

Model Systems Engineering Documents for Central Traffic Signal Systems (DRAFT FINAL)

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LIST OF ACRONYMS

ASC	Actuated Signal Controllers
ASCT	Adaptive Signal Control Technology
ATSPM	Automated Traffic Signal Performance Measures
CTSS	Central Traffic Signal System
CFR	Code of Federal Regulations
COTS	Commercially available Off-The-Shelf
DATEX	Data Exchange standard
DOT	Department of Transportation
FAR	Federal Acquisition Regulation
FMS	Field Management Stations
GO	Global Objects
ICM	Integrated Corridor Management
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
NCHRP	National Cooperative Highway Research Program
NEMA	National Electrical Manufacturers Association
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
PIF	Public Interest Finding
PS&E	Plans, Specifications and Estimates
RFI	Request For Information
RFP	Request For Proposal

RFQ	Request For Qualifications
SNMP	Simple Network Management Protocol
SSM	Signal System Master
STMP	Simple Transportation Management Protocol
TBC	Time base coordination
TIP	Transportation Improvement Program
TMC	Transportation or Traffic Management Center
TOC	Transportation or Traffic Operations Center
TOD	Time of Day
TRPS	Traffic Responsive Pattern Selection
TSS	Traffic Signal System, short for CTSS, Central Traffic Signal System
UTDF	Universal Traffic Data Format
XML	eXtensible Markup Language

EXECUTIVE SUMMARY

This guidance document for procuring Central Traffic Signal Systems (CTSS) is part of a series of Model Systems Engineering Documents. This guidance document incorporates the Model Systems Engineering Documents for Adaptive Signal Control Technology (ASCT) Systems, published in 2012 by the Federal Highway Administration (FHWA). Over 100 adaptive systems have been implemented in the United States since 2010, a significant number of these procurements have utilized the model systems engineering document process.

This guidance expands the scope to cover central traffic signal systems and performance management technologies. This framework will support the alignment of an agency's overarching objectives with their system operations strategies to guide the procurement of a system that best suits their needs within stated constraints. It will reduce the level of unmet expectations by stakeholders, improve the confidence of vendors that they will be able to verify compliance with stated requirements, and reduce the incidence of biased specifications.

The model systems engineering documents provide a framework for agencies to clearly articulate their needs, and specify succinct and comprehensive system requirements to guide the procurement and implementation of Intelligent Transportation Systems (ITS). Target procurements include those projects that:

- Cannot reasonably afford development of systems engineering documents from scratch.
- Make selections from existing device and software products in the market, rather than supporting new product or software development.

These model documents make it possible for agencies to develop meaningful systems engineering documents that will effectively support procurements and reduce risk for smaller, more routine ITS implementation projects.

Using these documents will support an agency's compliance with 23CFR940.11.

PART OF AN ITS IMPLEMENTATION PROCESS

A CTSS implementation project will be part of an overall ITS implementation strategy to support the agency's operations planning. The user will be able to identify the goals, objectives and activities from those planning efforts to select the appropriate needs within the Model Concept of Operations.

During the project phase, this Concept of Operations will support documentation of system requirements to a level of detail necessary for clarity during a CTSS procurement. Verification and Validation will confirm that the system fulfills the requirements and successfully meets the agency's needs. Demonstrably meeting needs ensures that the agency will attain the operations objectives driving the project.

WHAT THE USER WILL DO

The user will review sample statements that reflect each of the agency's needs related to their operations objectives. Following this guidance, the user will tailor these sample statements to address specific situations. Selecting and tailoring user needs in the Concept of Operations will link to a set of clear and concise requirements. This guidance leads the user to develop the following systems engineering documents:

- Concept of Operation.
- System Requirements.
- Verification Plan.
- Validation Plan.

PROCUREMENT SUPPORT

Central traffic signal systems procured using traditional low-bid processes impose an unnecessary risk on project success. A number of studies and experience has demonstrated that Intelligent Transportation Systems, including CTSS are complex and require sufficient integration and customization that are difficult to anticipate and manage effectively within a low-bid process. This guidance includes a discussion of procurement processes that make effective use of systems engineering documents to minimize project risk and comply with Federal procurement regulations.

When Federal funds are involved in a project, the systems engineering documents are subject to review by the appropriate FHWA Division Office, and must follow State procedures as determined between the FHWA Division Office and the State transportation agency.

CHAPTER 1. CONCEPT OF USE

PURPOSE

The primary objective of this Central Traffic Signal Systems (CTSS) Systems Concept of Use (COU) is to describe how the Systems Engineering (SE) Model Documents can guide the deployment of a central traffic signal system. The development of the COU ensures the procured and deployed CTSS is successfully meeting the user needs of the stakeholders who will be using the CTSS to convey information to the traveling public. The purpose of the SE Model Documents is to guide the user through the process of developing systems engineering documents for definition and procurement of a CTSS. The CTSS may be a brand-new deployment or an expansion of an existing system.

The Model Systems Engineering Documents for Central Traffic Signal Systems are intended for projects with the following characteristics:

- Relatively small, such that the project budget cannot be reasonably expected to fund systems engineering document development from scratch.
- Constrained to existing products in the market. The model documents are not intended to provide the detail necessary to support new significant software development.
- Applications of CTSS already well-defined in the transportation industry.

Agencies building large projects with custom software development or innovative applications will need to perform more detailed custom systems engineering, though these documents may provide an effective and time-saving starting point for that effort. For projects developing new approaches or new levels of integration, agencies should consider which systems engineering approach is best suited to the project. The approach contained in this document expects the user to fully understand their operational intentions, and to be able to find products already in the marketplace that support those intentions. For operational approaches where those intentions are not yet clear or where new products and approaches have to be developed, the agency may consider an iterative process as an alternative to approach used in these documents.

The reference architecture for a Central Traffic Signal System along with the scope of the CTSS Model Systems Engineering Documents is shown in Figure 1.

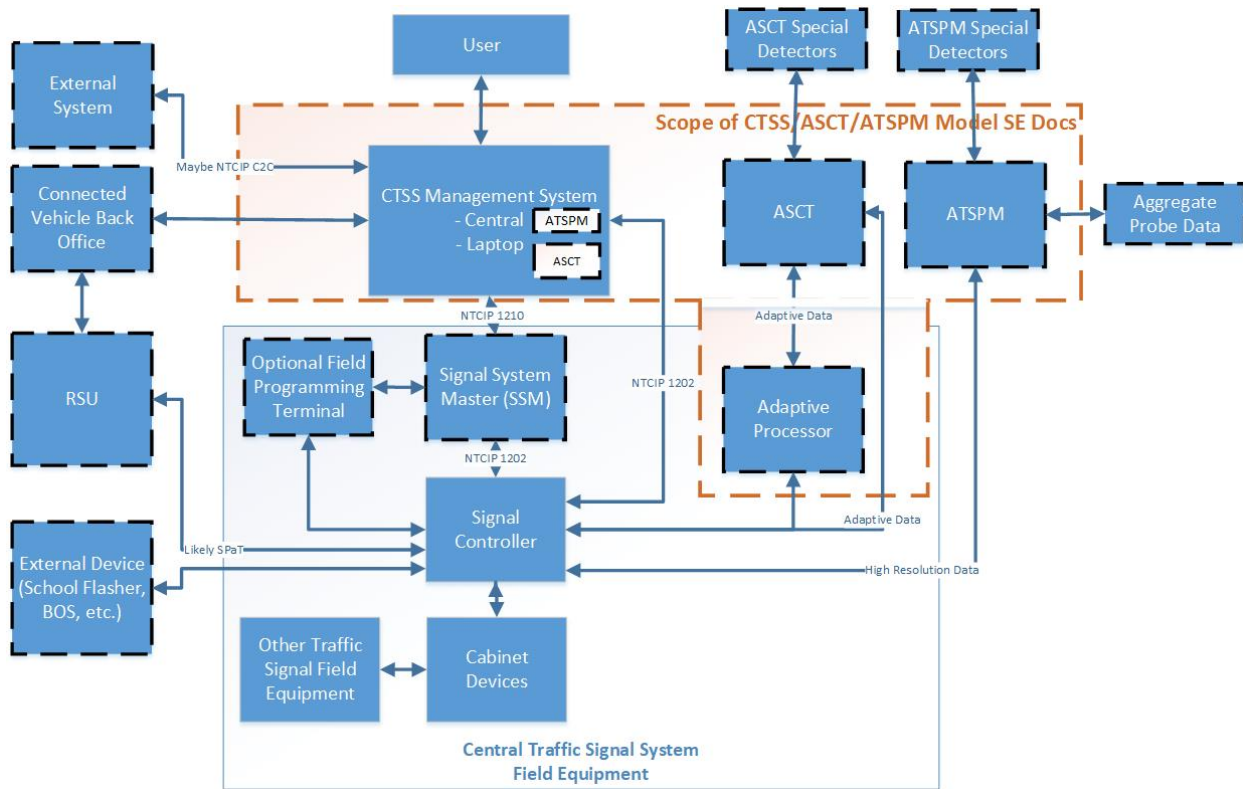


Figure 1. Reference Architecture for a Central Traffic Signal System with the scope of the CTSS Model SE Documents

The scope of the architecture shown in Figure 1 includes central systems only, and generally not field equipment noted by the brown dashed line denoting the scope of these model documents. One exception is an adaptive processor located in a field cabinet. The requirements herein cover the adaptive operation handled by that processor, but assume regular signal systems functions will be performed in a central system. The black dashed lines around many of the surrounding boxes indicate optional capabilities/systems. Within the CTSS Management System are optional Automated Traffic Signal Performance Monitoring (ATSPM) and Adaptive Signal Control Technology (ASCT) functionalities that can be implemented internally to the CTSS Management System or separately as shown by the ASCT/Adaptive Processor and ATSPM systems.

Another variation on the scope concerns signal system master (SSM) controllers, if used. If a system uses a SSM, then the SSM is acting as a field-located surrogate for many functions of the central system, and many of the requirements that apply to the central system will also apply to the SSM. But this document does not address that architecture specifically. The user should reference the Protocol Requirements List in National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) 1210, which covers needs and requirements for communications with field masters (and thus allows configuration of signal-system functionality that the SSM will manage) to tailor needs and requirements in this document for SSM architectures.

Vehicle-based technologies are not included in the scope of this document, but interfaces to it are shown in the reference architecture.

It should be emphasized that this document does not cover requirements related to selecting traffic signal controllers, though it does cover functionalities that local controllers will be expected to support. When faced with a local-controller selection task, the reader is encouraged to use the requirements herein to supplement whatever process is used to make that selection. Given the standard feature set generally available in the market, it is likely that any controller on the market will support the range of needs agencies face at the intersection level, though those agencies may have preferences about how those features are implemented. For cases that require special features, the reader is encouraged to develop requirements related to those special cases. One approach for doing this will be supported by NTCIP 1202, which is being updated as of this writing. The updated standard will include a Protocol Requirements List, which provides a tool for agencies to identify their needs as related to communications with local signal controllers. Given that most signal controllers work from signal timing parameters which are communicated via the interface covered by NTCIP 1202, that Protocol Requirements List will cover the vast majority of features and agencies, leaving the few special features to be handled separately. The reader will benefit from going through this model document for systems-related requirements before entering the Protocol Requirements List in the updated NTCIP 1202.

PROCESS

The target audience for this COU includes transportation agency professionals needing to procure relatively small-scale central traffic signal systems by following a standardized systems engineering process without the need to hire a consultant. The COU will help an agency align their processes, operations and needs with the CTSS System Engineering Model Documents, allowing the tailoring of the model document content.

This process will lead to a set of user needs, requirements, verification plan and validation plan to support a successful procurement of a central traffic signal system. A successful procurement results in a central traffic signal system that not only meets the agency’s needs but also provides a basis for ensuring that the procured system meets its advertised capabilities.

The overall framework for the set of SE Model Documents is depicted in Figure 2 below.

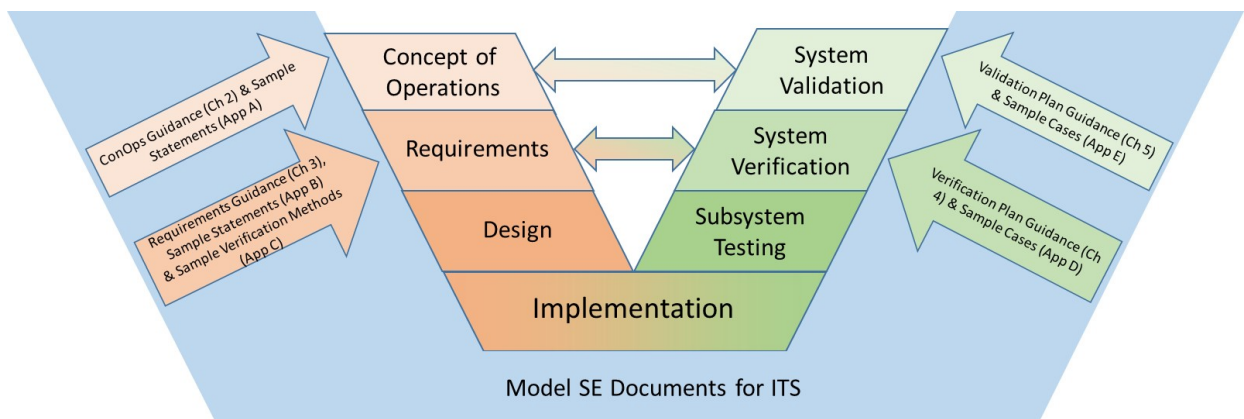


Figure 2. Concept of Use Process for SE Model Documents

The CTSS SE Model Documents begin with creating a Concept of Operations capturing typical representative use cases, and operational scenarios involving central traffic signal systems. Use cases capture the system actors and activities to accomplish a specific purpose. An actor defines a role, which may be filled by a person, a group of people, or an external system. The actors form the foundation for the definition of the users of the system and are critical to the high-level use cases, operational scenarios and user needs. Operational scenarios provide examples in narrative form of how those users, activities and systems work together in actual practice.

The ensuing analysis of the use cases, and operational scenarios lead directly to draft user needs (all embodied in the Concept of Operations), and the beginning of system validation cases validating the user needs documented in the Validation Plan. The user needs drive the definition of the requirements and the requirements verification methods (residing in the Requirements document) and a requirements Verification Plan. These have been previously reviewed and validated by operational CTSS Subject Matter Experts (SMEs). The CTSS SE Model Documents walk the user through the process of selecting and tailoring the pertinent use cases and operational scenarios to arrive at a set of user needs. Since the systems engineering process is being used, there is forward and backward traceability between the resulting user needs and the requirements. The verification plan and the requirements verification methods are directly traceable back to the requirements being verified. Correspondingly, the validation plan is directly traceable back to the user needs being validated.

The CTSS Model Systems Engineering Documents will provide an agency with a means to describe their existing and planned central traffic signal system operations using substantive systems engineering products. The user will tailor the needs and requirements provided in the model. The process will provide meaningful systems engineering support for a CTSS procurement with far less effort than developing systems engineering documents from scratch. The user will still be expected to understand their processes in applying a CTSS to solve their transportation management problems, but the model documents will provide guidance to the user to help them do so.

CONCEPT OF OPERATIONS

The first product of the application of the model documents will be a Concept of Operations for a central traffic signal system. The Concept of Operations (ConOps) is written from the perspective of the system operator, and it establishes the activities of the user in solving the transportation management problem at hand, using CTSS, as the basis for defining and defending requirements. The primary audience for the ConOps includes stakeholders who will participate in the operation of the system or be directly affected by it. The ConOps is responsible for capturing the stakeholder needs and expectations in a manner that is easily understandable to the stakeholder community, so that the stakeholder community can be confident that it properly models what they will do.

The needs and expectations must be defined succinctly enough to determine what functions the proposed system must be capable of fulfilling. Stakeholders who may play a role in tailoring or reviewing the ConOps may include system operators, maintenance staff, system managers, administrators, decision-makers, elected officials, and other non-technical readers. Every element of the subsequent documents in the project, including the requirements, verification

plan, designs, test procedures and processes and validation plan, must be able to be traced to statements of user need in the Concept of Operation. Ultimately, the ConOps describes how the agency will use the system, and in that manner, could be considered a prototype for an operating policy and procedure. It is the basis for validating (via the Validation Plan) the system when delivered to ensure that the system is acceptable, with “acceptable” being defined as fulfilling all the user needs. The guidance for the Concept of Operations can be found in Chapter 2 of this guidance document.

REQUIREMENTS DOCUMENT

After the ConOps is defined, corresponding system requirements are captured in the Central Traffic Signal System Requirements Document. The requirements document targets technical staff, system users, system designers and vendors. The ConOps describes what the users will do, and the requirements define what the system must do. Each of the requirements listed in this document must be linked to a corresponding need described in the ConOps. Every need in the ConOps must be linked to one or more requirements in the Requirements Document. The forward and backward traceability between needs and requirements makes it possible to define needed requirements during procurement, and to defend requirements if they are challenged during procurement. The Requirements Document becomes the principal systems engineering document during the procurement process, providing the basis for selection, progress verification, (in some cases) payment, and system acceptance.

Once the user has selected and defined their user needs, the SE Model Documents provide system requirements that are linked to those user needs. The guidance in the model documents will assist agency users in tailoring the model needs and requirements as needed, including any needed iteration between needs and requirements. During tailoring, you will need to iterate between needs and requirements to ensure that they remain traceable and consistent. Traceability ensures that each need is fully represented in the requirements, and each requirement is fully driven by needs. Consistency ensures that what is stated in the requirements will satisfy the user needs to which they are traced. Once all the needs and requirements are tailored for the specific project and checked for traceability and consistency, the ConOps and the Requirements documents will be complete and correct.

The Central Traffic Signal Systems Requirement Document does not define the design of the system, nor does it determine what technologies to use or how to implement them. This document sets the technical criteria that will be used to evaluate design and technology choices. It is the basis for verifying (via the Verification Plan) the system during design and when delivered to ensure that the system is acceptable, with “acceptable” being defined as fulfilling all the requirements. The recommended approach is to have an Acceptance Test of the procured system based on the system requirements. The guidance for the Requirements Document can be found in Chapter 3 of this guidance document.

VERIFICATION PLAN

This leads to the third document that the user will develop using the Model Documents, the Central Traffic Signal System Verification Plan. The Verification Plan is responsible for defining the verification testing that will demonstrate fulfillment of requirements. The target audience for

this document is the same as for the Requirements document. Generally, the implementing contractor will be responsible to fulfill the requirements. The Verification Plan describes the general verification effort including verification cases with corresponding requirements being fulfilled, including the method by which that determination will be made. It is critical that all requirements are verified within the scope of the Verification Plan. This is best done by tracing each requirement into a verification case and eventually into appropriate steps in the verification procedures. The Model Documents provide a direct mapping of verification cases to the requirements. The user simply needs to extract and tailor the corresponding verification cases related to the chosen set of requirements.

The Verification Plan does not describe detailed procedures for testing the Central Traffic Signal System. It is typical that the system developer/supplier/vendor will develop the verification test procedures that will map to the verification plan as part of the procurement process. The specific steps of a verification test procedure require a knowledge of the specific software and hardware technology and products that will be implemented. The guidance for the Verification Plan can be found in Chapter 4 of this guidance document.

VALIDATION PLAN

The fourth document that the user will develop using the Model Documents is the CTSS Validation Plan. The Validation Plan is responsible for defining the validation testing that will demonstrate that the system meets the user needs. The target audience for this document is the same as for the Concept of Operations (ConOps) document. Generally, the implementing contractor will not be responsible for validation. The Validation Plan describes the general validation effort including validation cases with corresponding user needs being fulfilled. The Model Documents provide a direct mapping of validation cases to the user needs categories. The user simply needs to extract and tailor the corresponding validation cases related to the chosen set of user needs.

The Validation Plan does not describe detailed procedures for validation testing of the Central Traffic Signal System. Typically, once the CTSS has been accepted, the users of the system will validate if the system meets their user needs according to the Validation Plan and subsequent validation procedures. The guidance for the Validation Plan can be found in Chapter 5 of this guidance document.

PROCUREMENT

Finally, the guidance within the model documents includes a general discussion of procurement approaches, and how the products of the systems engineering process support various procurement processes. The guidance for procurement can be found in Chapter 6 of this guidance document.

ASSEMBLING YOUR DOCUMENTS

The finished product of your efforts will be several systems engineering documents. In order to successfully prepare these documents, you will need to take the following steps:

1. Read this document completely.

2. Begin to prepare the Concept of Operations. Establish chapters in accordance with the Concept of Operations Sample Statements in Appendix A. While you are free to format the document to suit your needs, the statements follow the outline suggested in American National Standards Institute (ANSI) standard G-043-1992. As an alternative, you may simply take the table of sample statements and check those statements you wish to include.
3. Following the instructions in this document, copy and (only if necessary) edit relevant statements from the Table of Sample Statements for the Concept of Operations. Depending on how you answer each question in the guidance, select and edit each Concept of Operations statement. One should be cautious about editing the user needs too soon—the preferred approach is to make an initial selection first and then determine if gaps exist that require editing.
4. Some sections of the Concept of Operations require you to write appropriate text in accordance with the instructions contained in this document.
5. Each statement in the Concept of Operations table has a unique identifier. The needs statements (Chapter 4) each refer to at least one relevant System Requirement that should be considered to support the need statement. Each Concept of Operations statement also contains a reference to the relevant section of this Guidance Document.
6. Begin to prepare the System Requirements. Establish chapters in accordance with the System Requirements template. As an alternative, you may choose to include the System Requirements as an appendix to the Concept of Operations. In this case, you may simply take the table of sample statements and check those statements you wish to include.
7. For each need statement used from the Concept of Operations table, identify the System Requirements that are linked. Copy and edit each relevant requirement into the System Requirements document. Note that whenever you pick a “child” requirement, you should also select its “parent” requirement. You may also check off the requirements in the Model Requirements Document as they appear in the ConOps sample statements, rather than building a document from scratch.
8. If you describe needs in the Concept of Operations that are not covered by these sample statements, then you must either also create new requirements related to those needs, or take separate actions to support those needs if they do not lead to system requirement.
9. Prepare the Verification Plan. Establish chapters in accordance with the Verification Plan template. There is a suggested verification method for each System Requirement. Each high-level System Requirement also has an associated verification case name and description to get you started. Note that every System Requirement requires a verification test, which you will need to define to suit your situation.
10. Prepare the Validation Plan. Establish chapters in accordance with the Validation Plan template. Note that every need expressed in the Concept of Operations requires a corresponding validation test, which you will need to define to suit your situation. If you

define performance measurement in your requirements, some validation may be provided by the new system, while some may require separate off-line tests.

SUMMARY

In summary, the Central Traffic Signal System Model Documents will provide documentation templates that will guide the user through the selection and insertion of applicable user needs, requirements, verification cases and validation cases that are consistent with each other. The Model Documents will provide guidance to the user on selecting operational CTSS system capabilities that fit within the use cases and operational scenarios. The focus of this guidance is to develop documents that will enable the agency to successfully procure a CTSS that is currently available in the product market. It should be stressed that the responsibility for preparation of these CTSS Systems Engineering documents rests entirely with the procuring agency.

CHAPTER 2. CONCEPT OF OPERATIONS GUIDANCE

The Model Concept of Operations can be found in Appendix A. The chapters of the Model Concept of Operations, which are described in the sections below, follow a standard outline for concepts of operation established by the American National Standards Institute (ANSI/AIAA-G-043). There are competing standardized outlines for concepts of operations, but the ANSI outline was determined to be the most appropriate for infrastructure construction projects that establish new capabilities.

While the layout of the Concept of Operations described in this guidance will provide a logical flow for the intended readers, it is generally not prepared in this sequence. As practical traffic engineers, it is generally preferable to describe at an early stage the operational scenarios envisioned by the system users/operators. After initially describing the limitations of the existing system, you should describe all the situations in which you expect the system to provide benefit, and how you expect the system to operate in each situation. After describing the operational scenarios, you will then be in a position to better describe the specific system and user needs, the alternative strategies considered and why they were discarded, and the envisioned system. Then you will be able to revise the operational scenarios so they are consistent with the statements of needs and provide clear examples of the expected operation. The scenarios, however, come at the end of the Concept of Operations, and are used as examples of how the earlier parts of the document play out in real situations. Experienced traffic signal system operators will want to review those scenarios, but they can probably proceed through sample statements in the order in which they are presented in Appendix A.

For readers, not familiar with traffic signal systems operation, note that this document is not intended as a tutorial on traffic signal systems. Other literature already provides descriptions of what traffic signal systems do and generally how they work, and these are recommended for background reading for those who are not already familiar with the topic.

The Concept of Operations will be organized in the following chapters, following the structure recommended in ANSI G-043-1992:

1. Scope.
2. Referenced documents.
3. User-Oriented operational description.
4. Operational needs.
5. System overview.
6. Operational environment.
7. Support environment.
8. Operational scenarios.

Once you have completed the Concept of Operation, use this checklist to confirm that all critical information has been included:

- Is the reason for developing or procuring the system clearly stated? Note that operations planning documents should already establish that 1.) a traffic signal system is needed, and 2.) why it is needed, as the basis for programming the project, especially if it uses Federal funds. The user of this document might not enter this process until project development is underway, and so should reference the documentation used to justify the project for programming. If these planning documents do not exist, then it becomes especially important for the ConOps to freshly establish the problem to be solved by building the system. The sample statements are usually sufficient to reinforce planning documents with references thereto and minimal amplification.
- Are all the stakeholders identified and their anticipated roles described? This should include anyone who will operate, maintain, build, manage, use, or otherwise be affected by the system. It is, however, limited to users—those who do have a role in actual use. Thus, it is about the agency's management of traffic signals more than it is about the operation of the traffic signals as perceived by travelers. The management of field devices is the principal reason for having a system. The exception to this perspective concerns adaptive operation, where the adaptive algorithm has a true operational role, rather than simply a device management, configuration, and monitoring role.
- Are alternative operational approaches (such as maintaining the current system capabilities or no system, as appropriate to your situation) described and the selected approach justified?
- Is the portion of the regional Intelligent Transportation System (ITS) architecture being implemented identified?
- Is the external environment described? Does it include required interfaces to existing systems, both internal and external to your agency?
- Is the support environment described? Does it include maintenance? Does it explain where the users will sit, and from where they must be able to access the system?
- Is the operational environment described?
- Are there clear and complete descriptions of normal operational scenarios?
- Are there clear and complete descriptions of maintenance and failure scenarios?
- Do the scenarios include the viewpoints of all involved stakeholders? Do they make it clear who is doing what?
- Are all constraints on the system identified?

SCOPE (CHAPTER 1 OF THE CONCEPT OF OPERATIONS DOCUMENT)

The first product of the application of the model documents will be a Concept of Operations for a CTSS system. The Concept of Operations (ConOps) is written from the perspective of the system user/operator, and it establishes the activities of the user in solving the transportation management problem at hand, using CTSS, as the basis for defining and defending requirements. The primary audience for the ConOps includes stakeholders who will participate in the operation of the system or be directly affected by it. The ConOps is responsible for capturing the stakeholder needs and expectations in a manner that is easily understandable to the stakeholder community, so they can be confident that it properly models what they will do.

The needs and expectations must be defined succinctly enough to determine what functions the proposed system must be capable of fulfilling. Stakeholders who may play a role in tailoring or reviewing the ConOps may include system users/operators, maintenance staff, system managers, administrators, decision-makers, elected officials, and other non-technical readers. Every element of the subsequent documents in the project, including the requirements, verification plan, designs, and test procedures and processes, must be able to be traced to statements of user need in the Concept of Operation. Ultimately, the ConOps describes how the agency will use the system, and in that manner, could be considered a prototype for an operating policy and procedure.

Document Purpose and Scope

The first part of this chapter is a short statement of the purpose and scope of this document. This will briefly describe contents, intention, and audience. Sample statements that may be used in this chapter are contained in the Concept of Operations sample statements table in Appendix A. These statements should be customized to explicitly apply to your situation. One or two paragraphs will normally suffice.

Project Purpose and Scope

The second part of this chapter gives a brief overview of the purpose and scope of the system to be built. It includes a high-level description; describes what area will be covered by the project; and identifies which agencies will be involved, either directly or through interfaces. Sample statements that may be used in this chapter are contained in the Concept of Operations Sample Statements table. These statements should be customized to explicitly describe your project. One or two paragraphs will usually suffice. This section should be written late in the process, after the envisioned system has been described. It will be a summary to introduce the reader to the proposed system. Note that this section can (and should) reference and summarize planning documents that established the need for this project. Concepts of Operation are project documents, not planning documents, but must be built on a foundation of planning. Otherwise, the ConOps will have to include some remedial planning in the form of justifying why the project needs to be built. The intention is that this section can be a brief citation and a summary.

Procurement

The final section of this chapter will be a brief discussion of the proposed procurement process. The method of procurement should be determined early in this process, because it will have an

impact on the format and content of the system requirements document. See Chapter 6 herein for additional information.

REFERENCED DOCUMENTS (CHAPTER 2 OF THE CONOPS DOCUMENT)

This chapter is a place to list any supporting documentation and other resources that are useful in understanding the operations of the system. This could include any documentation of current operations and any operations plans that drive the objectives for building the system under development. In particular, it should include documents that define the overall goals and objectives of your agency that will be supported by the CTSS System, and the documents that justified funding for the project. These documents may be ITS strategic plans, Traffic Signal Management Plans, or similar. This includes local and regional transportation program and policy documents and relevant inter-agency, management and labor agreements and memoranda of understanding. It should reference the applicable statewide and/or regional ITS Architecture(s) and include relevant codes and standards, such as ANSI, Institute of Electrical and Electronics Engineers (IEEE), NTCIP, National Electrical Manufacturers Association (NEMA), Code of Federal Regulations (CFR) and National Electrical Code (NEC). It should also include references to detailed documentation of any required interfaces to other systems such as an Integrated Corridor Management (ICM) system. However, do not treat this as a bibliography. Only include documents that are referenced directly in the Concept of Operation, and that allow this document to summarize rather than reiterate. Sample statements that may be used in this section are contained in the Concept of Operations sample statements table (Appendix A).

USER-ORIENTED OPERATIONAL DESCRIPTION (CHAPTER 3 OF THE CONOPS DOCUMENT)

This chapter describes the operational problem to be solved and how a CTSS System helps the agency solve it. This is where we define the use cases related to application areas. When the use cases are selected in Chapter 3, it will guide you to which groups of user needs you need to select in Chapter 4, User Needs.

In the case of CTSS, the problems to be solved involve the agency's need to manage and maintain its traffic signal field infrastructure efficiently, which usually requires a remote access capability for programming and monitoring local traffic signal controllers. It also includes the agency's need to observe operational effectiveness in a way that supports improvement of the signal timings stored in local controllers. Finally, it includes the problem of tracking changes in traffic conditions that occur in ways traditional signal timing approaches cannot follow.

General Actors

The general actors represent the various roles and systems that interact with the CTSS System. Each actor represents a role, a user can have multiple roles and there can be multiple for the same type of actor. For example, a CTSS System Maintainer and a CTSS System User could be the same person or they could be different people.

Use Cases

Use cases capture the high-level typical interactions between an actor and a computer system. A use case needs to address a discrete goal of the actor/user. Besides the common use cases of system support (e.g., configuration, maintenance, etc.) the CTSS System use cases describe the user's activity in monitoring traffic signal effectiveness, making improvements in signal timing based on that monitoring, or in providing a system that monitors operation and makes improvements automatically.

OPERATIONAL NEEDS (CHAPTER 4 OF THE CONOPS DOCUMENT)

Traffic signals are built to safely assign right of way to motorists, pedestrians, cyclists, and other users at intersections where lesser forms of control are inadequate. At the intersection, most operators seek to distribute the green time fairly and efficiently, according to a variety of optimization objectives. Operators also seek to move as many vehicles as possible through the intersection during periods of congestion, when the signal leaves growing residual queues. When intersections and the traffic they serve interact with each other, operators seek to coordinate the timing to provide smooth flow, or in congested conditions when smooth flow is not possible, to manage queues so that they form where they do the least damage at the network level.

Traffic signals may also be used as part of a corridor strategy to manage traffic diverting away from a freeway that is congested, usually as a result of an incident.

To attain these objectives, signal operators need to be able to manage the database of signal timings in local controllers, maintain the operational effectiveness of local controllers, monitor that operational effectiveness, and monitor the effectiveness of the signal timings. Agencies generally expect such operation to be performed remotely in addition to in the field.

This chapter captures the stakeholder (including actual user/operator) needs and expectations answering the question "How will we use a traffic signal system to attain our goals and objectives?" which sets the foundation for the system requirements. The stakeholder needs and expectations must be defined in a manner that is easily understandable to the stakeholder community, so they can be confident that it properly models what they will do.

Each high-level grouping of user needs in Chapter Four of Appendix A includes the statement "Choose the user needs in this group if you chose [any on this list of use cases] in Chapter Three". This is how the user needs relate back to the use cases. In most cases, the user needs were categorized specifically by their corresponding use case.

Some user needs and their corresponding system requirements will require that the user of this document provide additional specification and tailoring to their CTSS environment. The user needs indicate where this is necessary by square brackets "[specify]".

ENVISIONED CTSS SYSTEM OVERVIEW (CHAPTER 5 OF THE CONOPS DOCUMENT)

This chapter is an overview of the envisioned CTSS. It describes, at a high-level, the main features, capabilities, and the scope of its coverage. The reader should describe its conceptual

architecture at a block diagram level with a high-level data flow diagram, which can be derived from the reference system architecture in Figure 1, or from a project architecture derived from the Regional ITS Architecture. This should not show design details. This description should reflect the needs described in the previous chapter. It should illustrate, either graphically or in words, each of the following categories of needs that are relevant:

- Network characteristics.
- Traffic signal system operating modes (i.e., will it require coordination, traffic-responsive plan selection, adaptive control, high-resolution performance measurement, etc.?)
- Interfaces to other systems.

A good way of illustrating the system is to draw out the activities undertaken by stakeholders in a specific situation, and highlight those that are anticipated to be augmented with the operation of the CTSS. An example of such a diagram, based on the typical physical architecture in NTCIP 1202, NTCIP 1210 and generated from the Regional Architecture Development for Intelligent Transportation (RAD-IT) (in which tool the project architecture can be derived from the Regional ITS Architecture), is illustrated in Figure 3.

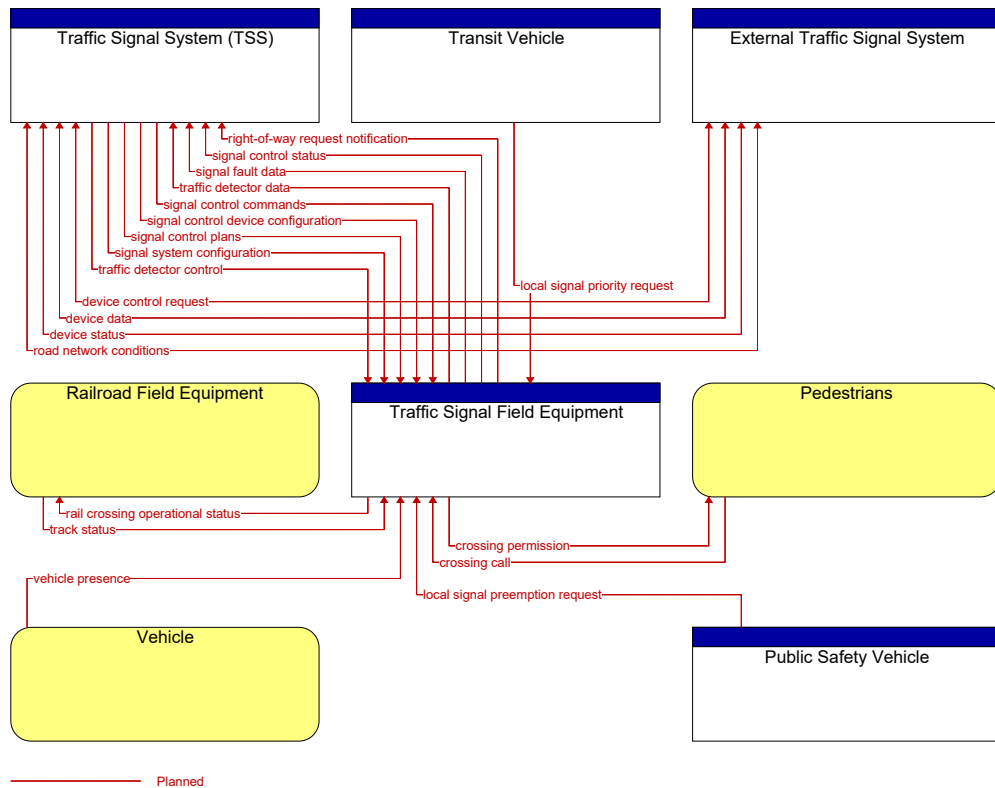


Figure 3. High-Level Representative CTSS Project Architecture Diagram

Each interface between ITS elements in the architecture diagram can have multiple communications standards associated with it. Using the Systems Engineering Tool for Intelligent Transportation (SET-IT) tool and converting the CTSS System Project Architecture results in a set of standardized communication protocol stacks for each “triple” (a combination of source element, information flow and destination element). An example of one of these communication protocol stack diagrams is shown in Figure 4. The entire set of standardized communication protocol diagrams for each interface can be found in Appendix F.

NTCIP-SNMP		
traffic detector control		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1209-TSS	Security Plane Undefined	ITS Application Information Layer NTCIP 1209-TSS
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 4. Sample Communications Protocol Standards for the NTCIP-SNMP Triple of External System → video surveillance control → External System Cameras based on the CCTV System Project Architecture Diagram

CTSS SYSTEM OPERATIONAL ENVIRONMENT (CHAPTER 6 OF THE CONOPS DOCUMENT)

This chapter describes both the operational environment and the physical environment within which the CTSS will operate.

Operational Environment

Describe the stakeholders. These should include all existing stakeholders who have an influence on the operation of the proposed CTSS. This will include Traffic Management Center (TMC) operations staff, signal systems operators that may not be housed in a TMC, maintainers, and staff of other agencies whose operation and duties may be affected by the envisioned CTSS.

The activities related to CTSS operation should be described, such as configuration, signal controller database management, system monitoring, traffic performance measurement, system performance monitoring, security, and inter-agency staff interactions.

The organizational structure should be described, highlighting any changes from the existing arrangements that are envisioned. An overview of the qualifications and experience of personnel should be presented along with clear definition of any roles and responsibilities that would be undertaken by contractors, vendors, consultants and staff of other agencies.

Sample statements that may be used in this section are contained in the Concept of Operations sample statements table (Appendix A).

Physical Environment

This section describes the facilities within which equipment and personnel will be housed, additional furniture and equipment that will be required, new computing hardware and software that will be required, operational procedures for operating the system and any additional support that will be needed.

For example, describe whether the equipment will be located in a TMC, at City Hall, at the maintenance yard or signal shop and/or in the field. Will field equipment need to be field hardened or located within an air-conditioned environment? Will existing power supplies be adequate or will additional service, uninterruptible power supply (UPS) and battery backups be required?

Will the operators be on duty or available 24/7 or during limited hours? Describe their required experience, skills and additional training needs.

Sample statements that may be used in this section are contained in the Concept of Operations sample statements table (Appendix A).

CTSS SUPPORT ENVIRONMENT (CHAPTER 7 OF THE CONOPS DOCUMENT)

This chapter describes the current and planned physical support environment. Describe what support equipment, personnel, training and procedures currently exist, and explain those that need to be acquired or implemented.

Describe any additional test equipment and repair tools that will be needed to support CTSS operation. Where will test equipment be located? Staff and equipment for maintaining the system may or may not be located at a signal shop that maintains and repairs field controllers.

Describe additional staff or contractors who will not be involved in the day-to-day operation of the system, but will be needed to support the operators and maintenance staff. This should include staff from the system vendor and/or consultants, who will provide additional on-going training, periodically audit the system setup and performance and support expansion of the system in the future.

Where multiple agencies are involved, describe the support that will be provided by or to other agencies. This should include any existing or proposed memoranda of understanding or operations and maintenance agreements that will affect the CTSS, or will need to be modified to include reference to the CTSS. This may include modifying the policies and procedures of those agencies in addition to developing new policies and procedures within your agency.

Sample statements that may be used in this chapter are contained in the Concept of Operations sample statements table (Appendix A).

PROPOSED OPERATIONAL SCENARIOS USING A CTSS (CHAPTER 8 OF THE CONOPS DOCUMENT)

The purpose of this chapter of the Concept of Operations document is to provide examples that illustrate how the system will be expected to operate and interface with the operators in typical circumstances. It is not intended to comprehensively describe the operation under all conditions. It is intended to illustrate to vendors, managers and decision-makers alike how you see your objectives being met by the system. This description is practically oriented and considers the practical limitations of available systems, which you expect to tolerate. It should not be a description of how you would like some imagined system to operate with no regard for the practical limitation of candidate systems, nor should it depend on staff resources and capabilities that are unlikely to be available when the system is in operation.

Each statement in a scenario should relate to a user need, although not all needs will be further described in a scenario. The statements in the description of each scenario do not directly generate requirements. Requirements are only generated from needs. The scenarios in the Concept of Operations sample statements table (Appendix A) simply provide examples of how the system meets some of the needs.

Once you have written the scenarios, if you are not satisfied that they describe an operation that will be adequate, you should then review your needs statements. If you wish to describe elements of the proposed operation that are not described by needs, then additional needs should be written.

CHAPTER 3. SYSTEM REQUIREMENTS GUIDANCE

The model System Requirements can be found in Appendices B and C. Appendix B lists the requirements with backward traceability to the needs, and Appendix C shows the method by which each requirement can be verified. The sections below describe the typical outline of a standard requirements document, as described by the International Organization for Standardization (ISO)/ Institute of Electrical and Electronics Engineers (IEEE) 29148:2011(E). For the projects targeted by these model documents, all of these sections may not be necessary, or are adequately covered in the Concept of Operations. We include them here for general information and context. The parts of the outline that are critical, however, include Chapters 3 and 4 of the IEEE outline, which include the requirements and verification methods. For this reason, the numbering for the functional requirements listed in Appendices B and C start with a “3.1”. This numbering approach is an artifact of the standardized numbering.

The chapters required for the System Requirements document are:

1. Scope of System or Sub-system
2. References
3. Requirements
4. Verification Methods
5. Supporting Documentation
6. Traceability Matrix
7. Glossary

This document sets the technical scope of the system to be built. It is the basis for verifying (via the Verification Plan) the system and sub-systems when delivered.

This document must be tailored to your project. All Central Traffic Signal System (CTSS) projects need a set of requirements defining what will be provided by the vendor. You will need to decide how extensively to document these requirements. One convenient way to gauge how many requirements to write and/or how much detail to have in the requirements document is to start at the finish line. The following should be asked when starting at the top level of the system:

- What are all the functions needed in order to demonstrate to the agency that the system is doing what it is expected to do?
- How well does the system need to perform the required functions?
- Under what conditions does the system need to operate?

Each of these tests will refer to a set of requirements. This is done for the system and the sub-systems. The depth of detail provided in these requirements derive from the task of selecting currently available products. These requirements do not provide sufficient depth to support significant development, particularly software development, as may occur in projects that are beyond the scope of model documents.

For many requirements, it may be sufficient to reference the existing product specifications after the requirements have been carefully reviewed. For example, the CTSS products that are on the market may have sufficient documentation to demonstrate that most requirements are fulfilled. The additional requirements would be for any minor modifications or enhancements needed. However, great care must be taken when referencing existing commercial product specifications to ensure the wording does not unnecessarily or unintentionally limit compliance to a single system when more than one is capable of fulfilling the requirements. The wording of the requirements is therefore derived from the meaning and wording of the needs to which they trace.

Once the requirements document has been completed, use this checklist to confirm that all critical information has been included.

- Is there a definition of all the major system functions?
- With each function of the system, is there a set of requirements that describes: what the function does, and under what conditions (e.g., environmental, reliability, and availability)?
- Are all terms, definitions, and acronyms defined?
- Are all supporting documents such as standards, concept of operations, and others referenced?
- Does each requirement have a link (traceability) to a higher-level requirement of a user-specified need or scenario?
- Is each requirement concise, verifiable, clear, feasible, necessary, unambiguous, and technology (vendor) independent?
- Are all technology dependent requirements identified as constraints?
- Does each requirement have a method of verification defined?
- Does each requirement trace to a verification case?

SCOPE OF SYSTEM OR SUB-SYSTEM (CHAPTER 1 OF THE REQUIREMENTS DOCUMENT)

This chapter is a brief overview of the system and statement of the purpose of this document. Briefly describe the contents, intention and audience for this document. Summarize the history of

system development, the proposed operation, and maintenance. Identify the project stakeholders, acquiring agency, users and support agencies. Identify current and planned operating sites. Generally, the similar material in the Concept of Operations provides sufficient coverage of this material, and thus is not needed for the projects for which the model documents are appropriately applied.

REFERENCES (CHAPTER 2 OF THE REQUIREMENTS DOCUMENT)

This chapter identifies all standards, policies, laws, the Concept of Operations document, concept exploration documents and other reference material that are needed to support the requirements. These documents are usually adequately referenced in the Concept of Operations.

REQUIREMENTS (CHAPTER 3 OF THE REQUIREMENTS DOCUMENT)

This chapter lists all the requirements necessary to define the proposed CTSS. Each requirement should be clear and concise, verifiable, feasible, necessary, unambiguous and technology independent. Each requirement should have a single statement. If adding or modifying requirements, DO NOT use terms such as "and", "but", "except" and other modifiers that combine more than one thought into a single requirement.

In general, each of the sample requirements falls into one of the following categories, although they are not expected to be organized in this manner:

- Functional Requirements (What the system shall do).
- Constraints (e.g., Technology, design, tools, and/or standards).

Sample requirements that may be used in the Requirements document are included in the System Requirements samples table (Appendix B). Each of these is directly related to one or more statements of need in the Concept of Operation.

Some of the requirements and their corresponding user needs will require additional specification and tailoring to the CTSS environment. The requirements indicate where this is necessary by brackets such as “[specify]”.

Note that the order of the requirements in Appendix B is organized by major system function, while the requirements are shown in “need order” in Appendix A. This helps vendors and system providers navigate the requirements more efficiently. Any changes to the requirements made while working through the Concept of Operations Sample Statements in Appendix A must be transferred to the model requirements in Appendix B.

VERIFICATION METHODS (CHAPTER 4 OF THE REQUIREMENTS DOCUMENT)

In this chapter, identify one of the following methods of verification for each requirement.

- Demonstration is used for a requirement that the system can demonstrate without external test equipment.

- Test is used for a requirement that requires some external piece of test equipment (such as logic analyzer or voltmeter).
- Analyze is used for a requirement that is met indirectly through a logical conclusion or mathematical analysis of a result. For example, algorithms for congestion: the designer may need to show that the requirement is met through the analysis of count and occupancy calculations in software or firmware.
- Inspection is used for verification through a visual comparison. For example, quality of welding may be done through a visual comparison against an in-house standard.

Suggested verification methods that may be used in the Requirements document are included in the Suggested Requirements Verification Methods table (Appendix C). Do not describe how, when or where the verification will be performed. This is separately covered in the Verification Plan document.

SUPPORTING DOCUMENTATION (CHAPTER 5 OF THE REQUIREMENTS DOCUMENT)

This optional chapter is a catchall for anything that may add to the understanding of the Requirements and cannot be logically located elsewhere. Examples of supporting documents include: diagrams, analysis, memos, stakeholders contact list and published documents related to similar projects. Most routine signal system projects will not need anything in this chapter.

TRACEABILITY MATRIX (CHAPTER 6 OF THE REQUIREMENTS DOCUMENT)

The traceability matrix traces the requirements in this document to the needs expressed in the Concept of Operation. Every requirement must support at least one user need. Appendix B provides traceability directly.

GLOSSARY (CHAPTER 7 OF THE REQUIREMENTS DOCUMENT)

The glossary is a list of terms unique to the project. A glossary of terms is provided in this document.

CHAPTER 4. VERIFICATION PLAN GUIDANCE

The model Verification Plan can be found in Appendix D. The chapters required for the Verification Plan are:

1. Purpose of Document
2. Scope of Project
3. Referenced Documents
4. Conducting Verification
5. Verification Identification

This verification plan describes the activity of verifying that the system being built satisfies all the requirements set out in the requirements documents.

The verification documents will include:

- A plan to initially lay out the specific verification effort.
- A detailed mapping of the requirements to verification cases.
- A report on the results of the Verification activities.

To ensure that all requirements are verified by this activity, trace each requirement into a verification case, then trace this in turn into a step in the Verification procedure.

The Verification Plan does not need to include verification procedures. These may be prepared by the vendor, but must be reviewed by the agency to ensure each verification case will be tested and appropriate results recorded. Indeed, it may be necessary for the vendor to provide verification procedures in the instance where the steps in the procedure may be dictated by the product they are providing. These steps may not be available when the Verification Plan is being developed. In relatively simple cases, the vendor may prepare both the Verification Plan and the procedures. In this situation, the agency must ensure that each requirement is mapped to at least one verification case.

Preparation of a stand-alone verification plan is strongly advised if:

- The system is complex.
- There are several separate verification activities being performed on the system.
- Multiple deployment sites are involved.
- Multiple stakeholders have to be satisfied.

There is also the question of how comprehensive to make the verification effort. It is impossible to verify all possible combinations of actions under all possible operational situations. A good rule of thumb is: if it was important enough to write down as a requirement, then it should be verified, at least once. In-process¹ verification performed on the needs and requirements will help ensure that the correct requirements are being verified.

Once the verification plan is completed, use the following checklist to ensure all critical information has been included.

- Does the Verification Plan answer all the questions of who, what, where, and when?
- Does the Verification Plan make clear what needs to happen if a failure is encountered?
- Does the Verification Plan document the configuration of the hardware, software?
- Are all requirements traced to a verification case?

PURPOSE OF THE DOCUMENT (CHAPTER 1 OF THE VERIFICATION PLAN DOCUMENT)

This section identifies the type of verification activity to be performed within this Verification Plan. For instance, this activity may validate the entire system, a sub-system, the deployment at a site, a burn-in, or any other verification activity called for in the Verification Plan.

SCOPE OF PROJECT (CHAPTER 2 OF THE VERIFICATION PLAN DOCUMENT)

This section gives a brief description of the planned project and the purpose of the system to be built. This section also describes the environment in which the project operates. It identifies the organization structures that encompass all stakeholders. It also gives a brief description of the role to be played by each stakeholder. This includes ad hoc and existing management work groups and multi-disciplinary technical teams that should be formed to support the project.

REFERENCED DOCUMENTS (CHAPTER 3 OF THE VERIFICATION PLAN DOCUMENT)

This is a list of all documents used in the preparation of this Verification Plan. This usually includes the Project Plan, (if one was written), and the applicable Requirements Documents. Reference to other documents, such as descriptions of external systems, standards, a Concept of Operations, and manuals may also be included.

¹ In-process verification is reviewing the needs and requirements during the definition stage by the stakeholders to ensure that all the needs have been identified and traced to appropriate requirements and have been reviewed for completeness for each of the needs.

CONDUCTING VERIFICATION (CHAPTER 4 OF THE VERIFICATION PLAN DOCUMENT)

This section provides details on how verification is accomplished. It defines: who does the verification; when and where it is to be done; the responsibilities of each participant before, during, and after verification; the deployed hardware and software configuration; and the documents to be prepared as a record of the verification activity.

This section also defines how anomalies are to be handled (that is, what to do when an unexpected situation or a failure occurs during verification).

In general, the following information should be included in this section:

- A description of the participating organizations and personnel and identification of their roles and responsibilities. This may include for example, a verification conductor, verification recorder, operators, and/or engineering support.
- Identification of the location of the verification effort, that is, the place, or places, where the verification must be observed.
- The deployed hardware and software configuration for all of the verification cases, including hardware and software under verification and any supporting equipment, software, or external systems. Several configurations may be necessary.
- Identification of the documents to be prepared to support the verification, including Verification Procedures, a Verification Report and descriptions of special equipment and software.
- Details of the actual conduct of verification, including:
 - Notification of participants
 - Emphasis on the management role of the verification conductor
 - Procedures for approving last minute changes to the procedures
 - The processes for handling a failure, including recording of critical information, determination of whether to stop the verification, restart, or skip a procedure, resolution of the cause of a failure (e.g. fix the software, reset the system, and/or change the requirements), and determination of the re-verification activities necessary as a result of the failure.

VERIFICATION IDENTIFICATION (CHAPTER 5 OF THE VERIFICATION PLAN DOCUMENT)

This section identifies the specific verification cases to be performed. A verification case is a logical grouping of functions and performance criteria (all from the Requirements Document) that are to be verified together. For instance, a specific verification case may cover all the

database download capabilities to be provided for programming a signal controller. There may be several individual requirements that define this capability, and they all are verified in one case. The actual grouping of requirements into a verification case is arbitrary; however, the grouping is usually based on the grouping of functional requirements in the Requirements Document. They should be related and easily combined into a reasonable set actions. Suggested verification cases that may be used in the Verification Plan document are included in the Verification Plan Sample Cases table (Appendix D).

Each case should contain at least the following information:

- A description name and a reference number
- A description of the objective of the verification case, usually taken from the wording of the requirement, to aid the reader understanding the scope of the case
- A complete list of requirements to be verified or traceability to the requirements in the requirements document. Since each requirement has a unique number, they can be accurately and conveniently referenced without repetition.
- Any data to be recorded or noted during verification, such as expected results of a step. Other data, such as a recording of a digital message sent to an external system, may be required to validate the performance of the system.
- A statement of the pass/fail criteria. Often this is just a statement that the system operates per the requirement.
- A description of the verification configuration. That is a list of the hardware and software items needed for verification and how they should be connected (in most cases this is the deployed system configuration). Often, the same configuration is used for several verification cases.
- A list of any other important assumptions and constraints necessary to conduct the verification case.

Each verification case in Appendix D corresponds to the same name of a section of requirements in Section 3 of the Requirements model document. The details of each verification case will need to be added as the system is further defined.

CHAPTER 5. VALIDATION PLAN GUIDANCE

The model Validation Plan can be found in Appendix E. The chapters required for the Validation Plan document are:

1. Purpose of Document
2. Scope of Project
3. Referenced Documents
4. Conducting Validation
5. Validation Identification

This document describes the activity of validation that the system being built meets the user needs and scenarios developed in the concept of operations. The validation documents will generally include three levels of validation documents:

- A plan to initially lay out the specific validation effort.
- The user's/operator's manual and/or a validation plan that defines the detailed operational procedures.
- A report on the results of the validation activities.

To ensure user needs and scenarios are validated by this activity, trace each need and scenario into a validation case, then into appropriate steps in the validation procedure.

A separate Validation Plan and procedures may be minimal for the simplest projects, especially where the system is commercially available and does not involve any custom software development, and where the agency staff have a very clear understanding of the purpose of the system. Preparation of a validation plan is strongly advised if:

- The system is more complex.
- There are several separate validation activities.
- Multiple deployment sites are involved.
- Multiple stakeholders have to be satisfied.

There is also the question of how comprehensive to make the validation effort. It is impossible to validate all possible combinations of actions under all possible operational situations. A good rule of thumb is: if it was important enough to write down as a need or scenario, then it should be validated, at least once. This may not, for example, validate all possible failure mode conditions

or all possible incident scenarios. In-process² validation performed on the needs will help ensure that end-to-end validation of the system will meet the stakeholder needs.

Once the Validation Plan has been prepared, use this checklist to ensure all critical information has been included.

- Does the Validation Plan answer all the questions of who, what, where, and when?
- Does the Validation Plan make clear what needs to happen if an unexpected situation or a failure is encountered?
- Does the Validation Plan document the configuration of the hardware and software?
- Are all applicable needs and scenarios traced to a validation case?

PURPOSE OF THE DOCUMENT (CHAPTER 1 OF THE VALIDATION PLAN DOCUMENT)

This section identifies the type of validation activity to be performed within this Validation Plan. For instance, this activity may validate the entire system, a sub-system, the deployment at a site, a burn-in, or any other validation activity called for in the Program Plan or in the Systems Engineering Management Plan.

SCOPE OF PROJECT (CHAPTER 2 OF THE VALIDATION PLAN DOCUMENT)

This section gives a brief description of the planned project and the purpose of the system to be built. Special emphasis is placed on the project's user needs and issues that must be addressed and validated.

This section also describes the environment in which the project operates. It identifies the organization structures that encompass all stakeholders. It also gives a brief description of the role to be played by each stakeholder. This includes ad hoc and existing management work groups and multi-disciplinary technical teams that should be formed to support the project.

REFERENCED DOCUMENTS (CHAPTER 3 OF THE VALIDATION PLAN DOCUMENT)

This is a list of all documents used in the preparation of this Validation Plan. This usually includes the Project Plan, (if one was written), and the applicable Requirements Documents. Reference to other documents, such as descriptions of external systems, standards, a Concept of Operations, and manuals may also be included.

² In-process validation is reviewing the needs and requirements during the definition stage by the stakeholders to ensure that all the needs have been identified and traced to appropriate requirements and have been reviewed for completeness for each of the needs.

CONDUCTING VALIDATION (CHAPTER 4 OF THE VALIDATION PLAN DOCUMENT)

This section provides details on how validation is accomplished. It defines: who does the validation; when and where it is to be done; the responsibilities of each participant before, during, and after validation; the deployed hardware and software configuration; and the documents to be prepared as a record of the validation activity.

This section also defines how anomalies are to be handled (that is, what to do when an unexpected situation or a failure occurs during validation).

In general, the following information should be included in this section:

- A description of the participating organizations, personnel, and identification of their roles and responsibilities. This may include for example, a validation conductor, validation recorder, operators, and/or engineering support.
- Identification of the location of the validation effort, that is, the place, or places, where the validation must be observed.
- The deployed hardware and software configuration for all of the validation cases, including hardware and software under validation and any supporting equipment, software, or external systems. Several configurations may be necessary.
- Identification of the documents to be prepared to support the validation, including Validation Procedures, a Validation Report and descriptions of special equipment and software.
- Details of the actual conduct of validation, including:
 - Notification of participants
 - Emphasis on the management role of the validation conductor
 - Procedures for approving last minute changes to the procedures
 - The processes for handling a failure, including recording of critical information, determination of whether to stop the validation, restart, or skip a procedure, resolution of the cause of a failure (e.g. fix the software, reset the system, and/or change the requirements), and determination of the re-validation activities necessary as a result of the failure.

VALIDATION IDENTIFICATION (CHAPTER 5 OF THE VALIDATION PLAN DOCUMENT)

This section identifies the specific validation cases to be performed. A validation case is a logical grouping of functions and performance criteria (all from the Concept of Operations Document) that are to be validated together. For instance, a specific validation case may cover Central

Traffic Signal System (CTSS) user permissions by the CTSS System Manager. There may be several individual user needs that define this capability, but they are validated in one case. The actual grouping of user needs into a case is arbitrary; however, the grouping is usually based on the grouping of user needs and the operational scenarios in the Concept of Operations. They should be related and easily combined into a reasonable set of procedure actions. Suggested validation cases that may be used in the Validation Plan document are included in the Validation Plan Sample Cases table (Appendix E).

Each case should contain at least the following information:

- A description name and a reference number.
- A description of the objective of the validation case, usually taken from the wording of the user need and/or scenario, to aid the reader understanding the scope of the case.
- A complete list of user needs and scenarios to be validated. For ease of tracing of user needs and scenarios into the Validation Plan and other documents, the user needs and scenarios are given numbers, so they can be accurately and conveniently referenced without repetition.
- Any data to be recorded or noted during validation, such as expected results of a step. Other data, such as a recording of a digital message sent to an external system, may be required to validate the performance of the system.
- A statement of the pass/fail criteria. Often this is just a statement that the system operates per the user need or scenario.
- A description of the validation configuration. That is a list of the hardware and software items needed for validation and how they should be connected (in most cases this is the deployed system configuration). Often, the same configuration is used for several validation cases.
- A list of any other important assumptions and constraints necessary to conduct the validation case.

Each validation case in Appendix E corresponds to the same name of a section of user needs in Section 4 of the Concept of Operations (ConOps) model document. The applicable operational scenarios defined in section 8 of the ConOps are referenced in each validation case. The details of each validation case will need to be added as the system is further defined.

CHAPTER 6. PURCHASING A SYSTEM USING SYSTEMS ENGINEERING DOCUMENTS

TRADITIONAL APPROACHES ARE RISKY FOR TECHNOLOGY PROJECTS

Most agencies buy systems by first exploring the marketplace to identify which technologies and products have the features they want, and then work from the sample specifications provided by the vendors of those technologies and products. They prepare plans and specifications, and then go out for bid. They then select the lowest responsible bidder, but they determine whether a bidder is responsible based on reputation or product affiliation. The bidder receives the contract, and then as part of mobilization, provides a material submittal, which includes product cut sheets describing what materials they intend to provide on the project.

For technology projects, prospective bidders select system and product providers based on cost or standing relationship, and usually require those providers to provide technical information needed to support the bid, and materials to include in the submittal.

The agency usually accepts the submittal unless it points to technologies and products different from what they had explored. If the contractor proposed a different provider, a negotiation begins where the contractor and the agency eventually come to an agreement.

The selection of the contractor and the contractor's providers is based mostly on cost. The acceptance of the providers is negotiated based on preferences, rather than on objective evaluation.

The problem emerges during implementation and testing, when the agency first has access to the supplied systems and products. At that point, they are able to see things not visible during market research, and the difference between what they have bought and what they are receiving come into focus. Those differences exist because their product selection (or the contractor's selection) did not actually do what they needed it to do, and as acceptance testing wears on, the agency comes to understand their needs and requirements more clearly.

Only two possibilities exist for resolving unmet emerging requirements: Either the agency sets those requirements aside (and does without), or the contractor and providers exceed their expected costs by modifying their product. Usually, both of these occur, and the outcome for the agency is that the system is more expensive than expected and less useful than needed. Even if the agency succeeds in requiring the contractor to absorb those extra costs, it is difficult to say that the project is as successful as it could have been.

One might call this the "consumer reports" approach, where we make choices based on testimonials, short demonstrations, and advertising claims. The process is shown in Figure 5.

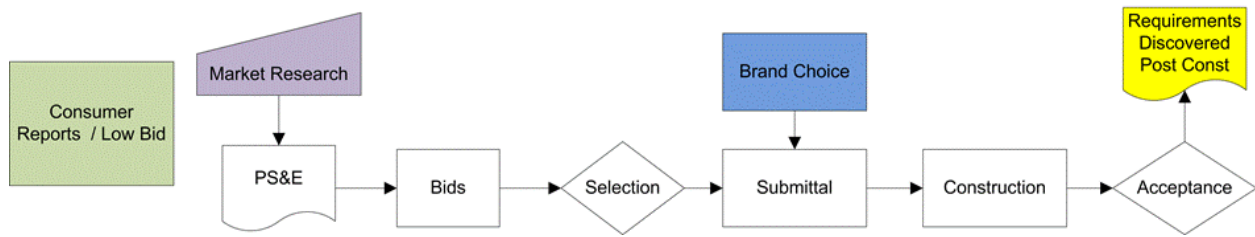


Figure 5. Consumer Reports acquisition approach

This process follows the traditional approach used for highway construction, and works reasonably well when all requirements are clearly understood and documented before the acquisition process begins. When requirements are not clearly understood, they will be discovered during the project, but after money has been spent and often too late to completely fulfill them.

REDUCING RISK USING REQUIREMENTS

With well-documented requirements, the agency can still use the low-bid process. But the requirements have a specific effect at several key milestones of the project, as shown in Figure 6.

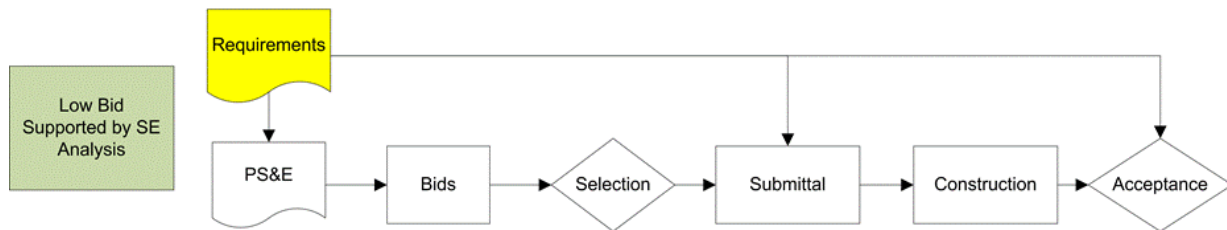


Figure 6. Low-bid process supported by requirements

Firstly, requirements developed before design can be used to evaluate design choices, and to provide a means by which the designer can know and demonstrate, by applying the Verification Plan to the design, that the design is complete and correct. This gives the agency a reason to have more confidence in the design documents.

Secondly, because the requirements will be included in the bid documents, the bidder has a basis for selecting technology and product providers. If a provider falls short later in the process, the contractor cannot claim that the requirements emerged after bidding, as is often the case with the first approach. This reduces the likelihood of the contractor making a poor choice and having to correct it at his expense during implementation.

Thirdly, the requirements give the agency a means of evaluating the materials submittal explicitly, without having to depend completely on brand reputation, testimonials, or sales activities. The agency should include a requirement in the Special Provisions governing the materials submittal, requiring the contractor to provide a detailed explanation of how the

proposed material supply will fulfill each requirement. This is, in essence, a pass through the Verification Plan. The agency can assess the materials submittal with much greater clarity and with much more leverage with the contractor if requirements are not fulfilled as expected.

Finally, the requirements provide a direct means of assessing work progress, and of determining when the system can be accepted.

REDUCING RISK FURTHER BY USING REQUIREMENTS FOR SELECTION

Agencies often believe that Federally-funded projects require a competitive-bid selection process. This is the case only for infrastructure construction, and does not apply to the acquisition of software systems. Software systems, like engineering services, can be acquired using a technical selection process based on a proposal. This process, when applied to Federal acquisitions, is called the Best Value approach because the selection of the most technically competent proposer provides the best value even if they do not have the lowest price. In most states, this process is the same as an engineering services acquisition, where cost is negotiated after making a technical selection. This process is shown in Figure 7, below.

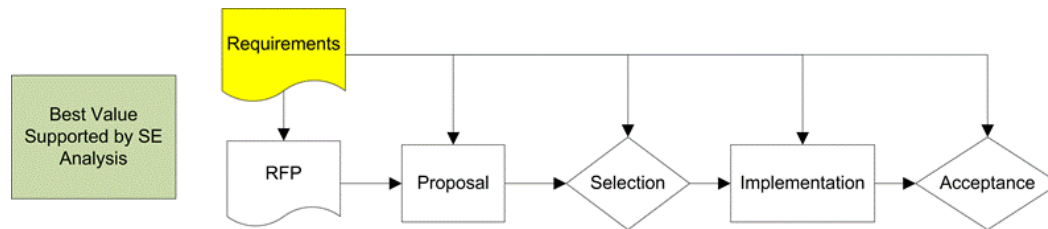


Figure 7. RFP-based technical selection acquisition process

In this process, the documented requirements are included in the request for proposals (RFP). The instructions to the proposers request that they provide a detailed explanation of how their proposed approach fulfills each requirement. The RFP should include the Concept of Operations, the Requirements, and the Verification Plan. The proposal will then be the proposer's written verification of their proposed approach.

The agency can then select the system that most closely fulfills their most important requirements. Even when none of the proposers fulfills all the requirements, agencies are able to make a reasoned and informed selection based on their needs.

The benefit this process offers over the previous process is that agencies can verify requirements fulfillment as the basis for selection, rather than after selection. This minimizes the risk of choosing the wrong provider.

SOLE-SOURCE ACQUISITIONS

According to Title 23 of the Code of Federal Regulation, Section 635, paragraph 411, federally-funded projects must be competitively acquired.

However, there are exceptions, which include:

1. The State Department of Transportation (DOT) certifies that there is no competing product that meets the specification. In a requirements-led process, this can be demonstrated by providing a requirements analysis that shows that only one product fulfills all of the requirements. As with any certification, what is being certified must be evidenced in facts, not opinions or judgements.
2. The State DOT certifies that the product is necessary for synchronization with existing installations. This is usually not appropriate for systems products that are the first such being acquired by an agency. However, there are cases where it does apply. Justification for synchronization will be easier if the system to which the new system must be compatible was competitively acquired using a requirements-driven process.
3. The Federal Highway Administration (FHWA) finds, on being presented with sufficient justification, that acquiring the technology is in the public interest even though there are other products or systems that also fulfill the requirements. These are known as public interest findings, and are in the public record, and must be carefully justified and evaluated.
4. The acquisition is made for experimental purposes, on a small scale. The scale should be small enough so that if the experiment fails, it can be discarded without unreasonable loss, or without the loss exceeding the value of the resulting knowledge gained by the experiment. The agency should also provide an experimental plan identifying the gap in knowledge that the acquisition would fill, the way in which the acquisition will fill it, and the way in which the evaluation will be made to determine the results of the experiment. Generally, such experimental projects are used to help an agency understand what they will do with a new technology, to provide the necessary education to support a realistic concept of operations. Experiments should not be made to verify products (i.e., to determine that they fulfill requirements). That sort of experimentation should be done using a pilot project, as discussed in the next section.

Systems installed on an experimental basis should not be expanded to a full implementation using synchronization to justify a sole-source acquisition. Doing so circumvents the meaning of the regulation and may not withstand an audit. At some point, either technical or price competition will be required.

SERVICES AND INFRASTRUCTURE

The RFP-based approach only works for software and services, and can only include hardware that is incidental to those acquisitions. For example, the computers on which the software runs will usually be considered incidental. However, physical infrastructure, including, for example, communications conduit and cable, pull boxes, traffic controller foundations and cabinet installations, and so on, must be competitively bid. Many Intelligent Transportation System (ITS) implementations include software, integration services, and infrastructure construction. For these projects, the best approach is to separate the software and services from the infrastructure construction, and contract them separately, using separate processes. The software and services can follow the RFP-based approach and the construction can be contracted by low bid.

Figure 8 shows a complex project where systems services and infrastructure construction are divided into separate tracks. The project is further complicated by having a first pilot phase, which allows the agency to confirm that they fully understand their needs and requirements, and have documented them completely and correctly.

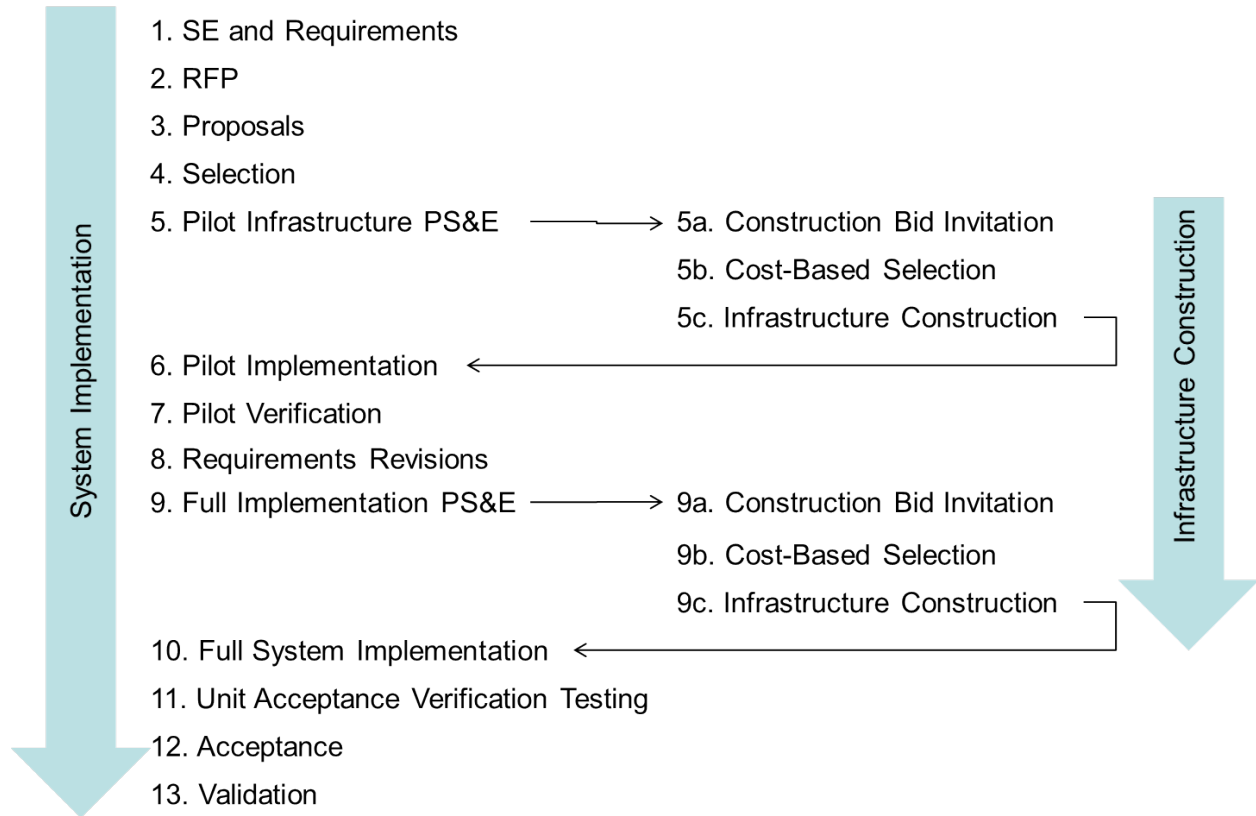


Figure 8. Complex project with both system services and infrastructure, and both pilot and full implementation phases

In this process, the concept of operations and requirements documents are completed, and then used as the basis for an RFP. The agency evaluates proposals and selects a system provider based on verification of the proposed approach against the requirements. The system provider then assists the agency in developing the design and specifications for the required physical infrastructure, which is then acquired using a conventional cost-based selection process.

The agency will verify the pilot phase of construction and system services against the requirements. In so doing, the agency will discover any deficiencies in the initial concept of operations and requirements documents, and will correct those documents as the basis for implementing the full system. The infrastructure component of the full system is then awarded to a contractor based on bid price. After implementation, the agency will verify final system against requirements, and once the implementation fulfills all requirements, the agency can accept it.

System providers usually have experience with acquisitions that separate services from infrastructure construction, and will build the cost of waiting for the completion of infrastructure construction into their negotiated price. The process should be fully identified in the initial RFP.

APPENDIX A: CONCEPT OF OPERATIONS TABLE OF SAMPLE STATEMENTS

ConOps Reference #	ConOps Sample Statements
1	Scope
1.1	Document Purpose and Scope
1.1.1	The scope of this document covers the consideration of a Traffic Signal System (TSS) including Adaptive Signal Control Technology (ASCT) and Automated Traffic Signal Performance Monitoring (ATSPM) for use within (describe the agency and/or geographic area covered by this consideration).
1.1.2	This document describes and provides a rationale for the expected operations of the proposed signal system.
1.1.3	It documents the outcome of stakeholder discussions and consensus building that has been undertaken to ensure that the system that is implemented is operationally feasible and has the support of stakeholders.
1.1.4	The intended audience of this document includes: system operators, administrators, decision-makers, elected officials, other nontechnical readers and other stakeholders who will share the operation of the system or be directly affected by it. (Edit list as appropriate)
1.2	Project Purpose and Scope
1.2.1	The purpose of providing a signal system is to overcome (describe why it is needed, such as to overcome specific deficiencies or limitations in the existing system).
1.2.2	The purpose of providing adaptive control in this area is to overcome (describe why it is needed, such as to overcome specific deficiencies or limitations in the existing system). An adaptive traffic signal system is one in which some or all the signal timing parameters are modified in response to changes in the traffic conditions, in real time.
1.2.3	The purpose of automated traffic signal performance measurement and monitoring is to validate and optimize how well single and multiple intersections are performing (describe specifics).
1.2.4	This project will establish a new traffic signal system or replace the existing traffic signal system with a new one.
1.2.5	This project will add adaptive capabilities to a new or existing coordinated signal system.
1.2.6	This project will add performance monitoring capabilities to a new or existing coordinated traffic signal system.
1.3	Procurement
1.3.1	The traffic signal system will be procured using [Edit this or choose alternative statement].
1.3.2	.a combination of best value procurement for software and system integration services, and low-bid procurement for equipment and construction services.

ConOps Reference #	ConOps Sample Statements
1.3.3	.a best value procurement process based on responses to a request for proposals.
1.3.4	.a low-bid process based on detailed plans and technical specifications.
1.3.5	A request for qualifications (RFQ) will be issued to all potential vendors. Responses will be used to develop a short list of suitable systems and a request for proposals (RFP) will be issued to those vendors. The selected system will be the one that provides the best value, subject to financial and schedule constraints.
1.3.6	Field equipment (parts and labor) will be procured using a low-bid process based on detailed plans and technical specifications.
1.3.7	A detailed procurement plan will be prepared after the system requirements have been determined.
2	Referenced Documents
2.1	The following documents have been used in the preparation of this Concept of Operations and stakeholder discussions. Some of these documents provide policy guidance for traffic signal operation in this area, some are standards with which the system must comply, while others report the conclusions of discussions, workshops and other research used to define the needs of the project and subsequently identify project requirements.
2.2	<p>References Specific to the Traffic Signal System Location</p> <ul style="list-style-type: none"> * Business Planning / Strategic Planning Documents for relevant agencies * Concept of Operations for related agency/facility-specific systems * Requirements of related systems * Studies identifying operational needs * Regional ITS Architecture documents * Planning studies and Master Plans * Transportation Improvement Programs (TIP) * Long Range Transportation Plans
2.3	<p>Systems Engineering</p> <ul style="list-style-type: none"> * “Systems Engineering Guidebook for ITS”, California Department of Transportation, Division of Research & Innovation, Version 3.0, (http://www.fhwa.dot.gov/cadiv/segb/) * "Systems Engineering for Intelligent Transportation Systems, An Introduction for Transportation Professionals", (http://ops.fhwa.dot.gov/publications/seitsguide/index.htm) * “Developing Functional Requirements for ITS Projects”, Mitretek Systems, April 2002 * "Developing and Using a Concept of Operations in Transportation Management System, FHWA TMC Pooled-Fund Study (http://tmcdfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/conops_tms_handbook.pdf)

ConOps Reference #	ConOps Sample Statements
	* National Cooperative Highway Research Program (NCHRP) Synthesis 307: Systems Engineering Processes for Developing Traffic Signal Systems
2.4	Adaptive Signals * NCHRP Synthesis 403: "Adaptive Traffic Control Systems: Domestic and Foreign State of Practice" (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_403.pdf)
2.5	Automated Traffic Signal Performance Measures * Sturdevant, J. R., T. Overman, E. Raamot, R. Deer, D. Miller, D. M. Bullock, C. M. Day, T. M. Brennan, H. Li, A. Hainen, and S. M. Remias. Indiana Traffic Signal Hi Resolution Data Logger Enumerations. Publication. , Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2012. doi: 10.4231/K4RN35SH. * Day, C. M., D. M. Bullock, H. Li, S. M. Remias, A. M. Hainen, R. S. Freije, A. L. Stevens, J. R. Sturdevant, and T. M. Brennan. Performance Measures for Traffic Signal Systems: An Outcome-Oriented Approach. Purdue University, West Lafayette, Indiana, 2014. doi: 10.5703/1288284315333.
2.6	ITS, Operations, Architecture, Other * 23 CFR Part 940, Intelligent Transportation System Architecture and Standards * Regional ITS Architecture Guidance Document; “Developing, Using, and Maintaining an ITS Architecture for your Region; National ITS Architecture Team; October, 2001
2.7	National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) * NTCIP 1201 – Global Objects (GO) * NTCIP 1202 – Actuated Signal Controllers (ASC) * NTCIP 1210 – Field Management Stations (FMS) * List other applicable NTCIP standards, utilize appendix containing interface standards
2.8	National Electrical Manufacturers Association (NEMA) * NEMA TS 2-2016 or later * List other applicable NEMA standards
2.9	PROCUREMENT * NCHRP 560: (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_560.pdf) * Special Experimental Project 14 (SEP 14): (http://www.fhwa.dot.gov/programadmin/contracts/sep_a.cfm) * The Road to Successful ITS Software Acquisition:(http://www.fhwa.dot.gov/publications/research/operations/its/98036/rdsuccessvol2.pdf)

ConOps Reference #	ConOps Sample Statements
	* Purchasing Intelligent Traffic Systems (ITS) and Traffic Technology: (http://www.fhwa.dot.gov/federal-aidessentials/catmod.cfm?id=100)
3	User-Oriented Operational Description
3.1	<p>The Existing System and Limitations of the Existing System [Explain how the lack of or inadequacy of traffic signal system is preventing achieving transportation management operational objectives. Describe the problem to be solved by deploying traffic signal system technologies.]</p> <p>[Explain how the inadequacy or lack of an adaptive system is preventing achieving transportation management operational objectives. Describe the problem to be solved by deploying adaptive technologies in a traffic signal system]</p> <p>[Explain how the inadequacy or lack of a performance monitoring system is preventing achieving transportation management operational objectives. Describe the problem to be solved by deploying performance monitoring technologies for a traffic signal system]</p>
3.1.1	Existing System
3.1.1.1	The existing system architecture is illustrated in Figure XX. (Provide an appropriate system network block diagram and describe the following elements, as applicable.) – Traffic Management Center (TMC) and workstations -Local hubs, on-street masters, etc. -Communications infrastructure (e.g., fiber optic cable, twisted wire pair cable, dial up, cell, serial or Ethernet communications) -Detection locations and technology (e.g., video, loops or other technology)
3.1.1.2	All of the traffic signals on the system are within the City limits and are connected to the existing signal system as illustrated in Figure XX.
3.1.1.3	While all signals are relatively close, the traffic conditions and distances vary. The signals are in multiple coordination groups and some operate in free mode.
3.1.1.4	The existing closed loop system consists of X signal groupings each with a master controller.
3.1.1.5	The signal system includes traffic signals all over the state and not grouped into one location.
3.1.1.6	The [Specify jurisdiction] is the only agency that will be accessing the traffic signal system.
3.1.1.7	The traffic signal system will be accessed by [INSERT RELEVANT AGENCIES] and maintained by the City through an intergovernmental agreement.
3.1.2	Limitations of the Existing System
3.1.2.1	The following statements summarize the limitations of the existing system that prevent it from satisfactorily accommodating the agency's needs. [Select from the following samples and create new descriptions that fit your situation.]

ConOps Reference #	ConOps Sample Statements
3.1.2.2	New traffic signal controllers and software were recently procured and the existing traffic signal system is not compatible with all of the features.
3.1.2.3	The existing closed loop system doesn't provide continual real-time monitoring of the traffic signal network.
3.1.2.4	The existing system is no longer supported by the vendor.
3.1.2.5	The mapping interface capabilities are limited. It is difficult to quickly add a new intersection to the system.
3.1.2.6	The alarm and flagging capabilities are limited.
3.1.2.7	The existing traffic signal system doesn't support high resolution data for performance monitoring.
3.1.2.8	The existing traffic signal system doesn't allow multiple agencies to be connected to the same system.
3.1.2.9	The existing traffic signal system doesn't allow multiple users to view the same intersection simultaneously.
3.1.2.10	The existing traffic signal system doesn't interface with other systems.
3.1.2.11	The existing traffic signal system doesn't have a laptop version that can be used at remote locations not connected to the network.
3.1.2.12	The user interface and display screens are old style, lack resolution, and do not clearly display sufficient data to efficiently support the operator.
3.2	Vision, Goals, and Objectives for the Proposed System
3.2.1	Traffic Signal System (TSS)/Adaptive Signal Control Technology (ASCT) Vision, Goals and Objectives
3.2.1-1	The agencies vision, goals and objectives for the proposed TSS are: [extract a summary from relevant planning documents. If planning documents do not provide vision, goals and objectives for the role of traffic signal systems in transportation management, summarize that role here].
3.2.1.1	TSS/ASCT Vision The vision of a TSS is to support efficient operations and maintenance of a traffic signal infrastructure.
3.2.1.1.1	The vision of the ASCT is to provide an advanced traffic control system that responds to changing traffic conditions, and reduces delays and corridor travel times, while balancing multimodal transportation needs. [Customize this statement to suit your situation.]
3.2.1.2	TSS/ASCT Goals
3.2.1.2.1	The goals of the TSS are: [Select from the following items and customize to suit your situation.]
3.2.1.2.1.1	Support vehicle, pedestrian and transit traffic mobility.
3.2.1.2.1.2	Provide measurable improvements in personal mobility
3.2.1.2.1.3	Support interoperability between agencies

ConOps Reference #	ConOps Sample Statements
3.2.1.2.1.4	Support regional systems
3.2.1.2.1.5	Support congestion and environment policy objectives
3.2.1.2.1.6	Meet a timely project implementation schedule Support the efficient maintenance of a state of good repair of the traffic signal infrastructure Support the agency's ability to provide good customer service related to traffic signal operation
3.2.1.3	TSS/ASCT User Objectives
3.2.1.3.1	The objectives of the TSS that support the stated goals are: [Select from the following items and customize to suite your situation.]
3.2.1.3.1.1	To support vehicle, pedestrian and transit traffic mobility: <ul style="list-style-type: none"> * Be capable of supporting priority operations for light rail and buses * Allow effective use of all controller features currently in use or proposed to be used * Minimize adverse effects caused by preemption and unexpected events
3.2.1.3.1.2	To support measurable improvements in personal mobility: <ul style="list-style-type: none"> * Adjust operations to changing conditions * Reduce delays * Reduce travel times * Provide the same level of safety provided by the existing system to vehicles, pedestrians and transit.
3.2.1.3.1.3	To support agency interoperability: <ul style="list-style-type: none"> * Provide facilities for data exchange and control between systems * Allow remote monitoring and control * Adhere to applicable traffic signal and ITS design standards
3.2.1.3.1.4	To support regional systems: <ul style="list-style-type: none"> * Be compliant with the regional ITS architecture * Allow center-to-center and system-to-system communication * Connect to regional traffic control systems * Report traffic conditions to regional traffic conditions information systems
3.2.1.3.1.5	To support environmental objectives: <ul style="list-style-type: none"> * Reduce vehicle emissions through operational improvements
3.2.1.3.1.6	To support a timely schedule: <ul style="list-style-type: none"> * Be sufficiently mature and robust that risk is low and little or no development time will be required.

ConOps Reference #	ConOps Sample Statements
	* Be ready for full operation by [Specify an appropriate date if you have an imposed deadline.]
3.2.1.4	TSS Operational Objectives (These objectives are appropriate for all traffic signal systems, not all systems modify operations in real time to attain these objectives. In many systems, the operator is expected to attain these objectives when designing signal timings, and the system is expected to facilitate the installation, maintenance, and monitoring of those signal timings.)
3.2.1.4.1	The operational objectives of the TSS will be to effect and demonstrate: [Select the samples appropriate to your situation]
3.2.1.4.1.1	Smooth flow of traffic along coordinated routes, particularly in uncongested conditions
3.2.1.4.1.2	Maximized throughput of traffic at bottleneck intersections, particularly in congested conditions
3.2.1.4.1.3	Equitable distribution of green time at the intersection (which may be to appropriately serve adjacent land uses or specific intersection users)
3.2.1.4.1.4	Managed queues, to prevent excessive queuing from reducing efficiency, particularly in congested conditions
3.2.1.4.1.5	Appropriate control of operation using a combination of these objectives
3.2.1.4.1.6	Appropriate selection of and response to objectives based on changing traffic conditions
3.2.1.4.1.7	For a critical isolated intersection, maximized intersection efficiency.
3.3	Strategies to be Applied by the Improved System
3.3-1	<p>This section describes in broad terms the improvements that are desirable in order to address the limitations described above. The main improvements that are desired are: [Select from the samples below and create new descriptions that suit your situation.]</p> <p>A set of use cases describe the strategies applied for a new or improved traffic signal system. The use cases defined in chapter three provide the framework for the user needs defined in chapter four of this document.</p>
3.3.1	General Actors
3.3.1-1	The general actors listed below represent the various roles and systems that interact with the Traffic Signal System (TSS). Each actor represents a role, a user can have multiple roles and there can be multiple for the same type of actor. For example, a TSS Maintainer and a TSS User could be the same person or they could be different people.
3.3.1.1	TSS Owner
3.3.1.1-1	The agency or organization that owns the system and sets policy for its use is represented by the TSS Owner actor.
3.3.1.2	TSS Operator

ConOps Reference #	ConOps Sample Statements
3.3.1.2-1	TSS Operators generally includes all roles that directly manipulate the TSS software. TSS Operators may also serve in other roles (e.g., Manager and Maintainer). Operators may be local or remote, but have access to the system controlling the traffic signals in question. A TSS Operator also includes external systems such as an ATMS (Advanced Traffic Management System) whose operators aren't identified as users of the TSS. It is left up to the ATMS for example to control the access of the ATMS operators. This is distinct from identifying remote operators who gain access through an External System, for whom the TSS will be responsible for handling their access control.
3.3.1.3	TSS Manager
3.3.1.3-1	The TSS Manager is a TSS Operator responsible for the overall operation of the system. The TSS Manager is expected to have full control of the system. The TSS Manager assigns TSS Operators, External Systems and TSS Maintainers their system permissions and capabilities.
3.3.1.4	External System
3.3.1.4-1	The External System actor represents the role of any type of external system to the TSS, through which a remote operator may gain access to the system.
3.3.1.5	TSS Maintainer
3.3.1.5-1	The TSS Maintainer is a TSS Operator who is receiving fault information, diagnosing faults and repairing faults.
3.3.1.6	TSS Designer
3.3.1.6-1	The TSS Designer actor represents the role of the designer of the TSS taking into account overall system requirements and constraints.
3.3.1.7	Traveling Public
3.3.1.7-1	This actor represents the role of the traveling public viewing the Traffic Signal Field Equipment including signal heads as well as pedestrian equipment.
3.3.2	Use Cases
3.3.2-1	Use cases capture the high-level typical interactions between an operator and a computer system. A use case needs to address a discrete goal of the user/operator. Besides the common use cases of system support (e.g., configuration, maintenance, etc.) the TSS use cases give the system operator the ability to better manage transportation-related situations.
3.3.2.1	Configuration of the Central Traffic Signal System (CTSS0 Management System This use case covers the overall configuration of a CTSS Management System including TSS Manager(s) configuring the traffic signal controller's network and managing access to the CTSS Management System. The configuration of operator access to the CTSS

ConOps Reference #	ConOps Sample Statements
	Management System as well as access to the databases is set up by the TSS Manager(s). The TSS Manager(s) also configure the overall CTSS Management System's system architecture, system fallback and the intersection display map. Fallback configuration for a controller is set up by the TSS User in the event of communications failure ascertained by the lack of response to a certain number of get requests.
3.3.2.2	Managing the Local Signal Controller Database The Managing the Local Signal Controller Database use case covers the operations performed by the TSS Operator when managing the database residing in local signal controllers. This use case covers TSS Operator operations for data entry, system validity checks to ensure that the central system database matches the controller database, accommodating Universal Traffic Data Format (UTDF) transfers, viewing and printing timing sheets, development of multiple versions of the timing database, upload and download of the timing database, database comparison, database change tracking and searching for intersection databases.
3.3.2.3	Monitoring the Traffic Signal Network This use case covers the TSS Operator monitoring the traffic signal network with the CTSS Management System. The TSS Operator configures the CTSS Management System to monitor specific and groups of traffic signal intersections and overall signal system status.
3.3.2.4	Managing the Traffic Signal Network The Managing the Traffic Signal Network use case covers the management of the traffic signal network by the TSS Operator. For adaptive signal control operations, reference the set of Adaptive Operations use cases. The primary centralized traffic signal systems operations for managing the traffic signal network by the TSS Operator include: enabling diversion plans, synchronizing the time clocks for a group of controllers, selecting plans based on time-of-day either local time-of-day or central system time-of-day, selecting plans based on traffic responsive patterns, selecting plans manually, synchronization of time-of-day clock with external systems, overriding time-of-day operation, remotely placing vehicle and pedestrian calls, manage external devices, managing emergency vehicle preemption, managing bus and light rail signal priority and managing rail preemption.
3.3.2.5	Performance Monitoring Note: Embedded or separate
3.3.2.5.1	Configure Enumerated Data to Intersection Mapping This use case is part of performance monitoring covering the TSS Operator configuring the mapping of the enumerated data to the intersection.
3.3.2.5.2	Retrieve / Store Enumerated Data This use case is part of performance monitoring covering the ability of the TSS Operator to store and retrieve the enumerated data.
3.3.2.5.3	Retrieve / Store High Resolution Traffic Detection Data This use case is part of performance monitoring covering the ability of the TSS Operator to store and retrieve the high-resolution traffic detection data.

ConOps Reference #	ConOps Sample Statements
3.3.2.5.4	Process Data into Performance Measurements This use case is part of the performance monitoring covering the TSS Operator’s initiation of the processing of the enumerated and high resolution traffic detection data into performance measurements.
3.3.2.5.5	Report Performance Measures The Report Performance Measures use case covers how the processed performance measures are reported to the TSS Operator. The performance measures are stored in a log, can be printed and displayed to the TSS Operator.
3.3.2.6	Adaptive Operation Note: The configuration of the Adaptive Signal Control Technologies (ASCT) can either be embedded as part of the CTSS Management System or separate from the CTSS Management System with an Adaptive Processor.
3.3.2.6.1	Implement Adaptive Strategies The Implement Adaptive Strategies use case is part of adaptive operations covering how the TSS Operator implements various adaptive strategies such as TBD via the ASCT.
3.3.2.6.2	Adaptively Control Signal Network The Adaptively Control Signal Network use case covers how the TSS Operator determines how the ASCT control the signal network using adaptive capabilities.
3.3.2.6.3	Adaptively Coordinate Signals with Adjacent System The Adaptively Coordinate Signals with Adjacent System use case covers where the TSS Operator prepares the ASCT to coordinate with an adjacent jurisdiction to facilitate coordination of adaptive progression.
3.3.2.6.4	Modify Adaptive Operation based on Queuing This use case covers when the TSS Operator configures the ASCT to modify the adaptive operation based on queuing conditions.
3.3.2.6.5	Accommodate Pedestrians within Adaptive Operation This use case covers when the TSS Operator configures the ASCT to accommodate pedestrians within its adaptive operation.
3.3.2.6.6	Operate Non-Adaptively The Operate Non-Adaptively use case covers when the TSS Operator configures the ASCT to suspend adaptive control under certain situations.
3.3.2.6.7	Managing Sensitivity to Changing Conditions This use case covers when the TSS Operator configures the ASCT to change its sensitivity to changing traffic conditions resulting in a timely non-erratic response.
3.3.2.6.8	Support Signal Controller Features This use case covers special signal controller features that require operational settings as part of the controller database management using a TSS, and features that a TSS or ASCT must allow to operate as the signal controller user intended.
3.3.2.6.9	Provide Security The Provide Security use case covers the system security features as managed by the TSS Manager.

ConOps Reference #	ConOps Sample Statements
3.3.2.6.10	Monitor and Control Adaptive Operation (was Monitoring and Control) The Monitor and Control Adaptive Operation use case covers how the TSS Operator ensures that the ASCT is performing correctly within a range of operating conditions.
3.3.2.6.11	Measure and Monitor Adaptive Performance The Measure and Monitor Adaptive Performance use case covers how the TSS Operator ensures that the ASCT is measuring and monitoring its performance.
3.3.2.6.12	Report Adaptive Performance The Report Adaptive Performance use case covers the reporting of the performance metrics to the TSS Operator by the ASCT.
3.3.2.6.13	Provide Adaptive Failure Notification The Provide Adaptive Failure Notification use case covers when the ASCT reports adaptive failures to the TSS Operator.
3.3.2.6.14	Accommodate Preemption and Priority Imposed on Adaptive Operations This use case covers when the TSS Operator configures the ASCT to accommodate adaptive operations when preemption and priority occur.
3.3.2.6.15	Respond to Adaptive System Failures This use case covers when the TSS Operator configures the ASCT to respond to adaptive-related system failures.
3.3.2.7	TSS Maintenance
3.3.2.7.1	The TSS Maintainer maintains the TSS by performing and testing all TSS capabilities both locally and remotely.
3.3.2.7.2	The TSS Maintainer maintains the TSS by performing remote updates of the signal controllers, controller firmware and TSS software.
3.3.2.8	Interfacing with External Systems
3.3.2.8.1	The TSS User interfaces with signal controllers and detectors from different manufacturers within the TSS.
3.3.2.8.2	The TSS Maintainer replaces signal controllers detectors from different manufacturers within the TSS.
3.3.2.8.3	The TSS Designer specifies different signal controller and detector interface standards within the TSS.
3.3.2.8.4	The TSS Designer specifies the existing signal controller and detector interfaces in order to integrate new signal controllers and detectors into an existing TSS.
3.3.2.8.5	The TSS Designer specifies the existing signal controller and detector interfaces in order to integrate a new TSS with existing signal controllers and detectors.
3.3.2.8.6	The TSS User interfaces with external TSS's to access information regarding signal controllers, intersections and groups of intersections.
3.3.2.8.7	The TSS User interfaces with external TSS's to allow the External System to access information regarding signal controllers, intersections and groups of intersections.

ConOps Reference #	ConOps Sample Statements
3.4	Alternative Strategies Considered
3.4-1	This section describes in broad terms the alternative strategies that were considered. [These should include: no change, new system, or new custom system.]

ConOps Reference #	ConOps Sample Statement	System Requirements
4	User Needs	
4-1	This chapter describes the operational needs related to user interface, database management, monitoring, reporting, and maintenance activities. The main purposes of a traffic signal system are: to provide remote access to field infrastructure and signal timing databases, and to monitor and report system performance.	
4.1	System Configuration	
4.1.1	TSS Network Characteristics	
4.1.1.1	The TSS Operator needs to view and control up to XXX traffic signal controllers, at various locations within the (agency).	3.1.3.1.1 The system shall control a minimum of XXX local signal controllers
4.1.1.2	The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.	3.1.3.1.2 The system shall allow intersections to be included in a group. 3.1.3.1.2.1 A group shall support up to XX signals. 3.1.3.1.3 The system shall allow an intersection to be included in two or more groups. 3.1.3.1.3.1 The system shall allow intersections to change grouping by time of day schedule.

ConOps Reference #	ConOps Sample Statement	System Requirements
		3.1.3.1.3.2 The system shall allow intersections to change grouping by manual command. 3.1.3.1.3.3 The system shall allow intersections to change grouping by (enter trigger).
4.1.1.3	The TSS Operator needs to change intersection grouping by time of day or other trigger.	3.1.3.1.2 The system shall allow intersections to be included in a group. 3.1.3.1.3 The system shall allow an intersection to be included in two or more groups. 3.1.3.1.3.1 The system shall allow intersections to change grouping by time of day schedule. 3.1.3.1.3.2 The system shall allow intersections to change grouping by manual command. 3.1.3.1.3.3 The system shall allow intersections to change grouping by (enter trigger).
4.1.1.4	The TSS operator needs to receive current time from a source to ensure time synchronization between signals.	3.1.8.1.1 The system shall receive the current time from a source: <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network
4.1.1.5	The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.	3.1.3.1.2 The system shall allow intersections to be included in a group. 3.1.3.1.3 The system shall allow an intersection to be included in two or more groups.

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.3.1.3.1 The system shall allow intersections to change grouping by time of day schedule.</p> <p>3.1.3.1.3.2 The system shall allow intersections to change grouping by manual command.</p> <p>3.1.8.1.2 The system shall re-sync the local controller time clock through a manual command.</p> <p>3.1.8.1.4 The system shall provide a time synch to each controller using:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network
4.1.2	Adaptive Network Characteristics	
4.1.2.1	The TSS Operator needs to adaptively control up to XXX signals, up to XXX miles from the TMC (or specified location).	<p>3.1.3.2.1 The ASCT shall control a minimum of XX signals concurrently. Note: communications network characteristics based on mileage distance.</p>
4.1.2.2	The TSS Operator needs to be able to adaptively control up to XX independent groups of signals	<p>3.1.3.2.2 The ASCT shall support groups of signals.</p> <p>3.1.3.2.2.1 The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.</p> <p>3.1.3.2.2.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall control a minimum of XX groups of signals.</p> <p>3.1.3.2.2.4</p> <p>Each group shall operate independently</p>
4.1.2.3	<p>The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.</p>	<p>3.1.3.2.2</p> <p>The ASCT shall support groups of signals.</p> <p>3.1.3.2.2.3</p> <p>The size of a group shall range from 1 to XX signals.</p> <p>3.1.3.2.2.5</p> <p>The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the ASCT system according to configured parameters.</p> <p>3.1.3.2.2.5.1</p> <p>The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to a time of day schedule. (For example: this may be achieved by assigning signals to different groups or by combining groups.)</p> <p>3.1.3.2.2.5.2</p> <p>The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to traffic conditions. (For example: this may be achieved by assigning signals to different groups or by combining groups.)</p> <p>3.1.3.2.2.5.3</p> <p>The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.</p>
4.1.3	<p>Traffic Performance Measurement Characteristics</p>	

ConOps Reference #	ConOps Sample Statement	System Requirements
4.1.3.1	The TSS Operator needs to configure performance measurement operations.	<p>3.1.3.3.1 The Performance Measurement Server shall configure how the high-resolution data is handled from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.]</p> <p>3.1.3.3.1.1 High-resolution data shall include all enumerated events as described in Sturdevant, et. al., Indiana High Resolution Data Logger Enumerations, November, 2012, or later document as developed under Pooled Fund Study TPF-5(377).</p> <p>3.1.3.3.1.2 High-resolution data interface is defined by (Specify latest interface control document, if available—Pooled Fund Study TPF-5(377), currently underway, will: Update the data logger specification to provide secure file transfer, incorporate new enumerations that have emerged, and logging new connected vehicle messages.</p> <p>3.1.3.3.1.3 The Performance Measurement Server shall be a separate server, independent of the TSS or ASCT.</p> <p>3.1.3.3.1.3.1 The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal.</p> <p>3.1.3.3.1.3.2 The Performance Measurement Server shall be co-located with the TSS. (In such cases, it shall be owned by the TSS System Manager.) [This requirement is exclusive of 3.1.3.3.1.3.3—choose one or the other]</p> <p>3.1.3.3.1.3.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The Performance Measurement Server shall be located at an alternative location [specify] and managed and maintained by a separate entity [specify]. [This requirement allows the server to be shared by multiple agencies but managed by one of them, or provided as a service by a private-sector provider. Please specify in this requirement. This requirement is exclusive of 3.1.3.3.1.3.2]</p> <p>3.1.3.3.1.3.4</p> <p>The Performance Measurement Server shall be integrated into the TSS (ASCT).</p> <p>3.1.3.3.1.3.4.1</p> <p>The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal. The open-source software may be revised to facilitate integration, or to extend to additional features that may be required herein.</p>
4.1.4	System Access and Security	
4.1.4.1	<p>The TSS Operator needs to manage the system database from the following locations: (EDIT TO SUIT YOUR SITUATION)</p> <ul style="list-style-type: none"> * Multiple workstations in the TMC * Multiple networked workstations on the City's LAN or WAN located at (USER SPECIFY) * Workstations at other Agencies' TMC (USER SPECIFY) 	<p>3.1.1.1</p> <p>The system shall provide monitoring and control access from the following locations.</p> <ul style="list-style-type: none"> * Agency TMC * Agency LAN or WAN * Other agency TMC (SPECIFY) * Local controller cabinets (hard wire) * Local controller cabinets (wireless) * Remote location via internet <p>3.1.1.2</p> <p>The system shall allow remote access using a secure Virtual Private Network (VPN).</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<ul style="list-style-type: none"> * At the local controller cabinet using a hard wire connection * At the local controller cabinet using a wireless connection * Remote locations connected to the internet (USER SPECIFY, such as employee's home, maintenance vehicle, etc.) 	
4.1.4.2	Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.	<p>3.1.1.3 The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.</p> <p>3.1.1.4 The system shall allow XX number of users to log on to the system simultaneously.</p> <p>3.1.1.5 The system shall allow multiple operators to access an intersection database simultaneously.</p> <p>3.1.1.6 The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.</p> <p>3.1.1.7 The system shall restrict control of each intersection database to a single user at a time.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.1.7.1 The system shall release lock of intersection database after a user-specified period of inactivity.</p> <p>3.1.1.7.2 The system shall allow access to a traffic signal database on a first come, first served basis.</p> <p>3.1.1.7.3 The system shall allow administrator to terminate intersection control by other users with lesser user rights.</p> <p>3.1.1.8 The system shall allow access to a traffic signal database based on user privileges.</p> <p>3.1.2.6 The system shall show operators/administrator who is logged in to the system at a given time.</p>
4.1.4.3	The TSS Operator needs to make changes to an intersection database, disabling the ability of other TSS Operators to simultaneously make changes to the same intersection database.	<p>3.1.1.4 The system shall allow XX number of users to log on to the system simultaneously.</p> <p>3.1.1.7 The system shall restrict control of each intersection database to a single user at a time.</p> <p>3.1.1.7.1 The system shall release lock of intersection database after a user-specified period of inactivity.</p> <p>3.1.1.7.3 The system shall allow administrator to terminate intersection control by other users with lesser user rights.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.1.4.4	The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.	<p>3.1.1.3 The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.</p> <p>3.1.1.4 The system shall allow XX number of users to log on to the system simultaneously.</p> <p>3.1.1.5 The system shall allow multiple operators to access an intersection database simultaneously.</p> <p>3.1.1.6 The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.</p> <p>3.1.1.7 The system shall restrict control of each intersection database to a single user at a time.</p> <p>3.1.1.7.2 The system shall allow access to a traffic signal database on a first come, first served basis.</p> <p>3.1.1.7.3 The system shall allow administrator to terminate intersection control by other users with lesser user rights.</p> <p>3.1.1.8 The system shall allow access to a traffic signal database based on user privileges.</p>
4.1.4.5	The TSS Operator needs to view the status of multiple agency signals, edit the	<p>3.1.1.3 The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>intersection databases, and/or create reports, as allowed by permission.</p>	<p>3.1.2.1 The system shall provide the ability to control and limit user access via user privileges (allowing for different levels of user access to system features and functions).</p> <ul style="list-style-type: none"> * Local access to the system * Remote access to the system * System monitoring * System manual override * Database * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * System parameters * Report generation * Configuration * Security alerts <p>3.1.2.5 The system shall provide full access to the administrator.</p>
4.1.4.6	<p>The TSS Operator needs secure access to the system consistent with the existing agency network policies.</p>	<p>3.1.2.4 The system shall comply with the agency's security policy as described in (specify appropriate policy document)</p> <p>3.1.2.5 The system shall provide full access to the administrator.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.1.4.7	The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.	<p>3.1.2.2 The system shall provide user privileges definable for the following:</p> <p>3.1.2.2.1 Geographic area</p> <p>3.1.2.2.2 Time of Day</p> <p>3.1.2.2.3 Device ownership</p> <p>3.1.2.3 The system shall provide user privileges definable on a functional level:</p> <p>3.1.2.3.1 TSS Manager</p> <p>3.1.2.3.2 TSS Operator</p> <p>3.1.2.3.3 External System</p> <p>3.1.2.3.4 TSS Maintainer</p> <p>3.1.2.7 For Adaptive Systems, the ASCT shall be implemented with a security policy that addresses the following selected elements:</p> <ul style="list-style-type: none"> * Local access to the ASCT * Remote access to the ASCT * System monitoring * System manual override * Development

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * Operations * User login * User password * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * Output activation * System parameters * Report generation * Configuration * Security alerts * Security logging * Security reporting * Database * Signal controller <p>3.1.2.9 The ASCT shall comply with the agency's security policy as described in (specify appropriate policy document).</p>
4.1.5	Overall Architecture	
4.1.5.1	The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):	<p>3.1.3.4.5 The system shall work with the existing communications architecture (DEFINE characteristics, specifications and layout of system).</p> <p>3.1.3.4.5.1 The system shall operate on a stand alone server located at (SPECIFY LOCATION)</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>	<p>3.1.3.4.5.2 The system shall operate as cloud based.</p> <p>3.1.3.4.5.3 The system shall operate with center to center capabilities.</p> <p>3.1.3.4.5.4 The system shall be integrated with an Advance Traffic Management System (SPECIFY)</p> <p>3.1.3.4.5.5 The system shall operate with on-street masters.</p>
4.1.5.2	The TSS Operator needs to access the system at all times to view status or manage the system.	<p>3.1.7.1.1 The system shall update the status of all traffic signal controller connected to the system every (XX) seconds.</p> <p>3.1.7.1.2 The system shall update the status of all traffic signal controllers connected to the system 24 hours a day, 7 days a week.</p>
4.1.5.3	The TSS Operator needs to fully operate the system within	3.1.3.4.1

ConOps Reference #	ConOps Sample Statement	System Requirements
	a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)	<p>The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)</p> <p>3.1.3.4.1.3 Communications media and protocols (list applicable equipment)</p> <p>3.1.3.4.1.3.1 AB3418E</p> <p>3.1.3.4.1.3.2 NTCIP (SPECIFY relevant items)</p> <p>3.1.3.4.4 The system shall fulfill requirements within a communications bandwidth limit of XX Mbps (specify applicable limits).</p> <p>3.1.3.4.6 The system shall use the following communications protocols with traffic signal controllers (SPECIFY as appropriate)</p> <p>3.1.3.4.6.1 Ethernet</p> <p>3.1.3.4.6.2 Serial</p> <p>3.1.3.4.6.3 Other [Specify]</p>
4.1.6	TSS Failure and Fallback Mode	
4.1.6.1	The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of	<p>3.1.6.2.1 The TSS shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)</p> <p>3.1.6.2.1.1</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	equipment, communications, or software failure.	<p>In the event of loss of communication to a user-specified signal controller, the TSS shall release control of all signal controllers within a user-specified group to local control.</p> <p>3.1.6.2.1.2 The TSS shall switch to the alternate operation in real time without operator intervention.</p> <p>3.1.8.2.2 The system shall allow the traffic signals to operate according to local control in case of communications failure.</p> <p>3.1.8.2.3 The system shall allow the traffic signals to operate according to local control in case of TSS failure.</p> <p>3.1.9.1.1.2 The ASCT shall operate non-adaptively when adaptive control equipment fails.</p> <p>3.1.9.1.1.2.1 The ASCT shall operate non-adaptively when a user-specified detector fails.</p> <p>3.1.9.1.1.2.2 The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.</p> <p>3.1.9.1.1.2.3 The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.</p> <p>3.1.9.1.1.2.4 The ASCT shall operate non-adaptively when a user-defined communications link fails.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.1.6.2	The TSS Operator needs to maintain a complete log of alarms and failure events.	<p>3.1.6.1.4 In the event of a failure, the TSS/ASCT shall log details of the failure in a permanent log.</p> <p>3.1.6.1.5 The permanent failure log shall be searchable, archivable and exportable.</p> <p>3.1.6.2.7 In the event of a communications failure, the TSS/ASCT shall log details of the failure in a permanent log.</p> <p>3.1.6.2.8 The permanent failure log shall be searchable, archivable and exportable.</p>
4.1.7	Adaptive Failure and Fallback	
4.1.7.1	The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.	<p>3.1.6.1.1 The ASCT shall take user-specified action in the absence of valid detector data from XX vehicle detectors within a group. (SELECT THE APPROPRIATE ACTION.)</p> <p>3.1.6.1.1.1 The ASCT shall release control to central system control.</p> <p>3.1.6.1.1.2 The ASCT shall release control to local operations to operate under its own time-of-day schedule.</p> <p>3.1.6.1.2 The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:</p> <p>3.1.6.1.2.1</p> <p>* Data from a user-specified alternate detector.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	3.1.6.1.2.2	
		* Stored historical data from the failed detector.
	3.1.6.1.2.3	
		The ASCT shall switch to the alternate source in real time without operator intervention.
	3.1.6.2.4	
		The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)
	3.1.6.2.4.1	
		In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.
	3.1.6.2.4.2	
		The ASCT shall switch to the alternate operation in real time without operator intervention.
	3.1.6.2.5	
		In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.
	3.1.6.2.6	
		The ASCT shall issue an alarm within XX minutes of detection of a failure.
	3.1.6.3.1	
		The ASCT shall execute user-specified actions when adaptive control fails:
	3.1.6.3.1.1	

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall release control to central system control.</p> <p>3.1.6.3.1.2</p> <p>The ASCT shall release control to local operations to operate under its own time-of-day schedule.</p> <p>3.1.6.3.2</p> <p>In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance</p> <p>3.1.6.3.4</p> <p>During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.</p> <p>3.1.9.1.1.2</p> <p>The ASCT shall operate non-adaptively when adaptive control equipment fails.</p> <p>3.1.9.1.1.2.1</p> <p>The ASCT shall operate non-adaptively when a user-specified detector fails.</p> <p>3.1.9.1.1.2.2</p> <p>The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.</p> <p>3.1.9.1.1.2.3</p> <p>The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.</p> <p>3.1.9.1.1.2.4</p> <p>The ASCT shall operate non-adaptively when a user-defined communications link fails.</p>
4.2	Managing Signal System and Field Device Database	

ConOps Reference #	ConOps Sample Statement	System Requirements
4.2.1	General Database Development	
4.2.1.1	The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.	<p>3.1.4.1 The system shall create a timing database that includes all settable signal timing parameters for a given intersection local controller based on TSS Operator input and appropriate look up tables (SPECIFY controller and firmware version).</p> <p>3.1.4.2 The system shall allow TSS Operator to enter all settable timing parameter values manually.</p> <p>3.1.4.3 The system shall provide default intersection timing database templates containing the following data (SPECIFY others if needed):</p> <ul style="list-style-type: none"> * Min green, Max green, walk, flashing don't walk, yellow, red * Emergency Vehicle Preemption data * Flashing yellow left turn arrow <p>3.1.4.4 The system shall create a copy of an entire intersection timing database.</p> <p>3.1.4.5 The system shall copy parts of one intersection timing database and paste to another intersection timing database (e.g., time of day schedule)</p> <p>3.1.4.6 The system shall copy parts of an intersection timing database and paste within the same database (e.g., timing pattern data)</p>
4.2.1.2	The TSS Operator needs to verify the validity of all parameters in the controller database, check for errors, and alert the TSS Operator before	<p>3.1.4.8 The system shall provide safeguards when developing new signal databases, including:</p> <ul style="list-style-type: none"> * Range checking * Timing plan verification

ConOps Reference #	ConOps Sample Statement	System Requirements
	downloading it to the field controller.	<ul style="list-style-type: none"> * Conflicting phases
4.2.1.3	The TSS Operator needs to interface with Optimization Software (SPECIFY TYPE and VERSION) in order to develop and update coordinated timing plans.	<p>3.1.4.10</p> <p>The system shall transfer the following signal timing data to and from Optimization Software (SPECIFY TYPE and Version):</p> <ul style="list-style-type: none"> * Node number * Phase number and direction * Phase minimum green * Phase vehicle yellow clearance * Phase pedestrian walk * Phase vehicle all red * Phase pedestrian clearance * Cycle length * Offset * Coordination splits
4.2.1.4	The TSS Operator needs to view and print timing sheets that include all the operational timing parameters, including phase diagrams. The timing sheets should be user customizable.	<p>3.1.4.9</p> <p>The system shall create a timing sheet that includes:</p> <ul style="list-style-type: none"> * All timing parameters relevant for operating a traffic signal. * Phase rotation diagram with north arrow * User selected parts of the timing database * Modified timings * User specified * Only non-zero timing parameters

ConOps Reference #	ConOps Sample Statement	System Requirements
4.2.1.5	The TSS Operator needs to develop, save and access timing parameters for a temporary condition (such as modifying phases during construction) or a new condition (such as new coordinated timings) without losing information in the original database.	<p>3.1.4.1 The system shall create a timing database that includes all settable signal timing parameters for a given intersection local controller based on TSS Operator input and appropriate look up tables (SPECIFY controller and firmware version).</p> <p>3.1.4.7 The system shall create up to (X) versions of an intersection timing database.</p> <p>3.1.5.17 The system shall clearly identify the official version of the timing database.</p>
4.2.2	General Database Management	
4.2.2.1	The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.	<p>3.1.5.1 The system shall upload/download the intersection database to a controller:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule <p>3.1.5.2 The system shall download the entire intersection database to a controller.</p> <p>3.1.5.3 The system shall upload the entire intersection database from a controller.</p> <p>3.1.5.4 The system shall download select parts of an intersection database to a controller.</p> <p>3.1.5.5 The system shall upload select parts of an intersection database from a controller.</p> <p>3.1.5.8</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The system shall request user confirmation of command prior to downloading data from the central database to a controller. 3.1.5.9</p> <p>The system shall request user confirmation of command prior to saving uploaded data from a controller in the central database. 3.1.5.11</p> <p>The system shall cancel upload/download if any interruptions occur during the process. 3.1.5.12</p> <p>The system shall revert to previous version of the database at the request of the user. 3.1.5.15</p> <p>The system shall save the entire uploaded intersection database. 3.1.5.16</p> <p>The system shall save selected parts of an uploaded intersection database.</p>
4.2.2.2	The TSS Operator needs to compare the field controller database with the central database and save all or part of the local controller database to the central database.	<p>3.1.5.14</p> <p>The system shall compare two intersection databases (central and local) and highlight the differences. 3.1.5.15</p> <p>The system shall save the entire uploaded intersection database. 3.1.5.16</p> <p>The system shall save selected parts of an uploaded intersection database.</p>
4.2.2.3	The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to	<p>3.1.5.2</p> <p>The system shall download the entire intersection database to a controller. 3.1.5.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.	<p>The system shall upload the entire intersection database from a controller. 3.1.5.4</p> <p>The system shall download select parts of an intersection database to a controller. 3.1.5.5</p> <p>The system shall upload select parts of an intersection database from a controller. 3.1.5.6</p> <p>The system shall download timing parameters to two or more controllers with one command. 3.1.5.7</p> <p>The system shall upload timing parameters from two or more controllers with one command. 3.1.5.8</p> <p>The system shall request user confirmation of command prior to downloading data from the central database to a controller. 3.1.5.9</p> <p>The system shall request user confirmation of command prior to saving uploaded data from a controller in the central database. 3.1.5.11</p> <p>The system shall cancel upload/download if any interruptions occur during the process.</p>
4.2.2.4	The TSS Operator needs to have a full and permanent record, created automatically, of any changes to data entered directly into a local controller, including a record of the date and time at which the each change is entered.	<p>3.1.5.10</p> <p>The system shall archive all intersection databases when commanded by user. 3.1.5.13</p> <p>The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * When the change occurred <p>3.1.5.15 The system shall save the entire uploaded intersection database.</p> <p>3.1.5.16 The system shall save selected parts of an uploaded intersection database.</p>
4.2.2.5	The TSS Operator needs to search the system for each intersection database by using the intersection name or number or using the system map to point to and select the intersection.	<p>3.1.5.18 The system shall provide multiple methods to open an intersection database:</p> <ul style="list-style-type: none"> * Dynamically select intersection on map * Search feature that uses intersection name and partial name * Search feature that uses intersection ID number
4.3	TSS Control	
4.3.1	The TSS Operator needs to operate all signals attached to the system based on their local time of day schedule.	<p>3.1.8.2.1 The system shall allow the traffic signals to operate in coordinated mode.</p> <p>3.1.8.3.1 The system shall operate in the following control modes:</p> <p>3.1.8.3.1.1 Time of day schedule</p> <p>3.1.8.3.1.5 Local control mode</p>
4.3.2	The TSS Operator needs to program commands for local	<p>3.1.8.3.1 The system shall operate in the following control modes:</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	operation based on central time of day schedule.	3.1.8.3.1.6 Central control mode 3.1.8.4.1 The system shall implement the following user-specified actions according to a time of day schedule: 3.1.8.4.1.1 Re-synch the local controller time clock 3.1.8.4.1.2 .Activate a coordination pattern 3.1.8.4.1.3 .Activate an external output 3.1.8.4.1.4 .Deactivate an external output
4.3.3	The TSS Operator needs to send and receive data from another system that would allow the two systems to be coordinated.	3.1.8.1.4 The system shall provide a time synch to each controller using: <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 3.1.8.2.17 The system shall receive data from another system (SPECIFY DETAILS). 3.1.8.2.20 The system shall send data to another system (SPECIFY DETAILS).
4.3.4	The TSS Operator needs to override time of day, with a manual command, at an	3.1.3.1.3 The system shall allow an intersection to be included in two or more groups. 3.1.3.1.3.2

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.</p>	<p>The system shall allow intersections to change grouping by manual command. 3.1.3.6</p> <p>The system shall download timing parameters to two or more controllers with one command. 3.1.8.2.4</p> <p>The system shall download manual command to the local controller to change intersection operations to free. 3.1.8.2.5</p> <p>The system shall download manual command to the local controller to change intersection operations to flash. 3.1.8.2.6</p> <p>The system shall download manual command to the local controller to implement a timing plan 3.1.8.2.7</p> <p>The system shall operate manual selection of timing plans as a higher priority over all other modes of plan selection. 3.1.8.2.8</p> <p>The system shall request confirmation from the TSS Operator before a manual command is implemented. 3.1.8.2.9</p> <p>The system shall provide a start and end time for manual commands. 3.1.8.2.10</p> <p>The system shall provide a duration for manual commands. 3.1.8.2.11</p> <p>The system shall revert to time of day operation after the manual command ends. 3.1.8.2.12</p> <p>The system shall time-stamp a log of all manual commands.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.3.5	<p>The TSS Operator needs to accommodate traffic in a network that displays predictable traffic patterns during variable periods. For example, the traffic pattern for the afternoon peak may be predictable enough to be served by a defined timing plan, but the time of day in which the condition appears may be variable from one day to the next. (Note: For operations not consistent with this need statement, consider using adaptive.)</p> <p>[When selecting this need, select one of the two child needs below. If you have no preference for the pattern selection method, select both, but include this text here: The Vendor may fulfill the requirements traced to either one of the child needs below.]</p>	<p>3.1.8.3.1 The system shall operate in the following control modes:</p> <p>3.1.8.3.1.1 Time of day schedule</p> <p>3.1.8.3.1.3 Traffic responsive</p> <p>3.1.8.5.1 The system shall operate in traffic responsive mode when commanded:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule * By external input command
4.3.5.1	<p>The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select</p>	<p>3.1.8.5.1.1 The TSS shall accept a user-defined assignment of intersection detectors as system detectors.</p> <p>3.1.8.5.1.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)</p>	<p>The TSS shall accept a user-defined occupancy weighting factor for each system detector. 3.1.8.5.1.3</p> <p>The TSS shall accept a user-defined traffic-responsive control period. 3.1.8.5.1.4</p> <p>The TSS shall sum volume plus weighted occupancy for each system detector over the duration of the control period (volume comprises distinct detection of on and off events, and weighted occupancy is the percentage of time the detector is occupied by a vehicle multiplied by the occupancy weighting factor) 3.1.8.5.1.5</p> <p>The TSS shall accept a user-defined detector weighting factor to be applied to each system detector volume plus weighted occupancy. 3.1.8.5.1.6</p> <p>The TSS shall multiply the volume plus weighted occupancy by the detector weighting factor. 3.1.8.5.1.7</p> <p>The TSS shall select coordination patterns based on threshold levels (this is an alternative to the pattern recognition method). 3.1.8.5.1.7.1</p> <p>The TSS shall accept a user-defined selection of system detectors designated as inbound detectors. 3.1.8.5.1.7.2</p> <p>The TSS shall accept a user-defined selection of system detectors designated as outbound detectors. 3.1.8.5.1.7.3</p> <p>The TSS shall total the weighted volume plus weighted occupancy for inbound detectors within each intersection group over the control period.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.8.5.1.7.4 The TSS shall total the weighted volume plus weighted occupancy for outbound detectors within each intersection group over the control period.</p> <p>3.1.8.5.1.7.5 The TSS shall accept user-defined thresholds for inbound pattern selection.</p> <p>3.1.8.5.1.7.6 The TSS shall accept user-defined thresholds for outbound pattern selection.</p> <p>3.1.8.5.1.7.7 The TSS shall accept different thresholds for increasing weighted volume plus weighted occupancy totals than for decreasing weighted volume plus weighted occupancy totals (this provides the ability to incorporate hysteresis).</p> <p>3.1.8.5.1.7.8 The TSS shall accept user-defined coordination pattern designations for each level of total weighted volume plus weighted occupancy bounded by thresholds.</p> <p>3.1.8.5.1.7.9 The TSS shall compare the weighted volume plus weighted occupancy totals against the defined thresholds.</p> <p>3.1.8.5.1.7.10 The TSS shall engage the inbound or outbound coordination pattern defined for the weighted volume plus weighted occupancy totals.</p>
4.3.5.2	The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without	<p>3.1.8.5.1.1 The TSS shall accept a user-defined assignment of intersection detectors as system detectors.</p> <p>3.1.8.5.1.2 The TSS shall accept a user-defined occupancy weighting factor for each system detector.</p> <p>3.1.8.5.1.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)</p>	<p>The TSS shall accept a user-defined traffic-responsive control period. 3.1.8.5.1.4</p> <p>The TSS shall sum volume plus weighted occupancy for each system detector over the duration of the control period (volume comprises distinct detection of on and off events, and weighted occupancy is the percentage of time the detector is occupied by a vehicle multiplied by the occupancy weighting factor) 3.1.8.5.1.5</p> <p>The TSS shall accept a user-defined detector weighting factor to be applied to each system detector volume plus weighted occupancy. 3.1.8.5.1.6</p> <p>The TSS shall multiply the volume plus weighted occupancy by the detector weighting factor. 3.1.8.5.1.8</p> <p>The TSS shall select coordination patterns based on pattern recognition (this is an alternative to the threshold method). 3.1.8.5.1.8.1</p> <p>The TSS shall accept a table of coordination pattern designations coupled to user-defined “signature” total weighted volume plus weighted occupancy values (totals over the duration of the control period). 3.1.8.5.1.8.2</p> <p>The TSS shall compare the total weighted volume plus weighted occupancy for each intersection group over the duration of the control period against the user-defined “signature” values. 3.1.8.5.1.8.3</p> <p>The TSS shall engage the coordination pattern with the signature value that comes closest to the total weighted volume plus weighted occupancy for the intersection group.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.3.6	<p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection 	<p>3.1.8.3.1 The system shall operate in the following control modes:</p> <p>3.1.8.3.1.1 Time of day schedule</p> <p>3.1.8.3.1.2 Manual control</p> <p>3.1.8.3.1.3 Traffic responsive</p> <p>3.1.8.3.1.4 External command</p> <p>3.1.8.5.1 The system shall operate in traffic responsive mode when commanded:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule * By external input command
4.3.7	<p>The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.</p>	<p>3.1.8.1.2 The system shall re-sync the local controller time clock through a manual command.</p> <p>3.1.8.1.3 The system shall re-sync the local controller's time clock automatically [Specify conditions for triggering automatic re-sync].</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.8.1.4 The system shall provide a time synch to each controller using:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network <p>3.1.8.2.1 The system shall allow the traffic signals to operate in coordinated mode.</p> <p>3.1.8.4.1 The system shall implement the following user-specified actions according to a time of day schedule:</p> <p>3.1.8.4.1.1 Re-synch the local controller time clock</p>
4.3.8	The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.	<p>3.1.8.2.12 The system shall time-stamp a log of all manual commands.</p> <p>3.1.8.2.13 The system shall place non-locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.</p> <p>3.1.8.2.14 The system shall place a locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.</p> <p>3.1.8.2.15 The system shall place a non-locking call replicating an emergency vehicle preemption call on a user specified preemption channel at a user specified intersection.</p> <p>3.1.8.2.16</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.3.9	The TSS Operator needs to turn on and off external devices, such as message signs, by manual command, by time of day, or based on a user defined trigger (such as volume).	<p>The system shall receive data from another system (SPECIFY DETAILS).</p> <p>3.1.8.2.21 The system shall turn on and turn off message signs from a manual command.</p> <p>3.1.8.2.22 The system shall turn on and turn off message signs based on a user specified trigger (SPECIFY).</p> <p>3.1.8.4.1 The system shall implement the following user-specified actions according to a time of day schedule:</p> <p>3.1.8.4.1.3 .Activate an external output</p> <p>3.1.8.4.1.4 .Deactivate an external output</p>
4.3.10	The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.	<p>3.1.8.2.16 The system shall receive data from another system (SPECIFY DETAILS).</p> <p>3.1.8.2.17 The system shall receive data from another system (SPECIFY DETAILS).</p> <p>3.1.8.2.18 In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined emergency vehicle preemption.</p> <p>3.1.8.2.20 The system shall send data to another system (SPECIFY DETAILS).</p> <p>3.1.8.2.24 The system shall interface with external emergency vehicle preemption system. (explain the external system and refer to other interfaces as appropriate)</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.3.11	The TSS Operator needs to accommodate bus and light rail transit signal priority (USER SPECIFY FOR NECESSARY DETAILS).	3.1.8.2.17 The system shall receive data from another system (SPECIFY DETAILS). 3.1.8.2.20 The system shall send data to another system (SPECIFY DETAILS). 3.1.8.2.25 The system shall interface with external light rail transit. (explain the external system and refer to other interfaces as appropriate) 3.1.8.2.26 The system shall interface with external bus priority system. (explain the external system and refer to other interfaces as appropriate)
4.3.12	The TSS Operator needs to accommodate rail preemption based on an external input from the railroad.	3.1.8.2.17 The system shall receive data from another system (SPECIFY DETAILS). 3.1.8.2.19 In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined railroad preemption. 3.1.8.2.20 The system shall send data to another system (SPECIFY DETAILS). 3.1.8.2.23 The system shall interface with external rail preemption system. (explain the external system and refer to other interfaces as appropriate)
4.3.13	The TSS Operator needs to configure when local controllers time clocks are automatically re-synced from an external time source. [Specify conditions for triggering automatic re-sync]	3.1.8.1.3 The system shall re-sync the local controller's time clock automatically [Specify conditions for triggering automatic re-sync].

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4	Adaptive System Operations	
4.4.1	Adaptive Strategies	
4.4.1.1	The system TSS Operator needs the ability to implement different strategies individually or in combination to suit different prevailing traffic conditions. These strategies include:	
4.4.1.1.1	<p>·Maximize the throughput on coordinated routes</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>	<p>3.1.9.1.1.7 The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)</p> <p>3.1.9.1.1.7.1 When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.</p> <p>3.1.9.1.1.10 The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)</p> <p>3.1.9.2.2 (Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.</p> <p>3.1.9.2.4 (Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.</p> <p>3.1.9.2.4.1</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route. 3.1.9.2.5
		(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green). 3.1.9.2.5.1
		(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values. 3.1.9.2.5.2
		(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range. 3.1.9.2.5.3
		(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy. 3.1.9.2.5.4
		(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value. 3.1.9.2.5.4.1
		(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions. 3.1.9.2.5.4.1.1
		(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate. 3.1.9.2.5.4.1.2
		(Sequence-based only) The increased limit shall be user-defined. 3.1.9.3.2

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)</p> <p>3.1.9.3.3</p> <p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p> <p>3.1.9.3.4</p> <p>(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.</p>
4.4.1.1.2	<p>·Provide smooth flow along coordinated routes</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of</p>	<p>3.1.9.1.1.7.4</p> <p>When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.</p> <p>3.1.9.1.1.10</p> <p>The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)</p> <p>3.1.9.2.2</p> <p>(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.</p> <p>3.1.9.2.4</p> <p>(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.</p> <p>3.1.9.2.4.1</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	supplying one type of adaptive operation or the other.)	<p>(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route. 3.1.9.2.5</p> <p>(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green). 3.1.9.2.5.1</p> <p>(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values. 3.1.9.2.5.2</p> <p>(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range. 3.1.9.2.5.3</p> <p>(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy. 3.1.9.2.5.4</p> <p>(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value. 3.1.9.2.5.4.1</p> <p>(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions. 3.1.9.2.5.4.1.1</p> <p>(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate. 3.1.9.2.5.4.1.2</p> <p>(Sequence-based only) The increased limit shall be user-defined. 3.1.9.3.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)</p> <p>3.1.9.3.3</p> <p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p> <p>3.1.9.3.4</p> <p>(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.</p>
4.4.1.1.3	<p>Distribute phase times in an equitable fashion</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of</p>	<p>3.1.9.1.1.7</p> <p>The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)</p> <p>3.1.9.1.1.7.3</p> <p>When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.</p> <p>3.1.9.1.1.8</p> <p>The ASCT shall provide maximum and minimum phase times.</p> <p>3.1.9.1.1.8.1</p> <p>The ASCT shall provide a user-specified maximum value for each phase at each signal controller.</p> <p>3.1.9.1.1.8.1.1</p> <p>The ASCT shall not provide a phase length longer than the maximum value.</p> <p>3.1.9.1.1.8.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	supplying one type of adaptive operation or the other.)	<p>The ASCT shall provide a user-specified minimum value for each phase at each signal controller.</p> <p>3.1.9.1.1.8.2.1</p> <p>The ASCT shall not provide a phase length shorter than the minimum value.</p> <p>3.1.9.2.2</p> <p>(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.</p> <p>3.1.9.2.3</p> <p>(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .</p> <p>3.1.9.2.5</p> <p>(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).</p> <p>3.1.9.2.5.1</p> <p>(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values.</p> <p>3.1.9.2.5.2</p> <p>(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range.</p> <p>3.1.9.2.5.3</p> <p>(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.</p> <p>3.1.9.2.5.4</p> <p>(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value.</p> <p>3.1.9.2.5.4.1</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions. 3.1.9.2.5.4.1.1</p> <p>(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate. 3.1.9.2.5.4.1.2</p> <p>(Sequence-based only) The increased limit shall be user-defined. 3.1.9.3.2</p> <p>(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.) 3.1.9.3.3</p> <p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy. 3.1.9.3.4</p> <p>(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection. 3.1.9.4.3</p> <p>The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.) 3.1.9.4.3.1</p> <p>The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value. 3.1.9.4.3.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.
4.4.1.1.4	<p>·Manage the lengths of queues</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>	<p>3.1.9.1.1.7.2</p> <p>When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.</p> <p>3.1.9.1.1.10</p> <p>The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)</p> <p>3.1.9.1.3.1</p> <p>The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.9.1.3.4</p> <p>When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.</p> <p>3.1.9.1.3.5</p> <p>The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.</p> <p>3.1.9.1.3.6</p> <p>The ASCT shall store queues at user-specified locations.</p> <p>3.1.9.2.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule. 3.1.9.2.4
		(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group. 3.1.9.2.4.1
		(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route. 3.1.9.2.5
		(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green). 3.1.9.2.5.1
		(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values. 3.1.9.2.5.2
		(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range. 3.1.9.2.5.3
		(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy. 3.1.9.2.5.4
		(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value. 3.1.9.2.5.4.1
		(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions.

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.9.2.5.4.1.1 (Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.</p> <p>3.1.9.2.5.4.1.2 (Sequence-based only) The increased limit shall be user-defined.</p> <p>3.1.9.3.2 (Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)</p> <p>3.1.9.3.3 (Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p> <p>3.1.9.3.4 (Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.</p> <p>3.1.13.3 The ASCT shall measure the length of queues to support the adaptive algorithm</p> <p>3.1.13.3.1 The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>
4.4.1.1.5	<p>·Manage the locations of queues within the network</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2</p>	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>	<p>When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode. 3.1.9.1.3.3</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy. 3.1.9.1.3.4</p> <p>When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller. 3.1.9.1.3.5</p> <p>The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations. 3.1.9.1.3.6</p> <p>The ASCT shall store queues at user-specified locations. 3.1.9.1.3.8</p> <p>When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value. 3.1.9.2.3</p> <p>(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .</p>
4.4.1.1.6	<p>At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).</p>	<p>3.1.9.1.1.8</p> <p>The ASCT shall provide maximum and minimum phase times. 3.1.9.1.1.8.1</p> <p>The ASCT shall provide a user-specified maximum value for each phase at each signal controller. 3.1.9.1.1.8.1.1</p> <p>The ASCT shall not provide a phase length longer than the maximum value. 3.1.9.1.1.8.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall provide a user-specified minimum value for each phase at each signal controller. 3.1.9.1.1.8.2.1</p> <p>The ASCT shall not provide a phase length shorter than the minimum value. 3.1.9.4.2</p> <p>The ASCT shall calculate a cycle length of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.) 3.1.9.4.3</p> <p>The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.) 3.1.9.4.3.1</p> <p>The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value. 3.1.9.4.3.2</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode. 3.1.9.4.4</p> <p>The ASCT shall calculate phase order, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)</p>
4.4.1.2	The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not	<p>3.1.9.5.2 (Phase-based only) The ASCT shall alter the state of the signal controller for all phases at the user-specified intersection.</p> <p>3.1.9.5.3 (Phase-based only) The ASCT shall calculate the time at which a user-specified phase shall be green at an intersection.</p> <p>3.1.9.5.4</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	explicitly calculate cycle, offset and split at all intersections.	<p>(Phase-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.</p> <p>3.1.9.5.5</p> <p>(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic released from user-specified phases at the user-specified critical intersection.</p> <p>3.1.9.5.6</p> <p>(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic arriving at user-specified phases at the user-specified critical intersection.</p> <p>3.1.9.5.7</p> <p>(Phase-based only) The ASCT shall adjust the state of the signal controller so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.</p>
4.4.1.3	The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.	<p>3.1.9.1.1.7</p> <p>The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)</p> <p>3.1.9.1.1.7.1</p> <p>When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.</p> <p>3.1.9.1.1.7.2</p> <p>When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.</p> <p>3.1.9.1.1.7.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.</p> <p>3.1.9.1.1.7.4</p> <p>When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.</p>
4.4.1.4	<p>The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.</p>	<p>3.1.9.1.1.9</p> <p>The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as by detecting repeated max-out.)</p> <p>3.1.9.1.1.9.1</p> <p>The ASCT shall alter operations, to minimize repeated phase failures.</p> <p>3.1.9.1.3.1</p> <p>The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3</p> <p>When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.9.1.3.4</p> <p>When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.</p> <p>3.1.9.2.3</p> <p>(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4.1.5	<p>The TSS Operator needs to minimize the chance that a queue forms at a specified location.</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.5 group when phase-based systems are allowed (phase-based systems do not explicitly calculate cycle, offset and split at all intersections). (Select requirements from two or all</p>	<p>3.1.9.2.5.5 (Sequence-based only) The ASCT shall adjust offsets to minimize the chance of stopping vehicles approaching a signal that have been served by a user-specified phase at an upstream signal.</p> <p>3.1.9.3.5 (Non-sequence-based only) The ASCT shall adjust signal timing so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.</p> <p>3.1.9.5.7 (Phase-based only) The ASCT shall adjust the state of the signal controller so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	three groups when the vendor is given the choice of supplying the type of adaptive operation.)	
4.4.1.6	The TSS Operator needs to modify the sequence of phases to support the various operational strategies.	<p>3.1.10.6 The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.</p> <p>3.1.10.6.1 Each permissible phase sequence shall be user-assignable to any signal timing plan.</p> <p>3.1.10.6.2 Each permissible phase sequence shall be executable by a time of day schedule.</p> <p>3.1.10.6.3 Each permissible phase sequence shall be executable based on measured traffic conditions</p> <p>3.1.10.7 The ASCT shall not prevent a phase/overlap output by time-of-day.</p> <p>3.1.10.8 The ASCT shall not prevent a phase/overlap output based on an external input.</p> <p>3.1.10.9 The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)</p>
4.4.1.7	The TSS Operator needs to fix the sequence of phases at any specified location. For example, the operator may need to fix the phase order at a diamond interchange.	<p>3.1.9.1.2.12 The ASCT shall not alter the order of phases at a user-specified intersection.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4.1.8	The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.	<p>3.1.9.1.1.11 The ASCT shall provide coordination along a route.</p> <p>3.1.9.1.1.11.1 The ASCT shall coordinate along a user-defined route.</p> <p>3.1.9.1.1.11.2 The ASCT shall determine the coordinated route based on traffic conditions.</p> <p>3.1.9.1.1.11.3 The ASCT shall determine the coordinated route based on a user-defined schedule.</p> <p>3.1.9.1.1.11.4 The ASCT shall store XX user-defined coordination routes.</p> <p>3.1.9.1.1.11.4.1 The ASCT shall implement a stored coordinated route by operator command.</p> <p>3.1.9.1.1.11.4.2 The ASCT shall implement a stored coordinated route based on traffic conditions.</p> <p>3.1.9.1.1.11.4.3 The ASCT shall implement a stored coordinated route based on a user-defined schedule.</p>
4.4.1.9	The TSS Operator needs to set signal timing parameters (such as minimum green, maximum green and extension time) to comply with agency policies.	<p>3.1.9.1.1.12 The ASCT shall not prevent the use of phase timings in the local controller set by agency policy.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4.2	Adaptive Monitoring and Control	
4.4.2.1	The TSS Operator needs to monitor and control all required features of adaptive operation from the following locations: (Edit and select as appropriate to suit your situation.)	3.1.2.8 The ASCT shall provide monitoring and control access at the following locations:
4.4.2.1.1	Agency TMC	3.1.2.8.1 Agency TMC
4.4.2.1.2	Maintenance facility	3.1.2.8.2 Agency LAN or WAN
4.4.2.1.3	Workstations on agency LAN or WAN located at (specify)	3.1.2.8.2 Agency LAN or WAN 3.1.2.8.3 Other agency TMC (Specify)
4.4.2.1.4	Other agency's TMC (specify)	3.1.2.8.3 Other agency TMC (Specify) 3.1.2.8.4 Other agency TMC (Specify)
4.4.2.1.5	Local controller cabinets	3.1.2.8.5 Local controller cabinets (wireless) 3.1.2.8.6 Local controller cabinets (hard wire)
4.4.2.1.6	Maintenance vehicles	3.1.2.8.7

ConOps Reference #	ConOps Sample Statement	System Requirements
		Remote locations via internet
4.4.2.1.7	Remote locations (specify)	3.1.2.8.8 Remote locations via internet
4.4.2.2	The operator needs to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system from the access points defined for those system components.	3.1.2.10 The ASCT shall not prevent access to the local signal controller database, monitoring or reporting functions by any installed signal management system.
4.4.3	Adaptive Coordination across boundaries	
4.4.3.1	The TSS Operator needs to adaptively control signals operated by (specify jurisdictions).	3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting

ConOps Reference #	ConOps Sample Statement	System Requirements
		* Duration of storage)
4.4.3.2	The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.	<p>3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.1 The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.2 The ASCT shall send control data to the XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.4 The ASCT shall send coordination data to the XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.5</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall send performance data to the XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.6</p> <p>The ASCT shall receive commands from the XX external system.</p> <p>3.1.17.1.8</p> <p>The ASCT shall conform its operation to an external system's operation.</p>
4.4.3.3	<p>The TSS Operator needs to adaptively coordinate signals on two crossing routes simultaneously. (Include signals on crossing arterials within the boundaries of the adaptive systems mapped in Chapter 3.)</p>	<p>3.1.17.1.8.4</p> <p>The ASCT shall support adaptive coordination on crossing routes.</p>
4.4.3.4	<p>The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.</p>	<p>3.1.17.1</p> <p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage)

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.17.1.8 The ASCT shall conform its operation to an external system's operation.</p> <p>3.1.17.1.8.1 The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)</p> <p>3.1.17.1.8.3 The ASCT shall alter its operation based on data received from another system.</p> <p>3.1.17.1.12 The ASCT shall conform its operation to an external system's operation.</p>
4.4.3.5	The TSS Operator needs to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.	<p>3.1.17.1.8.2 The ASCT shall operate a fixed cycle length to match the cycle length of an adjacent system.</p>
4.4.3.6	The TSS Operator needs to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.	<p>3.1.17.1.8 The ASCT shall conform its operation to an external system's operation.</p> <p>3.1.17.1.8.1 The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)</p> <p>3.1.17.1.12 The ASCT shall conform its operation to an external system's operation.</p>
4.4.4	Adaptive Queuing Interactions	

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4.4.1	The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2 When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3 When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.13.3 The ASCT shall measure the length of queues to support the adaptive algorithm</p> <p>3.1.13.3.1 The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>
4.4.4.2	The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2 When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3 When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.13.3 The ASCT shall measure the length of queues to support the adaptive algorithm</p> <p>3.1.13.3.1 The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.4.4.3	The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2 When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3 When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.13.3 The ASCT shall measure the length of queues to support the adaptive algorithm</p> <p>3.1.13.3.1 The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>
4.4.4.4	The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2 When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3 When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.9.1.3.4 When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.</p> <p>3.1.9.1.3.5 The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.9.1.3.6 The ASCT shall store queues at user-specified locations.</p> <p>3.1.9.1.3.7 The ASCT shall maintain capacity flow through user-specified bottlenecks.</p> <p>3.1.13.3 The ASCT shall measure the length of queues to support the adaptive algorithm</p> <p>3.1.13.3.1 The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>
4.4.4.5	The TSS Operator needs to prevent queues forming at user-specified locations.	<p>3.1.9.1.3.1 The ASCT shall detect the presence of queues at pre-configured locations.</p> <p>3.1.9.1.3.2 When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p> <p>3.1.9.1.3.3 When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p> <p>3.1.9.1.3.4 When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.</p> <p>3.1.9.1.3.5 The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.</p> <p>3.1.9.1.3.6 The ASCT shall store queues at user-specified locations.</p> <p>3.1.9.1.3.7</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall maintain capacity flow through user-specified bottlenecks. 3.1.13.3</p> <p>The ASCT shall measure the length of queues to support the adaptive algorithm 3.1.13.3.1</p> <p>The measurement shall be made with sufficient precision to support the adaptive algorithm.</p>
4.4.5	Adaptive Accommodation of Pedestrians	
4.4.5.1	The TSS Operator needs to accommodate infrequent pedestrian operation and then adaptively recover. (This is appropriate for rare pedestrian calls.)	<p>3.1.11.3</p> <p>When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times then resume adaptive operation.</p>
4.4.5.2	The TSS Operator needs to accommodate infrequent pedestrian operation while maintaining adaptive operation. (This is appropriate for pedestrian calls that are common but not so frequent that they drive the operational needs.)	<p>3.1.11.2</p> <p>When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.</p>
4.4.5.3	The TSS Operator needs to incorporate frequent pedestrian operation into routine adaptive operation. (This is appropriate	<p>3.1.11.2</p> <p>When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	when pedestrians are frequent enough that they must be assumed to be present every cycle or nearly every cycle.)	<p>3.1.11.5 The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.</p> <p>3.1.11.7 When specified by the user, the ASCT shall execute pedestrian recall on pedestrian phase adjacent to coordinated phases.</p> <p>3.1.11.8 When the pedestrian phases are on recall, the ASCT shall accommodate pedestrian timing during adaptive operation.</p>
4.4.5.4	The TSS Operator needs to accommodate the following custom pedestrian features. (Describe custom features in this need and then create appropriate requirements.)	<p>3.1.11.10 The ASCT shall accommodate the following custom pedestrian features. (Specify the requirements in conjunction with their corresponding need.)</p>
4.4.5.5	The TSS Operator needs to accommodate early start of walk and exclusive pedestrian phases.	<p>3.1.11.1 When a pedestrian phase is called, the ASCT shall execute pedestrian phases up to XX seconds before the vehicle green of the related vehicle phase.</p> <p>3.1.11.4 The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.</p>
4.4.6	Adaptive Accommodation of Preemption and Priority	
4.4.6.1	The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)	<p>3.1.14.1 The ASCT shall maintain adaptive operation at non-preempted intersections during railroad preemption.</p>

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		<p>3.1.14.3 The ASCT shall maintain adaptive operation at non-preempted intersections during Light Rail Transit preemption.</p> <p>3.1.14.4 The ASCT shall resume adaptive control of signal controllers when preemptions are released.</p> <p>3.1.14.5 The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)</p> <p>3.1.14.6 The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)</p> <p>3.1.14.7 The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.</p> <p>3.1.14.8 The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.</p>
4.4.6.2	The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)	<p>3.1.14.2 The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.</p> <p>3.1.14.4 The ASCT shall resume adaptive control of signal controllers when preemptions are released.</p> <p>3.1.14.5</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)</p> <p>3.1.14.6</p> <p>The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)</p> <p>3.1.14.7</p> <p>The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.</p> <p>3.1.14.8</p> <p>The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.</p>
4.4.6.3	The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)	<p>3.1.15.1</p> <p>The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.</p> <p>3.1.15.2</p> <p>The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.</p> <p>3.1.15.2.1</p> <p>The advance of start of green phase shall be user-defined.</p> <p>3.1.15.2.2</p> <p>Adaptive operations shall continue during the advance of the start of green phase.</p> <p>3.1.15.3</p> <p>The ASCT shall delay the end of a green phase, in response to a priority call.</p> <p>3.1.15.3.1</p> <p>The delay of end of green phase shall be user-defined.</p>

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		<p>3.1.15.3.2 Adaptive operations shall continue during the delay of the end of green phase.</p> <p>3.1.15.4 The ASCT shall permit at least XX exclusive transit phases.</p> <p>3.1.15.4.1 Adaptive operations shall continue when there is an exclusive transit phase call.</p> <p>3.1.15.5 The ASCT shall control vehicle phases independently of the following:</p> <p>3.1.15.5.1</p> <p style="padding-left: 40px;">* LRT only phases</p> <p>3.1.15.5.2</p> <p style="padding-left: 40px;">* Bus only phases</p> <p>3.1.15.6 The ASCT shall interface with external bus transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)</p> <p>3.1.15.7 The ASCT shall interface with external light rail transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)</p> <p>3.1.15.8 The ASCT shall accept a transit priority call from:</p> <ul style="list-style-type: none"> * a signal controller/transit vehicle detector; * an external system.

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4.4.7	Non-Adaptive Situations	3.1.9.1.1.1 The ASCT shall operate non-adaptively during the presence of a defined condition.
4.4.7.1	The TSS Operator needs to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.	3.1.9.1.1.1 The ASCT shall operate non-adaptively during the presence of a defined condition.
4.4.7.2	The TSS Operator needs to schedule pre-determined operation by time of day.	3.1.9.1.1.5 The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.
4.4.7.3	The TSS Operator needs to over-ride adaptive operation.	3.1.9.1.1.3 The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals. 3.1.9.1.1.4 The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation. 3.1.9.1.1.5 The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.
4.4.8	Adaptive System Responsiveness	
4.4.8.1	The TSS Operator needs to modify the ASCT operation to	3.1.9.6.1

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	closely follow changes in traffic conditions.	<p>The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.</p> <p>3.1.9.6.2 The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)</p> <p>3.1.9.6.3 The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.</p>
4.4.8.2	The TSS Operator needs to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.	<p>3.1.9.6.3 The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.</p> <p>3.1.9.6.5 The ASCT shall select cycle length from a list of user-defined cycle lengths.</p>
4.4.8.3	The TSS Operator needs to respond quickly to sudden large shifts in traffic conditions.	<p>3.1.9.6.4 When a large change in traffic demand is detected, the ASCT shall respond more quickly than normal operation, subject to user-specified limits. (DEFINE 'MORE QUICKLY')</p>
4.4.9	Adaptive Complex Coordination and Controller Features	<p>3.1.5.6 The system shall download timing parameters to two or more controllers with one command.</p>
4.4.9.1	The TSS Operator needs to implement the following advanced controller features	<p>3.1.9.1.2.1 The ASCT shall not prevent protected/permissive left turn phase operation.</p> <p>3.1.9.1.2.2</p>

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	while maintaining adaptive operation:	<p>The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions. 3.1.9.1.2.3</p> <p>The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating. 3.1.9.1.2.4</p> <p>The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input. 3.1.9.1.2.5</p> <p>The ASCT shall prevent skipping a user-specified phase according to a time of day schedule. 3.1.9.1.2.6</p> <p>The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value. 3.1.9.1.2.7</p> <p>The ASCT shall omit a user-specified phase based on measured traffic conditions. 3.1.9.1.2.8</p> <p>The ASCT shall omit a user-specified phase based on the state of a user-specified external input. 3.1.9.1.2.9</p> <p>The ASCT shall omit a user-specified phase according to a time of day schedule 3.1.9.1.2.10</p> <p>The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows:</p> <ul style="list-style-type: none"> * next phase; * next coordinated phase;user-specified phase.

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.9.1.2.11 The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows:</p> <ul style="list-style-type: none"> * previous phase; * next phase; * next coordinated phase; * user-specified phase. <p>3.1.10.1 When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.</p> <p>3.1.10.2 The ASCT shall provide a minimum of XX phase overlaps.</p> <p>3.1.10.3 The ASCT shall accommodate a minimum of XX phases at each signal</p> <p>3.1.10.4 The ASCT shall accommodate a minimum of XX rings at each signal.</p> <p>3.1.10.5 The ASCT shall accommodate a minimum of XX phases per ring</p> <p>3.1.10.6 The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.</p> <p>3.1.10.6.1 Each permissible phase sequence shall be user-assignable to any signal timing plan.</p> <p>3.1.10.6.2 Each permissible phase sequence shall be executable by a time of day schedule.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.10.6.3 Each permissible phase sequence shall be executable based on measured traffic conditions</p> <p>3.1.10.9 The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)</p> <p>3.1.10.10 The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)</p> <p>3.1.10.11 The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn. (SELECT AS APPLICABLE)</p> <p>3.1.10.12 The ASCT shall not prevent the local signal controller from performing actuated phase control using XX extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.</p> <p>3.1.10.12.1 The ASCT shall operate adaptively using user-specified detector channels.</p> <p>3.1.10.13 When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.</p> <p>3.1.10.14 (Describe requirements to suit other custom controller features that must be accommodated.)</p> <p>3.1.10.15</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall operate adaptively with the following detector logic. (DESCRIBE THE CUSTOM LOGIC)</p> <p>3.1.11.6 The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist:</p> <ul style="list-style-type: none"> * The user enables this feature * Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase * The phase is called after its normal start time * The associated pedestrian phase is not called <p>3.1.11.9 The ASCT shall not inhibit negative vehicle and pedestrian phase timing.</p> <p>3.1.12.1 The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.</p>
4.4.9.1.1	Service a phase more than once per cycle	<p>3.1.10.1 When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.</p>
4.4.9.1.2	Operate at least XX overlap phases	<p>3.1.10.2 The ASCT shall provide a minimum of XX phase overlaps.</p>
4.4.9.1.3	Operate four rings, 16 phases and up to three phases per ring (Edit to suit your needs).	<p>3.1.10.3 The ASCT shall accommodate a minimum of XX phases at each signal</p> <p>3.1.10.4 The ASCT shall accommodate a minimum of XX rings at each signal.</p> <p>3.1.10.5</p>

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4.4.9.1.4	Permit different phase sequences under different traffic conditions	<p>The ASCT shall accommodate a minimum of XX phases per ring</p> <p>3.1.10.6 The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.</p> <p>3.1.10.6.1 Each permissible phase sequence shall be user-assignable to any signal timing plan.</p> <p>3.1.10.6.2 Each permissible phase sequence shall be executable by a time of day schedule.</p> <p>3.1.10.6.3 Each permissible phase sequence shall be executable based on measured traffic conditions</p>
4.4.9.1.5	Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.	<p>3.1.9.1.2.6 The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.</p> <p>3.1.9.1.2.7 The ASCT shall omit a user-specified phase based on measured traffic conditions.</p> <p>3.1.9.1.2.8 The ASCT shall omit a user-specified phase based on the state of a user-specified external input.</p> <p>3.1.9.1.2.9 The ASCT shall omit a user-specified phase according to a time of day schedule</p>
4.4.9.1.6	Prevent one or more phases being skipped under certain traffic conditions or signal states.	<p>3.1.9.1.2.3 The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.</p> <p>3.1.9.1.2.4</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.</p> <p>3.1.9.1.2.5</p> <p>The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.</p>
4.4.9.1.7	Allow detector logic at an intersection to be varied depending on local signal states	<p>3.1.10.15</p> <p>The ASCT shall operate adaptively with the following detector logic. (DESCRIBE THE CUSTOM LOGIC)</p>
4.4.9.1.8	Accommodate the following custom features used by this agency (describe the features)	<p>3.1.10.14</p> <p>(Describe requirements to suit other custom controller features that must be accommodated.)</p>
4.4.9.1.9	Allow any phase to be designated as the coordinated phase	<p>3.1.10.9</p> <p>The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)</p>
4.4.9.1.10	Allow the operator to specify which phase receives unused time from a preceding phase	<p>3.1.9.1.2.10</p> <p>The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows:</p> <ul style="list-style-type: none"> * next phase; * next coordinated phase;user-specified phase. <p>3.1.9.1.2.11</p> <p>The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows:</p> <ul style="list-style-type: none"> * previous phase; * next phase;

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * next coordinated phase; * user-specified phase.
4.4.9.1.11	<p>Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using XX extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.</p>	<p>3.1.10.12 The ASCT shall not prevent the local signal controller from performing actuated phase control using XX extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.</p> <p>3.1.10.12.1 The ASCT shall operate adaptively using user-specified detector channels.</p> <p>3.1.12.1 The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.</p>
4.4.9.1.12	<p>Allow the coordinated phase to terminate early under prescribed traffic conditions</p>	<p>3.1.10.10 The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)</p>
4.4.9.1.13	<p>Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination</p>	<p>3.1.11.6 The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist:</p> <ul style="list-style-type: none"> * The user enables this feature * Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * The phase is called after its normal start time * The associated pedestrian phase is not called
4.4.9.1.14	Protected/permissive phasing and alternate left turn phase sequences.	3.1.9.1.2.1 The ASCT shall not prevent protected/permissive left turn phase operation. 3.1.9.1.2.2 The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.
4.4.9.1.15	Use flashing yellow arrow to control permissive left turns and right turns.	3.1.10.11 The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn. (SELECT AS APPLICABLE)
4.4.9.1.16	Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination. (E.g., double-cycle mid-block pedestrian crossing signals.)	3.1.10.13 When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.
4.4.9.1.17	Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk	3.1.11.9 The ASCT shall not inhibit negative vehicle and pedestrian phase timing.
4.4.10	Adaptive Alerts	
4.4.10.1	The TSS Operator needs to immediately notify maintenance	3.1.6.1.3

ConOps Reference #	ConOps Sample Statement	System Requirements
	and operations staff of alarms and alerts.	<p>In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.</p> <p>3.1.6.2.5</p> <p>In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.</p> <p>3.1.6.2.6</p> <p>The ASCT shall issue an alarm within XX minutes of detection of a failure.</p> <p>3.1.6.3.2</p> <p>In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance</p>
4.4.10.2	The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).	<p>3.1.6.1.3</p> <p>In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.</p> <p>3.1.6.2.5</p> <p>In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.</p> <p>3.1.6.2.6</p> <p>The ASCT shall issue an alarm within XX minutes of detection of a failure.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.6.3.2</p> <p>In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance</p>
4.5	Traffic and Operational Performance Measurement, Monitoring, and Reporting	
4.5.1	TSS Operational Reporting	
4.5.1.1	The TSS Operator needs to generate historical and real time reports that describe TSS operation.	<p>3.1.16.1.6</p> <p>The TSS shall collect and store phase data for every permitted phase, including the length of the phase split [This requirement may be superfluous in systems supported by high-resolution data. This requirement is intended to support legacy approaches to providing a split monitoring capability within traffic signal systems.]</p> <p>3.1.16.1.7</p> <p>The system shall collect and store the following logs in user-definable format:</p> <p>3.1.16.1.7.1</p> <p>Timing plan change</p> <p>3.1.16.1.7.2</p> <p>Signal phase change</p> <p>3.1.16.1.7.3</p> <p>Special function change</p> <p>3.1.16.1.7.4</p> <p>Coordination status change</p> <p>3.1.16.1.7.5</p> <p>Operating mode change</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>3.1.16.1.7.11 Emergency vehicle preemption on-off</p> <p>3.1.16.1.7.12 Transit priority request, on-off</p> <p>3.1.16.1.7.13 Action sets</p> <p>3.1.16.1.9 The system shall automatically transfer all logs, alarms, and reports to an archive system.</p> <p>3.1.16.1.10 The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).</p> <p>3.1.16.3.1 The system shall create performance measure reports from the data in the controller logs, including the following:</p> <ul style="list-style-type: none"> * Split logs (average split times, percent max out and force offs, percent gap outs, percent skips) * Detector health * Coordination plans * Pedestrian actuations * Transit signal priority actuations * Emergency vehicle preemption actuations * Real time split reports (showing programmed and actual splits) <p>3.1.16.3.2 The system shall create standard reports [specify].</p> <p>3.1.16.3.3</p>	

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The system shall create user customizable reports.</p> <p>3.1.16.3.4</p> <p>The system shall create the reports for a user-specified period.</p>
4.5.1.2	<p>The TSS Operator needs a permanent record of each detected fault.</p>	<p>3.1.16.1.7</p> <p>The system shall collect and store the following logs in user-definable format:</p> <p>3.1.16.1.7.6</p> <p>Equipment failure</p> <p>3.1.16.1.7.7</p> <p>Communications failure</p> <p>3.1.16.1.8</p> <p>The system shall store the logs, alarms, and reports for a user defined amount of time (at least (X) years) where they are easily accessible. [User specify]</p> <p>3.1.16.1.9</p> <p>The system shall automatically transfer all logs, alarms, and reports to an archive system.</p> <p>3.1.16.1.10</p> <p>The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).</p>
4.5.1.3	<p>The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.</p>	<p>3.1.5.13</p> <p>The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred <p>3.1.8.2.12</p> <p>The system shall time-stamp a log of all manual commands.</p> <p>3.1.16.1.7</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The system shall collect and store the following logs in user-definable format:</p> <p>3.1.16.1.7.8 Manual commands</p> <p>3.1.16.1.7.9 Operator log-on</p> <p>3.1.16.1.7.10 Operator log-off</p> <p>3.1.16.1.7.14 Database changes</p>
4.5.1.4	The TSS Operator needs a log of all software functions executed by the central system and local controllers.	<p>3.1.5.13 The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred <p>3.1.8.2.12 The system shall time-stamp a log of all manual commands.</p> <p>3.1.16.1.1 The system shall collect and store volume data for each detector.</p> <p>3.1.16.1.2 The system shall collect and store occupancy data for each detector.</p> <p>3.1.16.1.3 The system shall time stamp each detector actuation.</p> <p>3.1.16.1.4 The system shall upload local controller logs by TSS Operator manual command.</p> <p>3.1.16.1.5</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.5.1.5	The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.	<p>The system shall upload local controller logs according to a time of day schedule.</p> <p>3.1.5.19 The ASCT shall log the following events: (edit as appropriate)</p> <p>3.1.5.19.1 Time-stamped vehicle phase calls</p> <p>3.1.5.19.2 Time-stamped pedestrian phase calls</p> <p>3.1.5.19.3 Time-stamped emergency vehicle preemption calls</p> <p>3.1.5.19.4 Time-stamped transit priority calls</p> <p>3.1.5.19.5 Time-stamped railroad preemption calls</p> <p>3.1.5.19.6 Time-stamped start and end of each phase</p> <p>3.1.5.19.7 Time-stamped controller interval changes</p> <p>3.1.5.19.8 Time-stamped start and end of each transition to a new timing plan.</p>
4.5.2	Adaptive Operational Monitoring and Reporting	
4.5.2.1	The agency needs the (specify external decision support system) to be able to monitor the ASCT system automatically.	<p>3.1.17.1.3 The ASCT shall send monitoring data to the XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.7</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation)</p> <ul style="list-style-type: none"> * Specified cycle length * Specified direction of progression * Specified adaptive strategy
4.5.2.2	<p>The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.</p>	<p>3.1.5.22 The TSS shall store results of all signal timing parameter calculations for a minimum of XX days.</p> <p>3.1.5.23 The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency <p>3.1.5.30 The ASCT shall store the following data in XX minute increments: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length <p>3.1.16.4.1 The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.16.4.2 The ASCT shall report all intermediate calculated values that are affected by calibration parameters.</p> <p>3.1.16.4.3 The ASCT shall maintain a log of all signal state alterations directed by the ASCT.</p> <p>3.1.16.7.2 The TSS shall display stored data that illustrate adaptive input data and output decisions. (This display will be used by the TSS Operator.)</p>
4.5.2.3	The TSS Operator needs to store and report data that can be used to measure traffic performance under adaptive control.	<p>3.1.5.22 The TSS shall store results of all signal timing parameter calculations for a minimum of XX days.</p> <p>3.1.5.23 The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency <p>3.1.5.30 The ASCT shall store the following data in XX minute increments: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length

ConOps Reference #	ConOps Sample Statement	System Requirements
4.5.2.4	The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).	<p>3.1.5.20 The ASCT shall export its systems log in the following formats: (edit as appropriate)</p> <ul style="list-style-type: none"> * MS Excel * Text * CVS * Open source SQL database <p>3.1.5.21 The ASCT shall store the event log for a minimum of XX days</p> <p>3.1.5.24 The ASCT system shall archive all data automatically after a user-specified period not less than XX days.</p> <p>3.1.5.25 The ASCT shall provide data storage for a system size of XX signal controllers. The data to be stored shall include the following: (edit as appropriate)</p> <ul style="list-style-type: none"> * Controller state data * Reports * Log data * Security data * ASCT parameters * Detector status data <p>3.1.5.28 The ASCT shall store data logs in a standard database (specify as appropriate).</p>
4.5.2.5	The TSS Operator needs to report performance data in real time to (specify external system).	<p>3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.1 The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.5 The ASCT shall send performance data to the XX external system. (Insert appropriate requirements that suit your needs.)</p> <p>3.1.17.1.9 The ASCT shall set the state of external input/output states according to a time-of-day schedule.</p>
4.5.2.6	The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.	<p>3.1.5.23 The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * arrivals in green * green band efficiency
		<p>3.1.5.26</p> <p>The ASCT shall calculate and report relative data quality including:</p> <ul style="list-style-type: none"> * The extent data is affected by detector faults * Other applicable items
		<p>3.1.5.27</p> <p>The ASCT shall report comparisons of logged data when requested by the user:</p> <ul style="list-style-type: none"> * Day to day, * Hour to hour * Hour of day to hour of day * Hour of week to hour of week * Day of week to day week * Day of year to day of year
		<p>3.1.5.29</p> <p>The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.</p>
		<p>3.1.16.4.3</p> <p>The ASCT shall maintain a log of all signal state alterations directed by the ASCT.</p>
		<p>3.1.16.4.3.1</p> <p>The ASCT log shall include all events directed by the external inputs.</p>
		<p>3.1.16.4.3.2</p> <p>The ASCT log shall include all external output state changes.</p>
		<p>3.1.16.4.3.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The ASCT log shall include all actual parameter values that are subject to user-specified values.</p> <p>3.1.16.4.3.4</p> <p>The ASCT shall maintain the records in this ASCT log for XX period.</p> <p>3.1.16.4.3.5</p> <p>The ASCT shall archive the ASCT log in the following manner: (Specify format, frequency, etc., to suit your needs.)</p> <p>3.1.16.7.1</p> <p>The TSS shall provide predefined reports of stored data for non-technical recipients in accordance with user-specified formats. (Specify report formats to accompany this requirement.)</p> <p>3.1.16.7.2</p> <p>The TSS shall display stored data that illustrate adaptive input data and output decisions. (This display will be used by the TSS Operator.)</p>
4.5.3	Traffic Performance Collection and Storage	
4.5.3.1	The TSS Operator needs to collect and store high resolution data from traffic signal controllers.	<p>3.1.16.1.7</p> <p>The system shall collect and store the following logs in user-definable format:</p> <p>3.1.16.3.3</p> <p>The system shall create user customizable reports.</p> <p>3.1.16.3.4</p> <p>The system shall create the reports for a user-specified period.</p> <p>3.1.16.3.7</p> <p>The system shall produce performance reports consistent with:</p> <ul style="list-style-type: none"> * Attached performance report document (USER SPECIFIED - attach) * Purdue Pooled Fund Study

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.16.5.1 The Performance Measurement Server shall retrieve and store high-resolution data from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.</p> <p>3.1.16.5.1.1 High-resolution data are defined by (specify details).</p> <p>3.1.16.5.1.2 The Performance Measurement Server shall store uploaded high-resolution data for [specify timeframe].</p> <p>3.1.16.5.1.3 The TSS shall not prevent the local controller from accessing local devices as needed to store high-resolution data.</p>
4.5.4	Traffic Performance Processing	
4.5.4.1	The TSS Operator needs the system to accept high resolution controller data in order to calculate and report intersection and system performance measurements that support operational objectives.	<p>3.1.16.3.5 The system shall collect detector data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.</p> <p>3.1.16.3.6 The system shall collect signal phase data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.</p> <p>3.1.16.3.7 The system shall produce performance reports consistent with:</p> <ul style="list-style-type: none"> * Attached performance report document (USER SPECIFIED - attach) * Purdue Pooled Fund Study <p>3.1.16.6.1 The Performance Measurement Server shall process the collected and stored high resolution data to produce the following reports:</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * Signal Measures Charts: <ul style="list-style-type: none"> o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: <ul style="list-style-type: none"> o Usage
4.5.5	Traffic Performance Reports	
4.5.5.1	The TSS Operator needs to view reports showing traffic operational performance.	<p>3.1.16.7.3</p> <p>The Performance Measurement Server shall provide the following reports:</p> <ul style="list-style-type: none"> * Signal Measures Charts: <ul style="list-style-type: none"> o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: <ul style="list-style-type: none"> o Usage <p>3.1.16.7.3.1</p> <p>Performance measurement reports shall be consistent with descriptions in ATSPM version 4.0 (or later) documentation.</p> <p>3.1.16.7.4</p> <p>The TSS (ASCT) shall provide traffic performance measurement using probe vehicle reports provided by an external service [specify].</p> <p>3.1.16.7.5</p> <p>The TSS (ASCT) shall provide traffic performance measurement using [specify alternative approaches not covered in other requirements].</p>
4.5.6	Alerts	

ConOps Reference #	ConOps Sample Statement	System Requirements
4.5.6.1	The TSS Operator needs to receive alerts about traffic operational performance.	<p>3.1.16.8.1</p> <p>The TSS shall provide configurable alerts to the TSS Operator based on traffic operational performance. (Specify alerts to accompany this requirement.)</p>
4.5.6.2	The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.	<p>3.1.16.2.1</p> <p>The system shall create alerts of the following events:</p> <ul style="list-style-type: none"> * Detector fault/failure * Communication fault/failure * Flash mode * Preemption fault/failure * Transit signal priority fault/failure * Cabinet flash * Cabinet door open * Temperature out of range * Adaptive Processor and Algorithms (Note: Only with adaptive operations) <p>3.1.16.2.2</p> <p>The system shall provide an alert of any discrepancies between the central controller database and the infield database for each controller.</p> <p>3.1.16.2.3</p> <p>The system shall classify every alerts as critical, warning, and informational only, based user-specified rules.</p> <p>3.1.16.2.3.1</p> <p>The system shall alert TSS Operator via text message.</p> <p>3.1.16.2.3.2</p> <p>The system shall alert TSS Operator via email.</p> <p>3.1.16.2.3.3</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.5.6.3	The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.	<p>The system shall alert TSS Operator by message on TSS Operator's desktop.</p> <p>3.1.6.2.2 In the event of communications failure, the TSS shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.)</p> <p>3.1.6.2.3 The TSS shall issue an alarm within XX minutes of detection of a failure.</p>
4.5.6.4	The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).	<p>3.1.6.2.2 In the event of communications failure, the TSS shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.)</p> <p>3.1.6.2.3 The TSS shall issue an alarm within XX minutes of detection of a failure.</p>
4.5.7	Real-Time Monitoring	
4.5.7.1	The TSS Operator needs to observe the operation of traffic signal field equipment.	<p>3.1.7.1.3 The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection <p>3.1.7.1.6 The system shall move between levels seamlessly, without having to open new files or windows.</p> <p>3.1.7.1.7 The system shall have pan and zoom capabilities.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.7.1.8 The system shall automatically adjust the display depending on the 'zoom level'.</p> <p>3.1.7.1.14 The system shall display multiple individual intersection-level views simultaneously as separate displays or tiled windows (SPECIFY minimum and maximum numbers).</p>
4.5.7.1.1	The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.	<p>3.1.7.2.1 The system shall open the intersection display when the intersection on the main map is clicked on.</p> <p>3.1.7.2.2 The system shall show the current phase status of an intersection upon operator selection of the associated intersection icon on the map display.</p> <p>3.1.7.2.3 The system shall display the following traffic signal controller information:</p> <ul style="list-style-type: none"> * Intersection name/number * Controller type * Firmware and version * IP address <p>3.1.7.2.4 The system shall have the capability to display all controller outputs in real-time, including:</p> <ul style="list-style-type: none"> * Vehicle phases (including overlaps) * Pedestrian phases * Bicycle phases * Signs controlled by the signal controller <p>3.1.7.2.5</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The system shall have the capability to display all controller inputs in real time, including:</p> <ul style="list-style-type: none"> * Vehicle detector actuations * Pedestrian detector actuations * Bicycle detector actuations * Transit signal priority * Railroad preemption * Emergency vehicle preemption <p>3.1.7.2.6</p> <p>The system shall display the data shown on the virtual controller front panel based on a user-selected intersection.</p>
4.5.7.1.2	The TSS Operator needs to select a predetermined group of intersections to monitor.	<p>3.1.1.6</p> <p>The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.</p> <p>3.1.3.1.2</p> <p>The system shall allow intersections to be included in a group.</p> <p>3.1.3.1.2.1</p> <p>A group shall support up to XX signals.</p> <p>3.1.3.1.3</p> <p>The system shall allow an intersection to be included in two or more groups.</p> <p>3.1.3.1.3.1</p> <p>The system shall allow intersections to change grouping by time of day schedule.</p> <p>3.1.7.1.3</p> <p>The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * Corridor * Intersection <p>3.1.7.1.14</p> <p>The system shall display multiple individual intersection-level views simultaneously as separate displays or tiled windows (SPECIFY minimum and maximum numbers).</p>
4.5.7.1.3	The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.	<p>3.1.7.1.3</p> <p>The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection <p>3.1.7.1.4</p> <p>The system shall provide a display that uses a cloud based system map (SPECIFY DETAILS)</p> <p>3.1.7.1.5</p> <p>The system shall provide a display that uses an existing agency map as background (Autocad, GIS, JPEG, etc.)</p> <p>3.1.7.1.11</p> <p>The system shall provide a library of intersection drawings (e.g., standard four-legged intersections, standard tee intersection, five-legged intersection, six legged intersection, etc.) to develop intersection level graphics that are geometrically correct diagrams.</p> <p>3.1.7.1.12</p> <p>The system shall provide a library of symbols for inputs and outputs to help construct the intersection display.</p> <p>3.1.7.1.13</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		The system shall allow the TSS Operator to import customized graphical icons to the map icon library.
4.5.7.1.4	The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.	<p>3.1.7.1.3</p> <p>The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection <p>3.1.7.1.6</p> <p>The system shall move between levels seamlessly, without having to open new files or windows.</p> <p>3.1.7.1.7</p> <p>The system shall have pan and zoom capabilities.</p> <p>3.1.7.1.8</p> <p>The system shall automatically adjust the display depending on the 'zoom level'.</p> <p>3.1.7.1.9</p> <p>At the state wide and area-wide level map, the system shall display a color coded status of the following systems:</p> <ul style="list-style-type: none"> * Communication * Coordination * Intersection flash mode * Preemption
4.5.7.2	The TSS Operator needs to view a real-time time-space-diagram of user defined intersection group, including real time splits, offsets and	<p>3.1.7.1.10</p> <p>At the corridor level map, the system shall display the following timing related information:</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	coordinated phase detector actuations of each intersection in group.	<ul style="list-style-type: none"> * Real time or other measureable period [Specify period length(s)] time-space-diagrams * Split times * Phase status * Detector status (vehicle and pedestrian) * Local cycle lengths/timer * Background cycle length/timer * Offset * Intersection identifier
4.6	Data Storage	
4.6.1	The TSS Operator needs to access the data on the system for (XX) months after which it will be archived.	<p>3.1.16.1.8 The system shall store the logs, alarms, and reports for a user defined amount of time (at least (X) years) where they are easily accessible. [User specify]</p> <p>3.1.16.1.9 The system shall automatically transfer all logs, alarms, and reports to an archive system.</p> <p>3.1.16.1.10 The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).</p>
4.7	Constraints	
4.7.1	TSS Constraints	
4.7.1.1	The TSS Designer is constrained to using the following equipment: - Controller type (list acceptable equipment) -Controller firmware (list acceptable	<p>3.1.3.4.1 The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)</p> <p>3.1.3.4.1.1 Controller type (list applicable equipment)</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)	3.1.3.4.1.2 Local firmware (list applicable firmware) 3.1.3.4.1.3 Communications media and protocols (list applicable equipment) 3.1.3.4.2 The system shall fulfill all requirements when connected to XX local controller firmware (SPECIFY local controller firmware)
4.7.1.2	The TSS Designer needs to use equipment and software acceptable under current agency IT policies and procedures (USER TO SPECIFY)	3.1.2.4 The system shall comply with the agency's security policy as described in (specify appropriate policy document)
4.7.1.3	The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.	3.1.3.4.1 The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type) 3.1.3.4.1.3 Communications media and protocols (list applicable equipment) 3.1.3.4.1.3.1 AB3418E 3.1.3.4.1.3.2 NTCIP (SPECIFY relevant items) 3.1.3.4.3 The system shall fully satisfy all requirements when connected to the existing communications network
4.7.1.4	The TSS Designer needs to communicate to traffic signal	3.1.3.4.3

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).</p>	<p>The system shall fully satisfy all requirements when connected to the existing communications network</p> <p>3.1.3.4.6</p> <p>The system shall use the following communications protocols with traffic signal controllers (SPECIFY as appropriate)</p> <p>3.1.3.4.6.1</p> <p>Ethernet</p> <p>3.1.3.4.6.2</p> <p>Serial</p> <p>3.1.3.4.6.3</p> <p>Other [Specify]</p>
4.7.1.5	<p>The TSS Designer needs to use equipment and software acceptable under current agency IT policies and procedures.</p>	<p>3.1.18.1</p> <p>The vendor's software shall be fully operational within the following platform: (edit as appropriate)</p> <ul style="list-style-type: none"> * Windows-PC, * Linux, * Mac-OS, * Unix.
4.7.1.6	<p>The TSS Operator needs access to and operation of the system in all environmental conditions.</p>	<p>3.1.3.4.7</p> <p>Any field device installed as part of the TSS shall fulfill NEMA TS-2 environmental requirements.</p>
4.7.1.7	<p>The TSS Designer needs to fully implement the system with full capability within the available budget of \$(USER TO SPECIFY). (or included in</p>	<p>3.1.3.4.8</p> <p>The system shall be fully implemented within the available budget of \$[Specify]. (or included in procurement documents but not in system requirements)</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	procurement documents but not in system requirements)	
4.7.2	Adaptive Constraints	
4.7.2.1	The TSS Designer is constrained to use the following equipment:	
4.7.2.1.1	Controller type (list acceptable equipment)	3.1.18.3 The ASCT shall fully satisfy all requirements when connected with XX controllers (specify controller types).
4.7.2.1.2	Detector type (list acceptable equipment)	3.1.13.1 The ASCT shall be compatible with the following detector technologies (agency to specify): <ul style="list-style-type: none"> * Detector type A * Detector type B * Detector type C 3.1.13.2 The ASCT vendor shall specify detector requirements. <ul style="list-style-type: none"> 3.1.13.2.1 Vendor shall specify required detector accuracy 3.1.13.2.2 Vendor shall specify required detector output latency 3.1.13.2.3 Vendor shall specify detection zone coverage 3.1.13.2.4 Vendor shall specify mounting requirements

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>3.1.13.2.5 Vendor shall specify installation requirements</p> <p>3.1.13.2.6 Detectors verified against the provided requirements shall be deemed acceptable by the ASCT Vendor.</p> <p>3.1.13.2.7 The Vendor shall be responsible to provide expected functionality using verified detectors.</p> <p>3.1.18.2 The ASCT shall fully satisfy all requirements when connected with detectors from manufacturer XX (specify required detector types).</p>
4.8	Training	
4.8.1	TSS Training	
4.8.1.1	The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.	<p>3.1.19.1 The vendor shall provide training on all the operations of the system.</p> <p>3.1.19.2 The vendor shall provide a minimum of XX hours of training to a minimum of XX staff. (SPECIFY)</p> <p>3.1.19.3 The vendor shall provide a minimum of XX training sessions (specify how many sessions over what period).</p> <p>3.1.19.4 The vendor shall provide the following training (edit as appropriate).</p> <p>3.1.19.4.1 The vendor shall provide training on troubleshooting the system.</p> <p>3.1.19.4.2</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
		<p>The vendor shall provide training on system configuration. 3.1.19.4.3</p> <p>The vendor shall provide training on administration of the system. 3.1.19.4.6</p> <p>The vendor shall provide training on system calibration. 3.1.19.4.7</p> <p>The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references. 3.1.19.4.8</p> <p>The vendor's training shall be delivered at (SPECIFY location for training).</p>
4.8.2	Adaptive Training and Support	
4.8.2.1	The TSS Manager needs [Specify staff] involved in operations and maintenance of the adaptive system to receive appropriate training.	<p>3.1.19.4.4</p> <p>The vendor shall provide training on the operations of the adaptive system.</p>
4.8.3	Automated Traffic Signal Performance Measurement Training	
4.8.3.1	The TSS Manager needs [Specify staff] involved in operations and maintenance of the automated signal performance measurement system to receive appropriate training.	<p>3.1.19.4.5</p> <p>The vendor shall provide training on the operations of the automated traffic signal performance measurement and monitoring.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
4.9	External Interfaces	
4.9.1	<p>The TSS Operator needs to align coordinated traffic signals in the system in question with coordinated traffic signals in an adjacent system. (The intent of this need is to maintain cycle-offset-split signal coordination across system boundaries. Basic coordination can be provided by using timings that are compatible in both systems, following compatible time-of-day schedules, and maintaining synchronization of the time-of-day clocks. Under this need, the system is responsible only for the clock synchronization, and the user is responsible for compatible timings and schedules.)</p>	<p>3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.1 The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)</p>
4.9.2	The TSS Operator needs to select coordinated signal timing	3.1.17.1

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>patterns (including cycle, offset, split, special functions, and phase sequence) based on the timing patterns in current operation in an adjacent system. (This user need addresses both time-of-day and traffic responsive coordination modes. In addition to the clock synchronization provided in 4.9.1, this user need also requires the system to align its timing pattern in use with an adjacent system automatically. This user need does not mean the system will create signal timings that are compatible—that is assumed to be the responsibility of the user.)</p>	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.2 The ASCT shall send control data to the XX external system. (Insert appropriate requirements that suit your needs.)</p>
4.9.3	The TSS Operator needs to provide signal operational data to an external display service, which may be a regional display	3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert

ConOps Reference #	ConOps Sample Statement	System Requirements
	map at another traffic management center.	<p>appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.3 The ASCT shall send monitoring data to the XX external system. (Insert appropriate requirements that suit your needs.)</p>
4.9.4	The TSS Operator needs to allow control of the system by the operator of an external system. (The envisioned scenario is a freeway management operator engaging a particular coordinated signal timing pattern to carry traffic diverting around a freeway incident or bottleneck on appropriate arterial streets. This engagement may need to be done through the traffic management system in use by	<p>3.1.17.1 The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage)

ConOps Reference #	ConOps Sample Statement	System Requirements
	the freeway management operator.)	<p>3.1.17.1.4 The ASCT shall send coordination data to the XX external system. (Insert appropriate requirements that suit your needs.)</p>
4.9.5	The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.	<p>3.1.12.1 The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.</p> <p>3.1.12.2 The ASCT shall set a specific state for each special function output based on the current cycle length.</p> <p>3.1.12.3 The ASCT shall set a specific state for each special function output based on a time-of-day schedule.</p> <p>3.1.17.1.9 The ASCT shall set the state of external input/output states according to a time-of-day schedule.</p> <p>3.1.17.1.10 The ASCT output states shall be settable according to a time-of-day schedule.</p>
4.9.6	The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such	<p>3.1.9.1.1.6 The ASCT shall operate non-adaptively when commanded by an external system process.</p> <p>3.1.9.1.2.4</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	<p>as an ICM system or another signal system).</p>	<p>The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.</p> <p>3.1.9.1.2.8</p> <p>The ASCT shall omit a user-specified phase based on the state of a user-specified external input.</p> <p>3.1.10.8</p> <p>The ASCT shall not prevent a phase/overlap output based on an external input.</p> <p>3.1.17.1</p> <p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) <p>3.1.17.1.6</p> <p>The ASCT shall receive commands from the XX external system.</p> <p>3.1.17.1.7</p> <p>The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation)</p> <ul style="list-style-type: none"> * Specified cycle length

ConOps Reference #	ConOps Sample Statement	System Requirements
		<ul style="list-style-type: none"> * Specified direction of progression * Specified adaptive strategy <p>3.1.17.1.8 The ASCT shall conform its operation to an external system's operation.</p> <p>3.1.17.1.10 The ASCT output states shall be settable according to a time-of-day schedule.</p> <p>3.1.17.1.11 The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation)</p> <ul style="list-style-type: none"> ·Specified cycle length <p>3.1.17.1.12 The ASCT shall conform its operation to an external system's operation.</p>
4.10	Maintenance, Support and Warranty	
4.10.1	The TSS Manager needs the system to fulfill all the requirements for the life of the system. The agency therefore needs the system to be maintained to repair faults that are not defects in materials and workmanship.	<p>3.1.20.1 The Maintenance Vendor shall provide maintenance according to a separate maintenance contract. That contract should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.</p>
4.10.2	The agency needs the system to fulfill all requirements for the life of the system. The agency therefore needs support to keep software and software	<p>3.1.20.2 The Vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period of XX years. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.</p>

ConOps Reference #	ConOps Sample Statement	System Requirements
	environment updated as necessary to prevent requirements no longer being fulfilled.	
4.10.3	The agency needs the system to fulfill all requirements for the life of the system. The agency therefore needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.	3.1.20.3 The Vendor shall warrant the system to be free of defects in materials and workmanship for a period of XX years. Warranty is defined as correcting defects in materials and workmanship (subject to other language included in the purchase documents). Defect is defined as any circumstance in which the material does not perform according to its specification.

ConOps Reference #	ConOps Sample Statements
5	Envisioned System Overview
5.1	Proposed TSS Architecture
5.1.1	An architecture diagram showing all the high-level elements of the TSS/ASCT system based on the appropriate Regional ITS Architecture. [Insert system architecture diagram to illustrate proposed system in this section. Reference Guidance section's Concept of Use]
5.2	TSS/ASCT System Overview
5.2.1	<p>The agency plans to implement a traffic signal system comprising:</p> <ul style="list-style-type: none"> * Server(s) located at XX [provide preliminary system block diagram, reference Guidance section's Concept of Use] * TSS management * Map displays * Adaptive operation * Performance measurement and reporting * Communications as defined by XX Communications Plan * System detectors (for traffic-responsive and/or adaptive operation and/or performance measurement) (System detectors are not specifically covered by this document) * Traffic signal controllers (not covered specifically by this document) * Adaptive field processors (not covered specifically by this document) * Workstations located at XX * Additional field devices (describe) (not covered specifically by this document)
6	Operational Environment
6.1	TSS Operational Environment
6.1.1	The system will be operated and monitored from the [specify agency] [specify overall system name such as TMC].
6.1.2	The system will be operated and monitored from workstations located [specify who will have workstations and where they will be located].
6.1.3	The central server equipment will be housed at [specify location] in an [air-conditioned or non-air-conditioned] environment.
6.1.4	The [in-house operators and/or on-call contract staff] will handle complaints or requests for changes in operation on an as-needed basis.
6.1.5	Maintenance of all field equipment will be performed by [in-house and/or contract] staff

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6.1.6	Maintenance of the following field equipment will be performed by [in-house and/or contract] staff. [specify what equipment will be maintained by whom]
6.1.7	Funding for maintenance of the TSS will come from [specify funding program or source]. An increase of [specify \$] per year will be required to accommodate the additional equipment installed for the TSS.
6.1.8	Additional communications equipment and annual fees will be incurred with the TSS. This will amount to approximately [specify \$] per year, and will be covered by the [specify program or budget allocation details].
6.1.9	Replacement or repair of defective or failed equipment will be covered for [specify years] by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price.
6.1.10	The agency expects maintenance of parts and equipment for a period of [specify years] will be included in the purchase price.
6.1.11	The agency expects maintenance of all TSS management software for a period of [specify years] will be included in the purchase price.
6.1.12	The agency expects to operate this system using the latest software for a period of [specify years].
6.1.13	The agency will seek technical support from the vendor for assistance in using the TSS management software for [specify years].
6.1.14	Operations and maintenance staff will have the ability to log in to the system from remote locations via the internet, and have full functionality consistent with their access level.
6.1.15	Include any additional needs for support or information from the vendor that will be needed by your agency, and that will become requirements in the contract or purchase documents.
6.1.16	The central server will be a standard platform maintained by the [specify agency department] and able to be replaced independently from the software.
6.1.17	The agency selection of traffic signal equipment will not be constrained by the TSS software.
6.2	Adaptive Operational Environment
6.2.1	The system will be operated and monitored from the [specify agency] TMC.
6.2.2	The system will be operated and monitored from the [specify agency] signal shop.
6.2.3	The system will be operated and monitored from workstations located [specify who will have workstations and where they will be located].
6.2.4	An operator will be able to have full access to the system from each local controller or on-street master.
6.2.5	The central server equipment will be housed at [specify location] in an [air-conditioned or non-air-conditioned?] environment.

ConOps Reference #	ConOps Sample Statements
6.2.6	Equipment compatibility constraints
6.2.6.1	The central server will be a standard platform [maintained by the agency IT Department] and able to be replaced independently from the software.
6.2.6.2	The agency selection of controller will not be constrained by the adaptive software.
6.2.6.3	The agency prefers specific detector technology. [Specify your selected detector types].
6.2.6.4	The agency prefers to use the following controller types. [Specify acceptable controller types.]
6.2.7	The operators will already be experienced in setting up and fine tuning traditional coordinated signal systems. They will require training specific to the adaptive system, sufficient to allow them to set up, adjust and fine tune all aspects of the system.
6.2.8	The set up and fine tuning of the system will be contracted out. A review of the system's operation will be performed quarterly [specify frequency].
6.2.9	Complaints or requests for changes in operation will be handled by the in-house operators on an as-needed basis.
6.2.10	Complaints or requests for changes in operation will be handled by on-call contract staff on an as-needed basis.
6.2.11	Maintenance of all field equipment will be performed by in-house [OR contract] staff
6.2.12	Maintenance of the following field equipment will be performed by in-house [OR contract] staff. [specify what equipment will be maintained by whom.]
6.2.13	Funding for maintenance of the adaptive system will come from [specify funding program or source]. An increase of \$xxx per year will be required to accommodate the additional equipment installed for the adaptive system.
6.2.14	Additional communications equipment and annual fees will be incurred with the adaptive system. This will amount to approximately \$xxx per year, and will be covered by the [specify program or budget allocation details].
6.2.15	Replacement or repair of defective or failed equipment will be covered for xx years by the manufacturers' warranties. The labor cost of replacement during this period will be included in the purchase price.
6.2.16	The agency expects maintenance of parts and equipment for a period of XX years will be included in the purchase price. (Note: May not be eligible for Federal funding)
6.2.17	The agency expects maintenance of all adaptive system software for a period of xx years will be included in the purchase price.
6.2.18	The agency expects to operate this system using the latest software for a period of CC years.
6.2.19	The agency will seek technical support from the vendor for assistance in using the adaptive software for XX years.
6.2.20	Operations and maintenance staff will have the ability to log in to the system from remote locations via the internet, and have full functionality consistent with their access level.

ConOps Reference #	ConOps Sample Statements
6.2.21	The ASCT's operation will be able to be customized to suit the different situations that will be experienced in the different areas where it will operate.
6.2.21.1	The agency's experienced operators will be able to write customized routines using the ASCT's API.
6.2.21.2	The vendor will be able to provide customized routines that take advantage of the ASCT's API.
6.2.22	Include any additional needs for support or information from the vendor that will be needed by your agency, and that will become requirements in the contract or purchase documents.
7	Support Environment
7.1	TSS Support Environment
7.1.1	Institutions and Stakeholders
7.1.1.1	Existing stakeholders of the TSS include: [list all stakeholders, such as:] Sponsoring agency Neighboring agencies that will access the TSS Etc.
7.1.1.2	The stakeholders who will be affected by or have a direct interest in the TSS are: [list existing and include new stakeholders].
7.1.1.3	The activities that will be undertaken by the TSS stakeholders include: system operation, system monitoring and adjustment, system performance monitoring and evaluation.
7.1.1.4	The organizational structures of the units responsible for installation, operation and maintenance are illustrated in the attached organization chart. The roles, responsibilities and required qualifications and experience are described below. [Describe as appropriate]
7.1.2	Facilities
7.1.2.1	Describe the current and/or proposed [TMC or TSS Center].
7.1.2.2	Will there be a satellite and/or backup [TMC or TSS Center]?
7.1.2.3	Describe the locations elsewhere within the agency, such as on a LAN or WAN, from which access to the system will be required?
7.1.2.4	Is air-conditioning required?
7.1.2.5	Describe the location where a separate server will be located. (e.g., IT server room, TMC back room, remote hub)
7.1.2.6	Describe who is responsible for providing and maintaining staff facilities (e.g., personnel, public works, building services, etc.?)
7.1.2.7	Describe who is responsible for fire control facilities (e.g., part of operating group's responsibility, or the responsibility of another group, such as building services?)

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7.1.2.8	Describe who is responsible for secure access to the TMC, workshop, or office with TSS workstations? (e.g., Is it the responsibility of the operating group or another group, such as building services?)
7.1.3	System Architecture Constraints
7.1.3.1	The TSS processor/server will be protected within the agency's firewalls. The IT Department will provide resources, equipment and system management so that users/operators will have appropriate access to the system locally, from within the agency's LAN and from remote locations.
7.1.3.2	The communications media available for use by the system will be: [List Available Media, Provide a map or block diagram as appropriate. Show locations of any gaps, bandwidth and latency constraints, protocols and available alternatives.]
7.1.3.3	The [specify which State or Region] [Statewide or Regional] ITS Architecture provides the context for the TSS project. The TSS project fits within the ITS Architecture as illustrated in Figure XX. [Explain each architectural element and information flow in the CCTV System project. If additional elements or interfaces are added, explain why].
7.1.4	Utilities
7.1.4.1	Are utilities the responsibility of the operating group, or are they the responsibility of another group, such as building services?
7.1.5	Equipment
7.1.5.1	Describe what test equipment is required to support the TSS (e.g., communications testers, fiber testers, signal equipment testers). Is this currently available or is additional equipment required?
7.1.5.2	Will vehicles be the responsibility of the operating group or another group within the agency? What types of vehicles will be required, and how many?
7.1.6	Computing hardware
7.1.6.1	Describe the additional computing equipment required to support TSS operation, such as printer, copier, additional monitors, and scanner.
7.1.6.2	Describe who is responsible for maintenance and repair of the computing equipment?
7.1.6.3	Describe who is responsible for replacement of the computing equipment when it reaches the end of its useful life?
7.1.7	Software
7.1.7.1	Who is responsible for keeping software up to date?
7.1.7.2	Who is responsible for keeping software licenses current?
7.1.7.3	What controls are proposed governing software use and availability on workstations and other support computers?

ConOps Reference #	ConOps Sample Statements
7.1.8	Personnel
7.1.8.1	Describe how many users/operators will be available for routine operations. Will this be provided by existing staff or will additional staff be required?
7.1.8.2	Describe what hours users/operators will be available.
7.1.8.3	Describe what training users/operators will need.
7.1.8.4	Describe what maintenance staff will be required. Will this be provided by existing staff or will additional staff be required?
7.1.8.5	What qualifications and training will the maintenance staff require?
7.1.9	Operating procedures
7.1.9.1	Describe who will be responsible for backing up databases. How often will backups be required? Will backups be stored off-site?
7.1.10	Maintenance
7.1.10.1	Describe the arrangements for maintenance. (E.g., is it done in-house or contracted out? Is it 24/7? Is equipment repair done in-house or externally?)
7.2	Adaptive Support Environment
7.2.1	Institutions and Stakeholders
7.2.1.1	Existing stakeholders of the traffic signal system include: [list all stakeholders, such as:] <ul style="list-style-type: none"> * Sponsoring agency * Neighboring agencies that operate signals * Regional agency * Fire departments * Police departments * Transit agencies * Railroad operators
7.2.1.2	The stakeholders who will be affected by or have a direct interest in the adaptive system are: [List existing and include new stakeholders]
7.2.1.3	The activities that will be undertaken by the adaptive system stakeholders include: preparation of timing parameters, implementation and fine tuning, system monitoring and adjustment, system performance monitoring and evaluation.

ConOps Reference #	ConOps Sample Statements
7.2.1.4	The organizational structures of the units responsible for installation, operation and maintenance are illustrated in the attached organization chart. The roles, responsibilities and required qualifications and experience are described below. [Describe as appropriate]
7.2.2	Facilities
7.2.2.1	Describe the current and/or proposed TMC.
7.2.2.2	Will there be a satellite TMC (e.g., at Corp Yard, at a major event center, at a local EOC?)
7.2.2.3	Describe the locations elsewhere within the agency, such as on a LAN or WAN, from which access to the system will be required?
7.2.2.4	Is air-conditioning required?
7.2.2.5	Describe the location where a separate server will be located. (e.g., IT server room, TMC back room, signal maintenance area, remote hub, remote on-street cabinet)
7.2.2.6	Describe who is responsible for providing and maintaining staff facilities (e.g., personnel, public works, building services, etc.?)
7.2.2.7	Describe who is responsible for fire control facilities (e.g., part of operating group's responsibility, or the responsibility of another group, such as building services?)
7.2.2.8	Describe who is responsible for secure access to the TMC, workshop, or office with adaptive system workstations? (E.g., Is it the responsibility of the operating group or another group, such as building services?)
7.2.3	System Architecture Constraints
7.2.3.1	The adaptive processor/server will be protected within the agency's firewalls. The IT Department will provide resources, equipment and system management so that operators will have appropriate access to the system locally, from within the agency's LAN and from remote locations.
7.2.3.2	The communications media available for use by the system will be: [List available media, provide a map or block diagram as appropriate. Show locations of any gaps, bandwidth and latency constraints, protocols and available alternatives.]
7.2.3.3	The Regional ITS Architecture is illustrated in Figure XX. The adaptive system will operate within the local ITS Architecture of [NAME THE AGENCY]. It will interact with the Regional ITS Architecture in the following manner. [Describe the physical architecture. Include information flows.]
7.2.4	Utilities
7.2.4.1	Are utilities the responsibility of the operating group, or are they the responsibility of another group, such as building services?

ConOps Reference #	ConOps Sample Statements
7.2.5	Equipment
7.2.5.1	Describe what test equipment is required to support the adaptive system (e.g., communications testers, fiber testers, controller testers). Is this currently available or is additional equipment required?
7.2.5.2	Will vehicles be the responsibility of the operating group or another group within the agency? What types of vehicles will be required, and how many?
7.2.6	Computing hardware
7.2.6.1	Describe the additional computing equipment required to support the operation, such as printer, copier, additional monitors, and scanner.
7.2.6.2	Describe who is responsible for maintenance and repair of the computing equipment?
7.2.6.3	Describe who is responsible for replacement of the computing equipment when it reaches the end of its useful life?
7.2.7	Software
7.2.7.1	Who is responsible for keeping software up to date?
7.2.7.2	Who is responsible for keeping software licenses current?
7.2.7.3	What controls are proposed governing software use and availability on workstations and other support computers?
7.2.8	Personnel
7.2.8.1	Describe how many operators will be available for routine operations. Will this be provided by existing staff or will additional staff be required?
7.2.8.2	Describe what hours operators will be available.
7.2.8.3	Describe what training operators will need.
7.2.8.4	Describe what maintenance staff will be required. Will this be provided by existing staff or will additional staff be required?
7.2.8.5	What qualifications and training will the maintenance staff require?
7.2.9	Operating procedures
7.2.9.1	Describe who will be responsible for backing up databases. How often will backups be required? Will backups be stored off-site?
7.2.10	Maintenance
7.2.10.1	Describe the arrangements for maintenance. (e.g., is it done in-house or contracted out? Is it 24/7? Is equipment repair done in-house or externally?)
7.2.11	Disposal

ConOps Reference #	ConOps Sample Statements
7.2.11.1	Describe what material and/or equipment will need to be disposed of during the life of the project, and how it will be disposed.
7.2.11.2	Describe how system components will be disposed of at the end of their useful life.
8	Operational Scenarios
8.1	TSS Operational Scenarios Overview
8.1-1	<p>The following operational scenarios describe how the TSS is expected to operate under various conditions. The proposed TSS is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future project locations. Scenarios are described for the following operational conditions: [Edit to suit your situation.]</p> <ul style="list-style-type: none"> * New Signal * Time of Day Operation * Normal Routine Operations and Responding to Citizen Calls * Event Plans * Incident Plans * Detector Health Monitoring * Performance Measurement * Automated Traffic Signal Performance Measures * Updating Coordination Timing * Consultant (External) Access * Adjacent Agency Access * Loss of Communications or Server Fault
8.1.1	New Signal
8.1.1.1	<p>The agency is adding a new traffic signal to the system. They use the central system to enter the local timings to make the signal operational, including min and max times, ped timings, clearance timings, detector timings, preemption settings, phase sequencing, etc. The agency downloads the timing database to the controller in the office to bench test the timings. The controller is installed in the field and minor tweaks to the detector settings are made. The field timings are uploaded to the system and saved as the official database. The new signal is added to the map, which shows signal status at the highest level and detailed phase status at the intersection level. If the signal had coordinated timings, then the corridor level map would show coordination status.</p>
8.1.2	Time of Day Operation

ConOps Reference #	ConOps Sample Statements
8.1.2.1	The agency has developed coordinated timing plans for all of its major arterials. The timing plans operate based on the time of day scheduler. The central system provides a time synch for all of the signals so that they have the same exact time of day. The system also monitors what timing plan each signal is operating and compares it to the central database. Any discrepancies are logged and the operator alerted via email.
8.1.3	Normal Routine Operations and Responding to Citizen Calls
8.1.3.1	The agency gets a call from a citizen about a signal “not working”. In order to determine what the issue is, the operator logs onto the signal system to check the timings and verify that it operating as it is supposed to be. The signal status screen on the map shows that the signal has communication and it operating the a.m. peak plan. The operator uploads the timings from the controller and compares them to the timings in the central database. All timings are match. The operator then uploads the split logs and the operator finds that Phase 4 (side street) is serving the maximum time from 1 a.m. to 4 a.m. on some days. This leads the operator to suspect there is a problem with the video detection in the middle of the night. The maintenance technicians are dispatched to address this issue. For the next week, the operator uploads the split logs and sees that the split times look appropriate. Another example would be that the operator finds that the split time for Phase 1 is continually maxing out during the a.m. peak plan. Due to a new school in the area, traffic has increased and the phase needs additional time to serve the demand. The operator is able to adjust the a.m. peak splits and download them to the controller. The operator monitors the split logs for the next several weeks to see if the phase still maxes out.
8.1.4	Event Plans
8.1.4.1	There is a large stadium in town that hosts university football games and concerts. Some streets near the stadium are closed for two hours before big games. After the games, there are specific exit routes for traffic leaving the area. The operator has predetermined timing plans to operate during the pregame and the postgame time periods. The operator watches the CCTV cameras near the stadium to see when the streets are closed (or gets call from police) and then manually calls in the event timing plans, which operate until the start of the game. After the game, the operator manually calls in another set of event timings that operate for 30 minutes (which has been determined to be how long it takes for traffic to clear). Once the event is over, the timings revert to the regularly schedule timing plans.
8.1.5	Incident Plans

ConOps Reference #	ConOps Sample Statements
8.1.5.1	The agency has an arterial corridor that runs parallel to a freeway. Incidents on the freeway result in increased traffic on the arterial corridor as people avoid the congestion. The agency has developed special incident plans (flush plans) to handle the increase in traffic. The special plans can be called in by several different methods, including: manual override by the operator, volume trigger of a system detector(s) or an external trigger from the freeway management system. A request from an external system will send an alert to the operator who must confirm the requested action. Once the incident clears, the central system will call in the regularly scheduled timing plans via manual override by operator, volume trigger or external trigger.
8.1.6	Detector Health Monitoring
8.1.6.1	The agency has configured the signal system to report detector faults and failures. The detectors are configured to collect volume and occupancy on a cycle by cycle basis. If the detector is out of range (too high of volumes or too low of volumes), it will generate an alert which is accessible via a detector health report. Each morning, the operator reviews the detector health report to determine if there are any problem locations and then dispatches the signal technicians to address the issue. The operator may choose to download modified minimum or maximum green times if the detector issue cannot be fixed quickly. For detectors at critical intersections, the operator and lead technician receive a text alert (or email) of the problem (in addition to being logged in the detector health report).
8.1.7	Performance Measurement
8.1.7.1	The agency tracks several performance metrics with the central system. The agency has configured the detection and timing parameters to log data and the central system creates reports that are easy to read. On a monthly basis, the agency reviews the transit signal priority logs to see how many requests were received and granted and whether the result was early green or green extension. This report is reviewed with the transit agency to determine if any changes to the TSP timings is necessary. On a monthly basis, the agency reviews the percent arrival on green data and compares it to the previous month's data to see if there are any changes to the arrival patterns that need to be reviewed.
8.1.8	Automated Traffic Signal Performance Measures

ConOps Reference #	ConOps Sample Statements
8.1.8.1	<p>The agency uses automated performance measurement tools to monitor operation on coordinated systems on a daily basis. They used a report like the Phase Termination Report to identify systematic max-outs of phases, or to identify detector faults. They use a report like the Purdue Coordination Diagram to monitor the effectiveness of offsets and cycle lengths. These and other reports are built from high-resolution data uploaded from traffic signal controllers every few minutes, and stored in a server. The reports mine the data stored in that server for the period in question, which can be as recent as the previous upload period. The agency user can adjust the length of the time period covered by the report, from a few cycles to days, weeks, and months. The performance measurement software will compile intersection reports to provide an overall view of arterial and network operations. Based on all these reports, agency users will make routine revisions to the signal timing settings to improve operations, using subsequent reports to verify that the improvements were effective.</p>
8.1.9	<p>Updating Coordinated Timings</p>
8.1.9.1	<p>The agency is updating the coordinated timings along a corridor that has 23 signals. To develop the existing Synchro model, the agency uploads the existing timing databases and corresponding phase diagrams and sends to the consultant. The consultant develops the timings and gives the agency the new cycle, split, offsets for each signal. The agency enters the new coordinated timings and time of day schedule into the database and labels it “new”. The time of day schedule can be copied from one signal database to another to save time and reduce errors. As the timings are entered, the agency performs an error check of the coordinated timings to ensure they will operate in the field. The agency saves the existing timing databases as a back-up in case they need to revert back to them for any reason. The agency downloads the new databases to each signal and monitors that they are operating the appropriate plan. The agency and consultant drive the corridor to observe the timings and determine they need to make a few adjustments to splits and offsets. They log in remotely from a laptop to the traffic signal system and make the changes to the timing databases and download them to the signals. During the fine-tuning stage, the operator opens up the real-time time space diagram to see how the progression looks. The operator identifies one signal where the offset is 30 seconds off. The operator modifies the offset and downloads it to the controller. For the next several weeks, the operator and consultant log into the system and upload split logs and view the time space diagram to ensure that the timings are operating as they were designed to.</p>
8.1.10	<p>Consultant (External) Access</p>
8.1.10.1	<p>The agency receives a request for signal timing data from a consultant that is completing a traffic impact study. The consultant has remote access (read only) to the central system and is able to log into the system and retrieve the timing sheets.</p>
8.1.11	<p>Adjacent Agency Access</p>

ConOps Reference #	ConOps Sample Statements
8.1.11.1	The local agency has a corridor that has two DOT-owned traffic signals on it. The DOT maintains the traffic signal equipment and operates the signal timing. The local agency is able to log into the system to view the operations of the DOT signals and under special circumstances, make changes to the timing (incidents, events, etc.) when the DOT is unable to do so. The system maintains a permanent log of all the changes (what was changed, when it was changed and who made the change).
8.1.12	Loss of Communications or Server Fault
8.1.12.1	If the central server goes down or communications to the traffic signals is interrupted, the local traffic signal controllers need to continue to operate safely. The local controllers will operate based on the time of day schedule. The central system provides remote access and the ability to monitor the signals, but it doesn't control the operations of the local controllers.
8.2	Adaptive Operational Scenarios Overview
8.2-1	<p>The following operational scenarios describe how the ASCT system is expected to operate under various conditions. The proposed ASCT system is expected to be able to manage the following operational scenarios and issues envisioned for both the current and future project locations. Scenarios are described for the following operational conditions: [Edit to suit your situation.]</p> <ul style="list-style-type: none"> * Typical heavy congested conditions * Typical heavy uncongested conditions * Moderate balanced flows * Light balanced flows * Demand affecting event * Capacity affecting event * Fault conditions (communications, detection, adaptive processor) * Signal priority and preemption * Pedestrians * Installation <p>(For each scenario, as applicable, describe the following elements:</p> <ul style="list-style-type: none"> * Network * Traffic conditions * Operational objectives * Coordination and timing strategies * Summary of operations.)

ConOps Reference #	ConOps Sample Statements
8.2.1	Typical Heavy (Congested) Traffic
8.2.1.1	Example: Arterial Road with Diamond interchange
8.2.1.1.1	Road network
8.2.1.1.1-1	Broadway is an arterial road that passes through a diamond interchange. While the arterial primarily provides access to the freeway from residential areas to the east and west, it also serves a major shopping area, restaurants and office land uses adjacent to the freeway. Ramp meters are used on the freeway on-ramps during periods of heavy traffic on the freeway.
8.2.1.1.2	Traffic conditions
8.2.1.1.2-1	During the morning peak, traffic is heavy approaching the freeway from the residential areas. Congestion occurs at the freeway interchange and two other locations (A Street and B Street). During the afternoon commuter peak, traffic is heavy departing the freeway interchange, and congestion occurs at three locations, including east-bound left turns on Broadway east of the freeway at B Street and C Street.
8.2.1.1.3	Operational objectives
8.2.1.1.3-1	<p>The agency has a policy of seeking smooth flow on arterial streets for routes that carry predominantly through traffic, and equitable distribution of green time at intersections that predominantly serve adjacent land uses. When congested, the agency seeks to avoid building queues on freeway off-ramps, and seeks to minimize queue spill out into through lanes. In the morning peak, the operation is designed to provide through progression approaching the freeway, and to maximize throughput at other intersections along Broadway approaching the interchange. During the afternoon peak, the operation is designed to control queue buildup on the northbound freeway off-ramp and frontage road in order to prevent queue backup onto the freeway. The operational objectives under these conditions are to:</p> <ul style="list-style-type: none"> * Accommodate the traffic at all intersections with a minimum of phase failures * Control inflows to the diamond interchange to prevent queue spillback into upstream intersections; and * Provide smooth flow along the arterial road.
8.2.1.1.4	Coordination and signal timing strategies

ConOps Reference #	ConOps Sample Statements
8.2.1.1.4-1	<p>The diamond interchange runs a TTI-four-phase operation from a single signal controller. The coordination approach for the morning peak is progression, maximizing bandwidth in the direction approaching the freeway interchange. This requires a 90-second cycle which provides good resonant progression in both directions, with 40% bandwidth efficiency in the peak direction, when side-street volumes are low. This cycle length also minimizes delay with no effect on throughput at the diamond, given that the lost time is offset by the internal double clearance, which means that increasing the cycle length does not increase throughput. The coordination approach in the afternoon peak is to maximize progression bandwidth leaving the interchange, except at X which is routinely congested and the agency seeks to allow queues to build on the side-street approach to maximize throughput on the arterial. Queue formation on the eastbound arterial approach to the freeway is allowed to maximize the green time and throughput for the northbound ramp approach. The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * At the diamond interchange, select phase times that ensure queues do not exceed storage lengths. * At the critical intersection(s), select phase sequence that eliminates queue overflow in left turn bays * At each intersection, select phase times that eliminate phase failures * At the other arterial road intersections, provide sufficient time to serve all turning and side street traffic without phase failures * At the other arterial road intersections, provide green on the coordinated route phases in a manner that minimizes the stops for through traffic along the arterial.
8.2.1.1.5	Summary of Operation
8.2.1.1.5-1	<p>The actuated system will measure the traffic flow and determine when each of these operational objectives should be in force, and therefore which of the coordination and timing strategies to give priority to in making its adaptive decisions. The adaptive system will use the 90-second cycle in the morning peak to preserve resonant progression. The adaptive system will not alter the operation of the diamond interchange phase sequence. The adaptive system will seek to balance green time utilization when side-street demand is important, such as during the noon peak. The adaptive system will seek to minimize residual queuing at congested locations, preferring to build queue at x and y if demand cannot be accommodated. The adaptive system will prevent residual queue buildup on the freeway ramps. The adaptive system reports bandwidth, arrivals on red as a measure of bandwidth utilization, and phase utilization measurements that were used to adaptively adjust green times.</p>
8.2.1.2	Example: Arterial with one critical intersection
8.2.1.2.1	Road network

ConOps Reference #	ConOps Sample Statements
8.2.1.2.1-1	<p>The section of Broadway Road to be coordinated using ASCT has six signalized intersections. It is a six lane arterial road with a two way left turn lane, and exclusive left turn lanes at each intersection. Most of the intersections provide access to local businesses and residential areas. However, one intersection (name of cross street) is an arterial road that accommodates regional traffic rather than providing local access. There are no nearby signals on this cross street that require coordination with this critical intersection. This is an eight-phase intersection with protected left turns on all approaches. The other intersections have permissive left turns on the side streets. Broadway is classified by the MPO as an arterial road of regional significance.</p>
8.2.1.2.2	Traffic conditions
8.2.1.2.2-1	<p>There is one critical intersection (Cross Street) that has heavier traffic than the other intersections at all times of the day. At its heaviest (typically during the AM and PM peaks) most movements are congested with occasional phase failures. Traffic is heaviest in one direction when these conditions are experienced, typically northbound during the AM peak and southbound during the PM peak. The traffic on Broadway is 50% heavier than the traffic on (Cross Street) during this condition.</p>
8.2.1.2.3	Operational objectives
8.2.1.2.3-1	<p>The operational objectives for this arterial under these conditions are to:</p> <ul style="list-style-type: none"> * Maximize the throughput along Broadway; * Accommodate the traffic at the critical intersection with a minimum of phase failures; and * Provide smooth flow along the arterial through other intersections.
8.2.1.2.4	Coordination and signal timing strategies
8.2.1.2.4-1	<p>The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * At the critical intersection, select phase times that eliminate phase failures * At the critical intersection, select phase sequence that eliminates queue overflow in left turn bays * At the critical intersection, select phase times that eliminate queue overflow in left turn bays * At the critical intersection, distribute green time to maximize the throughput on Broadway * At the non-critical intersections, provide sufficient time to serve all turning and side street traffic without phase failures
8.2.1.2.5	Summary of operation

ConOps Reference #	ConOps Sample Statements
8.2.1.2.5-1	<p>Under these conditions, the ASCT system will select a phase arrangement and calculate phase times that accommodate traffic at the critical intersection. It will then set the timing at the other intersections to provide a green band in the direction of heaviest traffic along the arterial, to minimize the number of stops in that direction. The green time for the non-arterial phases at those intersections will be set to accommodate the traffic using those phases, while allocating the remaining time to the arterial road. The system will determine the sequence of phases on the arterial (lead-lead, lead-lag or lag-lag) that minimizes the stops in the non-coordinated direction under these conditions.</p>
8.2.1.3	Example: Arterial with several critical intersections
8.2.1.3.1	Road network
8.2.1.3.1-1	<p>The section of Broadway Road to be coordinated using ASCT has ten signalized intersections. It is a six lane arterial road two way left turn lane, and exclusive left turn lanes at each intersection. Two intersections (name of cross streets) are arterial roads that accommodate regional traffic rather than providing local access. There are no nearby signals on the cross streets that require coordination with this critical intersection. One intersection provides access to a major shopping district. These are all eight-phase intersections with protected left turns on all approaches. The remaining intersections provide access to local businesses and residential areas. Those intersections have protected left turns on Broadway and permissive left turns on the side streets. Broadway is classified by the MPO as an arterial road of regional significance.</p>
8.2.1.3.2	Traffic conditions
8.2.1.3.2-1	<p>At times when traffic conditions are very heavy, one of the three key intersections is the critical intersection. This varies depending on the level of demand on the two crossing arterials or activity in the shopping district. When traffic is very heavy, it is typically heaviest on Broadway in one direction (such as northbound during the AM peak and southbound during the PM peak). In these conditions, Broadway carries higher volumes than the crossing arterials.</p>
8.2.1.3.3	Operational objectives
8.2.1.3.3-1	<p>The operational objectives for this arterial under these conditions are to:</p> <ul style="list-style-type: none"> * Maximize the throughput along Broadway * Accommodate the traffic at the critical intersection with a minimum of phase; and * Provide smooth flow along the arterial through other intersections.
8.2.1.3.4	Coordination and signal timing strategies

ConOps Reference #	ConOps Sample Statements
8.2.1.3.4-1	<p>The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * Determine the critical intersection * At the critical intersection, select phase times that eliminate phase failures * At the critical intersection, select phase sequence that eliminates queue overflow in left turn bays * At the critical intersection, distribute green time to maximize the throughput on Broadway. * At the non-critical intersections, provide sufficient time to serve all turning and side street traffic without phase failures * At the non-critical intersections, provide green on the arterial road phases in a manner that minimizes the stops for through traffic along the arterial.
8.2.1.3.5	Summary of operation
8.2.1.3.5-1	<p>Under these conditions, the ASCT system will determine the critical intersection and select a phase arrangement and calculate phase times that accommodate traffic at that intersection. It will then set the timing at the other intersections to provide a green band in the direction of heaviest traffic along the arterial, to minimize the number of stops in that direction. The green time for the non-arterial phases at those intersections will be set to accommodate the traffic using those phases, while allocating the remaining time to the arterial road. The system will determine the sequence of phases on the arterial (lead-lead, lead-lag or lag-lag) that minimizes the stops in the non-coordinated direction under these conditions.</p>
8.2.1.4	Example: Crossing arterials
8.2.1.4.1	Road network
8.2.1.4.1-1	<p>Broadway is an arterial road with seven signalized intersections. Cross Street is also an arterial road with five signalized intersections, and it crosses Broadway, as illustrated in the figure.</p>
8.2.1.4.2	Traffic conditions
8.2.1.4.2-1	<p>During heavy traffic conditions (such as AM and PM peak) the Broadway/Cross Street intersections is the critical intersection, and queues develop on all approaches. Typically the northbound direction on Broadway is significantly heavier than the southbound. Likewise, the eastbound traffic on Cross Street is significantly heavier than the westbound.</p>
8.2.1.4.3	Operational objectives

ConOps Reference #	ConOps Sample Statements
8.2.1.4.3-1	<p>The operational objectives for these arterials under these conditions are to:</p> <ul style="list-style-type: none"> * Maximize the throughput along Broadway * Maximize the throughput along Cross Street * Accommodate the traffic at the critical intersection with a minimum of phase failures; and * Provide smooth flow along the arterial through other intersections.
8.2.1.4.4	Coordination and signal timing strategies
8.2.1.4.4-1	<p>The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * At the critical intersection, select phase times that eliminate phase failures * At the critical intersection, select phase sequence that eliminates queue overflow in left turn bays * At the non-critical intersections on both arterials, provide sufficient time to serve all turning and side street traffic without phase failures * At the non-critical intersections, provide green on the arterial road phases in a manner that minimizes the stops for through traffic along the arterial.
8.2.1.5	Example: Grid network
8.2.1.5.1	Road network
8.2.1.5.1-1	<p>The intersections to be coordinated are on a grid network with relatively fixed intersection spacing. The roads typically have four lanes plus separate left turn bays at intersections. Based on the intersection spacing and typical mid-block vehicle speeds, there is a resonant cycle length of approximately 60 seconds that would provide coordination on most streets. This cycle length would also accommodate pedestrian movements at all intersections.</p>
8.2.1.5.2	Traffic conditions
8.2.1.5.2-1	<p>During heavy traffic conditions (such as peak shopping periods and PM peak hours), the demand at many of the intersections cannot be accommodated at the resonant cycle length. In addition, at key locations the block length is such that not all of the demand on some approaches can be stored in the approach block.</p>
8.2.1.5.3	Operational objectives
8.2.1.5.3-1	<p>The operational objectives for the streets in this network under these conditions are to:</p> <ul style="list-style-type: none"> * Accommodate the traffic at all intersections with a minimum of phase failures; * Control inflows to blocks to prevent queue spillback into upstream intersections; and * Provide smooth flow along as many routes as possible through the network.
8.2.1.5.4	Coordination and signal timing strategies

ConOps Reference #	ConOps Sample Statements
8.2.1.5.4-1	<p>The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * Determine which routes need to be coordinated and which blocks can best accommodate no coordination, * At each intersection, select phase times that minimize phase failures; * Determine the critical intersection(s) within the network * At the critical intersection(s), select phase sequence that minimizes queue overflow in left turn bays * At the critical intersection(s), distribute green time to maximize the throughput on the coordinated routes. * At the non-critical intersections, provide sufficient time to serve all turning and side street traffic without phase failures * At the non-critical intersections, provide green on the coordinated route phases in a manner that minimizes the stops for through traffic along the coordinated route. * At intersections with limited approach block length, set the timing of upstream intersections so that queues do not exceed the block length.
8.2.1.5.5	Summary of Operation
8.2.1.5.5-1	<p>The network will operate at a 60 second cycle length, because that has been determined to be a resonant cycle length at which two-way progression can be provided on the coordinated routes. The ASCT will select the most appropriate phase sequence at intersections where phase sequence is permitted to vary, and select phase times that accommodate all pedestrian activity and distribute green times to minimize phase failures, and implement offsets that provide progression along the coordinated routes. Because XX block is short, the offsets will be set so that when a coordinated platoon passes through A Street, it will always clear B Street, so the block is cleared and available to store turning traffic from A Street.</p>
8.2.2	Typical Heavy (Uncongested) Traffic
8.2.2.1	Example: Isolated Intersection
8.2.2.1.1	Road network
8.2.2.1.1-1	<p>A Road and B Road are two important limited access arterials that intersect and there are no other intersections sufficiently close that traffic flow would benefit from providing coordination. At the intersection, each road has three through lanes on each approach, dual left turn lanes and exclusive right turn lanes. Although pedestrian crosswalks are provided, there are rarely pedestrians at this isolated location.</p>
8.2.2.1.2	Traffic conditions

ConOps Reference #	ConOps Sample Statements
8.2.2.1.2-1	Traffic is heavily directional during the commuter peaks. A Road is predominantly northbound during the AM and southbound during the PM, while B Road is predominantly eastbound during the AM and westbound during the PM. There is significant turning traffic in the peak directions. The left turn bays in the peak direction often overflow (east to north during the AM peak and west to south during the PM peak). There are occasional phase failures resulting in carryover queues at the end of phases. However, because of the high volumes and relatively long queues that form under vehicle-actuated (free) operation, there is a significant portion of each phase green during which the throughput is well below saturation flow, but not sufficiently low that phase gap-out occurs. The intersection delay (and therefore the LOS) would be improved by using a lower cycle length than can be achieved using normal vehicle-actuated operation.
8.2.2.1.3	Operational objectives
8.2.2.1.3-1	The operational objective for this case is to reduce delay by improving the efficiency of each phase.
8.2.2.1.4	Coordination and signal timing strategies
8.2.2.1.4-1	<p>The signal timing strategies used by the system to accommodate this situation are:</p> <ul style="list-style-type: none"> * Select a cycle length that minimizes overall delay at the intersection * Select a phase sequence that maximizes the efficiency of the movements in the peak direction * Distribute phase times to minimize phase failures on all approaches * Modify cycle length and phase times if necessary to accommodate occasional pedestrians
8.2.2.1.5	Summary of Operation
8.2.2.1.5-1	The adaptive system will measure the traffic flow and determine the appropriate cycle length and phase times to accommodate the current demand. When traffic volumes are sufficiently high, lead-lag operation will be selected for one or both approaches and unused time generally added to the phases serving the peak directions.
8.2.3	Moderate balanced flows
8.2.3.1	Arterial road with irregular spacing
8.2.3.1.1	Road network

ConOps Reference #	ConOps Sample Statements
8.2.3.1.1-1	<p>The section of Broadway Road to be coordinated using ASCT has six signalized intersections. It is a six lane arterial road with a two way left turn lane, and exclusive left turn lanes at each intersection. Most of the intersections provide access to local businesses and residential areas. However, one intersection (Cross Street) is an arterial road that accommodates regional traffic rather than providing local access. There are no nearby signals on this cross street that require coordination with this critical intersection. This is an eight-phase intersection with protected left turns on all approaches. The other intersections have permissive left turns on the side streets. There is no regular spacing between the intersections and therefore no "resonant" cycle length.</p> <p>Broadway is classified by the MPO as an arterial road of regional significance.</p>
8.2.3.1.2	Traffic conditions
8.2.3.1.2-1	<p>During business hours traffic uncongested and the flows along Broadway are similar in both directions. At lunch time there is an increase in traffic turning into and out of the several side streets that service local shops and restaurants. There is little pedestrian activity except at Cross Street where there are bus stops and local shops. There is enough side street and turning movement traffic that most signal phases are called every cycle. The left turn volumes are sufficiently high that they need protected turn phases to provide sufficiently capacity and prevent phase failures.</p>
8.2.3.1.3	Operational objectives
8.2.3.1.3-1	<p>The operational objectives for this condition are to:</p> <ul style="list-style-type: none"> * Provide smooth flow along Broadway; and * Provide signal timing that prevents phase failures at all intersections.
8.2.3.1.4	Coordination and signal timing strategies
8.2.3.1.4-1	<p>The coordination approach for these conditions is provide progression, maximizing bandwidth while providing two-way coordination. This can be done at a resonant cycle length of 80 seconds. The strategies applied while maintaining this cycle length are:</p> <ul style="list-style-type: none"> * At each intersection, provide sufficient time to serve all turning and side street traffic without phase failures; * At each intersection, select phase times (or offsets) that provide smooth flow along the arterial in both directions. * At each intersection, select phase sequence that provides smooth flow along the arterial * At the specified intersection, select phase times that will accommodate frequent use of all pedestrian phases. * At other intersections, select phase times that will accommodate occasional use of pedestrian phases.
8.2.3.1.5	Summary of Operation

ConOps Reference #	ConOps Sample Statements
8.2.3.1.5-1	The critical intersection will determine the minimum cycle length that can be used for the entire group. This cycle length will accommodate all phases and all pedestrian movements. Provided it is not higher than the 90 second resonant cycle length, the system will set the cycle length to be 90 seconds. It will detect the balanced flows and select offsets that provide a reasonable compromise between the two directions of travel. At the non-critical intersections, the non-coordinated phases will be set to accommodate pedestrians and vehicles, and all spare time will allocated to the coordinated phases to maximize the bandwidth for progression bands along the road. During periods (such as lunch time) when there is more turning traffic associated with local retail activity) extra time will be provided to those phases within the overall cycle length, at the expense of the coordinated phases on Broadway.
8.2.4	Light Balanced Flows
8.2.4.1	Arterial Road
8.2.4.1.1	Road network
8.2.4.1.1-1	The section of Broadway Road to be coordinated using ASCT has six signalized intersections. It is a six lane arterial road with a two way left turn lane, and exclusive left turn lanes at each intersection. Most of the intersections provide access to local businesses and residential areas. However, one intersection (Cross Street) is an arterial road that accommodates regional traffic rather than providing local access. There are no nearby signals on this cross street that require coordination with this critical intersection. This is an eight-phase intersection with protected left turns on all approaches. The other intersections have permissive left turns on the side streets. Broadway is classified by the MPO as an arterial road of regional significance.
8.2.4.1.2	Traffic conditions
8.2.4.1.2-1	During some periods of the weekdays and weekends traffic is light but predominantly passing along the arterial. There is little pedestrian activity and little side street and turning movement traffic. The left turn volumes are sufficiently light that they do not need protected turn phases to provide sufficiently capacity, and can normally be accommodated by permissive phases. There is a resonant cycle length of 45 seconds that will provide two-way coordination when the protected left turn phases are omitted.
8.2.4.1.3	Operational objectives
8.2.4.1.3-1	The operational objectives for this condition are to: <ul style="list-style-type: none"> * Provide smooth flow along Broadway; and * Provide signal timing that prevents phase failures at all intersections.
8.2.4.1.4	Coordination and signal timing strategies

ConOps Reference #	ConOps Sample Statements
8.2.4.1.4-1	<p>The coordination approach for this condition is to provide progression along the arterial, maximizing bandwidth while providing two-way coordination. The timing strategies applied to do this are:</p> <ul style="list-style-type: none"> * At each intersection, provide sufficient time to serve all turning and side street traffic without phase failures; * At each intersection, select phase times (or offsets) that provide smooth flow along the arterial in both directions; * At each intersection, omit protected turning phases to minimize the impact of occasional turning vehicles on other traffic; * At each intersection, select phase times that will accommodate occasional use of pedestrian phases.
8.2.4.1.5	Summary of Operation
8.2.4.1.5-1	<p>During light traffic conditions, protected left turn phases will be omitted and a cycle length of 45 seconds implemented. If traffic volumes decrease (such as during late nights), the 45 second cycle length and two-way coordination will be maintained unless the volumes fall below a minimum threshold, in which case the signals will be set to operate in free, vehicle-actuated mode. If traffic increases to the extent that it can no longer be accommodated within the 45 second cycle length, or left turning volumes can no longer be accommodated without the protected left turns, then a longer cycle length will be implemented and a new coordination strategy selected to match the current traffic conditions.</p>
8.2.5	Demand affecting event
8.2.5.1	High travel day (e.g., Mothers' Day, Superbowl)
8.2.5.1-1	<p>During periods of major activity within or close to the ASCT's area of operation, the traffic characteristics are often similar to the peak periods, either oversaturated or unsaturated. The system will behave in a similar fashion to those periods, and the detection system will determine whether unsaturated or oversaturated conditions prevail. If there is heavily directional traffic before or after the activity, the system will determine the predominant direction and coordinate accordingly, with an appropriate cycle length and offset. If the event traffic is not as heavy as peak hours, but the traffic on the corridor is still highly directional, then the system will recognize this and provide coordination predominantly in the heaviest direction, even though the cycle length may be similar to business hours (with balanced flows) cycle lengths.</p> <p>The entire corridor may be set by the operator to operate as one or more coordinated groups under this condition, or the system may have the freedom to operate it as one or more groups subject to user-specified criteria, such as similar required cycle lengths in different parts of the corridor, or the volume of traffic at key locations exceeds a threshold.</p>
8.2.6	Capacity affecting event
8.2.6.1	Incident within the system (construction, maintenance, fire, weather)

ConOps Reference #	ConOps Sample Statements
8.2.6.1-1	<p>When an incident occurs on the coordinated route and temporarily reduces the capacity of the route (such as emergency vehicles stopped, unscheduled construction/maintenance, or traffic crash), there will typically be congestion upstream of the blockage, and lighter than normal traffic downstream. In such a situation, it is appropriate for the downstream signals to operate with different characteristics from the upstream signals.</p> <p>If the downstream signals experience lighter traffic as a result of the blockage, those signals should be coordinated as a group, with cycle length, splits and/or offsets that react to the measured traffic. If the blockage is in the peak direction, then it may be appropriate to coordinate in the opposite direction if that traffic is similar to or greater than the normal peak direction. If the blockage is in the non-peak direction, there may be no need to depart from the normal operation.</p> <p>While intersections upstream from the blockage may register increased congestion, the appropriate response would not be to increase the capacity in the congested direction. On the contrary, the approach should be to match the capacity for phases in the direction towards the bottleneck to the actual capacity of the bottleneck, and prevent this movement from adversely affecting cross street traffic and the flow in the non-affected direction.</p> <p>The system will recognize the presence of an abnormal obstruction and modify the signal operation to react to the changed traffic conditions in an efficient manner.</p>
8.2.7	Fault Conditions
8.2.7.1	Communications Fault Condition
8.2.7.1-1	<p>If a communication failure prevents the adaptive system from continuing to control one or more intersections within a defined group, all signals within the group will revert to an appropriate, user-specified fallback mode of operation, either time-of-day operation or free operation. The fallback mode will be specified by the user based on location and time of day. All communication failure alarms will be automatically transmitted to maintenance and operations staff for appropriate attention.</p>
8.2.7.2	Detection Fault Condition

ConOps Reference #	ConOps Sample Statements
8.2.7.2-1	<p>The system will recognize a detector failure and take appropriate action to accommodate the missing data. For a local detector failure, the local controller will place a soft recall or maximum recall (to be user-specified) on the appropriate phase, and issue an alarm. For a detector that influences the adaptive operation (e.g., a system detector), the system will use data from an alternate (user-specified) detector, such as in an adjacent lane or at an appropriate upstream or downstream location. If the number of detector failures within a specified group exceeds a user-specified threshold, the system will cease adaptive operation and go to a fallback operation specified by the user (such as time-of-day operation or free operation). The fallback operation will be specified by the user based on location and time of day. All detector failure alarms will be automatically transmitted to maintenance and operations staff for appropriate attention.</p>
8.2.8	Priority and Preemption
8.2.8.1	Railroad Preemption
8.2.8.1.1	EXAMPLE PREEMPTION SCENARIO.
8.2.8.1.1-1	<p>XX arterial runs north-south and there are gated railroad grade crossings on several of the east-west routes that cross XX Arterial, namely XX Blvd and XX St. The rail line is approximately XXft. to the east of XX Arterial. The railroad gated crossing preempts the signals at XX intersection and also XX (TWO INTERSECTIONS ON THE ARTERIAL). Upon preemption, the signals on XX arterial introduce a clearance phase, to ensure any vehicles queued on or close to the railroad tracks can clear before the gates descend. Upon completion of the clearance interval, the signal continues limited operation. The phases that would normally send traffic in the direction of the grade crossing are inhibited until the gates are raised. Once the clearance sequence is completed, the signal returns to normal operation. There is also a queue detector on the eastbound departure side of XX Arterial, which detects the presence of a queue approaching the grade crossing when the gates are lowered. If such a queue is detected, the phases that normally send traffic in the direction of the grade crossing are inhibited as long as the gates remain lowered. When an intersection responds to railroad preemption, all signals within the coordinated group are released to local control, and operate according to a time-of-day schedule. Once the preemption is released, all the signals in the coordinated group return to adaptive control.</p>
8.2.8.2	Light Rail Priority
8.2.8.2.1	EXAMPLE LIGHT RAIL PRIORITY SCENARIO.

ConOps Reference #	ConOps Sample Statements
8.2.8.2.1-1	<p>LRT priority will be provided at each intersection on an LRT route. The input requesting priority will come EITHER from the centralized priority system The system will have the capability to extend the existing green if that will serve the LRV, introduce an early green by shortening or skipping other phases, or run a phase called exclusively by the LRV.</p> <p>The decision to provide priority will be determined within the local controller, based on user-definable and settable rules. These rules will include such items as: length of time or number of cycles since last priority was provided, and priority level if there are competing requests.</p> <p>The LRT system has its own logic to determine whether a priority request for an approaching LRV will be transmitted to the signal controller, based on such parameters as schedule adherence, route number, in-service or out-of-service and passenger loading. This logic will not reside within the adaptive system.</p>
8.2.8.3	Bus Signal Priority
8.2.8.3.1	EXAMPLE BUS PRIORITY SCENARIO.
8.2.8.3.1-1	<p>Bus priority will be provided at each intersection on a bus route. The input requesting priority will come from the centralized priority system.</p> <p>The system will have the capability to extend the existing green if that will serve the bus, introduce an early green by shortening or skipping other phases, or run a phase called exclusively by the bus.</p> <p>The decision to provide priority will be determined within the local controller, based on user-definable and settable rules. These rules will include such items as: length of time or number of cycles since last priority was provided, and priority level if there are competing requests.</p> <p>The bus system has its own logic to determine whether a priority request for an approaching bus will be transmitted to the signal controller, based on such parameters as schedule adherence, route number, in-service or out-of-service and passenger loading. This logic will not reside within the adaptive system.</p>
8.2.8.4	Emergency Vehicle Preemption
8.2.8.4-1	When an intersection responds to an EV preemption, other signals within the coordinated group continue to operate adaptively. The preempted signal returns to adaptive control once the preemption is released.
8.2.9	Scheduled Events
8.2.9-1	<p>The system will recognize the increasing traffic as patrons arrive for the event and adopt an appropriate mode of operation. During the event, when there is little associated traffic, the system will recognize the traffic conditions and operate normally, then recognize the changing traffic pattern as patrons begin to leave the event and adopt the appropriate mode of operation until the traffic clears.</p> <p>The system will then return to normal operation.</p>

ConOps Reference #	ConOps Sample Statements
8.2.10	Pedestrians
8.2.10-1	<p>Pedestrian crossing times must be accommodated. At locations with wide pedestrian crosswalks and a history of conflicts between turning vehicles and pedestrians, the pedestrian walk is displayed some seconds before the compatible vehicle green. At crosswalks with high pedestrian volumes, a pedestrian recall is used during the periods when the pedestrian volumes are high. Pedestrian recall is used for pedestrian phases that are adjacent to the coordinated movements.</p> <p>During periods when pedestrian volumes are high and queuing of the conflicting right turn movement becomes unacceptable, the vehicles are directed elsewhere by prohibiting the movement (such as by operating a No Right Turn sign).</p> <p>When side street traffic is light and no pedestrian is present, a vehicle may arrive on the side street shortly after the point at which its phase would normally be initiated. Typically it would then wait an entire cycle before being served. However, it is often possible to serve one or two side street vehicles within the remaining green time. So the system will be able to start a phase later than normal when there is no pedestrian call for that phase, provided it can be completed before the time the phase would normally end.</p>
8.2.11	Installation
8.2.11-1	<p>During installation and fine tuning, the operator will calibrate all the user-defined values in the system. In order to understand the response of the system to changes in traffic conditions, it is necessary to examine the results of intermediate calculations, in addition to the overall outputs and changes of state commanded by the system.</p> <p>For example, if a cycle length is calculated based on a calculated parameter, such as level of saturation of detectors in critical lanes on critical movements, then the state of that calculated parameter must be available for inspection for each detector. This will allow the operator to properly calibrate each detector, and then separately calibrate the parameters in the cycle length calculation or look-up table. This would also allow an operator to identify a faulty detector that is causing an incorrect measure to be calculated, even though the detector has failed; or identify a detector on which traffic behavior is different from other detectors on that phase, such as a left turn lane that has a heavy U-turn volume.</p>

APPENDIX B: SYSTEM REQUIREMENTS TABLE OF SAMPLE STATEMENTS

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3	Requirements	
3.1	Functional System Requirements	
3.1.1	Access Control	
3.1.1.1	<p>The system shall provide monitoring and control access from the following locations.</p> <ul style="list-style-type: none"> * Agency TMC * Agency LAN or WAN * Other agency TMC (SPECIFY) * Local controller cabinets (hard wire) * Local controller cabinets (wireless) * Remote location via internet 	<p>4.1.4.1 The TSS Operator needs to manage the system database from the following locations: (EDIT TO SUIT YOUR SITUATION)</p> <ul style="list-style-type: none"> * Multiple workstations in the TMC * Multiple networked workstations on the City's LAN or WAN located at (USER SPECIFY) * Workstations at other Agencies' TMC (USER SPECIFY) * At the local controller cabinet using a hard wire connection * At the local controller cabinet using a wireless connection * Remote locations connected to the internet (USER SPECIFY, such as employee's home, maintenance vehicle, etc.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.1.2	The system shall allow remote access using a secure Virtual Private Network (VPN).	4.1.4.1 The TSS Operator needs to manage the system database from the following locations: (EDIT TO SUIT YOUR SITUATION) <ul style="list-style-type: none"> * Multiple workstations in the TMC * Multiple networked workstations on the City's LAN or WAN located at (USER SPECIFY) * Workstations at other Agencies' TMC (USER SPECIFY) * At the local controller cabinet using a hard wire connection * At the local controller cabinet using a wireless connection * Remote locations connected to the internet (USER SPECIFY, such as employee's home, maintenance vehicle, etc.)
3.1.1.3	The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.1.3	The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.1.3	The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.	4.1.4.5 The TSS Operator needs to view the status of multiple agency signals, edit the intersection databases, and/or create reports, as allowed by permission.
3.1.1.4	The system shall allow XX number of users to log on to the system simultaneously.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.1.4	The system shall allow XX number of users to log on to the system simultaneously.	4.1.4.3 The TSS Operator needs to make changes to an intersection database, disabling the ability of other TSS Operators to simultaneously make changes to the same intersection database.
3.1.1.4	The system shall allow XX number of users to log on to the system simultaneously.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.5	The system shall allow multiple operators to access an intersection database simultaneously.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.1.5	The system shall allow multiple operators to access an intersection database simultaneously.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.6	The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.1.6	The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.6	The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.1.7	The system shall restrict control of each intersection database to a single user at a time.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.1.7	The system shall restrict control of each intersection database to a single user at a time.	4.1.4.3 The TSS Operator needs to make changes to an intersection database, disabling the ability of other TSS Operators to simultaneously make changes to the same intersection database.
3.1.1.7	The system shall restrict control of each intersection database to a single user at a time.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.7.1	The system shall release lock of intersection database after a user-specified period of inactivity.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.1.7.1	The system shall release lock of intersection database after a user-specified period of inactivity.	4.1.4.3 The TSS Operator needs to make changes to an intersection database, disabling the ability of other TSS Operators to simultaneously make changes to the same intersection database.
3.1.1.7.2	The system shall allow access to a traffic signal database on a first come, first served basis.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.1.7.2	The system shall allow access to a traffic signal database on a first come, first served basis.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.7.3	The system shall allow administrator to terminate intersection control by other users with lesser user rights.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.1.7.3	The system shall allow administrator to terminate intersection control by other users with lesser user rights.	4.1.4.3 The TSS Operator needs to make changes to an intersection database, disabling the ability of other TSS Operators to simultaneously make changes to the same intersection database.
3.1.1.7.3	The system shall allow administrator to terminate intersection control by other users with lesser user rights.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.1.8	The system shall allow access to a traffic signal database based on user privileges.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		functions at different intersections or to view the same intersection.
3.1.1.8	The system shall allow access to a traffic signal database based on user privileges.	4.1.4.4 The TSS Operator needs to view the status of an intersection or group of intersections even when another TSS Operator is editing the intersection database.
3.1.2	Security	
3.1.2.1	<p>The system shall provide the ability to control and limit user access via user privileges (allowing for different levels of user access to system features and functions).</p> <ul style="list-style-type: none"> * Local access to the system * Remote access to the system * System monitoring * System manual override * Database * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * System parameters * Report generation * Configuration * Security alerts 	4.1.4.5 The TSS Operator needs to view the status of multiple agency signals, edit the intersection databases, and/or create reports, as allowed by permission.
3.1.2.2	The system shall provide user privileges definable for the following:	4.1.4.7

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.2.1	Geographic area	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.2.2	Time of Day	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.2.3	Device ownership	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		conform to the agency's access and network infrastructure security policies.
3.1.2.3	The system shall provide user privileges definable on a functional level:	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.3.1	TSS Manager	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.3.2	TSS Operator	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.3.3	External System	4.1.4.7

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.3.4	TSS Maintainer	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.4	The system shall comply with the agency's security policy as described in (specify appropriate policy document)	4.1.4.6 The TSS Operator needs secure access to the system consistent with the existing agency network policies.
3.1.2.4	The system shall comply with the agency's security policy as described in (specify appropriate policy document)	4.7.1.2 The TSS Designer needs to use equipment and software acceptable under current agency IT policies and procedures (USER TO SPECIFY)
3.1.2.5	The system shall provide full access to the administrator.	4.1.4.5 The TSS Operator needs to view the status of multiple agency signals, edit the intersection databases, and/or create reports, as allowed by permission.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.2.5	The system shall provide full access to the administrator.	4.1.4.6 The TSS Operator needs secure access to the system consistent with the existing agency network policies.
3.1.2.6	The system shall show operators/administrator who is logged in to the system at a given time.	4.1.4.2 Multiple system TSS Operators need to log on to the system simultaneously in order to do independent functions at different intersections or to view the same intersection.
3.1.2.7	<p>For Adaptive Systems, the ASCT shall be implemented with a security policy that addresses the following selected elements:</p> <ul style="list-style-type: none"> * Local access to the ASCT * Remote access to the ASCT * System monitoring * System manual override * Development * Operations * User login * User password * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * Output activation * System parameters * Report generation 	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Configuration * Security alerts * Security logging * Security reporting * Database * Signal controller 	
3.1.2.8	The ASCT shall provide monitoring and control access at the following locations:	4.4.2.1 The TSS Operator needs to monitor and control all required features of adaptive operation from the following locations: (Edit and select as appropriate to suit your situation.)
3.1.2.8.1	Agency TMC	4.4.2.1.1 Agency TMC
3.1.2.8.2	Agency LAN or WAN	4.4.2.1.2 Maintenance facility
3.1.2.8.2	Agency LAN or WAN	4.4.2.1.3 Workstations on agency LAN or WAN located at (specify)
3.1.2.8.3	Other agency TMC (Specify)	4.4.2.1.3 Workstations on agency LAN or WAN located at (specify)
3.1.2.8.3	Other agency TMC (Specify)	4.4.2.1.4 Other agency's TMC (specify)
3.1.2.8.4	Other agency TMC (Specify)	4.4.2.1.4

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		Other agency's TMC (specify)
3.1.2.8.5	Local controller cabinets (wireless)	4.4.2.1.5 Local controller cabinets
3.1.2.8.6	Local controller cabinets (hard wire)	4.4.2.1.5 Local controller cabinets
3.1.2.8.7	Remote locations via internet	4.4.2.1.6 Maintenance vehicles
3.1.2.8.8	Remote locations via internet	4.4.2.1.7 Remote locations (specify)
3.1.2.9	The ASCT shall comply with the agency's security policy as described in (specify appropriate policy document).	4.1.4.7 The TSS Manager needs to have a security management and administrative system that allows access and operational privileges to be assigned, monitored and controlled by a TSS Manager, and conform to the agency's access and network infrastructure security policies.
3.1.2.10	The ASCT shall not prevent access to the local signal controller database, monitoring or reporting functions by any installed signal management system.	4.4.2.2 The operator needs to access to the database management, monitoring and reporting features and functions of the signal controllers and any related signal management system from the access points defined for those system components.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3	System Configuration	
3.1.3.1	Network Characteristics	
3.1.3.1.1	The system shall control a minimum of XXX local signal controllers	4.1.1.1 The TSS Operator needs to view and control up to XXX traffic signal controllers, at various locations within the (agency).
3.1.3.1.2	The system shall allow intersections to be included in a group.	4.1.1.2 The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.2	The system shall allow intersections to be included in a group.	4.1.1.3 The TSS Operator needs to change intersection grouping by time of day or other trigger.
3.1.3.1.2	The system shall allow intersections to be included in a group.	4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.
3.1.3.1.2	The system shall allow intersections to be included in a group.	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.3.1.2.1	A group shall support up to XX signals.	4.1.1.2

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.2.1	A group shall support up to XX signals.	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	4.1.1.2 The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	4.1.1.3 The TSS Operator needs to change intersection grouping by time of day or other trigger.
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.3.1.3.1	The system shall allow intersections to change grouping by time of day schedule.	4.1.1.2 The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.3.1	The system shall allow intersections to change grouping by time of day schedule.	4.1.1.3 The TSS Operator needs to change intersection grouping by time of day or other trigger.
3.1.3.1.3.1	The system shall allow intersections to change grouping by time of day schedule.	4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.
3.1.3.1.3.1	The system shall allow intersections to change grouping by time of day schedule.	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.3.1.3.2	The system shall allow intersections to change grouping by manual command.	4.1.1.2 The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.3.2	The system shall allow intersections to change grouping by manual command.	4.1.1.3

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to change intersection grouping by time of day or other trigger.
3.1.3.1.3.2	The system shall allow intersections to change grouping by manual command.	4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.
3.1.3.1.3.2	The system shall allow intersections to change grouping by manual command.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.3.1.3.3	The system shall allow intersections to change grouping by (enter trigger).	4.1.1.2 The TSS Operator needs to organize the traffic signals in two (or more) groups for coordination purposes.
3.1.3.1.3.3	The system shall allow intersections to change grouping by (enter trigger).	4.1.1.3 The TSS Operator needs to change intersection grouping by time of day or other trigger.
3.1.3.2	Adaptive Network Characteristics	
3.1.3.2.1	The ASCT shall control a minimum of XX signals concurrently. Note: communications network characteristics based on mileage distance.	4.1.2.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to adaptively control up to XXX signals, up to XXX miles from the TMC (or specified location).
3.1.3.2.2	The ASCT shall support groups of signals.	4.1.2.2 The TSS Operator needs to be able to adaptively control up to XX independent groups of signals
3.1.3.2.2	The ASCT shall support groups of signals.	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.2.2.1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	4.1.2.2 The TSS Operator needs to be able to adaptively control up to XX independent groups of signals
3.1.3.2.2.2	The ASCT shall control a minimum of XX groups of signals.	4.1.2.2 The TSS Operator needs to be able to adaptively control up to XX independent groups of signals
3.1.3.2.2.3	The size of a group shall range from 1 to XX signals.	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.2.2.4	Each group shall operate independently	4.1.2.2 The TSS Operator needs to be able to adaptively control up to XX independent groups of signals

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.2.2.5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the ASCT system according to configured parameters.	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.2.2.5.1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to a time of day schedule. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.2.2.5.2	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to traffic conditions. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.2.2.5.3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	4.1.2.3 The TSS Operator needs to vary the number of signals in an adaptively controlled group to accommodate the prevailing traffic conditions.
3.1.3.3	Traffic Performance Measurement Characteristics	
3.1.3.3.1	The Performance Measurement Server shall configure how the high-resolution data is handled from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.]	4.1.3.1 The TSS Operator needs to configure performance measurement operations.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.3.1.1	High-resolution data shall include all enumerated events as described in Sturdevant, et. al., Indiana High Resolution Data Logger Enumerations, November, 2012, or later document as developed under Pooled Fund Study TPF-5(377).	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.2	High-resolution data interface is defined by (Specify latest interface control document, if available—Pooled Fund Study TPF-5(377), currently underway, will: Update the data logger specification to provide secure file transfer, incorporate new enumerations that have emerged, and logging new connected vehicle messages.	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.3	The Performance Measurement Server shall be a separate server, independent of the TSS or ASCT.	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.3.1	The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal.	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.3.2	The Performance Measurement Server shall be co-located with the TSS. (In such cases, it shall be owned by the TSS System Manager.) [This requirement is exclusive of 3.1.3.3.1.3.3—choose one or the other]	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.3.3	The Performance Measurement Server shall be located at an alternative location [specify] and managed and maintained by a separate entity [specify]. [This requirement allows the server to be shared by multiple agencies but managed by one of them, or provided as a service by a private-sector provider. Please specify in	4.1.3.1 The TSS Operator needs to configure performance measurement operations.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	this requirement. This requirement is exclusive of 3.1.3.3.1.3.2]	
3.1.3.3.1.3.4	The Performance Measurement Server shall be integrated into the TSS (ASCT).	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.3.1.3.4.1	The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal. The open-source software may be revised to facilitate integration, or to extend to additional features that may be required herein.	4.1.3.1 The TSS Operator needs to configure performance measurement operations.
3.1.3.4	Overall Architecture	
3.1.3.4.1	The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.1	The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)	4.7.1.1 The TSS Designer is constrained to using the following equipment: -Controller type (list acceptable equipment) -Controller firmware (list acceptable firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.1	The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)	4.7.1.3 The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.
3.1.3.4.1.1	Controller type (list applicable equipment)	4.7.1.1 The TSS Designer is constrained to using the following equipment: -Controller type (list acceptable equipment) -Controller firmware (list acceptable firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)
3.1.3.4.1.2	Local firmware (list applicable firmware)	4.7.1.1 The TSS Designer is constrained to using the following equipment: -Controller type (list acceptable equipment) -Controller firmware (list acceptable firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)
3.1.3.4.1.3	Communications media and protocols (list applicable equipment)	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.1.3	Communications media and protocols (list applicable equipment)	4.7.1.1 The TSS Designer is constrained to using the following equipment: -Controller type (list acceptable equipment) -Controller firmware (list acceptable firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)
3.1.3.4.1.3	Communications media and protocols (list applicable equipment)	4.7.1.3 The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.
3.1.3.4.1.3.1	AB3418E	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.1.3.1	AB3418E	4.7.1.3 The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.
3.1.3.4.1.3.2	NTCIP (SPECIFY relevant items)	4.1.5.3

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.1.3.2	NTCIP (SPECIFY relevant items)	4.7.1.3 The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.
3.1.3.4.2	The system shall fulfill all requirements when connected to XX local controller firmware (SPECIFY local controller firmware)	4.7.1.1 The TSS Designer is constrained to using the following equipment: -Controller type (list acceptable equipment) -Controller firmware (list acceptable firmware) -Communication system (list acceptable equipment) -Cabinet type and size (list acceptable equipment) -Signal management system (list acceptable systems)
3.1.3.4.3	The system shall fully satisfy all requirements when connected to the existing communications network	4.7.1.3 The TSS Designer needs to use specific communications protocols (specify AB3418E, NTCIP, or other) to all existing and future traffic signal controllers connected to the system.
3.1.3.4.3	The system shall fully satisfy all requirements when connected to the existing communications network	4.7.1.4 The TSS Designer needs to communicate to traffic signal controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.4	The system shall fulfill requirements within a communications bandwidth limit of XX Mbps (specify applicable limits).	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.5	The system shall work with the existing communications architecture (DEFINE characteristics, specifications and layout of system).	4.1.5.1 The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION): <ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>
3.1.3.4.5.1	The system shall operate on a stand alone server located at (SPECIFY LOCATION)	4.1.5.1 The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>
3.1.3.4.5.2	The system shall operate as cloud based.	<p>4.1.5.1</p> <p>The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):</p> <ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.5.3	The system shall operate with center to center capabilities.	<p>systems engineering activities to develop needs and requirements related to these interfaces.</p> <p>4.1.5.1 The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):</p> <ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>
3.1.3.4.5.4	The system shall be integrated with an Advance Traffic Management System (SPECIFY)	<p>4.1.5.1 The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):</p> <ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<ul style="list-style-type: none"> * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>
3.1.3.4.5.5	The system shall operate with on-street masters.	<p>4.1.5.1</p> <p>The TSS Operator needs to operate the system with the following architecture (EDIT TO SUIT YOUR SITUATION):</p> <ul style="list-style-type: none"> * Standalone server located at XX * Virtual server * On-street masters * Center to center (multiple servers) * Integrated with an Advanced Traffic Management System * Cloud based <p>Note: These interfaces are beyond the scope of the Model Systems Engineering documents, and responding to these needs will require additional systems engineering activities to develop needs and requirements related to these interfaces.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.6	The system shall use the following communications protocols with traffic signal controllers (SPECIFY as appropriate)	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.6	The system shall use the following communications protocols with traffic signal controllers (SPECIFY as appropriate)	4.7.1.4 The TSS Designer needs to communicate to traffic signal controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).
3.1.3.4.6.1	Ethernet	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.6.1	Ethernet	4.7.1.4 The TSS Designer needs to communicate to traffic signal controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).
3.1.3.4.6.2	Serial	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.6.2	Serial	4.7.1.4 The TSS Designer needs to communicate to traffic signal controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.3.4.6.3	Other [Specify]	4.1.5.3 The TSS Operator needs to fully operate the system within a communications bandwidth limit of XXX Mbps. (SPECIFY APPLICABLE LIMITS)
3.1.3.4.6.3	Other [Specify]	4.7.1.4 The TSS Designer needs to communicate to traffic signal controllers using Ethernet protocol (OR SERIAL OR OTHER. USER TO SPECIFY).
3.1.3.4.7	Any field device installed as part of the TSS shall fulfill NEMA TS-2 environmental requirements.	4.7.1.6 The TSS Operator needs access to and operation of the system in all environmental conditions.
3.1.3.4.8	The system shall be fully implemented within the available budget of \$[Specify]. (or included in procurement documents but not in system requirements)	4.7.1.7 The TSS Designer needs to fully implement the system with full capability within the available budget of \$(USER TO SPECIFY). (or included in procurement documents but not in system requirements)
3.1.3.6	The system shall download timing parameters to two or more controllers with one command.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.4	Database Development	
3.1.4.1	The system shall create a timing database that includes all settable signal timing parameters for a given intersection local controller based on TSS Operator input and appropriate look up tables (SPECIFY controller and firmware version).	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.
3.1.4.1	The system shall create a timing database that includes all settable signal timing parameters for a given intersection local controller based on TSS Operator input and appropriate look up tables (SPECIFY controller and firmware version).	4.2.1.5 The TSS Operator needs to develop, save and access timing parameters for a temporary condition (such as modifying phases during construction) or a new condition (such as new coordinated timings) without losing information in the original database.
3.1.4.2	The system shall allow TSS Operator to enter all settable timing parameter values manually.	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.
3.1.4.3	The system shall provide default intersection timing database templates containing the following data (SPECIFY others if needed):	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Min green, Max green, walk, flashing don't walk, yellow, red * Emergency Vehicle Preemption data * Flashing yellow left turn arrow 	copying and editing values. The database needs to be a complete and accurate representation of the local controller database.
3.1.4.4	The system shall create a copy of an entire intersection timing database.	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.
3.1.4.5	The system shall copy parts of one intersection timing database and paste to another intersection timing database (e.g., time of day schedule)	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.
3.1.4.6	The system shall copy parts of an intersection timing database and paste within the same database (e.g., timing pattern data)	4.2.1.1 The TSS Operator needs to quickly and efficiently configure local and coordinated signal timing parameters, by entering the values manually or copying and editing values. The database needs to be a complete and accurate representation of the local controller database.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.4.7	The system shall create up to (X) versions of an intersection timing database.	4.2.1.5 The TSS Operator needs to develop, save and access timing parameters for a temporary condition (such as modifying phases during construction) or a new condition (such as new coordinated timings) without losing information in the original database.
3.1.4.8	The system shall provide safeguards when developing new signal databases, including: <ul style="list-style-type: none"> * Range checking * Timing plan verification * Conflicting phases 	4.2.1.2 The TSS Operator needs to verify the validity of all parameters in the controller database, check for errors, and alert the TSS Operator before downloading it to the field controller.
3.1.4.9	The system shall create a timing sheet that includes: <ul style="list-style-type: none"> * All timing parameters relevant for operating a traffic signal. * Phase rotation diagram with north arrow * User selected parts of the timing database * Modified timings * User specified * Only non-zero timing parameters 	4.2.1.4 The TSS Operator needs to view and print timing sheets that include all the operational timing parameters, including phase diagrams. The timing sheets should be user customizable.
3.1.4.10	The system shall transfer the following signal timing data to and from Optimization Software (SPECIFY TYPE and Version): <ul style="list-style-type: none"> * Node number * Phase number and direction * Phase minimum green * Phase vehicle yellow clearance * Phase pedestrian walk 	4.2.1.3 The TSS Operator needs to interface with Optimization Software (SPECIFY TYPE and VERSION) in order to develop and update coordinated timing plans.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Phase vehicle all red * Phase pedestrian clearance * Cycle length * Offset * Coordination splits 	
3.1.5	Database Management	
3.1.5.1	<p>The system shall upload/download the intersection database to a controller:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule 	<p>4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.</p>
3.1.5.2	The system shall download the entire intersection database to a controller.	<p>4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.</p>
3.1.5.2	The system shall download the entire intersection database to a controller.	<p>4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.</p>
3.1.5.3	The system shall upload the entire intersection database from a controller.	4.2.2.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.3	The system shall upload the entire intersection database from a controller.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.4	The system shall download select parts of an intersection database to a controller.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.4	The system shall download select parts of an intersection database to a controller.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.5	The system shall upload select parts of an intersection database from a controller.	4.2.2.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.5	The system shall upload select parts of an intersection database from a controller.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.6	The system shall download timing parameters to two or more controllers with one command.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.6	The system shall download timing parameters to two or more controllers with one command.	4.4.9 Adaptive Complex Coordination and Controller Features
3.1.5.7	The system shall upload timing parameters from two or more controllers with one command.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.8	The system shall request user confirmation of command prior to downloading data from the central database to a controller.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.8	The system shall request user confirmation of command prior to downloading data from the central database to a controller.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.9	The system shall request user confirmation of command prior to saving uploaded data from a controller in the central database.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.9	The system shall request user confirmation of command prior to saving uploaded data from a controller in the central database.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.10	The system shall archive all intersection databases when commanded by user.	4.2.2.4 The TSS Operator needs to have a full and permanent record, created automatically, of any changes to data entered directly into a local controller, including a record of the date and time at which the each change is entered.
3.1.5.11	The system shall cancel upload/download if any interruptions occur during the process.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.11	The system shall cancel upload/download if any interruptions occur during the process.	4.2.2.3 The TSS Operator needs to upload and download timings to a single intersection or a group of intersections, such as to download a command for a special incident timing plan along a corridor or to change the offset at multiple intersections while fine tuning the coordinated timings.
3.1.5.12	The system shall revert to previous version of the database at the request of the user.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.5.13	<p>The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred 	<p>4.2.2.4 The TSS Operator needs to have a full and permanent record, created automatically, of any changes to data entered directly into a local controller, including a record of the date and time at which the each change is entered.</p>
3.1.5.13	<p>The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred 	<p>4.5.1.3 The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.</p>
3.1.5.13	<p>The system shall log any changes made to the database, including:</p> <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred 	<p>4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.</p>
3.1.5.14	<p>The system shall compare two intersection databases (central and local) and highlight the differences.</p>	<p>4.2.2.2 The TSS Operator needs to compare the field controller database with the central database and save all or part of the local controller database to the central database.</p>
3.1.5.15	<p>The system shall save the entire uploaded intersection database.</p>	<p>4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.5.15	The system shall save the entire uploaded intersection database.	4.2.2.2 The TSS Operator needs to compare the field controller database with the central database and save all or part of the local controller database to the central database.
3.1.5.15	The system shall save the entire uploaded intersection database.	4.2.2.4 The TSS Operator needs to have a full and permanent record, created automatically, of any changes to data entered directly into a local controller, including a record of the date and time at which the each change is entered.
3.1.5.16	The system shall save selected parts of an uploaded intersection database.	4.2.2.1 The TSS Operator needs to quickly and efficiently upload and download timing parameters between the system and local controllers with no risk of data corruption or errors.
3.1.5.16	The system shall save selected parts of an uploaded intersection database.	4.2.2.2 The TSS Operator needs to compare the field controller database with the central database and save all or part of the local controller database to the central database.
3.1.5.16	The system shall save selected parts of an uploaded intersection database.	4.2.2.4 The TSS Operator needs to have a full and permanent record, created automatically, of any

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		changes to data entered directly into a local controller, including a record of the date and time at which the each change is entered.
3.1.5.17	The system shall clearly identify the official version of the timing database.	4.2.1.5 The TSS Operator needs to develop, save and access timing parameters for a temporary condition (such as modifying phases during construction) or a new condition (such as new coordinated timings) without losing information in the original database.
3.1.5.18	The system shall provide multiple methods to open an intersection database: * Dynamically select intersection on map * Search feature that uses intersection name and partial name * Search feature that uses intersection ID number	4.2.2.5 The TSS Operator needs to search the system for each intersection database by using the intersection name or number or using the system map to point to and select the intersection.
3.1.5.19	The ASCT shall log the following events: (edit as appropriate)	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.1	Time-stamped vehicle phase calls	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.2	Time-stamped pedestrian phase calls	4.5.1.5

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.3	Time-stamped emergency vehicle preemption calls	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.4	Time-stamped transit priority calls	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.5	Time-stamped railroad preemption calls	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.6	Time-stamped start and end of each phase	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.19.7	Time-stamped controller interval changes	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.5.19.8	Time-stamped start and end of each transition to a new timing plan.	4.5.1.5 The TSS Operator needs to report the exact state of signal timing and input data for a specified period, to allow historical analysis of the system operation.
3.1.5.20	The ASCT shall export its systems log in the following formats: (edit as appropriate) * MS Excel * Text * CVS * Open source SQL database	4.5.2.4 The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).
3.1.5.21	The ASCT shall store the event log for a minimum of XX days	4.5.2.4 The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).
3.1.5.22	The TSS shall store results of all signal timing parameter calculations for a minimum of XX days.	4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.
3.1.5.22	The TSS shall store results of all signal timing parameter calculations for a minimum of XX days.	4.5.2.3 The TSS Operator needs to store and report data that can be used to measure traffic performance under adaptive control.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.5.23	<p>The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency 	<p>4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.</p>
3.1.5.23	<p>The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency 	<p>4.5.2.3 The TSS Operator needs to store and report data that can be used to measure traffic performance under adaptive control.</p>
3.1.5.23	<p>The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency 	<p>4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.</p>
3.1.5.24	<p>The ASCT system shall archive all data automatically after a user-specified period not less than XX days.</p>	<p>4.5.2.4</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).
3.1.5.25	<p>The ASCT shall provide data storage for a system size of XX signal controllers. The data to be stored shall include the following: (edit as appropriate)</p> <ul style="list-style-type: none"> * Controller state data * Reports * Log data * Security data * ASCT parameters * Detector status data 	<p>4.5.2.4</p> <p>The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).</p>
3.1.5.26	<p>The ASCT shall calculate and report relative data quality including:</p> <ul style="list-style-type: none"> * The extent data is affected by detector faults * Other applicable items 	<p>4.5.2.6</p> <p>The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.</p>
3.1.5.27	<p>The ASCT shall report comparisons of logged data when requested by the user:</p> <ul style="list-style-type: none"> * Day to day, * Hour to hour * Hour of day to hour of day * Hour of week to hour of week * Day of week to day week * Day of year to day of year 	<p>4.5.2.6</p> <p>The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.5.28	The ASCT shall store data logs in a standard database (specify as appropriate).	4.5.2.4 The TSS Operator needs to store all operational data and signal timing parameters calculated by the adaptive system, and export selected data to (specify appropriate external system).
3.1.5.29	The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.5.30	The ASCT shall store the following data in XX minute increments: (edit as appropriate) * volume * occupancy * queue length	4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.
3.1.5.30	The ASCT shall store the following data in XX minute increments: (edit as appropriate) * volume * occupancy * queue length	4.5.2.3 The TSS Operator needs to store and report data that can be used to measure traffic performance under adaptive control.
3.1.6	Failure Events and Fallback	
3.1.6.1	Detector Failure	
3.1.6.1.1	The ASCT shall take user-specified action in the absence of valid detector data from XX vehicle	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	detectors within a group. (SELECT THE APPROPRIATE ACTION.)	the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.1.1	The ASCT shall release control to central system control.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.1.2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.6.1.2.1	* Data from a user-specified alternate detector.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.2.2	* Stored historical data from the failed detector.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.2.3	The ASCT shall switch to the alternate source in real time without operator intervention.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.1.3	In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.4.10.1 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.6.1.3	In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.4.10.2 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).
3.1.6.1.4	In the event of a failure, the TSS/ASCT shall log details of the failure in a permanent log.	4.1.6.2 The TSS Operator needs to maintain a complete log of alarms and failure events.
3.1.6.1.5	The permanent failure log shall be searchable, archivable and exportable.	4.1.6.2 The TSS Operator needs to maintain a complete log of alarms and failure events.
3.1.6.2	Communications Failure	
3.1.6.2.1	The TSS shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.6.2.1.1	In the event of loss of communication to a user-specified signal controller, the TSS shall release control of all signal controllers within a user-specified group to local control.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.6.2.1.2	The TSS shall switch to the alternate operation in real time without operator intervention.	4.1.6.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.6.2.2	In the event of communications failure, the TSS shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.5.6.3 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.
3.1.6.2.2	In the event of communications failure, the TSS shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.5.6.4 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).
3.1.6.2.3	The TSS shall issue an alarm within XX minutes of detection of a failure.	4.5.6.3 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.
3.1.6.2.3	The TSS shall issue an alarm within XX minutes of detection of a failure.	4.5.6.4 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).
3.1.6.2.4	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.2.4.1	In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.2.4.2	The ASCT shall switch to the alternate operation in real time without operator intervention.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.2.5	In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.6.2.5	In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.4.10.1 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.
3.1.6.2.5	In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	4.4.10.2 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).
3.1.6.2.6	The ASCT shall issue an alarm within XX minutes of detection of a failure.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.2.6	The ASCT shall issue an alarm within XX minutes of detection of a failure.	4.4.10.1 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.
3.1.6.2.6	The ASCT shall issue an alarm within XX minutes of detection of a failure.	4.4.10.2 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.6.2.7	In the event of a communications failure, the TSS/ASCT shall log details of the failure in a permanent log.	4.1.6.2 The TSS Operator needs to maintain a complete log of alarms and failure events.
3.1.6.2.8	The permanent failure log shall be searchable, archivable and exportable.	4.1.6.2 The TSS Operator needs to maintain a complete log of alarms and failure events.
3.1.6.3	Adaptive Processor Failure	
3.1.6.3.1	The ASCT shall execute user-specified actions when adaptive control fails:	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.3.1.1	The ASCT shall release control to central system control.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.3.1.2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.3.2	In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.6.3.2	In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance	4.4.10.1 The TSS Operator needs to immediately notify maintenance and operations staff of alarms and alerts.
3.1.6.3.2	In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance	4.4.10.2 The TSS Operator needs to immediately and automatically pass alarms and alerts to the (specify external system).
3.1.6.3.3	The permanent failure log shall be searchable, archivable and exportable.	
3.1.6.3.4	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.7	Monitoring	
3.1.7.1	Mapping	
3.1.7.1.1	The system shall update the status of all traffic signal controller connected to the system every (XX) seconds.	4.1.5.2 The TSS Operator needs to access the system at all times to view status or manage the system.
3.1.7.1.2	The system shall update the status of all traffic signal controllers connected to the system 24 hours a day, 7 days a week.	4.1.5.2 The TSS Operator needs to access the system at all times to view status or manage the system.
3.1.7.1.3	The system shall provide a map that displays different levels of information: * Statewide * Area-wide * Corridor * Intersection	4.5.7.1 The TSS Operator needs to observe the operation of traffic signal field equipment.
3.1.7.1.3	The system shall provide a map that displays different levels of information: * Statewide * Area-wide * Corridor * Intersection	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.7.1.3	<p>The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection 	<p>4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.</p>
3.1.7.1.3	<p>The system shall provide a map that displays different levels of information:</p> <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection 	<p>4.5.7.1.4 The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.</p>
3.1.7.1.4	<p>The system shall provide a display that uses a cloud based system map (SPECIFY DETAILS)</p>	<p>4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.</p>
3.1.7.1.5	<p>The system shall provide a display that uses an existing agency map as background (Autocad, GIS, JPEG, etc.)</p>	<p>4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.</p>
3.1.7.1.6	<p>The system shall move between levels seamlessly, without having to open new files or windows.</p>	<p>4.5.7.1 The TSS Operator needs to observe the operation of traffic signal field equipment.</p>
3.1.7.1.6	<p>The system shall move between levels seamlessly, without having to open new files or windows.</p>	<p>4.5.7.1.4</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.
3.1.7.1.7	The system shall have pan and zoom capabilities.	4.5.7.1 The TSS Operator needs to observe the operation of traffic signal field equipment.
3.1.7.1.7	The system shall have pan and zoom capabilities.	4.5.7.1.4 The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.
3.1.7.1.8	The system shall automatically adjust the display depending on the 'zoom level'.	4.5.7.1 The TSS Operator needs to observe the operation of traffic signal field equipment.
3.1.7.1.8	The system shall automatically adjust the display depending on the 'zoom level'.	4.5.7.1.4 The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.7.1.9	<p>At the state wide and area-wide level map, the system shall display a color coded status of the following systems:</p> <ul style="list-style-type: none"> * Communication * Coordination * Intersection flash mode * Preemption 	<p>4.5.7.1.4 The TSS Operator needs to view real time communications status, operational status and equipment status for all equipment connected to the signal system. The status should be color coded to quickly see issues.</p>
3.1.7.1.10	<p>At the corridor level map, the system shall display the following timing related information:</p> <ul style="list-style-type: none"> * Real time or other measureable period [Specify period length(s)] time-space-diagrams * Split times * Phase status * Detector status (vehicle and pedestrian) * Local cycle lengths/timer * Background cycle length/timer * Offset * Intersection identifier 	<p>4.5.7.2 The TSS Operator needs to view a real-time time-space-diagram of user defined intersection group, including real time splits, offsets and coordinated phase detector actuations of each intersection in group.</p>
3.1.7.1.11	<p>The system shall provide a library of intersection drawings (e.g., standard four-legged intersections, standard tee intersection, five-legged intersection, six legged intersection, etc.) to develop intersection level graphics that are geometrically correct diagrams.</p>	<p>4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.</p>
3.1.7.1.12	<p>The system shall provide a library of symbols for inputs and outputs to help construct the intersection display.</p>	<p>4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.7.1.13	The system shall allow the TSS Operator to import customized graphical icons to the map icon library.	4.5.7.1.3 The TSS Operator needs to quickly and efficiently set up the intersection status display on the map, including all inputs and outputs at the intersection.
3.1.7.1.14	The system shall display multiple individual intersection-level views simultaneously as separate displays or tiled windows (SPECIFY minimum and maximum numbers).	4.5.7.1 The TSS Operator needs to observe the operation of traffic signal field equipment.
3.1.7.1.14	The system shall display multiple individual intersection-level views simultaneously as separate displays or tiled windows (SPECIFY minimum and maximum numbers).	4.5.7.1.2 The TSS Operator needs to select a predetermined group of intersections to monitor.
3.1.7.2	Intersection Status	
3.1.7.2.1	The system shall open the intersection display when the intersection on the main map is clicked on.	4.5.7.1.1 The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.7.2.2	The system shall show the current phase status of an intersection upon operator selection of the associated intersection icon on the map display.	4.5.7.1.1 The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.7.2.3	The system shall display the following traffic signal controller information:	4.5.7.1.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Intersection name/number * Controller type * Firmware and version * IP address 	The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.7.2.4	<p>The system shall have the capability to display all controller outputs in real-time, including:</p> <ul style="list-style-type: none"> * Vehicle phases (including overlaps) * Pedestrian phases * Bicycle phases * Signs controlled by the signal controller 	4.5.7.1.1 The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.7.2.5	<p>The system shall have the capability to display all controller inputs in real time, including:</p> <ul style="list-style-type: none"> * Vehicle detector actuations * Pedestrian detector actuations * Bicycle detector actuations * Transit signal priority * Railroad preemption * Emergency vehicle preemption 	4.5.7.1.1 The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.7.2.6	The system shall display the data shown on the virtual controller front panel based on a user-selected intersection.	4.5.7.1.1 The TSS Operator needs to view real time display of an intersection and typical controller front panel information status of operating mode, phases, and detectors.
3.1.8	Control	
3.1.8.1	Time Management	

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.1.1	<p>The system shall receive the current time from a source:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	<p>4.1.1.4 The TSS operator needs to receive current time from a source to ensure time synchronization between signals.</p>
3.1.8.1.2	<p>The system shall re-sync the local controller time clock through a manual command.</p>	<p>4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.</p>
3.1.8.1.2	<p>The system shall re-sync the local controller time clock through a manual command.</p>	<p>4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.</p>
3.1.8.1.3	<p>The system shall re-sync the local controller's time clock automatically [Specify conditions for triggering automatic re-sync].</p>	<p>4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.</p>
3.1.8.1.3	<p>The system shall re-sync the local controller's time clock automatically [Specify conditions for triggering automatic re-sync].</p>	<p>4.3.13 The TSS Operator needs to configure when local controllers time clocks are automatically re-synced from an external time source. [Specify conditions for triggering automatic re-sync]</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.1.4	<p>The system shall provide a time synch to each controller using:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	<p>4.1.1.5 The TSS Operator needs to coordinate traffic signals managed by another system. Note: Cross-jurisdictional heading.</p>
3.1.8.1.4	<p>The system shall provide a time synch to each controller using:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	<p>4.3.3 The TSS Operator needs to send and receive data from another system that would allow the two systems to be coordinated.</p>
3.1.8.1.4	<p>The system shall provide a time synch to each controller using:</p> <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	<p>4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.</p>
3.1.8.2	System Management	
3.1.8.2.1	<p>The system shall allow the traffic signals to operate in coordinated mode.</p>	<p>4.3.1 The TSS Operator needs to operate all signals attached to the system based on their local time of day schedule.</p>
3.1.8.2.1	<p>The system shall allow the traffic signals to operate in coordinated mode.</p>	<p>4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		coordinated timings and other operations that require a common time.
3.1.8.2.2	The system shall allow the traffic signals to operate according to local control in case of communications failure.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.8.2.3	The system shall allow the traffic signals to operate according to local control in case of TSS failure.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.8.2.4	The system shall download manual command to the local controller to change intersection operations to free.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.5	The system shall download manual command to the local controller to change intersection operations to flash.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.2.6	The system shall download manual command to the local controller to implement a timing plan	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.7	The system shall operate manual selection of timing plans as a higher priority over all other modes of plan selection.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.8	The system shall request confirmation from the TSS Operator before a manual command is implemented.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.9	The system shall provide a start and end time for manual commands.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.2.10	The system shall provide a duration for manual commands.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.11	The system shall revert to time of day operation after the manual command ends.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.12	The system shall time-stamp a log of all manual commands.	4.3.4 The TSS Operator needs to override time of day, with a manual command, at an intersection or group of intersections at any time until manually set back to scheduled operation, or expiration of a timer to cancel the override.
3.1.8.2.12	The system shall time-stamp a log of all manual commands.	4.3.8 The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.
3.1.8.2.12	The system shall time-stamp a log of all manual commands.	4.5.1.3

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.8.2.12	The system shall time-stamp a log of all manual commands.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.
3.1.8.2.13	The system shall place non-locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.	4.3.8 The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.
3.1.8.2.14	The system shall place a locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.	4.3.8 The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.
3.1.8.2.15	The system shall place a non-locking call replicating an emergency vehicle preemption call on a user specified preemption channel at a user specified intersection.	4.3.8 The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.
3.1.8.2.16	The system shall receive data from another system (SPECIFY DETAILS).	4.3.8 The TSS Operator needs to send manual commands to simulate vehicle and pedestrian detection and preemption calls.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.2.16	The system shall receive data from another system (SPECIFY DETAILS).	4.3.10 The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.
3.1.8.2.17	The system shall receive data from another system (SPECIFY DETAILS).	4.3.3 The TSS Operator needs to send and receive data from another system that would allow the two systems to be coordinated.
3.1.8.2.17	The system shall receive data from another system (SPECIFY DETAILS).	4.3.10 The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.
3.1.8.2.17	The system shall receive data from another system (SPECIFY DETAILS).	4.3.11 The TSS Operator needs to accommodate bus and light rail transit signal priority (USER SPECIFY FOR NECESSARY DETAILS).
3.1.8.2.17	The system shall receive data from another system (SPECIFY DETAILS).	4.3.12 The TSS Operator needs to accommodate rail preemption based on an external input from the railroad.
3.1.8.2.18	In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined emergency vehicle preemption.	4.3.10 The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.2.19	In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined railroad preemption.	4.3.12 The TSS Operator needs to accommodate rail preemption based on an external input from the railroad.
3.1.8.2.20	The system shall send data to another system (SPECIFY DETAILS).	4.3.3 The TSS Operator needs to send and receive data from another system that would allow the two systems to be coordinated.
3.1.8.2.20	The system shall send data to another system (SPECIFY DETAILS).	4.3.10 The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.
3.1.8.2.20	The system shall send data to another system (SPECIFY DETAILS).	4.3.11 The TSS Operator needs to accommodate bus and light rail transit signal priority (USER SPECIFY FOR NECESSARY DETAILS).
3.1.8.2.20	The system shall send data to another system (SPECIFY DETAILS).	4.3.12 The TSS Operator needs to accommodate rail preemption based on an external input from the railroad.
3.1.8.2.21	The system shall turn on and turn off message signs from a manual command.	4.3.9 The TSS Operator needs to turn on and off external devices, such as message signs, by manual command,

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		by time of day, or based on a user defined trigger (such as volume).
3.1.8.2.22	The system shall turn on and turn off message signs based on a user specified trigger (SPECIFY).	4.3.9 The TSS Operator needs to turn on and off external devices, such as message signs, by manual command, by time of day, or based on a user defined trigger (such as volume).
3.1.8.2.23	The system shall interface with external rail preemption system. (explain the external system and refer to other interfaces as appropriate)	4.3.12 The TSS Operator needs to accommodate rail preemption based on an external input from the railroad.
3.1.8.2.24	The system shall interface with external emergency vehicle preemption system. (explain the external system and refer to other interfaces as appropriate)	4.3.10 The TSS Operator needs to accommodate centrally directed emergency vehicle preemption based on an external input from the emergency system.
3.1.8.2.25	The system shall interface with external light rail transit. (explain the external system and refer to other interfaces as appropriate)	4.3.11 The TSS Operator needs to accommodate bus and light rail transit signal priority (USER SPECIFY FOR NECESSARY DETAILS).
3.1.8.2.26	The system shall interface with external bus priority system. (explain the external system and refer to other interfaces as appropriate)	4.3.11 The TSS Operator needs to accommodate bus and light rail transit signal priority (USER SPECIFY FOR NECESSARY DETAILS).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.3	Control Modes	
3.1.8.3.1	The system shall operate in the following control modes:	<p>4.3.1 The TSS Operator needs to operate all signals attached to the system based on their local time of day schedule.</p>
3.1.8.3.1	The system shall operate in the following control modes:	<p>4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.</p>
3.1.8.3.1	The system shall operate in the following control modes:	<p>4.3.5 The TSS Operator needs to accommodate traffic in a network that displays predictable traffic patterns during variable periods. For example, the traffic pattern for the afternoon peak may be predictable enough to be served by a defined timing plan, but the time of day in which the condition appears may be variable from one day to the next. (Note: For operations not consistent with this need statement, consider using adaptive.)</p> <p>[When selecting this need, select one of the two child needs below. If you have no preference for the pattern selection method, select both, but include this text here: The Vendor may fulfill the requirements traced to either one of the child needs below.]</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.3.1	The system shall operate in the following control modes:	<p>4.3.6</p> <p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection
3.1.8.3.1.1	Time of day schedule	<p>4.3.1</p> <p>The TSS Operator needs to operate all signals attached to the system based on their local time of day schedule.</p>
3.1.8.3.1.1	Time of day schedule	<p>4.3.5</p> <p>The TSS Operator needs to accommodate traffic in a network that displays predictable traffic patterns during variable periods. For example, the traffic pattern for the afternoon peak may be predictable enough to be served by a defined timing plan, but the time of day in which the condition appears may be variable from one day to the next. (Note: For operations not consistent with this need statement, consider using adaptive.)</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		[When selecting this need, select one of the two child needs below. If you have no preference for the pattern selection method, select both, but include this text here: The Vendor may fulfill the requirements traced to either one of the child needs below.]
3.1.8.3.1.1	Time of day schedule	<p>4.3.6</p> <p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection
3.1.8.3.1.2	Manual control	<p>4.3.6</p> <p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.3.1.3	Traffic responsive	<p>4.3.5</p> <p>The TSS Operator needs to accommodate traffic in a network that displays predictable traffic patterns during variable periods. For example, the traffic pattern for the afternoon peak may be predictable enough to be served by a defined timing plan, but the time of day in which the condition appears may be variable from one day to the next. (Note: For operations not consistent with this need statement, consider using adaptive.)</p> <p>[When selecting this need, select one of the two child needs below. If you have no preference for the pattern selection method, select both, but include this text here: The Vendor may fulfill the requirements traced to either one of the child needs below.]</p>
3.1.8.3.1.3	Traffic responsive	<p>4.3.6</p> <p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection
3.1.8.3.1.4	External command	4.3.6

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection
3.1.8.3.1.5	Local control mode	<p>4.3.1 The TSS Operator needs to operate all signals attached to the system based on their local time of day schedule.</p>
3.1.8.3.1.6	Central control mode	<p>4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.</p>
3.1.8.4	Time of Day Operation	
3.1.8.4.1	The system shall implement the following user-specified actions according to a time of day schedule:	<p>4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.4.1	The system shall implement the following user-specified actions according to a time of day schedule:	4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.
3.1.8.4.1	The system shall implement the following user-specified actions according to a time of day schedule:	4.3.9 The TSS Operator needs to turn on and off external devices, such as message signs, by manual command, by time of day, or based on a user defined trigger (such as volume).
3.1.8.4.1.1	Re-synch the local controller time clock	4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.
3.1.8.4.1.1	Re-synch the local controller time clock	4.3.7 The TSS Operator needs to keep local intersection controllers in synch with each other to operate coordinated timings and other operations that require a common time.
3.1.8.4.1.2	.Activate a coordination pattern	4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.
3.1.8.4.1.3	.Activate an external output	4.3.2

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to program commands for local operation based on central time of day schedule.
3.1.8.4.1.3	.Activate an external output	4.3.9 The TSS Operator needs to turn on and off external devices, such as message signs, by manual command, by time of day, or based on a user defined trigger (such as volume).
3.1.8.4.1.4	.Deactivate an external output	4.3.2 The TSS Operator needs to program commands for local operation based on central time of day schedule.
3.1.8.4.1.4	.Deactivate an external output	4.3.9 The TSS Operator needs to turn on and off external devices, such as message signs, by manual command, by time of day, or based on a user defined trigger (such as volume).
3.1.8.5	Traffic Responsive Operation	
3.1.8.5.1	The system shall operate in traffic responsive mode when commanded: * By manual TSS Operator command * By time of day schedule * By external input command	4.3.5 The TSS Operator needs to accommodate traffic in a network that displays predictable traffic patterns during variable periods. For example, the traffic pattern for the afternoon peak may be predictable enough to be served by a defined timing plan, but the

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>time of day in which the condition appears may be variable from one day to the next. (Note: For operations not consistent with this need statement, consider using adaptive.)</p> <p>[When selecting this need, select one of the two child needs below. If you have no preference for the pattern selection method, select both, but include this text here: The Vendor may fulfill the requirements traced to either one of the child needs below.]</p>
3.1.8.5.1	<p>The system shall operate in traffic responsive mode when commanded:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule * By external input command 	<p>4.3.6</p> <p>The TSS Operator needs to enable a diversion plan in case of an incident (or other activities). The TSS Operator needs to be enabled at an intersection or a group of intersections and select the appropriate operating plan based on:</p> <ul style="list-style-type: none"> * Time of day schedule * Manual command * Command from an external system (USER SPECIFY) * Traffic responsive pattern selection
3.1.8.5.1.1	<p>The TSS shall accept a user-defined assignment of intersection detectors as system detectors.</p>	<p>4.3.5.1</p> <p>The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.1	The TSS shall accept a user-defined assignment of intersection detectors as system detectors.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.2	The TSS shall accept a user-defined occupancy weighting factor for each system detector.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.2	The TSS shall accept a user-defined occupancy weighting factor for each system detector.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.3	The TSS shall accept a user-defined traffic-responsive control period.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.3	The TSS shall accept a user-defined traffic-responsive control period.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.4	The TSS shall sum volume plus weighted occupancy for each system detector over the duration of the control period (volume comprises distinct detection of on and off events, and weighted occupancy is the percentage of time the detector is occupied by a vehicle multiplied by the occupancy weighting factor)	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.5.1.4	The TSS shall sum volume plus weighted occupancy for each system detector over the duration of the control period (volume comprises distinct detection of on and off events, and weighted occupancy is the percentage of time the detector is occupied by a vehicle multiplied by the occupancy weighting factor)	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.5	The TSS shall accept a user-defined detector weighting factor to be applied to each system detector volume plus weighted occupancy.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.5	The TSS shall accept a user-defined detector weighting factor to be applied to each system detector volume plus weighted occupancy.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.5.1.6	The TSS shall multiply the volume plus weighted occupancy by the detector weighting factor.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.6	The TSS shall multiply the volume plus weighted occupancy by the detector weighting factor.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.7	The TSS shall select coordination patterns based on threshold levels (this is an alternative to the pattern recognition method).	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.1	The TSS shall accept a user-defined selection of system detectors designated as inbound detectors.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.2	The TSS shall accept a user-defined selection of system detectors designated as outbound detectors.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.3	The TSS shall total the weighted volume plus weighted occupancy for inbound detectors within each intersection group over the control period.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.4	The TSS shall total the weighted volume plus weighted occupancy for outbound detectors within each intersection group over the control period.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.5.1.7.5	The TSS shall accept user-defined thresholds for inbound pattern selection.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.6	The TSS shall accept user-defined thresholds for outbound pattern selection.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.7	The TSS shall accept different thresholds for increasing weighted volume plus weighted occupancy totals than for decreasing weighted volume plus weighted occupancy totals (this provides the ability to incorporate hysteresis).	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.8	The TSS shall accept user-defined coordination pattern designations for each level of total weighted volume plus weighted occupancy bounded by thresholds.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.9	The TSS shall compare the weighted volume plus weighted occupancy totals against the defined thresholds.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.7.10	The TSS shall engage the inbound or outbound coordination pattern defined for the weighted volume plus weighted occupancy totals.	4.3.5.1 The network is linear and displays inbound and outbound traffic patterns such that the TSS Operator needs to select patterns using an inbound and outbound threshold selection scheme. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the threshold level selection method.)
3.1.8.5.1.8	The TSS shall select coordination patterns based on pattern recognition (this is an alternative to the threshold method).	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.8.5.1.8.1	The TSS shall accept a table of coordination pattern designations coupled to user-defined “signature” total weighted volume plus weighted occupancy values (totals over the duration of the control period).	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.8.2	The TSS shall compare the total weighted volume plus weighted occupancy for each intersection group over the duration of the control period against the user-defined “signature” values.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.8.5.1.8.3	The TSS shall engage the coordination pattern with the signature value that comes closest to the total weighted volume plus weighted occupancy for the intersection group.	4.3.5.2 The network is not linear and does not display pronounced inbound and outbound traffic patterns, such that the TSS Operator needs to select patterns based on which pattern most closely matches the demand conditions, without regard to inbound or outbound emphasis. (This need is appropriate for agencies that have already decided to use traffic-

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		responsive selection of coordination patterns using the pattern-matching selection method.)
3.1.9	Adaptive Operations	
3.1.9.1	General	
3.1.9.1.1	Mode of Operation	
3.1.9.1.1.1	The ASCT shall operate non-adaptively during the presence of a defined condition.	4.4.7 Non-Adaptive Situations
3.1.9.1.1.1	The ASCT shall operate non-adaptively during the presence of a defined condition.	4.4.7.1 The TSS Operator needs to detect traffic conditions during which adaptive control is not the preferred operation, and implement some pre-defined operation while that condition is present.
3.1.9.1.1.2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.9.1.1.2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.2.1	The ASCT shall operate non-adaptively when a user-specified detector fails.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.9.1.1.2.1	The ASCT shall operate non-adaptively when a user-specified detector fails.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.9.1.1.2.2	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.9.1.1.2.2	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.2.3	The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.9.1.1.2.3	The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.
3.1.9.1.1.2.4	The ASCT shall operate non-adaptively when a user-defined communications link fails.	4.1.6.1 The TSS Operator needs the local traffic signal controllers to fall back to local control without causing disruption to traffic flow, in the event of equipment, communications, or software failure.
3.1.9.1.1.2.4	The ASCT shall operate non-adaptively when a user-defined communications link fails.	4.1.7.1 The TSS Operator needs to fall back to non-adaptive operation as defined in section 4.3, as specified by the operator, without causing disruption to traffic flow, in the event of equipment, communications and software failure. Non-adaptive operation is defined in the TSS needs and requirements.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.3	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	4.4.7.3 The TSS Operator needs to over-ride adaptive operation.
3.1.9.1.1.4	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation.	4.4.7.3 The TSS Operator needs to over-ride adaptive operation.
3.1.9.1.1.5	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	4.4.7.2 The TSS Operator needs to schedule pre-determined operation by time of day.
3.1.9.1.1.5	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	4.4.7.3 The TSS Operator needs to over-ride adaptive operation.
3.1.9.1.1.6	The ASCT shall operate non-adaptively when commanded by an external system process.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.9.1.1.7	The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.7	The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.7	The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)	4.4.1.3 The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.
3.1.9.1.1.7.1	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the	4.4.1.1.1 ·Maximize the throughput on coordinated routes

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	signal controllers, maximizing the throughput of the coordinated route.	Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.7.1	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.	4.4.1.3 The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.
3.1.9.1.1.7.2	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.1.1.7.2	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.	4.4.1.3 The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.
3.1.9.1.1.7.3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.7.3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	4.4.1.3 The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.7.4	When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.7.4	When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.	4.4.1.3 The TSS Operator needs to change the operational strategy (for example, from smooth flow to maximizing throughput or managing queues) based on changing traffic conditions.
3.1.9.1.1.8	The ASCT shall provide maximum and minimum phase times.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.8	The ASCT shall provide maximum and minimum phase times.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.1.1.8.1	The ASCT shall provide a user-specified maximum value for each phase at each signal controller.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.8.1	The ASCT shall provide a user-specified maximum value for each phase at each signal controller.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.8.1.1	The ASCT shall not provide a phase length longer than the maximum value.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.8.1.1	The ASCT shall not provide a phase length longer than the maximum value.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.1.1.8.2	The ASCT shall provide a user-specified minimum value for each phase at each signal controller.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.8.2	The ASCT shall provide a user-specified minimum value for each phase at each signal controller.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.1.1.8.2.1	The ASCT shall not provide a phase length shorter than the minimum value.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.8.2.1	The ASCT shall not provide a phase length shorter than the minimum value.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.9	The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as by detecting repeated max-out.)	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.
3.1.9.1.1.9.1	The ASCT shall alter operations, to minimize repeated phase failures.	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.1.11	The ASCT shall provide coordination along a route.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.1	The ASCT shall coordinate along a user-defined route.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.2	The ASCT shall determine the coordinated route based on traffic conditions.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.1.11.3	The ASCT shall determine the coordinated route based on a user-defined schedule.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.4	The ASCT shall store XX user-defined coordination routes.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.4.1	The ASCT shall implement a stored coordinated route by operator command.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.4.2	The ASCT shall implement a stored coordinated route based on traffic conditions.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.11.4.3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	4.4.1.8 The TSS Operator needs to designate the coordinated route based on traffic conditions and the selected operational strategy.
3.1.9.1.1.12	The ASCT shall not prevent the use of phase timings in the local controller set by agency policy.	4.4.1.9 The TSS Operator needs to set signal timing parameters (such as minimum green, maximum

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		green and extension time) to comply with agency policies.
3.1.9.1.2	Allowable Phases	
3.1.9.1.2.1	The ASCT shall not prevent protected/permissive left turn phase operation.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.1	The ASCT shall not prevent protected/permissive left turn phase operation.	4.4.9.1.14 Protected/permissive phasing and alternate left turn phase sequences.
3.1.9.1.2.2	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.2	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	4.4.9.1.14 Protected/permissive phasing and alternate left turn phase sequences.
3.1.9.1.2.3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:

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3.1.9.1.2.3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	4.4.9.1.6 Prevent one or more phases being skipped under certain traffic conditions or signal states.
3.1.9.1.2.4	The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.4	The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.	4.4.9.1.6 Prevent one or more phases being skipped under certain traffic conditions or signal states.
3.1.9.1.2.4	The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.9.1.2.5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	4.4.9.1.6 Prevent one or more phases being skipped under certain traffic conditions or signal states.

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3.1.9.1.2.6	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.6	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	4.4.9.1.5 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
3.1.9.1.2.7	The ASCT shall omit a user-specified phase based on measured traffic conditions.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.7	The ASCT shall omit a user-specified phase based on measured traffic conditions.	4.4.9.1.5 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
3.1.9.1.2.8	The ASCT shall omit a user-specified phase based on the state of a user-specified external input.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.8	The ASCT shall omit a user-specified phase based on the state of a user-specified external input.	4.4.9.1.5 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
3.1.9.1.2.8	The ASCT shall omit a user-specified phase based on the state of a user-specified external input.	4.9.6

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.9.1.2.9	The ASCT shall omit a user-specified phase according to a time of day schedule	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.9	The ASCT shall omit a user-specified phase according to a time of day schedule	4.4.9.1.5 Allow one or more phases to be omitted (disabled) under certain traffic conditions or signal states.
3.1.9.1.2.10	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows: * next phase; * next coordinated phase;user-specified phase.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.9.1.2.10	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows: * next phase; * next coordinated phase;user-specified phase.	4.4.9.1.10 Allow the operator to specify which phase receives unused time from a preceding phase
3.1.9.1.2.11	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows: * previous phase; * next phase;	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * next coordinated phase; * user-specified phase. 	
3.1.9.1.2.11	<p>The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows:</p> <ul style="list-style-type: none"> * previous phase; * next phase; * next coordinated phase; * user-specified phase. 	<p>4.4.9.1.10 Allow the operator to specify which phase receives unused time from a preceding phase</p>
3.1.9.1.2.12	<p>The ASCT shall not alter the order of phases at a user-specified intersection.</p>	<p>4.4.1.7 The TSS Operator needs to fix the sequence of phases at any specified location. For example, the operator may need to fix the phase order at a diamond interchange.</p>
3.1.9.1.3	Oversaturation	
3.1.9.1.3.1	<p>The ASCT shall detect the presence of queues at pre-configured locations.</p>	<p>4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		strategy, particularly when congestion is present, is covered under 4.4.1.5.
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.4.1 The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.4.2 The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.4.3 The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	<p>4.4.1.1.4</p> <ul style="list-style-type: none"> ·Manage the lengths of queues <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	<p>4.4.1.1.5</p> <ul style="list-style-type: none"> ·Manage the locations of queues within the network <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.4.1 The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.4.2 The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.4.3 The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.1.3.3	<p>When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p>	<p>4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.</p>
3.1.9.1.3.3	<p>When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.</p>	<p>4.4.4.1 The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.4.2 The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.4.3 The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.5	The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.1.3.5	The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.5	The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.5	The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.6	The ASCT shall store queues at user-specified locations.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.6	The ASCT shall store queues at user-specified locations.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.1.3.6	The ASCT shall store queues at user-specified locations.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.6	The ASCT shall store queues at user-specified locations.	4.4.4.5

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.7	The ASCT shall maintain capacity flow through user-specified bottlenecks.	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.9.1.3.7	The ASCT shall maintain capacity flow through user-specified bottlenecks.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.9.1.3.8	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2	Sequence-based Adaptive Coordination	

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.2.1	Use this section if sequence-based adaptive coordination is likely to provide acceptable operation in your situation.	
3.1.9.2.2	(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.	<p>4.4.1.1.1</p> <ul style="list-style-type: none"> ·Maximize the throughput on coordinated routes <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.2.2	(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.	<p>4.4.1.1.2</p> <ul style="list-style-type: none"> ·Provide smooth flow along coordinated routes <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.2.2	(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.2	(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.2.3	(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.3	(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	4.4.1.1.5 ·Manage the locations of queues within the network Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.2.3	(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	4.4.1.4 The TSS Operator needs to detect repeated phase failures and control signal timing to prevent phase failures building up queues. The TSS Operator in this case is trying to prevent a routine queue from forming where it will block another movement in the cycle unnecessarily. For example, the TSS Operator may need to prevent a queue resulting from the trailing end of the through green from blocking the storage needed by an entering side-street left turn in the subsequent phase. An overall queue management strategy, particularly when congestion is present, is covered under 4.4.1.5.
3.1.9.2.4	(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		supplying one type of adaptive operation or the other.)
3.1.9.2.4	(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.4	(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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		supplying one type of adaptive operation or the other.)
3.1.9.2.4.1	(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.4.1	(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.4.1	(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5	(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5	(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5	(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5	(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.1	(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.1	(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.1	(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.2	(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.3	(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.3	(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.4	(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.4	(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.4	(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1	(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.4.1	(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.4.1	(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.1	(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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		supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.1	(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.1	(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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3.1.9.2.5.4.1.1	(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.2	(Sequence-based only) The increased limit shall be user-defined.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of

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		supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.2	(Sequence-based only) The increased limit shall be user-defined.	<p>4.4.1.1.2</p> <ul style="list-style-type: none"> ·Provide smooth flow along coordinated routes <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.2.5.4.1.2	(Sequence-based only) The increased limit shall be user-defined.	<p>4.4.1.1.3</p> <ul style="list-style-type: none"> ·Distribute phase times in an equitable fashion <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of</p>

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		supplying one type of adaptive operation or the other.)
3.1.9.2.5.4.1.2	(Sequence-based only) The increased limit shall be user-defined.	<p>4.4.1.1.4</p> <ul style="list-style-type: none"> ·Manage the lengths of queues <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.2.5.5	(Sequence-based only) The ASCT shall adjust offsets to minimize the chance of stopping vehicles approaching a signal that have been served by a user-specified phase at an upstream signal.	<p>4.4.1.5</p> <p>The TSS Operator needs to minimize the chance that a queue forms at a specified location.</p> <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.5 group when phase-based systems are</p>

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		allowed (phase-based systems do not explicitly calculate cycle, offset and split at all intersections). (Select requirements from two or all three groups when the vendor is given the choice of supplying the type of adaptive operation.)
3.1.9.3	Non-sequence-based adaptive coordination	
3.1.9.3.1	Use this section if non-sequence-based adaptive coordination is likely to provide acceptable operation in your situation.	
3.1.9.3.2	(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.2	(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when

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		<p>sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.2	<p>(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)</p>	<p>4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.2	<p>(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)</p>	<p>4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.3	<p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p>	<p>4.4.1.1.1</p> <ul style="list-style-type: none"> ·Maximize the throughput on coordinated routes <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.3	<p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p>	<p>4.4.1.1.2</p> <ul style="list-style-type: none"> ·Provide smooth flow along coordinated routes <p>Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split).</p>

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		<p>Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.3	<p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p>	<p>4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.3.3	<p>(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.</p>	<p>4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.4	(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.4.1.1.1 ·Maximize the throughput on coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.4	(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.4.1.1.2 ·Provide smooth flow along coordinated routes Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.4	(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.4	(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.3.5	(Non-sequence-based only) The ASCT shall adjust signal timing so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	4.4.1.5 The TSS Operator needs to minimize the chance that a queue forms at a specified location. Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.5 group when phase-based systems are allowed (phase-based systems do not explicitly calculate cycle, offset and split at all intersections). (Select requirements from two or all three groups when the vendor is given the choice of supplying the type of adaptive operation.)
3.1.9.4	Single intersection adaptive operation	
3.1.9.4.1	Use this section if non-coordinated adaptive coordination is likely to provide acceptable operation in your situation.	

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3.1.9.4.2	The ASCT shall calculate a cycle length of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.4.3	The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)
3.1.9.4.3	The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.4.3.1	The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value.	4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.9.4.3.1	<p>The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value.</p>	<p>4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).</p>
3.1.9.4.3.2	<p>When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.</p>	<p>4.4.1.1.3 ·Distribute phase times in an equitable fashion Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.4.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.4.4	The ASCT shall calculate phase order, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	4.4.1.1.6 At an isolated intersection, optimize operation with a minimum of phase failures (based on the optimization objectives).
3.1.9.5	Phase-based adaptive coordination	
3.1.9.5.1	Use this section if phase-based adaptive coordination is likely to provide acceptable operation in your situation.	
3.1.9.5.2	(Phase-based only) The ASCT shall alter the state of the signal controller for all phases at the user-specified intersection.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.
3.1.9.5.3	(Phase-based only) The ASCT shall calculate the time at which a user-specified phase shall be green at an intersection.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.5.4	(Phase-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.
3.1.9.5.5	(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic released from user-specified phases at the user-specified critical intersection.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.
3.1.9.5.6	(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic arriving at user-specified phases at the user-specified critical intersection.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.
3.1.9.5.7	(Phase-based only) The ASCT shall adjust the state of the signal controller so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	4.4.1.2 The system operator needs to manage the coordination in small groups of signals to link phase service at some intersections with phase service at

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		adjacent intersections. Note: Phase-based systems do not explicitly calculate cycle, offset and split at all intersections.
3.1.9.5.7	(Phase-based only) The ASCT shall adjust the state of the signal controller so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	4.4.1.5 The TSS Operator needs to minimize the chance that a queue forms at a specified location. Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.5 group when phase-based systems are allowed (phase-based systems do not explicitly calculate cycle, offset and split at all intersections). (Select requirements from two or all three groups when the vendor is given the choice of supplying the type of adaptive operation.)
3.1.9.6	Responsiveness	
3.1.9.6.1	The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.	4.4.8.1 The TSS Operator needs to modify the ASCT operation to closely follow changes in traffic conditions.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.9.6.2	The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)	4.4.8.1 The TSS Operator needs to modify the ASCT operation to closely follow changes in traffic conditions.
3.1.9.6.3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.4.8.1 The TSS Operator needs to modify the ASCT operation to closely follow changes in traffic conditions.
3.1.9.6.3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	4.4.8.2 The TSS Operator needs to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.
3.1.9.6.4	When a large change in traffic demand is detected, the ASCT shall respond more quickly than normal operation, subject to user-specified limits. (DEFINE 'MORE QUICKLY')	4.4.8.3 The TSS Operator needs to respond quickly to sudden large shifts in traffic conditions.
3.1.9.6.5	The ASCT shall select cycle length from a list of user-defined cycle lengths.	4.4.8.2 The TSS Operator needs to constrain the selection of cycle lengths to those that provide acceptable operations, such as when resonant progression solutions are desired.
3.1.10	Adaptive Advanced Controller Operation	

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.10.1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	4.4.9.1.1 Service a phase more than once per cycle
3.1.10.2	The ASCT shall provide a minimum of XX phase overlaps.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.2	The ASCT shall provide a minimum of XX phase overlaps.	4.4.9.1.2 Operate at least XX overlap phases
3.1.10.3	The ASCT shall accommodate a minimum of XX phases at each signal	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.3	The ASCT shall accommodate a minimum of XX phases at each signal	4.4.9.1.3 Operate four rings, 16 phases and up to three phases per ring (Edit to suit your needs).
3.1.10.4	The ASCT shall accommodate a minimum of XX rings at each signal.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.10.4	The ASCT shall accommodate a minimum of XX rings at each signal.	4.4.9.1.3 Operate four rings, 16 phases and up to three phases per ring (Edit to suit your needs).
3.1.10.5	The ASCT shall accommodate a minimum of XX phases per ring	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.5	The ASCT shall accommodate a minimum of XX phases per ring	4.4.9.1.3 Operate four rings, 16 phases and up to three phases per ring (Edit to suit your needs).
3.1.10.6	The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.
3.1.10.6	The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.6	The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.	4.4.9.1.4 Permit different phase sequences under different traffic conditions
3.1.10.6.1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	4.4.1.6

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to modify the sequence of phases to support the various operational strategies.
3.1.10.6.1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.6.1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	4.4.9.1.4 Permit different phase sequences under different traffic conditions
3.1.10.6.2	Each permissible phase sequence shall be executable by a time of day schedule.	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.
3.1.10.6.2	Each permissible phase sequence shall be executable by a time of day schedule.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.6.2	Each permissible phase sequence shall be executable by a time of day schedule.	4.4.9.1.4 Permit different phase sequences under different traffic conditions
3.1.10.6.3	Each permissible phase sequence shall be executable based on measured traffic conditions	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.10.6.3	Each permissible phase sequence shall be executable based on measured traffic conditions	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.6.3	Each permissible phase sequence shall be executable based on measured traffic conditions	4.4.9.1.4 Permit different phase sequences under different traffic conditions
3.1.10.7	The ASCT shall not prevent a phase/overlap output by time-of-day.	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.
3.1.10.8	The ASCT shall not prevent a phase/overlap output based on an external input.	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.
3.1.10.8	The ASCT shall not prevent a phase/overlap output based on an external input.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.10.9	The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)	4.4.1.6 The TSS Operator needs to modify the sequence of phases to support the various operational strategies.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.10.9	The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.9	The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)	4.4.9.1.9 Allow any phase to be designated as the coordinated phase
3.1.10.10	The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.10	The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)	4.4.9.1.12 Allow the coordinated phase to terminate early under prescribed traffic conditions
3.1.10.11	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn. (SELECT AS APPLICABLE)	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.11	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn. (SELECT AS APPLICABLE)	4.4.9.1.15 Use flashing yellow arrow to control permissive left turns and right turns.
3.1.10.12	The ASCT shall not prevent the local signal controller from performing actuated phase control using XX	4.4.9.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.12	The ASCT shall not prevent the local signal controller from performing actuated phase control using XX extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	4.4.9.1.11 Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using XX extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.
3.1.10.12.1	The ASCT shall operate adaptively using user-specified detector channels.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.12.1	The ASCT shall operate adaptively using user-specified detector channels.	4.4.9.1.11 Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using XX extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.10.13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.	4.4.9.1.16 Service side streets and pedestrian phases at minor locations more often than at adjacent signals when this can be done without compromising the quality of the coordination. (E.g., double-cycle mid-block pedestrian crossing signals.)
3.1.10.14	(Describe requirements to suit other custom controller features that must be accommodated.)	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.14	(Describe requirements to suit other custom controller features that must be accommodated.)	4.4.9.1.8 Accommodate the following custom features used by this agency (describe the features)
3.1.10.15	The ASCT shall operate adaptively with the following detector logic. (DESCRIBE THE CUSTOM LOGIC)	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.10.15	The ASCT shall operate adaptively with the following detector logic. (DESCRIBE THE CUSTOM LOGIC)	4.4.9.1.7 Allow detector logic at an intersection to be varied depending on local signal states

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3.1.11	Adaptive Pedestrians	
3.1.11.1	When a pedestrian phase is called, the ASCT shall execute pedestrian phases up to XX seconds before the vehicle green of the related vehicle phase.	4.4.5.5 The TSS Operator needs to accommodate early start of walk and exclusive pedestrian phases.
3.1.11.2	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.4.5.2 The TSS Operator needs to accommodate infrequent pedestrian operation while maintaining adaptive operation. (This is appropriate for pedestrian calls that are common but not so frequent that they drive the operational needs.)
3.1.11.2	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	4.4.5.3 The TSS Operator needs to incorporate frequent pedestrian operation into routine adaptive operation. (This is appropriate when pedestrians are frequent enough that they must be assumed to be present every cycle or nearly every cycle.)
3.1.11.3	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times then resume adaptive operation.	4.4.5.1 The TSS Operator needs to accommodate infrequent pedestrian operation and then adaptively recover. (This is appropriate for rare pedestrian calls.)
3.1.11.4	The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.	4.4.5.5 The TSS Operator needs to accommodate early start of walk and exclusive pedestrian phases.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.11.5	The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.	4.4.5.3 The TSS Operator needs to incorporate frequent pedestrian operation into routine adaptive operation. (This is appropriate when pedestrians are frequent enough that they must be assumed to be present every cycle or nearly every cycle.)
3.1.11.6	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist: <ul style="list-style-type: none"> * The user enables this feature * Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase * The phase is called after its normal start time * The associated pedestrian phase is not called 	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.11.6	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist: <ul style="list-style-type: none"> * The user enables this feature * Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase * The phase is called after its normal start time * The associated pedestrian phase is not called 	4.4.9.1.13 Allow flexible timing of non-coordinated phases (such as late start of a phase) while maintaining coordination

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.11.7	When specified by the user, the ASCT shall execute pedestrian recall on pedestrian phase adjacent to coordinated phases.	4.4.5.3 The TSS Operator needs to incorporate frequent pedestrian operation into routine adaptive operation. (This is appropriate when pedestrians are frequent enough that they must be assumed to be present every cycle or nearly every cycle.)
3.1.11.8	When the pedestrian phases are on recall, the ASCT shall accommodate pedestrian timing during adaptive operation.	4.4.5.3 The TSS Operator needs to incorporate frequent pedestrian operation into routine adaptive operation. (This is appropriate when pedestrians are frequent enough that they must be assumed to be present every cycle or nearly every cycle.)
3.1.11.9	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.11.9	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	4.4.9.1.17 Use negative pedestrian phasing to prevent an overlap conflicting with a pedestrian walk/don't walk
3.1.11.10	The ASCT shall accommodate the following custom pedestrian features. (Specify the requirements in conjunction with their corresponding need.)	4.4.5.4 The TSS Operator needs to accommodate the following custom pedestrian features. (Describe custom features in this need and then create appropriate requirements.)

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3.1.12	Adaptive Special Functions	
3.1.12.1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	4.4.9.1 The TSS Operator needs to implement the following advanced controller features while maintaining adaptive operation:
3.1.12.1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	4.4.9.1.11 Allow the controller to respond independently to individual lanes of an approach. This may be implemented in the signal controller using XX extension/passage timers, which may be assignable to each vehicle detector input channel. This may allow the adaptive operation to be based on data from a specific detector, or by excluding specific detectors.
3.1.12.1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	4.9.5 The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
3.1.12.2	The ASCT shall set a specific state for each special function output based on the current cycle length.	4.9.5 The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
3.1.12.3	The ASCT shall set a specific state for each special function output based on a time-of-day schedule.	4.9.5 The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
3.1.13	Adaptive Detection	
3.1.13.1	The ASCT shall be compatible with the following detector technologies (agency to specify): * Detector type A * Detector type B * Detector type C	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2	The ASCT vendor shall specify detector requirements.	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.1	Vendor shall specify required detector accuracy	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.2	Vendor shall specify required detector output latency	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.3	Vendor shall specify detection zone coverage	4.7.2.1.2

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		Detector type (list acceptable equipment)
3.1.13.2.4	Vendor shall specify mounting requirements	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.5	Vendor shall specify installation requirements	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.6	Detectors verified against the provided requirements shall be deemed acceptable by the ASCT Vendor.	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.2.7	The Vendor shall be responsible to provide expected functionality using verified detectors.	4.7.2.1.2 Detector type (list acceptable equipment)
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.4.1 The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.4.2 The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.4.3 The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.4.4 The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	4.4.1.1.4 ·Manage the lengths of queues Note to user when selecting these requirements: Select from requirements in the 3.1.9.2 group when

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		<p>sequence-based systems are allowed (sequence-based systems explicitly calculate cycle, offset, and split). Select from requirements in the 3.1.9.3 group when non-sequence-based systems are allowed (non-sequence-based systems do not explicitly calculate cycle, offset, and split). (Select requirements from both groups when the vendor is given the choice of supplying one type of adaptive operation or the other.)</p>
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	<p>4.4.4.1 The TSS Operator needs to detect queues from outside the system and modify the ASCT operation to accommodate the queuing.</p>
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	<p>4.4.4.2 The TSS Operator needs to detect queues within the system's boundaries and modify the ASCT operation to accommodate the queuing.</p>
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	<p>4.4.4.3 The TSS Operator needs to detect queues propagating outside its boundaries from within the ASCT boundaries, and modify its operation to accommodate the queuing.</p>
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	4.4.4.4

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to store queues in locations where they can be accommodated without adversely affecting adaptive operation.
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	4.4.4.5 The TSS Operator needs to prevent queues forming at user-specified locations.
3.1.14	Adaptive Railroad and Emergency Vehicle Preemption	
3.1.14.1	The ASCT shall maintain adaptive operation at non-preempted intersections during railroad preemption.	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.2	The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)
3.1.14.3	The ASCT shall maintain adaptive operation at non-preempted intersections during Light Rail Transit preemption.	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.4	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.4	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.14.5	The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.5	The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)
3.1.14.6	The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.6	The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)
3.1.14.7	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.7	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.14.8	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	4.4.6.1 The TSS Operator needs to adaptively accommodate railroad and light rail preemption (explain further)
3.1.14.8	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	4.4.6.2 The TSS Operator needs to adaptively accommodate emergency vehicle preemption (explain further)
3.1.15	Adaptive Transit Priority	
3.1.15.1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.2.1	The advance of start of green phase shall be user-defined.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.2.2	Adaptive operations shall continue during the advance of the start of green phase.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.15.3	The ASCT shall delay the end of a green phase, in response to a priority call.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.3.1	The delay of end of green phase shall be user-defined.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.3.2	Adaptive operations shall continue during the delay of the end of green phase.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.4	The ASCT shall permit at least XX exclusive transit phases.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.4.1	Adaptive operations shall continue when there is an exclusive transit phase call.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.5	The ASCT shall control vehicle phases independently of the following:	4.4.6.3

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.5.1	* LRT only phases	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.5.2	* Bus only phases	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.6	The ASCT shall interface with external bus transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.7	The ASCT shall interface with external light rail transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)
3.1.15.8	The ASCT shall accept a transit priority call from: * a signal controller/transit vehicle detector; * an external system.	4.4.6.3 The TSS Operator needs to adaptively accommodate bus and light rail transit signal priority (explain further)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16	Traffic and Operational Performance Measurement, Monitoring and Reporting	
3.1.16.1	TSS Collection and Storage	
3.1.16.1.1	The system shall collect and store volume data for each detector.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.
3.1.16.1.2	The system shall collect and store occupancy data for each detector.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.
3.1.16.1.3	The system shall time stamp each detector actuation.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.
3.1.16.1.4	The system shall upload local controller logs by TSS Operator manual command.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.
3.1.16.1.5	The system shall upload local controller logs according to a time of day schedule.	4.5.1.4 The TSS Operator needs a log of all software functions executed by the central system and local controllers.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.1.6	The TSS shall collect and store phase data for every permitted phase, including the length of the phase split [This requirement may be superfluous in systems supported by high-resolution data. This requirement is intended to support legacy approaches to providing a split monitoring capability within traffic signal systems.]	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7	The system shall collect and store the following logs in user-definable format:	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7	The system shall collect and store the following logs in user-definable format:	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.
3.1.16.1.7	The system shall collect and store the following logs in user-definable format:	4.5.1.3 The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.16.1.7	The system shall collect and store the following logs in user-definable format:	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.1.7.1	Timing plan change	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.2	Signal phase change	4.5.1.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.3	Special function change	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.4	Coordination status change	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.5	Operating mode change	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.6	Equipment failure	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.
3.1.16.1.7.7	Communications failure	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.
3.1.16.1.7.8	Manual commands	4.5.1.3 The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.16.1.7.9	Operator log-on	4.5.1.3

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.16.1.7.10	Operator log-off	4.5.1.3 The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.16.1.7.11	Emergency vehicle preemption on-off	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.12	Transit priority request, on-off	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.13	Action sets	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.7.14	Database changes	4.5.1.3 The TSS Operator needs a time-stamped record of who accesses the system, all manual commands, and data changes made during a session.
3.1.16.1.8	The system shall store the logs, alarms, and reports for a user defined amount of time (at least (X) years) where they are easily accessible. [User specify]	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.1.8	The system shall store the logs, alarms, and reports for a user defined amount of time (at least (X) years) where they are easily accessible. [User specify]	4.6.1 The TSS Operator needs to access the data on the system for (XX) months after which it will be archived.
3.1.16.1.9	The system shall automatically transfer all logs, alarms, and reports to an archive system.	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.9	The system shall automatically transfer all logs, alarms, and reports to an archive system.	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.
3.1.16.1.9	The system shall automatically transfer all logs, alarms, and reports to an archive system.	4.6.1 The TSS Operator needs to access the data on the system for (XX) months after which it will be archived.
3.1.16.1.10	The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.1.10	The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).	4.5.1.2 The TSS Operator needs a permanent record of each detected fault.
3.1.16.1.10	The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).	4.6.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to access the data on the system for (XX) months after which it will be archived.
3.1.16.2	TSS Alerts	
3.1.16.2.1	<p>The system shall create alerts of the following events:</p> <ul style="list-style-type: none"> * Detector fault/failure * Communication fault/failure * Flash mode * Preemption fault/failure * Transit signal priority fault/failure * Cabinet flash * Cabinet door open * Temperature out of range * Adaptive Processor and Algorithms (Note: Only with adaptive operations) 	<p>4.5.6.2</p> <p>The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.</p>
3.1.16.2.2	The system shall provide an alert of any discrepancies between the central controller database and the infield database for each controller.	<p>4.5.6.2</p> <p>The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.</p>
3.1.16.2.3	The system shall classify every alerts as critical, warning, and informational only, based user-specified rules.	<p>4.5.6.2</p> <p>The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.</p>
3.1.16.2.3.1	The system shall alert TSS Operator via text message.	4.5.6.2

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.
3.1.16.2.3.2	The system shall alert TSS Operator via email.	4.5.6.2 The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.
3.1.16.2.3.3	The system shall alert TSS Operator by message on TSS Operator's desktop.	4.5.6.2 The TSS Operator needs to immediately know when a hardware or software fault occurs at a local intersection.
3.1.16.3	TSS Performance Measurement Reporting	
3.1.16.3.1	The system shall create performance measure reports from the data in the controller logs, including the following: <ul style="list-style-type: none"> * Split logs (average split times, percent max out and force offs, percent gap outs, percent skips) * Detector health * Coordination plans * Pedestrian actuations * Transit signal priority actuations * Emergency vehicle preemption actuations * Real time split reports (showing programmed and actual splits) 	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.3.2	The system shall create standard reports [specify].	4.5.1.1

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.3.3	The system shall create user customizable reports.	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.3.3	The system shall create user customizable reports.	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.3.4	The system shall create the reports for a user-specified period.	4.5.1.1 The TSS Operator needs to generate historical and real time reports that describe TSS operation.
3.1.16.3.4	The system shall create the reports for a user-specified period.	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.3.5	The system shall collect detector data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.	4.5.4.1 The TSS Operator needs the system to accept high resolution controller data in order to calculate and report intersection and system performance measurements that support operational objectives.
3.1.16.3.6	The system shall collect signal phase data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.	4.5.4.1 The TSS Operator needs the system to accept high resolution controller data in order to calculate and

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		report intersection and system performance measurements that support operational objectives.
3.1.16.3.7	The system shall produce performance reports consistent with: * Attached performance report document (USER SPECIFIED - attach) * Purdue Pooled Fund Study	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.3.7	The system shall produce performance reports consistent with: * Attached performance report document (USER SPECIFIED - attach) * Purdue Pooled Fund Study	4.5.4.1 The TSS Operator needs the system to accept high resolution controller data in order to calculate and report intersection and system performance measurements that support operational objectives.
3.1.16.4	Adaptive Collection and Storage	
3.1.16.4.1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.
3.1.16.4.2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.
3.1.16.4.3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.5.2.2

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.
3.1.16.4.3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.4.3.1	The ASCT log shall include all events directed by the external inputs.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.4.3.2	The ASCT log shall include all external output state changes.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.4.3.3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.4.3.4	The ASCT shall maintain the records in this ASCT log for XX period.	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.4.3.5	The ASCT shall archive the ASCT log in the following manner: (Specify format, frequency, etc., to suit your needs.)	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.5	High Resolution Traffic Performance Measurement Collection and Storage	
3.1.16.5.1	The Performance Measurement Server shall retrieve and store high-resolution data from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.5.1.1	High-resolution data are defined by (specify details).	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.5.1.2	The Performance Measurement Server shall store uploaded high-resolution data for [specify timeframe].	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.5.1.3	The TSS shall not prevent the local controller from accessing local devices as needed to store high-resolution data.	4.5.3.1 The TSS Operator needs to collect and store high resolution data from traffic signal controllers.
3.1.16.6	High Resolution Traffic Performance Measurement Processing	
3.1.16.6.1	The Performance Measurement Server shall process the collected and stored high resolution data to produce the following reports: * Signal Measures Charts: o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: o Usage	4.5.4.1 The TSS Operator needs the system to accept high resolution controller data in order to calculate and report intersection and system performance measurements that support operational objectives.
3.1.16.7	High Resolution Traffic Performance Measurement Reports	
3.1.16.7.1	The TSS shall provide predefined reports of stored data for non-technical recipients in accordance with user-specified formats. (Specify report formats to accompany this requirement.)	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.7.2	The TSS shall display stored data that illustrate adaptive input data and output decisions. (This display will be used by the TSS Operator.)	4.5.2.2 The TSS Operator needs to store and report data used to calculate signal timing and have the data available for subsequent analysis.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.7.2	The TSS shall display stored data that illustrate adaptive input data and output decisions. (This display will be used by the TSS Operator.)	4.5.2.6 The TSS Operator needs to generate historic and real-time reports that effectively support operation, maintenance and reporting of system performance and traffic conditions.
3.1.16.7.3	The Performance Measurement Server shall provide the following reports: * Signal Measures Charts: o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: o Usage	4.5.5.1 The TSS Operator needs to view reports showing traffic operational performance.
3.1.16.7.3.1	Performance measurement reports shall be consistent with descriptions in ATSPM version 4.0 (or later) documentation.	4.5.5.1 The TSS Operator needs to view reports showing traffic operational performance.
3.1.16.7.4	The TSS (ASCT) shall provide traffic performance measurement using probe vehicle reports provided by an external service [specify].	4.5.5.1 The TSS Operator needs to view reports showing traffic operational performance.
3.1.16.7.5	The TSS (ASCT) shall provide traffic performance measurement using [specify alternative approaches not covered in other requirements].	4.5.5.1 The TSS Operator needs to view reports showing traffic operational performance.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.16.8	High Resolution Traffic Performance Measurement Alerts	
3.1.16.8.1	The TSS shall provide configurable alerts to the TSS Operator based on traffic operational performance. (Specify alerts to accompany this requirement.)	4.5.6.1 The TSS Operator needs to receive alerts about traffic operational performance.
3.1.17	External Interfaces	
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	4.4.3.1 The TSS Operator needs to adaptively control signals operated by (specify jurisdictions).
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol 	4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	<p>4.4.3.4 The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.</p>
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol 	<p>4.5.2.5 The TSS Operator needs to report performance data in real time to (specify external system).</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	<p>4.9.1 The TSS Operator needs to align coordinated traffic signals in the system in question with coordinated traffic signals in an adjacent system. (The intent of this need is to maintain cycle-offset-split signal coordination across system boundaries. Basic coordination can be provided by using timings that are compatible in both systems, following compatible time-of-day schedules, and maintaining synchronization of the time-of-day clocks. Under this need, the system is responsible only for the clock synchronization, and the user is responsible for compatible timings and schedules.)</p>
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol 	<p>4.9.2 The TSS Operator needs to select coordinated signal timing patterns (including cycle, offset, split, special functions, and phase sequence) based on the timing patterns in current operation in an adjacent system. (This user need addresses both time-of-day and traffic responsive coordination modes. In addition to the clock synchronization provided in 4.9.1, this user need also requires the system to align its timing</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	<p>pattern in use with an adjacent system automatically. This user need does not mean the system will create signal timings that are compatible—that is assumed to be the responsibility of the user.)</p>
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	<p>4.9.3 The TSS Operator needs to provide signal operational data to an external display service, which may be a regional display map at another traffic management center.</p>
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation 	<p>4.9.4 The TSS Operator needs to allow control of the system by the operator of an external system. (The envisioned scenario is a freeway management operator engaging a particular coordinated signal timing pattern to carry traffic diverting around a freeway incident or bottleneck on appropriate arterial streets. This engagement may need to be done through the traffic management system in use by the freeway management operator.)</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	<ul style="list-style-type: none"> * Frequency of storage * Frequency of reporting * Duration of storage) 	
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage * Frequency of reporting * Duration of storage) 	<p>4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).</p>
3.1.17.1.1	<p>The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)</p>	<p>4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.</p>
3.1.17.1.1	<p>The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)</p>	<p>4.5.2.5 The TSS Operator needs to report performance data in real time to (specify external system).</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.17.1.1	The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)	4.9.1 The TSS Operator needs to align coordinated traffic signals in the system in question with coordinated traffic signals in an adjacent system. (The intent of this need is to maintain cycle-offset-split signal coordination across system boundaries. Basic coordination can be provided by using timings that are compatible in both systems, following compatible time-of-day schedules, and maintaining synchronization of the time-of-day clocks. Under this need, the system is responsible only for the clock synchronization, and the user is responsible for compatible timings and schedules.)
3.1.17.1.2	The ASCT shall send control data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.
3.1.17.1.2	The ASCT shall send control data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.9.2 The TSS Operator needs to select coordinated signal timing patterns (including cycle, offset, split, special functions, and phase sequence) based on the timing patterns in current operation in an adjacent system. (This user need addresses both time-of-day and traffic responsive coordination modes. In addition to the clock synchronization provided in 4.9.1, this user need also requires the system to align its timing pattern in use with an adjacent system automatically.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		This user need does not mean the system will create signal timings that are compatible—that is assumed to be the responsibility of the user.)
3.1.17.1.3	The ASCT shall send monitoring data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.5.2.1 The agency needs the (specify external decision support system) to be able to monitor the ASCT system automatically.
3.1.17.1.3	The ASCT shall send monitoring data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.9.3 The TSS Operator needs to provide signal operational data to an external display service, which may be a regional display map at another traffic management center.
3.1.17.1.4	The ASCT shall send coordination data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.
3.1.17.1.4	The ASCT shall send coordination data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.9.4 The TSS Operator needs to allow control of the system by the operator of an external system. (The envisioned scenario is a freeway management operator engaging a particular coordinated signal timing pattern to carry traffic diverting around a freeway incident or bottleneck on appropriate arterial streets. This engagement may need to be done

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
		through the traffic management system in use by the freeway management operator.)
3.1.17.1.5	The ASCT shall send performance data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.
3.1.17.1.5	The ASCT shall send performance data to the XX external system. (Insert appropriate requirements that suit your needs.)	4.5.2.5 The TSS Operator needs to report performance data in real time to (specify external system).
3.1.17.1.6	The ASCT shall receive commands from the XX external system.	4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.
3.1.17.1.6	The ASCT shall receive commands from the XX external system.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.17.1.7	The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation) * Specified cycle length * Specified direction of progression * Specified adaptive strategy	4.5.2.1 The agency needs the (specify external decision support system) to be able to monitor the ASCT system automatically.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.17.1.7	<p>The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation)</p> <ul style="list-style-type: none"> * Specified cycle length * Specified direction of progression * Specified adaptive strategy 	<p>4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).</p>
3.1.17.1.8	<p>The ASCT shall conform its operation to an external system's operation.</p>	<p>4.4.3.2 The TSS Operator needs to send data to another system that would allow the other system to coordinate with the ASCT system.</p>
3.1.17.1.8	<p>The ASCT shall conform its operation to an external system's operation.</p>	<p>4.4.3.4 The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.</p>
3.1.17.1.8	<p>The ASCT shall conform its operation to an external system's operation.</p>	<p>4.4.3.6 The TSS Operator needs to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.</p>
3.1.17.1.8	<p>The ASCT shall conform its operation to an external system's operation.</p>	<p>4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).</p>
3.1.17.1.8.1	<p>The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be</p>	<p>4.4.3.4</p>

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	achieved via detection, with no direct connection to the other system.)	The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.
3.1.17.1.8.1	The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)	4.4.3.6 The TSS Operator needs to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.
3.1.17.1.8.2	The ASCT shall operate a fixed cycle length to match the cycle length of an adjacent system.	4.4.3.5 The TSS Operator needs to constrain the adaptive system to operate a cycle length compatible with the crossing arterial.
3.1.17.1.8.3	The ASCT shall alter its operation based on data received from another system.	4.4.3.4 The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.
3.1.17.1.8.4	The ASCT shall support adaptive coordination on crossing routes.	4.4.3.3 The TSS Operator needs to adaptively coordinate signals on two crossing routes simultaneously. (Include signals on crossing arterials within the boundaries of the adaptive systems mapped in Chapter 3.)
3.1.17.1.9	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	4.5.2.5 The TSS Operator needs to report performance data in real time to (specify external system).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.17.1.9	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	4.9.5 The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
3.1.17.1.10	The ASCT output states shall be settable according to a time-of-day schedule.	4.9.5 The TSS Operator needs to be able to turn on signs that control traffic or provide driver information when specific traffic conditions occur, when needed to support the adaptive operation, when congestion is detected at critical locations or according to a time-of-day schedule.
3.1.17.1.10	The ASCT output states shall be settable according to a time-of-day schedule.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.17.1.11	The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation) ·Specified cycle length	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.17.1.12	The ASCT shall conform its operation to an external system's operation.	4.4.3.4 The TSS Operator needs to receive data from another system that will allow the ASCT system to coordinate its operation with the adjacent system.
3.1.17.1.12	The ASCT shall conform its operation to an external system's operation.	4.4.3.6 The TSS Operator needs to detect traffic approaching from a neighboring system and coordinate the ASCT operation with the adjacent system.
3.1.17.1.12	The ASCT shall conform its operation to an external system's operation.	4.9.6 The TSS Operator needs to react to commands issued by (specify an external control or decision support system, such as an ICM system or another signal system).
3.1.18	Software	
3.1.18.1	The vendor's software shall be fully operational within the following platform: (edit as appropriate) * Windows-PC, * Linux, * Mac-OS, * Unix.	4.7.1.5 The TSS Designer needs to use equipment and software acceptable under current agency IT policies and procedures.
3.1.18.2	The ASCT shall fully satisfy all requirements when connected with detectors from manufacturer XX (specify required detector types).	4.7.2.1.2 Detector type (list acceptable equipment)

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.18.3	The ASCT shall fully satisfy all requirements when connected with XX controllers (specify controller types).	4.7.2.1.1 Controller type (list acceptable equipment)
3.1.19	Training	
3.1.19.1	The vendor shall provide training on all the operations of the system.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.2	The vendor shall provide a minimum of XX hours of training to a minimum of XX staff. (SPECIFY)	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.3	The vendor shall provide a minimum of XX training sessions (specify how many sessions over what period).	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.4	The vendor shall provide the following training (edit as appropriate).	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.4.1	The vendor shall provide training on troubleshooting the system.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.19.4.2	The vendor shall provide training on system configuration.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.4.3	The vendor shall provide training on administration of the system.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.4.4	The vendor shall provide training on the operations of the adaptive system.	4.8.2.1 The TSS Manager needs [Specify staff] involved in operations and maintenance of the adaptive system to receive appropriate training.
3.1.19.4.5	The vendor shall provide training on the operations of the automated traffic signal performance measurement and monitoring.	4.8.3.1 The TSS Manager needs [Specify staff] involved in operations and maintenance of the automated signal performance measurement system to receive appropriate training.
3.1.19.4.6	The vendor shall provide training on system calibration.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
3.1.19.4.7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.19.4.8	The vendor's training shall be delivered at (SPECIFY location for training).	4.8.1.1 The TSS Manager needs all staff involved in operations and maintenance to receive appropriate training.
3.1.20	Maintenance, Support and Warranty	
3.1.20.1	The Maintenance Vendor shall provide maintenance according to a separate maintenance contract. That contract should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.	4.10.1 The TSS Manager needs the system to fulfill all the requirements for the life of the system. The agency therefore needs the system to be maintained to repair faults that are not defects in materials and workmanship.
3.1.20.2	The Vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period of XX years. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.	4.10.2 The agency needs the system to fulfill all requirements for the life of the system. The agency therefore needs support to keep software and software environment updated as necessary to prevent requirements no longer being fulfilled.
3.1.20.3	The Vendor shall warrant the system to be free of defects in materials and workmanship for a period of XX years. Warranty is defined as correcting defects in	4.10.3 The agency needs the system to fulfill all requirements for the life of the system. The agency

Requirements Document Reference Number	System Requirements Sample Statements	Need Statement (ConOps)
	materials and workmanship (subject to other language included in the purchase documents). Defect is defined as any circumstance in which the material does not perform according to its specification.	therefore needs the system to remain free of defects in materials and workmanship that result in requirements no longer being fulfilled.

APPENDIX C: SUGGESTED REQUIREMENTS VERIFICATION METHODS

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.1.1	The system shall provide monitoring and control access from the following locations. <ul style="list-style-type: none"> * Agency TMC * Agency LAN or WAN * Other agency TMC (SPECIFY) * Local controller cabinets (hard wire) * Local controller cabinets (wireless) * Remote location via internet 	Demonstration
3.1.1.2	The system shall allow remote access using a secure Virtual Private Network (VPN).	Demonstration
3.1.1.3	The system shall allow operators from different agencies to view/edit traffic signal databases owned by other agencies, subject to assigned privilege level.	Demonstration
3.1.1.4	The system shall allow XX number of users to log on to the system simultaneously.	Demonstration
3.1.1.5	The system shall allow multiple operators to access an intersection database simultaneously.	Demonstration
3.1.1.6	The system shall allow multiple TSS Operators to view the status of an intersection or group of intersections simultaneously.	Demonstration
3.1.1.7	The system shall restrict control of each intersection database to a single user at a time.	Demonstration
3.1.1.7.1	The system shall release lock of intersection database after a user-specified period of inactivity.	Demonstration
3.1.1.7.2	The system shall allow access to a traffic signal database on a first come, first served basis.	Demonstration
3.1.1.7.3	The system shall allow administrator to terminate intersection control by other users with lesser user rights.	Demonstration
3.1.1.8	The system shall allow access to a traffic signal database based on user privileges.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.2.1	<p>The system shall provide the ability to control and limit user access via user privileges (allowing for different levels of user access to system features and functions).</p> <ul style="list-style-type: none"> * Local access to the system * Remote access to the system * System monitoring * System manual override * Database * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * System parameters * Report generation * Configuration * Security alerts 	Demonstration
3.1.2.2	The system shall provide user privileges definable for the following:	Demonstration
3.1.2.2.1	Geographic area	Demonstration
3.1.2.2.2	Time of Day	Demonstration
3.1.2.2.3	Device ownership	Demonstration
3.1.2.3	The system shall provide user privileges definable on a functional level:	Demonstration
3.1.2.3.1	TSS Manager	Demonstration
3.1.2.3.2	TSS Operator	Demonstration
3.1.2.3.3	External System	Demonstration
3.1.2.3.4	TSS Maintainer	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.2.4	The system shall comply with the agency's security policy as described in (specify appropriate policy document)	Analysis
3.1.2.5	The system shall provide full access to the administrator.	Demonstration
3.1.2.6	The system shall show operators/administrator who is logged in to the system at a given time.	Demonstration
3.1.2.7	<p>For Adaptive Systems, the ASCT shall be implemented with a security policy that addresses the following selected elements:</p> <ul style="list-style-type: none"> * Local access to the ASCT * Remote access to the ASCT * System monitoring * System manual override * Development * Operations * User login * User password * Administration of the system * Signal controller group access * Access to classes of equipment * Access to equipment by jurisdiction * Output activation * System parameters * Report generation * Configuration * Security alerts * Security logging 	Analysis

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	<ul style="list-style-type: none"> * Security reporting * Database * Signal controller 	
3.1.2.8	The ASCT shall provide monitoring and control access at the following locations:	Demonstration
3.1.2.8.1	Agency TMC	Demonstration
3.1.2.8.2	Agency LAN or WAN	Demonstration
3.1.2.8.3	Other agency TMC (Specify)	Demonstration
3.1.2.8.4	Other agency TMC (Specify)	Demonstration
3.1.2.8.5	Local controller cabinets (wireless)	Demonstration
3.1.2.8.6	Local controller cabinets (hard wire)	Demonstration
3.1.2.8.7	Remote locations via internet	Demonstration
3.1.2.8.8	Remote locations via internet	Demonstration
3.1.2.9	The ASCT shall comply with the agency's security policy as described in (specify appropriate policy document).	Analysis
3.1.2.10	The ASCT shall not prevent access to the local signal controller database, monitoring or reporting functions by any installed signal management system.	Demonstration
3.1.3.1.1	The system shall control a minimum of XXX local signal controllers	Demonstration
3.1.3.1.2	The system shall allow intersections to be included in a group.	Demonstration
3.1.3.1.2.1	A group shall support up to XX signals.	Demonstration
3.1.3.1.3	The system shall allow an intersection to be included in two or more groups.	Demonstration
3.1.3.1.3.1	The system shall allow intersections to change grouping by time of day schedule.	Demonstration
3.1.3.1.3.2	The system shall allow intersections to change grouping by manual command.	Demonstration
3.1.3.1.3.3	The system shall allow intersections to change grouping by (enter trigger).	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.3.2.1	The ASCT shall control a minimum of XX signals concurrently. Note: communications network characteristics based on mileage distance.	Demonstration
3.1.3.2.2	The ASCT shall support groups of signals.	Demonstration
3.1.3.2.2.1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be defined by the user.	Demonstration
3.1.3.2.2.2	The ASCT shall control a minimum of XX groups of signals.	Demonstration
3.1.3.2.2.3	The size of a group shall range from 1 to XX signals.	Demonstration
3.1.3.2.2.4	Each group shall operate independently	Demonstration
3.1.3.2.2.5	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the ASCT system according to configured parameters.	Demonstration
3.1.3.2.2.5.1	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to a time of day schedule. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	Demonstration
3.1.3.2.2.5.2	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system according to traffic conditions. (For example: this may be achieved by assigning signals to different groups or by combining groups.)	Demonstration
3.1.3.2.2.5.3	The boundaries surrounding signal controllers that operate in a coordinated fashion shall be altered by the system when commanded by the user.	Demonstration
3.1.3.3.1	The Performance Measurement Server shall configure how the high-resolution data is handled from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.]	Demonstration
3.1.3.3.1.1	High-resolution data shall include all enumerated events as described in Sturdevant, et al., Indiana High Resolution Data Logger Enumerations, November, 2012, or later document as developed under Pooled Fund Study TPF-5(377).	Demonstration
3.1.3.3.1.2	High-resolution data interface is defined by (Specify latest interface control document, if available—Pooled Fund Study TPF-5(377), currently underway, will: Update the	Test

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	data logger specification to provide secure file transfer, incorporate new enumerations that have emerged, and logging new connected vehicle messages.	
3.1.3.3.1.3	The Performance Measurement Server shall be a separate server, independent of the TSS or ASCT.	Inspection
3.1.3.3.1.3.1	The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal.	Demonstration
3.1.3.3.1.3.2	The Performance Measurement Server shall be co-located with the TSS. (In such cases, it shall be owned by the TSS System Manager.) [This requirement is exclusive of 3.1.3.3.1.3.3—choose one or the other]	Inspection
3.1.3.3.1.3.3	The Performance Measurement Server shall be located at an alternative location [specify] and managed and maintained by a separate entity [specify]. [This requirement allows the server to be shared by multiple agencies but managed by one of them, or provided as a service by a private-sector provider. Please specify in this requirement. This requirement is exclusive of 3.1.3.3.1.3.2]	Inspection
3.1.3.3.1.3.4	The Performance Measurement Server shall be integrated into the TSS (ASCT).	Inspection
3.1.3.3.1.3.4.1	The Performance Measurement Server shall run ATSPM version 4.0 (or more recent version) available from the FHWA Open Source Application Development Portal. The open-source software may be revised to facilitate integration, or to extend to additional features that may be required herein.	Demonstration
3.1.3.4.1	The system shall fully satisfy all requirements when connected to XX local controllers (SPECIFY local controller type)	Demonstration
3.1.3.4.1.1	Controller type (list applicable equipment)	Inspection
3.1.3.4.1.2	Local firmware (list applicable firmware)	Inspection
3.1.3.4.1.3	Communications media and protocols (list applicable equipment)	Demonstration
3.1.3.4.1.3.1	AB3418E	Demonstration
3.1.3.4.1.3.2	NTCIP (SPECIFY relevant items)	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.3.4.2	The system shall fulfill all requirements when connected to XX local controller firmware (SPECIFY local controller firmware)	Demonstration
3.1.3.4.3	The system shall fully satisfy all requirements when connected to the existing communications network	Demonstration
3.1.3.4.4	The system shall fulfill requirements within a communications bandwidth limit of XX Mbps (specify applicable limits).	Test
3.1.3.4.5	The system shall work with the existing communications architecture (DEFINE characteristics, specifications and layout of system).	Demonstration
3.1.3.4.5.1	The system shall operate on a stand alone server located at (SPECIFY LOCATION)	Inspection
3.1.3.4.5.2	The system shall operate as cloud based.	Demonstration
3.1.3.4.5.3	The system shall operate with center to center capabilities.	Demonstration
3.1.3.4.5.4	The system shall be integrated with an Advance Traffic Management System (SPECIFY)	Demonstration
3.1.3.4.5.5	The system shall operate with on-street masters.	Demonstration
3.1.3.4.6	The system shall use the following communications protocols with traffic signal controllers (SPECIFY as appropriate)	Demonstration
3.1.3.4.6.1	Ethernet	Demonstration
3.1.3.4.6.2	Serial	Demonstration
3.1.3.4.6.3	Other [Specify]	Demonstration
3.1.3.4.7	Any field device installed as part of the TSS shall fulfill NEMA TS-2 environmental requirements.	Test
3.1.3.4.8	The system shall be fully implemented within the available budget of \$[Specify]. (or included in procurement documents but not in system requirements)	Analysis
3.1.3.6	The system shall download timing parameters to two or more controllers with one command.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.4.1	The system shall create a timing database that includes all settable signal timing parameters for a given intersection local controller based on TSS Operator input and appropriate look up tables (SPECIFY controller and firmware version).	Demonstration
3.1.4.2	The system shall allow TSS Operator to enter all settable timing parameter values manually.	Demonstration
3.1.4.3	The system shall provide default intersection timing database templates containing the following data (SPECIFY others if needed): <ul style="list-style-type: none"> * Min green, Max green, walk, flashing don't walk, yellow, red * Emergency Vehicle Preemption data * Flashing yellow left turn arrow 	Demonstration
3.1.4.4	The system shall create a copy of an entire intersection timing database.	Demonstration
3.1.4.5	The system shall copy parts of one intersection timing database and paste to another intersection timing database (e.g., time of day schedule)	Demonstration
3.1.4.6	The system shall copy parts of an intersection timing database and paste within the same database (e.g., timing pattern data)	Demonstration
3.1.4.7	The system shall create up to (X) versions of an intersection timing database.	Demonstration
3.1.4.8	The system shall provide safeguards when developing new signal databases, including: <ul style="list-style-type: none"> * Range checking * Timing plan verification * Conflicting phases 	Demonstration
3.1.4.9	The system shall create a timing sheet that includes: <ul style="list-style-type: none"> * All timing parameters relevant for operating a traffic signal. * Phase rotation diagram with north arrow * User selected parts of the timing database 	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	<ul style="list-style-type: none"> * Modified timings * User specified * Only non-zero timing parameters 	
3.1.4.10	<p>The system shall transfer the following signal timing data to and from Optimization Software (SPECIFY TYPE and Version):</p> <ul style="list-style-type: none"> * Node number * Phase number and direction * Phase minimum green * Phase vehicle yellow clearance * Phase pedestrian walk * Phase vehicle all red * Phase pedestrian clearance * Cycle length * Offset * Coordination splits 	Demonstration
3.1.5.1	<p>The system shall upload/download the intersection database to a controller:</p> <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule 	Demonstration
3.1.5.2	The system shall download the entire intersection database to a controller.	Demonstration
3.1.5.3	The system shall upload the entire intersection database from a controller.	Demonstration
3.1.5.4	The system shall download select parts of an intersection database to a controller.	Demonstration
3.1.5.5	The system shall upload select parts of an intersection database from a controller.	Demonstration
3.1.5.6	The system shall download timing parameters to two or more controllers with one command.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.5.7	The system shall upload timing parameters from two or more controllers with one command.	Demonstration
3.1.5.8	The system shall request user confirmation of command prior to downloading data from the central database to a controller.	Demonstration
3.1.5.9	The system shall request user confirmation of command prior to saving uploaded data from a controller in the central database.	Demonstration
3.1.5.10	The system shall archive all intersection databases when commanded by user.	Demonstration
3.1.5.11	The system shall cancel upload/download if any interruptions occur during the process.	Demonstration
3.1.5.12	The system shall revert to previous version of the database at the request of the user.	Demonstration
3.1.5.13	The system shall log any changes made to the database, including: <ul style="list-style-type: none"> * What was changed * Who made the change * When the change occurred 	Demonstration
3.1.5.14	The system shall compare two intersection databases (central and local) and highlight the differences.	Demonstration
3.1.5.15	The system shall save the entire uploaded intersection database.	Demonstration
3.1.5.16	The system shall save selected parts of an uploaded intersection database.	Demonstration
3.1.5.17	The system shall clearly identify the official version of the timing database.	Demonstration
3.1.5.18	The system shall provide multiple methods to open an intersection database: <ul style="list-style-type: none"> * Dynamically select intersection on map * Search feature that uses intersection name and partial name * Search feature that uses intersection ID number 	Demonstration
3.1.5.19	The ASCT shall log the following events: (edit as appropriate)	Demonstration
3.1.5.19.1	Time-stamped vehicle phase calls	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.5.19.2	Time-stamped pedestrian phase calls	Demonstration
3.1.5.19.3	Time-stamped emergency vehicle preemption calls	Demonstration
3.1.5.19.4	Time-stamped transit priority calls	Demonstration
3.1.5.19.5	Time-stamped railroad preemption calls	Demonstration
3.1.5.19.6	Time-stamped start and end of each phase	Demonstration
3.1.5.19.7	Time-stamped controller interval changes	Demonstration
3.1.5.19.8	Time-stamped start and end of each transition to a new timing plan.	Demonstration
3.1.5.20	<p>The ASCT shall export its systems log in the following formats: (edit as appropriate)</p> <ul style="list-style-type: none"> * MS Excel * Text * CVS * Open source SQL database 	Demonstration
3.1.5.21	The ASCT shall store the event log for a minimum of XX days	Demonstration
3.1.5.22	The TSS shall store results of all signal timing parameter calculations for a minimum of XX days.	Demonstration
3.1.5.23	<p>The ASCT shall store the following measured data in the form used as input to the adaptive algorithm for a minimum of XX days: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy * queue length * phase utilization * arrivals in green * green band efficiency 	Demonstration
3.1.5.24	The ASCT system shall archive all data automatically after a user-specified period not less than XX days.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.5.25	<p>The ASCT shall provide data storage for a system size of XX signal controllers. The data to be stored shall include the following: (edit as appropriate)</p> <ul style="list-style-type: none"> * Controller state data * Reports * Log data * Security data * ASCT parameters * Detector status data 	Demonstration
3.1.5.26	<p>The ASCT shall calculate and report relative data quality including:</p> <ul style="list-style-type: none"> * The extent data is affected by detector faults * Other applicable items 	Demonstration
3.1.5.27	<p>The ASCT shall report comparisons of logged data when requested by the user:</p> <ul style="list-style-type: none"> * Day to day, * Hour to hour * Hour of day to hour of day * Hour of week to hour of week * Day of week to day week * Day of year to day of year 	Demonstration
3.1.5.28	<p>The ASCT shall store data logs in a standard database (specify as appropriate).</p>	Demonstration
3.1.5.29	<p>The ASCT shall report stored data in a form suitable to provide explanations of system behavior to public and politicians and to troubleshoot the system.</p>	Analysis
3.1.5.30	<p>The ASCT shall store the following data in XX minute increments: (edit as appropriate)</p> <ul style="list-style-type: none"> * volume * occupancy 	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	* queue length	
3.1.6.1.1	The ASCT shall take user-specified action in the absence of valid detector data from XX vehicle detectors within a group. (SELECT THE APPROPRIATE ACTION.)	Test
3.1.6.1.1.1	The ASCT shall release control to central system control.	Test
3.1.6.1.1.2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	Test
3.1.6.1.2	The ASCT shall use the following alternate data sources for operations in the absence of the real-time data from a detector:	Test
3.1.6.1.2.1	* Data from a user-specified alternate detector.	Test
3.1.6.1.2.2	* Stored historical data from the failed detector.	Test
3.1.6.1.2.3	The ASCT shall switch to the alternate source in real time without operator intervention.	Test
3.1.6.1.3	In the event of a detector failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	Test
3.1.6.1.4	In the event of a failure, the TSS/ASCT shall log details of the failure in a permanent log.	Test
3.1.6.1.5	The permanent failure log shall be searchable, archivable and exportable.	Demonstration
3.1.6.2.1	The TSS shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)	Test
3.1.6.2.1.1	In the event of loss of communication to a user-specified signal controller, the TSS shall release control of all signal controllers within a user-specified group to local control.	Test

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.6.2.1.2	The TSS shall switch to the alternate operation in real time without operator intervention.	Test
3.1.6.2.2	In the event of communications failure, the TSS shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	Test
3.1.6.2.3	The TSS shall issue an alarm within XX minutes of detection of a failure.	Test
3.1.6.2.4	The ASCT shall execute user-specified actions when communications to one or more signal controllers fails within a group. (SELECT THE APPROPRIATE ACTION)	Test
3.1.6.2.4.1	In the event of loss of communication to a user-specified signal controller, the ASCT shall release control of all signal controllers within a user-specified group to local control.	Test
3.1.6.2.4.2	The ASCT shall switch to the alternate operation in real time without operator intervention.	Test
3.1.6.2.5	In the event of communications failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance management system.	Test
3.1.6.2.6	The ASCT shall issue an alarm within XX minutes of detection of a failure.	Test
3.1.6.2.7	In the event of a communications failure, the TSS/ASCT shall log details of the failure in a permanent log.	Test
3.1.6.2.8	The permanent failure log shall be searchable, archivable and exportable.	Demonstration
3.1.6.3.1	The ASCT shall execute user-specified actions when adaptive control fails:	Demonstration
3.1.6.3.1.1	The ASCT shall release control to central system control.	Demonstration
3.1.6.3.1.2	The ASCT shall release control to local operations to operate under its own time-of-day schedule.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.6.3.2	In the event of adaptive processor failure, the ASCT shall issue an alarm to user-specified recipients. (This requirement may be fulfilled by sending the alarm to a designated list of recipients by a designated means, or by using an external maintenance	Test
3.1.6.3.3	The permanent failure log shall be searchable, archivable and exportable.	Demonstration
3.1.6.3.4	During adaptive processor failure, the ASCT shall provide all local detector inputs to the local controller.	Test
3.1.7.1.1	The system shall update the status of all traffic signal controller connected to the system every (XX) seconds.	Demonstration
3.1.7.1.2	The system shall update the status of all traffic signal controllers connected to the system 24 hours a day, 7 days a week.	Demonstration
3.1.7.1.3	The system shall provide a map that displays different levels of information: <ul style="list-style-type: none"> * Statewide * Area-wide * Corridor * Intersection 	Demonstration
3.1.7.1.4	The system shall provide a display that uses a cloud based system map (SPECIFY DETAILS)	Demonstration
3.1.7.1.5	The system shall provide a display that uses an existing agency map as background (Autocad, GIS, JPEG, etc.)	Demonstration
3.1.7.1.6	The system shall move between levels seamlessly, without having to open new files or windows.	Demonstration
3.1.7.1.7	The system shall have pan and zoom capabilities.	Demonstration
3.1.7.1.8	The system shall automatically adjust the display depending on the 'zoom level'.	Demonstration
3.1.7.1.9	At the state wide and area-wide level map, the system shall display a color coded status of the following systems:	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	<ul style="list-style-type: none"> * Communication * Coordination * Intersection flash mode * Preemption 	
3.1.7.1.10	<p>At the corridor level map, the system shall display the following timing related information:</p> <ul style="list-style-type: none"> * Real time or other measureable period [Specify period length(s)] time-space-diagrams * Split times * Phase status * Detector status (vehicle and pedestrian) * Local cycle lengths/timer * Background cycle length/timer * Offset * Intersection identifier 	Demonstration
3.1.7.1.11	The system shall provide a library of intersection drawings (e.g., standard four-legged intersections, standard tee intersection, five-legged intersection, six legged intersection, etc.) to develop intersection level graphics that are geometrically correct diagrams.	Demonstration
3.1.7.1.12	The system shall provide a library of symbols for inputs and outputs to help construct the intersection display.	Demonstration
3.1.7.1.13	The system shall allow the TSS Operator to import customized graphical icons to the map icon library.	Demonstration
3.1.7.1.14	The system shall display multiple individual intersection-level views simultaneously as separate displays or tiled windows (SPECIFY minimum and maximum numbers).	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.7.2.1	The system shall open the intersection display when the intersection on the main map is clicked on.	Demonstration
3.1.7.2.2	The system shall show the current phase status of an intersection upon operator selection of the associated intersection icon on the map display.	Demonstration
3.1.7.2.3	The system shall display the following traffic signal controller information: <ul style="list-style-type: none"> * Intersection name/number * Controller type * Firmware and version * IP address 	Demonstration
3.1.7.2.4	The system shall have the capability to display all controller outputs in real-time, including: <ul style="list-style-type: none"> * Vehicle phases (including overlaps) * Pedestrian phases * Bicycle phases * Signs controlled by the signal controller 	Demonstration
3.1.7.2.5	The system shall have the capability to display all controller inputs in real time, including: <ul style="list-style-type: none"> * Vehicle detector actuations * Pedestrian detector actuations * Bicycle detector actuations * Transit signal priority * Railroad preemption * Emergency vehicle preemption 	Demonstration
3.1.7.2.6	The system shall display the data shown on the virtual controller front panel based on a user-selected intersection.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.8.1.1	The system shall receive the current time from a source: <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	Demonstration
3.1.8.1.2	The system shall re-sync the local controller time clock through a manual command.	Demonstration
3.1.8.1.3	The system shall re-sync the local controller's time clock automatically [Specify conditions for triggering automatic re-sync].	Demonstration
3.1.8.1.4	The system shall provide a time synch to each controller using: <ul style="list-style-type: none"> * WWV radio * Network Time Protocol server * GPS time source * Neighboring traffic signal network 	Demonstration
3.1.8.2.1	The system shall allow the traffic signals to operate in coordinated mode.	Demonstration
3.1.8.2.2	The system shall allow the traffic signals to operate according to local control in case of communications failure.	Test
3.1.8.2.3	The system shall allow the traffic signals to operate according to local control in case of TSS failure.	Test
3.1.8.2.4	The system shall download manual command to the local controller to change intersection operations to free.	Demonstration
3.1.8.2.5	The system shall download manual command to the local controller to change intersection operations to flash.	Demonstration
3.1.8.2.6	The system shall download manual command to the local controller to implement a timing plan	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.8.2.7	The system shall operate manual selection of timing plans as a higher priority over all other modes of plan selection.	Demonstration
3.1.8.2.8	The system shall request confirmation from the TSS Operator before a manual command is implemented.	Demonstration
3.1.8.2.9	The system shall provide a start and end time for manual commands.	Demonstration
3.1.8.2.10	The system shall provide a duration for manual commands.	Demonstration
3.1.8.2.11	The system shall revert to time of day operation after the manual command ends.	Demonstration
3.1.8.2.12	The system shall time-stamp a log of all manual commands.	Demonstration
3.1.8.2.13	The system shall place non-locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.	Demonstration
3.1.8.2.14	The system shall place a locking demand on user specified pedestrian and vehicle phases, at a user specified intersection, from the central.	Demonstration
3.1.8.2.15	The system shall place a non-locking call replicating an emergency vehicle preemption call on a user specified preemption channel at a user specified intersection.	Demonstration
3.1.8.2.16	The system shall receive data from another system (SPECIFY DETAILS).	Demonstration
3.1.8.2.17	The system shall receive data from another system (SPECIFY DETAILS).	Demonstration
3.1.8.2.18	In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined emergency vehicle preemption.	Demonstration
3.1.8.2.19	In the presence of external input, the system shall direct user-configured local controllers or groups to engage a user-defined railroad preemption.	Demonstration
3.1.8.2.20	The system shall send data to another system (SPECIFY DETAILS).	Demonstration
3.1.8.2.21	The system shall turn on and turn off message signs from a manual command.	Demonstration
3.1.8.2.22	The system shall turn on and turn off message signs based on a user specified trigger (SPECIFY).	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.8.2.23	The system shall interface with external rail preemption system. (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.8.2.24	The system shall interface with external emergency vehicle preemption system. (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.8.2.25	The system shall interface with external light rail transit. (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.8.2.26	The system shall interface with external bus priority system. (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.8.3.1	The system shall operate in the following control modes:	Demonstration
3.1.8.3.1.1	Time of day schedule	Demonstration
3.1.8.3.1.2	Manual control	Demonstration
3.1.8.3.1.3	Traffic responsive	Demonstration
3.1.8.3.1.4	External command	Demonstration
3.1.8.3.1.5	Local control mode	Demonstration
3.1.8.3.1.6	Central control mode	Demonstration
3.1.8.4.1	The system shall implement the following user-specified actions according to a time of day schedule:	Demonstration
3.1.8.4.1.1	Re-synch the local controller time clock	Demonstration
3.1.8.4.1.2	.Activate a coordination pattern	Demonstration
3.1.8.4.1.3	.Activate an external output	Demonstration
3.1.8.4.1.4	.Deactivate an external output	Demonstration
3.1.8.5.1	The system shall operate in traffic responsive mode when commanded: <ul style="list-style-type: none"> * By manual TSS Operator command * By time of day schedule * By external input command 	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.8.5.1.1	The TSS shall accept a user-defined assignment of intersection detectors as system detectors.	Demonstration
3.1.8.5.1.2	The TSS shall accept a user-defined occupancy weighting factor for each system detector.	Demonstration
3.1.8.5.1.3	The TSS shall accept a user-defined traffic-responsive control period.	Demonstration
3.1.8.5.1.4	The TSS shall sum volume plus weighted occupancy for each system detector over the duration of the control period (volume comprises distinct detection of on and off events, and weighted occupancy is the percentage of time the detector is occupied by a vehicle multiplied by the occupancy weighting factor)	Inspection/Analysis
3.1.8.5.1.5	The TSS shall accept a user-defined detector weighting factor to be applied to each system detector volume plus weighted occupancy.	Demonstration
3.1.8.5.1.6	The TSS shall multiply the volume plus weighted occupancy by the detector weighting factor.	Inspection/Analysis
3.1.8.5.1.7	The TSS shall select coordination patterns based on threshold levels (this is an alternative to the pattern recognition method).	Test
3.1.8.5.1.7.1	The TSS shall accept a user-defined selection of system detectors designated as inbound detectors.	Demonstration
3.1.8.5.1.7.2	The TSS shall accept a user-defined selection of system detectors designated as outbound detectors.	Demonstration
3.1.8.5.1.7.3	The TSS shall total the weighted volume plus weighted occupancy for inbound detectors within each intersection group over the control period.	Inspection/Analysis
3.1.8.5.1.7.4	The TSS shall total the weighted volume plus weighted occupancy for outbound detectors within each intersection group over the control period.	Inspection/Analysis
3.1.8.5.1.7.5	The TSS shall accept user-defined thresholds for inbound pattern selection.	Demonstration
3.1.8.5.1.7.6	The TSS shall accept user-defined thresholds for outbound pattern selection.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.8.5.1.7.7	The TSS shall accept different thresholds for increasing weighted volume plus weighted occupancy totals than for decreasing weighted volume plus weighted occupancy totals (this provides the ability to incorporate hysteresis).	Demonstration
3.1.8.5.1.7.8	The TSS shall accept user-defined coordination pattern designations for each level of total weighted volume plus weighted occupancy bounded by thresholds.	Demonstration
3.1.8.5.1.7.9	The TSS shall compare the weighted volume plus weighted occupancy totals against the defined thresholds.	Inspection/Analysis
3.1.8.5.1.7.10	The TSS shall engage the inbound or outbound coordination pattern defined for the weighted volume plus weighted occupancy totals.	Test
3.1.8.5.1.8	The TSS shall select coordination patterns based on pattern recognition (this is an alternative to the threshold method).	Test
3.1.8.5.1.8.1	The TSS shall accept a table of coordination pattern designations coupled to user-defined “signature” total weighted volume plus weighted occupancy values (totals over the duration of the control period).	Demonstration
3.1.8.5.1.8.2	The TSS shall compare the total weighted volume plus weighted occupancy for each intersection group over the duration of the control period against the user-defined “signature” values.	Inspection/Analysis
3.1.8.5.1.8.3	The TSS shall engage the coordination pattern with the signature value that comes closest to the total weighted volume plus weighted occupancy for the intersection group.	Test
3.1.9.1.1.1	The ASCT shall operate non-adaptively during the presence of a defined condition.	Test
3.1.9.1.1.2	The ASCT shall operate non-adaptively when adaptive control equipment fails.	Test
3.1.9.1.1.2.1	The ASCT shall operate non-adaptively when a user-specified detector fails.	Test
3.1.9.1.1.2.2	The ASCT shall operate non-adaptively when the number of failed detectors connected to a signal controller exceeds a user-defined value.	Test
3.1.9.1.1.2.3	The ASCT shall operate non-adaptively when the number of failed detectors in a group exceeds a user-defined value.	Test

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.1.1.2.4	The ASCT shall operate non-adaptively when a user-defined communications link fails.	Test
3.1.9.1.1.3	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptively controlling a group of signals.	Demonstration
3.1.9.1.1.4	The ASCT shall operate non-adaptively when a user manually commands the ASCT to cease adaptive operation.	Demonstration
3.1.9.1.1.5	The ASCT shall operate non-adaptively in accordance with a user-defined time-of-day schedule.	Demonstration
3.1.9.1.1.6	The ASCT shall operate non-adaptively when commanded by an external system process.	Demonstration
3.1.9.1.1.7	The ASCT shall alter the adaptive operation to achieve required objectives in user-specified conditions. (The required objectives are specified in Needs Statement 4.1.1)	Analysis
3.1.9.1.1.7.1	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of the signal controllers, maximizing the throughput of the coordinated route.	Demonstration
3.1.9.1.1.7.2	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers, preventing queues from exceeding the storage capacity at user-specified locations.	Demonstration
3.1.9.1.1.7.3	When current measured traffic conditions meet user-specified criteria, the ASCT shall alter the state of signal controllers providing equitable distribution of green times.	Demonstration
3.1.9.1.1.7.4	When current measured traffic conditions meet user-defined criteria, the ASCT shall alter the state of signal controllers providing two-way progression on a coordinated route.	Demonstration
3.1.9.1.1.8	The ASCT shall provide maximum and minimum phase times.	Demonstration
3.1.9.1.1.8.1	The ASCT shall provide a user-specified maximum value for each phase at each signal controller.	Demonstration
3.1.9.1.1.8.1.1	The ASCT shall not provide a phase length longer than the maximum value.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.1.1.8.2	The ASCT shall provide a user-specified minimum value for each phase at each signal controller.	Demonstration
3.1.9.1.1.8.2.1	The ASCT shall not provide a phase length shorter than the minimum value.	Demonstration
3.1.9.1.1.9	The ASCT shall detect repeated phases that do not serve all waiting vehicles. (These phase failures may be inferred, such as by detecting repeated max-out.)	Demonstration
3.1.9.1.1.9.1	The ASCT shall alter operations, to minimize repeated phase failures.	Demonstration
3.1.9.1.1.10	The ASCT shall determine the order of phases at a user-specified intersection. (The calculation will be based on the optimization function.)	Demonstration
3.1.9.1.1.11	The ASCT shall provide coordination along a route.	Demonstration
3.1.9.1.1.11.1	The ASCT shall coordinate along a user-defined route.	Demonstration
3.1.9.1.1.11.2	The ASCT shall determine the coordinated route based on traffic conditions.	Demonstration
3.1.9.1.1.11.3	The ASCT shall determine the coordinated route based on a user-defined schedule.	Demonstration
3.1.9.1.1.11.4	The ASCT shall store XX user-defined coordination routes.	Demonstration
3.1.9.1.1.11.4.1	The ASCT shall implement a stored coordinated route by operator command.	Demonstration
3.1.9.1.1.11.4.2	The ASCT shall implement a stored coordinated route based on traffic conditions.	Demonstration
3.1.9.1.1.11.4.3	The ASCT shall implement a stored coordinated route based on a user-defined schedule.	Demonstration
3.1.9.1.1.12	The ASCT shall not prevent the use of phase timings in the local controller set by agency policy.	Demonstration
3.1.9.1.2.1	The ASCT shall not prevent protected/permissive left turn phase operation.	Demonstration
3.1.9.1.2.2	The ASCT shall not prevent the protected left turn phase to lead or lag the opposing through phase based upon user-specified conditions.	Demonstration
3.1.9.1.2.3	The ASCT shall prevent skipping a user-specified phase when the user-specified phase sequence is operating.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.1.2.4	The ASCT shall prevent skipping a user-specified phase based on the state of a user-specified external input.	Demonstration
3.1.9.1.2.5	The ASCT shall prevent skipping a user-specified phase according to a time of day schedule.	Demonstration
3.1.9.1.2.6	The ASCT shall omit a user-specified phase when the cycle length is below a user-specified value.	Demonstration
3.1.9.1.2.7	The ASCT shall omit a user-specified phase based on measured traffic conditions.	Demonstration
3.1.9.1.2.8	The ASCT shall omit a user-specified phase based on the state of a user-specified external input.	Demonstration
3.1.9.1.2.9	The ASCT shall omit a user-specified phase according to a time of day schedule	Demonstration
3.1.9.1.2.10	The ASCT shall assign unused time from a preceding phase that terminates early to a user-specified phase as follows: * next phase; * next coordinated phase;user-specified phase.	Demonstration
3.1.9.1.2.11	The ASCT shall assign unused time from a preceding phase that is skipped to a user-specified phase as follows: * previous phase; * next phase; * next coordinated phase; * user-specified phase.	Demonstration
3.1.9.1.2.12	The ASCT shall not alter the order of phases at a user-specified intersection.	Demonstration
3.1.9.1.3.1	The ASCT shall detect the presence of queues at pre-configured locations.	Demonstration
3.1.9.1.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.1.3.3	When queues are detected at user-specified locations, the ASCT shall execute user-specified adaptive operation strategy.	Demonstration
3.1.9.1.3.4	When queues are detected at user-specified locations, the ASCT shall omit a user-specified phase at a user-specified signal controller.	Demonstration
3.1.9.1.3.5	The ASCT shall meter traffic into user-specified bottlenecks by storing queues at user-specified locations.	Demonstration
3.1.9.1.3.6	The ASCT shall store queues at user-specified locations.	Demonstration
3.1.9.1.3.7	The ASCT shall maintain capacity flow through user-specified bottlenecks.	Demonstration
3.1.9.1.3.8	When queues are detected at user-specified locations, the ASCT shall limit the cycle length of the group to a user-specified value.	Demonstration
3.1.9.2.2	(Sequence-based only) The ASCT shall select cycle length based on a time of day schedule.	Demonstration
3.1.9.2.3	(Sequence-based only) The ASCT shall calculate phase lengths for all phases at each signal controller to suit the current coordination strategy .	Demonstration
3.1.9.2.4	(Sequence-based only) The ASCT shall calculate offsets to suit the current coordination strategy for the user-specified reference point for each signal controller along a coordinated route within a group.	Demonstration
3.1.9.2.4.1	(Sequence-based only) The ASCT shall apply offsets for the user-specified reference point of each signal controller along a coordinated route.	Demonstration
3.1.9.2.5	(Sequence-based only) The ASCT shall calculate a cycle length for each cycle based on its optimization objectives (as required elsewhere, e.g., progression, queue management, equitable distribution of green).	Demonstration
3.1.9.2.5.1	(Sequence-based only) The ASCT shall limit cycle lengths to user-specified values.	Demonstration
3.1.9.2.5.2	(Sequence-based only) The ASCT shall limit cycle lengths to a user-specified range.	Demonstration
3.1.9.2.5.3	(Sequence-based only) The ASCT shall calculate optimum cycle length according to the user-specified coordination strategy.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.2.5.4	(Sequence-based only) The ASCT shall limit changes in cycle length to not exceed a user-specified value.	Demonstration
3.1.9.2.5.4.1	(Sequence-based only) The ASCT shall increase the limit for the following XX cycles based on a change in conditions.	Demonstration
3.1.9.2.5.4.1.1	(Sequence-based only) The change in conditions shall be defined by XX successive adaptive increases in cycle length at the maximum rate.	Demonstration
3.1.9.2.5.4.1.2	(Sequence-based only) The increased limit shall be user-defined.	Demonstration
3.1.9.2.5.5	(Sequence-based only) The ASCT shall adjust offsets to minimize the chance of stopping vehicles approaching a signal that have been served by a user-specified phase at an upstream signal.	Demonstration
3.1.9.3.2	(Non-sequence-based only) The ASCT shall calculate the appropriate state of the signal to suit the current coordination strategy at the critical signal controller. (A critical signal controller is defined by the user.)	Demonstration
3.1.9.3.3	(Non-sequence-based only) At non-critical intersections within a group, the ASCT shall calculate the time at which a user-specified phase shall be green, relative to a reference point at the critical intersection, to suit the current coordination strategy.	Demonstration
3.1.9.3.4	(Non-sequence-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	Demonstration
3.1.9.3.5	(Non-sequence-based only) The ASCT shall adjust signal timing so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	Demonstration
3.1.9.4.2	The ASCT shall calculate a cycle length of a single intersection, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	Demonstration
3.1.9.4.3	The ASCT shall calculate optimum phase lengths, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.4.3.1	The ASCT shall limit the difference between the length of a given phase and the length of the same phase during its next service to a user-specified value.	Demonstration
3.1.9.4.3.2	When queues are detected at user-specified locations, the ASCT shall execute user-specified timing plan/operational mode.	Demonstration
3.1.9.4.4	The ASCT shall calculate phase order, based on current measured traffic conditions. (The calculation is based on the optimization objectives.)	Demonstration
3.1.9.5.2	(Phase-based only) The ASCT shall alter the state of the signal controller for all phases at the user-specified intersection.	Demonstration
3.1.9.5.3	(Phase-based only) The ASCT shall calculate the time at which a user-specified phase shall be green at an intersection.	Demonstration
3.1.9.5.4	(Phase-based only) When demand is present, the ASCT shall implement a user-specified maximum time between successive displays of each phase at each intersection.	Demonstration
3.1.9.5.5	(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic released from user-specified phases at the user-specified critical intersection.	Demonstration
3.1.9.5.6	(Phase-based only) The ASCT shall alter the operation of the non-critical intersections to minimize stopping of traffic arriving at user-specified phases at the user-specified critical intersection.	Demonstration
3.1.9.5.7	(Phase-based only) The ASCT shall adjust the state of the signal controller so that vehicles approaching a signal that have been served during a user-specified phase at an upstream signal do not stop.	Demonstration
3.1.9.6.1	The ASCT shall limit the change in consecutive cycle lengths to be less than a user-specified value.	Demonstration
3.1.9.6.2	The ASCT shall limit the change in phase times between consecutive cycles to be less than a user-specified value. (This does not apply to early gap-out or actuated phase skipping.)	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.9.6.3	The ASCT shall limit the changes in the direction of primary coordination to a user-specified frequency.	Demonstration
3.1.9.6.4	When a large change in traffic demand is detected, the ASCT shall respond more quickly than normal operation, subject to user-specified limits. (DEFINE 'MORE QUICKLY')	Demonstration
3.1.9.6.5	The ASCT shall select cycle length from a list of user-defined cycle lengths.	Demonstration
3.1.10.1	When specified by the user, the ASCT shall serve a vehicle phase more than once for each time the coordinated phase is served.	Demonstration
3.1.10.2	The ASCT shall provide a minimum of XX phase overlaps.	Demonstration
3.1.10.3	The ASCT shall accommodate a minimum of XX phases at each signal	Demonstration
3.1.10.4	The ASCT shall accommodate a minimum of XX rings at each signal.	Demonstration
3.1.10.5	The ASCT shall accommodate a minimum of XX phases per ring	Demonstration
3.1.10.6	The ASCT shall provide a minimum of XX different user-defined phase sequences for each signal.	Demonstration
3.1.10.6.1	Each permissible phase sequence shall be user-assignable to any signal timing plan.	Demonstration
3.1.10.6.2	Each permissible phase sequence shall be executable by a time of day schedule.	Demonstration
3.1.10.6.3	Each permissible phase sequence shall be executable based on measured traffic conditions	Demonstration
3.1.10.7	The ASCT shall not prevent a phase/overlap output by time-of-day.	Demonstration
3.1.10.8	The ASCT shall not prevent a phase/overlap output based on an external input.	Demonstration
3.1.10.9	The ASCT shall not prevent the following phases to be designated as coordinated phases. (User to list all required phases.)	Demonstration
3.1.10.10	The ASCT shall have the option for a coordinated phase to be released early based on a user-definable point in the phase or cycle. (User select phase or cycle.)	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.10.11	The ASCT shall not prevent the controller from displaying flashing yellow arrow left turn or right turn. (SELECT AS APPLICABLE)	Demonstration
3.1.10.12	The ASCT shall not prevent the local signal controller from performing actuated phase control using XX extension/passage timers as assigned to user-specified vehicle detector input channels in the local controller.	Demonstration
3.1.10.12.1	The ASCT shall operate adaptively using user-specified detector channels.	Demonstration
3.1.10.13	When adaptive operation is used in conjunction with normal coordination, the ASCT shall not prevent a controller serving a cycle length different from the cycles used at adjacent intersections.	Demonstration
3.1.10.14	(Describe requirements to suit other custom controller features that must be accommodated.)	Demonstration
3.1.10.15	The ASCT shall operate adaptively with the following detector logic. (DESCRIBE THE CUSTOM LOGIC)	Demonstration
3.1.11.1	When a pedestrian phase is called, the ASCT shall execute pedestrian phases up to XX seconds before the vehicle green of the related vehicle phase.	Demonstration
3.1.11.2	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times during adaptive operations.	Demonstration
3.1.11.3	When a pedestrian phase is called, the ASCT shall accommodate pedestrian crossing times then resume adaptive operation.	Demonstration
3.1.11.4	The ASCT shall execute user-specified exclusive pedestrian phases during adaptive operation.	Demonstration
3.1.11.5	The ASCT shall execute pedestrian recall on user-defined phases in accordance with a time of day schedule.	Demonstration
3.1.11.6	The ASCT shall begin a non-coordinated phase later than its normal starting point within the cycle when all of the following conditions exist: * The user enables this feature	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	<ul style="list-style-type: none"> * Sufficient time in the cycle remains to serve the minimum green times for the phase and the subsequent non-coordinated phases before the beginning of the coordinated phase * The phase is called after its normal start time * The associated pedestrian phase is not called 	
3.1.11.7	When specified by the user, the ASCT shall execute pedestrian recall on pedestrian phase adjacent to coordinated phases.	Demonstration
3.1.11.8	When the pedestrian phases are on recall, the ASCT shall accommodate pedestrian timing during adaptive operation.	Demonstration
3.1.11.9	The ASCT shall not inhibit negative vehicle and pedestrian phase timing.	Demonstration
3.1.11.10	The ASCT shall accommodate the following custom pedestrian features. (Specify the requirements in conjunction with their corresponding need.)	Demonstration
3.1.12.1	The ASCT shall set a specific state for each special function output based on the occupancy on a user-specified detector.	Demonstration
3.1.12.2	The ASCT shall set a specific state for each special function output based on the current cycle length.	Demonstration
3.1.12.3	The ASCT shall set a specific state for each special function output based on a time-of-day schedule.	Demonstration
3.1.13.1	<p>The ASCT shall be compatible with the following detector technologies (agency to specify):</p> <ul style="list-style-type: none"> * Detector type A * Detector type B * Detector type C 	Analysis
3.1.13.2	The ASCT vendor shall specify detector requirements.	Inspection/Analysis
3.1.13.2.1	Vendor shall specify required detector accuracy	Inspection/Analysis
3.1.13.2.2	Vendor shall specify required detector output latency	Inspection/Analysis

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.13.2.3	Vendor shall specify detection zone coverage	Inspection/Analysis
3.1.13.2.4	Vendor shall specify mounting requirements	Inspection/Analysis
3.1.13.2.5	Vendor shall specify installation requirements	Inspection/Analysis
3.1.13.2.6	Detectors verified against the provided requirements shall be deemed acceptable by the ASCT Vendor.	Inspection/Analysis
3.1.13.2.7	The Vendor shall be responsible to provide expected functionality using verified detectors.	Demonstration
3.1.13.3	The ASCT shall measure the length of queues to support the adaptive algorithm	Test
3.1.13.3.1	The measurement shall be made with sufficient precision to support the adaptive algorithm.	Test
3.1.14.1	The ASCT shall maintain adaptive operation at non-preempted intersections during railroad preemption.	Demonstration
3.1.14.2	The ASCT shall maintain adaptive operation at non-preempted intersections during emergency vehicle preemption.	Demonstration
3.1.14.3	The ASCT shall maintain adaptive operation at non-preempted intersections during Light Rail Transit preemption.	Demonstration
3.1.14.4	The ASCT shall resume adaptive control of signal controllers when preemptions are released.	Demonstration
3.1.14.5	The ASCT shall execute user-specified actions at non-preempted signal controllers during preemption. (E.g., inhibit a phase, activate a sign, display a message on a DMS)	Demonstration
3.1.14.6	The ASCT shall operate normally at non-preempted signal controllers when special functions are engaged by a preemption event. (Examples of such special functions are a phase omit, a phase maximum recall or a fire route.)	Demonstration
3.1.14.7	The ASCT shall release user-specified signal controllers to local control when one signal in a group is preempted.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.14.8	The ASCT shall not prevent the local signal controller from operating in normally detected limited-service actuated mode during preemption.	Demonstration
3.1.15.1	The ASCT shall continue adaptive operations of a group when one of its signal controllers has a transit priority call.	Demonstration
3.1.15.2	The ASCT shall advance the start of a user-specified green phase in response to a transit priority call.	Demonstration
3.1.15.2.1	The advance of start of green phase shall be user-defined.	Demonstration
3.1.15.2.2	Adaptive operations shall continue during the advance of the start of green phase.	Demonstration
3.1.15.3	The ASCT shall delay the end of a green phase, in response to a priority call.	Demonstration
3.1.15.3.1	The delay of end of green phase shall be user-defined.	Demonstration
3.1.15.3.2	Adaptive operations shall continue during the delay of the end of green phase.	Demonstration
3.1.15.4	The ASCT shall permit at least XX exclusive transit phases.	Demonstration
3.1.15.4.1	Adaptive operations shall continue when there is an exclusive transit phase call.	Demonstration
3.1.15.5	The ASCT shall control vehicle phases independently of the following:	Demonstration
3.1.15.5.1	* LRT only phases	Demonstration
3.1.15.5.2	* Bus only phases	Demonstration
3.1.15.6	The ASCT shall interface with external bus transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.15.7	The ASCT shall interface with external light rail transit priority system in the following fashion..... (explain the external system and refer to other interfaces as appropriate)	Demonstration
3.1.15.8	The ASCT shall accept a transit priority call from: * a signal controller/transit vehicle detector;	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	* an external system.	
3.1.16.1.1	The system shall collect and store volume data for each detector.	Demonstration
3.1.16.1.2	The system shall collect and store occupancy data for each detector.	Demonstration
3.1.16.1.3	The system shall time stamp each detector actuation.	Demonstration
3.1.16.1.4	The system shall upload local controller logs by TSS Operator manual command.	Demonstration
3.1.16.1.5	The system shall upload local controller logs according to a time of day schedule.	Demonstration
3.1.16.1.6	The TSS shall collect and store phase data for every permitted phase, including the length of the phase split [This requirement may be superfluous in systems supported by high-resolution data. This requirement is intended to support legacy approaches to providing a split monitoring capability within traffic signal systems.]	Demonstration
3.1.16.1.7	The system shall collect and store the following logs in user-definable format:	Demonstration
3.1.16.1.7.1	Timing plan change	Demonstration
3.1.16.1.7.2	Signal phase change	Demonstration
3.1.16.1.7.3	Special function change	Demonstration
3.1.16.1.7.4	Coordination status change	Demonstration
3.1.16.1.7.5	Operating mode change	Demonstration
3.1.16.1.7.6	Equipment failure	Demonstration
3.1.16.1.7.7	Communications failure	Demonstration
3.1.16.1.7.8	Manual commands	Demonstration
3.1.16.1.7.9	Operator log-on	Demonstration
3.1.16.1.7.10	Operator log-off	Demonstration
3.1.16.1.7.11	Emergency vehicle preemption on-off	Demonstration
3.1.16.1.7.12	Transit priority request, on-off	Demonstration
3.1.16.1.7.13	Action sets	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.16.1.7.14	Database changes	Demonstration
3.1.16.1.8	The system shall store the logs, alarms, and reports for a user defined amount of time (at least (X) years) where they are easily accessible. [User specify]	Demonstration
3.1.16.1.9	The system shall automatically transfer all logs, alarms, and reports to an archive system.	Demonstration
3.1.16.1.10	The archive system shall store each log, alarm and report for a minimum of (X) years (USER SPECIFY).	Inspection
3.1.16.2.1	<p>The system shall create alerts of the following events:</p> <ul style="list-style-type: none"> * Detector fault/failure * Communication fault/failure * Flash mode * Preemption fault/failure * Transit signal priority fault/failure * Cabinet flash * Cabinet door open * Temperature out of range * Adaptive Processor and Algorithms (Note: Only with adaptive operations) 	Test
3.1.16.2.2	The system shall provide an alert of any discrepancies between the central controller database and the infield database for each controller.	Test
3.1.16.2.3	The system shall classify every alerts as critical, warning, and informational only, based user-specified rules.	Demonstration
3.1.16.2.3.1	The system shall alert TSS Operator via text message.	Demonstration
3.1.16.2.3.2	The system shall alert TSS Operator via email.	Demonstration
3.1.16.2.3.3	The system shall alert TSS Operator by message on TSS Operator's desktop.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.16.3.1	<p>The system shall create performance measure reports from the data in the controller logs, including the following:</p> <ul style="list-style-type: none"> * Split logs (average split times, percent max out and force offs, percent gap outs, percent skips) * Detector health * Coordination plans * Pedestrian actuations * Transit signal priority actuations * Emergency vehicle preemption actuations * Real time split reports (showing programmed and actual splits) 	Demonstration
3.1.16.3.2	The system shall create standard reports [specify].	Demonstration
3.1.16.3.3	The system shall create user customizable reports.	Demonstration
3.1.16.3.4	The system shall create the reports for a user-specified period.	Demonstration
3.1.16.3.5	The system shall collect detector data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.	Demonstration
3.1.16.3.6	The system shall collect signal phase data consistent with the Indiana Traffic Signal High Resolution Data Logger Enumerations.	Demonstration
3.1.16.3.7	<p>The system shall produce performance reports consistent with:</p> <ul style="list-style-type: none"> * Attached performance report document (USER SPECIFIED - attach) * Purdue Pooled Fund Study 	Demonstration
3.1.16.4.1	The ASCT shall report measures of current traffic conditions on which it bases signal state alterations.	Demonstration
3.1.16.4.2	The ASCT shall report all intermediate calculated values that are affected by calibration parameters.	Demonstration
3.1.16.4.3	The ASCT shall maintain a log of all signal state alterations directed by the ASCT.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.16.4.3.1	The ASCT log shall include all events directed by the external inputs.	Demonstration
3.1.16.4.3.2	The ASCT log shall include all external output state changes.	Demonstration
3.1.16.4.3.3	The ASCT log shall include all actual parameter values that are subject to user-specified values.	Demonstration
3.1.16.4.3.4	The ASCT shall maintain the records in this ASCT log for XX period.	Demonstration
3.1.16.4.3.5	The ASCT shall archive the ASCT log in the following manner: (Specify format, frequency, etc., to suit your needs.)	Demonstration
3.1.16.5.1	The Performance Measurement Server shall retrieve and store high-resolution data from local traffic signal controllers. [This requires the agency to provide traffic signal controllers that store the high-resolution data, which are not covered by these Model Documents.	Demonstration
3.1.16.5.1.1	High-resolution data are defined by (specify details).	Demonstration
3.1.16.5.1.2	The Performance Measurement Server shall store uploaded high-resolution data for [specify timeframe].	Demonstration
3.1.16.5.1.3	The TSS shall not prevent the local controller from accessing local devices as needed to store high-resolution data.	Demonstration
3.1.16.6.1	<p>The Performance Measurement Server shall process the collected and stored high resolution data to produce the following reports:</p> <ul style="list-style-type: none"> * Signal Measures Charts: <ul style="list-style-type: none"> o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: <ul style="list-style-type: none"> o Usage 	Demonstration
3.1.16.7.1	The TSS shall provide predefined reports of stored data for non-technical recipients in accordance with user-specified formats. (Specify report formats to accompany this requirement.)	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.16.7.2	The TSS shall display stored data that illustrate adaptive input data and output decisions. (This display will be used by the TSS Operator.)	Demonstration
3.1.16.7.3	<p>The Performance Measurement Server shall provide the following reports:</p> <ul style="list-style-type: none"> * Signal Measures Charts: <ul style="list-style-type: none"> o Approach Delay o Approach Speed o Approach Volume o Arrivals on Red o Pedestrian Delay o Preemption Details o Purdue Coordination Diagram o Purdue Link Pivot o Purdue Phase Termination o Purdue Split Failures o Split Monitor o Turning Movement o Yellow and Red Actuations * Reports: <ul style="list-style-type: none"> o Usage 	Demonstration
3.1.16.7.3.1	Performance measurement reports shall be consistent with descriptions in ATSPM version 4.0 (or later) documentation.	Demonstration
3.1.16.7.4	The TSS (ASCT) shall provide traffic performance measurement using probe vehicle reports provided by an external service [specify].	Demonstration
3.1.16.7.5	The TSS (ASCT) shall provide traffic performance measurement using [specify alternative approaches not covered in other requirements].	Demonstration
3.1.16.8.1	The TSS shall provide configurable alerts to the TSS Operator based on traffic operational performance. (Specify alerts to accompany this requirement.)	Demonstration
3.1.17.1	<p>The TSS (ASCT) shall support external interfaces according to the referenced interface control documents and the following detailed requirements. (Insert appropriate requirements that suit your needs. Interface data flows should be documented in your ITS</p> <ul style="list-style-type: none"> * Information layer protocol * Application layer protocol * Lower layer protocol * Data aggregation * Frequency of storage 	Analysis

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
	<ul style="list-style-type: none"> * Frequency of reporting * Duration of storage) 	
3.1.17.1.1	The ASCT shall send operational data to XX external system. (Insert appropriate requirements that suit your needs.)	Demonstration
3.1.17.1.2	The ASCT shall send control data to the XX external system. (Insert appropriate requirements that suit your needs.)	Demonstration
3.1.17.1.3	The ASCT shall send monitoring data to the XX external system. (Insert appropriate requirements that suit your needs.)	Demonstration
3.1.17.1.4	The ASCT shall send coordination data to the XX external system. (Insert appropriate requirements that suit your needs.)	Demonstration
3.1.17.1.5	The ASCT shall send performance data to the XX external system. (Insert appropriate requirements that suit your needs.)	Demonstration
3.1.17.1.6	The ASCT shall receive commands from the XX external system.	Demonstration
3.1.17.1.7	<p>The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation)</p> <ul style="list-style-type: none"> * Specified cycle length * Specified direction of progression * Specified adaptive strategy 	Demonstration
3.1.17.1.8	The ASCT shall conform its operation to an external system's operation.	Demonstration
3.1.17.1.8.1	The ASCT shall alter its operation to minimize interruption of traffic entering the system. (This may be achieved via detection, with no direct connection to the other system.)	Demonstration
3.1.17.1.8.2	The ASCT shall operate a fixed cycle length to match the cycle length of an adjacent system.	Demonstration
3.1.17.1.8.3	The ASCT shall alter its operation based on data received from another system.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.17.1.8.4	The ASCT shall support adaptive coordination on crossing routes.	Demonstration
3.1.17.1.9	The ASCT shall set the state of external input/output states according to a time-of-day schedule.	Demonstration
3.1.17.1.10	The ASCT output states shall be settable according to a time-of-day schedule.	Demonstration
3.1.17.1.11	The ASCT shall implement the following commands from the XX external system when commanded: (Edit as appropriate for your situation) ·Specified cycle length	Demonstration
3.1.17.1.12	The ASCT shall conform its operation to an external system's operation.	Demonstration
3.1.18.1	The vendor's software shall be fully operational within the following platform: (edit as appropriate) * Windows-PC, * Linux, * Mac-OS, * Unix.	Demonstration
3.1.18.2	The ASCT shall fully satisfy all requirements when connected with detectors from manufacturer XX (specify required detector types).	Demonstration
3.1.18.3	The ASCT shall fully satisfy all requirements when connected with XX controllers (specify controller types).	Demonstration
3.1.19.1	The vendor shall provide training on all the operations of the system.	Demonstration
3.1.19.2	The vendor shall provide a minimum of XX hours of training to a minimum of XX staff. (SPECIFY)	Demonstration
3.1.19.3	The vendor shall provide a minimum of XX training sessions (specify how many sessions over what period).	Demonstration
3.1.19.4	The vendor shall provide the following training (edit as appropriate).	Demonstration
3.1.19.4.1	The vendor shall provide training on troubleshooting the system.	Demonstration

Requirements Document Reference Number	System Requirements Sample Statements	Verification Method
3.1.19.4.2	The vendor shall provide training on system configuration.	Demonstration
3.1.19.4.3	The vendor shall provide training on administration of the system.	Demonstration
3.1.19.4.4	The vendor shall provide training on the operations of the adaptive system.	Demonstration
3.1.19.4.5	The vendor shall provide training on the operations of the automated traffic signal performance measurement and monitoring.	Demonstration
3.1.19.4.6	The vendor shall provide training on system calibration.	Demonstration
3.1.19.4.7	The vendor's training delivery shall include: printed course materials and references, electronic copies of presentations and references.	Inspection
3.1.19.4.8	The vendor's training shall be delivered at (SPECIFY location for training).	Demonstration
3.1.20.1	The Maintenance Vendor shall provide maintenance according to a separate maintenance contract. That contract should identify repairs necessary to preserve requirements fulfillment, responsiveness in effecting those repairs, and all requirements on the maintenance provider while performing the repairs.	Inspection
3.1.20.2	The Vendor shall provide routine updates to the software and software environment necessary to preserve the fulfillment of requirements for a period of XX years. Preservation of requirements fulfillment especially includes all IT management requirements as previously identified.	Inspection
3.1.20.3	The Vendor shall warrant the system to be free of defects in materials and workmanship for a period of XX years. Warranty is defined as correcting defects in materials and workmanship (subject to other language included in the purchase documents). Defect is defined as any circumstance in which the material does not perform according to its specification.	Inspection

APPENDIX D: VERIFICATION PLAN SAMPLE CASES

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
1	TSS Access Control	This verification case will test the access control requirements of the Traffic Signal System (TSS). Requirements include the TSS Manager assigning access control to the other user roles as well as the TSS allowing the various users to configure, monitor and control TSS Field Equipment. The requirements also cover the TSS Maintainer running diagnostics and testing. The TSS User access control capabilities will be verified in accordance with their corresponding requirements. No additional hardware or software besides the TSS itself is envisioned to accomplish this verification test.	3.1.1	Access Control
2	TSS Security	This verification case tests the TSS security requirements. These requirements include specification of TSS User privileges to system features and functions. The user privileges are also defined for geographic area, time of day and device ownership. The verification of the TSS security requirements should be in compliance with the agency's security policy. Corresponding ASCT system security requirements will be tested if adaptive capabilities are selected.	3.1.2	Security

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
3	System Configuration	This verification case will test the system configuration requirements of the TSS. Requirements include the TSS allowing the TSS User configuration of the TSS as well as arbitration and configuration of the parameters for data logging and number of users. In addition, requirements also include managing network characteristics (both traditional signal systems and adaptive), traffic performance measurement characteristics, and overall traffic system architecture.	3.1.3	System Configuration
4	TSS Database Development	The TSS Database Development verification case will test the ability to create and manage signal timing database and parameter settings. In addition this verification case covers the transfer of signal timing data from optimization software.	3.1.4	Database Development
5	TSS Database Management	This verification case covers the testing of database upload and download to a signal controller. It also covers archival of all intersection databases. Special adaptive signal control technology capabilities (as applicable) are also included in this verification case.	3.1.5	Database Management
6	TSS Fault Management	This verification case will test the TSS handling of faults. Requirements include running system diagnostics, detection and reporting of suspected system faults, detection and reporting of suspected detector failures, detection and reporting of adaptive processor faults (if applicable) and detection and reporting of suspected communications faults.	3.1.6	Failure Events and Fallback

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
7	TSS Field Equipment Monitoring	This verification case will test the TSS Field Equipment monitoring requirements of the TSS. Requirements include the TSS allowing the TSS User to select which mapping capability to display a set of TSS Field Equipment as well as allowing the TSS Manager to monitor the TSS Field Equipment intersection status.	3.1.7	Monitoring
8	TSS Field Equipment Control	This verification case will test the TSS Field Equipment control requirements of the TSS. Requirements include the TSS allowing the TSS User to control time management, system management, different control modes, time-of-day operation and traffic responsiveness.	3.1.8	Control
9	General Adaptive Operation	The general adaptive operation verification case covers mode of operation for sequence-based and non-sequence-based operations, allowable phases, and oversaturation.	3.1.9	Adaptive Operations
9	General Adaptive Operation	The general adaptive operation verification case covers mode of operation for sequence-based and non-sequence-based operations, allowable phases, and oversaturation.	3.1.9.1	General
10	Sequence-Based Adaptive Coordination	This verification case describes the sequence-based adaptive coordination tests, assuming that adaptive sequence-based coordination is being used.	3.1.9.2	Sequence-based Adaptive Coordination
11	Non-Sequenced-Based Adaptive Coordination	This verification case describes the non-sequence-based adaptive coordination tests, assuming that adaptive non-sequence-based coordination is being used.	3.1.9.3	Non-sequence-based adaptive coordination
12	Single Intersection Adaptive Operation	This verification case satisfies the requirements for adaptive single intersection operation. These requirements are appropriate for your system if non-coordinated adaptive coordination is likely to provide acceptable operation in your situation.	3.1.9.4	Single intersection adaptive operation

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
13	Phase-Based Adaptive Coordination	This verification case satisfies the requirements for adaptive phase-based intersection operation. These requirements are appropriate for your system if phase-based adaptive coordination is likely to provide acceptable operation in your situation.	3.1.9.5	Phase-based adaptive coordination
14	Adaptive Responsiveness	This verification case covers how the TSS responds in an adaptive system environment where detection shows large changes in traffic demand.	3.1.9.6	Responsiveness
15	Adaptive Advanced Controller Operation	This verification case describes the testing needed for the adaptive advanced controller operations requirements. A number of different advanced capabilities are covered along with user specified phase sequences for each signal and detector logic.	3.1.10	Adaptive Advanced Controller Operation
16	Adaptive Pedestrians	The Adaptive Pedestrians verification case covers the capabilities of the adaptive system when a pedestrian phase is called. The TSS will accommodate pedestrian crossing times and then resume adaptive operation.	3.1.11	Adaptive Pedestrians
17	Adaptive Special Functions	This verification case describes how the Adaptive Special Functions requirements are tested, including setting a specific state for each special function output based on the occupancy on a user-specified detector. The TSS with adaptive capabilities also can set a specific state for each special function output based on the current cycle length and/or the time-of-day schedule.	3.1.12	Adaptive Special Functions
18	Adaptive Detection	This verification case describes the compatibility of the TSS/ASCT with certain detector technologies. The selection of detector technologies is beyond the scope of these model documents. The TSS/ASCT needs to ensure that the measurement of the length of queues is supported by the adaptive algorithm.	3.1.13	Adaptive Detection

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
19	Adaptive Railroad and Emergency Vehicle Preemption	This verification case covers the testing of the Adaptive Railroad and Emergency Vehicle Preemption requirements. The TSS/ASCT will maintain adaptive operations for non-preempted intersections during railroad, light rail transit and emergency vehicle preemption. The TSS/ASCT will resume adaptive control of preempted signal controllers when the preemptions are released.	3.1.14	Adaptive Railroad and Emergency Vehicle Preemption
20	Adaptive Transit Priority	This verification case covers the testing of the Adaptive Transit Priority requirements. The TSS/ASCT will maintain adaptive operations for a group when one of its signal controllers has a bus or light rail signal priority call. The TSS/ASCT will either advance the start of a user-specified green phase or delay the end of a green phase, in response to a priority call.	3.1.15	Adaptive Transit Priority
21	Traffic and Operational Performance Measurement, Monitoring and Reporting	This verification case describes how the TSS requirements are tested for the overall traffic and operational performance measurement, monitoring and reporting functions. This includes: TSS data collection and storage, TSS alerts, TSS performance measurement reporting, adaptive system data collection and storage, high resolution traffic performance measurement collection and storage, high resolution traffic performance measurement processing, high resolution traffic performance measurement reports and high resolution traffic performance measurement alerts.	3.1.16	Traffic and Operational Performance Measurement, Monitoring and Reporting

Case #	Case Name	Case Description	Requirement #	High-Level Requirement
22	External Interfaces	This verification case will test the TSS constraints and external interface requirements in conformance with NTCIP 1202, NTCIP 1210 and NEMA TS 2. Requirements include the interoperability and interchangeability of TSS Field Equipment with different interface standards within the TSS, accommodating existing communications interfaces, and accommodating agency IT policies.	3.1.17	External Interfaces
23	TSS Maintenance	This verification case will test the TSS maintenance requirements. Requirements include how the TSS Maintainer will maintain TSS operations, the durability of the TSS equipment, TSS Field Equipment that complies with environmental standards, the serviceability of the TSS Field Equipment, availability of serviceable parts, ability of the TSS Maintainer to remotely test devices, ability of the TSS Maintainer to access TSS Field Equipment diagnostic information, ability of the TSS Maintainer to set TSS failure conditions that trigger alarms visible to the TSS User, and allow the TSS Maintainer to remotely update software and firmware.	3.1.20	Maintenance, Support and Warranty

APPENDIX E: VALIDATION PLAN SAMPLE CASES

Case #	Case Name	Case Description	Need #	Need Category
1	Configure TSS	<p>This validation case will validate the user needs associated with configuring the TSS. The TSS Manager's user needs of configuring user permissions as well as allowing a set number of users with TSS access with arbitration of user requests for access will be validated. In addition, validation of the ability of the TSS User to enter and store information about the TSS and TSS Field Equipment characteristics will be covered by this validation case. This validation case also covers TSS and ASCT failure and fallback.</p>	4.1	System Configuration
2	Managing the Signal System and Field Device Database	<p>This validation case will validate the user needs associated with managing the traffic</p>	4.2	Managing Signal System and Field Device Database

		signal system and field device database. The user needs are grouped by general database development and general database management.		
3	TSS Control	This validation case will validate the user needs associated with TSS control including coordination (by time of day, local schedule, central schedule, manual command, external control, or traffic responsive selection of pattern), simulating controller inputs, central priority and preemption, and controller time clock resynchronization.	4.3	TSS Control
4	Adaptive System Operations	This validation case will validate the user needs associated with adaptive system operations. The user needs are grouped in the following categories: Adaptive Strategies, Adaptive Monitoring and Control, Adaptive Coordination	4.4	Adaptive System Operations

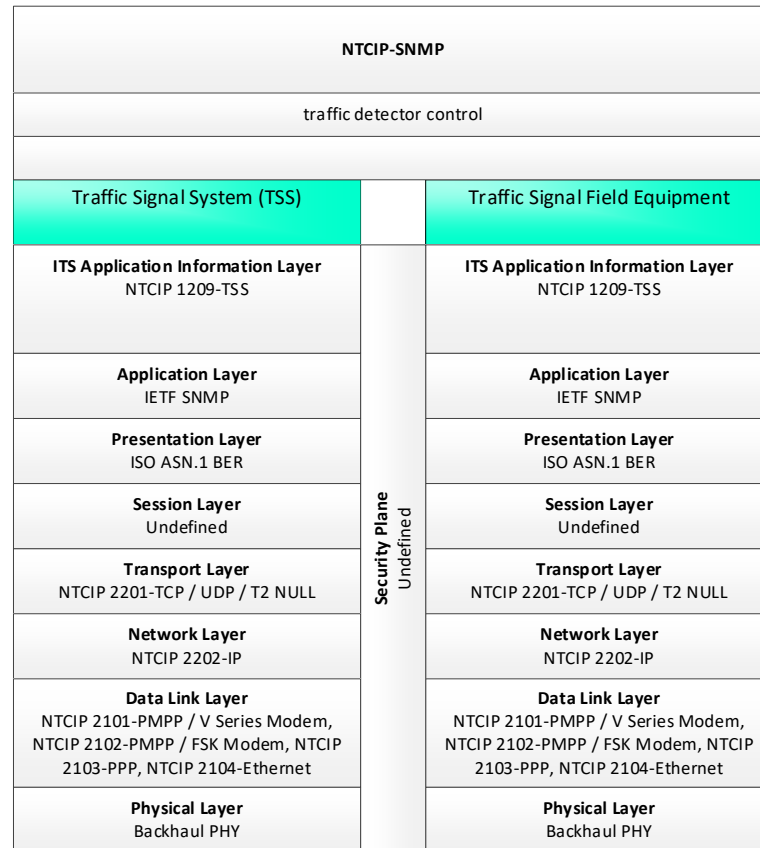
		across Boundaries, Adaptive Queuing Interactions, Adaptive Accommodation of Pedestrians, Adaptive Accommodation of Preemption and Priority, Non-Adaptive Situations, Adaptive System Responsiveness, Adaptive Complex Coordination and Controller Features and Adaptive Alerts.		
5	Traffic and Operational Performance Measurement, Monitoring and Reporting	This validation case will validate the user needs associated with traffic and operational performance measurement, monitoring and reporting. The user needs are grouped in the following categories: Logging and reports; alarms and alerts; performance measurement, analysis, and reporting; and real-time monitoring.	4.5	Traffic and Operational Performance Measurement, Monitoring, and Reporting
6	Data Storage	This validation case will validate the user needs associated with data	4.6	Data Storage

		storage. The primary user need is for the TSS Operator to access the data stored by the TSS for a specified period of time after which it will be archived.		
7	Constraints	This validation case will validate the user needs associated with constraints imposed on the TSS design. The TSS Designer may be constrained to using particular equipment, communications, protocols and software in particular environmental conditions within a specified project budget.	4.7	Constraints
8	Training	This validation case will validate the user needs associated with TSS/ASCT training. All staff involved in operations and maintenance will be trained on TSS, ASCT and ATSPM as appropriate for the procured system.	4.8	Training

9	External Interfaces	This validation case will validate the user needs associated with external interfaces to adjacent systems. System clock synchronization, coordinated and compatible signal timings, sharing of signal operational data with external systems, external system control, and control of external devices such as signs are some of the user needs validated by this case.	4.9	External Interfaces
10	Maintenance	This validation case will validate the user needs associated with making sure the system meets all needs during the life of the system. The ability to repair faults and keep the software and software environment updated is covered by this validation case. Validation of the needs of the TSS Maintainer to safely maintain the TSS Field Equipment	4.10	Maintenance, Support and Warranty

will also be covered by
this validation case.

APPENDIX F: STANDARDIZED COMMUNICATIONS PROTOCOL STACK INTERFACE DIAGRAMS



* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 9. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal System → traffic detector control → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
traffic detector control		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1209-TSS	Security Plane Undefined	ITS Application Information Layer NTCIP 1209-TSS
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 10. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal System → traffic detector control → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
traffic detector data		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1209-TSS	Security Plane Undefined	ITS Application Information Layer NTCIP 1209-TSS
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 11. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal Field Equipment → traffic detector data → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
traffic detector data		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1209-TSS	Security Plane Undefined	ITS Application Information Layer NTCIP 1209-TSS
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 12. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal Field Equipment → traffic detector data → Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
road network conditions		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 13. Communications Protocol Standards Example for the XML Triple of Traffic Signal System → road network conditions → External Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
road network conditions		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 14. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of Traffic Signal System → road network conditions → External Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
road network conditions		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 15. Communications Protocol Standards Example for the XML Triple of External Traffic Signal System → road network conditions → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
road network conditions		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 16. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of External Traffic Signal System → road network conditions → Traffic Signal System based on the CTSS Project Architecture Diagram

RSE Field to Field		
track status		
Railroad Field Equipment		Traffic Signal Field Equipment
ITS Application Information Layer IEEE 1570-2002	Security Plane IEEE 1609.2	ITS Application Information Layer IEEE 1570-2002
Application Layer Undefined		Application Layer Undefined
Presentation Layer ISO ASN.1 UPER	Security Plane IETF DTLS, IETF TLS	Presentation Layer ISO ASN.1 UPER
Session Layer IETF DTLS, IETF TLS		Session Layer IETF DTLS, IETF TLS
Transport Layer IETF UDP, IETF TCP		Transport Layer IETF UDP, IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 17. Communications Protocol Standards Example for the RSE Field to Field Triple of Railroad Field Equipment → track status → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

RSE Field to Field		
rail crossing operational status		
Traffic Signal Field Equipment		Railroad Field Equipment
ITS Application Information Layer IEEE 1570-2002	Security Plane IEEE 1609.2	ITS Application Information Layer IEEE 1570-2002
Application Layer Undefined		Application Layer Undefined
Presentation Layer ISO ASN.1 UPER	Security Plane IETF DTLS, IETF TLS	Presentation Layer ISO ASN.1 UPER
Session Layer IETF DTLS, IETF TLS		Session Layer IETF DTLS, IETF TLS
Transport Layer IETF UDP, IETF TCP		Transport Layer IETF UDP, IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 18. Communications Protocol Standards Example for the RSE Field to Field Triple of Traffic Signal Field Equipment → rail crossing operational status → Railroad Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal control status		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 19. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal Field Equipment → signal control status → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal control status		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 20. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal Field Equipment → signal control status → Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device data		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 21. Communications Protocol Standards Example for the XML Triple of Traffic Signal System → device data → External Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device data		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 22. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of Traffic Signal System → device data → External Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device data		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 23. Communications Protocol Standards Example for the XML Triple of External Traffic Signal System → device data → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device data		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 24. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of External Traffic Signal System → device data → Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device status		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 25. Communications Protocol Standards Example for the XML Triple of Traffic Signal System → device status → External Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device status		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 26. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of Traffic Signal System → device status → External Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device status		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 27. Communications Protocol Standards Example for the XML Triple of External Traffic Signal System → device status → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device status		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 28. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of External Traffic Signal System → device status → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal control commands		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 29. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal System → traffic detector control → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal control commands		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 30. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal System → signal control commands → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal control device configuration		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 31. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal System → signal control device configuration → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal control device configuration		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 32. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal System → signal control device configuration → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal control plans		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 33. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal System → signal control plans → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal control plans		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 34. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal System → signal control plans → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal system configuration		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 35. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal System → signal system configuration → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal system configuration		
Traffic Signal System (TSS)		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 36. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal System → signal system configuration → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

Legacy Short Range Communications		
local signal preemption request		
Public Safety Vehicle		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1211-SCP	Security Plane Undefined (Security)	ITS Application Information Layer NTCIP 1211-SCP
Application Layer Undefined		Application Layer Undefined
Presentation Layer Undefined	Security Plane Undefined (Security)	Presentation Layer Undefined
Session Layer Undefined		Session Layer Undefined
Transport Layer Undefined		Transport Layer Undefined
Network Layer Undefined		Network Layer Undefined
Data Link Layer Undefined		Data Link Layer Undefined
Physical Layer Undefined		Physical Layer Undefined

Figure 37. Communications Protocol Standards Example for the Legacy Short Range Communications Triple of Public Safety Vehicle → local signal preemption request → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

Legacy Short Range Communications		
local signal priority request		
Transit Vehicle		Traffic Signal Field Equipment
ITS Application Information Layer NTCIP 1211-SCP, APTA TCIP	Security Plane Undefined (Security)	ITS Application Information Layer NTCIP 1211-SCP, APTA TCIP
Application Layer Undefined		Application Layer Undefined
Presentation Layer Undefined	Security Plane Undefined (Security)	Presentation Layer Undefined
Session Layer Undefined		Session Layer Undefined
Transport Layer Undefined		Transport Layer Undefined
Network Layer Undefined		Network Layer Undefined
Data Link Layer Undefined		Data Link Layer Undefined
Physical Layer Undefined		Physical Layer Undefined

Figure 38. Communications Protocol Standards Example for the Legacy Short Range Communications Triple of Transit Vehicle → local signal priority request → Traffic Signal Field Equipment based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
right-of-way request notification		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 39. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal Field Equipment → local signal preemption request → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
right-of-way request notification		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1202-ASC, NTCIP 1211-SCP	Security Plane Undefined	ITS Application Information Layer NTCIP 1202-ASC, NTCIP 1211-SCP
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 40. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal Field Equipment → right-of-way request notification → Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device control request		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 41. Communications Protocol Standards Example for the XML Triple of Traffic Signal System → device control request → External Traffic Signal System based on the CTSS Project Architecture Diagram

XML		
device control request		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane HTTP Auth, FTP Auth, IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer IETF HTTP, IETF FTP, NTCIP 2306		Application Layer IETF HTTP, IETF FTP, NTCIP 2306
Presentation Layer W3C XML, IETF GZIP		Presentation Layer W3C XML, IETF GZIP
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 42. Communications Protocol Standards Example for the XML Triple of External Traffic Signal System → device control request → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device control request		
External Traffic Signal System		Traffic Signal System (TSS)
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 43. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of External Traffic Signal System → device control request → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SMTP		
signal fault data		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1201-GO, NTCIP 1202-ASC	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1201-GO, NTCIP 1202-ASC
Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps		Application Layer NTCIP 2301-STMP (OER) / SNMP, NTCIP 1103 SNMP Traps
Presentation Layer NTCIP 1102-OER		Presentation Layer NTCIP 1102-OER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as 1.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 44. Communications Protocol Standards Example for the NTCIP-STMP Triple of Traffic Signal Field Equipment → signal fault data → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-SNMP		
signal fault data		
Traffic Signal Field Equipment		Traffic Signal System (TSS)
ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1201-GO, NTCIP 1202-ASC	Security Plane Undefined	ITS Application Information Layer NTCIP 1210-FMS, NTCIP 1201-GO, NTCIP 1202-ASC
Application Layer IETF SNMP		Application Layer IETF SNMP
Presentation Layer ISO ASN.1 BER		Presentation Layer ISO ASN.1 BER
Session Layer Undefined		Session Layer Undefined
Transport Layer NTCIP 2201-TCP / UDP / T2 NULL		Transport Layer NTCIP 2201-TCP / UDP / T2 NULL
Network Layer NTCIP 2202-IP		Network Layer NTCIP 2202-IP
Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet		Data Link Layer NTCIP 2101-PMPP / V Series Modem, NTCIP 2102-PMPP / FSK Modem, NTCIP 2103-PPP, NTCIP 2104-Ethernet
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between the center and field, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 45. Communications Protocol Standards Example for the NTCIP-SNMP Triple of Traffic Signal Field Equipment → signal fault data → Traffic Signal System based on the CTSS Project Architecture Diagram

NTCIP-DATEX-ASN		
device control request		
Traffic Signal System (TSS)		External Traffic Signal System
ITS Application Information Layer ITE TMDD	Security Plane IETF TLS	ITS Application Information Layer ITE TMDD
Application Layer NTCIP 2304 – AP-DATEX		Application Layer NTCIP 2304 – AP-DATEX
Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER		Presentation Layer NTCIP 1102-OER, ISO ASN.1 BER
Session Layer IETF TLS		Session Layer IETF TLS
Transport Layer IETF TCP		Transport Layer IETF TCP
Network Layer IETF IPv6		Network Layer IETF IPv6
Data Link Layer LLC and MAC compatible with Physical and Network		Data Link Layer LLC and MAC compatible with Physical and Network
Physical Layer Backhaul PHY		Physical Layer Backhaul PHY

* Backhaul PHY represents any mechanism for transmitting raw bits in the physical layer between centers, such as I.430/431, SONET/SDH, IEEE 802.3, IEEE 802.11 or any other viable physical layer specification or standard.

Figure 46. Communications Protocol Standards Example for the NTCIP-DATEX-ASN Triple of Traffic Signal System → device control request → External Traffic Signal System based on the CTSS Project Architecture Diagram

APPENDIX G: GLOSSARY

CTSS	Central Traffic Signal System: The system that manages traffic signal databases and monitors the operation of traffic signal controllers. The software communicates with the traffic signals in the field from a central location such as a TMC.
COTS	Commercially available Off-The-Shelf. This is an FAR term defining a non-developmental item of supply that is both commercial and sold in substantial quantities in the commercial marketplace, and that can be procured or utilized under government contract in precisely the same form as available to the general public.
Low-bid	Contract awarded to the “lowest responsible bidder”. Bid is based on a complete set of plans and specifications that precisely defines the facilities to be built.
Natural cycle length	The cycle length at which an intersection would run with minimum overall delay.
Real-time	Activity that occurs simultaneously with or very soon after an event. For example, real-time control involves taking action based on measurements immediately after the measurement is completed.
Specification	The project-specific detailed requirements for a CTSS to be purchased by an agency or a statement by a manufacturer defining the detailed features provided by the CTSS.
Synch point	Reference point in signal phase or cycle used to synchronize operation of adjacent signals.
TSS	Traffic Signal System, short for CTSS, Central Traffic Signal System

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