with implications not only for passenger service but also for operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. Peak period operations are particularly important for transit service and this is also the most difficult time to reduce bus delays.*	

5

RQID: F9003.405	**Title:** Evaluate Performance on System Average Truck Delay
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance will be judged on average delay throughout the day for trucks traversing the system.	
Supporting Text: *Average truck delay is the broadest aggregate measure of system performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

6

RQID: F9003.406	**Title:** Evaluate Performance on System Peak Period Average Truck Delay
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4

Requirement Text: MMITSS performance will be judged on average delay during the peak period for trucks traversing the system.
Supporting Text: *Average truck delay is the broadest aggregate measure of system performance on trucks, and is relevant to all MMITSS use cases, including those that are not intended to improve it and may make it worse. This requirement is concerned with average truck delay throughout the system during peak periods. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

1

RQID: F9003.507	**Title:** Evaluate Performance on System Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the average delay experienced by emergency vehicles responding to emergencies while traversing the system throughout the day.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9003.508	**Title:** Evaluate Performance on System Peak Period Average Emergency Vehicle Delay
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the average delay experienced by emergency vehicles responding to emergencies while traversing the system during the peak period.	
Supporting Text: *Emergency vehicle delays can lead to deaths or exacerbated injuries of victims needing emergency assistance, making this an important performance measure. These delays can only be measured for equipped emergency vehicles, so this performance measure should be focused on the EV priority use cases. Since emergency vehicle response is most challenging during peak period congestion, this evaluation has greater impact than the all day average delay. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9006	**Title:** Evaluate Performance on System Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays for vehicles traversing the system.	
Supporting Text: *The variability of delay of vehicles traversing the system is the statistical variability, dispersion, or variation of delay of those vehicles over the time period of interest. This parent requirement is decomposed into child requirements for all day vehicle delay variability and peak period vehicle delay variability. It is further decomposed into transit delay variability for all day and peak period timeframes as defined in Section 12.7.1 of the Final MMITSS ConOps.*	

4

RQID: F9006.001	**Title:** Evaluate Performance on System All Day Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for vehicles traversing the system.	
Supporting Text: *The all day delay variability for all vehicles traversing the system is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9006.002	**Title:** Evaluate Performance on System Peak Period Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1,13.3.2, 13.3.4, 13.3.5

Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for vehicles traversing the system.
Supporting Text: *The peak period delay variability for all vehicles traversing the system is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*

1

RQID: F9006.203	**Title:** Evaluate Performance on System All Day Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for transit vehicles traversing the system.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

2

RQID: F9006.204	**Title:** Evaluate Performance on System Peak Period Transit Delay Variability
Verification: A	**Traceability:** ConOps §12.7.2; Use Case 13.3.2
Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for transit vehicles traversing the system.	
Supporting Text: *The variability of delay is an important measure of reliability of transit service, with implications for both passenger service and operating efficiency of the transit fleet. It is relevant not only to the transit signal priority use cases, but also to the other use cases that may impose delays on transit. The variability is most crucial for peak period operations, when transit bus service is under maximum stress.*	

3

RQID: F9006.505	**Title:** Evaluate Performance on System All Day Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays throughout the day for emergency vehicles responding to emergencies while traversing the system.	
Supporting Text: *The all day delay variability for emergency vehicles responding to emergencies while traversing the system is the statistical variability, dispersion, or variation of delay of those vehicles measured over an entire 24-hour period. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9006.506	**Title:** Evaluate Performance on System Peak Period Emergency Vehicle Delay Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of delays during the peak period for emergency vehicles responding to emergencies while traversing the system.	
Supporting Text: *The peak period delay variability for emergency vehicles responding to emergencies while traversing the system is the statistical variability, dispersion, or variation of delay of those vehicles over the time period defined by local agencies as the peak period. A large variability indicates that the system is not adequately responding to the importance (high level of priority). At the System level, a high value of variability could reflect the performance of MMITSS to provide adequate section level priority. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9009	**Title:** Evaluate Performance on System Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5

Requirement Text: MMITSS performance will be judged on the total travel time associated with traversing the system.	
Supporting Text: *Total system travel time is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the system. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

1

RQID: F9009.001	**Title:** Evaluate Performance on System All Day Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the total travel time throughout the day for vehicles traversing the system.	
Supporting Text: *Total system travel time evaluated on an all-day basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the system. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

2

RQID: F9009.002	**Title:** Evaluate Performance on System Peak Period Vehicle Total Travel Time
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the total travel time during the peak period for vehicles traversing the system.	
Supporting Text: *Total travel time evaluated on an peak period basis is defined as the cumulative time that all vehicles require to travel when inside the boundaries of the system. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

3

RQID: F9009.503	**Title:** Evaluate Performance on System All Day Emergency Vehicle Response Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the emergency vehicle response time throughout the day while responding to emergencies while traversing the system.	
Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for handling emergencies, which is best measured at the system level. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

4

RQID: F9009.504	**Title:** Evaluate Performance on System Peak Period Emergency Vehicle Response Time
Verification: A	**Traceability:** ConOps §12.7.5; Use Case 13.3.5
Requirement Text: MMITSS performance will be judged on the emergency vehicle response time during the peak period while traversing the system while responding to emergencies.	
Supporting Text: *A meaningful measure of emergency vehicle operational performance is the response time for handling emergencies, which is best measured at the system level. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

5

RQID: F9012	**Title:** Evaluate Performance on System Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time by vehicles traversing the system.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

6

RQID: F9012.001	**Title:** Evaluate Performance on System All day Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time throughout the day by vehicles traversing the system.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: F9012.002	**Title:** Evaluate Performance on System Peak Period Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the variability of the travel time during the peak period by vehicles traversing the system.	
Supporting Text: *Travel time variability indicates the operational consistency of the intersection and a quality of service to users, who can plan their travel more efficiently. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: F9012.403	**Title:** Evaluate Performance on System All Day Freight Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times throughout the day of freight vehicles traversing the system.	
Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. This measure is relevant for complete trips, so it should be determined at the system level. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: F9012.404	**Title:** Evaluate Performance on System Peak Period Freight Vehicle Travel Time Variability
Verification: A	**Traceability:** ConOps §12.7.4; 13.3.4
Requirement Text: MMITSS performance will be judged on the variability of travel times during the peak period of freight vehicles traversing the system.	
Supporting Text: *Reliability of travel time is an important measure of operational efficiency for trucking, so that pickups and deliveries can be scheduled more tightly. This measure is relevant for complete trips, so it should be determined at the system level. This may not be measurable directly from MMITSS data sources, but may require dispatch data from truck fleet operators. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements.*	

RQID: F9015	**Title:** Evaluate Performance on System Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the number of stops incurred by vehicles traversing the system.	
Supporting Text: *The number of stops is an important measure of system level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements. This requirement (parent and children) is a "will" requirement because number-of-stops evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

RQID: F9015.001	**Title:** Evaluate Performance on System All Day Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the number of stops throughout the day incurred by vehicles traversing the system.	
Supporting Text: *The number of stops is an important measure of system level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements. This requirement (parent and children) is a "will" requirement because number-of-stops evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

1

RQID: F9015.002	**Title:** Evaluate Performance on System Peak Period Number of Stops
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on the number of stops during the peak period incurred by vehicles traversing the system.	
Supporting Text: *The number of stops is an important measure of system level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements. This requirement (parent and children) is a "will" requirement because number-of-stops evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

2

RQID: F9015.403	**Title:** Evaluate Performance on System All Day Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance will be judged on the number of stops throughout the day incurred by freight vehicles traversing the system.	
Supporting Text: *The number of freight vehicle stops is an important measure of section level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements. This requirement (parent and children) is a "will" requirement because number-of-stops evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

3

RQID: F9015.404	**Title:** Evaluate Performance on System Peak Period Number of Freight Vehicle Stops
Verification: A	**Traceability:** ConOps §12.7.4; Use Case 13.3.4
Requirement Text: MMITSS performance will be judged on the number of stops during the peak period incurred by freight vehicles traversing the section.	
Supporting Text: *The number of freight vehicle stops is an important measure of system level inefficiency, with a particularly strong relationship to energy consumption and pollutant emissions and goods movement efficiency and pavement damage. Since this is a performance evaluation requirement, it does not rely on a MMITSS performance measurement and can employ field study measurements. This requirement (parent and children) is a "will" requirement because number-of-stops evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

4

RQID: F9018	**Title:** Evaluate Performance on System Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.3, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on total vehicle throughput traversing the system.	

Supporting Text: *Peak period throughput is an important measure of the productivity and capacity of the system when its performance is being pushed to its limits. This parent requirement is broken into two system measures: all-day throughput and peak period throughput. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit). This requirement (parent and children) is a "will" requirement because throughput evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*

RQID: F9018.001	**Title:** Evaluate Performance on System All Day Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on throughput throughout the day by vehicles traversing the system.	
Supporting Text: *All day throughput is an overall measure of the productivity and capacity of the system. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit). This requirement (parent and children) is a "will" requirement because throughput evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

RQID: F9018.002	**Title:** Evaluate Performance on System Peak Period Vehicle Throughput
Verification: A	**Traceability:** ConOps §12.7.1; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: MMITSS performance will be judged on throughput during the peak period by vehicles traversing the system.	
Supporting Text: *Peak period throughput is an important measure of the productivity and capacity of the system when its performance is being pushed to its limits. The throughput measures include only vehicle counts in this measure to account for vehicular interactions among multiple travel modes (e.g., transit). This requirement (parent and children) is a "will" requirement because throughput evaluation at a system level is beyond the five-year timeframe of "shall" requirements.*	

6.6 Administrative Requirements

6.6.1 Safety Requirements

There are other USDOT projects focused on applications of connected vehicle technologies to improve safety. As such, the PFS Panel has suggested that pursuing safety-specific applications in the MMITSS research project is outside the intended project scope, although MMITSS needs to remain ever conscious of the safety implications of the applications intended to improve mobility. The MMITSS project has and will coordinate with the connected vehicle safety project teams to ensure that the system architectures are compatible and that the MMITSS leverages the technological foundations developed in these other projects.

The importance of safety in the MMITSS development process has been noted throughout the initial research project, as is evident in the Stakeholder feedback integrated into the Traceability Matrix (See Section 7.6) and written feedback on the MMITSS ConOps. In the latter, the MMITSS research team was reminded that "while not specifically a safety system, development and deployment of MMITSS must follow a structured product development process to address the potential unintended safety consequences of such a system."[5]

Aspects of system safety are addressed for the MMITSS prototypes in the form of fault tolerant behavior and error handling (See Section 6.4.5 for applicable requirements). Fault tolerance and error handling

[5] VIIC Comments to the Multi-Modal Intelligent Traffic Signal System (MMITSS) Concept of Operations, Version 3.0 (Final Submission), Vehicle Infrastructure Integration Program Cooperative Agreement #DTFH61-05-H-00003, Work Order #16 – ITS Mobility Programs, 12/15/2011, V3.

requirements provide the guidance and constraints on how MMITSS will respond to expected, probabilistic, or catastrophic errors or events that could impact system safety. Since MMITSS is currently a research project, the requirements governing safety are a mere subset of those that would be imposed on a fully integrated and operational system. For a fully deployed system, these requirements would be expanded to ensure that great care has been taken to address error handling that could prevent or minimize safety hazards.

For the MMITSS research prototypes, the fault tolerance and error handling requirements are focused on errors or events that would require MMITSS to transfer control of the intersection and section traffic systems to the nominal operation of the underlying traffic signal controllers (TSC). Such situations would exist if MMITSS suffered a loss of power, loss of communication with the TSC, or loss of communication with equipped vehicles and equipped travelers (total loss or sufficient periods of communication loss).

As MMITSS progresses beyond Phase II, coordination with related DMA programs and V2I Safety program areas will enable leveraging of findings from safety programs such as those focused on red light running and curve speed warnings.

6.6.2 Standards Compliance and Compatibility Requirements

The preliminary activities of the MMITSS research project have given consideration to many of the more prominent standards governing signalized intersections and supporting infrastructure (e.g., J2735, DSRC, NTCIP, SAE, etc.). In the fielding and testbed deployment of the MMITSS research prototypes, the compatibility requirements are presented in Section 6.1.1 (e.g., B0101, B0102, and B0103).

After the MMITSS research project demonstrates feasibility of an integrated multi-modal traffic signal system, subsequent development will need to focus on accepted traffic signal standards compliance and compatibility with the broad spectrum of physical traffic signal implementations across the country. During the Phase II Testbed Deployment, MMITSS functionality will be achieved through the integration of new software modules on existing or modify hardware (e.g., OBEs, RSEs, and TSCs). This integration process is likely to produce unique findings with interfacing standardized hardware and software modules supporting existing traffic functionality. As such, MMITSS Phase II should consider developing a formalize process of logging, tracking, and reporting these findings with the standards development organizations such as NTCIP and SAE through existing mechanisms such as ENTERPRISE (fostered by DOT RITA ITS Standards Program and FHWA PFS).

6.6.3 Security Requirements

The data-rich environment associated with MMITSS and other connected vehicle projects invokes responsibility for data and information security. As supported in the use cases (Section 7.2), transmission and processing of data and information are critical to harnessing the benefits promised by MMITSS. For clarity, data and information are distinguished by their current state of usability. Data is considered to be “raw” or unprocessed, which is unusable until it is transformed (e.g., calibrated, scaled, etc.). In contrast, information is considered to be in a usable form that does not require further processing, although it can be enhanced by further processing. As is evident in the MMITSS Data Requirements (Section 6.2) and the MMITSS Performance Measures Requirements (Section 6.5.1), even the MMITSS prototypes will collect and process significant data and information. However, the MMITSS prototypes are deployed in a research context in which equipped vehicles are configured for the sole purpose of showing viability of the system.

As the development of MMITSS progresses from the research prototype to more advanced deployments, data security and information assurance requirements must be imposed that are consistent with the rest of the USDOT connected vehicle program. As such, the proposed path forward for the MMITSS prototypes consists of following the advice shared by one of the project reviewers: "The appropriate nationally consistent security model should be implemented at both the Arizona and California Test beds, consistent with other connected vehicle deployment activities."[6]

After the research-based deployment phase of the project, MMITSS can investigate the possibility of adopting the security processes deployed in the DMA Safety Pilot such as the use of Local Certificate Distribution System (LCDS) and public key infrastructure (PKI).

6.6.4 Privacy Requirements

In addition to future data security requirements, information assurance and privacy requirements are needed for future MMITSS development efforts and deployments. These requirements will need to consider the data elements most applicable to privacy such as vehicle identification, vehicle heading, and vehicle travel paths. In addition to specific data elements, the transmission and archiving of data will encounter privacy issues in future MMITSS deployments. As presented in Section 6.2.2, the MMITSS prototypes will employ a "Vehicle ID" data element as an identifier that is not associated with a VIN. Whereas this masks the privacy issues for this research project, it does not address the future issue. Therefore, this section has been included in the MMITSS Requirements Document as a reminder and placeholder for requirements addressing the privacy of the driving public.

6.6.5 Data Archiving Requirements

As promoted in the Stakeholder feedback (See Section 7.6), data archiving of collected, measured, and estimated MMITSS data serves a variety of needs. For system development, the archived data is critical in assessing system performance over varying time intervals (e.g., short-term, mid-term, and long-term performance) and for performance evaluation of competing designs. Agencies fielding, operating, and maintaining MMITSS deployments will be interested in the operational and state-of-health (SOH) performance. Original equipment manufacturers (OEMs) will be interested in the data for assessing reliability, availability, maintainability, and lifecycle costs. For these reasons and those listed in the Traceability Matrix, the data archiving requirements are critical at all levels of the system development process. As such, the reader will note that the requirements listed in this section have RQIDs implying their presence in even the MMITSS research prototypes.

RQID: A8101	**Title:** Archive MMITSS-Measured Performance Measures
Verification: A	**Traceability:** ConOps §11.0, §11.1.2, 12.7; Use Cases 11.1.2
Requirement Text: The MMITSS shall archive performance measures (defined in Section 6.5.1) that were estimated, updated, and collected by MMITSS based on a user-selectable timeframe, interval, and duration.	
Supporting Text: *This parent requirement is concerned with archiving/storing performance measures that were estimated, calculated, updated, and collected by MMITSS. It provides the flexibility for the TMC or governing agency to select the timeframe or interval for archiving and for how long data shall be retained in the archive. This parent requirement has children at the intersection, section, and system level corresponding to the measures of interest. The archived performance measures can be used for historical statistical analysis. In specific cases, these archived measurements can be used in analysis and verification of MMITSS Performance Evaluation Requirements listed in Section 6.5.2.*	

RQID: C8101.101	**Title:** Archive Intersection Level Performance Measures
Verification: A	**Traceability:** ConOps §11.0, §11.1.2, 12.7; Use Cases 11.1.2
Requirement Text: The MMITSS shall archive intersection level performance measures (defined in Section 6.5.1) based on a user-selectable timeframe, interval and duration.	

[6] Ibid

Supporting Text: *The archived section performance measures can be used for historical statistical analysis. It provides the flexibility for the TMC or governing agency to select the timeframe or interval for archiving and for how long data shall be retained in the archive. In specific cases, these archived measurements can be used in analysis and verification of MMITSS Performance Evaluation Requirements listed in Section 6.5.2. Simulation will be used to validate that MMITSS is archiving the performance measures at the right interval.*

1

RQID: C8101.102	**Title:** Archive Section Level Performance Measures
Verification: A	**Traceability:** ConOps §11.0, §11.1.2, 12.7; Use Cases 11.1.2
Requirement Text: The MMITSS shall archive section level performance measures (defined in Section 6.5.1) based on a user-selectable timeframe, interval, and duration.	
Supporting Text: *The archived section performance measures can be used for historical statistical analysis. It provides the flexibility for the TMC or governing agency to select the timeframe or interval for archiving and for how long data shall be retained in the archive. In specific cases, these archived measurements can be used in analysis and verification of MMITSS Performance Evaluation Requirements listed in Section 6.5.2. . Simulation will be used to validate that MMITSS is archiving the performance measures at the right interval.*	

2

RQID: C8101.103	**Title:** Archive System Level Performance Measures
Verification: A	**Traceability:** ConOps §11.0, §11.1.2, 12.7; Use Cases 11.1.2
Requirement Text: The MMITSS shall archive system level performance measures (defined in Section 6.5.1) based on a user-selectable timeframe or interval.	
Supporting Text: *The archived system performance measures can be used for historical statistical analysis. In specific cases, these archived measurements can be used in analysis and verification of MMITSS Performance Evaluation Requirements listed in Section 6.5.2. . Simulation will be used to validate that MMITSS is archiving the performance measures at the right interval.*	

3

6.6.6 Priority Policy Requirements

RQID: A8001	**Title:** Support N-Level Priority Policy
Verification: A	**Traceability:** ConOps §11.0, §11.1.1, §11.2, §11.3, §11.4, §11.5; Use Case 13.3.1, 13.3.2, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall provide a framework for implementing an agency-influenced, multiple levels (N-Levels) of priority policy.	
Supporting Text: *This requirement establishes a framework and mechanism for implementing a priority policy where each mode can be given priority over other modes and within each mode vehicles can be given relative priority over other vehicles. For example, transit vehicles may be determined to have priority over freight vehicles and a transit vehicle that is late and fully occupied can be given priority over a late vehicle that is empty. Emergency vehicles can be given priority over transit and freight. Generally, rail is given the highest level of priority due to the need for track clearance.*	

4

RQID: A8002	**Title:** Support Fleet Management Systems (FMS) Vehicle Priority Policies
Verification: T	**Traceability:** ConOps §11.0, §11.1.1, §11.2, §11.4, §11.5; Use Case 13.3.1, 13.3.2, 13.3.4, 13.3.5
Requirement Text: The MMITSS shall integrate fleet vehicle priority allocations as defined by Fleet Management Systems (FMS) into the multiple level (N-Level) priority policy.	
Supporting Text: *This requirement establishes a mechanism for allowing each modal fleet management system to determine the priority level of each vehicle in its fleet. The criterion for determining the priority level is specific to the particular fleet management system.*	

5

RQID: C8002.201	**Title:** Support Transit Management Vehicle Priority Policy
Verification: T	**Traceability:** ConOps §11.0, §11.1.1, §11.2; Use Case 13.3.1, 13.3.2
Requirement Text: The MMITSS shall integrate transit vehicle priority allocations as defined by Transit Management Systems into the multiple level (N-Level) priority policy.	

Supporting Text: *This requirement establishes a mechanism for allowing a transit fleet management system to determine the priority level of each transit vehicle in its fleet. The criterion for determining the priority level is specific to the particular transit management system.*

RQID: C8002.402	**Title:** Support Freight Management Vehicle Priority Policy
Verification: T	**Traceability:** ConOps §11.0, §11.1.1, §§11.4; Use Case 13.3.4
Requirement Text: The MMITSS shall integrate freight vehicle priority allocations as defined by Freight Management Systems into the multiple level (N-Level) priority policy.	
Supporting Text: *This requirement establishes a mechanism for allowing a freight fleet management system to determine the priority level of each freight vehicle. The criterion for determining the priority level is specific to the particular freight management system.*	

RQID: C8002.503	**Title:** Support Emergency Vehicle Management Priority Policy
Verification: T	**Traceability:** ConOps §11.0, §11.1.1, §11.5; Use Case 13.3.1, 13.3.5
Requirement Text: The MMITSS shall integrate emergency vehicle priority allocations as defined by Emergency Vehicle Management Systems (EMS) into the multiple level (N-Level) priority policy.	
Supporting Text: *This requirement establishes a mechanism for allowing an emergency vehicle management system to determine the priority level of each emergency vehicle. The criterion for determining the priority level is specific to the particular emergency management system.*	

RQID: A8102	**Title:** Emergency Vehicle Priority Strategies Programmed on Traffic Signal Controller
Verification: I	**Traceability:** ConOps §11.0, §11.5; Use Case 11.5.1
Requirement Text: The MMITSS priority strategies for emergency vehicles may be programmed on Traffic Signal Controllers (TSCs) by local agencies.	
Supporting Text: *This requirement allows MMITSS to provide priority signal timing for priority requests using traffic signal controllers that the operating agency has programmed with priority strategies for emergency vehicles. It is possible that the strategies may not be programmed on existing traffic signal controllers, but may be programmed on external processing equipment, such as on an RSE.*	

6.7 Deployment Requirements

As the MMITSS development matures, deployment requirements will be defined to specify the installation processes and constraints, personnel requirements, training requirements, and related issues. Upgradeability requirements pertain to both the mature MMITSS deployment and MMITSS prototypes.

6.7.1 Upgradeability Requirements

Periodically, nomadic devices configured with MMITSS application software will need to be upgraded to offer enhanced service, greater functionality, or to address software issues. Since a nomadic device is not encompassed completely in the MMITSS system boundary (in a Venn diagram sense), both the owner of the nomadic device and MMITSS have collaborative responsibilities and corresponding requirements to maintain software to the latest version or at least a supported version. This section provides information on software upgrades imposed on the MMITSS to support equipped non-motorized travelers. The nomadic device owner has the responsibility of installing, maintaining, and operating the device in the manner prescribed to receive consideration by MMITSS.

RQID: A8301	**Title:** Upgrade Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.2, §11.3; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to downloadable, nomadic device application (embedded software) upgrades that maintain and update equipped traveler functionality when installed and operated properly.	

Supporting Text: *MMITSS shall provide a downloadable software application upgrade to owners of compatible nomadic devices for the purpose of maintaining, enhancing, and upgrading equipped traveler functionality when installed and operated in accordance with provided instructions, applicable laws, and communication control range of a MMITSS intersection, section, or system.*

RQID: C8301.301	**Title:** Upgrade Certified Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.2; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to downloadable, certified nomadic device application (embedded software) upgrades that maintain and update equipped traveler functionality when installed and operated properly.	
Supporting Text: *MMITSS shall provide downloadable software application upgrades to owners of compatible nomadic devices for the purpose of maintaining, enhancing, and upgrading equipped traveler functionality when installed and operated in accordance with provided instructions, applicable laws, and communication control range of a MMITSS intersection, section, or system. The application upgrade is certified in the sense that the local governing agency or neighboring agencies have certified and approved its use by general non-motorized travelers within the boundaries of the MMITSS being supported by the agency or agencies. As is common with mobile apps, the end-user may be required to stipulate or agree to the upgrades in order to continue receiving service consideration from the MMITSS.*	

RQID: C8301.302	**Title:** Upgrade Authorized Nomadic Device Application
Verification: D	**Traceability:** ConOps §4, §4.1.3, §5, §9.3.4, §9.3.6, §11.0, §11.0.2; Use Case 13.3.3
Requirement Text: The MMITSS shall provide access to downloadable, authorized nomadic device application (embedded software) upgrades that maintain and update equipped traveler functionality for pedestrians with disabilities when installed and operated properly.	
Supporting Text: *MMITSS shall provide downloadable and authorized software application upgrades to owners of compatible nomadic devices that have been identified by an agency as authorized to participate in the MMITSS with special consideration reserved for pedestrians with disabilities. The difference between a certified and authorized nomadic device has to do with the degree of consideration provided to address specific disabilities such as mobility, vision, and hearing loss. Since the physical control of a nomadic device is outside the scope of MMITSS, the user is responsible for installing, maintaining, and operating the application according to the guidance provided. The application is authorized in the sense that the local governing agency or neighboring agencies have certified and approved its use by specific non-motorized travelers analogous to the process of issuing a handicapped parking placard or license plate. As is common with mobile apps, the end-user may be required to stipulate or agree to the upgrades in order to continue receiving service consideration from the MMITSS.*	

7 Appendices

7.1 Acronyms

ABSM	Alternate Basic Safety Message
AC	Alternating Current
ADA	Americans with Disabilities Act (1990)
AQ	Air Quality
APS	Accessible Pedestrian Signals
ASC	Actuated Signal Controller
ATIS	Advanced Traveler Information Systems
ATDM	Active Traffic and Demand Management
ATV	All-Terrain Vehicle
BRT	Bus Rapid Transit
BSM	Basic Safety Messages
CA	California
CDRL	Contract Deliverables Requirements List
CMMI	Capability Maturity Model Integration
CONOPS	Concept of Operations
CTS	Cooperative Transportation System
CV	Connected Vehicle
DC	Direct Current
DMA	Dynamic Mobility Applications
DOORS	Dynamic Object Oriented Requirement System
DOT	Department of Transportation
DSRC	Dedicated Short Range Communication
EMS	Emergency Medical/Management Services
ESD	Electro-static Discharge
ETA	Estimated Time of Arrival
EV	Emergency Vehicle
EVP	Emergency Vehicle Preemption
FHWA	Federal Highway Administration
FOM	Figure of Merit
FPS	Feet Per Second
FTA	Federal Transit Administration
FYA	Flashing Yellow Arrow
GID	Geometric Intersection Description
GPS	Global Positioning Systems
IC	Information Center
ID	Identification
IM	Incident Management
INCOSE	International Council on Systems Engineering
ISIG	Intelligent Traffic Signal System
ITS	Intelligent Transportation System
LCDS	Local Certificate Distribution System
LOS	Level of Service
MD	Maryland
MHz	Megahertz (10^6 Hertz)
MMITSS	Multi-Modal Intelligent Traffic Signal System
MOE	Measures of Effectiveness
MPH	Miles Per Hour
MTBF	Mean Time Between Failure
MTTF	Mean Time to Failure
NHTSA	National Highway Traffic Safety Administration
NTCIP	National Transportation Communications for ITS Protocol
OBE	On-Board Equipment

OD	Origin-Destination
OEM	Original Equipment Manufacturer
PATH	Partners for Advanced Transportation Technology
PFP	Pooled Fund Project
PFS	Pooled Fund Study
PI	Principal Investigator
PII	Personally Identifiable Information
PKI	Public Key Infrastructure
PMPP	Point to Multi-Point Protocol
POV	Privately Owned Vehicle
R&D	Research and Development
RSE	Roadside Equipment
RV	Recreational Vehicle
SE	Systems Engineering
SPaT	Signal Phase and Timing
SRM	Signal Request Message
SSM	Signal Status Message
STMP	Simple Transportation Management Protocol
SVN	Subversion (PFP Repository with Version Control)
SyRS	System Requirements
TMDD	Traffic Management Data Dictionary
TSC	Traffic Signal Controller
TSP	Transit Signal Priority
UA	University of Arizona
UC	University of California
UML	Unified Modeling Language
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VDOT	Virginia Department of Transportation
VMT	Vehicle Miles Traveled

7.2 Use Case-to-Requirements Mappings

The systems engineering approach prescribed throughout the MMITSS project was to have the Stakeholder Input Report and Assessment of Prior and Ongoing Research Report drive the development of the MMITSS Concept of Operations (ConOps). The ConOps relied incorporated the MMITSS Conceptual Architecture (Figure 1) and the development of use cases to develop and define the MMITSS concept of operations. By design and prescription, the use cases were to be the primary source for defining functional requirements for MMITSS. Stakeholder inputs and subsequent PFS Panel feedback from review meetings and formal documentation has influenced functional requirements and served as a source for other requirement types.

Examples of use case-to-requirements mapping were presented during the MMITSS Requirements Walkthrough on December 4, 2012. These mappings have undergone additional definition and refinement since the Walkthrough meeting and are presented in this section. The remaining use cases from the ConOps have been included and the mappings reflect the state of the requirements definition and approval process. In cases where a requirement is referred to as A20##, F31##, or similar reference, the particular requirement has not yet passed the MMITSS Requirements Review Process. As such, the requirement has not received a complete RQID specification.

Use Case: Basic Signal Actuation – Multiple Equipped Vehicle Actuation

ID: Section 11.1.1.3

Brief Description: This use case describes the basic traffic signal actuation by several connected vehicles on different approaches to a traffic signal.

Primary Actor: Several Equipped Vehicles (OBEs)

Secondary Actors: Traffic Signal Controller

Precondition:

1. The intersection has extension detectors 250 feet from the stop bar on all approaches.
2. The designed operating speed is 35 mph.
3. The traffic signal controller is programmed to extend the phase 5.0 seconds after the vehicle leaves the extension detector.

Main Flow:

1. The use case begins when any one of the equipped vehicles enters the radio range of an RSE.
2. The following steps occur for each vehicle that approaches the intersection:
    a. The OBE receives MAP and SPaT messages from the RSE.
    b. The RSE receives Basic Safety Messages (BSM) from the OBE.
    c. The RSE tracks the OBE to estimate when the vehicle will arrive and wants to cross the intersection stop bar (note: route information is not assumed to be available).
    d. The RSE/MMITSS determines the appropriate traffic signal phase to serve the vehicle (translates BSM data into a phase request).
    e. The RSE matches the detector call to the OBE location and prevents the gap timer from timing the detection event.
    f. If the service phase is not timing (active), the RSE places a call for the phase based on when the vehicle will arrive and the phase max time.
    g. If the service phase is timing, the RSE will hold the phase green until the vehicle crosses the stop bar or the phase max time or coordination force off point is reached. If the vehicle will not be able to reach the stop bar before the maximum time is reached, the phase will be allowed to terminate early (efficiency).
3. The RSE updates the performance measures based on the vehicles served.
4. The use case ends.

Post Condition:

1. The vehicle safely crosses the stop bar during a green signal.

Alternative Flow:

1. (2c) An equipped vehicle changes speed and the RSE updates its travel time estimate.
2. (2e) The OBE position and the detector location do not match (errors) so the gap timer is allowed to time. The phase is still held green.
3. (2g) The equipped vehicle will not arrive during the green interval and the vehicle has to stop for a Red Signal.
4. (2e) The RSE cannot match the detector call to the OBE location because the connected vehicle has changed route/path and the track is dropped.
5. (3) The RSE updates the delay and stop performance measures.

Comments:

Item #	Section 11.1.1.3 Basic Signal Actuation – Multiple Equipped Vehicle Actuation RQID
Pre 1	A2101 Acquire Intersection Field Sensor Detection Data
2	N/A
3	C2011.001 Control Signal Actuation for Equipped Vehicles
Main 1	N/A
2a	C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles
2b	C2001.001 Acquire Equipped Vehicle Status Data
2c	C2006.001 Track Equipped Vehicles Near Intersection C2007.001 Estimate Intersection Expected Time of Arrival of Equipped Vehicles
2d	A2014 Process Basic Status Messages A2103 Determine Traffic Signal Phase for Tracked Vehicle
2e	C2011.001 Control Signal Actuation for Equipped Vehicles A2101 Acquire Intersection Field Sensor Detection Data C2014.001 Match Tracked Vehicle Location With Field Sensor Location
2f	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.005 Call the Signal Phase Associated with a Tracked Equipped Vehicle A2012 Acquire Intersection Signal Timing Parameters C2012.002 Acquire Intersection Active Interval Information C2007.001 Estimate Intersection Expected Time of Arrival of Equipped Vehicles
2g	C2011.001 Control Signal Actuation for Equipped Vehicles C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
3	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2007.001 Estimate Intersection Expected Time of Arrival of Equipped Vehicles C2006.001 Track Equipped Vehicles Near Intersection
2	N/A
3	N/A
4	N/A
5	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability

Use Case: Coordinated Section of Signals
ID: Section 11.1.2
Brief Description: This use case describes how connected vehicles operate in a coordinated section of signals and how they can provide information for dynamic offset adjustment.
Primary Actor: Several Equipped Vehicles (OBEs) organized in a platoon
Secondary Actors: Section Traffic Signal Controller as part of the Traffic Management Center (TMC)
Precondition: 1. A group (platoon) of vehicles is traveling along the coordinated direction of travel in a traffic control section. [Note: A platoon will be defined as a group of vehicles that have short and similar headways between vehicles.] 2. Each traffic signal controller in the section has a coordination plan that consists of a cycle length, a set of phase splits, and an offset. The cycle length is common for the section. The phase splits are determined based on single intersection phase demand and queueing.
Main Flow: 1. The use case begins when the group of vehicles (platoon) enters the coordinated section. The lead vehicle and trailing vehicle define the head and tail of the platoon, respectively. The BSMs from the equipped vehicles and vehicle count data from loop detectors are used to estimate the size of the platoon. 2. Using BSM's from equipped vehicles in the platoon, the RSE tracks the movement of the identified platoon approaching the intersection and forwards the BSMs to the TMC. 3. The TMC processes the BSMs to estimate performance measures related to platoon progression through the section. The performance measures include the stop frequency of platoons, queue length at individual intersections, and travel time of platoons between intersections. 4. The TMC monitors the estimated performance measures over time, identifies the intersection(s) with inappropriate offset(s) causing disruption of platoon progression through the section. 5. The TMC selects the most appropriate offsets for each intersection along the section. The selection of the offsets will take into consideration the queue discharging time at individual intersections and expected travel time between intersections. 6. The TMC sends the desired offsets to the individual traffic signal controllers and each controller adjusts its offset accordingly. 7. Repeat step b to f until the platoon exits the coordinated section, when the use case ends.
Post Condition: 1. A platoon of vehicles has progressed through a coordinated section of traffic signals and the coordination performance measures have been collected.
Alternative Flow: 1. (f) If progression is desired in both directions, the adjustment of the offset must consider a trade-off between the two directions of travel.
Comments:

1

Item #	Section 11.1.2 Coordinated Section of Signals RQID
Pre 1	A3003 Characterize a Platoon C3003.001 Identify the Leading and Trailing Vehicles of a Platoon C3003.004 Track a Platoon of Vehicles
2	N/A
Main 1	C2101.001 Acquire Intersection Field Sensor Detection – Traffic Counts C3003.002 Estimate Platoon Size C3003.001 Identify the Leading and Trailing Vehicles of a Platoon C3003.004 Track a Platoon of Vehicles
2	C3003.004 Track a Platoon of Vehicles C3003.003 Identify a Platoon of Vehicles A3006 Acquire Basic Vehicle Status Information A4103 Acquire Section Level Performance Measures
3	C3003.006 Estimate Number of Stops of a Platoon in a Section A2013 Estimate Intersection Performance Measures C3003.005 Estimate Platoon Travel Time Between Intersections
4	A3004 Identify an Intersection with Inappropriate Offset
5	A3005 Calculate Appropriate Intersection Offset(s) for the Section C3005.001 Calculate Appropriate Intersection Offset(s) Based on Queue Discharging Time and Expected Travel Time
6	A3103 Set Intersection Offset(s) at Each Intersection in the Section
7	N/A
Post 1	A3005 Calculate Appropriate Intersection Offset(s) for the Section
Alt 1	A3005 Calculate Appropriate Intersection Offset(s) for the Section C3005.002 Calculate Intersection Offsets for Multiple Directions of Travel

Use Case: Congestion Control
ID: Section 11.1.3
Brief Description: One or more intersections are experiencing persistent phase failures on one or more movements. The traffic signal control system can take a variety of actions to reduce the duration and extent of the congestion. These actions include increasing the phase split and/or cycle length, managing the queues by metering at upstream intersections, and flushing (or other strategies) [Review NCHRP 3-79]. Phase Failure performance measures can be estimated more accurately using CV data by determining if the phase failure is caused by vehicles that arrived during the current cycle or of they were present in the previous cycle(s).
Primary Actor: Intersection Performance Measures (phase failures)
Secondary Actors:
Precondition: 1. The intersection has sufficient detection to identify phase failures, e.g. stop bar detection. 2. There are a sufficient number of CV's in the traffic stream to accurately identify true phase failures.
Main Flow: 1. The use case begins when one or more traffic signal phases report a phase failure for more than X (configurable parameter, default = 3) cycles. A phase failure in a CV system should be defined as vehicles not being served in two or more cycles (as opposed to traditional measure of occupancy at stop bar detectors throughout the entire service (green time). 2. The intersection controller evaluates alternative intersection strategies including: a. Free Operation b. Split adjustment c. Cycle length modification d. Queue Management 3. If one of the local strategies is evaluated to be feasible, the controller will implement the strategy. Performance measures are updated. Repeat step 2 until the phase failure no longer persists and the queue does not exceed upstream capacity. 4. If phase failure persists and the queue grows to exceed the upstream capacity the intersection will notify upstream traffic signal controllers to start metering flow into the congested region. Performance measures are updated. 5. If the phase failure does not occur for Y (configurable parameter, default=2) cycles, the intersection will return to normal operation, and notify upstream signals to stop metering, and the use case ends. 6. Performance measures are updated.
Post Condition: 1. One or more congested movements at an intersection are no longer congested and the queues are cleared every cycle.
Alternative Flow: 1. (3) If one of the local strategies is not feasible, the controller will notify upstream signal controllers to start metering.
Comments:

1

Item #	Section 11.1.3 Congestion Control RQID
Pre 1	N/A
2	N/A
Main 1	A2104 Determine Phase Failure Status
2	A2105 Evaluate Alternative Strategies for Phase Failure Management C2105.101 Evaluate Free Operation for Phase Failure Management C2105.102 Evaluate Split Adjustment for Phase Failure Management C2105.103 Evaluate Cycle Length Modification for Phase Failure Management C2105.104 Evaluate Queue Management for Phase Failure Management
3	A3106 Determine Phase Failure Strategy A2107 Implement Strategy for Phase Failure Management A2013 Estimate Intersection Performance Measures C2013.003 Estimate Intersection Queue Length
4	A3104 Implement Flow Metering at Upstream Intersections Neighboring the Congested Intersection A2013 Estimate Intersection Performance Measures
5	A2104 Determine Phase Failure Status A3105 Monitor Phase Failure Status
6	A2013 Estimate Intersection Performance Measures C2007.006 Estimate Phase Failure Duration
Post 1	N/A
Alt 1	A3104 Implement Flow Metering at Upstream Intersections Neighboring the Congested Intersection

Use Case: Dilemma Zone Protection

ID: Section 11.1.4

Brief Description: This use case is an extension of the Basic Signal Actuation use case with special considerations for dilemma zone protection.

Primary Actor: Several Equipped Vehicles (OBEs)

Secondary Actors: Traffic Signal Controller, Infrastructure Advance Warning Flashers

Precondition:

1. The intersection has a pair of dilemma zone detectors on the approach spaced such that vehicles between the first and second detector could stop if the signal changed to yellow.
2. The extension timer in the traffic signal controller is set to be long enough to allow a vehicle to safely cross the stop bar after exiting the second (downstream) detector.

Main Flow:

1. The use case begins when any one of the Equipped Vehicles enters the radio range of an RSE.
2. The following steps occur for each vehicle that approaches the intersection:
    a. The OBE receives MAP and SPaT messages from the RSE.
    b. The RSE receives Basic Safety Messages (BSM) from the OBE.
    c. The RSE tracks the OBE to estimate when the vehicle will arrive and want to cross the intersection stop bar (note: route information is not assumed to be available).
    d. The RSE estimates the required stopping time/distance based on the vehicle characteristics.
    e. The RSE/MMITSS determines the appropriate traffic signal phase to serve the vehicle (translates BSM data into a phase request).
    f. The RSE matches the detector call to the OBE location and prevents the gap timer from timing the detection event.
    g. If the service phase is not timing (active), the RSE places a call for the phase based on when the vehicle will arrive and the phase max time.
    h. If the service phase is timing, the RSE will hold the phase green until the vehicle crosses the stop bar or the phase max time or coordination force off point is reached. If the vehicle will not be able to reach the stop bar before the maximum time is reached, the phase will be allowed to terminate early (efficiency).
    i. If the vehicle will not reach the stop bar before the maximum time occurs, the infrastructure based warning flashers are set to an on-state and a warning message is transmitted to the vehicle.
3. The RSE updates the vehicles served performance measures.
4. The use case ends.

Post Condition:

1. The vehicle legally crosses the stop bar or the vehicle stops safely.

Alternative Flow:

1. (2c) An equipped vehicle changes speed and the RSE updates its travel time estimate.
2. (2f) The OBE position and the detector location do not match (errors) so the gap timer is allowed to time the normal dilemma zone protection. The phase is still held green.
3. (1) The Equipped Vehicle will not arrive during the green interval and the vehicle has to stop for a Red Signal. (3) The RSE updates the Delay and Stop performance measures.

Comments:

1

2

Item #	Section 11.1.4 Dilemma Zone Protection RQID
Pre 1	N/A
2	N/A
Main 1	N/A
2a	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
2b	A2001 Acquire Basic Status Data from Equipped Vehicles and Travelers C2001.001 Acquire Equipped Vehicle Status Data
2c	C2006.001 Track Equipped Vehicles Near Intersection C2007.001 Estimate Intersection Expected Time of Arrival of Equipped Vehicles
2d	F2019.001 Estimate Required Stopping Distance for Passenger Vehicles F2019.202 Estimate Required Stopping Distance for Transit Vehicles F2019.403 Estimate Required Stopping Distance for Freight Vehicles
2e	A2014 Process Basic Status Messages A2103 Determine Traffic Signal Phase for Tracked Vehicle
2f	A2014 Process Basic Status Messages C2014.001 Match Tracked Vehicle Location With Field Sensor Location C2011.001 Control Signal Actuation for Equipped Vehicles
2g	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.005 Call the Signal Phase Associated with a Tracked Equipped Vehicle
2h	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
2i	A2106 Control Infrastructure Advance Warning Flashers A2020 Provide Warning Message to Equipped Vehicles
3	A2013 Estimate Intersection Performance Measures A2013 Estimate Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2006.001 Track Equipped Vehicles Near Intersection C2007.001 Estimate Intersection Expected Time of Arrival of Equipped Vehicles
2	C2014.001 Match Tracked Vehicle Location With Field Sensor Location
3	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability

1

2

Use Case: Basic TSP Scenario - Single Transit Vehicle at One Signalized Intersection
ID: Section 11.2.1.1
Brief Description: This use case describes the basic priority control for connected transit vehicles
Primary Actor: Transit Vehicle Equipped with On-board Equipment (OBE)
Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller (TSC)
Precondition: 1. The transportation agency(ies) have established a policy for priority control (called N-level priority) and the fleet management (transit) system is prepared to provide priority levels for vehicles on routes. 2. The traffic signal controller is programmed with a variety of priority control schemes such as early green, green extension, phase rotation, phase skipping, and etc. or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.
Main Flow: 1. The use case begins when an equipped transit vehicle enters the radio range of an RSE. 2. The OBE receives MAP and SPaT messages from the RSE. 3. The OBE send Basic Safety Messages (BSM). 4. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) if needed. 5. The RSE receives and tracks the BSM. 6. The RSE receives SRM. 7. The RSE manages and prioritizes requests (SRM) from multiple transit vehicles on the same or conflicting movements with the consideration of the prevailing traffic conditions and the requested level of priority (as determined by the vehicle and the established policy). 8. The RSE determines the best signal timing plan to accommodate the active priority request and sends it to the TSC for further processing and execution. 9. The TSC sends updated Signal Status Message (SSM) to the RSE and the RSE broadcasts the SSM to any connected vehicle (CV) approaching the intersection. 10. The OBE receives the SSM and determines if and when the request will become active at the intersection. 11. The OBE determines that the transit vehicle has cleared the intersection and sends a new SRM to cancel the priority request. 12. The RSE receives the cancel SRM and sends it to the TSC. 13. The RSE updates the transit vehicle served performance measures. 14. The case ends.
Post Condition: 1. The transit vehicle safely crosses the stop bar during a green signal.
Alternative Flow: 1. (7) The transit vehicle changes speed and the RSE updates its priority timing based on travel time estimates. 2. (8) The transit vehicle will not arrive during green max window and vehicle has to stop at red signal. (13) The RSE updates the delay and stop performance measures.
Comments:

1

Item #	Section 11.2.1.1 Basic TSP Scenario - Single Transit Vehicle at One Signalized Intersection RQID
Pre 1	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
2	N/A
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	A2001 Acquire Basic Status Data from Equipped Vehicles and Travelers C2001.001 Acquire Equipped Vehicle Status Data
4	A2002 Acquire Signal Request Data from Equipped Vehicles and Travelers C2002.202 Acquire Equipped Transit Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles
6	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data C2003.201 Acquire Intended Travel Path from Equipped Transit Vehicles
7	C2010.202 Process Signal Request Message from Equipped Transit Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data - Delay
8	C2011.001 Control Signal Actuation for Equipped Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
9	C2009.001 Provide Signal Status Data to Equipped Vehicles
10	Optional. The OBE can Re-Send a Request for Priority if Needed
11	A2002 Acquire Signal Request Data from Equipped Vehicles and Travelers Note: A cancel request is realized by a pre-designated value of level of priority
12	C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
13	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
14	N/A
Post 1	N/A
Alt 1	C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
2	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability

1

Use Case: Variation of Basic TSP Scenario – TSP at Nearside Bus-Stop

ID: Section 11.2.1.1.1

Brief Description: This use case describes the TSP control for a connected transit vehicle at a nearside bus-stop.

Primary Actor: Transit Vehicle equipped with on-board equipment (OBE)

Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller(TSC)

Precondition:

1. The transportation agency(ies) have established a policy for priority control (called N-level priority) and the fleet management (transit) system is prepared to provide priority levels for vehicles on routes.
2. The traffic signal controller is programmed with a variety of priority control schemes such as early green, green extension, phase rotation, phase skipping, etc. or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.

Main Flow:

1. The use case begins when an equipped transit vehicle enters the radio range of an RSE.
2. The OBE receives MAP and SPaT messages from the RSE.
3. The OBE send Basic Safety Messages (BSM).
4. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) if needed. The SRM contains the level of priority requested.
5. The RSE receives and tracks the BSM.
6. The RSE receives SRM containing the level of priority.
7. The RSE determines the needs for advancing the green phase to clear the queue in front of the transit vehicle to allow the vehicle entering the near-side stop.
8. Upon finishing passenger loading and alighting (door closed), the OBE determines the readiness of the bus to move and sends an SRM.
9. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) if needed. The SRM contains the level of priority requested.
10. The RSE manages priority to allow the bus clear the intersection with strategies including green extension or early green treatment for bus-stop in the mixed traffic lane, or special phase for the transit vehicle to move out of the pullout prior to non-transit traffic on the same movement.
11. The OBE determines that the transit vehicle has cleared the intersection and sends a new SRM to cancel the priority request.
12. The RSE receives the cancel SRM and sends it to the TSC.
13. The RSE updates the transit vehicles served performance measures.
14. The case ends.

Post Condition:

1. The transit vehicle moves safely out from the bus stop with reduced intersection delay.

Alternative Flow:

1. (4) If the bus is not eligible, or priority is not needed, the use case ends.

Comments:

Item #	Section 11.2.1.1.1 Variation of Basic TSP Scenario – TSP at Nearside Bus-Stop RQID
Pre 1	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
2	N/A
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	A2001 Acquire Basic Status Data from Equipped Vehicles and Travelers C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles
6	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data C2003.201 Acquire Intended Travel Path from Equipped Transit Vehicles
7	C2010.202 Process Signal Request Message from Equipped Transit Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data – Delay C2011.001 Control Signal Actuation for Equipped Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
8	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data
9	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data C2003.201 Acquire Intended Travel Path from Equipped Transit Vehicles
10	C2011.001 Control Signal Actuation for Equipped Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
11	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data Note: A cancel request is realized by a pre-designated value of level of priority
12	C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
13	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability
14	N/A
Post 1	N/A
Alt 1	C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control

1

Use Case: Variation of Basic TSP Scenario for Transit Buses - Transit Vehicle Special Signal Treatment for Protected Left-Turn
ID: Section 11.2.1.1.2
Brief Description: This use case describes the special priority control for a connected transit vehicle making a protected left-turn
Primary Actor: Transit Vehicle equipped with on-board equipment (OBE)
Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller(TSC)
Precondition: 1. The transportation agency(ies) have established a policy for priority control (called N-level priority) and the fleet management (transit) system is prepared to provide priority levels for vehicles on routes. 2. The traffic signal controller is programmed with a variety of priority control schemes such as early green, green extension, phase rotation, phase skipping, and etc. or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.
Main Flow: 1. The use case begins when an equipped transit vehicle enters the radio range of an RSE. 2. The OBE receives MAP and SPaT messages from the RSE. 3. The OBE send Basic Safety Messages (BSM). 4. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) if needed. The SRM contains the level of priority requested. 5. The RSE receives and tracks the BSM. 6. The RSE determines the needs for advancing the green phase to clear the queue in front of the transit vehicle to allow the vehicle entering the left-turn pocket, and manages coordinated priority timing between the through and left-turn movements. 7. The OBE determines that the bus has cleared the intersection and sends a new SRM to cancel the priority request. 8. The RSE receives the cancel SRM and sends to the TSC. 9. The TSC ends priority control and returns to normal traffic signal control. 10. The RSE updates the transit vehicle served performance measures. 11. The case ends.
Post Condition: 1. The transit vehicle makes a safe left-turn with reduced intersection delay.
Alternative Flow:
Comments:

1

Item #	11.2.1.1.2 Variation of Basic TSP Scenario for Transit Buses – Transit Vehicle Special Signal Treatment for Protected Left-Turn RQID
Pre 1	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
2	N/A
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles
6	C2010.202 Process Signal Request Message from Equipped Transit Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data – Delay A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control C2011.001 Control Signal Actuation for Equipped Vehicles
7	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data Note: A cancel request is realized by a pre-designated value of level of priority
8	C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
9	N/A
10	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability
11	N/A
Post 1	N/A

1

Use Case: Extended TSP Scenario - Single Transit Vehicle at a Section of Signalized Intersections

ID: Section 11.2.3

Brief Description: This use case describes the basic priority control for a connected transit vehicle travelling through a section of signalized intersections.

Primary Actor: Transit Vehicle Equipped with On-board Equipment (OBE)

Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller (TSC)

Precondition:

1. Multiple signalized intersections are equipped with RSEs and have RSE-to-RSE communication enabled.
2. The RSEs store transit route GID data or this data is available from the transit management system.
3. The traffic signal controllers in the section are programmed with a variety of priority control schemes such as early green, green extension, phase rotation, phase skipping, and etc. or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.

Main Flow:

1. The use case begins when an equipped transit vehicle enters the radio range of an RSE.
2. The OBE receives MAP and SPaT messages from the immediate approaching RSE.
3. The OBE sends Basic Safety Messages (BSM).
4. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) containing the level of priority.
5. The RSE receives and tracks BSM.
6. The RSE receives an SRM and forwards the SRM to the TMC.
7. The Traffic Management Center (TMC) forms a section of signalized intersections based on patterns of transit stops along the route.
8. The TMC manages and prioritizes requests (SRM) from the transit vehicles to issue priority based on prevailing traffic conditions at a section of signalized intersections and the requested level of priority (as determined by the vehicle and the established policy).
9. The TMC determines the best coordinated signal timing strategy along the section of signalized intersections to accommodate the active priority request.
10. The TMC sends priority timing to the traffic signal controllers (via RSE-to-RSE communication) for further processing and execution.
11. The TSC sends updated SSM to the RSE and the SSM is relayed to the OBE.
12. The OBE receives the SSM and determines if and when the request will become active at the intersection.
13. The OBE determines that the transit vehicle has cleared the intersection and sends a new SRM to cancel the priority request.
14. The RSE receives the cancel SRM and sends it to the TSC. The TSC resumes normal operations.
15. The RSE updates the transit vehicles served performance measures.
16. The case ends.

Post Condition:

1. The transit vehicle safely travels through a section of signalized intersections.

Alternative Flow:

1. (8) The TMC receives levels of priority associated with each active priority request from the transit Fleet Management systems and uses this information to manage and prioritize requests (SRM).
2. The transit vehicle will not arrive during green max windows at one or more signalized intersections and has to stop at red signal. (15) The RSE updates the delay and stop performance measures.

Comments:

Item #	11.2.3 Extended TSP Scenario - Single Transit Vehicle at Section of Signalized Intersections RQID
Pre 1	Assumption of CV environment
2	C4004.201 Store Available Transit Route Data F4003 Acquire Vehicle Route Data F4003.204 Acquire Dynamic Transit Route Information Updates
3	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.202 Estimate Intersection Expected Time of Arrival of Equipped Transit Vehicles
6	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data C2003.201 Acquire Intended Travel Path from Equipped Transit Vehicles C3001.202 Acquire Active Transit Vehicle Priority Requests in a Section
7	F4003 Acquire Vehicle Route Data F4003.204 Acquire Dynamic Transit Route Information Updates C4004.201 Store Available Transit Route Data
8	C2010.202 Process Signal Request Message from Equipped Transit Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data – Delay A4103 Acquire Section Level Performance Measures
9	C3102.002 Determine Section Signal Coordination Timing
10	C2011.001 Control Signal Actuation for Equipped Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control C3101.001 Command Signal Coordination
11	C2009.001 Provide Signal Status Data to Equipped Vehicles
12	Optionally, the OBE can Re-Send a Request for Priority if Needed (Repeat Step 4)
13	C2002.202 Acquire Equipped Transit Vehicles Signal Request Data Note: A cancel request is realized by a pre-designated value of level of priority
14	C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
15	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
16	N/A
Post 1	N/A
Alt 1	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
2	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures

1

Use Case: Equipped Pedestrian Signal Activation

ID: Section 11.3.2

Brief Description: This use case describes the basic logic for activation of pedestrian crosswalk triggered by nomadic devices.

Primary Actor: Equipped Pedestrian (handheld nomadic device with authorized application)

Secondary Actors: Traffic Signal Controller (TSC)

Precondition:

1. The traffic signal controller is programmed with a variety of priority control schemes such as early green, green extension, phase rotation, phase skipping, and etc. or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.

Main Flow:

1. The Use Case begins when an Equipped Pedestrian approaches the cross walk near an intersection.
2. As the Equipped Pedestrian approaches the intersection:
    a. The handheld device receives MAP and SPaT messages from the RSE.
    b. As the pedestrian arrives at the intersection, they point the nomadic device toward the intended direction of travel, and selects the key on the nomadic device to send an SRM.
    c. The RSE receives Alternative Basic Safety Messages (ABSM) and Signal Request Message (SRM) from the nomadic device.
    d. The RSE/MMITSS determines the appropriate traffic signal phase to serve the pedestrian (translates SRM data into a phase request).
    e. The RSE determines which SRM's (from multiple) is to be served.
    f. The RSE notifies the traffic signal controller (or logic) of the active requests including desired phase and service time.
    g. The RSE transmits a status message (SSM) with information about which pedestrian requests will be served and wait time to the corresponding nomadic device(s).
    h. The controller activates crosswalk light.
    i. The RSE continuously receives ABSM from the nomadic device and extends the crosswalk phase if pedestrian presence has not ended within the minimum clearance time.
3. The RSE updates the performance measures based on pedestrians served.
4. The use case ends.

Post Condition:

1. The Equipped Pedestrian crosses the intersection safely using the crosswalk.

Alternative Flow:

1. Interrupt – A pedestrian may cancel the call at any time. The nomadic device will send an SRM cancel service request.
2. Pedestrians with disabilities may use authorized nomadic devices to request earlier or a longer than normal crossing time.

Comments:

1

2

Item #	11.3.2 Equipped Pedestrian Signal Activation RQID
Pre 1	A8001 Support N-Level Priority Policy
Main 1	N/A
2a	C2004.302 Provide Signal Phase and Timing Data to Equipped Non-Motorized Travelers C2005.302 Provide Geometric Intersection Description (GID) Data to Equipped Travelers
2b	C2003.302 Acquire Intended Travel Path from Equipped Pedestrians
2c	C2001.302 Acquire Equipped Non-motorized Traveler Status Data C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data
2d	C2010.303 Process Signal Request Message from Equipped Non-Motorized Traveler
2e	C2010.303 Process Signal Request Message from Equipped Non-Motorized Traveler A8001 Support N-Level Priority Policy A2101 Acquire Intersection Field Sensor Detection Data A2012 Acquire Intersection Signal Timing Parameters C2012.001 Acquire Intersection Signal Intervals C2012.002 Acquire Intersection Active Interval Information
2f	C2011.302 Control Signal Actuation for Equipped Travelers C2011.303 Call Pedestrian Phase and Interval
2g	C2009.302 Provide Signal Status Data to Equipped Non-Motorized Travelers
2h	C2011.302 Control Signal Actuation for Equipped Travelers
2i	C2006.302 Track Equipped Non-Motorized Traveler Near Intersection C2011.304 Provide Pedestrian Clearance Extension
3	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data (Note: A Cancel of Request is represented by a pre-designated value of level of priority)
2	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.304 Provide Pedestrian Clearance Extension C2011.303 Call Pedestrian Phase and Interval

Use Case: Equipped Bicyclist Signal Activation

ID: Section 11.3.3

Brief Description: This use case describes the basic logic for cyclists equipped with nomadic devices.

Primary Actor: Equipped Bicyclist handheld nomadic device with registered application

Secondary Actors: Traffic Signal Controller (TSC)

Precondition:

1. None

Main Flow:

1. The Use Case begins when an Equipped Bicyclist approaches an intersection.
2. As the Equipped Bicyclist approaches the intersection:
   a. The handheld device receives MAP and SPaT messages from the RSE.
   b. Bicyclist is informed of the arrival at the intersection, pointing the nomadic device toward the intended direction of travel, and pushes a key on the nomadic device to send an SRM.
   c. The RSE receives Alternative Basic Safety Messages (ABSM) and Signal Request Message (SRM) from the nomadic device, including estimates of time to arrival of the Cyclist at the stop bar, and determines Cyclist's intended direction.
   d. The RSE/MMITSS determines the appropriate traffic signal phase to serve the Cyclist (translates SRM data into a phase request).
   e. The RSE determines which SRM's (from multiple) is to be served (Priority ranking? Or maximum number).
   f. The RSE notifies the traffic signal controller (or logic) of the active requests including desired phase and service time.
   g. The RSE transmits a signal status message (SSM) with information about which Cyclist requests will be served and wait time to the corresponding nomadic device(s).
   h. The controller activates the phase for requested direction.
   i. The RSE continuously receives ABSM from the nomadic device and extends the phase if Bicyclist presence has not ended within the minimum clearance time.
3. The RSE updates the Bicyclist served performance measures.
4. The use case ends.

Post Condition:

1. The Equipped Bicyclist crosses the intersection safely.

Alternative Flow:

1. (2c) The nomadic device updates the ABSM with new arrival information based on a change of speed or route change.
2. Interrupt – A Bicyclist may cancel the call at any time. The nomadic device will send an SRM cancel service request.

Comments:

1

2

Item #	11.3.3 Equipped Bicyclist Signal Activation RQID
Pre 1	N/A
Main 1	N/A
2a	C2004.302 Provide Signal Phase and Timing Data to Equipped Non-Motorized Travelers C2005.302 Provide Geometric Intersection Description (GID) Data to Equipped Travelers
2b	C2003.302 Acquire Intended Travel Path from Equipped Pedestrians
2c	C2001.302 Acquire Equipped Non-motorized Traveler Status Data C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data
2d	C2010.303 Process Signal Request Message from Equipped Non-Motorized Traveler
2e	A8001 Support N-Level Priority Policy C2012.001 Acquire Intersection Signal Intervals C2012.002 Acquire Intersection Active Interval Information
2f	C2011.302 Control Signal Actuation for Equipped Travelers C2011.303 Call Pedestrian Phase and Interval
2g	C2009.302 Provide Signal Status Data to Equipped Non-Motorized Travelers
2h	C2011.001 Control Signal Actuation for Equipped Vehicles
2i	C2006.302 Track Equipped Non-Motorized Traveler Near Intersection A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
3	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2001.302 A Acquire Equipped Non-motorized Traveler Status Data C2006.302 Track Equipped Non-Motorized Traveler Near Intersection
2	C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data (Note: A Cancel of Request is represented by a pre-designated value of level of priority)

1

Use Case: Inclement Weather Accommodations for Non-Motorized Travelers
ID: Section 11.3.4
Brief Description: This use case describes the logic for accommodating pedestrians during inclement weather.
Primary Actor: Equipped Pedestrian handheld nomadic device with registered application
Secondary Actors: Traffic Signal Controller (TSC)
Precondition: 1. Infrastructure-based weather sensors, CV weather sensors, and/or nomadic devices provide verification of inclement weather near intersection. 2. Weather conditions impact a pedestrian's ability to cross the street in the normally allocated time.
Main Flow: 1. The Use Case begins when an Equipped Pedestrian approaches the cross walk near an intersection. 2. As the Equipped Pedestrian approaches the intersection: a. The handheld device receives MAP and SPaT messages from the RSE. b. Pedestrian is informed of the arrival at the intersection, pointing the nomadic device toward the intended direction of travel, and pushes a key on the nomadic device to send an SRM. c. The RSE receives Alternative Basic Safety Messages (ABSM) and Signal Request Message (SRM) from the nomadic device, including estimates of time to arrival of the pedestrian at the crosswalk, and determines Pedestrian's intended direction. d. The RSE/MMITSS determines the appropriate traffic signal phase to serve the pedestrian (translates SRM data into a phase request). e. The RSE determines the impact of the weather conditions (e.g. direction of wind/rain/snow) on a pedestrian in the desired direction of travel. f. The RSE notifies the traffic signal controller (or logic) of the active requests including desired phase and weather modified service time. g. The RSE transmits a status message (SSM) with information about which pedestrian requests will be served and wait time. h. The controller activates crosswalk light. i. The RSE continuously receives ABSM from the nomadic device and extends the crosswalk phase if pedestrian presence has not ended within the minimum clearance time. 3. The RSE updates the pedestrian served performance measures. 4. The use case ends.
Post Condition: *1.* The Pedestrian crosses the intersection efficiently and safely during inclement weather.
Alternative Flow: *1.* (2c) The nomadic device updates the ABSM with new arrival information based on a change of speed or route change. *2.* Interrupt – A pedestrian may cancel the call at any time. The nomadic device will send an SRM cancel service request.
Comments:

1

Item #	11.3.4 Inclement Weather Accommodations for Non-Motorized Travelers RQID
Pre 1	A2016 Acquire Extended Status Data from Equipped Vehicles F2016.002 Acquire Extended Status Data - Weather Data Elements
2	N/A
Main 1	N/A
2a	C2004.302 Provide Signal Phase and Timing Data to Equipped Non-Motorized Travelers C2005.302 Provide Geometric Intersection Description (GID) Data to Equipped Travelers
2b	C2003.302 Acquire Intended Travel Route from Equipped Pedestrian
2c	C2001.302 Acquire Equipped Non-motorized Traveler Status Data C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data
2d	C2010.303 Process Signal Request Message from Equipped Non-Motorized Traveler
2e	A8001 Support N-Level Priority Policy A2016 Acquire Extended Status Data from Equipped Vehicles F2016.002 Acquire Extended Status Data - Weather Data Elements F2017 Estimate Intersection Weather Data with Extended Status Data A2012 Acquire Intersection Signal Timing Parameters C2012.001 Acquire Intersection Signal Intervals C2012.002 Acquire Intersection Active Interval Information
2f	C2011.302 Control Signal Actuation for Equipped Non-Motorized Travelers C2011.303 Call Pedestrian Phase and Interval
2g	C2009.302 Provide Signal Status Data to Equipped Non-Motorized Travelers
2h	C2011.302 Control Signal Actuation for Equipped Travelers
2i	C2006.302 Track Equipped Non-Motorized Traveler Near Intersection A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.304 Provide Pedestrian Clearance Extension
3	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2001.302 Acquire Equipped Non-motorized Traveler Status Data C2006.302 Track Equipped Non-Motorized Traveler Near Intersection
2	C2002.303 Acquire Equipped Non-Motorized Travelers Signal Request Data (Note: A Cancel of Request is represented by a pre-designated value of level of priority)

1

Use Case: Basic FSP Scenario - Single Equipped Truck Approaches an Intersection
ID: Section 11.4.1.1
Brief Description: This use case describes the basic signal priority control for a connected truck approaching an intersection
Primary Actor: Truck Equipped with On-board Equipment (OBE)
Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller (TSC)
Precondition: 1. The transportation agency(ies) have established a policy for priority control (called N-level priority) and the fleet management (freight) system is prepared to provide priority levels for vehicles on routes. 2. The traffic signal controller is programmed with a variety of priority control schema such as early green and green extension or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.
Main Flow: 1. The use case begins when an equipped truck enters the radio range of an RSE. 2. The OBE receives MAP and SPaT messages from the RSE. 3. The OBE send Basic Safety Messages (BSM) to the RSE. 4. The OBE determines the eligibility for priority and sends a Signal Request Message (SRM) if needed. The SRM includes the level of requested priority which can differentiate the case that the truck can or cannot make a safe stop before the stop bar. 5. The RSE receives and tracks the BSM. 6. The RSE receives SRM and determines the best signal timing plan to accommodate the active priority request, based on the prevailing traffic conditions and the level of requested priority. 7. The RSE sends the priority timing plan to the TSC for further processing and execution. 8. The TSC sends updated SSM to the RSE and the RSE broadcasts the updated SPaT messages. 9. The OBE receives and tracks SPaT to determine if and when the request will become active at the intersection. 10. The OBE determines that the truck has cleared the intersection and sends a cancel SRM to the RSE. 11. The RSE receives the cancel SRM and sends it to the TSC. 12. The TSC ends the priority granting and returns to the normal traffic signal control. 13. The RSE updates the truck served performance measures. 14. The case ends.
Post Condition: 1. The truck avoided an unnecessary stop and safely cleared the intersection, or 2. The truck made a safe stop before the stop bar and then safely cleared the intersection with reduced intersection delay.
Alternative Flow: 1. (3) The truck changes speed and the RSE updates its priority timing plan based on travel time estimates. 2. (6) If the TSC cannot accommodate the priority request, the RSE sends a warning to the OBE to advice the driver decelerating earlier for a safe stop before the stop bar. The OBE can re-send a SRM if needed (repeat from step 4).
Comments:

1

Item #	11.4.1.1 Basic FSP Scenario - Single Equipped Truck Approaches an Intersection RQID
Pre 1	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
2	N/A
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.404 Acquire Equipped Freight Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
6	C2010.404 Process Signal Request Message from Equipped Freight Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data - Delay
7	C2011.001 Control Signal Actuation for Equipped Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
8	C2009.001 Provide Signal Status Data to Equipped Vehicles
9	Optional. The OBE can Re-Send a Request for Priority if Needed (Repeat Step 4)
10	A2002 Acquire Signal Request Data from Equipped Vehicles and Travelers Note: A cancel request is realized by a pre-designated value of level of priority
11	C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
12	N/A
13	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability
14	N/A
Post 1	N/A
2	N/A
Alt 1	C2001.001 Acquire Equipped Vehicle Status Data C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control
2	C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles C2009.001 Provide Signal Status Data to Equipped Vehicles C2002.404 Acquire Equipped Freight Vehicles Signal Request Data

1

Use Case: Basic FSP Scenario - Multiple Equipped Trucks Approach an Intersection
ID: Section 11.4.1.2
Brief Description: This use case describes the basic signal priority control for multiple connected trucks approaching an intersection.
Primary Actor: Trucks Equipped with On-board Equipment (OBE)
Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller(TSC)
Precondition: 1. The traffic signal controller is programmed with a variety of priority control schema such as early green and green extension or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests. 2. The transportation agency(ies) have established a policy for priority control (called N-level priority) and the fleet management (Freight) system is prepared to provide priority levels for vehicles on routes.
Main Flow: 1. The use case begins when more than one equipped trucks enters the radio range of an RSE. 2. The OBEs receives MAP and SPaT messages from the RSE. 3. The OBEs sends Basic Safety Messages (BSM) to the RSE. 4. The OBEs determine the eligibility for priority and send a Signal Request Message (SRM) if needed. The SRM shall include the level of requested priority which can differentiate the case that the truck can or cannot make a safe stop before the stop bar. 5. The RSE receives and tracks BSMs from multiple trucks. 6. The RSE receives SRMs, manages and prioritizes SRM requests from multiple trucks. Request prioritization will consider the prevailing traffic conditions and the levels of requested priority. 7. The RSE determines the best signal timing plan to accommodate the active priority requests and sends it to the TSC for further processing and execution. 8. The TSC sends updated SSM to the RSE and the RSE broadcasts updated SPaT messages. 9. The OBE receives and tracks the SPaT messages and determines if and when the request will become active at the intersection. 10. The OBE determines that the truck has cleared the intersection and sends a cancel SRM to the RSE. 11. The RSE receives the cancel SRM and sends it to the TSC. 12. The TSC ends the granting of the active priority. 13. The RSE repeats steps 7 & 9 for remaining active priority requests. 14. The RSE updates the trucks served performance measures. 15. The case ends.
Post Condition: Each of the equipped trucks either: 1. avoided an unnecessary stop and safely cleared the intersection, or 2. made a safe stop before the stop bar and then safely cleared the intersection with reduced intersection delay.
Alternative Flow: 1. (3) Trucks change speed and the RSE updates priority timing plan based on travel time estimates. 2. (8) If the TSC cannot accommodate the priority request from a truck, the RSE sends a warning to the associated OBE to advice the driver decelerating earlier for a safe stop before the stop bar. The OBE can re-send a SRM if needed (repeat from step 4).
Comments:

1

Item #	11.4.1.2 Basic FSP Scenario - Multiple Equipped Trucks Approach an Intersection RQID
Pre 1	Assumption of CV environment
2	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.404 Acquire Equipped Freight Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
6	C2010.404 Process Signal Request Message from Equipped Freight Vehicle A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data - Delay
7	C2010.404 Process Signal Request Message from Equipped Freight Vehicle A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data - Queue Length C3002.003 Acquire Intersection Performance Measure Data – Delay A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control C2011.001 Control Signal Actuation for Equipped Vehicles
8	C2009.001 Provide Signal Status Data to Equipped Vehicles
9	C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles A2103 Determine Traffic Signal Phase for Tracked Vehicle
10	C2002.404 Acquire Equipped Freight Vehicles Signal Request Data Note: A cancel request is realized by a pre-designated value of level of priority
11	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
12	N/A
13	Repeat Step 7 to 9
14	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay C2013.006 Estimate Intersection Delay Variability A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay C2015.006 Update Estimates of Intersection Delay Variability
15	N/A
Post 1	N/A
2	N/A
Alt 1	C2006.001 Track Equipped Vehicles Near Intersection C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
2	C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles C2009.001 Provide Signal Status Data to Equipped Vehicles C2002.404 Acquire Equipped Freight Vehicles Signal Request Data

1

Use Case: Coordinated FSP Scenario
ID: Section 11.4.2
Brief Description: This use case describes the priority control for multiple connected trucks travelling through a signalized truck arterial.
Primary Actor: Trucks Equipped with On-board Equipment (OBE)
Secondary Actors: Road Side Equipment (RSE) & Traffic Signal Controller (TSC)
Precondition: 1. The truck arterial is equipped with multiples RSEs and has RSE-to-RSE communication enabled. 2. The traffic signal controllers are programmed with a variety of priority control schema such as early green and green extension or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.
Main Flow: 1. The use case begins when an equipped truck enters the radio range of an RSE along the arterial. 2. The OBE receives MAP and SPaT messages from the immediate downstream RSE. 3. The OBE sends Basic Safety Messages (BSM) to the downstream RSE. 4. The OBE determine the eligibility for priority and send a Signal Request Message (SRM) to the downstream RSE. The SRM shall include the level of requested priority which can differentiate the case that the truck can or cannot make a safe stop before the stop bar. 5. The RSE receives and tracks BSMs from multiple trucks. 6. The RSEs receives SRMs and communicate with each other to estimate the stop patterns of equipped trucks along the arterial. 7. The RSEs jointly form sections of intersections based on the estimated trucks’ stop patterns, and determine the best coordinated priority timing plans for each of the signal sections along the arterial. 8. The RSE sends priority timing plan to the associated traffic signal controller for further processing and execution. 9. The TSC sends updated SSM to the RSE and the RSE broadcasts the updated SPaT messages. 10. The OBE receives and tracks the SPaT messages, and determines if and when the request will become active at the intersection. 11. The OBE determines that the truck has cleared the intersection and sends a cancel SRM to the immediate RSE. 12. The RSE receives the cancel SRM and sends it to the TSC. 13. The TSC ends the granting of the active priority. 14. The RSE repeats steps 7 & 9 for remaining active priority requests. 15. The RSE updates the trucks served performance measures. 16. The case ends.
Post Condition: 1. The trucks safely travel through the arterial while experiencing minimum delays reduced number of stops for a red signal.
Alternative Flow: 1. (3) Trucks change speed and the RSEs update coordinated priority timing plans based on truck travel time and stop pattern estimates. 2. (8) If the TSC cannot accommodate the priority request from a truck, the RSE sends a warning to the associated OBE to advice the driver decelerating earlier for a safe stop before the stop bar. The OBE can re-send a SRM if needed (repeat from step 4)
Comments:

1

Item #	11.4.2 Coordinated FSP Scenario RQID
Pre 1	Assumption of CV environment
2	A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies
Main 1	N/A
2	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
3	C2001.001 Acquire Equipped Vehicle Status Data
4	C2002.404 Acquire Equipped Freight Vehicles Signal Request Data
5	C2006.001 Track Equipped Vehicles Near Intersection C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
6	C2010.404 Process Signal Request Message from Equipped Freight Vehicle C3001.403 Acquire Active Freight Vehicle Priority Requests in a Section
7	C4004.402Store Available Freight Route Data F4003 Acquire Vehicle Route Data F4003.405 Acquire Dynamic Freight Route Information Updates A8001 Support N-Level Priority Policy A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies A3002 Acquire Intersection Performance Measure Data C3002.001 Acquire Intersection Performance Measure Data – Queue Length C3002.003 Acquire Intersection Performance Measure Data – Delay A3001 Acquire Active Priority Requests in a Section A4103 Acquire Section Level Performance Measures C3102.002 Determine Section Signal Coordination Timing
8	C3101.001 Command Signal Coordination A3102 Determine Signal Timing Parameters to Accommodate Priority, Coordination, and Congestion Control C2011.001 Control Signal Actuation for Equipped Vehicles
9	C2009.001 Provide Signal Status Data to Equipped Vehicles
10	Optionally, the OBE can Re-Send a Request for Priority if Needed (Repeat Step 4)
11	C2002.404 Acquire Equipped Freight Vehicles Signal Request Data Note: A cancel request is realized by a pre-designated value of level of priority
12	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.006 Provide Dynamic Passage Interval for Tracked Equipped Vehicles
13	N/A
14	Repeat step 7 to 9 for active priority requests
15	A2013 Estimate Intersection Performance Measures C2013.005 Estimate Intersection Delay A2015 Update Estimates of Intersection Performance Measures C2015.005 Update Estimates of Intersection Delay
16	N/A
Post 1	N/A
Alt 1	C2006.001 Track Equipped Vehicles Near Intersection C2007.404 Estimate Intersection Expected Time of Arrival of Equipped Freight Vehicles
2	C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles C2009.001 Provide Signal Status Data to Equipped Vehicles A2002 Acquire Signal Request Data from Equipped Vehicles and Travelers C2002.404 Acquire Equipped Freight Vehicles Signal Request Data

1

Use Case: Emergency Vehicle Priority – Single or Multiple Vehicles

ID: 11.5.1 and 11.5.2

Brief Description: This use case describes the basic logic for single intersection based emergency vehicle priority (preemption) with multiple vehicles

Primary Actor: Emergency Vehicle

Secondary Actors: Traffic Signal Controller

Precondition:

1. Emergency Vehicle is in Active Response Mode
2. The traffic signal controllers are programmed with a variety of priority control schema such as early green and green extension or the traffic signal controller has an intelligent algorithm for providing priority signal timing for priority requests.

Main Flow:

1. The use case begins when any one of the Equipped Emergency Vehicles (EV) enters the radio range of an RSE.
2. The following steps occur for each EV that approaches the intersection:
    a. The OBE receives MAP and SPaT messages from the RSE.
    b. The RSE receives Basic Safety Messages (BSMs) from the OBE.
    c. The OBE computes the estimated arrival time (min,max) and desired movement (inlane, outlane) as available.
    d. The OBE determines the eligibility for priority and establishes the proper level of priority.
    e. The OBE sends a Signal Request Message (SRM) to the RSE.
    f. The RSE/MMITSS determines the appropriate traffic signal phase to serve the vehicle (translates SRM data into a phase request).
    g. The RSE determines which SRMs (from multiple vehicles) can be served (Priority ranking? Or maximum number).
    h. The RSE notifies the traffic signal controller (or logic) of the active requests including desired phase and service time.
    i. The RSE transmits a status message (SSM) with information about which requests will be served (feedback to the vehicle).
3. The RSE updates the vehicles served performance measures.
4. The use case ends.

Post Condition:

1. The EVs safely cross the stop bar.

Alternative Flow:

1. (2c) The OBE updates the SRM with new arrival information based on a change of speed or route change.
2. (2d) If the OBE determines that the vehicle is not eligible for priority, the use case ends and the EV operates as any normal vehicle.
3. Interrupt – An emergency vehicle may terminate its emergency status at any time. The OBE will send an SRM cancel service request.

Comments:

Item #	11.5.1 and 11.5.2 Emergency Vehicle Priority – Single or Multiple Vehicles RQID
Pre 1	A2501 Acquire Active Response Mode Status of Emergency Vehicle
2	A8102 Emergency Vehicle Priority Strategies Programmed on Traffic Signal Controller
Main 1	N/A
2a	C2005.001 Provide Geometric Intersection Description (GID) Data to Equipped Vehicles C2004.001 Provide Intersection Signal Phase and Timing Data to Equipped Vehicles
2b	C2001.001 Acquire Equipped Vehicle Status Data
2c	C2007.505 Estimate Intersection Expected Time of Arrival of Emergency Vehicles
2d	C1003.503 Determine Emergency Vehicle Eligibility C1004.503 Determine Emergency Vehicle Level of Priority
2e	C2002.505 Acquire Emergency Vehicles Signal Request Data C3001.504 Acquire Active Emergency Vehicle Priority Requests in a Section
2f	C2010.505 Process Signal Request Message from Emergency Vehicle
2g	C2010.505 Process Signal Request Message from Emergency Vehicle A8001 Support N-Level Priority Policy A2021 Process Multiple Requests for Priority A8002 Support Fleet Management Systems (FMS) Vehicle Priority Policies C8002.503 Support Emergency Management Vehicle Priority Policy
2h	A2011 Control Signal Actuation for Equipped Vehicles and Travelers C2011.005 Call the Signal Phase Associated with a Tracked Equipped Vehicle
2i	C2009.001 Provide Signal Status Data to Equipped Vehicles
3	A2013 Estimate Intersection Performance Measures A2015 Update Estimates of Intersection Performance Measures
4	N/A
Post 1	N/A
Alt 1	C2002.505 Acquire Emergency Vehicles Signal Request Data C3001.504 Acquire Active Emergency Vehicle Priority Requests in a Section
2	C2002.505 Acquire Emergency Vehicles Signal Request Data
3	C2002.505 Acquire Emergency Vehicles Signal Request Data

7.3 External References

INCOSE-TP-2003-002-03.2, "Systems Engineering Handbook", January 2010

NASA/SP-2007-6105 Rev1, "NASA Systems Engineering Handbook", http://www.acq.osd.mil/se/docs/NASA-SP-2007-6105-Rev-1-Final-31Dec2007.pdf , December 2007

NTCIP 1202, "Object Definitions for Actuated Traffic Signal Controller (ASC) Units", http://www.ntcip.org/library/documents/pdf/1202v0107d.pdf , January 2005

SAE J2735, "Dedicated Short Range Communications (DSRC) Message Set Dictionary", http://standards.sae.org/j2735_200911/ , November 2009

7.4 Requirements Checklist

As part of the MMITSS Requirements Development Process and MMITSS Requirements Review Process, the following checklist was used by both the requirement author and requirements reviewer to ensure that the IEEE 1233 guidance on well-formed requirements was followed with respect to abstract, unambiguous, traceable, and validatable[7]. The requirements checklist shown below expands the guidance of IEEE 1233 to include the authors' past experience in writing requirements for ISIG, EVP, satellite systems, robotics, software-defined radios, missiles, and process equipment applications. In some aspects, it is equivalent to a lessons-learned synopsis.

☐ The requirement is written as a single, concise, *stand-alone* and complete sentence.

☐ The requirement text does not include the words: any, all, always, never, no, none, many, most, or few.

☐ The requirement is testable.

☐ The requirement is attainable.

☐ The requirement is unambiguous and does not include the words: minimize, maximize, optimize, improve, degrade, user-friendly, easy, fast, rapid, quick, slow, sufficient, excessive, or adequate.

☐ The requirement does not call for compliance with a standard (e.g., SAE J2735, NTCIP, IEEE-488, etc.) without specifying a specific sentence, section, subsection, or specific context of the specific standard.

☐ The requirement avoids using conjunctions, especially the word "and." Rewrite to eliminate "and" if possible.

☐ The requirement does not specify a specific solution or hardware implementation.

☐ The level of a "shall" requirement is compatible with a "Proof-of-Concept" design versus a system specification.

☐ The requirement is consistent in language and level of detail with other MMITSS requirements.

☐ Regulatory and safety requirements use the word "will" or "should" instead of "shall' to communicate the future implications of the requirement after the research development and deployment is completed.

☐ Requirements related to system data archival, data dissemination, data security, and information assurance use the word "will" or "should" instead of "shall" to communicate the future implications of the requirement after the research development and deployment is completed.

☐ The requirement is compatible with Sponsor guidance on appropriate timeframe (5 years initial deployment, 10 year full deployment).

☐ The requirement is in compliance with the backward compatibility guidance given by the Sponsor – Point of departure is the Battelle Study "SPaT."

☐ The requirement does not use the words: disabled, handicapped, or impaired to describe a person with disabilities.

☐ You have reread the requirement and have reached satisfactory answers to the questions: Why is this requirement needed? Is it independent of existing requirements (coverage)?

[7] ibid, p.19-20.

7.5 Change Log Information

7.5.1 Accepted Changes

This section will be used to track technical changes (i.e., not spelling, formatting, etc.) after the submission of the FINAL version and subsequent revisions. Typically, a table structure or format is used that lists the requirement ID, revised requirement text, previous requirement text, CCB ID (after FINAL document version) and a brief explanation of the motivation for the change.

If the change is associated with a supplemental section of the document (i.e., not associated with a particular requirement ID), the section, page number, and paragraph number are referenced along with a brief description of the change. If the change affects an approved process, then a CCB ID is referenced.

7.5.2 Pending Changes

This section will be used to track pending changes to requirements at the time of a published revision to the MMITSS System Requirements Document. It informs the reader of issues and changes that could or will occur in future revisions.

7.5.3 Deferred Changes

This section will be used to track requested changes that have been declined by the Change Control Board (CCB) review. It serves as a close-out of previously pending issues.

7.6 MMITSS Traceability Matrix

The following subsections are organized into traceability matrices to provide information on how the MMITSS project has addressed the Stakeholder inputs, comments, and feedback received during the Stakeholder Webinar on June 4, 2012. The Stakeholder inputs are divided into subsections corresponding to: (1) ISIG, (2) transit signal priority, (3) pedestrian mobility, (4) freight signal priority, (5) emergency vehicle preemption/priority, (6) other/misc., and (7) cross-cutting issues.

Each traceability matrix is organized into columns consisting of RQID, Input ID#, Related Inputs and ConOps Mapping. The first column provides the requirement or requirements that address the Stakeholder input. The Input ID# is the number assigned to the comment and offers information on the topic and subtopic related to the Stakeholder Webinar agenda topic. The “Related Inputs” column is completed for cases where a Stakeholder input was entered during a specific agenda topic, but had applicability to other topic areas. The “ConOps Mapping” provides the corresponding section of the MMITSS ConOps that addresses the Stakeholder input and subsequent requirement. Finally, the reader will note that each individual requirement in this document contains a “Traceability” cell that identifies the corresponding information, but is organized by RQID rather than the Input ID# used in this section of the document.

1 ### 7.6.1 MMITSS Requirements Traceability Matrix – ISIG

2

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
A8001, A8002	1.1.1		§5	Intelligent Traffic Signals are more than just adaptive signal control.
A3101, A3102	1.1.2		§11.0.1, §11.0.2, §11.1.2	It is important to remember that isolated intersection operation is not usually the optimal approach in a dense urban environment where signal operation needs to look at a larger population of signals and a managed implementation - i.e., the central systems need to optimize the network.
F2017	1.1.3	PED	§8, §13.3.3	*MMITSS should* incorporate flexible multi-objective optimization that can be altered depending on the operational conditions: bad weather, code red AQ, special event, and so on.
A2007, A3102	1.1.4		§11.1.2, §11.1.3	*Connected vehicles can provide* optimization of section based on known arrival times of vehicles.
A2007	1.1.5		§11.1.2, §11.1.3	*Connected vehicles can provide* second-by-second optimization, based on real-time vehicle arrivals if high enough market penetration.
N/A Scope	1.1.6	N/A Scope	N/A Scope	*Connected vehicles can provide* dynamic re-routing.
A2101, A3101, A3102, C3102.002	1.1.7		§11.0.1 §11.0.2 §11.1.3	If the density of vehicles is present - then we can determine which areas are "busy" and where there is/is not capacity - faster detection of incidents - so we can support network optimization not just a single arterial.
A3102, C3102.001, C3102.002	1.1.8		§11.1.3	Most current signal timing is based on volumes. Until there is 100 percent market penetration, connected vehicles will not be able to provide volume information. Therefore, looking into prior research related to using travel times or speed profiles as the basis for signal timing would be important.
A2105, A2107, A3101, A3102, A2013	1.1.9		§11.1.3	A traffic signal system should include existing detection systems already in place, identify congestion hot points and implement appropriate signal timing, arterial travel-time and delay monitoring, passage of emergency vehicles through the signals with minimal disruptions to commuter traffic.
A2006, A2013	1.1.10		§11.1.2, §11.1.3	*Connected vehicles can provide intersection control improvements to include the* number of vehicles approaching the intersection, number of vehicles leaving the intersection in the respective directions, and approach speeds.
A3003, A3102, C3102.001, C3102.002	1.1.11		§11.1.2	*Connected vehicles can provide* coordination control, with known platoon sizes and locations.
F2003, C2003.201, F2003.303	1.1.11.1	TSP, FSP, EVP	§11.5.2	Knowing routes of vehicles requiring priority/preemption allows for prediction and planning in real-time .e.g. preparing for a left turn if several signals upstream along vehicles known route.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
C2014.001, A2101	1.1.12	TSP, FSP, EVP	§11.1.1.2, Others	It is critical to find controller solutions that can combine connected vehicle data with existing sensor data to improve controller performance.
A2101	1.1.13	All	§11.1.1.2, §11.1.3, §9.1	Development of new controller algorithms that can make use of connected vehicle data in a less than 100% penetration environment. Need to move away from our current gap based control approach.
A2013	1.1.13.1		§11.0.1, §11.0.2, §12.7.1	Agreed. Data should be good for analysis, planning, and operations monitoring.
A2013	1.1.14		§11.1.2, §11.1.3	Added data at the intersection level should allow us to provide improved local adaptive signal control operation.
A2105, A3102	1.1.15		§11.1.2	Adaptive system timing should be included *in MMITSS ISIG*.
A2001, A2006	1.1.16		§11.1.1.2, §11.1.1.3, §13.3.1	Connected vehicles can provide high-speed transmission of SPaT and of vehicle positioning.
A2001, A2006	1.1.17		§11.1.1.2, §11.1.1.3	Connected vehicles can improve intersection control by reducing and eliminating infrastructure based sensors and replacing with vehicle or human based dynamic sensors reducing costs and increasing signal operation efficiencies.
A2006, C2014.001, A2101	1.1.17.1		§11.1.1.2, §11.1.1.3	This seems like pie in the sky to eliminate all sensors. *Stakeholder input offers insight on maintaining duality of sensors - CV and existing/fixed sensors.*
A2001, A2006, A2101	1.1.18	TSP, PED, FSP	§11.1.1.2, §11.1.1.3	Connected vehicles could provide improvement to detection methods.
A2001, A2006, A2101	1.1.19		§11.1.1.2, §11.1.1.3	Connected vehicles can provide better operational control during heavy rains or storms/ construction when loops and video are unreliable.
A3102, A8001	1.1.20	CC	§11.0	Connected vehicles can provide the ability to prioritize vehicles in a multi-modal environment.
A3102, A8001	1.1.20.1		§11.0	I think this is a logical conclusion and should be the focus.
A2001, A2006	1.1.21		§11.0, §8, §13.3.2	Connected vehicles can provide controller algorithm improvements by making use of individual vehicle data that can be provided via a connected vehicle system.
A2001, A2006	1.1.21.1			It seems like anonymity of the data will limit this significantly.
A2001, A2006, A2011	1.1.22		§11.1.2	Use connected vehicle sample speeds for selecting timing program.
C2013.003	1.1.23		§11.1.2, §11.1.3	Connected vehicles can provide speed information by lane and accurate queue information.
A2104, A3104	1.1.24		§11.1.2, §11.1.3	C*onnected vehicles can provide* queue spillback detection between/among intersections.
A2001, A2016	1.1.25		§13.3.1	Consideration of vehicle weight, performance when traversing the intersection when setting phase length and other settings.
C2013.003	1.1.26		§11.1.2, §11.1.3	Connected vehicles can provide improved oversaturated control; queue lengths easier to estimate.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
A2001	1.1.27		§11.2.1	Determining the number of vehicles awaiting the left hand turn - and traffic approaching to determine whether a FYA or a protected movement is warranted; detection of speeds to determine appropriate clearance intervals.
A2104	1.1.28		§11.1.2, §11.1.3	Connected vehicles can provide detection of gridlock conditions/violations.
A2104	1.1.29		§6, §5, §11.1.3	*Connected vehicles can provide* incident detection where traffic is slow or stopped for prolonged periods of time.
A2104	1.1.30		§11.1.3	Incident detection *should be included in MMITSS (ISIG).*
N/A Scope	1.1.31	N/A Scope	N/A Scope	Connected vehicles could provide more accurate traffic demand for different movements.
A3101, A3102	1.1.32		§11.1.2, §11.1.3	*Connected vehicles can* measure and improve progression through a corridor.
A2006, A2007	1.1.33		§11.1.4	Connected vehicles can provide improved safety - dilemma zone reduction.
A2001, A2006, A2007	1.1.34		§11.1.4	*MMITSS should include* better solutions to the dilemma zone problem through use of individual vehicle data available with a connected vehicle system.
A2001, A2006, A2007	1.1.34.1		§11.1.4	It would seem there are some equity issues on this particular application. I am not saying it isn't a good idea.
A9101	1.1.35		§11.0.1, §11.0.2, §12.7.1	Connected vehicles could provide measures of effectiveness, such as travel times, to monitor ongoing signal operations. *Signal/System State of Health Monitoring*
	1.1.35.1	CC	§11.0.1, §11.0.2, §9.3.3, §12.7	One particularly important area that I haven't seen much thought on (Inrix offers this) is the archival data and a notice of effectiveness as it relates to more typical conditions. Also, long term tracking of performance.
A2013, A3002	1.1.36		§11.1.2, §12.7.1	*Connected vehicles can provide* measures of effectiveness for section control improvements.
A2013, A3002, A2007	1.1.37		§11.0.1, §11.0.2, §12.7.1	*Connected vehicles can provide* intersection levels of effectiveness, system travel time, and intersection approach information.
A3102, C3102.001, C3102.002	1.1.38		§11.0, §11.0.1, §11.1.2	Split or regroup intersections for coordination based on measured MOEs.
C3102.002	1.1.39		§11.0.1, §11.0.2, §12.7.1	*Connected vehicles can provide* travel time/sample speeds for selecting timing programs for section control improvements.
A2013, A3002	1.1.40		§11.0.1, §11.0.2, §12.7.1	Connected vehicles can provide a lot more data for performance measurement.
A8001	1.1.41	PED	§11.3.4, §11.0	Connected vehicles can provide better coordination between pedestrians and vehicle needs.
N/A Scope	1.1.42	N/A Scope	N/A Scope	Need O-D information (which is prohibited today) to help optimize the network/section.
N/A Scope	1.1.43	N/A Scope	N/A Scope	On-the-fly priority corridor identification, processing predicted O-D data *should be included in MMITSS (ISIG).*

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	1.1.44	N/A Scope	N/A Scope	If one were to use the in-vehicle communications - then parking information, event parking information, street closures etc. could be communicated to the individuals or selectively of we had O-D information.
A8001, A8002	1.1.45	EVP, TSP, FSP	§11.0, §11.0.1, §11.0.2	Multimodal priority is my primary interest as opposed to the auto-based ideas within this category.
C2002.303, F2003,303	1.1.46	PED	§11.3.2, §13.3.3	Bikes should be considered to be vehicles.
C2002.303, F2003,303	1.1.46.1		§11.3.2, §13.3.3	Bike should be considered to be vehicles if they are operating in a bike lane or separated bike facility.
N/A	1.1.47	N/A	N/A	Some of the ideas described here concern me. It would seem that some of these should be separated into what the Researchers believe to be true and what is likely to occur.
N/A	1.1.48	N/A	N/A	Larry, there was a harmonization meeting with the Europeans regarding SPaT. They need the changes by end of 2013.
N/A	1.1.49	N/A	N/A	Larry, there are a couple of projects in Europe regarding intelligent signal control with regard to Eco Driving.
	1.2			***ISIG Performance Measures and Goals***
N/A Scope	1.2.1	N/A Scope	N/A Scope	Emissions and fuel reductions as well as travel times or corridor throughputs.
A3002	1.2.2		§11.0.1, §11.0.2, §12.7.1	Arterial travel-time, degree of saturation, or occupancy on green.
A2013, A3002	1.2.3		§4, §11.0.2	Per person delay versus per vehicle delay.
A9038	1.2.4		§11.0.1, §11.0.2, §12.7.1	Travel time reduction in the network would seem to be the end-users ideal performance measure.
A9047	1.2.5		§11.0.1, §11.0.2,	Can we optimize for reliable system-level throughput?
	1.2.6			Can the overarching optimization algorithm also throttle data collection in real time to reduce communications costs and data storage costs?
	1.2.7			What is the minimum set of data required to realize these applications and can a fixed time interval reporting system feasibly accommodate these data needs?
N/A	1.2.8	N/A	N/A	The problem with these types of projections is that you have to layer on the growth in VMT or shrinkage depending on demographics and the economy - and the cost of mobility!
N/A Scope	1.2.9	N/A Scope	N/A Scope, §9.3.1	None of your measures seem to involve safety in any way, are you not short-changing yourselves as to the benefits beyond congestion?
N/A	1.2.10	N/A	N/A	Recall that "8-track" was a clear failure in less than 4 years. *The reference is to music storage and delivery that provided transformative performance in mobile music capability but negligible performance in longevity.*

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	1.2.11			The first goal might be defining what the goal requires (i.e., a level of percentage population need to determine reasonable data on your five items). For example, if the evening rush hour needs 8% population and you are not there yet, what you 'can know' below this tipping point is what needs to be learned first.
N/A	1.2.12	N/A	N/A	Without knowing potential/capabilities from this technology, guesses are not very useful. I would think this is a follow up exercise after we prove we can do it and assess the basic operational aspects.
N/A	1.2.13	N/A	N/A	Picking percentages for improvement or metrics now without knowing capabilities seems like a valueless action - too premature, any guess is good.
	1.2.14			Is there any new baseline that "ten years out" we can agree on in any of this?

7.6.2 MMITSS Requirements Traceability Matrix – Transit Signal Priority

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
A2001, A2016	2.1.1		§11.2.1.1	Connected vehicle information can provide priority specific to turn movement (i.e., more time needed for right turn).
A3101, C3101.001	2.1.2		§11.2.1.1, §12.6.1	For buses, you can get passenger counts, service type, schedule adherence, etc. *with connected vehicles.*
A3101, C3101.001	2.1.3		§11.0	Connected vehicle information should provide service based on vehicle type, loading, schedule delay, etc.
A3101, C3101.001	2.1.4		§12.6.1, §11.0	Connected vehicle information should provide better priority-based service to transit vehicles (compared to current first come first served approach).
A8001	2.1.4.1	CC	§5, §12.1	This is exactly what I think should be an outcome achieved as a part of this project. Find ways to get public sector vehicles equipped and use information strategically to deliver better service.
A3101, C3101.001	2.1.5		§11.2.1.1	Connected vehicle information can provide priority-level relative to bus occupancy.
	2.1.5.1			In Portland, we don't worry about the current occupancy because there is always someone downstream that the bus will pick up. That's a policy distinction that may not be appropriate everywhere.
A3101, C3101.001	2.1.6		§4.1.2	Connected vehicle information should provide priority only if transit vehicle is delayed.
	2.1.6.1		§4.1.2	In Portland, the bus system does this. It should be something that would be integrated with the system and in an ideal situation you would also have that data as a signal operator.
A3101, C3101.001, A2001	2.1.7		§11.0	Connected vehicle information should provide the ability to assess speed of various vehicles requesting priority can lead to better assignment of priority in multi-modal environment.
N/A Scope	2.1.8	PED	N/A Scope, §9.3.1	Don't forget to improve pedestrian safety as related to transit vehicle movements. We need to use Connected Vehicle data to better inform the transit vehicle operator and pedestrian to avoid accidents.
N/A	2.1.8.1	PED	N/A	This is an intriguing concept that I would support.
N/A Scope	2.1.9	N/A Scope	N/A Scope	*Connected vehicle information can improve* communications between bus and transit operation center.
A2001	2.1.10		§6	It is not so much the connected vehicle program - but the ability of the appropriate vehicles to communicate their requests in real-time to the intersection/systems to improve their passage, reduce conflicts, avoid accidents, etc.
	2.1.11			Connection protection can be improved *with connected vehicle information*.
N/A Scope	2.1.12	N/A Scope	N/A Scope	Connected Vehicle information can improve connection protection to guarantee transfers on low frequency routes.
A3101, C3101.001	2.1.13		§11.0.1	*Connected vehicle information can provide* better tracking and monitoring of flexible fixed route and demand responsive services.
	2.1.14		§11.1.3	Bus diversion can be improved *with connected vehicle*

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
				information.
N/A	2.1.15	N/A	§11.2.1.1	*Connected vehicle information can provide* more innovative control strategies for transit vehicles (e.g., transit vehicles turning left from the far right lane).
N/A Scope	2.1.16	N/A Scope	N/A Scope	Connected vehicle information can improve conversion from fixed route to para-transit/jitney service.
C8002.201	2.1.17		§11.0.2	*The traffic signal system needs information on* passengers behind schedule or potentially missing connections.
C8002.201	2.1.18		§4, §11.0.1, §11.2, §13.3.2	Of course this data will be used, but when a vehicle is not 'behind' this data is also used to sharply reduce any action that might otherwise be taken.
C8002.201	2.1.19		§11.0.2	*The traffic signal system needs information on* bus occupancy.
C2003.201	2.1.20		§11.0.1	*The traffic signal system needs information on* the transit vehicle's route and turn decision (left, right, through).
A2001, A2016, A8001	2.1.21		§5, §11.0	*The traffic signal system needs information on* the vehicle type and a relative priority based on function or vehicle type - fire truck, ambulance, etc. The vehicle dynamics need to play a role.
N/A	2.1.22	N/A	N/A	In answer to Larry's question, the signal needs to know and will not (never) trust others in this regard in the absence of truth.
A8001, A8002	2.1.23		§11.0.2	*The role of the transit data in making a priority decision* should be balanced against overall optimization -- one of many users.
A8001, A8002	2.1.24		§11.0.2	The request can come from the individual bus/passengers but granting of priority should be made at the infrastructure level (intersection or section or system).
C2001.001, A8002	2.1.25		§11.2.1.1	I think transit data should be used. I don't think it matters where and what happens on the decision side as long as there is appropriate communication throughout the system to get the information to the right people.
A3101, A3102	2.1.26	FSP	§11.0.1	This decision must he shared - the vehicle does not know the balance of the service requests - - so it is broader - because it involves the route, the intersection, the section - not just the intersection. The vehicle type and priority should have a greater impact - it becomes more complicated when you try to integrate freight priority!
	2.2			***Transit Priority Granting***
A8001	2.2.1		§9.3.4	Of course not! *Should priority be granted to every qualified vehicle.*
A8001	2.2.2		§5, §9.3.4	If it is light rail, perhaps. If it is bus, then no.
A8001	2.2.3		§5	How do you define "qualified"?
N/A Scope	2.2.4	N/A Scope	N/A Scope	Consider not only if the bus is ahead or behind schedule, but how the travelers are doing (if they have a logged itinerary) with respect to schedule or planned connections.
C8002.201	2.2.5		§11.0.2, §4	Consider number of passengers on the transit vehicle.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
A8001, A8002	2.2.6		§11.0	The ideal priority solution would combine the needs of approaching transit vehicles with those of other road users.
A3005	2.2.7	All	§11.0, §11.2.1.1	Assign priority based on existing traffic conditions at that time.
C2003.201	2.2.8		§13.3.2	There needs to be a budget. But, it is likely that the optimal solutions are route, as well as localized issues. So, broadband communications and DSRC are likely to be required.
A8002	2.2.9		§11.0.2	If you are going to grant priorities during peak periods, this needs to be considered during the planning of operational parameters to budget these times.
A8002	2.2.10		§4, §5	I think this is something that is user-definable based on policies by the transit agency.
	2.3			***Transit Performance Measures***
A3002	2.3.1		§12.7.2	On-time performance, number of successful connections made, ratio of transit travel time to POV travel time are performance measures for Transit Vehicle Priority.
N/A Scope	2.3.2	N/A Scope	N/A Scope	And again, we are using delay as the measure of success rather than safety at all.
N/A	2.3.3	N/A	N/A	Again, how do we know without assessing the basic capabilities?
A8002	2.3.4		§9.3.4, §11.0.2	Intuitional trust by a multiple local agency of a transit agency that cover them seems very unlikely to occur, even in ten years. If the transit vehicle states why it needs a call (I am behind and I have xx people on board), then it seems likely that the ASC will be able to grant without understanding the need further.
	2.4			***Transit - Other***
N/A Scope	2.4.1	N/A Scope	N/A Scope	Note that much of the discussion focuses on the use of near-field/DSRC communications with the intersection. Yet the scenarios shown (for a section-route) are more of a central directed function. So, it becomes the ability of the vehicle to communicate its needs to the central system so that it can "program" the route, manage potential conflicts and actually dynamically re-route the vehicle if necessary.
A8002	2.4.2		§13.2	There is a wide body of knowledge on transit signal priority applications. This is often the most common application sited for connected vehicle use.

7.6.3 MMITSS Requirements Traceability Matrix – Pedestrian Mobility

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	3.1			***Pedestrian Communications***
B0101	3.1.1		§5, §6, §9.1	The communications method needs to be cost effective, easy to use, and made available to all pedestrian users. It must be a technology and solution that is also easily used by someone with limited visual capabilities.
B0101	3.1.2	CC		Is there a latency requirement for pedestrians that would suggest one communications alternative over the other?
B0101	3.1.4			It will depend on the latency necessary for the application to receive data, process it and then provide feedback to the pedestrian in a timely manner.
F2018.302	3.1.5		§9.3.6	Advisory or "active safety" warning systems? It depends on the applications you are considering.
B0101	3.1.6	CC	§9.2	DSRC is better for safety. Wi-Fi can take too long to make the connection. 3G/4G is not always available or can be dropped.
B0101	3.1.7	CC	§9.2	Wi-Fi has the correct range and is already on most devices!
N/A Scope	3.1.7.1	CC	N/A Scope	The user has to enable the Wi-Fi to be on. It also makes battery life less and could be prone to issues.
B0101	3.1.8	CC	§9.1	All of the above communication methods and others not yet known. I still fail to see the need to pick the winner here when the application and the ConOps are still quite young.
B0101	3.1.9		§9.3.2	Whatever *communication method* has the best security.
B0101	3.1.10		§9.1	Because it is not reasonable to require a pedestrian to have a special device just for walking around, we should use communications that people would have anyway for consumer reasons. This would suggest 3G/4G, Bluetooth, or Wi-Fi.
B0101	3.1.11		§9.1	It is probably best to test some combination of wireless technologies and see which works best. The solution could include more than one too.
B0101	3.1.12		§9.1	Wi-Fi is good. It's on most smart phones and has enough range.
B0101	3.1.13		§9.1	Probably Bluetooth or 3G/4G.
B0101	3.1.14		§9.1	*(ConOps Workshop)* DSRC can be used similar to cell phone communication.
	3.2			***Pedestrian Intersection Control Improvements***
C2011.302, C2011.304	3.2.1		§11.0.2	On-demand all pedestrian phases, predictive pedestrian phase lengths, and/or 2-minute look-ahead pedestrian movement predictions are intersection control improvements that could benefit pedestrians.
C2011.304	3.2.2		§11.3.2, §9.3.6	Extend phase length for slow-moving pedestrians.
C2011.304	3.2.3		§9.3.6	Do not increase phase lengths for every type of pedestrians.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
C2001.302	3.2.4		§11.0.2	Better knowledge of true pedestrian demand at an intersection could provide improvements at the controller level (get past our current fixed time approach).
C2003.302	3.2.5		§11.0.2	Knowing the full crossing pattern as opposed to single approach crossing is an intersection control improvement that could benefit pedestrians.
A2011	3.2.6		§11.0.2	On-demand and adaptable intersection control improvements could benefit pedestrians.
C2001.302, C2011.303	3.2.7		§11.0.2	Better dynamic service time to pedestrian movements (adaptable Walk/Don't Walk) is an intersection control improvement that could benefit pedestrians.
A2001, C2003.302	3.2.8		§11.0.2	Better knowledge of vehicle positions and speeds should theoretically allow shorter cycle lengths for the same performance. That would improve pedestrian LOS more than anything else.
F2016.002, F2017	3.2.9		§11.3.4, §13.3.3	If possible, integrate severe-weather information into the phase length determination. Imagine crossing the street with a Chicago-style headwind, an icy surface, or Monsoon-type water hazard (puddle size and water flow rate). Standing on the street corner in Tucson during or after rainfall is an invitation to a “vehicle shower” or spraying. Imagine the pedestrian benefit of reducing the wait-time during inclement weather.
	3.3			***Disadvantaged Pedestrian***
C2011.304	3.3.1		§9.3.6	They are the only ones that it makes sense to assist!
C2011.304	3.3.2		§9.3.6	This is an area where the 'kinds' of disability need more agreement so that we can work up to saying what we will not in fact do (or cannot do).
C2011.304	3.3.3		§9.3.6	Require that the handicapped have the device - keep conventional devices - but enhance available walk and clearance time to manage special cases only.
B0103	3.3.4			Meet ADA requirements with hardware less likely to get knocked over by vehicles and less likely to annoy neighbors of the signal.
C2005.302	3.3.5		§11.3.4	Curb cut information, sidewalk closures, icy/wet crosswalk or sidewalk conditions are additional considerations that could be made for disadvantaged pedestrians.
F2016.002, C2005.302	3.3.5.1		§11.3.4, §13.3.3	This seems like a pretty difficult hurdle to overcome. How would you get information on icy crosswalks? Closed sidewalks would be good.
N/A Scope	3.3.6	N/A Scope	N/A Scope	Log all special services and note where basic services are lacking so they can avoid these intersections altogether.
C2005.302, C2006.001	3.3.7		§11.3.2, §13.3.3, §9.3.6	Which street they are facing, which phase is currently active, and vehicles violating the pedestrian phase are additional considerations that could be made for disadvantaged pedestrians.
F2018.303	3.3.8		§11.3.2, §13.3.3, §9.3.6	Use GPS on their phone to tell them if they are straying out of crosswalk.
	3.4			***Pedestrian Performance Measures and Goals***

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	3.4.1	N/A Scope	§9.3.6	Pedestrian accessibility, by level of ambulatory capability
N/A	3.4.2	N/A	§11.3.2	High level of equipped pedestrians
N/A Scope	3.4.3	N/A Scope	N/A Scope	Fewer injuries for the handicapped.
N/A Scope	3.4.4	N/A Scope	N/A Scope §9.3.1	This really needs to be more than just pedestrians - - fewer injuries with less wasted capacity!
N/A Scope	3.4.5	N/A Scope	N/A Scope §9.3.1	Improving safety for pedestrians should be a performance measure more so than reducing pedestrian delay.
C9001.309	3.4.5.1		N/A	An argument for reduce delay leads to better compliance of pedestrian signal indications.
A8001	3.4.6		§11.0.2, §12.7	Better service level or performance measure level for pedestrians without impacting vehicle travel time.
A2013, C9001.309	3.4.6.1		§11.0.2, §12.7	This is a value choice that should be made at the policy level. In Portland, there are places where we would disagree with this. Also, in the late night operations, why would one vehicle be more important than one pedestrian?
C9001.309	3.4.7		§11.0.2, §12.7	Is delay the only performance measure? It may not only be about delay but more about safety. Their delay may actually be longer rather than shorter. If we find there is only one pedestrian at a light it may take longer for them to cross.
N/A Scope	3.4.8	N/A Scope	§4.1.3	Can we measure the goal in term of platooning pedestrian movements in downtown areas in some useful way?
N/A Scope	3.4.9	N/A Scope	N/A Scope, §9.3.1	Pedestrian Safety is more important than mobility.
C2001.302, C2002.303	3.4.10		§4, §9.1	Give consideration of how remote devices would interface with the traffic controller and how that might affect standards.
N/A	3.4.11	N/A	N/A	I sometimes wonder if we are spending too much time staring at devices rather than looking around in our environment.
N/A Design Issue	3.4.12		§13.3.3	Pedestrians should not have to stare at the device to know signal status. The device should work unobtrusively and alert only when there is conflict.
N/A	3.4.13		§11.1.3	Any improvements will be very dependent on penetration. This is an area that I don't think has been researched.
C2011.302, C2011.304	3.4.14		§9.3.6	Do not focus on the able bodied - if they are too stupid to press a simple button why give them a tool to really mess things up!
	3.5			***Pedestrian - Other***
A2001, A2002	3.5.1		§11.0.2, §4.1.3, §11.3.2	*Connected vehicles can provide* pedestrian wave accommodation (special events).

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	3.5.2	N/A Scope	N/A Scope	There are plans to include a pedestrian/transit vehicle safety application during the Connected Vehicle Safety Pilot. The goal is to study how V2I data could improve transit vehicle versus pedestrian accidents in crosswalks.
N/A Scope	3.5.3	N/A Scope	N/A Scope	You should add the technology (from Israel) being used by FTA to detect pedestrians at intersections as part of the Safety Pilot Model Deployment in Ann Arbor.
N/A	3.5.4	N/A	N/A	There are pedestrian applications being researched at the University of Idaho and University of Minnesota. There was a presentation at the ITS America Conference regarding a mobile APS application developed at the University of Minnesota.

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7.6.4 MMITSS Requirements Traceability Matrix – Freight Signal Priority

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
A8002	4.1.1		§9.3.4	I think transit, freight, emergency, and maintenance vehicle priorities are really very similar from a technical level of traffic control. The operational priorities - business rules - dictate priorities.
A8002	4.1.2		§8, §5	Freight is too narrow a theme. What about construction equipment, road and winter maintenance vehicles, and other types of heavy vehicles. Truck signal priority would include freight and all classes of heavy vehicles excluding transit.
	4.2			***Freight-Traffic Management Strategies***
A8001	4.2.1		§9.3.4	*Strategies* similar to transit vehicles, but they may be at a low priority because these are run by private for-profit organizations.
C4003.402, A8002	4.2.2		§11.0 §11.1.3	Considerations should be made on the operations of the terminals or ports where freight is operating in and out. Example ship arrivals, train arrivals at intermodal facilities, etc. These operations present large areas of congestion around these facilities.
C2007.404	4.2.3		§11.4	Truck turning radii should be taken into consideration near freight facilities when signal timing is set.
C2007.404, F2019.403	4.2.4		§11.4	*Traffic management strategies* should strive to make safety improvements for heavy vehicles approaching intersections.
C2007.404, F2019.403	4.2.5		§13.3.4	Truck intersection safety improvements at downgrade approaches especially in mountainous areas.
C2007.404, F2019.403	4.2.6		§11.4	*Traffic management strategies that incorporate* consideration of truck acceleration and deceleration times.
N/A Scope	4.2.7	N/A Scope	§11.4	*Traffic management strategies should incorporate* dynamic stop bar locations to provide acceptable turning movement for freight movements, say sharp left hand turns.
C2007.404	4.2.8		§11.4, §11.0.1	Avoid having trucks come to a full stop.
F2019.403	4.2.9		§11.4.1.1, §11.4.1.2, §13.3.4 §11.1.4	Trucks maybe should get a longer yellow indication because they are less inclined to stop.
C2007.404	4.2.10		§11.4.1.1 §11.4.1.2 §13.3.4 §11.1.4	Dilemma zone elimination for trucks.
A8001. C2011.001	4.2.11		§11.0.1	Increased green time during peak periods of freight traffic will keep trucks moving.
A8001	4.2.12	All	§9.3.4	MNDOT studies found that providing priority to trucks increased the signal cycle length, resulting in increased delay to other vehicles that approximately cancelled out the benefit provided to the trucks.
C2007.404, C2016.001, F2019.403	4.2.13		§11.0.1	Identify trucks and/or large and heavy vehicles through the intersection and allow appropriate passage time automatically.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	4.2.14	N/A Scope	N/A Scope	Travel time information provided trucks for various routes would be advantageous.
A3003, C8002.402	4.2.15		§11.0.1, §11.4.2	Given the density, one would want to platoon these vehicles to create a smoother travel through the network - basically granting them with a priority if one could work with the entry and dispatch process to group the vehicles.
N/A Scope	4.2.16	N/A Scope	N/A Scope	Can multiple truck from or to (OD pairs) be treated in some useful way to increase laminar flow types?
	4.3			***Freight - Connected Vehicle Information***
A8001	4.3.1	ISIG	§11.0	*Connected vehicles* can provide optimization based on number of commercial vehicles.
C4003.402	4.3.1.1			O-D info and schedule adherence requirements could be fed into algorithms.
C2001.001, C2016.001	4.3.2		§11.4 §11.4.2	Ability to detect vehicle class, speed, etc. would enhance safety.
C2001.001, C2016.001	4.3.3		§11.4 §11.4.1.1 §11.4.1.2	Schedule criticality, vehicle size and weight, turning radius, and acceleration/deceleration performance information will enhance traffic control strategies for trucks.
C2007.404, C2016.001, F2019.403	4.3.4		§11.4 §11.4.2	Speed, weight, and dimensions information will enhance traffic control strategies for trucks.
C2001.001, C2007.404, C2016.001, F2019.403	4.3.5		§11.4 §11.4.1.1 §11.4.1.2 §11.1.4 §11.4.2	One needs more vehicle dynamics - breaking distance, mass, immediate speeds, etc. so that clearance times and progression speeds can be managed.
C2007.404, F2019.403, C8002.402	4.3.6		§11.4 §11.4.1.1 §11.4.1.2 §11.1.4 §11.4.2	Having data on the vehicle type and potentially load or information on stopping ability could help us improve control decisions at the intersection.
C8002.402	4.3.7		§9.3.4	Maybe something on criticality of cargo, for example perishable items, medical, etc. will enhance traffic control strategies for trucks.
F2003	4.3.8		§11.0.1, §11.4.2	Current lane and direction of travel information will enhance traffic control strategies for trucks.
C2007.404, C2016.001	4.3.9		§11.4	Turn radius, speed, and lane being occupied information will enhance traffic control strategies for trucks.
C4003.402	4.3.10		§11.0.1	The expected/desired path through the network will enhance traffic control strategies for trucks.
C2011.001	4.3.11		§11.4.1.1 §13.3.4	When a signal knows a truck is arriving, it can adjust its assumptions for startup, clearance time, and other factors for that particular phase.
N/A Scope	4.3.12	N/A Scope	§9.3.4	Fewer emissions (e.g., priority to trucks on an uphill approach) information will enhance traffic control strategies for trucks.
C8002.402	4.3.13		§9.3.4	Shouldn't this information already be taken into consideration by dispatchers? Is it necessary for trucks to be connected vehicles?

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
C8002.402	4.3.14		§9.3.4	Assumptions that are being made are not realistic. In particular, in V2V we are struggling with how to identify what's being pulled – communication issues are huge. Cargo ID is also a challenge – hazmat maybe not so much, but shippers don't want to give out info on what they are carrying with a HUGE benefit. More understanding of the industry (and not what the states want) is needed.
	4.4			***Freight Priority Requests***
C8002.402	4.4.1		§11.0	Need to establish some measure to determine if and when trucks should be given priority.
A8001, C8002.402	4.4.2		§9.3.4 §11.0.1 §11.1.3	Trucks should request priority similar to transit and emergency vehicles only at peaks during the day where operations of terminals cause congestion.
C8002.402	4.4.3		§9.3.4	In the off-peak, yes, especially if a train or ship they are delivering to are scheduled to leave shortly.
A8001, C8002.402	4.4.4		§9.3.4	Yes, *trucks should be able to request priority in a manner similar transit and emergency vehicles,* but they should be granted low priority.
C2007.404, F2019.403	4.4.5		§11.4.1.1 §13.3.4	No but in a safety scenario where the green could be extended for a truck that may not be able to stop.
N/A Scope	4.4.6	N/A Scope	§11.0.1, §11.4.2	There are other considerations - suggest mandating platooning rather than random dispersion!
N/A Scope	4.4.7	N/A Scope	N/A Scope	There should be an economic factor as well, so trucks could pay more for priority when they have a time-critical load.
N/A Scope	4.4.8	N/A Scope	N/A Scope	MNDOT had good success in using two loop detectors 30 feet apart in the approach lane. Cars were too short to trigger both loops simultaneously. It was a low cost easy way to detect trucks in advance of the intersection.
	4.5			***Freight - HazMat***
C8002.402	4.5.1	ISIG	§11.4	The type of HazMat (flammable, etc.) is connected vehicle information that could be used to make traffic management decisions. The more dangerous the cargo is, the higher its priority.
C8002.402	4.5.2		§11.4	Suggest also adding oversize and overweight trucks that require permits from DOT specific to trips they make.
C8002.402	4.5.3	ISIG	§11.4 §11.0.1	Do you really want to grant priority for HAZMAT at all intersections? Obviously there is a need to track this cargo through the network and to take this movement in account for TSP or EVP - so as not to create a dangerous situation.
C8002.402	4.5.4		§11.4	Please keep in mind that greater than 90% of all hazmat is NOT placarded or marked. Only a very small amount should get signal treatment.
C8002.402	4.5.5		§11.4	Making traffic system operator aware of HAZMAT vehicle being present in the system/network might be of help.
	4.6			***Freight Priority Performance Measures and Goals***
C2013.005	4.6.1		§12.7.4	Delay management is a realistic performance measure.
A9031.001, C2013.005	4.6.2		§12.7.1, §12.7.4	Should not just measure truck delay, but also the total delay at the intersection? Decreasing the truck delay can increase delay to other vehicles.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
C9054.403, C4103.001, C4103.006	4.6.3		§12.7.4	Accident rates at intersections, minimized stops - so stops is a good measure. I am not sure that travel time is the measure - waiting time is. But, where you place the waiting time is important - at start or end is the best - not at random locations throughout the network?
C4103.405	4.6.4		§12.7.4	Freight/goods reliability by time of day and condition (rain, special event, etc.) are realistic performance measures.
A9053	4.6.5		§11.0.1, §11.0.2	With all due respect, you have a school there that dumps vehicles out. Use that situation like someone might use the corridor in Long Beach that loads and offloads shipping containers form the harbors. Set up a test that note the clearance time pre/post to clear the day's load out and compare that with the impact on the cross street in some way.
	4.7			***Freight - Other***
N/A	4.7.1	N/A	N/A	Here are links to 2 Minnesota projects on truck priority at traffic signals: http://www.dot.state.mn.us/guidestar/2006_2010/truck_priority.html http://www.dot.state.mn.us/guidestar/2001_2005/truck_priority/truckpriorityfinal.pdf

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7.6.5 MMITSS Requirements Traceability Matrix – Emergency Vehicle Preemption

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	5.1			***EVP - Connected Vehicle Information***
A8001, C8002.503	5.1.1		§9.3.4	*Connected vehicle information can* better handle priority service for all types of Emergency Vehicles (fire versus police versus ambulance, etc.).
A3101	5.1.2		§11.5.2	*Connected vehicle information* should be able to better facilitate route priority for emergency vehicles.
A3101, A8001, C8002.503	5.1.3		§11.5.1	Ideally we should handle emergency vehicle service as a priority over preemption.
C8002.503	5.1.4		§11.5.1	*Connected vehicle information* can eliminate preemption in non-emergency situations.
C8002.503	5.1.5		§11.5.1	*Connected vehicle information can* ensure that pre-emption is used by only approved vehicles.
C2008.505, A8001, C8002.503	5.1.6		§11.5.1	CV allows for arbitrary phase order, which should speed up coordinated system recovery after preemption.
C2008.505	5.1.7		§11.5.1	*Connected vehicle information can provide* quicker transition into and out of preemption.
C3001.504	5.1.8	CC	§11.5.2	Preemption could be improved by taking into account the vehicle's planned route. For example, optical preemption affects all the signals within some distance straight ahead of the emergency vehicle, even if the vehicle will be turning at the nearest intersection. Instead, you could preempt the signal around the corner (assuming you can get DSRC to work around corners with buildings!).
F2018.001	5.1.9		§11.5.2	Alerting vehicles of impending conflicts - and routing complete O-D solutions for each vehicle. Again, this needs broadband communications and network management (traffic) so that EVP is not just a local issue.
C9037.509, C9037.510	5.1.10		§11.5.2	Vehicle O-Ds and complete paths can be used to anticipate system-level effects/response.
C8002.503	5.1.11		§11.5.1	*Connected vehicle information can provide* better handling of priority at intersections when multiple EVs arriving from multiple directions and at different times.
N/A Scope	5.1.12	N/A Scope	N/A Scope	*Connected vehicle information can improve preemption/priority* by providing route information back to EV operators so they can make better informed dynamic re-routing decisions (such as if approaching a rail crossing that is under control).
N/A Scope	5.1.13	N/A Scope	N/A Scope	Connected vehicle information can provide dynamic mainline/progression routing from vehicle to scene.
N/A Scope	5.1.14	N/A Scope	N/A Scope	Two-way communication with the EV driver to let them know status of request *could improve preemption/priority.*
C2016.001	5.1.15		§6, §8	Existing road conditions will be better known with connected vehicles.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	5.1.16	N/A Scope	N/A Scope	Have the EV OBE transmit its location, heading, vehicle class, and incident location they are responding to. Then, the traffic signal can make a decision based on vehicle class which vehicle to give priority to.
C2002.505, C3001.504	5.1.17		§11.5.1	*Connected vehicle information* can eliminate field infrastructure for some existing technology.
N/A Scope	5.1.18	N/A Scope	N/A Scope	As vehicle pass by the RSU of the signal control and ask for preemption or priory they will state their agency affiliation (in the DSRC messages). The RSU should gather this for DOT use to know who has arrived on scene (the way they came in). This is vital in some incidents to know very quickly and relate to other (IC and back office).
	5.2			***EVP - Priority Contention***
C8002.503	5.2.1		§11.5.1	Vehicle class/type, incident location and type, severity of incident etc. will help the traffic control decide whether to grant priority or not and if yes, which EV to give priority to.
C2007.505, F2019.001, C8002.503	5.2.2		§9.3.4	Mostly vehicle type, ability to stop, and predicted time-to-intersection should be considered in determining priority.
C8002.503	5.2.3		§9.3.4	Vehicle type versus class of emergency being serviced *should be considered in determining priority.*
C8002.503	5.2.4		§9.3.4	EMTs first, followed by Fire s*hould be considered in determining priority.*
C8002.503	5.2.5		§9.3.4	Link *priority decision* to data from emergency dispatch regarding the level of the emergency response (e.g., fire versus a cat stuck in the tree).
A8001, C8002.503	5.2.6		§11.0, §9.3.4, §9.3.5	There must basically be an off-line discussion of priority - i.e., the region needs to establish a priority scheme for its operations (not just vehicles - but vehicle and mission) so that the prioritization can take place at a higher level and even alternate routes can be suggested or required. EVP is not just a localized problem - it needs to be handled for routes!
C8002.503	5.2.7		§11.5.2	*Priority contention for several requesting vehicle should consider* adherence to predicted route.
	5.3			***EVP - Performance Measures and Goals***
C9037.509, C9037.510	5.3.1		§12.7.5	Response time improvement.
C9037.509, C9037.510	5.3.2		§12.7.5	Reduction in response time (2)
C2008.505	5.3.3			Improved system recovery from preemption.
N/A Scope	5.3.4	N/A Scope	N/A Scope	Accessibility measures -- how far can a single vehicle reach from its home base, reliably across the network within a specific response threshold?
C9501.501, C9501.502	5.3.5		§12.7.5	Reduced accident of EVP actions at intersections is about the only measure. We already have EVP and route EVP which grants green-waves, etc. About the only benefit that could be added is to route other vehicles away from the area. How does one measure those?

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A	5.3.6	N/A	N/A	I think people are being far too optimistic on gains for EVP.
C2007.505, C2008.505	5.3.7		§13.2	Not all response vehicles arrive at the same time, by design, nor do they come/leave at the same speed or stage at the same places. See IEEE work for some concept to perhaps steal or reuse.
C8002.503	5.3.8			A major problem in emergency vehicle coordination credentials and rights is those “out of home service” vehicles come and operate in the region during regional problem (seasonal fires are good example). We need a solution that accepts this reality and the different equipment types that often need to cooperate.
C9031.001, C9031.002	5.3.9			In general, performance measures should be based on impacts to non-priority vehicles.

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7.6.6 MMITSS Requirements Traceability Matrix – Other

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
F2016.002, F2017	6.1.1	All	§11.3.4, §13.3.3, §8	Weather conditions affecting signal clearance durations should be considered.
	6.1.2	All		Weather/roadway flooding *should be considered.*
	6.1.3		§11.2.2.1, §13.3.2	Highway-Railroad Interface
A8001	6.1.4		§11.2.2.1, §13.3.2	Highway-Railroad Interface - Agree with this topic. Signal priority to clear waiting areas for signals that cross over a rail grade crossing very important. Also, once train is occupying crossing and blocking road, signal would give priority to cross traffic until train clears crossing.
	6.1.5			Prior knowledge of train arrival at crossings to be able to perform pre-preemption and post-preemption timing plans.
A8001	6.1.6			Better exchange of data between rail side and controller to ensure the safe and efficient operation of signals at an active rail crossing.
	6.1.7			Interconnected grade crossings and traffic signals where queue space must be forced off due to potential train/vehicle collision - railroad preemption.
	6.1.8			At-grade, non-equipped crossings remains a big issue to Federal Railroad Administration that may benefit from DSRC but I am not sure how as I type this.
	6.1.9			Reconfiguration of at-grade crossings, especially those near traffic signals, must be designed for all vehicles, not just cars.
	6.1.10			We should include interconnected traffic signals and grade crossing locations with gates/lights/traffic signals (i.e., railroad preemption).
	6.1.11			Special events (without being told explicitly that it's a special event) should be considered.
	6.1.12		§11.1.1.4	Arterial-Freeway Interchanges
	6.1.13		§11.1.1.4	Suggest including ramp meters to the system
	6.1.14		§11.1.1.4	Ramp meter spill back and ramp meter priority s*hould be considered.*
N/A Scope	6.1.15	EVP	N/A Scope	Alternate routes for EVP and incident mitigation should be considered.
	6.2			***Other - Special Classes of Users***
N/A	6.2.1	N/A	N/A	Should we be giving priority to these special classes of vehicles/situations or rely on the overall system improvements to better serve these special cases?
C2006.001	6.2.2		§11.5.1, §11.5.2	Yes - EVP routes - most systems can support this now - the connected vehicle simply adds the en-route tracking.
	6.3			***Other - Special Cases of Traffic Management***
A2011	6.3.1		§13.3.1	Active Traffic Demand and Management
	6.3.2			This is an important area, maybe check into the experiences of recent evacuation events for insights

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
N/A Scope	6.3.3	N/A Scope	N/A Scope	This is just a better opportunity to communicate into the vehicles if they have in-vehicle displays.
A3101, A3105	6.3.4	ISIG		Incident detour traffic management should be considered.
A8001	6.3.5	PED	§13.3.3	Don't forget the pedestrians in the concept of "traffic."
	6.3.6			Signal operations while signal is under maintenance or in flash should be considered.
	6.3.7			As mentioned in another post, work zone and many other events overlaid with signal operations in a clear way remains to be developed and the test beds should support this need.
N/A Scope	6.3.8	N/A Scope	N/A Scope	Should the system include a “surveillance” function?

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7.6.7 MMITSS Requirements Traceability Matrix – Cross-Cutting Issues

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	7.1			***Cross-Cutting - Communications***
	7.1.1			There are already commercially available transit signal priority/emergency vehicle preemption systems that use GPS and radio communications with the signal. It would be useful to work with these vendors to incorporate DSRC rather than try to re-invent the whole system just to use DSRC.
A2004, C2004.001, C2004.302	7.1.2		§13.3.1, §13.3.2, §13.3.3, §13.3.4, §13.3.5, §4.1.3, §5, §8, §9.1, §11.0, §11.4.1, §11.5.1	Many of these applications need not be DSRC centric - but rather in an urban setting, this is more likely a broad-band communications using on-board GPS and better location etc. to support priority and preemption without localized infrastructure. A DSRC centric is not an optimal solution unless you suggest that SPaT is present!
	7.1.3			DSRC may have difficulty communicating around corners in downtown areas
	7.1.4			Do we have good technical data on the density of DSRC and vehicles around an intersection - within range?
	7.1.5			Since many intersections have communications lines already in place, perhaps a more robust method of using DSRC is needed than cascading the information intersection to intersection.
	7.1.6			Is it really practical to equip all of the signals in an urban environment with the DSRC/SPaT - or are we going to see advances in broad-band communications that will make this more practical?
	7.1.7			Not significant - broadband is more likely a deployment alternative in urban settings (in comparison to the DSRC mentioned in the scenario description.)
	7.1.8	Transit		Will DSRC give us the distance needed to solve both transit signal priority under all conditions (including environmental)? The stated range for 5.9GHz DSRC is 1000 meters (30 meters for 915MHz predecessor).
	7.1.9	ISIG		Standards - NTCIP 1103 V3 is critical.
A2004, C2004.001, C2004.302	7.1.10	ISIG	§13.3.1, §13.3.2, §13.3.3, §13.3.4, §13.3.5, §4.1.3, §5, §8, §9.1, §11.0, §11.4.1, §11.5.1	Expansion of NTCIP 1202 to add support for SPaT is an outcome of the Battelle SPaT work. Funding is to be available for updating 1202. Hopefully the SPaT additions will be a focus of this funded effort.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	7.1.11			A wealth of safety information could be gained from I-to-V communication, for example operator behavior could be identified, and corrective actions taken within transit fleets using collected data.
	7.1.12			Perhaps learn when we need to equip and when we do not is the key research need in this regard.
	7.1.13			A NHTSA decision in 2013 could mandate V2V on new vehicles. It will not likely mandate any V2I applications. Therefore, even the equipped vehicles may not be capable of interacting with the roadside infrastructure for V2I apps. We need to identify a mechanism for getting the V2I apps into the vehicles.
	7.1.14	ISIG	§5	In theory all aspects of traffic signal control can be improved with Connected vehicle information.
	7.1.15		§11.5, §11.0.1	*Connected vehicles can provide* coordinated priority through the section by path for time critical users (freight, transit, EV).
	7.2			***Cross-Cutting - Data and Information Security***
	7.2.1		§9.3.2	What about data security? This is subject to much corruption?
	7.2.2		§9.3.3	All of *the data should be archived* - this effort helps us collect data to analyze the signal and traffic operations that will help answer the questions you asking beforehand that we really can't intelligently answer at this point.
	7.2.3		§9.3.2, §9.3.3	Keep data disaggregate but anonymous.
	7.2.4		§9.3.2, §9.3.3	Data should be open and shared.
	7.2.5		§9.3.2, §9.3.3	Keep all data (everything) in a standardized format.
	7.2.5		§9.3.3	*MMITSS project* needs to be careful about what data is archived due to FOIA. You do not want to get called into court for every traffic accident.
	7.2.6		§9.3.3	*MMITSS project will* want to keep performance measure data.
	7.2.7		§9.3.2, §9.3.3	Government generated date is equivalent to public data and should be freely available. We can also expect private concerns to merge/fuse the data to provide added value!
	7.2.8		§9.3.3	*Archive r*eal-time 24x7 continuously.
	7.2.9			*Archiving frequency* depends on type of data. Follow Section 1201 for real-time data.
	7.2.10		§9.3.3	*The data should be archived* long enough for folks to use it throughout the R&D process of connected vehicles.
	7.2.11		§9.3.3	*The data should be archived* indefinitely.
	7.2.12		§9.3.3	When stripped of PII, keep data around to support longitudinal performance assessment.
	7.2.13			I may be on the fringe here, but I don't think a signal should have to archive much, if any, data to operate effectively. The goal should be to "forget" as much data as soon as possible to protect privacy.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	7.2.14			A signal's internal logic should be enough to manage traffic effectively. I don't see any need to store vehicle data at the signal-level. Data should be "forgotten" as soon as possible.
	7.2.15		§9.3.2, §9.3.3	Security *protection* from hackers s*hould be included in the security requirements for archived data.*
	7.2.16		§9.3.2, §9.3.3	Privacy of data will be a critical issue to public acceptance of the end system.
	7.2.17			I am not sure we have agreed on who owns data being broadcast by vehicles, individuals, and fleets. Consequently, maybe we don't have any authority to capture or archive data?
	7.2.18		§9.3.2, §9.3.3	There should be no implied ownership. If it is publically collected, it is freely available to the public and that needs to be part of the O&M costs associated with the data. A better question - who will bear the cost of creating and maintaining the database?
	7.2.19		§9.3.2	Each agency/company should have their own policy on security and privacy of data.
	7.2.19.1		§9.3.2	With respect to comment #1, there will need to be a uniform policy on security and privacy nationwide. I don't think leaving it up to each agency will work.
	7.2.20		§12.7.6	How do we police the accuracy of the data provided? Bad data can make the archive worthless!
	7.2.21		§9.3.2, §12.7.6	The integrity of the data must be guaranteed - but everyone should have access - no restrictions! The major issue is who certifies the integrity of the data.
	7.2.22		§12.7.6	Quality of the data is key.
	7.3			***Cross-Cutting - Maintenance and Operations***
	7.3.1		§12.5.1, §12.2, §12.3	This is a completely new requirement (i.e., communications management) for transportation agencies and may be somewhat challenging for some agencies. We need both operational and performance expectations identified.
	7.3.2		§12.5.1	Any DSRC used for safety applications will make maintenance of the DSRC a high priority item, which may be difficult with limited maintenance staff. It also may involve different staff skills than currently employed for signal maintenance.
	7.3.3		§12.5.1, §12.2, §12.3	Communications issues for remote, rural locations and smaller communities are maintenance and operations issues that need to be included *in the MMITSS ConOps.*
	7.3.4		§12.5.1, §12.2, §12.3	Do the agencies have the communications expertise to support this stuff?
	7.3.5			Beware of high levels of availability - traffic cabinets and traffic field equipment often takes serious time to fix - sometimes days!
	7.3.6			Most of our traffic signals do not have internet connectivity. Providing such internet connectivity for every roadside DSRC will be a big issue.

RQID	Input ID#	Related Inputs	ConOps Mapping	Stakeholder Input/Feedback
	7.3.7		§12.7.6	If you get the internet, you also get time sync. How many intersections would benefit from a simple external time sync and not any internet connection? Is this a real problem or one that clearly will get solved by other means over the ten year time frame?
	7.3.8		§12.2, §12.3	Certification of equipment is essential; ongoing calibration and easy swap maintenance is required.
	7.3.9		§12.7.6	*MMITSS project* may need to provide performance measures as to repose and turnaround time to maintenance of an equipped intersections due to safety implications.
	7.3.10		§5, §10.1	It seems that the area of work zones and incident management when overlaid on a signal control areas is a major missing element in your list. We would want the test bed to be in a position to be able to study this further.
N/A	7.3.11	N/A	N/A	How do we factor in possible lessons learned from the Safety Pilot (timing of this project versus Safety Pilot could be an issue)?
N/A	7.3.12	N/A	N/A	It is important that the lessons learned are practical for the rank-and-file deployers - not just the "bleeding edge" agencies such as MNDOT.

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